

Assessment of the Proposed Policies for a Carbon Capture and Storage Regulatory Framework in
Ontario

by

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Author's Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Abstract

Since 2022, Ontario has been investigating the possibility of developing a Carbon Capture and Storage (CCS) framework as they aim to reduce carbon emissions and align with the federal government's goals of net-zero emissions by 2050. This CCS regulatory framework should focus on hard-to-abate sectors where alternative renewable energy technologies are in their early stages, or they are difficult to be transitioned. However, within the research field of CCS in Ontario from a policy perspective, there are minimal journal articles and grey-literature documents that discuss this topic. Therefore, the purpose of this thesis is to understand and analyze Ontario's proposal of their regulatory framework for CCS and to give recommendations to the CCS framework by comparing it against the information gathered from other jurisdictions (Alberta, Saskatchewan, the United States, Europe and Australia). Key research questions are 1. How can the knowledge gained from other regions regarding CCS help Ontario's hard-to-abate sectors to understand approvals, licensing, and liability? 2. What are some other necessary policies that Ontario would need to expand upon and potentially adopt from various jurisdictions? And 3. How did companies and governments in other jurisdictions communicate to the public about the need for this technology? The thesis first developed a literature review to compare and contrast policies from other jurisdictions by researching and synthesizing various peer-reviewed journal articles and grey literature. Then, a semi-structured interview was needed to explore any unique perspectives from interviewees with expertise in CCS, and also to understand whether the results aligned with the information from the literature review. Following the interviews, the analysis of the results were accomplished by using 'codes' and 'themes', which allows for a simplified understanding of which information is unique. As a result, there were unique findings from the interviews such as ensuring proper industries are utilizing CCS,

explaining the purpose of CCS, ensuring that the regulatory framework for CCS is properly developed, and the potential for CCS to utilize a carbon market through an Emissions Trading System (ETS). In November 2024, Ontario introduced Bill 228, which contains an Act called the Geologic Carbon Storage Act, 2024. This Act contains the key core components of the regulatory framework, such as ownership, liabilities, and approvals and assessments. As a result, a description and analysis of this Act was undertaken to understand how it compares against my research findings. In conclusion, to answer the first research question, the findings resulted in requiring Ontario to vest in the pore space, implement a unitization statute, implement a transfer of liabilities once certain pre-conditions are met and a post-stewardship fund to cover liability costs. As for the second research question, the other necessary policies include expanding upon environmental assessments methods, using a systems analysis approach to understand the outcomes of developing CCS, incorporating CCS into carbon pricing schemes, and Ontario's plans on how they should utilize their CCS. The findings for the final research question recommend that the Ontario government and companies recognize the social demographic backgrounds of Ontario; ensure that Ontario is integrating and engaging with communities closely; explaining the downsides of not developing a CCS project; and respecting a community's decision if they do not wish to engage with the project. Bill 228 is consistent with these findings, namely the inclusion of a liability transfer; a stewardship fund to cover the liabilities for the Crown; unitization of pore spaces; risk management; monitoring, measurement and verification (MMV); emergency response; and various approvals and assessments. However, the ownership of pore spaces deviates from these findings, as Ontario vests pore ownership to the surface owners but still allows the Crown to vest in the pore space when required.

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Key Definitions/Abbreviations

- CCS – Carbon Capture and Storage
- CO2-EOR – Carbon Dioxide Enhanced Oil Recovery
- Competent Authority – For EU’s Competent Authority, they are usually referred to each country’s respective departments depending on the context – i.e., Dutch Ministry of Foreign Affairs
- Crown – Refers to the respective Canadian government mentioned within the sentence
- EPEA - Environmental Protection and Enhancement Act
- ERCB - Energy Resources Conservation Board
- ERO – Environmental Registry of Ontario
- EU – European Union
- ETS – Emissions Trading System
- Indemnify – to protect against damage, loss, or injury/to make compensation for damage, loss or injury suffered.
- ITC - Investment Tax Credit
- MNRF- Ministry of Natural Resources and Forestry
- Natural corollary to vesting – as a natural consequence/result of acquiring a certain property by an entity (whether that would be a person or organization)
- OGCA – Oil and Gas Conservation Act
- TIER - Technology Innovation and Emissions Reduction
- UK – United Kingdom
- US – United States

1.0 Introduction

With global temperatures increasing, extreme natural weather phenomena such as wildfires, flooding, and intense hurricanes have been occurring more frequently than usual (United Nations, 2023). The rise in global temperatures is due to increased global emissions since the Industrial Revolution or after the 1850s – Figure 1 and 2 shows the increased emissions over time (Masson-Delmotte, et al., 2021).

Every tonne of CO₂ emissions adds to global warming

Global surface temperature increase since 1850–1900 (°C) as a function of cumulative CO₂ emissions (GtCO₂)

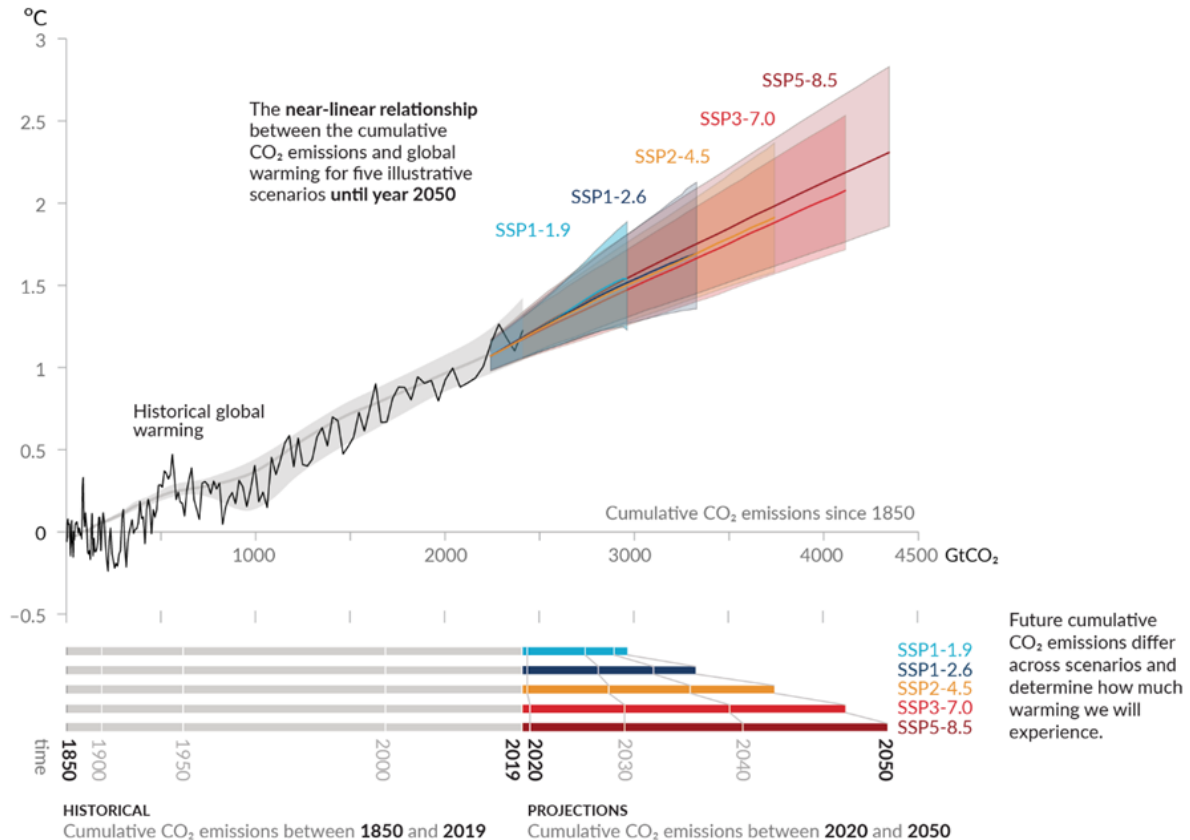


Figure 1. Showing 5 different projections with varying amounts of CO₂ emission and degree of warming. Coloured boxes on the upper part of the graph show a range of temperatures (Masson-Delmotte, et al., 2021)

Observed warming is driven by emissions from human activities, with greenhouse gas warming partly masked by aerosol cooling

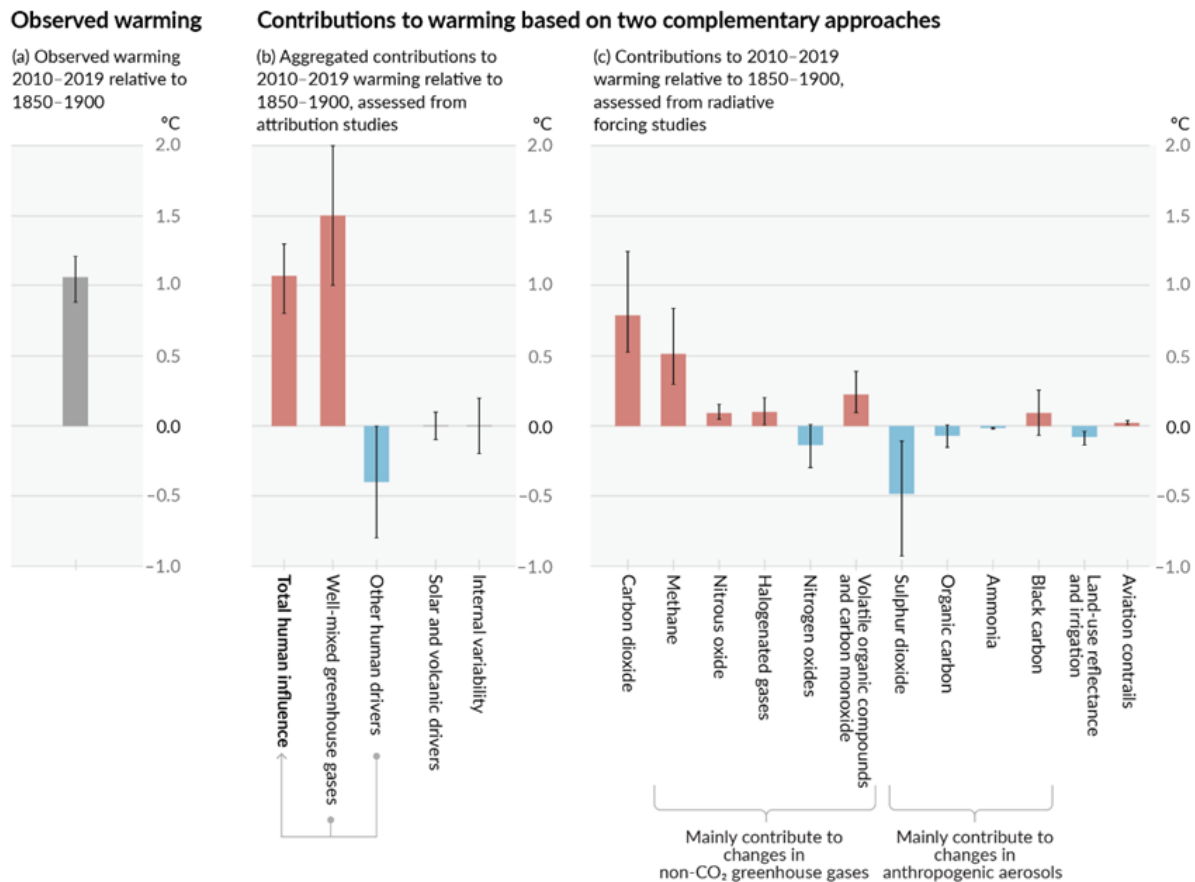


Figure 2. Graphs show how human influence and greenhouse gases led to increased temperature and the types of chemicals that contribute to or reduce global temperatures. These are based on 2010–2019 warming relative to 1850–1900 (Masson-Delmotte, et al., 2021)

As we emit increasing amounts of carbon emissions, our global temperature will increase, and this, in turn, will affect our ocean systems, increase the likelihood of extreme weather, longer heatwaves, damage to our ecosystems, increased wildfires, melting of polar ice caps, etc. (Masson-Delmotte, et al., 2021). To further emphasize the crisis of this situation, the wildfires, extreme weather events, and prolonged extreme heat events during the summer of 2023 further exemplified the connection between increased global temperatures and increased/prolonged extreme weather-related events (United Nations, 2023).

This has resulted in developed nations focusing on mitigating carbon emissions through various means, such as switching to the use of renewable resources – especially for the industrial sector. However, certain industrial sectors – such as cement and steel - have trouble in transitioning certain parts of their production process into using renewable sources and are therefore known as “hard-to-abate” sectors. The difficulty in transitioning is due to a relatively high proportion of fixed process emissions, while others like steel have high heat requirements (Kim, et al., 2022). Due to these sectors having difficulty transitioning into renewable sources, carbon capture and storage (CCS) was highlighted to be an intermediate measure to divert hard-to-abate emissions from the atmosphere. (Note: Carbon Capture and Storage (CCS) and Carbon Sequestration are interchangeable terms; however, from now on they will be instead referred to as “CCS” where possible.)

CCS technology has existed since the late 1990s and early 2000s within Canada. Starting with the Weyburn-Midale CO₂-EOR project, CCS technology has also existed and been demonstrated in other regions around the world such as the US, Europe, and Australia (Brown, et al., 2005). Figure 3 shows that most CCS projects are occurring in the US and Canada, and many of the projects are considered in advanced development, construction, or operation (Global CCS Institute, 2023).



Figure 3. The dots show various CCS projects in operation, construction, advanced development, or early development (Global CCS Institute, 2023).

The increased development in CCS within the US and Canada is due to their suitability to store carbon underground in regions where saline aquifers are prominent, as it is considered the main method of storage, and Figures 4 and 5 show the suitability of storing carbon. However, before injecting CO₂ into the saline aquifers, CCS operators must understand the geophysical properties such as the depth and size or capacity of the aquifer so that CO₂ can be properly injected. After injection, the operators would also then have to monitor the CO₂ plumes to ensure that there is no effluent of CO₂ into drinking water, and the first injection is especially critical as the geological complexity and lack of sufficient data has a high risk of leakage. As a result, there are four different trapping mechanisms to cease the migration of the plume and these include (Gholami, Iglauer, & Raza, 2021):

1. Structure trapping is where tight seal caprock stops the migration of CO₂

2. Residual trapping occurs when the capillary force of the pore structure immobilizes the plume of CO₂
3. Dissolution trapping occurs where, over time, the CO₂ mixes with brine
4. Mineral trapping where CO₂ transforms into a mineral due to a chemical reaction with rocks

In addition, other methods of storage can include oil/gas reservoirs, deep un-minable coal seams, coal bed methane, and shale formation during enhanced gas recovery (Edlmann, Foroozesh, Kumar, Lim, & Rezk, 2020).

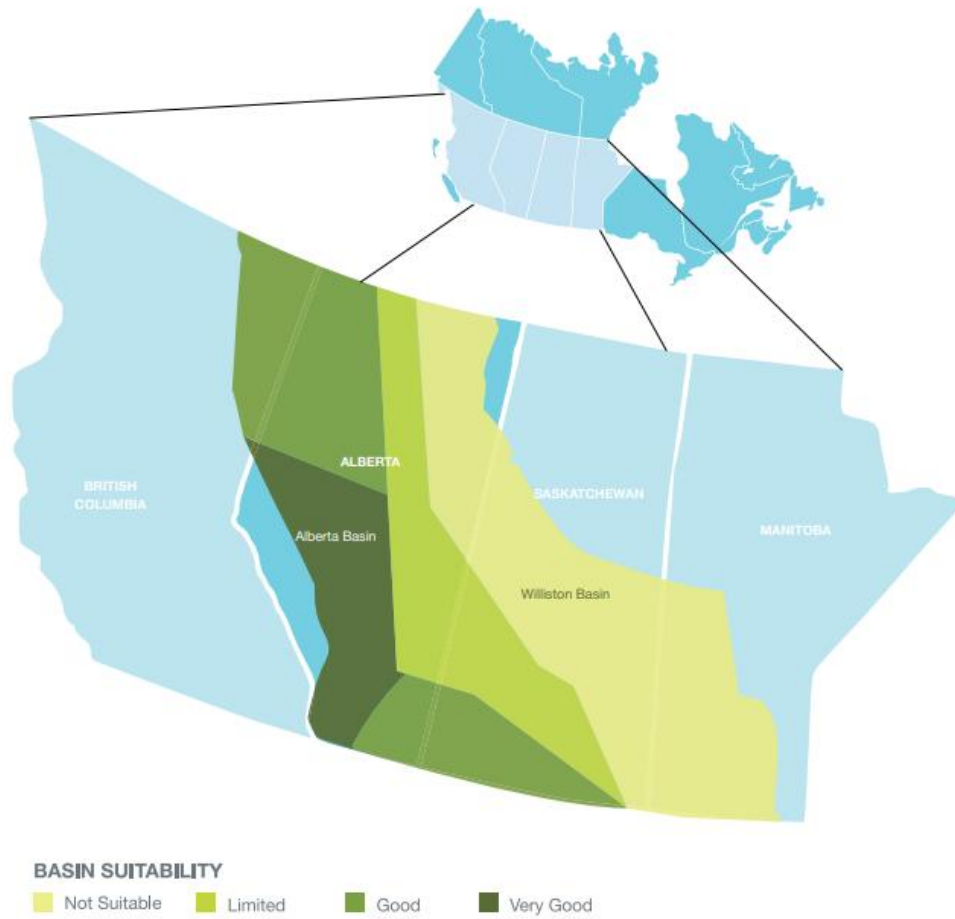


Figure 3. CO₂ Sequestration Suitability in the Western Canadian Sedimentary Basin⁷

Figure 4. Map of Western Canada showing its suitability in CCS (Electricity and Alternative Energy and Carbon Capture and Storage Division, 2013)

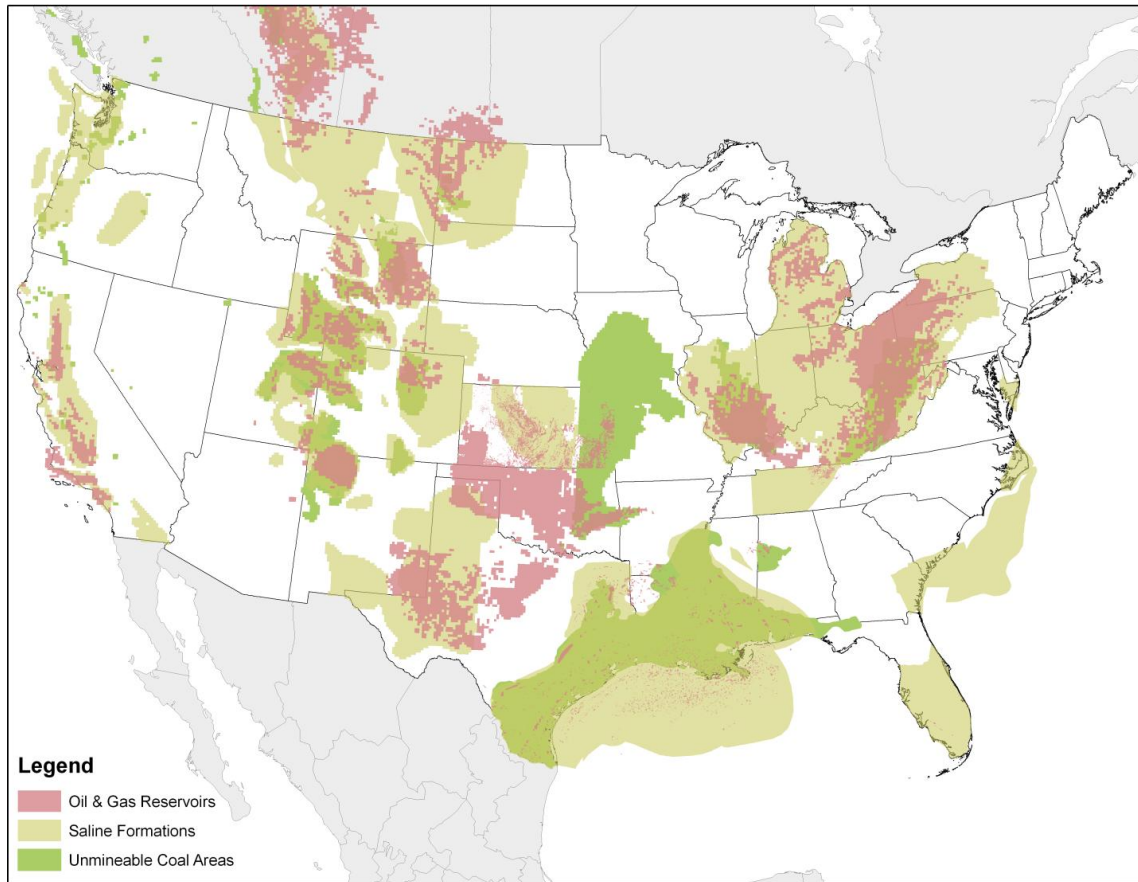


Figure 5. Map of the Contiguous United States of America, showing the potential areas for developing a CCS project (United States Environmental Protection Agency, 2017).

As a result of the “hard-to-abate” sectors, Ontario is developing a CCS regulatory framework for the following two reasons:

1. Meeting its climate goals to reduce carbon emissions – specifically with hard-to-abate sectors and aligning with the federal government’s goal to achieve net zero by 2050 (Ministry of Natural Resources and Forestry, 2022).
2. And just as importantly, taking advantage of this new technology in Ontario.

As of the published proposal in 2024 by the Ontario government, there have been several clarifications on how its regulatory framework will be developed, based on the feedback and comments received in the Environmental Registry of Ontario (ERO). However, Ontario's recent

proposals present several problems: the lack of clarification and specifics on pore ownership and liability, certain necessary policies that Ontario may need to expand upon, and the lack of outlines on communication with the public from Ontario. Therefore, this thesis hopes to give a comprehensive review of the legal works and policies being implemented by Ontario for CCS and understand what industries can do to prepare for developing a CCS project. In addition, the thesis will compare policies in different jurisdictions and clarify and improve upon Ontario's existing policies.

In summary, researchers collectively agree that hard-to-abate sectors may utilize CCS as an intermediate step in mitigating emissions; however, at the time of writing this thesis, Ontario had yet to finalize its policy framework – therefore the Ontario government should look towards other provinces of Canada, and regions such as the US, Europe and Australia regarding policies to develop a Made-in-Ontario approach. Because the context of CCS is a wide field, this research's overall aim is to analyze the regulatory practices proposed (i.e., who licenses the wells and lands? What sort of approvals are needed? How are they managing the licenses?). To consolidate even further, the research will be focused on answering the three research questions:

1. How can the knowledge gained from other regions with highly developed CCS policies help Ontario's hard-to-abate sectors understand potential approvals, licensing, and liability?
2. What are some other necessary policies that Ontario would need to expand upon and potentially adopt from various jurisdictions?
3. In jurisdictions with CCS Policies, how did companies and governments communicate to the public about the need for this technology?

The following chapters will describe the literature review and the policy context by understanding Ontario's proposed policies, comparing the property rights and liability policies developed by other jurisdictions, how Ontario can effectively communicate CCS to the public, and understanding other necessary policies that require further clarification. While these policies may or may not be implemented by the Ontario government, the policies discussed within this literature review may be beneficial for countries initially implementing a CCS framework or for companies to adopt best practices in developing safe and effective CCS.

1.1. Policy Context for Ontario

This section will go over a detailed context behind Ontario's decision to develop a CCS regulatory framework, focusing on why it is needed, the geology of Southern Ontario, Ontario's position in its regulatory processes during the writing of this thesis, and describing its next steps. Note that some of this information cites the Environmental Registry of Ontario's postings on discussions regarding the development of a Regulatory Framework. The information gathered from expert interviewees for this thesis were based on policy developments for Ontario in August 2024.

While this report focuses on regulatory frameworks, it is also just as important to mention the geographical extent of where carbon can be stored and the geophysical properties of Ontario as a background context for this regulatory framework. Preliminary studies show that areas located north of Lake Erie and Sarnia-Lambton are potentially suitable areas for carbon injection due to the Cambrian-age sandstone formations. However, this is dependent on the injection method which can potentially limit the pore volume that is accessible (Craik, 2022; Morris, 2022). Recommended depths were also another concern, as Alberta required CCS operators to locate pore space with a depth greater than 1000m. In Ontario's case, the depths would need to

be below 800 meters and contain suitable cap rock for CO₂ to be sequestered under supercritical conditions for proper storage as the Mount Simon formation is found below 800 meters (Chatzis, Croiset, Douglas, Shafeen, & Seckington, 2005; Whittingham & Wong, 2006; Lemieux, Sharp, & Shkarupin, 2020). Figures 6, 7 and 8 show the extent.

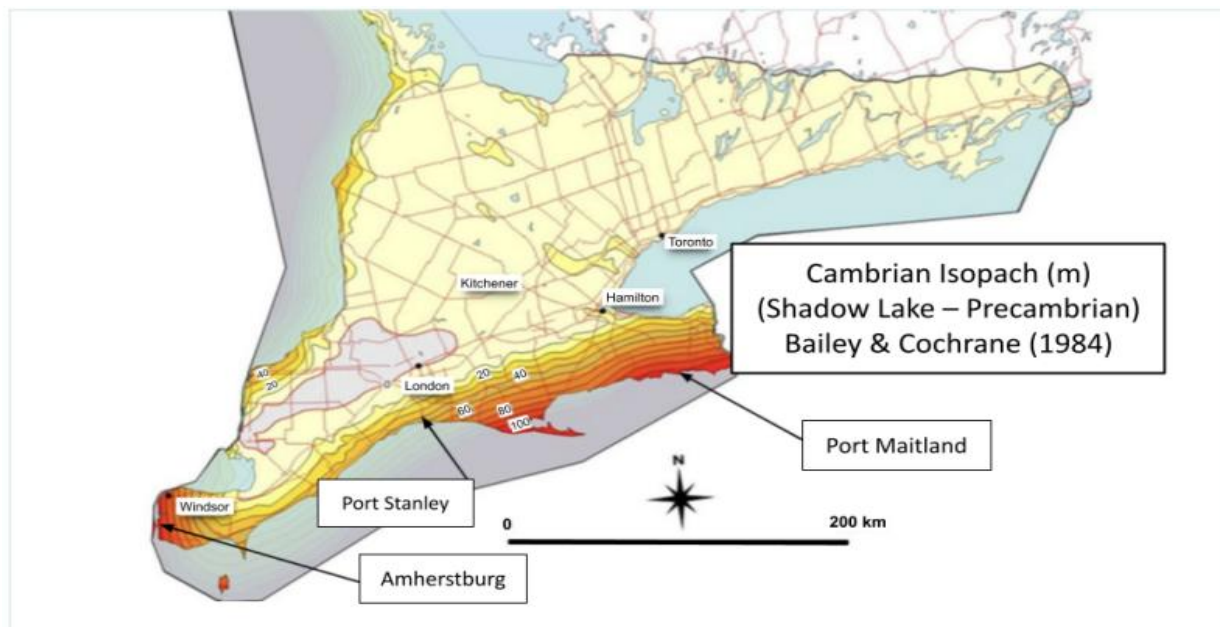


Figure 6. The thickness of the saline Cambrian sandstone aquifer in meters beneath southern Ontario (Bailey Geological Services Ltd. and Cochrane, R.O., 1984).

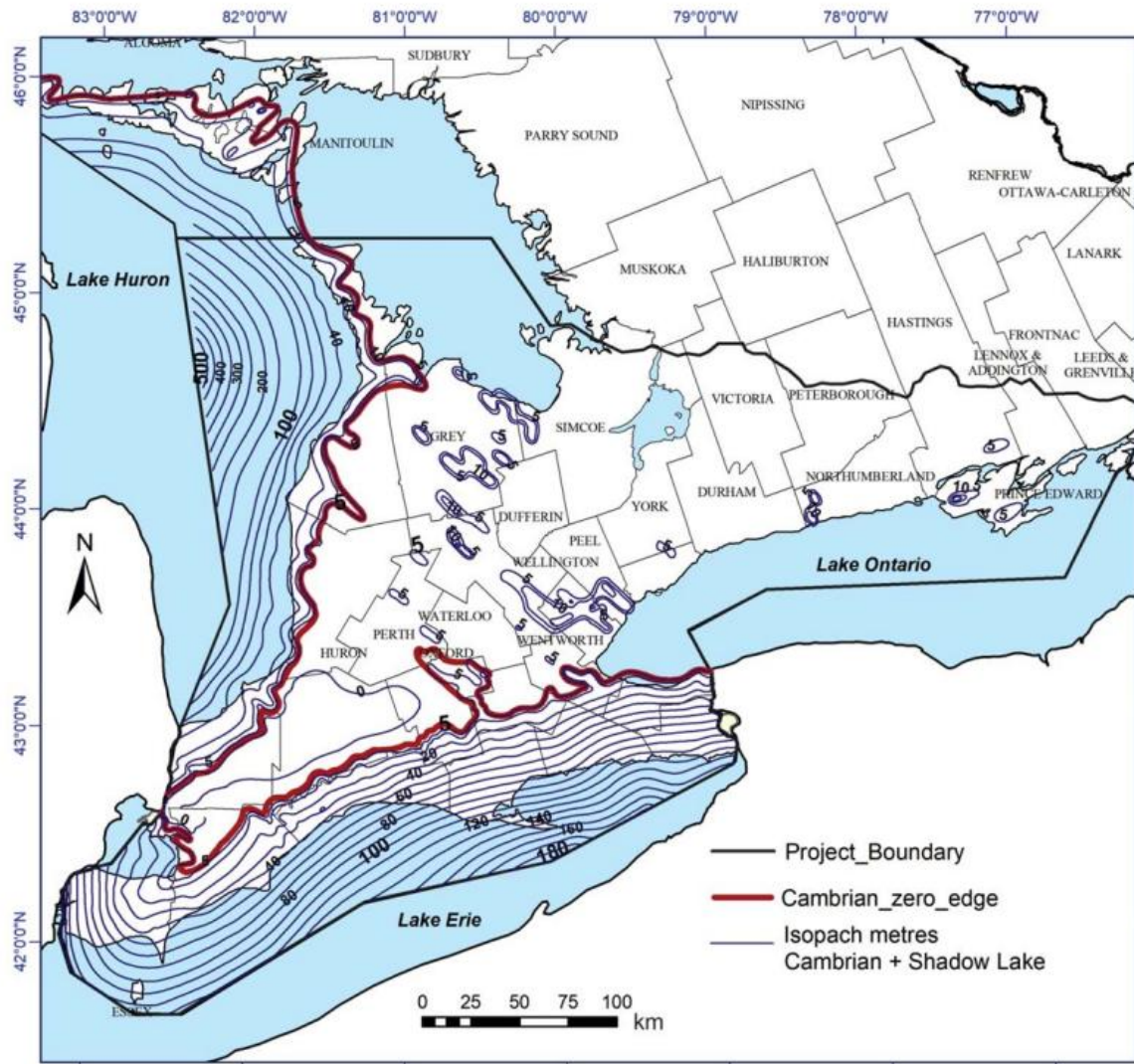


Figure 7. Another map of saline Cambrian aquifer (Carter, et al., 2021).

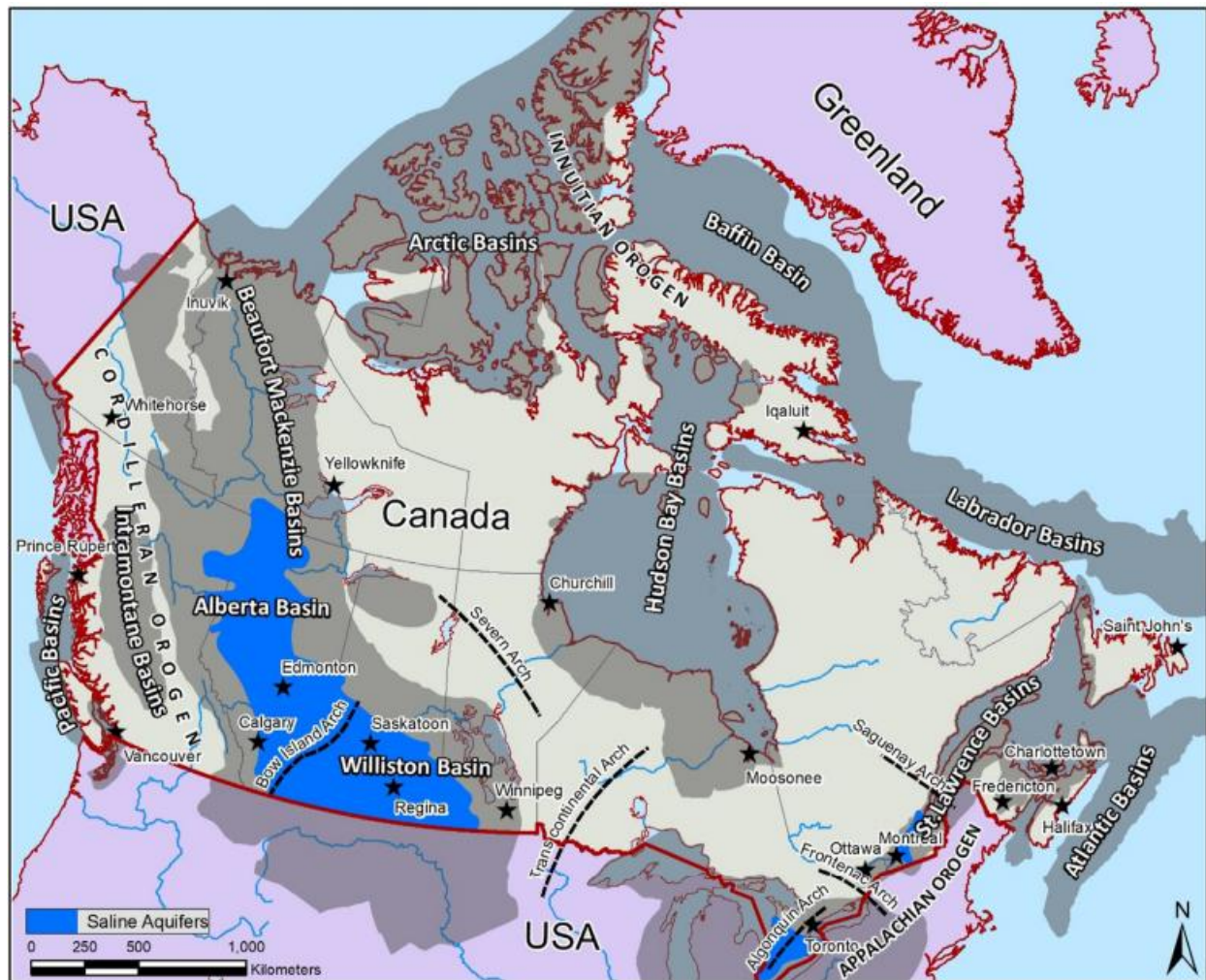


Figure 8. An expanded look of deep saline aquifers with potential for carbon storage (Lemieux, Sharp, & Shkarupin, 2020).

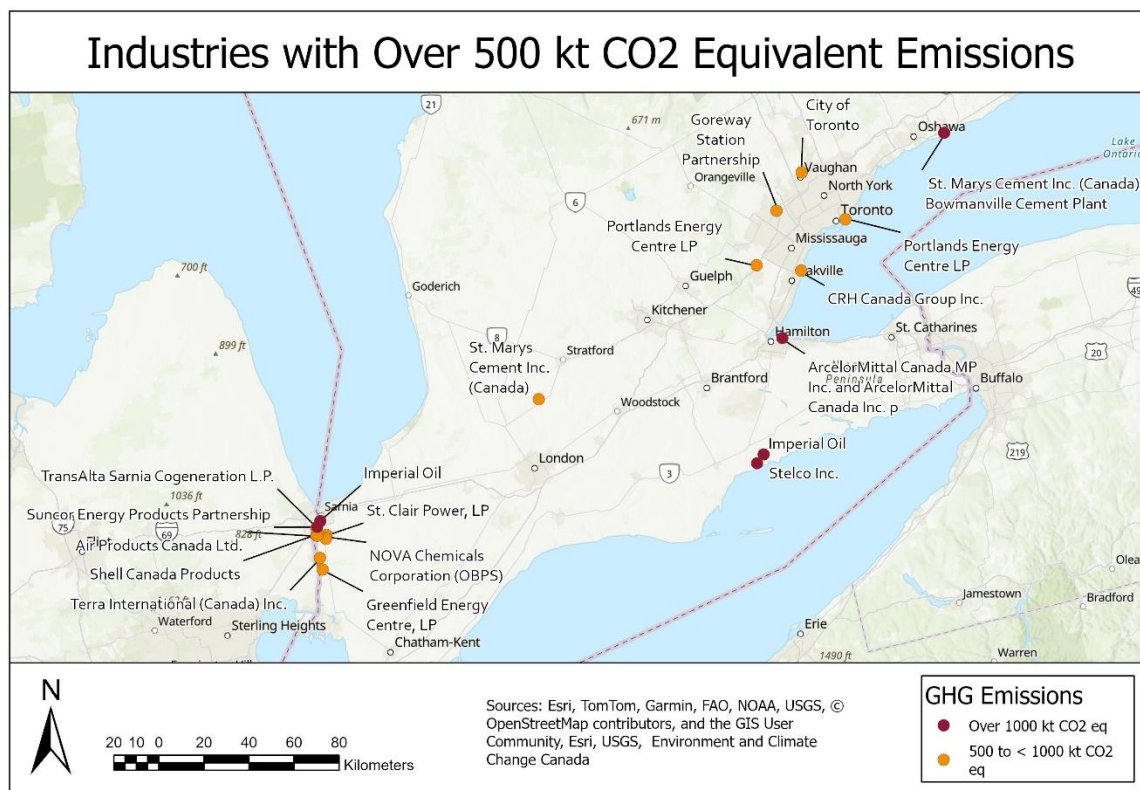


Figure 9. Industries with over 500kt CO2 equivalent emissions

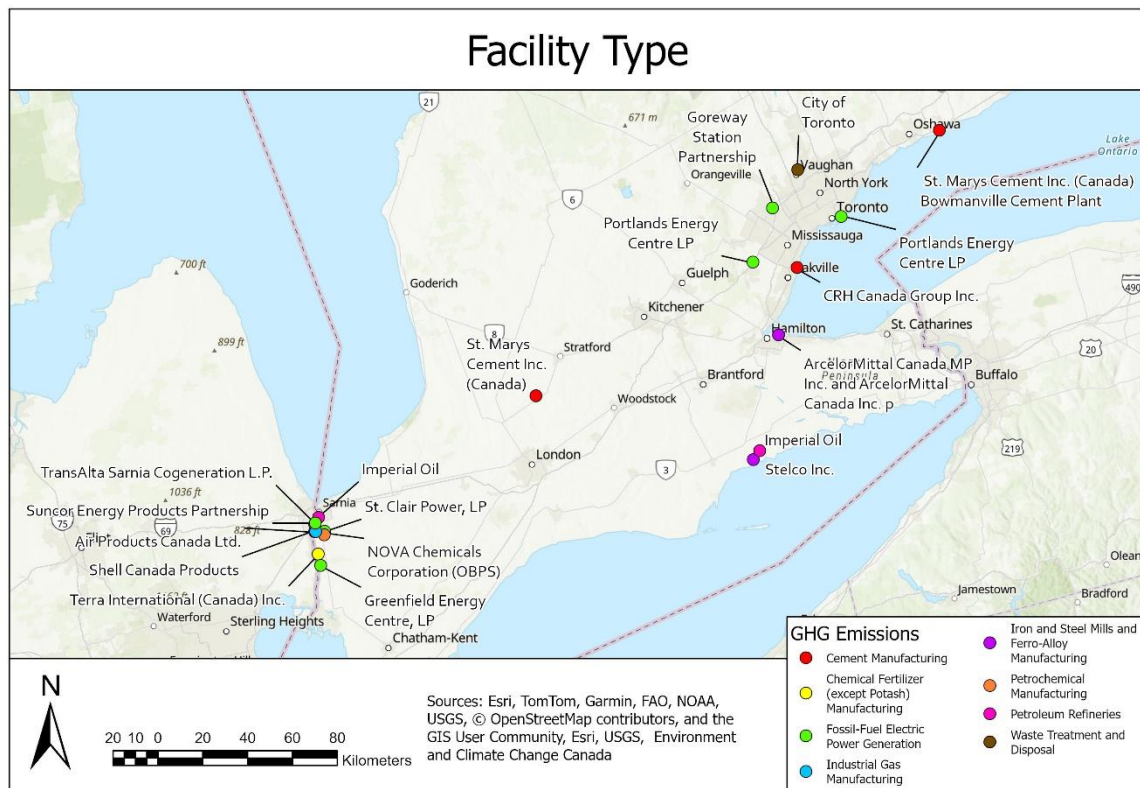


Figure 10. Facility types based on industrial emissions greater than 500kt CO₂ equivalent

While the Government of Ontario previously looked into CCS in 2007 (the program was then referred to as Geological Sequestration of Carbon Dioxide), it was only on January 11th, 2022, that the Government of Ontario investigated developing a CCS regulatory framework (Carter, Gunter, Lazorek, & Craig, 2007). In addition, since the first publication of the Environmental Registry of Ontario (ERO) about CCS, various research institutes took an in-depth analysis of the viability of CCS before 2022 (Ministry of Natural Resources and Forestry, 2022; Bailey Geological Services Ltd. and Cochrane, R.O., 1984). As previously mentioned, the context behind Ontario pursuing a CCS regulatory framework is due to two reasons:

1. Meeting its climate goals to reduce carbon emissions – specifically with hard-to-abate sectors, and to align with the federal government’s net-zero emissions by 2050 (Ministry of Natural Resources and Forestry, 2022).
2. And just as importantly, taking advantage of this new technology in Ontario.

In addition to the two reasons, 20 Mt of CO₂ emissions were emitted in 2020 by industrial sectors – a large portion of which were from “hard-to-abate” sectors (Hart, 2024; Nykvist, Olsson, & Vogl, 2021; Craik, 2022). Figures 9 and 10 show industries that accrue over 500 kt CO₂ equivalent emission within Southern Ontario and its respective facility types in 2022. What was interesting within these figures is that iron and steel mills have the highest CO₂ emissions released – anywhere from 3768.21 to 3960.61 kt CO₂ equivalent. The rest of the facility types accrued less than 3768.21 CO₂ equivalent, and in total, the amount of emissions released from all of these companies with greater than 500 kt CO₂ equivalent equates to 28,961.48 kt CO₂ equivalent. The other facility types include cement, chemical fertilizer (except potash), industrial gas, petrochemical, petroleum refineries, and waste treatment and disposal.

As a hypothetical, if the amount of emissions is set at a consistent rate of 28,961.48 kt CO₂ per year, then by 2050 about 810,921.44 kt CO₂ or 810.92 Mt CO₂ equivalent would need to be sequestered to achieve net zero emissions. A report done by Clean Prosperity estimated that Ontario would only have about 730 Mt of capacity, in which the amount of emissions produced within the 2022-2050 range would far surpass the capacity limit (Felder, Hervas, & Noyahr, 2024). However, in a realistic scenario, the amount of emissions would be determined by how much demand is required by these industries and if there was any technological improvements in reducing carbon emissions.

To specifically define which industries constitutes as “hard-to-abate”, as stated earlier in section 1.0, industries that rely on a relatively high proportion of fixed emission processes have difficulty in transitioning into renewable sources. Steel production, for instance, is a hard-to-abate sector that require metallurgical coal to develop quality steel – especially since the blast furnace is a mature technology with unique desirable mechanical properties that make it difficult to replace with less emitting alternatives (Nykvist, Olsson, & Vogl, 2021). Additionally, various technologies have been researched and developed so that these hard-to-abate sectors can reduce emissions. However, these alternative solutions are only in the research phase or early development phase; whereas CCS has already been implemented on large scales across several countries, including the US and Canada, Figure 3 shows the CCS facilities that are operational, in construction, advanced development, or in early development.

With the context of Ontario’s reasons for pursuing a CCS regulatory framework understood, the following section will cover a list of key proposed policies and concerns acknowledged by the Crown:

Designating proposed projects as special projects would require an additional set of criteria, which includes but is not limited to:

- The purpose of the project is to test, assess, pilot, or demonstrate an activity, method, or technology that is new or innovative to Ontario (Ministry of Natural Resources and Forestry, 2023b).
- The project would involve the use of one or more new existing wells to access underground geological formations of the Cambrian age (Ministry of Natural Resources and Forestry, 2023b).

- The minister believes that the project can be designed, constructed, operated, and decommissioned in a manner that protects people and the environment (Ministry of Natural Resources and Forestry, 2023b).
- Applicants are required to notify the following parties which include a project description and digital copies of any application submissions, including any expert review documentation (Ministry of Natural Resources and Forestry, 2023c).
- Requirement of financial security before a carbon special project application and the removal of specific exemptions and security caps for all wells – this would properly ensure that the applicants have enough funds available for plugging and cap decommissioning wells and potentially ensure that even if a company ceases to exist, the security set aside will allow for the government to step in and decommission the well (Ministry of Natural Resources and Forestry, 2023c).
- A time limit on the designation after the request has been submitted and approved (Ministry of Natural Resources and Forestry, 2023c).
- The usage of Canadian Standard Association (CSA) Z741 Geological storage of carbon dioxide to determine the baseline standards for CCS storage (Ministry of Natural Resources and Forestry, 2023c).

In addition to the previous set of criteria, the following information would also be needed for a special project (Ministry of Natural Resources and Forestry, 2023c):

- Description of the proponent (i.e., operational history, experience, and expertise with similar projects).
- Description of the Project (i.e., location, activities, wells, and other ‘works’ to be used).

- Description of the technology, method, or activity that the project seeks to advance – i.e., the technology readiness level.
- Description of project benefits and the proponent’s plans, if any, for information sharing – i.e., how the project will benefit Ontarians, and how and when findings of the special project will be released to the public.
- Any exemptions and substitutions requested.

Once a special project has been approved and submitted - proponents can now apply for a well license and injection permits which would require the following components (Ministry of Natural Resources and Forestry, 2023c):

- The purpose and scope of the project.
- The project is designed for the site-specific geologic environment to which the project relates.
- The suitability of the project concerning surface and sub-surface conditions.
- Suitable plans are in place to ensure remedial actions or measures are taken to address any issues that may impact or be impacted by the project; various important environmental safety regulations will be followed to ensure no harm is done to the environment and public.

In addition to well license and injection permits, the application requirements for a special project to assess, test, pilot, or demonstrate carbon storage include (Ministry of Natural Resources and Forestry, 2023c):

- Detailed project description
- Identification of:

- Area of Review – a geographical boundary where the applicant predicts the proposed project could adversely affect people, the environment, or other resource users.
 - Carbon Storage Surface Area Boundary – another geographical boundary that delineates all works, including wells; the furthest lateral extent of the storage complex; and any additional area adjacent to the storage complex to reasonably protect the storage from other projects.
- Confirmation from the applicant that they have received the necessary rights to all the lands where the project will be located and that they have notified the landowners.
- An independent insurance company to determine the types and amount of insurance coverage for the proposed special project – especially regarding liability and pollution damage.
- Plans and programs that address the full lifecycle of the project, including the design, construction, operation, maintenance, monitoring, abandonment, and decommissioning and the safety of the wells, any underground reservoir proposed to be used, and other associated works proposed to be used during the lifecycle of the project.
- Any documentation required by CSA Z741 Geological storage of carbon dioxide.
 - CSA Z741 is a standardized document developed by the Canadian Standards Association which describes how to promote safe long-term carbon storage, engage with local communities, develop a risk assessment, and minimize risks to human and environmental health.

- Ontario is proposing to also use CSA Z741 to determine whether geological storage projects fall outside of the scope of the CSA to provide a custom application plan, which documentation is required by CSA related to site screening, risk management, well infrastructure development, monitoring and verification, and closure.

It is important to note that the designation of the special project allows it to be exempt from certain requirements but replaced with other requirements that are better suited to adapt the authorization and requirements needed. These include notifying and consulting with Indigenous communities, municipalities, and neighbours; and respecting the design, construction, operation, maintenance, monitoring, abandonment and decommissioning of any wells and other works (Ministry of Natural Resources and Forestry, 2023c).

Clarity on storage rights and how to acquire them was addressed where applicants of special carbon storage projects would require land rights in developing a CCS project – but did not specify how this acquisition would occur. There is the possibility that companies will use their own land/private land to demonstrate CCS – however, if a pore space is greater than the surface land extent or if they cross a pore space boundary, how would a company address this? (Ministry of Natural Resources and Forestry, 2023c).

Ontario also has proposed a new eligibility criterion for special projects to prohibit projects from permanently disposing of any substance except for (Ministry of Natural Resources and Forestry, 2023c):

- Projects to assess, test, pilot or demonstrate carbon storage.
- Projects that involve the disposal of oil field fluid (which are already regulated under the act) – also where the oil field fluid refers to:

- a) anything that has been used as a well-drilling fluid and
- b) formation water that is recovered from a well.

Suggestions and comments acknowledged by the Crown that were posted on ERO regarding the "*Proposed regulatory provisions for 'special projects' using wells to test or demonstrate new and innovative activities, including carbon storage, and to remove well security caps and exemptions for all types of wells under this legislation going forward*" included (Ministry of Natural Resources and Forestry, 2023c):

- To prioritize opportunities for Canadian businesses and workers over foreign companies, as proposed by one Indigenous community.
- Faster implementation of a commercial scale framework and broader provincial Carbon Capture, Use and Storage (CCUS) approach.
- Supporting hydrogen storage as part of the special project proposal.
- Licensing of engineering professionals under the Professional Engineers Act, including asking for those requirements to be broadened to include those with limited licenses.
- Assessing municipal drinking water sources/areas and prohibiting carbon storage as well as oil and gas activities in higher-risk areas unless endorsed by a risk management official for the source protection area.

There were also comments of criticism of the proposal regarding CCS where this negative emissions technology may not reduce emissions at source and may support the continued use of fossil fuels. (Ministry of Natural Resources and Forestry, 2022).

While the Ontario government has rebutted, describing that the regulatory framework will provide Ontario with support for a transition into a low-carbon economy, it is unclear what this

exactly means. This similar statement was reiterated in another ERO posting (Ministry of Natural Resources and Forestry, 2022; Ministry of Natural Resources and Forestry, 2023c).

Note that due to the industry's concerns about the removal of exemptions and security caps for well licenses that are transferred - potentially costing its members more and resulting in more wells with no operator, the requirement of a financial security has not been included:

- Requirement of financial security before a carbon special project application and the removal of specific exemptions and security caps for all wells – this would properly ensure that the applicants have enough funds available for plugging and cap decommissioning wells and potentially ensure that even if a company ceases to exist, the security set aside will allow for the government to step in and decommission the well (Ministry of Natural Resources and Forestry, 2023c).

Note that as of the 2023 ERO posting, well operators of hydrocarbon storage wells were exempt from providing financial security. This financial security was dependent on the depth of the well, and therefore the amount of security required was set as follows:

- \$3000 for onshore wells less than 450m deep
- \$6000 for onshore wells between 450m - 800m deep
- \$10,000 for onshore wells more than 800m deep
- \$15,000 for all offshore wells

Also, the limit or "cap" on the maximum amount of security required for each operator was:

- Unplugged wells on land - \$70,000.
- Unplugged wells located in water-covered areas - \$200,000.

Therefore, the proposed regulatory changes to the Exploration, Drilling and Production regulation (O. Reg 245/97) under the OGSRA were as follows:

1. Eliminating well security exemptions for operators of hydrocarbon storage cavern wells that own both the surface and mineral rights, historical wells, and private wells in the following circumstances:
 - a. When wells are newly drilled, deepened or converted to other uses.
 - b. When a well license is transferred to the operator.
 - These changes would apply on a going-forward basis and therefore would not apply to the wells currently held by operators unless they are seeking one of the described changes.
2. Remove the operator security caps for all wells regulated under the OGSRA framework under the following circumstances:
 - These changes would only apply when an operator is seeking one of the described changes
 - Assisting operators in setting aside security funds for wells where transfers are being requested for a large number of wells. If the amount of financial security to be set aside above an operator's existing security cap is greater than 70k for onshore wells or greater than 200k for offshore wells, the regulation would allow the required security to be established through equal quarterly payments over 2 years.
3. When two or more companies amalgamate, security that is already held in trust by the amalgamating companies would no longer be released to the operator based on a maximum-security cap. Going forward, the amalgamated company would be subject

to an increased operator security cap equal to the amount held by each company before amalgamation.

Each section of this literature review will understand what CCS policies have been implemented in various regions around the world and determine whether the policies gathered from various regions have been mentioned in Ontario's ERO posting on August 2024, In November 2024, Ontario introduced Bill 228, the Resource Management and Safety Act, which includes a new Geologic Carbon Storage Act. This bill is discussed below in Section 5.2.

1.2. Literature Review

Before discussing the core parts of the literature review, section 1.2.1 will first go over the method of finding resources for the literature review. These resources include various grey literature (including government and news publications, non-profit documentation, and intergovernmental publications - such as the Government of Canada, the United Nations, International Energy Agency, etc.) and peer-reviewed articles.

The reason for using grey literature for this thesis is to understand policies and how they compare against or relate to policies implemented by other governments within Canada and the U.S. - which usually is listed under government publications and recommended by intergovernmental organizations. Using these sources, the literature review aims to give a clear understanding of what information is already published or released, and whether there are any gaps within the literature review. These gaps will then be used as questions for semi-structured interviews to ask key informants (these key informants were researchers and staff in organizations with significant expertise in CCS). To start, section 1.2.2 will delve deeper into understanding the key questions of ownership, liabilities, approvals and assessments, and post-

closure liabilities. This section will specifically uncover why these elements are important and their role within the regulatory framework.

In section 1.2.3, the review will then go over the ownership of property rights and pore space as there is no clarification on whether the government of Ontario would be vested in all the pore spaces, or the surface owners would own the pore space underneath. Section 1.2.4 will discuss how different regions manage liabilities, specifically post-closure liabilities. Section 1.2.5 will then cover understanding how to effectively communicate to the public about the need for a CCS project. Section 1.2.6 will go over other necessary policies that Ontario should clarify, and section 1.2.7 will summarize the information gathered from various literature articles.

1.2.1. Finding Resources for Literature Review

Finding relevant and recently peer-reviewed literature specifically regarding carbon sequestration for Ontario was difficult as Ontario has only recently investigated implementing a CCS framework. Therefore, the search methodology was expanded to include grey literature sources but still limiting the temporal parameters to any content on or after 2020 if possible. To broaden the scope further, other regions have been included to understand what policies they have implemented, and then to compare to see what Ontario could implement to improve their policies. The geographic scope specifically includes Alberta, Saskatchewan, Australia, parts of the US and Europe where CCS is prevalent. In addition to these parameters, for this literature review, I have time-bound my review of Ontario's websites for any updated CCS policies to August 2024.

As a result of analyzing and understanding the various peer-reviewed articles, grey literature documents and Ontario's Environmental Registry of Ontario postings, these three research questions aimed to assist in developing the methods:

1. How can the knowledge gained from other regions with highly developed CCS policies help Ontario's hard-to-abate sectors understand potential approvals, licensing, and liability?
2. What are some other necessary policies that Ontario would need to clarify and potentially adopt from various jurisdictions?
3. In jurisdictions with CCS policies, how did companies and governments communicate to the public about the need for this technology?

1.2.2. Scope of the Regulatory Framework

A regulatory framework for CCS requires the following core elements: ownership, approvals and assessments, and post-closure liabilities. Without these elements, it is difficult to develop a regulatory framework as each element has various hurdles that a government would need to address.

Starting with ownership, Ontario must clarify whether the Crown would own the pore space or the surface owners would own the pore space. The Ontario government should also recognize the pros and cons of the two different ownership types, which will be uncovered throughout the thesis.

Approvals and assessments on the other hand refers to whether companies are allowed to develop infrastructure for CCS and have permission to inject CO₂ based on the various environmental, geophysical and risk assessments submitted to the authority who governs the development of CCS. These assessments are critical for a regulatory framework as it protects the public and environment from any risks, such as risk of CO₂ leakage or seismic activity. The inclusion of assessments also creates a standardization and good stewardship of companies to properly ensure that CCS projects are developed in a safe manner. While Ontario has these

assessments set in place for other infrastructure projects, they have not elaborated on which specific assessments companies would require for CCS.

The last important element is post-closure liabilities, specifically where the governing authority for CCS transfers the liabilities from companies to the Crown. Ontario has not specifically stated how this process would occur, and how would Ontario cover their costs in liabilities if a post-closure liability transfer has occurred.

1.2.3. Ownership of Pore Space

When developing the policies for ownership of property rights and pore space, there have been various issues surrounding these topics as there is no one right solution for each country. As a result, countries have implemented several types of policies surrounding CCS. International examples include:

1. Australia – Where the Crown owns all land fifty feet below the surface, except in the case of freehold alienated before 1892 (alienated (property)): transferred to the ownership of another person or group). Also stated that “any seal or reservoir of an underground geological formation and any associated geological attributes or features” is part of the underground geological storage formations. Additionally, the CO₂ sequestration will become a property of the state after injection, drilling and development have been finished – however, companies are still liable for any damages (Morgan, 2013).
2. England and Wales – The Crown/states are the only entities that can distribute CCS licenses for storage once a site has been identified – specifically regarding property rights. This “monopoly” on the “new resource” of underground formation will not only eliminate the risks of surface owners blocking the entire formation of storage but also CCS operators would only have to deal with a single predictable owner (Morgan, 2013).

3. The United States has different policies and regulations regarding CCS from state to state. Here are three state examples:

- a. Illinois – the state of Illinois does not have any official legislation or case law regarding accessing property rights to pore space CO₂ storage. However, the state does recognize the title or real property rights (property in the form of land) or both in the subsurface for CO₂ storage (Greenberg, Whittaker, O'Brien, & Hemrich, 2022).
- b. Indiana – Defines pore space as subsurface cavities or voids that can be used for carbon sequestration (CCS) and defines “pore space owner” as a person, trust, corporation, or any other entity that has the title to, a right to, or an interest in pore space (Greenberg, Whittaker, O'Brien, & Hemrich, 2022).
- c. Utah – Defines pore space as subsurface porous material possessing free space, naturally or artificially created between the mineral grains, and expressed as a percentage and excluding “void or cavern space created by the removal of minerals in the course of solution mining” (Greenberg, Whittaker, O'Brien, & Hemrich, 2022).

As for Canada, like the US, each province has their method of how to define who owns the land and pore space. The province of Alberta, for instance, has the most developed regulatory framework for CCS – which includes defining how pore space is acquired. Specifically, after rounds of consultation, research and community engagement, the new legislation that was added to the Minerals and Mines Act for Alberta has included these three main clauses:

1. The first clause states that - “No government grant of lands or mines and minerals ever operated as a conveyance of title to pore space below the surface of the land” (In

simplified terms: “No government has access to lands or mines and minerals has ever operated as an entity of transferring of title to property from one party to another – regarding the pore space below land”) (Laurin, 2021)

2. The second clause then backs up its claims from the first paragraph by declaring in positive terms that the pore space is wholly owned by the provincial government (Laurin, 2021).
3. Finally, the third clause ties the previous two clauses back into the Province’s Land Titles Act – where any pore spaces are exempt from the provincial government granting any pore space due to the surface owner’s title. Due to the province’s acquisition and handling of pore space, the government needed to put in place a disposal scheme where potential CCS operators could acquire disposal rights from the province (Bankes N. D., 2011; Laurin, 2021).

These three clauses clarify who owns the land and pore space and determine how these pore spaces will be transferred to companies that are developing CCS, and the disposal scheme would allow operators to drill beneath the ground and inject carbon dioxide.

Also, Bankes (2011) had questions about pore space ownership, such as whether it would be enough to obtain consent based on the projected geographical area of the injection plume. And what happens when an owner is unwilling to contribute its pore space for what the operator believes to be a reasonable price? While this journal article does not specifically address those issues, it does mention that the new legislation for Alberta within that time responded to this uncertainty by giving the province the pore space for disposal purposes and acting on any compensation claims (Bankes N. D., 2011). Unitization can also potentially help avoid the issue of a holdout situation where an owner is unwilling to contribute its pore space for a reasonable

price. Unitization is a process that allows operators to proceed with injections after reaching an agreement with a minimum percentage of owners (Howard, 2022).

In comparison to Alberta's ownership of pore space, Saskatchewan has a different system when it comes to owning pore space for CCS. Specifically, there may be lands that are freehold - where the owner has built property on top of the land and has total control over his land – but also has control over the pore space underneath one's property. However, there are also lands owned by the Crown (Government of Saskatchewan, 2023). Unfortunately, there does not seem to be any information specifically regarding a regulatory framework for CCS for Saskatchewan – however, one article noted that its regulatory framework could look similar to Alberta's regulatory framework (Wilson & Condor, 2013).

1.2.4. Liabilities

Regarding liabilities, Ontario has mentioned eliminating well security exemptions for operators of hydrocarbon storage cavern wells that own both the surface and mineral rights, historical wells, and private wells. However, due to the industry's concerns about the removal of exemptions and security caps for well licenses that are transferred, there is the potential for higher costs to its members resulting in more wells with no operator; therefore, this policy was not moved forward by the government (Ministry of Natural Resources and Forestry, 2023c).

As for examples from different jurisdictions, both Alberta and the European Union's (EU) CCS directive have a process where post-closure liability would be passed down to the state, but for the EU they would exclude the monitoring and corrective measures, and add that the Competent Authority can decide to release the operator from its duties before the 20 years is up - assuming that the geological conditions are suitable for a handover (Makuch, Georgieva, & Oraee-Mirzamani, 2020; Bankes, Poschwatta, & Shier, 2007). This 20-year gap is to ensure that

the operator can afford to run the site and to ensure that the captured carbon is safe with no significant future leakage; however, the time frame can vary anywhere from 10 years to 50 years (Makuch, Georgieva, & Oraee-Mirzamani, 2020; Bankes, Poschwatta, & Shier, 2007; Bankes N. , 2019; Greenberg, Whittaker, O'Brien, & Hemrich, 2022).

In addition, various task forces and commentators have argued that for both the public interest and the long geological periods associated with CCS, it required that the government assumes the long-term liabilities associated with CCS operations post-closure (Bankes N. D., 2011; Snyder, Anderson, Keith, Sendall, & Youzwa, 2008). These may include tort-based liabilities (such as health, property damage, or other economic loss), re-abandonment of a well, and Greenhouse Gas (GHG) accounting liabilities (Bankes N. D., 2011). Also, Bankes N. D. (2011) denotes that Alberta has decided to accept the transfer of liability, which raised four questions for him, and he describes how the four questions are being addressed which is discussed below:

1. When does the province assume the statutory liabilities and assume a duty to indemnify?

The province assumes the liabilities described in the Act and the duty to indemnify when the Minister issues a closure certificate to a lessee. Specifically, once the lessee has met several conditions including abandonment and reclamation obligation, the closure period has passed, and the captured carbon dioxide is stable and predictable with no significant risk of future leakage, the lessee can apply for a closure certificate (Bankes N. D., 2011)

2. What liabilities does the province assume? When a closure certificate is issued, the province then assumes certain prescribed obligations of the lessee who holds the provincial disposal agreement, that would otherwise accrue to that person. Specifically, the obligations that the lessee might have under the Oil and Gas Conservation Act

(OGCA), are the duty to abandon or re-abandon any well and the duty to take any safety requirements if any incident occurs. This assumption is achieved by having the Energy Resources Conservation Board (ERCB) amend its records to show that the Crown is listed as the licensee through legislation.

- The second set of obligations is under the Environmental Protection and Enhancement Act (EPEA) where the Crown is responsible for any spills or contamination and any ongoing responsibility under the surface reclamation provisions of EPEA (Bankes N. D., 2011).

3. How does the indemnification work? Where there's an indemnity arrangement, which is an agreement by which the province agrees to cover the defined costs and liabilities that may normally be incurred by the lessee (previous CCS operator) (Also note that the indemnified is the lessee or the previous CCS operator, while the indemnity is that province). The province steps into the shoes of the party being indemnified, and an indemnity does not expand the scope of the liability that would otherwise be incurred by the party being indemnified.

- In this case, the province indemnifies the lessee against its liabilities concerning any action in tort brought by a third party if the liability is attributable to an act done or omitted to be done by the lessee. It is also important to note that the Crown has no duty to indemnify unless and until a person suffering harm can establish that the lessee would have been liable in tort. Noted that it will be challenging for a person suffering harm, especially if the tort liability is fault-based - i.e., must establish negligence.

- Another key point the authors mentioned is whether the industry can cover a wide variety of possible claims that might be made against the participants in a CCS project. And important to recognize that the assumption of liability and the indemnity arrangements only apply to the lessee of the agreement (Bankes N. D., 2011)
4. How will the province fund these arrangements? It was noted that the province put into law where the relevant industry (emitters and injectors) pays into a fund to cover some or all the province's potential future liabilities – and it is more consistent with the polluter pays principle. However, this can become difficult as other potential liabilities such as the need to re-abandon an injection or other well, or potential tort liabilities will be difficult to estimate in advance. Because of this, the province will enable a CCS Act where a Post-closure Stewardship Fund will be established. This fund will only be used for Monitoring, Measurement and Verification or the assumption of statutory liabilities by the province (Bankes N. D., 2011).

1.2.5. Communicating to the Public about CCS

Throughout this literature review, potential risks have been discussed for CCS. Because public knowledge about CCS is limited, certain members of the public would be concerned about the idea of injecting and storing carbon underneath the surface and whether this would impact their groundwater, soil contamination and potential seismic activity (Nielsen, Stavrianakis, & Morrison, 2022; Rui, Zeng, & Dindoruk, 2024). This could present some concerns to certain members of the public about the necessity of CCS. Therefore, Ontario needs to clarify its role in public communication with stakeholders, and local and Indigenous communities; outline what

safeguards are in place for groundwater contamination prevention and any other potential risks; and what role CCS plays within the context of Ontario's emission reduction.

Alberta's CCS framework is a notable example for Ontario to review regarding its communication with safeguards and risk assessments. Specifically, the ERCB Directive 071 requires that all oil and gas licensees implement Measurement, Monitoring and Verification (MMV) plans, a corporate-level Emergency Response Plan (ERP) and an Emergency Planning Zone (EPZ). An MMV is required as it addresses health, safety, and environmental risks; evaluates sequestration performance and ensures that the site is suitable for closure. An ERP is required as it develops several scenarios and plans how the company should respond to specific emergencies. EPZ is also required as it defines an area where a well, pipeline and/or any facilities containing hazardous products are located (Electricity and Alternative Energy and Carbon Capture and Storage Division, 2013). The ERP and EPZ are required for licensees as it addresses potential hazards of accidental release of CO₂ during transportation and injection that may cause harm to the public and the environment.

As for explaining the purpose of CCS, Ontario recognizes that once a CCS regulatory framework and its projects are in place, it would support the industry, encouraging sector innovation, and reducing emissions. However, further emphasis should be placed on what potential benefits the public would receive - this in turn would increase the likelihood of their social license to operate (SLO). SLO is defined as informal permission given by the local community and broader society to industry to pursue technical work (Ministry of Natural Resources and Forestry, 2022; Gough, Cunningham, & Mander, 2018).

Once the government – or Ontario for this matter -has outlined the role of CCS in carbon emissions reductions, the risk assessments and safeguards in place, and the reason for CCS, the

next step is to determine how Ontario plans to develop public outreach about CCS. Alberta for instance gave public education and conducted outreach campaigns – where the campaign would provide information about CCS through newspapers, websites, and television advertisements. Social media advertisements/commercials could also be included (Electricity and Alternative Energy and Carbon Capture and Storage Division, 2013). This step is important because it was noted that the lack of knowledge of CCS and differences in risk perception are the key reasons why resistance against the development of CCS is high (Cherepovitsyn, Tcvetkov, & Fedoseev, 2019). Once outreach campaigns are completed, specific CCS projects may host open houses and other direct communication with stakeholders and communities located near these projects – outlining the project’s plans/proposal and engaging with local communities along the way.

As for engaging with local and Indigenous communities, Ontario has not specified how they would address potential project impacts. Therefore, Ontario needs to clarify these three key questions:

1. Where are these pore spaces located, and to what extent do they reach nearby communities?
2. What are the specific safeguards in ensuring that local and Indigenous communities are not affected by CCS?
3. Outlining the various methods of transporting carbon emissions and determine which is the safest method.

These key questions are critical in deciding how Ontario expects local and Indigenous communities to be informed about CCS projects. Effective communication is also a critical component as it may result in a higher sense of trust towards companies who are developing CCS projects - which Ontario has already acknowledged within their Fall 2023 proposal.

To ensure proper engagement, a research study has noted that while communication is a key factor for CCS projects to be successful, communication alone would not be enough to persuade local and Indigenous communities to accept CCS. Instead, the active collaborative/participatory approach was noted to have a higher chance of success in these projects. The reason for a lack of success in developing these projects is due to assumptions of passive acceptance, which resulted in negative connotations as disadvantaged communities did not have access to relevant information nor had their voices heard. To gain acceptance/trust from the public, capacity building would be needed so that local communities can access all relevant projects and determine the outcome of those projects (Nielsen, Stavrianakis, & Morrison, 2022). This capacity building is important because some members of the community may have experienced knowledge in some aspects of CCS in combination with knowledge about their community/the surrounding land; this in turn could help steer the project in a better position where both parties can agree on the project (Dewulf, Craps, & Brugnach, 2017).

For instance, in Australia, a company called ZeroGen went far and beyond to not only recognize and communicate with Indigenous communities but also to involve them in their projects directly. Specifically, the objectives that they have accomplished include early engagement, resourcing traditional owners to ensure their full involvement and developing strategies that offer the traditional owners an opportunity to play important roles. This resourcing refers to traditional owners acquiring appropriate legal and technical advice to assist them with cultural heritage and native title matters, and ZeroGen additionally provided resources to groups to assist with their input in the early planning phase of CCS projects (Simpson & Ashworth, 2009).

In conclusion, under Ontario's regulatory proposal, it was noted that applicants for a CCS project would need to take on the mantle of developing a risk assessment and inform any parties that request information about the project (this includes the project description, digital copies of any application submissions and any expert review documentation) (Ministry of Natural Resources and Forestry, 2023c). However, Ontario should also highlight that communication and community involvement are vital elements of a CCS project for two major reasons:

1. Level of trust and acceptance towards CCS projects.
2. Communication to the locals of potential risks and safeguards to ensure safety to the public and the environment.

As noted earlier, local and Indigenous communities are far more likely to trust and cooperate with companies that are transparent and are willing to let these communities be a part of the project (Nielsen, Stavrianakis, & Morrison, 2022). Therefore, to develop successful CCS projects, Ontario and its applicants need to define the necessity for CCS, describe every step of the project, explain what infrastructure will be built, and communicate how the safeguards will allow for adequate protection for the public and the environment. While applicants would need to inform any of the parties mentioned by the government for each project, the government should be the one to spearhead informing the public about CCS in a general context. Therefore, Ontario should look towards Alberta's policies as the Albertan government has made great strides in developing clear and effective communication such as notifying landowners, occupants and residents, including First Nations and Metis regarding MMV activities, inherent risks of the project, subsurface CO₂ dispersion and precedents set. In addition, Alberta has considered different methods of communication such as open houses, information packages, advertising in local media, and public outreach.

Ontario did, however, clarify that under the “notification and engagement requirements”, applicants would be required to provide a project description, any application submissions and any expert review documentation upon request for the following parties but not limited to (Ministry of Natural Resources and Forestry, 2023c):

- Landowners, local municipalities, and regional municipalities within the area of review
- Any person from whom the applicant has acquired any rights relating to the use of the land or project
- Indigenous communities and organizations, as identified by the ministry
- Any other ministries of the provincial or federal government or agencies identified by the ministry.

The application submitted would include the risks that communities may potentially face, what safeguards are there to protect in the event of an issue, and other viable alternatives when developing CCS projects due to the requirements of carbon storage applications (Ministry of Natural Resources and Forestry, 2023c). Developing open communication with local and Indigenous communities was also another strong method that the Crown might consider – especially since clear communication can build trust in CCS projects.

1.2.6. Further Discussion of Other Necessary Elements

While Ontario does require proponents to conduct environmental assessments and communication to Indigenous communities for various infrastructure projects, Ontario’s proposed regulatory framework for CCS, however, mentions minimal information on how the industry would conduct environmental assessments and their engagements with Indigenous communities. Therefore, research was undertaken to understand what specific environmental policies were required in other jurisdictions’ regulatory frameworks.

One such policy comes from Alberta, where the Shell Quest CCS project implemented various policies and engagements, such as doing outreach programs to local Indigenous communities and stakeholders who may be affected by the project to communicate their intent and progress/development and develop a measuring, monitoring, and verification (MMV) plan. Federal and provincial governments require and mandate these policies and engagements (Electricity and Alternative Energy and Carbon Capture and Storage Division, 2013). An MMV plan is required for two distinct reasons:

1. Ensure conformance indicating the long-term security of CO₂ storage would be monitored, and would need three requirements (Bourne, Crouch, & Smith, 2014):
 - a. Show that the pressure and CO₂ development inside the storage complex are consistent with models.
 - b. Evaluate and adapt injection and monitoring to optimize storage performance.
 - c. Provide monitoring data necessary to support CO₂ inventory reporting.
2. Ensure containment by demonstrating the current security of CO₂ storage, and this would need an additional three requirements (Bourne, Crouch, & Smith, 2014):
 - a. Verify containment and the absence of environmental effects outside the storage complex.
 - b. Detect early warning signs of any unexpected loss of containment.
 - c. Activate additional safeguards to prevent any significant environmental impacts.

In addition, the federally mandated policies/legislation/engagements can include the Environmental Impact Assessment (EIA), which is already required for certain policies under the federal law – especially for projects that are funded by the federal government - such as the Alberta Carbon Trunk Line and Quest - and any projects that involve interprovincial or

international components would be under federal regulations/legislations. Also, a provincial EIA was needed for any projects built within the Province of Alberta, but it was determined based on its review of each project. (Electricity and Alternative Energy and Carbon Capture and Storage Division, 2013).

Another important policy that Ontario may implement is risk analysis and evaluation for risk assessment. Risk assessment both identifies sources of potential CO₂ leakage and estimates their magnitude and probability through the systematic use of project information; and examines the acceptability of these risks, considering the needs, issues, and concerns of stakeholders (Chalaturnyk, et al., 2004). From the updated proposal, Ontario has also mentioned that a risk assessment would be required when submitting carbon storage special projects, and any documents required by CSA Z741 for risk management (Ministry of Natural Resources and Forestry, 2023c). This assessment has also been used by the International Energy Agency Greenhouse Gas R&D Programme (IEAGHG) Weyburn Project in Saskatchewan. While the Weyburn project had implemented similar environmental and regulatory policies to Alberta's CCS Regulatory Framework, unlike Alberta's corporate-level ERP and EPZ, the Weyburn assessment introduces alternative scenarios for the long-term fate of CO₂ using a modified variation of a systems analysis approach (Rostron & Whittaker, 2011; Chalaturnyk, et al., 2004).

To accomplish the long-term risk assessments, a system model of the geosphere and biosphere was constructed. (The Quest CCS Project had an additional two elements/domains – atmosphere and hydrosphere):

- Geosphere - refers to reservoirs and incorporates all geological, hydrogeological and petrophysical information assimilated for the model (Chalaturnyk, et al., 2004).

- Biosphere - anything from the surface to 300m below the ground surface such as soil, surface water, atmosphere, fauna, and flora (Bowden, Pershke, & Chalaturnyk, 2013; Chalaturnyk, et al., 2004).

In addition to the two main elements, a list of features, events and processes was developed to assist in identifying the processes that could be relevant to the performance of the system. Where features are described as physical characteristics of the system such as permeability, events are discrete occurrences influencing the system, and processes that identify the physics of change within the system (Chalaturnyk, et al., 2004). While the Crown has not implemented a systems analysis as part of their submission application requirement – there is a plausibility that under the Ministry’s discretion and a company’s decision, a systems analysis can be implemented. Especially for complex special projects (i.e., varying well types, groundwater flow regimes, and fluid characteristics), the Ministry may opt for a custom application plan (Chalaturnyk, et al., 2004).

Also, the Ontario government should consider the investment in CCS as there is a significant cost in developing a CCS project. Currently, at the national level, there are various funding opportunities for CCS. The CCUS Investment Tax Credit (ITC) for instance was announced in 2022 and proposes to provide a 50 percent credit for equipment associated with point-source CCUS projects, declining in 2030 and 2040 to incentivize early adoption. Table 1 in the Appendix shows the depreciation over time in investment tax credit rates (Finance Canada, 2022). Specifically, the federal government expects to invest \$8.6 billion by 2030 into the ITC (McKenzie & MacDougall, 2023). The Clean Fuel Regulation on the other hand allows facilities to create compliance credits for projects that reduce the emissions intensity of fossil fuels, and

the Canada Growth Fund would be used for accelerating the deployment of CCUS using financing tools (McKenzie & MacDougall, 2023).

At the provincial level, using Alberta as an example with their industrial carbon pricing system called Technology Innovation and Emissions Reduction (TIER), this system has allowed CCUS to reduce emissions at a regulated large emitter or to be eligible for emissions offsets if the CO₂ is exported offsite for geological sequestration or enhanced oil recovery (McKenzie & MacDougall, 2023). Alberta has also developed the Alberta Carbon Capture Incentive Program (ACCIP) which will support and accelerate the development of CCUS projects – specifically providing a 12 percent grant for new eligible capital costs. In total, the Alberta government is expecting to provide between \$3.2 to \$5.3 billion of support between 2024 and 2035 (Government of Alberta, 2023).

As a result, Ontario should also invest in reducing the cost of implementing CCS – the methods to narrow this gap can include market-based or regulatory mechanisms, financial incentives, direct funding for demonstration projects, and investment into research and development to reduce costs (Mitrović & Malone, 2011).

The third and final suggestion for Ontario's policies is to consider other negative emissions technologies such as carbon dioxide removal and carbon capture utilization alongside carbon capture and storage. The Federal government lists these technologies under a term called “Carbon Management.” While these technologies are promising, as of 2024 they are still in the beginning stages of research and development. Once these technologies have fully matured, the Ontario government should reference these as “Carbon Management” or “Negative-emissions Technologies” (Natural Resources Canada, 2023).

In addition to the aforementioned policies that are necessary for Ontario's regulatory framework for CCS, Ontario should also consider including risk of potential "lock-ins" or "path dependencies."

Specifically, certain individuals who commented on the Fall 2023 MNRF's ERO posting have raised concerns that fossil fuel companies may potentially use CCS to continue their fossil fuel production. While Ontario has vaguely addressed that they hope to reduce carbon emissions and manage them overall, they have not addressed the fossil fuel issue and did not specify whether there would be any limitations on what industries will be allowed to use CCS.

And lastly, Ontario should recognize that CCS should be viewed as bridging the gap to encourage innovation and the development of alternative technologies that reduce carbon emissions. While not proven and tested within Ontario and at larger scales, potential alternative technologies/methods can include "Green Steel" and a "Circular Economy" (Bleischwitz, et al., 2020; Pathak, et al., 2022).

In conclusion, the crucial elements that Ontario would need to expand upon in its regulatory framework include developing the CCS operator's intent and progress to develop an MMV plan to ensure containment; ensuring what the expectations for an EIA in CCUS should include; implementing a risk analysis and evaluation; using a systems analysis to determine alternative scenarios for the long-term fate of CO₂; leveraging the use of CCUS ITC; recommending Ontario to invest into CCS; and the concerns regarding the reliance on CCS to continue the use of fossil fuel for hard-to-abate sectors.

1.2.6.1. Feedback/Concerns from Organizations, Industries and Individuals

It is also important to look at organizations and individual commenters, as they gave specific concerns about the regulatory framework - some of these comments can assist in

understanding other necessary policies Ontario should expand upon or give further insights to policy preferences for pore ownership and liabilities.

Wells and Well Operators:

- The government should direct efforts towards addressing the larger safety and environmental risks of onshore and offshore commercial orphan wells (Brekveld, 2023).
- The Ministry should consider methods to help assist well operators to access financial security to responsibly manage the end of life for all private wells (Brekveld, 2023).
- Any conversion, change, or transfer of a well license provides the opportunity for landowners to update easement or lease contract arrangements (Brekveld, 2023).
- Mentioned that Alberta has a Small-Scale and Remote (SSR) Carbon Sequestration Tenure by way of a Mineral Rights Information Bulletin – This permits the development of smaller projects and avoids the complexities of the “hub approach” which could be useful in Ontario (Individual-93615, 2023).
- Another individual highlighted the need for further open communication towards well owners, as Haldimand County well owners do not know that there is an opportunity to comment on proposed changes (Individual-93642, 2023).

Pore Space and Liability: :

- Advocated for a more comprehensive regulatory framework to be introduced up front, including the declaration of suitable underground pore space as a provincial asset (also known as vesting) (Canadian Manufacturers & Exporters, 2023).
- Regarded that the narrow parameters for carbon capture to occur - which is on a demonstration basis, and private land only. Overlooks the complexity and high risk

for proponents to engage in extensive discussions with property owners and stakeholders to secure rights for such projects (Canadian Manufacturers & Exporters, 2023).

- Noted that surface rights holders may have rights to the pore space beneath them or it may sit with mineral rights holders – but the proposed regulatory provisions are not clear about where the ownership of geologic pore space rests (Valiaho, 2023).
- Consider options for equitable distribution and processes to access pore space (Valiaho, 2023).
- Recommended that Ontario should develop a process that allows for the transfer of long-term liability of stored carbon to the province (Valiaho, 2023). The Ontario Petroleum Institute also suggested a similar process called a “closure certificate” where at the end of the life of the CCUS project, the province would become the owner of the injected CO₂ and assume all associated obligations/liabilities (Lewis, 2023).
- Recommended that Ontario develop a two-stage permit application process where:
 - First stage – allow projects to assess the suitability of a proposed CO₂ storage reservoir and reduce the administrative burden (Valiaho, 2023).
 - Second stage – Approve a commercial-stage project, and it would consist of a fulsome MMV plan and build on the knowledge and data gained through the evaluation stage (Valiaho, 2023).

Fund Security:

- Explained that it would be better to have the Ministry collect and manage the funds – and struggles to understand the need for a private well owner to establish security in the form of a “trust” (Individual-93485, 2023).

First Nations and Community Engagement:

- Noted that the Ministry’s recognition in engaging with Indigenous communities on proposals is positive as it shows that Ontario is willing to ensure adequate consultation and accommodation of First Nations’ interests. Further suggested that the commitment should extend to seeking the involvement of First Nations on a basis that advances reconciliation (Individual-93615, 2023).

1.2.7. Conclusion

This literature review shows the complexity of developing and managing CCS, and as a result, it was broken down into four parts followed by a summary of each part and their takeaways:

1. Section 1.2.2 went over the scope of the regulatory framework by describing the importance of ownership, approvals and assessments, and liabilities in the context of a regulatory framework for CCS.
2. Section 1.2.3 discussed ownership, where this part reviews policies in different regions regarding who should own the pore space and how acquisition of land space can be achieved.
3. Section 1.2.4 reviewed the long-term liabilities associated with CCS, in addition to understanding how these liabilities are transferred from applicants to the government.

4. Section 1.2.5 discussed how Ontario might communicate to the community in terms of how they are protected against potential risks from CCS and the justification of why CCS is needed.

5. Section 1.2.6 describes other necessary policies for Ontario's regulatory framework.

These policies includes MMVs, Environmental Impact Assessments, investment towards CCS, method of engagement with local and Indigenous communities and understanding which industries can develop CCS. In addition, this section also presented comments and concerns from industries and individuals regarding Ontario's regulatory framework.

Section 1.2.3 shows that in comparison to how other jurisdictions acquired access to pore space, Ontario has a few choices. The main two methods are Crown acquisition like Alberta or placing the acquisition based on each mineral or landowner like most US states. While Ontario did hint towards proponents/applicants needing to gain permission from the landowners, in their discussion paper, the government has asked the public and industry to determine what will be the best option in dealing with pore acquisition. Regardless of the methods, the ministry would need to determine whether any consultation with Indigenous communities is needed (Ministry of Natural Resources and Forestry, 2024; Ministry of Natural Resources and Forestry, 2023c). Ultimately, adopting a US method of acquisition would result in individual mineral and landowners having a say in CCS projects, whereas adoption of an Alberta method allows proponents to streamline their process of pore acquisition without having to ask several mineral and landowners. It is important to also note that for the US method of pore acquisition, there is a threshold amount for how many percentages of acquisition are required for the project to move forward – in most states, this percentage is set at 60% (Greenberg, Whittaker, O'Brien, & Hemrich, 2022).

As for section 1.2.4, which discusses liabilities and post-closure, Ontario has proposed an approach where an upfront financial security deposit must be set aside when applying for a carbon storage special project – especially since limiting the security caps can increase the risk of insufficient security amounts. This can also potentially eliminate the risk of companies being unable to pay for decommissioning wells if they cease to exist – the company would have already needed to set aside the funds before applying (Ministry of Natural Resources and Forestry, 2023c). However, Ontario has recognized that industry is concerned about the removal of exemptions and security caps for well licenses that are transferred. Potentially, such removals would cost the industry more and result in more wells with no operator; therefore, this proposal has not been moved forward. Liability has been another concern, as comments have suggested that the province should take over the project after the end of the life of a CCS project through a “closure certificate” – this would make Ontario assume all associated obligations and liabilities. Both Alberta and the EU’s CCS Directive are examples of governments that assumed all obligations and liabilities after closure of a CCS projects (Bankes N. D., 2011).

Section 1.2.5 of the literature review discussed how to effectively communicate to the public about risk mitigation such as potential CO₂ migration to groundwater and what role CCS plays with reducing CO₂ emissions. It was concluded that the Crown should play an integral role in informing the general public about CCS, while proponents/applicants would need to give specific information about the CCS project that they are developing to nearby affected communities and develop capacity building by involving local and Indigenous community members for each project. From Ontario’s September 2023 proposal, it was noted that companies would be required to distribute information to certain members of the public when the public requests this information. This information includes a project description, digital copies of any

application submissions and any expert review documentation (Ministry of Natural Resources and Forestry, 2023c).

Ontario would also need to answer three key questions when developing a CCS project, which are: (1) Where are these pore spaces located, and to what extent do they reach nearby communities? (2) What are the specific safeguards in ensuring that local and Indigenous communities are not affected by CCS? (3) Outline the various methods of transporting carbon emissions and determine which is the safest method. These key questions are critical in deciding how the Ontario government engages with local and Indigenous communities. Ontario should also review its purpose for developing CCS, specifically recommending that Ontario should only provide access to CCS development for hard-to-abate sectors and encourage other non-hard-to-abate sectors to transition into utilizing renewable sources. These hard-to-abate sectors are defined in section 1.1 as industries with a relatively high proportion of fixed emission processes where it is difficult to transition into renewable sources. The specific hard-to-abate industries include but are not limited to cement, steel, iron, coal-fired power generation and chemical synthesis industries (Kumar, Tiwari, & Milani, 2024).

The last section of the literature review – section 1.2.6 - discussed other necessary elements regarding the proposed regulatory policies, and comments from industries and individuals that were deemed to be significant. The key takeaway policies include implementing environmental monitoring measures such as an MMV plan, environmental impact assessments, and risk analysis based on Alberta's regulatory policies for CCS. The inclusion of environmental practices allows for not only good stewardship towards the environment but also respect for communities living within the area. Investment in CCS is also important for Ontario to consider as there was only minimal mention of provincial federal investment within their ERO postings.

As a result, when looking at Alberta's investment strategies, the conclusion is to introduce market-based or regulatory mechanisms, financial incentives, direct funding for demonstration projects, and investment into research and development to reduce costs (Mitrović & Malone, 2011). This would result in accelerated development for CCS and incentives for industries to utilize CCS.

While documents can give exceptional breadth and depth in understanding how CCS functions, discussing topics related to CCS with key informants such as government officials and industry experts can allow the interviewer to acquire specific and accurate information that may not appear in documents and peer-reviewed articles (Hay & Cope, 2021). Under the interview umbrella, a semi-structured interview was chosen as it allows for interviewers to ask further questions whenever a participant discusses a new topic that relates to CCS. Therefore, a semi-structured interview was undertaken to understand more about how Ontario should address certain key policy decisions in developing a framework and to give industries an idea of how their CCS projects can be successful.

2.0 Methods

2.1. Interview Method

Before selecting participants, research ethics was submitted to the University of Waterloo Ethics Research Board – REB 46182. Participants were selected by using a snowball method where participants were asked at the end of the interview for anyone that they think we should be in touch with or ask them to send our recruitment letter on our behalf - it is phrased this way to avoid any identification between interviewees. Initial participants were selected through journal articles and grey-literature articles and their respective authors; also, a group of participants was provided by an industry partner as part of the NSERC Alliance Project. The background of study participants includes government sectors, non-profit organizations, CCS-related organizations, and researchers.

NVivo software was used to qualitatively analyze the interviews. It was noted that 8-12 interviews would be the ideal amount, as any less than this amount would give too little information and higher than 12 would potentially result in receiving redundant information (Hay & Cope, 2021). One way to achieve a higher number of interviews while minimizing redundant information is to interview different key informants from different regions and professional backgrounds. While the time frame was limited for my research, I was able to interview the recommended minimum amount of 8 interviewees. Despite the number of interviewees on the lower end, a significant amount of unique information was revealed during the analysis to develop a thesis.

2.2. Method of Analysis

A thematic analysis was conducted because it allows for tremendous “theoretical flexibility” and applies to various kinds of data as well as a range of data set sizes (Braun & Clarke, 2013). This method is also well suited to semi-structured interviews (Naeem, Ozuem, Howell, & Ranfagni, 2023).

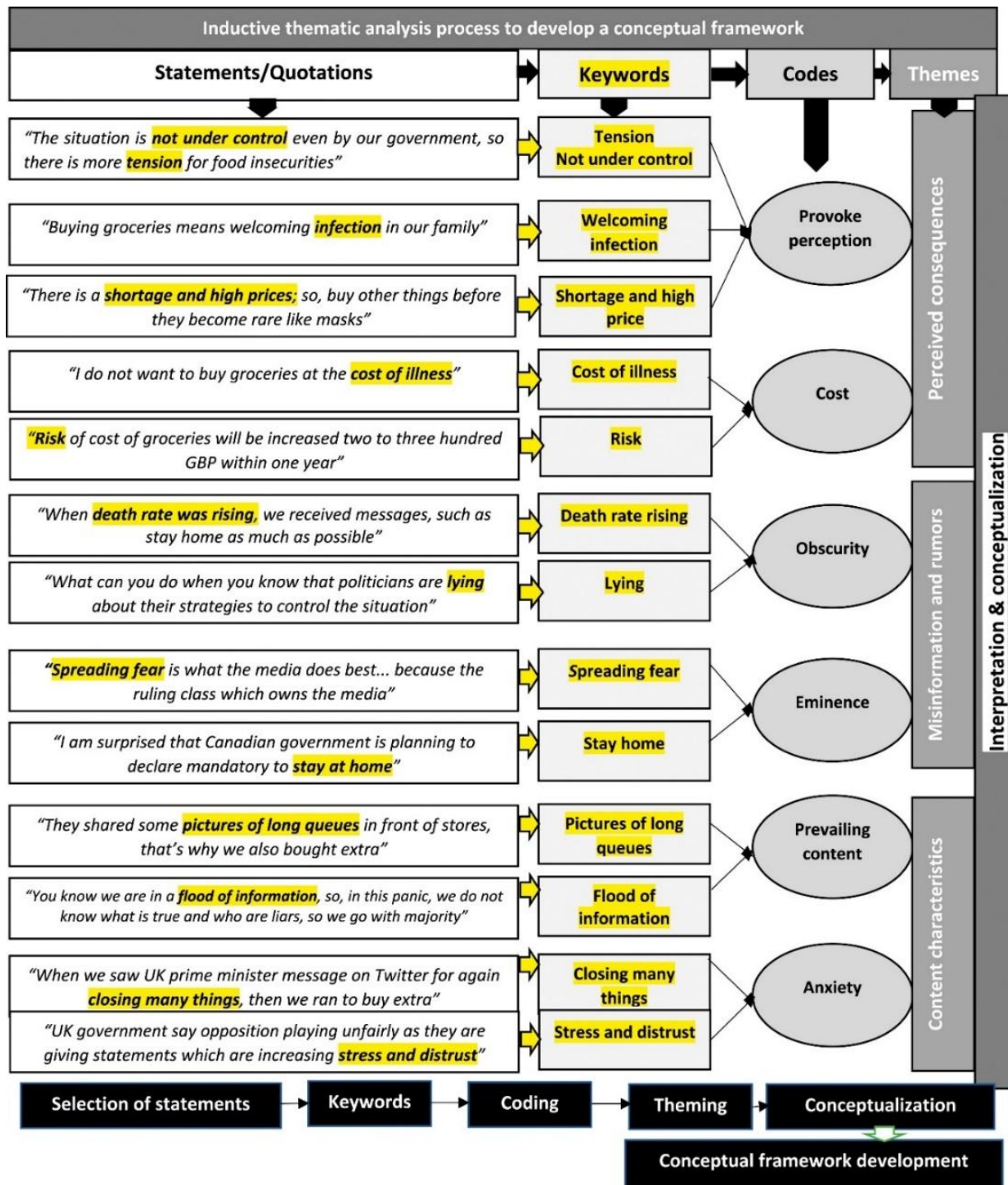


Figure 11. The thematic approach that was used in the exemplar study (Naeem & Ozuem, 2022).

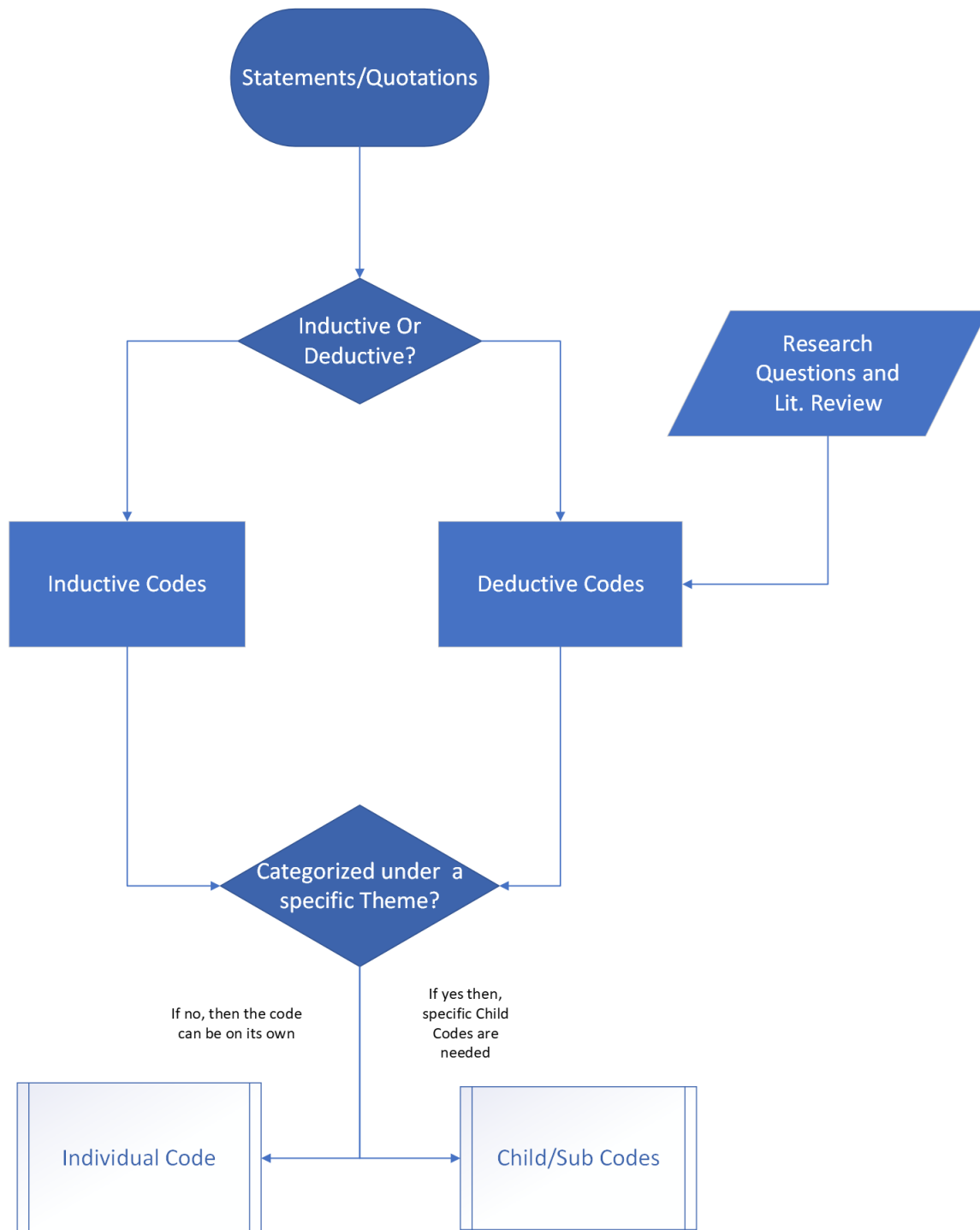


Figure 12. Repurposed Inductive Thematic Process based on Figure 11

Figure 11 shows a process used for a thematic analysis of interview transcripts that investigated how social media misinformation and rumours contributed to the phenomenon of

“panic buying” (Naeem and Ozuem, 2022). In their research, the process was to gather a selection of statements deemed important, and then shorten it down to keywords, the keywords were then merged into codes, which were then further merged into three different themes.

In the context of this research, the coding process was simplified to understand whether these statements or quotations are under inductive or deductive codes as shown in Figure 12. Specifically, deductive codes are predetermined codes that came from the research questions and literature review, which include but are not limited to communication/community engagement, mineral and landowner rights, and environmental regulations and assessment. Inductive coding, on the other hand, comes from information that is synthesized based on the quote it represents. For instance, “Nuclear Waste” is specifically referencing a quote that describes nuclear waste in Ottawa.

After defining codes, these were then either categorized into themes (which had respective child/sub-codes) or individual codes themselves. It is noted that the three deductive codes referenced earlier are retroactively also considered “themes,” and these themes are used to organize codes that are like each other under a theme. Later in the results section, a mind map/diagram of this will be shown in further detail.

Once coding was accomplished, a comparative analysis was conducted with the information from the literature review. This method determined whether there were novel policies that have not been mentioned within the literature review, or reiterated policies already mentioned within the literature review.

To simplify and give some specific examples of the process of how the transcript was coded, the research questions will be used as a catalyst to understand what keywords are needed:

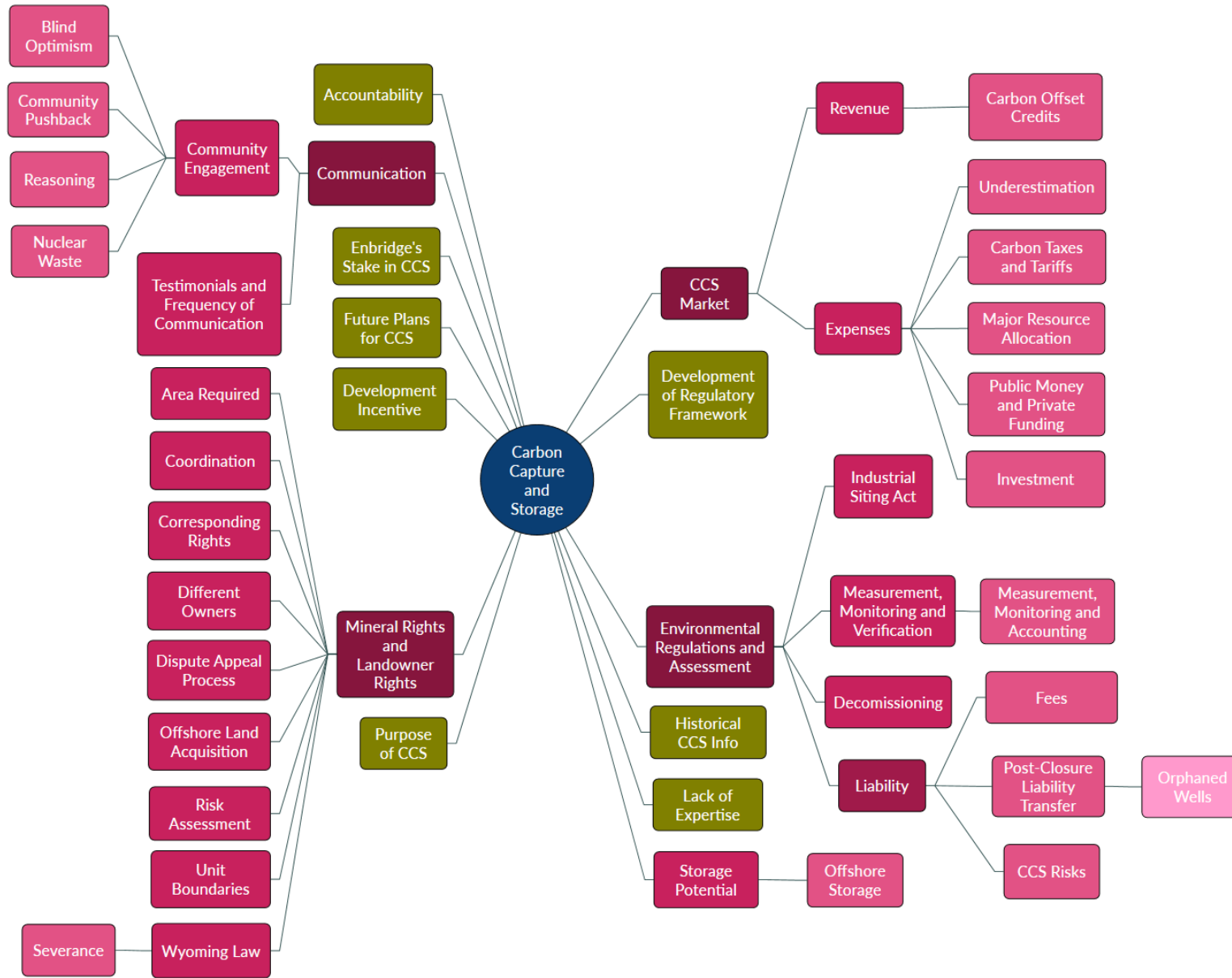
1. How can the knowledge gained from other regions with highly developed CCS policies help Ontario's hard-to-abate sectors understand potential approvals, licensing, and liability?
 - Certain keywords/phrases could include "(insert province name) has done approvals in 'x' way", "licensing", "approvals", and "liabilities". This specific question would be focused on understanding other regions in how they developed their CCS in comparing them against Ontario's potential CCS policies. “Mineral Rights and Landowner Rights” was deemed to be the deductive coding/theme for this research question.
2. What are some other necessary policies that Ontario would need to expand upon and potentially adopt from various jurisdictions?
 - While this question also applies to approvals, licensing and liability, it can broaden the scope of policies considered to other areas such as environmental, financial and health/community-related risks or concerns.
3. In jurisdictions with CCS Policies, how did companies and governments communicate to the public about the need for this technology?
 - As reiterated in my literature review, communication may be crucial in a successful CCS project. While this research question focuses on other jurisdictions, anyone with expertise in public outreach and communication will also have recommendations on how Ontario should approach the public. The main code/theme was under “communication and community engagement”.

3.0 Results

The results of accomplishing a semi-structured interview gave interesting insights into policies developed in regions such as the US and Europe. Additionally, interviewees from Canada gave a comprehensive analysis of Ontario's carbon capture and storage progress for a regulatory framework and compared it against other provinces' regulatory frameworks and/or policies (Alberta, British Columbia, and Saskatchewan).

To give a simple breakdown of the results based on the interviews and coding, here is a diagram of all the codes listed:

Figure 13.
Mind Map
of the
various
codes and
themes



As explained in detail within the methods section, the quotes gathered from the eight interviews have been reorganized based on whether the quoted information is not found within the literature review (inductive) or includes similar information within the literature review (deductive). For example, the quotes from the code "Risk Assessment" are deductive as the code itself is also mentioned within the literature review. Whereas "Historical CCS Info" refers to quotes that describe when Ontario first considered some form of CCS in 2007 - this information was not presented within the literature review.

The four inductive themes are mineral rights and landowner rights; environmental regulations and assessment; communication; and CCS market. The first three themes are considered "deductive" as they come from the three research questions or literature review topics, whereas the CCS market code was considered "inductive". As a result, to differentiate the different codes, they are represented in six different colours – the main topic of carbon capture and storage is represented in dark blue, themes are represented in dark red, individual codes are represented in green, and the sub-codes are represented in maroon, dark pink or light pink.

It is important to note that despite certain codes categorized under deductive themes, they can still be unique to the theme. For instance, the coding “Nuclear Waste” refers to how communication and community engagement were handled, but it is unique in that this specific information has not been mentioned within the literature review.

Table 2 in the Appendix shows a list of interviewees listed by each letter, and each interviewee will have a generalized description of their profession to understand what their background knowledge is and to internally organize which interviewee letter corresponds with their name without giving identifiable information. Table 3 in the Appendix on the other hand displays quotes from various interviewees that provide a unique description of how CCS should

be developed in Ontario's regulatory framework. Each quote will be associated with a specific code, quote number and the corresponding interviewee letter to determine which interviewee provided this quote. These quotes will be further analyzed within the Analysis section – this analysis section will either use a direct quote from an interviewee or paraphrase the quote from an interviewee. Additionally, there may be other quotes that are paraphrased and are not listed within Table 3 in the Appendix. These quotes will however be referenced by the interviewee letter.

4.0 Analysis

Applying the mind map in Figure 13 and interpreting quotes in the Appendix in Table 4, the following section will analyze that information in further detail and make a clear conclusion about what important policies are required for Ontario to develop a regulatory framework for CCS. This section will also review policies mentioned by study participants that supplement the literature review.

4.1. Mineral Rights and Landowners

As explained within the literature review, interviewees discussed how pore ownership, and land and mineral owners are distributed within Alberta, Saskatchewan, BC, Wyoming, and the EU. For Alberta, the Crown owns the pore space, but companies would still need land and mineral rights from the owners for accessing pore space, whereas Saskatchewan requires proponents to speak with mineral rights holders to access their pore space. Wyoming has passed a law where surface owners own the pore space beneath their property, and therefore permission or access is required for any sequestration – as noted by Interviewee D in quotes 26 and 29. They then went on to specifically state that there are three types of subsurface ownership - federal, state, and private lands.

As for how Ontario should regulate pore access, Interviewee E has noted that based on their experience and understanding of CCS regulations regarding pore space from other jurisdictions, they presume that Ontario should own the pore space, specifically saying that "Considering the density of rural population in Ontario relative to other parts of Canada, it would be my perspective that it would be prudent of them [Government of Ontario] if they are wanting to enable CCS projects, Southwestern Ontario, that they would need to essentially, create the

opportunity for the Crown to be the purveyor of the pore space" as noted in quote 27. In addition, Interviewee C has also agreed that Ontario would need to own the pore space: "So here, what industries [are] calling for is without interfering with the mineral rights, what they want the provincial government to do is to access - to make the pore space which is just full - filled with brine, they want to make that a Crown property. Now offshore beneath Lake Erie, where it is attractive to actually, uh, inject beneath the lake bottom into the same Cambrian Formation offshore - it is Crown land already for onshore" as noted in quote 28.

The reason behind advocating for the Ontario government to acquire pore space as a Crown is due to engaging with several different owners. As Interviewee C puts it, "Because there is uncertainty otherwise and this is what is worrying people, particularly developers like Enbridge, who don't want to have to talk to perhaps 100 different landowners and negotiate". In addition to engaging with several landowners, sometimes the owners of land and minerals may be different, as interviewee B stated that despite a person selling their land or farm, their mineral rights would still be held. In addition, Interviewee D noted that since Wyoming vests its pore space to the surface owners, CCS operators would need to engage with federal, state, and private surface owners. As a result, if Ontario adopts policies where the surface owner owns the pore space, this will result in CCS operators in Ontario encountering challenges with engaging multiple surface owners.

Most importantly, putting ownership of pore space to private landowners can result in several complications for companies planning to develop a CCS project. Interviewee D discussed how companies would need to know the extent of the plume site as plumes can overlap. In addition, parcels can be potentially fragmented into 10 different people and the interviewee was concerned about whether you would need to acquire consent from all of them. On top of these

issues, there is also the complexity of different landowners giving sequestration rights to different companies, which results in the companies requiring to coordinate and determine the liability if plumes overlap.

As a result, Wyoming has implemented policies such as the dispute appeal process where if the mineral rights holder won't allow proponents to have access to the pore space, the government will step in and appeal it for them - assuming that the minerals aren't affected, as noted by Interviewee D. Interviewee D also notes that in Wyoming, legal concepts called unitization and *corresponding rights* were implemented. Unitization allows for the government to create a geologic storage unit that would combine all the pore space in the unit for the purpose of operations for a single operator, and this ultimately requires that 80% of the owners within a unit must consent to geologic storage. As for corresponding rights, this concept refers to all owners within the unit being entitled to share proportionately in the economic benefits generated by sequestration activities. Specifically, this legal concept will ensure that the state will protect the corresponding rights of the owner to use pore space for economic purposes (Righetti, 2017).

However, Interviewee F said that while the Crown owning subsurface is not an issue, there can be issues where a farmer can own a large plot of land, and the farmer may not be able to profit off that land due to competing surface activities from operators sequestering carbon in underground pore space.

From analyzing the information given by interviewees, much of the information has also been addressed within the literature review - specifically emphasizing that the Ontario government needs to vest in the pore space so that the complexity of communicating with several different private pore owners would be simplified. Ontario would also need to consider implementing a unitization and corresponding rights statute if surface owners own the pore space.

This will ensure adequate compensation is given to private surface owners who may be impacted and protect the owner's ability to use pore space for economic purposes.

4.2. Communication

In addition to clarifying the pore ownership, many interviewees agreed that communication is a key component in a successful CCS project, especially when doing an in-depth engagement with the community. Interviewee E points out examples of these engagements such as starting consultation as early as possible, looking for opportunities with local businesses, and addressing questions from the community such as how CCS works, its impacts on communities' businesses and whether construction noises will be a problem. Interviewee H also noted that each region has different communities with different understandings of CCS - this is something that both the Ontario government and CCS applicants would need to consider when developing a CCS project.

For instance, in places like Alberta and some US states, communities may know what CCS is, and what potential risks the owners may face. Also, Interviewee C mentioned how despite clear communications, sometimes the public does not want waste to be stored near their community for several reasons in quote 9. While Interviewee B in quote 10 specifically mentions the nuclear waste management up north, and the First Nations have rejected this project. As a result, at some point, project proponents simply must move on and try to find another area or community that can accept waste disposal.

4.3. CCS Risks and Environmental Regulations and Assessment

Since communication is a key component in ensuring that the public understands what is required in terms of developing a CCS project, it is also important to let the public know about the potential risks and how operators will protect the environment and public health.

Interviewees B and D denote that the biggest concern for CCS risks is within the ‘well’ or ‘well bore’ where there is the potential for failure in some capacity - this results in a migration pathway of carbon dioxide into drinking sources/groundwater. To prevent this situation from occurring, Interviewee D has said that Wyoming has an underground injection control program that is part of the Safe Water Drinking Act. This is done by characterizing and evaluating injection pressures, fracture pressures for the confining zones, and the salinity. In addition, other environmental regulations can include a measurement, monitoring, and verification (MMV) program – which for an environmental regulation, ensures long-term security of CO₂ storage and demonstrates that there is the absence of any environmental effects, laws for endangered species, clean air, clean water, and any discharges of effluence (Dean & Tucker, 2017).

4.4. Post-Closure Liability Transfer

Some interviewees raised concerns about how post-closure liability transfer would occur, especially since there is the chance for some companies to not exist within the next several decades - these companies may go bankrupt or merge with other companies. Interviewee D has noted that Wyoming has a statute that provides for liability transfer to the state but also highlights that this is a complicated process, as the company must demonstrate that the CO₂ plume has stabilized and stopped expanding within 30 years. As a result, this ensures proponents applying for a CCS project recognize the importance of the environment and the public, and it encourages good stewardship which allows companies to be provided with an off-ramp if they are in good standing. For companies that do not reach the threshold for a liability transfer, they would have to use the bond to cover their liabilities. Interviewee D has further explained that these bonds are set amount of money that the company would have to pay up front. These bonds are held by the state until the 30-year period is met, and the CO₂ plume has stopped expanding,

in which case these bonds will then be transferred over to the company. If the company isn't stewarding well, cannot achieve liability transfer or the company is unable to pay for their liabilities, then the state will use those bonds to cover their liabilities. These liabilities can include containment losses, damage to private property, and plug-in abandonment.

4.5. Complications of CCS

The previous topics that were discussed were already mentioned within the literature review and emphasized the major components of developing a CCS project. However, there is also information that Ontario could benefit from based on different jurisdictions' CCS regulatory policies and different concerns that several interviewees have raised regarding the development of a CCS regulatory framework.

4.5.1. Purpose of CCS, Reasoning, and Carbon Taxes and Tariffs

Within the literature review, it was noted that it is important to let the public know the purpose of CCS and the reasons why the development of a CCS project would be beneficial. Interviewee A specifically mentioned that the source of CO₂ is incredibly important for regulatory development as that dictates which industries can develop CCS - this also may mitigate some backlash against the development of CCS, especially with fossil fuel and oil companies potentially leveraging the use of CCS in prolonging their production.

However, if the public still has negative criticisms regarding CCS, there can be arguments made that CCS is valuable. In quote 25, Interviewee C said that if we do not inject CO₂ underground, the industry may have to shut down - resulting in a loss of 1000-2000 jobs and destruction of their tax base. It is especially concerning on a bigger picture as this could lead to potential tariffs from the EU, United Kingdom (UK), and the US due to producing products that may generate more CO₂ than any EU, UK, or American industries.

Aside from that, Interviewee C also explained that Canadian industries themselves may be faced with carbon tax issues. Specifically in quote 6 saying that "Lots [of] industries having to close because the carbon price is [prohibitive]. Now the carbon price for industry is meant to be by 2030 \$170 a ton - that's a lot of tonnage. That's a lot of money, if you make 2,000,000 or 3,000,000 tons of steel a year, you're gonna produce two or three million tonnes of CO₂ and multiply that by 170 bucks a tonne Yeah, you're spending a lot of your bottom line of your profits on CO₂." This would result in potential problems with industries sustaining their business, and therefore this argument could be made as to why CCS is important.

4.5.2. Development Speed of CCS, Future of CCS, and Lack of Expertise

Interviewee F was particularly concerned about the development process of CCS and the future of CCS. They have specifically mentioned in quote 2 that the speed of the development of Ontario's regulatory framework is too fast and raised concerns on potentially missing out on quality assurance for the regulatory framework. In addition, the interviewee later explained that Ontario would need to clarify their intentions on implementing potentially new legislation regarding renewable alternatives for hard-to-abate sectors, highlighting the position of CCS to reduce emissions and the speed at which Ontario would take advantage of developing a CCS regulatory framework.

However, in quote 5 Interviewee C has noted concerns regarding the expertise of Ontario in developing their CCS sector, specifically the development of the regulatory framework is slow because Ontario doesn't know what they don't know, and they are worried about making major mistakes. As a result, they have indirectly hinted that Ontario should speed up its process of forming its regulatory framework due to national carbon taxes and tariffs affecting carbon-intensive industries and resulting in potential shutdowns - this is in stark contrast to Interviewee

F's stance on slowing the development and ensuring that the regulatory framework does not miss any quality assurance.

4.5.3. CCS Investment, Fees, and Market

Ontario may need to figure out and understand whether compensation for landowners is needed regardless of which pore ownership method they would choose. This method - as alluded to by Interviewee B in quote 18 - has noted that in Saskatchewan and Alberta, "...that does not necessarily mean you have to pay them any kind of royalty fees. You're more likely to have to pay an annual fee to the landowner to use part of their land for your injection wells and your injection infrastructure." It is important to note that while annual fees refer to the use of their land, it is likely that the royalty fees that Interviewee B is mentioning refers to the extraction of minerals. This could potentially alleviate some of the concerns mentioned by Interviewee F regarding where the farmer or surface owner may not be able to profit from the land.

With the fees in place, there is also the opportunity for creating "buy-in" by the members of the local community who have an economic interest in the project - as noted by Interviewee D in quote 20 - and it assumes that this would be a result of Ontario emphasizing surface owners owning the pore space beneath them. However, it is arguable that even with Ontario vesting in pore space, community members could be invested in this project. This in turn would create an economic benefit to both the proponent developing this project but also for the local community.

Ontario could also consider implementing a Cap-and-Trade system or an Emissions Trading System (ETS) that the EU has considered, where the use of this system may allow CCS to play a role. In quote 11, Interviewee G specifically stated that the revenues of the ETS and the cap-and-trade system can be directly funded into the CCS projects, and they noted that the EU and the Dutch government have already implemented this. In combination with setting a

domestic carbon price for certain industries, this ETS can be a market-based tool to directly invest into CCS, especially if companies see the value of profiting from CO₂ through revenues related to the emissions avoided (La Hoz Theuer & Olarte, 2023).

5.0 Policy Recommendations and Analysis of Bill 228

This section will go over the information gathered from the literature review and the interview results for policy recommendations. In addition to the policy recommendations, Bill 228 will be analyzed to understand how Ontario has decided to proceed with their regulatory framework for CCS, and how it compares against my findings and recommendations on Ontario's policies.

5.1. Policy Recommendations Informed by Research

Combining the information gathered from the literature review and results from the interviews, this section will give policy recommendations based on the four main components of a regulatory framework with any other necessary policies for Ontario to consider.

Ownership of Pore Space:

In section 1.2.3, the analysis of the literature surrounding ownership of pore space found that there are two general methods of owning the pore space: (1) Crown owns the pore space or (2) surface owners own the pore space. At least 3 of the interviewees also specified that their region defined who owns the pore space. Where Wyoming and Saskatchewan's pore space ownership lies on the surface owner, and Alberta's pore space is owned by the government. Ontario would also need to recognize that the two different approaches to ownership have their respective pros and cons, specifically involving the methods of acquiring surface rights from each surface owner. For instance, if the Ontario government proceeds with acquiring pore space to the Crown, this would result in companies not being required to ask each individual surface owner for surface access to the pore space. However, this results in less autonomy for individual private surface owners to negotiate who can access their pore space and how much compensation

is required. The opposite would occur if the surface owners owned the pore space, which would require companies to ask each surface owner but would result in more autonomy for private surface owners. As a result of the complicated process in asking each individual owner for access to the pore space, it would be wise for Ontario to own pore space to simplify the process of pore acquisition – this aligns with Interviewee B and C’s statement in suggesting that Ontario should also own the pore space.

Regardless of the method that Ontario will choose, there were two important questions that Bankes (2011) had about pore ownership, the first was whether it would be enough to obtain consent based on the injection of plume of the projected geographical area. And what happens if an owner is unwilling to contribute to its pore space for a reasonable price? To answer both questions, a unitization statute can be implemented, which is a process where operations can proceed with injections after reaching an agreement with a minimum percentage of owners. It is especially important if Ontario decides to have the surface owner own the pore space underneath their property. And this allows for avoiding the issue of a holdout situation where an owner is unwilling to contribute its pore space for a reasonable price. Alternatively, the second question can be resolved by implementing a dispute appeal process where, in Section 4.1, interviewee D who was knowledgeable in Wyoming’s CCS policies, have noted that Wyoming has a dispute appeal process where if the mineral rights holder won’t allow access to pore space, the government will step in and appeal for them.

Liabilities:

Section 1.2.4 first introduces the importance of post-closure liability transfer as a result of eventual shutdown for companies due to a variety of reasons. In regions where CCS is highly developed, such as the EU and Alberta, post-closure liability transfer policies are in place that are

highly regulated to determine who is qualified for a liability transfer. The EU specifically instructs industries to ensure that the captured CO₂ is safe and to monitor that there will not be any significant future leakage for a minimum of 20 years. The specific liabilities should include tort-based liabilities, re-abandonment of a well, and Greenhouse Gas (GHG) accounting liabilities. As for examples from the interviewees, Wyoming requires the company to demonstrate that the CO₂ has stabilized and stopped expanding within 30 years, and this results in an encouragement of good stewardship for companies to be provided with an “off-ramp” if they are in good standing. However, these companies would also require payment for bonds which are a set amount of money that the companies pay up front, and they would be returned once a liability transfer is completed. However, if the company is unable to pay for their liabilities or cannot achieve liability transfer, then the government would use the bonds to cover the liabilities.

Therefore, it is recommended that Ontario should develop a post-closure liability transfer, where companies would ensure that the pore space has not expanded within a set period of time and companies would pay up a set amount of money to cover liabilities incurred by the Crown during the operations for CCS in the form of a stewardship fund.

Approvals and Assessment:

Often, various assessments are needed to achieve a post-closure liability transfer as these assessments also dictate how a company ensures that the CO₂ plume is not expanding. These assessments can include but are not limited to MMV, environmental assessments, ERP, EPZ, risk assessments to identify potential sources of CO₂ leakage, and a long-term risk assessment through the use of a system model of the geosphere and biosphere. Therefore, it is recommended

that Ontario consider these policies under the idea of “approvals and assessments” and to clarify what types of assessments are needed.

Other Necessary Elements:

In addition to approvals and assessments, Ontario should consider how the regulatory framework interfaces with the following policies: the utilization of CCUS Investment Tax Credit (ITC) and Canada Growth Fund; the purpose of CCS and how the development of a regulatory framework would benefit local residents and the economy; ensuring that the CCS regulatory framework is developed at a speed where Ontario can effectively address public concerns regarding CCS; ensuring that local and Indigenous communities are involved through community engagement practices; and providing compensation fees to a private landowner to access their pore space.

5.2. Policy Description and Analysis of Bill 228

In November 2024, Ontario introduced Bill 228, which outlined one of the four acts that was entitled the Geologic Carbon Storage Act, 2024. The Geologic Carbon Storage Act includes nine parts: Part 1 is the Interpretation, Purpose and Prohibitions; Part 2 is the Ownership of and Rights to Pore Space; Part 3 is the Authorization; Part 4 is the Obligation and Operation and Closure of Carbon Storage Sites; Part 5 is the Reviews and Appeals before Tribunal; Part 6 is the Enforcement; Part 7 is the Carbon Storage Stewardship Fund; Part 8 is General; and Part 9 is the Related Amendments, Commencement and Short Title. This section will first outline and define any relevant information that relates to my thesis from the Geologic Carbon Storage Act and then analyze how it compares against the policy recommendations informed by research in section 5.1.

5.2.1. Description of Bill 228 Policies Relevant to Thesis

In Part 1, section 1, Ontario legally defines various CCS terminology such as “pore space” and “Crown” under the Interpretation section. In section 2, Ontario also outlines the purpose of CCS, defining what constitutes as “carbon storage activities”, and in section 4, the Crown outlines the prohibitions in pursuing CCS except for specific conditions. These conditions include the research and evaluation activities or carbon storage activities performed in an area of the province that is prescribed by the regulations as an area in which carbon storage sites may be located; and if the regulations specify types of storage repositories whose use is permitted for that area of the province, relate to the use of a type of permitted storage repository. The condition also includes that activities can be performed in the case of research and evaluation activities, under the authority of a research and evaluation permit or a storage permit, or in the case of carbon storage activities, under the authority of a storage permit.

In Part 2, section 6, Ontario defines that “surface rights” refers to the land other than the ores, mines and minerals that are on, in or under land. In section 7, Ontario then went on to clarify that the ownership of the pore space lies on the real property form part of the surface rights. However, the Lieutenant Governor in Council has the ability create a regulation where the rights to the pore space are taken by the Crown without the consent of any persons who own those rights in section 8. Ontario has also highlighted that the authorized holders would be required to compensate to owners of pore space whose rights have been taken by the Crown in subsection 3 of section 9.

Part 3 goes into detail about research and evaluation licenses, storage licenses, permits, unitization, referral to the Ontario Energy Board, completeness of applications, Authorization

valid for the period of time set out by the minister, and suspensions – subsections 1 and 2 (11), and section 12, 13, 14, 16, 17, and 20 respectively.

In subsection 3 of section 12, Ontario specifically states that for the issuance of permits, the activities are carried out in a manner that protects public safety and the environment; has obtained the rights to use of land and to pore space necessary for the activities sought; identifies potential impacts on agriculture, drinking water sources, current or planned surface and subsurface activities (which includes mining and mineral development, oil and gas activities, and underground geologic storage), and using the assessment to mitigate those impacts; and adequate consultation with Indigenous communities has been carried out.

Due to Ontario's vesting pore space on to surface owners, in section 13, for persons applying for a storage permit, the Tribunal may order that under the unitization order, the rights to the pore space within a unit area be joined for the purpose of a carbon storage site; that the management of construction, development, use, decommissioning, oversight of the carbon storage site, and the remediation and restoration of associated lands are to be carried out by the person described in the order; and that the costs and benefits of operation within the unit area be apportioned in the manner specified within the order. The Tribunal would also need to be satisfied that the unitization would best optimize the use of storage repositories; person(s) requesting the order have made efforts in good faith to obtain consent of all landowners to convey their rights to the pore space; person(s) requesting the order have obtained consent from landowners whose interests represent the majority; and that the landowners who have not consented have been or will be equitably compensated.

Part 4 subsection 2 of section 23 mentions that the Tribunal would require the permit holder to perform an MMV under this Act, the regulations, or an order issued under this Act. In

section 24, the Minister may order the permit holder to temporarily or permanently cease injection due to the following reasons: CO₂ no longer being contained or is at risk of ceasing to be contained within the storage repository area; permit holder has contravened, is contravening or will contravene on this Act; any part of the works for a CCS project becomes a hazard to the public, the environment or is about to be used in a manner that constitutes a hazard to the public or the environment; or no CO₂ injection has occurred during a time period specified.

Note that a closure certificate and transfer of liabilities are undertaken if the Minister is satisfied that the CO₂ within the storage repository is in a stable and predictable condition and that there is no significant risk of future of leakage. The storage permit holder also would need to meet and satisfy requirements of section 25. The two important requirements include where a permit holder shall not close a carbon storage site unless the conditions prescribed by the regulations made by the Minister have been met and has obtained a written approval by the Minister. The second important requirement includes where the permit holder would also be required to a) decommission all wells, storage, repositories and ancillary works that make up the carbon storage site; b) remediate and restore the lands used for the carbon storage site in accordance with the regulations made by the Minister; c) continue to manage the carbon storage site in accordance with this Act, regulations made by the Minister and any applicable orders or authorizations issued under this Act for the duration of the time period prescribed by the Minister; d) perform notification and consultation activities; e) satisfy any other conditions of the approval or order to close the carbon storage site; and f) satisfy any other requirements relating to the closure of the carbon storage site. As for covering the liabilities incurred by the Crown, the authorized holders require payment to the fund as prescribed and in accordance with the regulations under the Carbon Storage Stewardship Fund.

Part 8 covers the roles of the Lieutenant Governor in Council and the Minister in the context of this Act. Specifically, the Lieutenant Governor can make regulations defining any term or expression used in this Act that is not defined within the Geologic Carbon Storage Act, 2024; prescribing matters or considerations; clarifying questions of ownership or rights in respect of land or pore space; requiring and governing the registration of notices on title with respect to lands; and respecting any matter necessary or advisable to carry out effectively the intent and purpose of this Act.

The Minister may make regulations regarding the protection of public safety or the environment in connection with a carbon storage site; governing a system of financial assurances, including giving of securities; requiring persons performing activities in relation to this Act have specified qualifications; requiring any documents to be reviewed by an expert; requiring and governing storage resource assessments and how the storage potential of a storage repository and carbon storage site are assessed and characterized; requiring plans about the design, construction, installation, use, maintenance and decommissioning of wells, storage repositories, ancillary works, and the closure of carbon storage sites; requiring plans regarding risk management, monitoring, measurement and verification, and emergency response; requiring public and local consultation and engagement on plans, especially including Indigenous communities; and prescribing rules for when notices or other documents prepared under this Act are received.

5.2.2. Analysis and Comparison of Bill 228 to Thesis

As mentioned earlier, this bill reveals the core components that are needed to develop a regulatory framework – the ownership, approvals, assessments, and post-closure liability. The specific policies in Bill 228 that align with my recommendations for Ontario include the transfer

of post-closure liability; definition of CCS; compensation to owners for the use of lands; the use of unitization due to surface owners owning the pore space; plans for risk management, MMV and an emergency response; local and public consultation and engagement on plans – including Indigenous communities; and a carbon storage stewardship fund to cover the liability expenses incurred by the Crown.

However, one key difference between my findings and this bill is defining who gets to own the pore space and how this ownership occurs. In section 5.1, based on the researched information gathered, I recommended that Ontario should own all of its spore space due to complications with communicating with each individual private surface owner to access their land and pore space. Ontario has decided to let surface owners own the pore space; however, the pore space can be vested in the Crown assuming that certain pre-conditions are met and the Lieutenant Governor has identified the lands in which the pore space are located. These pre-conditions include where the Lieutenant Governor in Council considers it in the public interest and the rights taken by and vested in the Crown are in relation to pore space that underlies lands that are both owned or controlled by the Crown and privately owned.

The bill differs from other regulatory frameworks studied for this thesis, such as Alberta. There may be to two major reasons for such differences. The first reason is the amount of industries emitting CO₂ in Alberta in comparison to Ontario. Alberta has several manufacturing, and oil and gas industries where CO₂ emissions are greater than Ontario. In fact, the data gathered from the Environment and Climate Change Canada's Facility Greenhouse Gas Database (2024) shows a single company in Alberta that released 13317.16 kt CO₂ equivalent, which is more than the combined emissions of the top 3 emitters in Ontario. Due to the scale of emissions in Alberta, it is abundantly clear that developing CCS was necessary for the province to reduce

emissions to meet the net-zero carbon emissions standard by 2050, and alleviating any contentious issues with other nations utilizing carbon tariffs.

The second reason is due to Alberta's comprehensive expertise in subsurface regulations with oil and gas and increased pore space in comparison to Ontario. Alberta has extensively built their oil and gas industry, and the local communities that live near these refineries have a better understanding of how pore ownership and acquisition works – this may reduce community opposition in acquisition of pore space for CCS.

As a result of this, Alberta knew that with a large amount of industries utilizing CCS and its extensive experience with regulating subsurface activities, vesting the pore space to the government was the correct choice as industries would not be required to contact each individual surface/landowner for access and use of their pore space. In Ontario, the amount of hard-to-abate facilities and industries is substantially lower than Alberta. The level of energy production should also be noted as Ontario generates about 86% of its electricity from sources that produce little to no emissions, while Alberta generates 57% of its electricity mostly from gas (Ministry of Energy and Electrification, 2023; Alberta Electric System Operator, 2025). Because the energy production of gas plays a significant role in supplying electricity, this results in gas industries in Alberta utilizing CCS to reduce the province's emissions.

Ontario also may have gone with letting surface owners own the pore space to ensure that private surface owners have full autonomy on negotiating compensation fees and concerns regarding the development of CCS on their property. The strict regulation may have also resulted from the lack of pore space in Ontario in comparison to Alberta, thereby restricting the CCS projects to significant CO₂ emitters in hard-to-abate sectors. In addition, it is presumed that Ontario has requested that the Lieutenant Governor have the ability to vest in the pore space in

selected areas in the event that the amount of private owners is exceedingly large. This results in reduced labor in communicating with each individual private owner and negotiating for compensation, and ensures that there is no complication if each landowner gives sequestration rights to a different company.

Overall, while Bill 228 addresses the concerns regarding the four core components of a regulatory framework, it is unclear how Ontario would determine how much land is required for pore space and CCS activities. Specifically, Ontario would need to consider the potential brine displacement versus the projected CO₂ plume for its pore space boundaries. This concern was brought up by Interviewee D with respect to Wyoming. This also creates complications for liabilities if different pore space owners have different companies using their pore space – would a combination of both companies be permitted? Ontario also did not address whether companies would be able to merge their CCS productions into a single pore space – such as a CCS hub. Therefore, it is still recommended that Ontario vest in its pore space to reduce the complexity of consulting each private surface owner. In addition, the limited pore space storage in Ontario in comparison to Alberta also further emphasizes in Ontario owning the pore space as this allows Ontario to manage its pore space efficiently.

5.3. Limitations and Future Research

During the time I was matriculated in my master's program, Ontario released a few ERO postings to update on the development of their regulatory framework. This made it challenging to produce research that remained timely. Despite this challenge, I have further emphasized how companies and other forms of government can use this knowledge to gain a better understanding of the regulatory framework, and I incorporated new policy development announced by Ontario as much as I could.

Although I was only able to conduct 7 interviews initially (the 8th interview was accomplished at a much later date), some of the topics discussed with the 7 interviewees had reached saturation. To illustrate the saturation of the topics, Figure 14 displays a chart that compares the number of coding references by their coding counterparts, and Table 4 in the Appendix shows the codes or topics that reached saturation and additional unique codes I have gathered from the interviewees. I was unable to change the font size of the codes due to NVivo's software, but essentially the size of the boxes represents the number of coding references. Liability, Mineral Rights and Landowner Rights, Post-closure Liability Transfer, Communication, Community Engagement and Development Incentives had a large number of references in the interviews.



Figure 14. Chart that compares the number of coding references by their coding counterparts

In addition, during my time researching CCS, one important topic that I came across was understanding how we can engage with local Indigenous communities in the development of these CCS projects. Unfortunately, this area was not further studied as I do not have any experience with Indigenous communities near CCS projects, therefore it is recommended that researchers should focus on:

1. Taking some time for researchers to develop meaningful relationships with the Indigenous community
2. Or co-creating meaningful research with someone from the community.

In addition, a researcher focused on this topic would require time to research within this area, as they would need to follow principles and guidelines stated within the TCPS 2 (2022) Chapter 9: Research Involving the First Nations, Inuit, and Métis Peoples of Canada. When involving Indigenous peoples, the three principles that express the core ethical value of respect for human dignity also apply here, which are – Respect for Persons, Concern for Welfare and Justice. In addition, there are 22 provisions/articles which the researcher must understand and adhere to when conducting research with Indigenous peoples. These include but are not limited to the nature and extent of engaging with the communities; respect for First Nations, Inuit or Métis; ensuring that all avenues of formal approval for projects are considered, taking into consideration all voices – including those who do not have a voice in formal leadership; and forming a research agreement (Interagency Advisory Panel on Research Ethics, 2023).

6.0 Conclusion

The main goal of this research was to understand how Ontario might position itself to prepare for developing a regulatory framework on CCS. The secondary goal was to gather, collect, and synthesize this information so that industries and governments interested in developing a regulatory framework can review this thesis and understand what some of the important policies are for effective CCS projects. This thesis first identified the context behind Ontario's decision to pursue a regulatory framework and presumed that they were:

1. Producing a regulatory framework so that Ontario can meet its climate goals to reduce carbon emissions – specifically with hard-to-abate sectors and aligning with the federal government's goal to achieve net zero by 2050 (Ministry of Natural Resources and Forestry, 2022).
2. Investigating the viability and justification of storing carbon underground.

Then, a policy review and literature review helped to solidify what policies Ontario has already developed, and what new policies they can use through reviewing other jurisdictions' policies in the UK, US, EU, Australia, Alberta and Saskatchewan. The three key areas reviewed and researched include the ownership of pore space, mineral rights, and property/surface rights; how to effectively communicate with the public about CCS ; and other necessary policies for Ontario's regulatory framework.

The three research questions are:

1. How can the knowledge gained from other regions with highly developed CCS policies help Ontario's hard-to-abate sectors understand potential approvals, licensing, and liability?

2. What are some other necessary policies that Ontario would need to expand upon and potentially adopt from various jurisdictions?
3. In jurisdictions with CCS Policies, how did companies and governments communicate to the public about the need for this technology?

In addition to literature review, semi-structured interviews were conducted. Such interviews allowed niche information to be given that may not be present through documents, journal articles, or books. Also, semi-structured interviews were chosen as they allow the interviewee to discuss other relevant details about CCS.

Once interviews were finished, they were then transcribed, reviewed and analyzed in two different ways - inductive coding and deductive coding. The idea behind this method was to determine whether a specific quote from each of the interviewees fell under one of these two categories. Deductive coding primarily used codes from the literature review and the research questions - i.e., mineral and landowner rights, communication, and environmental assessment. In contrast, inductive coding was applied to new information that was not found within the literature review. Also, the deductive codes simultaneously acted as 'themes', and these themes were created to gather and organize individual codes that share a common theme - these individual codes are referred to as child, or sub-codes. For instance, the code 'area of review' was deemed to be fitting under mineral and landowner rights. However, there were several exceptions where a specific code did not have a strong enough relationship with one of the themes, and therefore these codes acted as individual codes.

The results of the codes gave some interesting insights on how CCS policies should be developed, with codes that are unique such as the future of CCS, the development speed of CCS, the purpose of CCS, carbon taxes and tariffs, nuclear waste, potential for Ontario to utilize a cap

and trade system, and Enbridge's stake in CCS. The interviewees also highlighted the importance of policies such as defining ownership, implementing a post-closure liability transfer, various approvals and assessments, communication and engagement with the community and CCS risks.

As a result of the information gathered from the literature review and interviewees, policy recommendations were given in the context of pore ownership, liabilities, approvals and assessments, and other necessary elements. During my time in developing and finishing my thesis, Ontario introduced Bill 228 in November 2024 which included an Act called the Geologic Carbon Storage Act, 2024. This bill and Act resulted in describing what the Act consists of and highlighting relevant policies to my thesis. Then, an analysis and comparison was conducted to understand specifically which policies Ontario has adopted, and my thoughts on this Act. In analyzing Bill 228 and my thesis, the following information will answer the three research questions stated earlier.

1. How can the knowledge gained from other regions with highly developed CCS policies help Ontario's hard-to-abate sectors understand potential approvals, licensing, and liability?

As a result of understanding approvals, licensing and liability in regions with highly developed CCS such as Alberta, Saskatchewan, Wyoming and the EU, Ontario has two main methods on who should own the pore space. The first method is for Ontario to let surface owners also own the pore space underneath their property and this allows for individual owners to acquire higher autonomy on who can use their land. While this may allow for individuals to have some form of economic interest in these projects, several complications can lead to slow development of CCS or shutdown of the project. These complications include compensation to landowners for the usage of their land, parcel fragmentation resulting in potentially requiring all of the consents based on the number of owners for that parcel, and determining which company

is liable if either the pore space or plume crosses another boundary. Examples of this method include but are not limited to Wyoming and Saskatchewan.

The second method is for Ontario to own all the pore spaces, which results in reduced autonomy for individual landowners but simplifies the application process for developing CCS. Specifically, CCS applicants do not require asking each individual for the usage of their own pore space. However, similar to Alberta's policies, the landowner should be separate from owning the pore space. Ontario would also need to require applicants to notify landowners of the use of their pore space underneath their property.

While Ontario has decided to set ownership to surface owners but have the ability for the Crown to vest in certain areas for ownership, it is still recommended that Ontario fully vest into the pore space. The justification behind this recommendation is due to the reduction in complexity in acquiring rights for pore space, and ensuring that each company has access to pore space equitably.

In either of the pore acquisition methods, Ontario would require a transfer of liability from the CCS operator to the government after certain pre-conditions are met - especially since the CO₂ that is stored would need to be monitored for long periods, and a stewardship fund to cover the liabilities for the Crown. For example, Wyoming has set criteria where operators would need to demonstrate that the CO₂ plume has stopped expanding and does not encounter any problems or containment losses for a set period of 30 years, and this results in the transfer of liabilities to the state. The EU also has a similar approach where if the Competent Authority assumes that the geological conditions are suitable, a transfer of liability can occur.

Unitization would also be required, especially if Ontario is planning to have surface owners own the pore space, as this will allow a process where operations can proceed with

injections after reaching an agreement with a minimum percentage of owners – for instance, in Wyoming this was 80%.

In Bill 228, Ontario has requested to implement a liability transfer with the transfer occurring when the time period prescribed by the regulations made by the Minister has elapsed. This liability transfer would result in the Crown assuming all obligations of the holder of the storage permit for the carbon storage site; becoming the owner of the wells and ancillary works making up the carbon storage site, but clear of all interests, charges and liens, and assumes responsibility for operating them; and assuming any rights, duties or obligations prescribed by the regulations. To cover the costs of the potential liability that Ontario may incur, the Lieutenant Governor would require authorization holders (or proponents developing the CCS project) to pay into the Carbon Storage Stewardship Fund. Ontario also has proposed a unitization process due to pore ownership being vested to surface owners.

2. What are some other necessary policies that Ontario would need to expand upon and potentially adopt from various jurisdictions?

While Ontario has acknowledged important monitoring programs and environmental assessments such as the MMV and ERP, other necessary policies that Ontario may need to expand upon include implementing various environmental assessments such as the ERP and EPZ from Alberta; using a systems analysis approach to understand what are the possible outcomes of developing a CCS project due to its complexity; and incorporating CCS into carbon pricing schemes such as TIER in Alberta or the ETS in the EU.

Other necessary policies also include the Ontario government's plans in how they want to utilize CCS, especially recommending that Ontario distribute its CCS permits to hard-to-abate sectors. Specifically, understanding which industries are considered hard to abate is a concern

because Interviewee A had noted that within Germany, there had been political pushback due to concerns with prolonging industries that use non-renewable sources. If Ontario is not selective with their industries in using CCS, the provincial government may also receive pushback from the public.

3. In jurisdictions with CCS Policies, how did companies and governments communicate to the public about the need for this technology?

To communicate to the public about the need for CCS, the Ontario government and companies should first understand the social demographic backgrounds of Ontario and how much knowledge they have about CCS. Regions where oil and gas industries are prominent, such as Alberta, may have communities that understand CCS. Regardless of their knowledge of CCS, it is recommended that the Ontario government and companies start consultation as early as possible, look for opportunities with local businesses and address any types of questions from the community. The consultation could include how CCS is developed, how CO₂ is transported, and most importantly how communities are safeguarded from potential CO₂ migration into their groundwater.

Some individuals may raise concerns about why CCS is important and what are the downsides of not pursuing development of a CCS project. To explain the downsides, Interviewee C mentioned that some industries may shut down and jobs will be lost as a result of potential tariffs from the EU, UK and the US due to producing products with higher CO₂ emissions, and the potential increase in carbon taxes. This statement may convince individuals to understand the negative implications of not participating in a CCS regulatory framework.

Despite the reasons for the need for CCS, some communities may want nothing to do with developing CCS near their community, and therefore the applicants would need to look for

other areas to develop their CCS project. A great example of this occurred when the Canadian Nuclear Laboratories were planning to dispose of one million cubic meters of radioactive waste, and this resulted in local communities opposing and challenging this project in court (Bulowski, 2024). Therefore, the most important aspect of developing a CCS project is to have a two-way street that allows for engagement and active collaboration between the companies proposing CCS and local communities hosting CCS to understand where they would want these CCS projects to occur.

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Appendix

Project Type	2023-2030	2031-2040	After 2040
Eligible capture equipment used in a direct air capture project	60%	30%	0%
All other eligible capture equipment	50%	25%	0%
Eligible transportation, storage, and use equipment	37.5%	18.75%	0%

Table 1. Depreciation of national CCUS Investment Tax Credit rates over time (Finance Canada, 2022).

Project Type	2023-2030	2031-2040	After 2040
Eligible capture equipment used in a direct air capture project	60%	30%	0%
All other eligible capture equipment	50%	25%	0%
Eligible transportation, storage, and use equipment	37.5%	18.75%	0%

Table 2. Depreciation of national CCUS Investment Tax Credit rates over time (Finance Canada, 2022).

Interviewee Letter	Interviewee's Profession
Interviewee A	Professor/Researcher in Germany
Interviewee B	Communications/non-for-profit in Saskatchewan
Interviewee C	Professor/Researcher at Waterloo
Interviewee D	Professor/Researcher in Wyoming
Interviewee E	Policy and Regulatory Specialist in Canada
Interviewee F	Policy Advisor in Southwestern Ontario
Interviewee G	Professor/Researcher in the Netherlands
Interviewee H	PhD Candidate/Researcher in Germany

Table 3. List of interviewees and their respective professions

Code	Quote	Quote #
Future of CCS	“There's always the case of like, well, who's going to look after this later? As is it, you know, like it's great that it's happening now is it also on the plan like is there also a plan later for like a slow phase-out of these type of uhm the type of energy that's used right now that we don't consider necessarily consider as clean as it can be and does this just kind of justify the continued use of those type of resources or is there a broader plan that there will be some emphasis put on making it more economically viable for like replacements of industries that still rely on like natural gas to be able to kind of transition them over so that we will no	1

	longer need this and also carbon storage, then overall potentially is kind of like if you think about it like has a timeline associated with it, if you if you move in that direction.... There should be thought about like that bigger picture, right?" – Interviewee F	
Development Speed of CCS	"Umm can you can miss things and so I'm hoping that I understand why the clock is running on the provincial government to get this up and running because you know, that's like a major incentive for them to have to like [to] put it in place. And I just hope that from what I've seen uh from policy? Sometimes and from and from, like governments that come in and sort of prioritize speed. Is that like you may miss out on quality insurance and I don't think that's kind of like a fair trade off in in this instance? The other part of it to me is I know they've maintained it as flexible and I'm glad that they've kind of like made linkages to climate change. Uh, I just hope that it continues to, uh, preserve that that link." – Interviewee F	2

	“We are all waiting and have been waiting for over a year now for clear Regulatory Framework. And the concern with an industry that will have to spend the dollars and have to organize Carbon Capture, transportation and storage, is that what we will see later this year and something is due to be released in the next month or two, will be impractical.” – Interviewee C	3
Purpose of CCS	“Is the clarification of what types of CO₂ could be stored, so the source of the CO₂ is an incredibly important point for regulatory development. So I think in Canada, because you're such a fossil fuel heavy country, they probably won't be so careful about it. And maybe people don't care, but they probably should.” – Interviewee A	4
Lack of Expertise	“The Ministry of Natural Resources does not have that expertise to understand how it is done or more importantly, how it should be done because they're the regulator. This is part of the reason they're moving so slowly is they don't know what they don't know. And they're worried about making serious mistakes.” – Interviewee C	5

Carbon Taxes and Tariffs	"Lots [of] industries having to close because the carbon price is prohibited. Now the carbon price for industry is meant to be by 2030 a \$170 a ton - that's a lot of tonnage. That's a lot of money, if you make 2,000,000 or 3,000,000 tons of steel a year, you're gonna produce two or three million tonnes of CO2 and multiply that by 170 bucks a day. Yeah, you're spending a lot of your bottom line of your profits on CO2." – Interviewee C	6
	“The European Union and the US may institute carbon border adjustment mechanisms – tariffs - if our industry is seen to be making products that generate more CO2 than American or European or British industry. So we can be caught many different ways. We can be caught here with carbon taxes. We could be caught at the border with tariffs. And much of the steel industry and chemical industry, they are a huge exporters from Ontario into the US.” – Interviewee C	7

Nuclear Waste	“Right now, there's a controversy in the Ottawa Valley Chalk of a nuclear labs can that Canadian nuclear labs at Chalk River has built and a new secure landfill for the wastes on its site? It's bitterly opposed, but that was a long-delayed safety measure to progress bring together all the unconfined wastes on its property.” – Interviewee C	8
	“The nuclear waste management organization is right now doing the same thing with two nuclear waste sites, one about 100 kilometers from Waterloo and one up near Thunder Bay. Whether or not they'll get they'll be successful in persuading the communities as well as the local First Nations to accept the waste sites beneath 700 meters down beneath there land is questionable, and they've been working on this now for five or six years. Regular meetings with First Nations and so on and so forth. ... and at the end the First Nations rejected the sight even though it was better than any other site that has been identified anywhere in the world, they just didn't want anything to do with it, not on my First Nation's property.” – Interviewee C	9

	“You know, that's a bit like trying to find, you know, Canada has to find a place to put its nuclear waste, and there's two or three communities after years and years of searching that are kind of agreed that they would be willing to have it near that right. But you just have to at some point a community is just not interested in the project. You just have to move on and move and try to find another operator where it happens.” – Interviewee B	10
CCS Market	“The other thing you can do with [Emissions Trading Scheme] ETS of course, is to use the revenues of the ETS, the cap-and-trade system directly and pump them directly in in this project. So, this is also something that the EU is doing so and also the Dutch government is doing. So because you can actually set a domestic carbon pricing for certain industries. So this is obviously a market based tool that you can use, right?” – Interviewee G	11

	“Legislation dealing with certification of carbon removals, which is also meant to somehow create a voluntary market for carbon removals - this is a very contested controversial legislation, which has been passed last year but it does include CCUS big time. This is actually one of the main focuses is together with carbon farming so under this scheme, essentially CCS projects would gain credits for their marginal abatement of CO2 that they could use on the market, and probably this would also need be linked to the emission trading system to make it even more active” – Interviewee G	12
Enbridge’s Stake in CCS	“Enbridge which has the most to gain really from this because it already has established pipeline networks. Which means it has pipeline rights of way. And although these pipelines can probably not be repurposed for CO2, the fact that they've got rights of way means they have. essentially a head start in building a CO2 pipeline network between the emitters and any potential Storage hub that is developed. – Interviewee C	13

Environmental Regulations	“... most important environmental regulatory brief program we have is the underground injection control program, which is part of the Safe Drinking Water Act. So CO2 injection wells are permitted for the most part under Class six of that, which requires very extensive characterization and the main purpose of the safe Drinking Water Act is to prevent underground injections from creating intrusions into underground sources of drinking water. So it's primarily concerned with preventing containment losses, making sure you're not having, let's say, brine pushed out into drinking water formations. And so to do that, they really characterize and evaluate injection pressures, the fracture pressures for the confining zones, the salinity and confining sort of formations for the plume to determine what is the maximum rate somebody can inject at where they can inject, you know how many wells they can have, how you would expect that plume to perform - and so that's probably the main one. – Interviewee D	14
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	“In Wyoming, we have what's called primacy over the program. So it's a federal law, but the state has enforcement and administration responsibility based on an agreement that they have with the federal government. So we have state laws which are actually a little bit stricter than the federal UIC program [Protecting Underground Sources of Drinking Water from Underground Injection] laws that allows the state to administer according to our laws by the Department of Environmental Quality.” – Interviewee D	15
	“In addition, you're going to have all of the laws that would apply to any other industrial facility, so laws for endangered species, for clean air, for clean water, f discharges of any effluence.” – Interviewee D	16

CCS Risk	“The vast majority of risk within the CO2 project rests down well. It rests in potentially a failure in some capacity for the well bore or in deep in the reservoir potential migration pathway, either through a fault or something else into another level above the injection zone.” – Interviewee B	17
CCS Fees	“So yes, you do need to get permission in Saskatchewan and Alberta to inject from the mineral rights holders - that does not necessarily mean you have to pay them any kind of royalty. You're more likely to have to pay an annual fee to the landowner to use part of their land for your injection wells and for your injection infrastructure.” – Interviewee B	18
Post -Closure Liability Transfer	“We also have a statute that provides for liability transfer to the state. It's very difficult to obtain that, though. The company has to demonstrate that the CO2 plume has stabilized and has stopped expanding, and they have to demonstrate that they don't have any liabilities, technical problems or containment losses, and if they can do that, the state actually will take title to the CO2 and all of the facilities and be responsible for long-term stewardship thereafter.” – Interviewee D	19
CCS Investment	“I would say the other side of that that we've seen is that at least where these transactions are happening. Which of course that adds to the cost of doing CCS because you have	20

	to pay all of these people. But that creates buy-in by the members of the local community who have an economic interest in the project, and so they are perhaps more supportive of seeing projects go forward, good, because if the project is successful, they will personally, you know, internalize an economic benefit. Umm, so they may be more likely to support sequestration projects than somebody who, you know lives above state or federally owned minerals.” – Interviewee D	
CCS Communication	“How to do consultation on CCS - start as early as possible and listen to the challenges that are being said and identify areas that collaboration can be made. There are opportunities for local businesses. There are opportunities for local community to be involved and economic benefits for community when these things happen, ranging from retaining of jobs in heavy mining sectors to new jobs in the development of I guess the capture facility itself” – Interviewee E	21

	“With folks that have questions is critical, and ensuring that you have a wide range of people who can answer the different types of question. See this is incredibly complicated to talk to the general talk about it is not something that people - generally think of like even how does capture work? Why are we putting CO2 underground” – Interviewee E	22
	“...then you'll have questions about the business, the impact, the, the number of trucks that will going to be on roads when is construction all of those different pieces. So you have to start bringing these conversations up early, listening to challenges and identifying those.” – Interviewee E	23

	“But what has to be kept in mind is this is what I was alluding to with this regional differences is that you cannot expect them to be totally similar across regions. You have to consider that there are differences in the economy, the economical background, the social economic background of two regions, and so also of the residents there.” – Interviewee H	24
Reasoning	“One of the more important issues that may change people's minds is if you say to them, well, ok, if you don't allow this CO2 to be injected underground, then the emitter which is making, uh, steel or concrete or refining oil nearby may have to shut down. That will mean loss of 1000 or two more jobs, a destruction of your tax base. and how are you gonna be able to afford to keep all your schools and hospitals open when your tax base has been so depleted?” – Interviewee C	25
Mineral Rights and Landowners,	"So in Wyoming, we have three types of subsurface ownership. We have federal ownership, which is in our public lands, like those that are managed by the Bureau of	26

and Pore Ownership	Land Management. We have state owned lands that are administered by the state of Wyoming and then we have private on lands which are held by individuals." – Interviewee D	
	"Considering the density of rural population in Ontario relative to other parts of Canada, it would be my perspective that it would be prudent of them if they are wanting to enable CCS projects, Southwestern Ontario, that they would need to essentially, create the opportunity for the Crown to be the purveyor of the pore space... you would have a substantial number of negotiations to go through and it may, may, may or may not, but make the project not viable" – Interviewee E	27
	"So here, what industries [are] calling for is without interfering with the mineral rights, what they want the provincial government to do is to access - to make the pore space which is just full - filled with brine, they want to make that a Crown property. Now offshore beneath Lake Erie, where it is attractive to actually, uh, inject beneath the lake bottom into the same Cambrian Formation offshore - it is Crown land already for onshore." – Interviewee C	28

	"Umm, the first thing that our state had to do was determine whether the pore space was part of the surface estate or part of the mineral estate, and drawing from some of the common law as it developed in Wyoming, the legislature actually passed a law saying that the pore space was owned by the owner of the surface estate and that owner could be federal - it could be state or it could be private." – Interviewee D	29
	"Um, one of the things that's being considered now is where you draw those unit boundaries. Are you drawing them along the entire area of review, where you're going to have, you know, pressure increases in brine displacement or are you drawing it only around your CO2 plume?" – Interviewee D	30

Table 4. List of quotes based on codes and the interviewee. Each quote is numbered to give a quick and easy reference.