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An Integrated Approach to CCS: A Canadian Environmental Superpower Opportunity

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Abstract

The wide-scale public and governmental pressure to reduce the emissions of greenhouse gasses in developed nations has the potential to threaten the future growth and profitability of energy intensive industries. Because of this new paradigm, a group of 20 major oil & gas, power, fertilizer and chemical producers in Canada joined forces in 2005 to form the Integrated CO_2 Network (ICO$_2$N) group of companies. This group recognized that developing CO_2 capture and storage (CCS) within a vision of a long-term, large-scale integrated system would ensure that the technology is developed as quickly and cost-effectively as possible, and would encourage continued economic growth decoupled from increases in greenhouse gas (GHG) emissions.

Decisions about a phased and integrated CCS system requires a long-term focus on Canada's energy and environmental policy objectives (2020 and beyond). This paper outlines the efforts to date by ICO$_2$N to move CCS forward in Canada – through its work on the economics of deploying CCS technology in Canada, what deployment of an integrated CO_2 capture, transportation and storage network can look like and the evaluation of public private partnerships to share in the risks of early CCS adoption. Analysis is presented that quantifies the overall potential of the technology and explores the benefits and costs associated with CCS, including the associated benefits of the development of an EOR industry through the deployment of an integrated CCS system. It also puts forward 5 key elements of deployment that are necessary to enable the widespread deployment of CCS at lowest possible cost.

The ICO$_2$N group of companies includes the following nineteen companies: Suncor, TransAlta, Sherrit, Agrium, Air Products, Shell, Husky, ConocoPhillips, Syncrude, Imperial Oil, Nexen, Canadian Natural Resources Limited, Keyera, EPCOR, Total, Chevron, StatoilHydro, Opti, Devon, and BP.

Keywords: CO_2 capture and sequestration, Canada, infrastructure, CO_2 pipeline, enhanced oil recovery, systems approach, CCS policy

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1. Introduction

Canada has a unique opportunity to be a world leader in the implementation of Carbon Capture and Storage (CCS), and this has been recognized and advocated by an alliance of Canadian companies through the Integrated CO_2 Network (ICO_2N). As a country with strong and expanding energy and resource extraction industries, Canada faces unique challenges relative to other industrialized nations in decoupling increases in greenhouse gas (GHG) emissions from economic growth. Industry, stakeholders and governments recognize this challenge, and for the most part support the accelerated development of CCS. The majority of these groups also agree that CCS is a key technology for addressing GHG emissions [1].

What is ICO_2N?

ICO_2N is an alliance of 20 of Canada's largest industrial companies that have been working together for more than three years to advance the understanding of the policies, economics and technologies of carbon capture and storage. ICO_2N includes the following companies: Suncor, TransAlta, Sherrit, Agrium, Air Products, Shell, Husky, ConocoPhillips, Syncrude, Imperial Oil, Nexen, Canadian Natural Resources Limited, Keyera, EPCOR, Total, Chevron, StatoilHydro, Opti, Devon, and BP. As a group, ICO_2N represents:

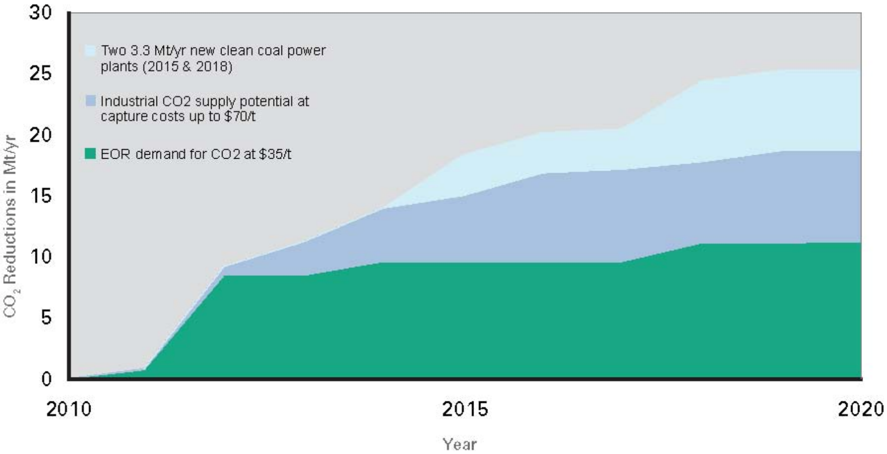
- 100 million metric tons per year of CO_2 emissions
- 60% of Alberta's electricity generation
- 95% of the production from the oil sands.

ICO_2N stands for Integrated CO_2 Network: a proposed system for the capture, transport, distribution and storage of carbon dioxide. It is not an individual project, but rather a comprehensive way forward for implementing CCS in Canada. CCS involves capturing carbon dioxide (CO_2) from large industrial sources before it is emitted into the atmosphere. Once captured, CO_2 can be safely and permanently stored in deep geological formations or injected into mature oil fields to enhance oil recovery (EOR). Together, these are key elements of a long-term integrated vision for a CCS system that capitalizes on Canada's unique opportunities, and ICO_2N has been working with government to remove the regulatory, technical and economic barriers to widespread CCS deployment.

The potential for CCS in Canada

ICO_2N's analyses indicate that through a phased buildup of CCS there is the potential to ultimately reduce CO_2 emissions by more than 20 million metric tons per year over the next decade – the equivalent of annually removing about four million cars off the road. In addition, with the right long-term approach, reductions could grow to more than 50 million metric tons per year, roughly 13% of Canada's current GHG emissions. Figure 1 illustrates a potential deployment curve for CCS in Canada to 2020.

Figure 1 Potential deployment of CCS in Canada [2]



There are many significant challenges associated with CCS. Governments and industry are already actively involved in defining the appropriate public policy frameworks that will be required, the amount of investment to be shared in implementing projects, and the amount of risk each party should assume related to capturing, transporting and sequestering CO_2.

Integrated network approach

ICO_2N has developed an economic model to evaluate the optimal infrastructure deployment for CCS. This model has initially been applied to a network system in the western province of Alberta, which has the highest concentration of large CO_2 emitters in Canada. Alberta is also primarily over the Western Canada Sedimentary Basin (WCSB), which is particularly promising for direct CO_2 storage in saline formation, as well as use of CO_2 in enhanced oil recovery (EOR). The economic model takes into account the capital costs, operating costs, and the timing and construction schedules needed to phase in and develop the pipeline system.

A key conclusion of ICON's work is that it makes sense to plan a large, integrated system from the beginning and build it in phases. This will enable economies and efficiencies of scale and allow the CO_2 to flow to a variety of end uses, including EOR and direct saline formation storage. It is also feasible to design such a system because the CO_2 source locations, the destinations and the projected volumes all are known. This approach would result in the following phases being constructed:

Table 1 **Illustrative phases, timing and CO_2 quantities for integrated pipeline network**

Phase	**Development**	**Major source types**	**Total CO_2 quantities (Mt/yr)**
Phase 1a	Initial capture at major source locations and first stage of oversized pipelines	Power, refining, upgrading, chemicals	5Mt/yr
Phase 1b	Volume ramp up with further connecting pipelines	Incremental contributions from above, plus in-situ extraction from oil-sands	10-15 Mt/yr
Phase 2	Volume ramp up with construction of large volume, manifold pipeline backbone	Additional incremental growth in all sectors, particularly power generation as facilities reach end of life and are replaced	15-25 Mt/yr

Figure 2 Proposed pipeline network for a CCS system in Alberta [2]

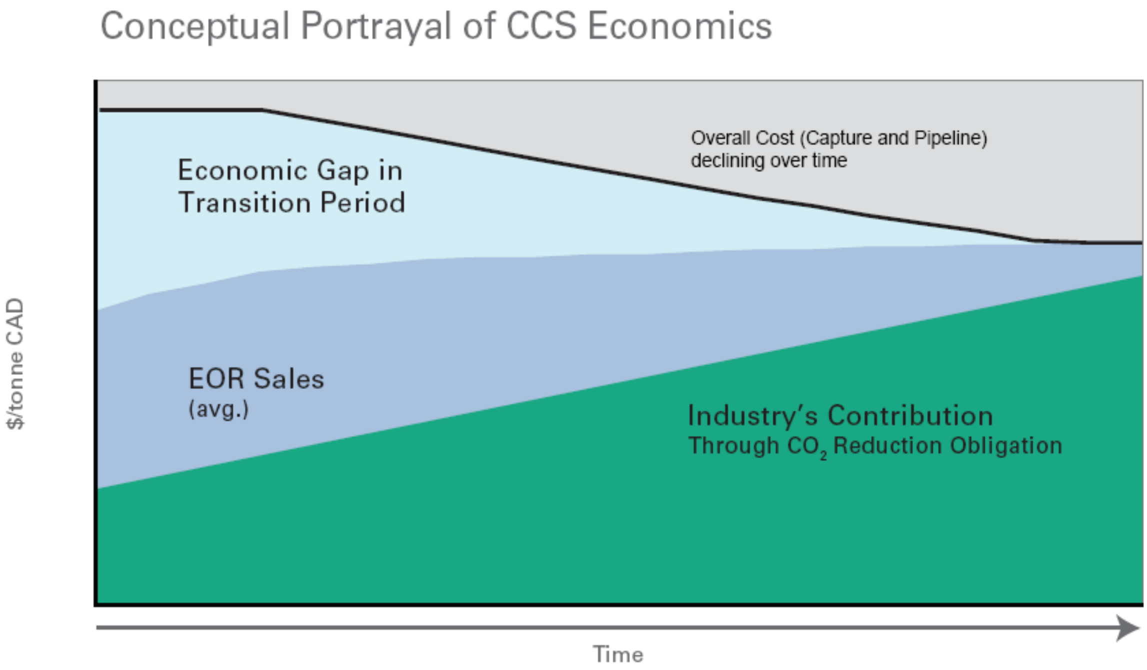
2. Economics of CCS in Canada

The ICO_2Ng roup has done an extensive amount of work in analyzing the challenges and opportunities for CCS from both an investment and a public policy perspective. This analysis has concluded that cl ose cooperation between industry and government is needed in CCS design, funding, and policies to support this transformative environmental initiative. This is particularly true because of the large, initial economic gap that exists for deploying CCS in early years. The main factors are the following:

- The high costs of capital, operating and maintenance for CCS projects
- Carbon constraints and regulations that haven't yet risen to a level that will drive independent CCS investment
- Uncert ainty around greenhouse gas regulations
- Uncertainty on the price and access to CO_2 sales for enhanced oil recovery

The risks and uncertainty will be highest during the initial years of deployment of CCS. In later years, the expectation is that costs will be reduced through learning by doing as CCS projects are developed and operated, and the compliance costs will increase, effectively closing the gap, although it is uncertain at this point when this will happen. Figure 3 provides an illustration of the ga p.

Figure 3 **Financial gap of CCS in Canada [2]**



3. Five elements of deployment

In order to overcome the financial gap and uncertainties, ICO_2N has put forward five key elements of deployment for policymakers and project developers. These five elements are intended to address the uncertainties for project developers around CCS deployment, and to ensure that infrastructure is built with the end in mind – maximizing GHG reductions through CCS while minimizing costs. ICO_2N's five elements of deployment are as follows:

Element 1: A Long-term, systems approach to potential common infrastructure (pipeline and saline aquifer)

It is crucial that CCS infrastructure be built in a manner that fits into a long-term deployment plan and avoid proliferation of duplicate, undersized infrastructure that would ultimately increase the overall per unit cost of CCS, and potentially limit the development of an EOR market. This must be done through a long-term, systems approach to the permitting, financing, construction and access of infrastructure. This means:

- All portions of the pipeline infrastructure that receive government support should operate as a common carrier and be open access.
- Pipeline segments of initial projects should be oversized to the scale of long-term plan. Routing of pipeline segments should be reviewed and, if necessary, adjusted to fit with longer-term routing requirements that are more efficient.
- Toll levelization for pipeline charges should be instituted to ensure early users are not penalized for lower utilization factors, and the costs are spread over the life of the pipeline.
- Phasing of pipeline development based on initial project selection to minimize upfront costs.
- Common, centralized non-EOR storage locations should be encouraged.

Element 2: Developing a robust EOR market that helps to support capture

One of the key factors driving the early deployment of CCS in Alberta is EOR and there is significant public good attached to its development. EOR represents the potential to extract value from oilfields that are currently at the end of their lives. This provides potential for a significant revenue stream for capture companies through the sale of CO_2 to EOR end-use customers. This extra compensation for capture can help to kick-start the initial deployment of CCS and will mitigate the amount of government support required in the early years to help encourage CCS investment.

The difficulty with this opportunity, as ICO_2N's analysis suggests, is that the EOR market may quickly become oversupplied with CO_2 if left to market forces alone. The CO_2 capture to EOR market is not a natural market as CCS will be driven by other factors, namely climate change policy, and the CO_2 is essentially a by-product. Once installed CO_2 capture plants will operate like must run power facilities and will not be able to adjust their production volume to respond to market demand. In a situation of oversupply, which is anticipated if CCS deployment reaches the level projected by Alberta government in the next decade [3] it is expected that the CO_2 price for sale to EOR will fall to the marginal cost of direct saline formation storage. This situation will lead to either a very high net compliance costs for capture companies which will impact their international competitiveness or additional cost to government to help support capture activities and cover a wider cost gap. At the same time EOR companies will potentially enjoy a windfall from CO_2 priced much lower than what the economics of EOR can support.

It is society's best interest for the government to take a proactive role in helping to ensure that a robust EOR market develops and that fair market prices for CO_2 are paid. The role for government could entail active market participation or some form of price management, either fixed or tied to an index. For instance, a price for CO_2 sold to EOR could be tied to a percentage of a crude oil benchmark price, such as West Texas Intermediate (WTI), to ensure EOR projects are still profitable. Further incentives should also be considered to stimulate EOR. A sound policy is likely the single largest opportunity to reduce the financial gap associated with CCS and will ultimately result in more CO_2 reductions for any given level of government contribution.

Element 3: Financial incentives

Even though a fair price paid for CO_2 going to EOR will reduce the financial gap and lessen the need for government support, this does not apply to volumes going to non-EOR direct saline formation storage. It will be necessary to provide further financial support during a transition period when the combination of the value of CO_2 reductions (equivalent to compliance costs or market CO_2 credit value) plus the EOR revenue are less than the total capture costs.

Such incentives could take the form of direct project incentives applied pursuant to an ongoing RFP program, public investment in infrastructure, fiscal incentives such as accelerated capital cost allowance (ACCA) for CCS investments or transferable tax credits or incentives applied on a per tonne reduced basis. The latter could be managed through a form of reverse auction whereby the government stated its annual fiscal incentive and firms bid on the amount of reductions they would generate for a given dollar amount of incentive.

Element 4: GHG regulations alignment

It is important that broad GHG regulations act to encourage investment in CCS rather than hinder it. If there is regulatory misalignment there is the risk that investing in CCS will not be pursued. A regulatory burden that leads to premature mandating of CCS, without corresponding CCS incentives from government, will render some industrial activities uncompetitive, especially for those that compete on the international commodities markets which may not be exposed to similar emission constraints.

GHG reduction regulations should complement CCS policies and provide significant certainty so that business investment decisions can be made. Federal and state/provincial governments should align regulations related to compliance measures. Such alignment is needed in the following areas:

- Offset credit management rights that includes a provision that an offset credit is created for each tonne of CO_2 stored and that they can be readily transferred between parties (for example between EOR and capture companies) as part of ongoing commercial arrangements.
- If, as a compliance option, governments allows industry to pay in to a fund (such as the Technology Fund currently in operation in Alberta), the operation of this fund including magnitude, time frame, allocation of credits and directed use of funds must be done in a way that it is sufficient to support and encourage CCS. Pre-certification for projects under development, where offset credits are generated by the investment in CCS technologies and can be used for future compliance requirements is also important to provide flexibility in the years prior to operational start up.
- Avoid any measure leading to premature CO_2 oversupply to the EOR market, a price collapse and a very high net CCS cost.

Element 5: Other government regulatory alignment (CCS specific / non-compliance related)

Policymakers should develop a broad regulatory regime to manage CCS. In addition to the items discussed above, these should include the following:

- Streamlined approval processes for siting direct storage operations
- Defining ownership and management of direct storage pore space
- Regulatory provisions related to storage including storage criteria and monitoring rules to be followed by operators of storage facilities, and safety provisions, including related stakeholder engagement and communication regarding infrastructure
- Development of a long-term stewardship regime
- Accounting/liability provisions built into the tenure system providing for responsibilities to account for possible CO_2 leakage during the EOR recycling stages and any other leakage for other reasons
- Ultimate transition of storage liability to governments after a reasonable timeframe has demonstrated storage integrity.

4. The path forward

Canada has the opportunity to be an energy and environmental superpower, and CCS is vitally important to the sustainability of Canada's oil, gas and chemicals sectors, and to the continued use of cost effective coal-fired power generation as the world searches for lower carbon energy sources. The country can capitalize on the geology of the western Canadian Sedimentary Basin (WCSB) to effect large scale CCS. The WCSB region provides not only significant amounts of CO_2 emissions as a function of hydrocarbon production and upgrading and coal fueled power generation but also contains reservoirs in relative proximity with vast potential to store CO_2.

It makes environmental and economic sense to develop initial CCS projects within a vision of a long-term, large-scale integrated system. Such a system can be built in phases. Decisions about a phased and integrated CCS system require a long-term focus on Canada's energy and environmental policy objectives (2020 and beyond). The economics of CCS implementation are complex and a robust CCS policy that addresses many of the concerns and potential market failures is needed in order to ensure optimal system design and enable large-scale CCS deployment over the long-term.

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