

The Effect of Carbon Pricing in Alberta in terms of Deployability of Small Modular Reactor

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1. Introduction

Alberta's oil sands plants are currently and mostly dependent on natural gas to meet requirements of the steam and electricity in Alberta, Canada. However, it emits huge amount of greenhouse gas (GHG) which shall be significantly reduced to obey the *Oil Sands Emissions Limit Act* and the *Greenhouse Gas Pollution Pricing Act*. It was reported [1] that small modular reactors (SMRs) could potentially play a role in providing competitively-priced, environmentally-acceptable, and dependable/ reliable heat, power, and hydrogen for oil sands operations in order to meet the goals of the above two Acts. In the present study, the carbon policy in Canada will be briefly investigated and then the effect of carbon pricing upon increase of the levelized cost of electricity (LCOE) will be examined. Finally, the possibility of deployment of SMRs in Alberta will be discussed.

2. Carbon Policy in Canada

In this section, carbon policies in Canada including capping oil sands emissions and the price on carbon pollution are dealt with.

2.1 Carbon Emission in Canada

According to Energy fact book 2022-2023 [2], GHG emissions from oil and gas production in Canada have gone up 15% between 2000 and 2020, largely from increased oil sands production, particularly in situ extraction in Alberta. During this period, oil sands production emissions more than tripled while conventional oil and natural gas emissions decreased by 26% as shown in Figure 1.

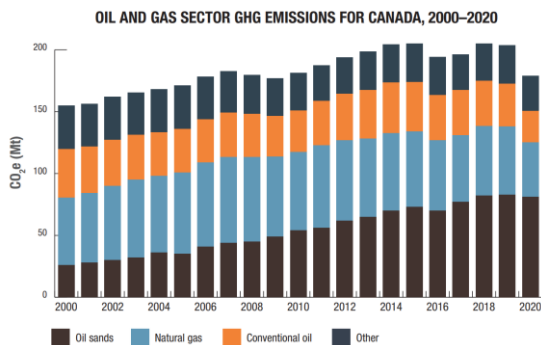


Fig. 1. Oil and gas sector GHG emissions for Canada, 2000-2020 [2].

2.2 Climate Leadership Plan

Alberta's Climate Leadership Plan was introduced in 2015 to reduce carbon emissions and diversify the economy. It is founded on four key pillars:

- (1) Capping oil sands emissions at 100 megatonnes per year,
- (2) Putting a price on greenhouse gas emissions,
- (3) Ending pollution from coal-fired electricity and developing more renewable energy, and
- (4) Reducing methane emissions from industry by 45 per cent by 2025.

2.3 Oil Sands Emissions Limit Act

The Act establishes a 100 megatonne limit for greenhouse gas emissions from all oil sands sites, excluding emissions attributable to new upgraders or increased capacity at existing upgraders up to a combined maximum of 10 megatonnes and emissions attributable to the electric energy portion of cogeneration. The Act also provides authority to make regulations to implement the limit.

As shown in Figure 2, the oil sands emission of Alberta is around 80 megatonnes since 2018 [3].

Table A12-10 GHG Emissions for Alberta by Canadian Economic Sector, Selected Years								
	1990	2005	2015	2016	2017	2018	2019	2020
	Mt CO ₂ e							
GHG TOTAL	165.6	237.1	284.3	268.2	275.8	276.5	278.8	256.5
Oil and Gas	62.0	105.3	141.6	134.0	138.1	146.6	146.8	132.8
Upstream Oil and Gas	58.4	100.7	136.6	128.9	132.8	141.3	141.4	128.0
Natural Gas Production and Processing	23.9	50.5	45.7	42.3	39.5	42.0	41.7	32.8
Conventional Oil Production	15.5	13.8	16.7	14.6	13.8	14.6	13.8	11.2
Conventional Light Oil Production	9.8	11.1	12.6	11.1	10.5	11.0	10.5	8.5
Conventional Heavy Oil Production	5.7	2.7	4.2	3.4	3.3	3.6	3.3	2.7
Frontier Oil Production	-	-	-	-	-	-	-	-
Oil Sands (Mining, In-situ, Upgrading)	15.1	32.4	70.7	67.7	74.8	79.7	80.5	78.8
Mining and Extraction	2.2	5.6	11.1	11.3	12.9	14.8	15.4	14.9
In-situ	4.5	12.2	38.1	37.8	41.5	43.6	42.9	41.2
Upgrading	8.4	14.6	21.4	18.7	20.4	21.2	22.2	22.6
Oil, Natural Gas and CO ₂ Transmission	3.9	3.9	3.4	4.3	4.6	5.1	5.4	5.2
Downstream Oil and Gas	3.6	4.7	5.0	5.2	5.3	5.3	5.4	4.9
Petroleum Refining	3.2	4.4	4.8	5.0	5.1	5.1	5.2	4.7
Natural Gas Distribution	0.4	0.3	0.2	0.2	0.2	0.2	0.2	0.2

Fig. 2. GHG Emissions for Alberta by Canadian Economic Sector [3].

2.4 The price on carbon pollution

Since 2019, the Canada Government has ensured it is no longer free to pollute by establishing a national minimum price on carbon pollution starting at C\$20 per tonne in 2019, increasing at C\$10 per tonne per year to C\$50 in 2022. In order to accelerate the market adoption of the technologies and practices needed to reduce emissions and to build a prosperous low carbon economy, Canada proposed in a Healthy Environment and a Healthy Economy [4] to increase the price on carbon pollution annually at a rate of C\$15 per tonne

per year from 2023-2030. Table I summarizes the price on carbon pollution from 2018 to 2030.

Table I: The price on carbon pollution

Year	Carbon Pricing (C\$/tCO ₂)	Rate
2018	10	▲ 10 C\$/tCO ₂ /yr
2019	20	
2020	30	
2021	40	
2022	50	▲ 15 C\$/tCO ₂ /yr
2023	65	
2024	80	
2025	95	
2026	110	
2027	125	
2028	140	
2029	155	
2030	170	

2.5 Greenhouse Gas Pollution Pricing Act (GGPPA)

The GGPPA came into effect on June 21, 2018. It establishes the framework for the federal carbon pollution pricing system. The aim of the legislation is to put a price on all greenhouse gases that play a significant role in trapping heat in the atmosphere through binding minimum national standards on the federal government and all of the provinces and territories of Canada.

3. The Effect of Carbon Pricing

3.1 Carbon Intensity

According to IAEA [5], GHG emissions from electricity generation technologies are summarized in Table II.

Table II: GHG emissions from various technologies

(Unit: gCO₂/kWh)

	Min	Max	Median
Nuclear	5.1	6.4	5.75
Wind onshore	7.8	16	11.9
Wind offshore	12	23	17.5
Solar PV	8	83	45.5
Solar CSP	27	122	74.5
Hydropower	6	147	76.5
Natural gas with CCS	92	220	156
Coal with CCS	147	469	308
Natural gas	403	513	458
Coal	751	1095	923

For Alberta, the following data are referred [3]:

Table III: CO₂ Intensity for Alberta [3]

Year	2019	2020
CO ₂ Intensity (g CO ₂ /kWh)	630	590

3.2 Calculation of LCOE Increase due to Carbon Pricing

The effect of carbon pricing upon the increase of LCOE is summarized in Figure 3. As Shown in the figure, when the carbon pricing 170 C\$/tCO₂ applies, the LCOE increase of Alberta industries will be 7.4 cent/kWh, while that of natural gas and coal will be 5.8 cent/kWh and 11.8 cent/kWh, respectively.

These values are large compared to the original LCOE without carbon pricing. Therefore, there is a room for deployment of SMR in Alberta to replace the old natural gas facilities in the near future. In this regards, further study is required.

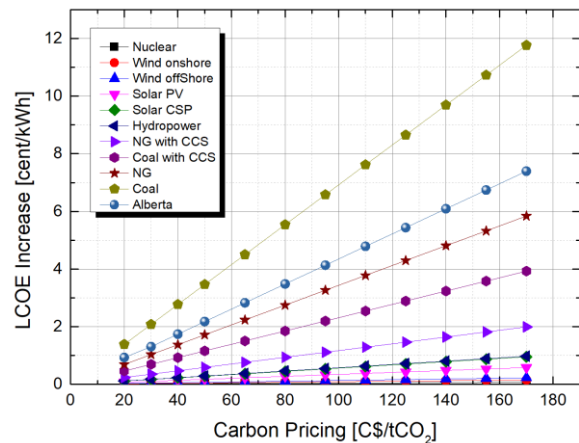


Fig. 3. The Effect of Carbon Pricing upon the Increase of LCOE

4. Conclusions

In the present study, carbon policies in Canada including capping oil sands emissions and the price on carbon pollution were investigated. Also, the effect of carbon pricing upon the increase of LCOE was reported. The results showed that they were large compared to the original LCOE without carbon pricing. Therefore, there is a potential for deployment of SMR in Alberta to replace the old natural gas facilities in the near future. In this regards, further study is required.

ABBREVIATION

CCS	carbon capture and storage
CSP	concentrated solar power
GGPPA	greenhouse gas pollution pricing act
GHG	greenhouse gas

LCOE levelized cost of electricity
PV photovoltaic
SMR small modular reactor

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