Subsidies and emissions reduction goals

The failure of CCUS in Canada during the past decade

Supplementary submission to the Standing Committee on Environment and Sustainable Development

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Standing Committee on Environment and Sustainable Development
House of Commons
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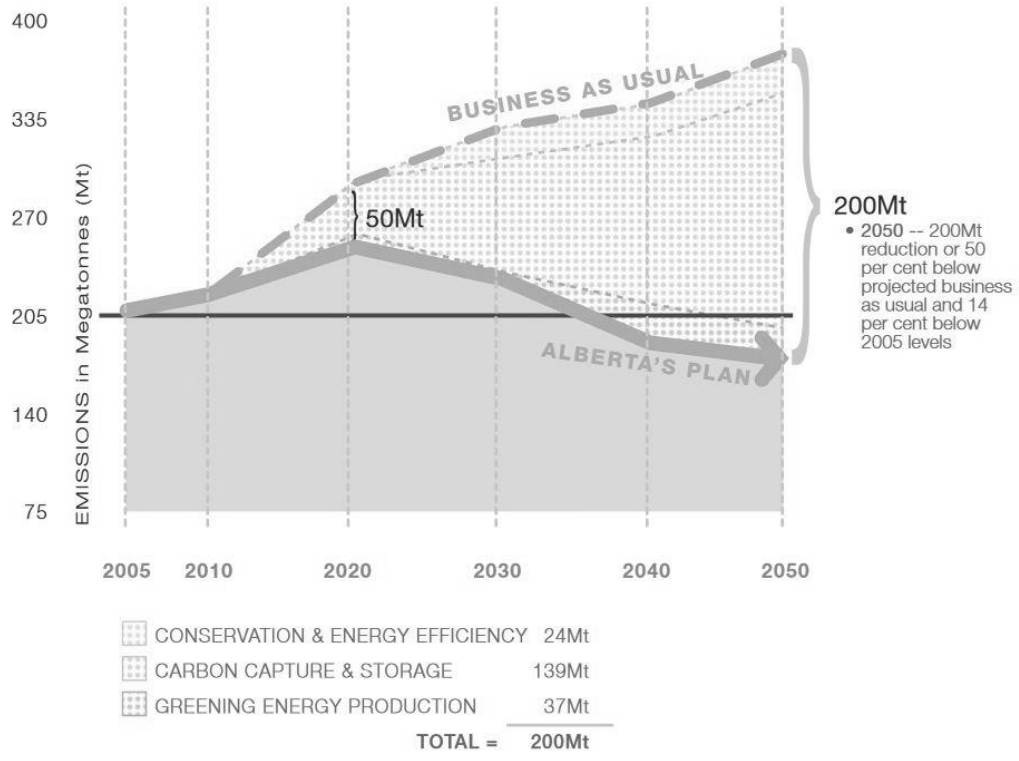
Re: Oil sands sub-sector and CCUS subsidies – supplementary submission

I was asked by a member of the Committee during the proceedings on March 31, 2022, to provide additional information concerning Canada's experience with CCUS during the past decade, and the lessons we can draw from that experience.

1. The failure of Carbon Capture and Storage (CCS) in Alberta: 2008-2014

Figure A below reproduces a graph published in 2008 by the Province of Alberta in a document called *Alberta's 2008 Climate Change Strategy*, when the province launched what it described as the renewal of its climate change policy. At the core of that ambitious new plan was a commitment to deploy CCS technology on a large scale. The premise of the plan was that bitumen production would be able to continue to expand without increasing emissions.

Figure A: Graph representing Alberta's 2008 emissions reduction plan



Source: *Alberta's 2008 Climate Change Strategy*, p.24.

In 2005, Alberta's share of Canada's total emissions was about 31%, reaching 37% by 2014. By 2008, the fast-expanding oil sands industry had already become the largest source of emissions growth in the Canadian economy. The Federal Government held back from exercising any regulating role over the industry's emissions. The matter was left entirely to Alberta.

The dotted top line on the graph (Figure A) represents the pathway of Alberta's "business as usual" emissions: that line depicts the projected level of CO_2 emissions that, according to the Alberta government, would be produced in the province in the absence of any new carbon-reduction policies. In the 2008 plan, Alberta's projected 2050 "business as usual" emissions were 384 Mt: that estimate of the annual emissions level by 2050 was largely driven by the continued expansion of oil sands production up to 2050. The bottom line on the graph shows that under the 2008 plan, total emissions by 2050 were anticipated to be only 194 Mt – an astonishing 200 Mt less than the business-as-usual outcome. Most significantly, the graph shows that by 2050, 139 Mt of that reduction of CO_2 emissions would be achieved by the large-scale implementation of CCS.

At the heart of Alberta's 2008 plan was the ambition to continue rapid oil sands production, with the declared expectation that by 2020 the installation of CCS would avoid any further increase in the absolute level of emissions. The plan promised that CCS would achieve a *30 Mt reduction by 2020*. But that promise only aimed to curb the "upstream emissions" at production sites in Alberta.

2. The background of CCS technology: it is not a new technology

By 2008, when Alberta announced its new climate policy, CCS was already broadly recognized as an advanced technology available to reduce CO_2 emissions at large "fixed-site" operations. It was not a speculative technology.

Long before that, basic CCS technology had been used for many years in the U.S. and elsewhere for enhanced oil recovery (EOR) in semi-depleted oil fields. In that application, CO_2 is injected underground into declining oil fields, where the pressure of the injected CO_2 drives the remaining crude oil through existing wells to the surface. There have been many years of successful commercial experience in separating CO_2 at industrial plants, and long experience in the transfer of the gas by pipeline and its injection into semi-depleted oil fields. The technology used for EOR is virtually identical to what is required for CCS, although it was widely acknowledged that a successful application of CCS to sequestering CO_2 at large fixed-site emitters like power plants would require a huge scaling up of the technology.

In addition, by 2008, several other major commercial applications of CCS had been operating for some years. The oldest of those was the Sleipner Project, a Norwegian undertaking that began operation in 1996. CO_2 is stripped from the natural gas produced at a North Sea offshore gas field and injected into a saline aquifer deep below the seabed. In a second installation, at the In Salah gas field in Algeria, CO_2 was stripped from natural gas and re-injected underground into a sandstone reservoir.

Canada already had some direct experience with CCS. There was an EOR project operated since 2004 by Encana in the Willisdon basin in Alberta. About 3000 to 5000 tonnes of CO_2 per day (1.0 Mt to 2.0 Mt annually) was being injected underground into a semi-depleted oil field. The CO_2 was supplied by pipeline from a coal gasification plant in North Dakota, where CO_2 was separated from the gases generated during an industrial process that makes synthetic gas (methane). There had been a monitoring system at Weyburn to evaluate the potential of CCS technology since 2004.

A comprehensive study of CCS called the *Special Report on Carbon Capture and Storage* was published in 2005 by the IPCC. 100 specialists examined the state of technical knowledge available about the separation of CO_2 in industrial settings. They assessed the stage of development of the three known processes at that time. Two, *post-combustion* separation and *pre-combustion* separation, were described as "mature market" technologies. A third type of process, known as *oxyfuel combustion*, was then described as still being at the "demonstration" stage of development.

The International Energy Agency (IEA) had also long identified CCS as the essential technology that will be relied upon to capture CO_2 emissions from coal-fired electricity generation plants and other large industrial emitters. In its annual *World Energy Outlook* reports, the IEA since at least 2010 had been advocating CCS as the "key abatement option" to achieve large emissions savings at industrial sites. The IEA called for large-scale deployment of CCS by 2020, which it regarded at the time as technically feasible. In a special report published in June 2013, entitled *Redrawing the Energy-Climate Map*, the IEA summarized the current state of CCS technology:

> *"While the technology is available today, projects need to be scaled-up significantly from existing levels in order to demonstrate carbon capture and storage from a typical coal-fired power plant. Experience gained from large demonstration projects will be essential, both to perfecting technical solutions and driving down costs".*
>
> IEA, *Redrawing the Energy Climate Map*, June 2013, p. 25-26

The IEA concluded that two conditions would have to be met before any widespread adoption of CCS could be achieved. Firstly, innovation and demonstration projects would need to lower the per-tonne cost of capturing CO_2. Secondly, governments must adopt a carbon price that is *higher* per tonne than the cost of capturing emissions, to create an economic incentive for industrial emitters to install this relatively expensive technology. That is the essential condition that Alberta failed to meet.

3. The abandonment of CCS in Alberta in 2014

In 2014, the government of Alberta quietly abandoned its entire CCS strategy. By then, seven years had passed since the Alberta plan was unveiled. Four carbon capture projects in Alberta were originally announced. Two were later cancelled. No further government funding has ever been committed to support additional projects.

On July 18, 2014, *The Globe and Mail* published an article headlined "Alberta leadership hopeful Prentice lets carbon capture go". Jim Prentice, a former federal cabinet minister then campaigning to become the new leader of Alberta's governing Conservative Party, was quoted as follows:

> *"I don't believe carbon capture and storage is the panacea," he said. "It's not capable of achieving the reductions in emissions that are required, and it is expensive, and in certain contexts, it's quite unproven."*
>
> — *The Globe and Mail*, July 18, 2014 (emphasis added)

Prentice described CCS as a "science experiment." He declared that if he became premier of Alberta, his government would discontinue any further financial support for CCS. This was an extraordinary and far-reaching change of policy. At the time, Mr. Prentice held no elected office. There had been no prior discussion in the Alberta legislature and there was no explanation from the provincial government. CCS technology was the sole foundation for achieving 70% of Alberta's planned carbon reductions over the next 35 years. In his media interview, Prentice declared that CCS technology was not capable of making the required reductions. In September 2014, Prentice became premier of Alberta. He confirmed that CCS technology no longer had government support in Alberta.

In May 2015, a new NDP majority government took power, under Premier Rachel Notley. During the provincial election the NDP promised to end the government's "costly and ineffective carbon capture experiment" and reinvest the funding in public transit. In Alberta there was no political support for CCS. The new NDP government confirmed that no other government funding was planned to support development of the technology, although it agreed to continue funding the two existing CCS projects.

In that way, Alberta's entire CCS strategy ceased to exist.

Today in the oil sands there are only two existing CCS projects. One is the "Quest Project", located at Shell Canada's Scotford Upgrader near Edmonton. Designed to capture and inject underground 1.2 Mt of CO_2 every year, it became operational in November 2015. That amount represents 35% of the total CO_2 emitted annually from the upgrader's steam methane units, which produce hydrogen for upgrading bitumen. The capital cost was about $1.35 billion, two-thirds of which was paid for by subsidies from Canada and Alberta. The only other CCS project is the Alberta Carbon Trunk Line, a 240-km pipeline that will transport CO_2 from a fertilizer plant and a bitumen refinery located near Edmonton. The pipeline is to transport the CO_2 south to semi-depleted oil fields, where the gas will be injected underground and used for EOR.

In July of 2014, just a week before Mr. Prentice made his announcement, Alberta's Auditor-General issued a scathing report confirming that the province's bold plan to install CCS in the oil sands would not meet any of the goals set for 2020. Although the plan was originally announced in 2008, virtually nothing had been done to carry the scheme into effect, according to the findings of the Auditor-General.[1]

4. The *Technology Prospects* Report (May 18, 2015)

Not long after Alberta confirmed that it was dropping support for CCS, a panel of experts on technological innovation in the oil sands industry completed a major report called *Technological Prospects for Reducing the Environmental Footprint of Canadian Oil Sands* (referred to hereinafter as "*Technological Prospects*").[2] The study, published by the Council of Canadian Academies, May 28, 2015, was originally commissioned by Natural Resources Canada, with the support of Environment Canada. A panel of twelve leading engineers and other experts, most of them from Alberta and experienced in oil sands extraction and processing, were appointed to examine whether technological innovation has the potential to significantly reduce the environmental footprint of oil sands development.

The report reviewed the entire range of carbon reduction technologies currently available or under development, including technologies still at the experimental stage that may become commercially available within the next 15 years. The panel explained the scope of their review:

> *Technologies at an early stage of development (i.e., biologically assisted processes) are noted but not necessarily emphasized due to a lack of information and uncertainty about their potential performance. The technologies reviewed include those deemed by the Panel to be commercial in the near to midterm (about 15 years) as well as those that could become viable over the longer term (beyond 15 years).*
>
> — *Technological Prospects*, Introduction, p.9 (emphasis added)

One section of the report (section 6.2) deals specifically with CCS. It identifies *the high cost of carbon capture technology* as the principal barrier to any large-scale adoption of the technology in the near future. The *Technological Prospects* report concluded that CCS technology would likely have a very limited role in future efforts to reduce emissions in the oil sands. The panel's conclusion was that CCS is too expensive to be adopted during the next ten to fifteen years in the oil sands. Due to the huge capital investment needed for a single CCS installation, the technology is most promising for very large industrial sites (e.g., coal-fired electrical generating plants) that generate high volumes of concentrated CO_2 at a single location. The report explained that, in the oil sands, the most likely future use of CCS will be in applications that capture emissions from hydrogen production in upgraders – a specialized high-emitting industrial activity connected to processing bitumen at open-pit mining operations. But upgraders are a relatively small part of the oil sands emissions problem in Alberta.

In comparison, the fastest expanding area of bitumen production – and therefore the fastest growing source of emissions – is in situ (underground extraction) operations, which are smaller in scale. The panel was not optimistic about the prospect that CCS can ever become an affordable technology at these smaller-scale in situ sites, because they do not offer the needed high volume of emissions to justify the cost:

> *More expensive would be the capture of CO_2 from in situ projects because these represent smaller and geographically dispersed sources of emissions.*
>
> — *Technological Prospects*, p. 130 (emphasis added)

Even after the expensive technology is installed, operating expenses are substantial. The "capture" stage, which involves compressing huge volumes of separated CO_2 gas, is a highly energy-intensive process; that process consumes a lot of natural gas, which adds to costs (and ironically also adds to carbon emissions at the site). The panel identified another difficulty that may impede efforts in the future to adopt CCS technology:

> *… retrofitting an existing facility to capture CO_2 is generally more expensive per tonne of CO_2 sequestered than designing a new one to include CCS from the start ... This is important in a fast-growing industry such as the oil sands where the rapid pace of development may "lock in" existing capital equipment and processes.*
>
> — *Technological Prospects*, p. 128 (emphasis added)

The failure of Alberta's 2008 plan based on CCS technology was a matter of enormous consequence. CSS was assumed to be the means of achieving 70% of Alberta's entire carbon reduction objective up to 2050. It was the technological solution that was going to allow bitumen production to continue to expand after 2020, while *simultaneously achieving absolute reductions* in the amount of CO_2 emissions released during the extraction process in Alberta. But again, it is important to keep in mind that even Alberta's ambitious plan would have done nothing to reduce the massive ongoing growth of the "downstream emissions" from our exported oil. That was never discussed.

5. Carbon pricing in the oil sands

One of the impediments to rapid technological innovation, according to the *Technological Prospects* report, was in part the relatively low price and abundant supply of natural gas in Alberta:

> *As for resource inputs, natural gas, one of the most important inputs in oil sands operations, is widely used to generate steam, electricity, and hydrogen (in upgrading). Low gas prices, however, discourage investments in, for example, solvent-assisted in situ recovery, use of alternative sources of power like hydro, and improvements in energy efficiency, all of which would reduce GHG emissions.*
>
> — *Technological Prospects*, Executive Summary, p. xxi (emphasis added

The panel observed that because natural gas was cheap, there was no big incentive for oil sands producers to search out alternate methods of extracting bitumen – that is, methods that do not depend on burning natural gas to generate steam – because the alternate methods are more expensive.

The *Technological Prospects* report also acknowledged that Alberta's Specified Gas Emitters Regulation (the SGE regulation) had not created enough of an economic incentive to make a difference:

> *While Alberta's Specified Gas Emitters Regulation does impose a carbon compliance price on large emitters (as one option should they not meet annual CO_2 emission intensity reduction targets of up to 12%), it is only a modest economic incentive for firms to invest in new technologies that reduce GHG emissions, amounting to only a few cents per barrel.*
>
> — *Technological Prospects*, Executive Summary, p. xxi (emphasis added)

The *Specified Gas Emitters Regulation* (SGER) came into force in Alberta in July 2007. The policy rationale was that a monetary penalty on CO_2 emitted above a defined limit per barrel would give oil sands operators an *economic incentive* to invest in technological innovations to reduce emissions intensity. The SGER was based on a nominal carbon price of $15 per tonne. New plants were entitled to a complete exemption for their initial three years of operation. After that, within the next six years, they were required to show a 12% reduction of emissions per barrel (the "performance standard"), measured against what they achieved in their own third year of operation.

Under the SGER scheme, however, achieving the specified emissions reductions was not mandatory. In lieu of attaining the prescribed reductions, a producer had the option to simply make the required penalty payment to a government-administered fund. The weakness of the SGER was due to the low amount of the non-compliance payment. The carbon price was levied *only on the share of emissions that exceeded the performance standard*. The other 88% of the emissions at a production facility were emitted free of charge. The actual cost to a producer who failed to meet the standard worked out to about 20 cents per barrel.

Minor changes to this scheme were announced on June 25, 2015. The required emissions reduction per barrel (the "performance standard") was slightly raised. The carbon price per tonne was to be raised effective January 2017. The cost for non-compliance would still be only about 60 cents per barrel. In its key elements, the SGER remained unchanged for ten years.

On August 14, 2015, the province's new Environment Minister announced the appointment of a five-member Climate Change Advisory Panel, which was chaired by University of Alberta economist Andrew Leach. Simultaneously, the government issued what it called the *Climate Leadership Discussion Document*.[3]

The *Discussion Document* contains a surprisingly candid summary of the dilemmas facing the newly elected Alberta government: the steady rise of emissions in the oil sands; the collapse of Alberta CCS strategy; the Federal Government's promise (announced by the Harper Government on May 30, 2015) to achieve a 30% absolute reduction of Canada's total emissions by 2030; the fact that Alberta contributes 37% of Canada's total emissions. The paper contained a blunt critique of the existing SGER

approach. Addressing the scheme's "intensity-based tools", the *Discussion Document* comments:

> *The current requirements ask these large industries to reduce their emissions intensity by 12% below a historical baseline. This means that each facility can continue to emit most of its emissions (88% per of its emissions intensity).*
>
> — *Discussion Document*, p. 10 (emphasis added)

It acknowledged that the average carbon price under the existing scheme in Alberta was $1.80 per tonne of CO_2:

> *In Alberta, the average price for carbon for a regulated facility is the total cost of policy per total unit of emissions. A facility that has had constant emissions and production since the baseline will have an average cost of up $1.80/ tonne (12% of emissions at $15). This will increase to $6.00 by 2017 (20% at $30).*
>
> — *Discussion Document*, p. 17

The Alberta government released a new Climate Leadership Plan on November 20, 2015. A 90-page report, entitled *Climate Leadership: Report to Minister*,[4] was produced by the Advisory Panel chaired by economist Andrew Leach. The November 20, 2015 report candidly discussed the failure of *Alberta's 2008 Climate Change Strategy*. It concluded that the 2008 plan's ambitious target that oil sands emissions would begin to decline by 2020 was never supported by sufficiently stringent carbon prices and regulations to achieve the promised results:

> *… these targets were based on a computer model under the assumption that Alberta's policies would include "… a strict regulation that all large, new industrial facilities are required to incorporate carbon capture and storage by 2015 wherever possible". The latter of those assumptions, a requirement to adopt carbon capture and storage in industrial facilities, was supposed to have led to the lion's share of reductions posited in the target by 2050 but neither these regulations nor the modeled carbon price were imposed.*
>
> — *Climate Leadership*, November 20, 2015, p. 25 (emphasis added)

The deep emissions reductions promised by Alberta's 2008 plan were premised on the assumption that the government would impose a significant carbon price and enact a mandatory regulation requiring oil sands producers to *incorporate carbon capture and storage by 2015*. But that was never done. Alberta's Auditor General had warned in an October 2008 report that the necessary regulation had not been put in place.

6. Coal-fired electricity in the developed economies: CCS abandoned

In the U.S., the Kemper plant in Mississippi was supposed to have been the first CCS-equipped coal-fired electricity generating ("clean coal") plant in the country. In June

2017, after enormous delays, technical problems, and some $7.5 billion in costs, it was announced the plant would instead use natural gas: see *Bloomberg*, Jim Polson, June 21, 2017, "First-of-Its-Kind Clean Coal Plant May Not Burn Coal at All". Funding for a second U.S. "clean coal" project (FutureGen in Illinois) was also suspended. The problem was the monumental costs of building coal plants equipped with CCS, combined with the rapidly falling costs of renewable energy options – onshore wind power and solar photovoltaics.[5]

A report published by the IEA in June 2013, *Redrawing the Energy-Climate Map – World Energy Outlook Special Report*, included a discussion of CCS at page 77-82. It examined proposed emissions-reduction policies under the IEA's 450 Scenario, aimed to keep global warming below the 2°C. The IEA warned in 2013 that if CCS was not widely deployed by 2020, faster reductions in fossil fuel use will have to occur in the transportation sector to meet overall CO_2 reduction targets. Delays in deploying CCS will therefore accelerate the need to curb global oil consumption:

> *For oil producers, the effect of delaying CCS would be indirect: in order to keep cumulative CO_2 emissions the same in the absence of CCS, the transport sector would need to compensate by reducing emissions further through widespread deployment of electric vehicles.*
>
> — IEA, p.80 (emphasis added)

The future role for CCS technology was dramatically downgraded in the IEA's subsequent annual *World Energy Outlook 2017*, report published in November 2017. In 2011, the IEA had projected that CCS would by 2035 account for 22% of all needed global emissions reductions, while the shift to renewable energy would provide only 21% of the needed cuts. In the 2017 report, CCS is expected to account for only 9% of emissions cuts by 2040, while renewables account for 36%. The expectation twelve years ago was that massive adoption of CCS would delay the need to shut down coal-fired facilities, allowing more time for a transition to renewable sources. But the continued high cost of CCS and the rapid fall of renewable energy prices changed the outlook.

In his 2010 book, *Ten Technologies to Save the Planet*, Chris Goodall provided a succinct and plain language review of CCS technology in the chapter titled "Capturing Carbon". Goodall believed at that time that worldwide commercial installation was unlikely till about 2028. Goodall, an economist, in his later 2016 book, *The Switch*, questioned whether CCS had any large future role in coal-fired electricity in developed economies. He focused on how the cost of solar power was by then falling much faster than anticipated, and in many places in the world was approaching parity with the cost of electricity produced at existing coal plants. Goodall foresaw the implication that, as solar power becomes even cheaper over the next decade, producing electricity from coal plants equipped with expensive CCS will not prove competitive: "Is CCS really the answer?" *Carbon Commentary*, August 24, 2016. Goodall examined the high cost of the electricity produced at the Boundary Dam plant in Saskatchewan, which started up in 2014. It was the first operating CCS-equipped coal-fired power plant in the world.[6]

7. Failure

After six years of silence about CCUS in Canada, the Canada's Energy Regulator (CER) in its annual report *Canada's Energy Future 2020* published November 24, 2020, suddenly began to promote the benefits of CCUS technology as a climate solution. But it offered only a brief and generic discussion.[7]

Yet neither the Federal Government, nor the CER nor Environment Canada have produced any detailed analysis or data providing costs and projecting the timelines and magnitude of promised reductions in oil sands emissions by 2030, or by 2050, using CCUS. Since November 2020 all we have had is promotional online material published by group of Canada's six largest oil sands producers (in their *Pathways to Net-Zero initiative*, July 2021) claiming oil sands producers by 2050 will cut their annual emissions by 68 Mt, of which they say 36 Mt will be "captured" by CCUS and newspaper reports based on interviews with prominent oil sands industry executives saying they need $75 billion to make this work. Their promise is that this ambitious plan will allow Canada's oil sands producers to maintain high levels of oil sands production for another 30 years.[8]

CCUS is a prohibitively expensive technology. It has never yet, anywhere in the world, proven to be economically viable for large-scale, industry-wide installation. It would add massive additional costs to Alberta's already high cost per barrel operations.

One fundamental reason for the failure of CCUS in Alberta and in other jurisdictions is that governments have been consistently *unwilling to impose sufficiently stringent carbon prices on producers* to create any economic incentive for producers themselves to install the costly technology.

That situation persists in Canada, given the output-based pricing scheme under Part 2 of the Federal *Greenhouse Gas Pollution Pricing Act*. The performance standard for heavy oil bitumen is 54.4 Kg CO_2 per barrel, which means producers pay a carbon price only on the relatively small portion of their emissions per barrel that exceed that standard.[9] A producer operating, for example, at the industry average of about 68 Kg CO_2 per barrel is obliged to pay the carbon price on only 13.6 Kg CO_2, on $1/5^{th}$ of its actual emissions. The rest it gets to emit "for free". Other oil sand facilities operating at the slightly lower performance standard (set just 20% below the industry average) pay no carbon price at all. Where is the economic incentive for producers to install costly CCUS? Instead, the oil sands industry proposes that the costs of CCUS be paid by massive public subsidies.

But even if all this envisioned technological and financial re-structuring of the oil sands industry over the next 30 years based on CCUS has any air of reality, the tragedy is that if we follow this fantastical vision by 2050 Canada will still be producing 4.8 million bpd of oil – about 2% less than in 2019. We will still be exporting a full 85% of the total life-cycle emissions from our continued high levels of oil sands production.[10]

David Gooderham

NOTES

1. *Report of the Auditor General of Alberta*, July 2014, "Environment and Sustainable Resource Development – Climate Change Follow-up", at pp. 39 – 47: https://www.oag.ab.ca/wp-content/uploads/2020/05/2014_-_Report_of_the_Auditor_General_of_Alberta_-_July_2014.pdf

2. *Technological Prospects* report: http://www.scribd.com/doc/266900630/Technological-Prospects-for-Reducing-the-Environmental-Footprint-of-Canadian-Oil-Sands#scribd

3. *Alberta Climate Leadership Discussion Document*, August 14, 2015: https://open.alberta.ca/dataset/4c418f2d-684d-4a3f-bd82-ea1f9b7ccef0/resource/29fa9635-83f6-4c3c-841c-180b3ca69bdd/download/climate-leadership-discussion-document.pdf

4. *Alberta Climate Leadership Plan: Report to Minister*, November 20, 2015: https://open.alberta.ca/dataset/212a6266-b8d3-4822-b208-9221da2a0966/resource/9f52cd8e-5477-45a6-a337-f2d64d091cf9/download/2015-climate-leadership-report-to-minister.pdf

5. *Forbes*, May 3, 2017, Jeffery Rissman and Robbie Orvis of Energy Innovation, "Carbon Capture and Storage: An Expensive Option For Reducing U.S. CO_2 Emissions": https://www.forbes.com/sites/energyinnovation/2017/05/03/carbon-capture-and-storage-an-expensive-option-for-reducing-u-s-co2-emissions/2/#329fb46215d5 ; Bloomberg, June 21, 2017: https://www.bloomberg.com/news/articles/2017-06-21/a-first-of-its-kind-clean-coal-plant-may-end-up-burning-no-coal

6. Chris Goodall, August 24, 2016: https://www.carboncommentary.com/blog/2016/8/24/is-ccs-really-the-answer?rq=%20carbon%20capture%20and%20storage

7. Canada's Energy Future 2020, November 24, 2020 (CER): https://www.cer-rec.gc.ca/en/data-analysis/canada-energy-future/2020/canada-energy-futures-2020.pdf

8. "The Pathways Vision", promising a 22 Mt reduction of oil sands emissions by 2030 and a total 68 Mt reduction of production-related emissions by 2050: https://www.oilsandspathways.ca ; *The Globe and Mail*, March 7, 2021, "Alberta seeks billions in federal funding for carbon capture projects": https://www.theglobeandmail.com/business/article-alberta-seeks-billions-in-federal-funding-for-carbon-capture-projects/ ; *Financial Times*, January 6, 2022, Canada defends oil sands despite emissions cuts: interview with Minister of Natural Resources Jonathan Wilkinson: "… Wilkinson also indicated that the federal government could help pay for a vast new project proposed by oil sands producers to capture greenhouse gas emissions in Alberta …" https://www.ft.com/content/7e2688b8-86bb-4bf3-a285-6f1f3bbc4547

9. *Output-based Pricing System Regulations*: https://laws-lois.justice.gc.ca/PDF/SOR-2019-266.pdf published July 10, 2019, see Schedule 1 at page 77-78

10. *Canada's Energy Future 2021*, CER, December 9, 2021: https://www.cer-rec.gc.ca/en/data-analysis/canada-energy-future/2021/canada-energy-futures-2021.pdf