Molten Carbonate Fuel Cells for SAGD

Transitioning Alberta's Oil Sands and Electricity Grid for a Low Carbon Energy Future

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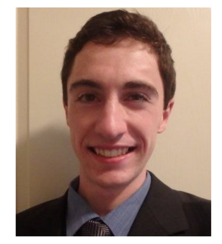
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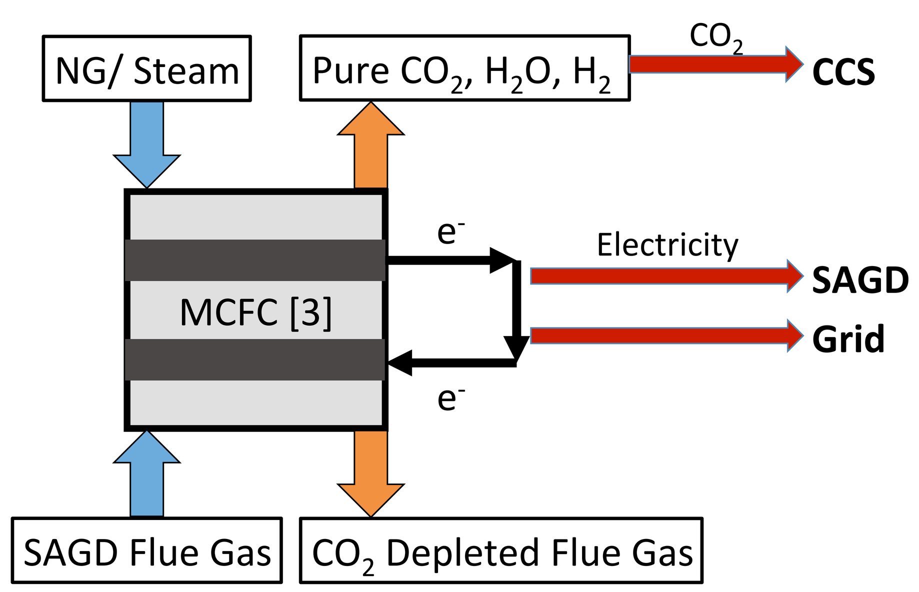
INTRODUCTION

Greenhouse gas (GHG) emissions from Steam Assisted Gravity Drainage (SAGD) of over 24 Mt CO2e/yr (76 kg CO_2e/bbl) have undermined public support for both oil sands development and market access. The resulting adverse economic impacts are driving the need for technologies to greatly reduce the CO_2 footprint associated with oil sands recovery.

Molten carbonate fuel cells (MCFC) have been proposed [1,2] for integration into SAGD facilities where they could:

- Capture 90% of the CO2 emissions associated with SAGD steam generation (OTSG)
- Provide a low GHG source of electricity for SAGD
- Supply surplus low GHG power to the coal dominated Alberta electrical grid

This study will explore the system level potential of the MCFC technology.



METHODS

Assumptions:

- Low growth oil sands model
- MCFC capture of 90% CO_2 from flue gas (higher possible) [2]
- Alternative scenario includes CO_2 compression needs [2]

Parameter	Value
Reference Facility Output	33,000 (bbl/day) [2]
SAGD Steam Oil Ratio	3 (bbl H_2O/bbl)
MCFC Size	76 MW [2]
Coal Emission Factor	1020 (kg CO_2e/MWh)
NG-SC Emission Factor	500 (kg CO_2e/MWh)
NG-CC Emission Factor	380 (kg CO_2e/MWh)
SAGD Emission Factor	76.3 (kg CO_2e/bbl bitumen)

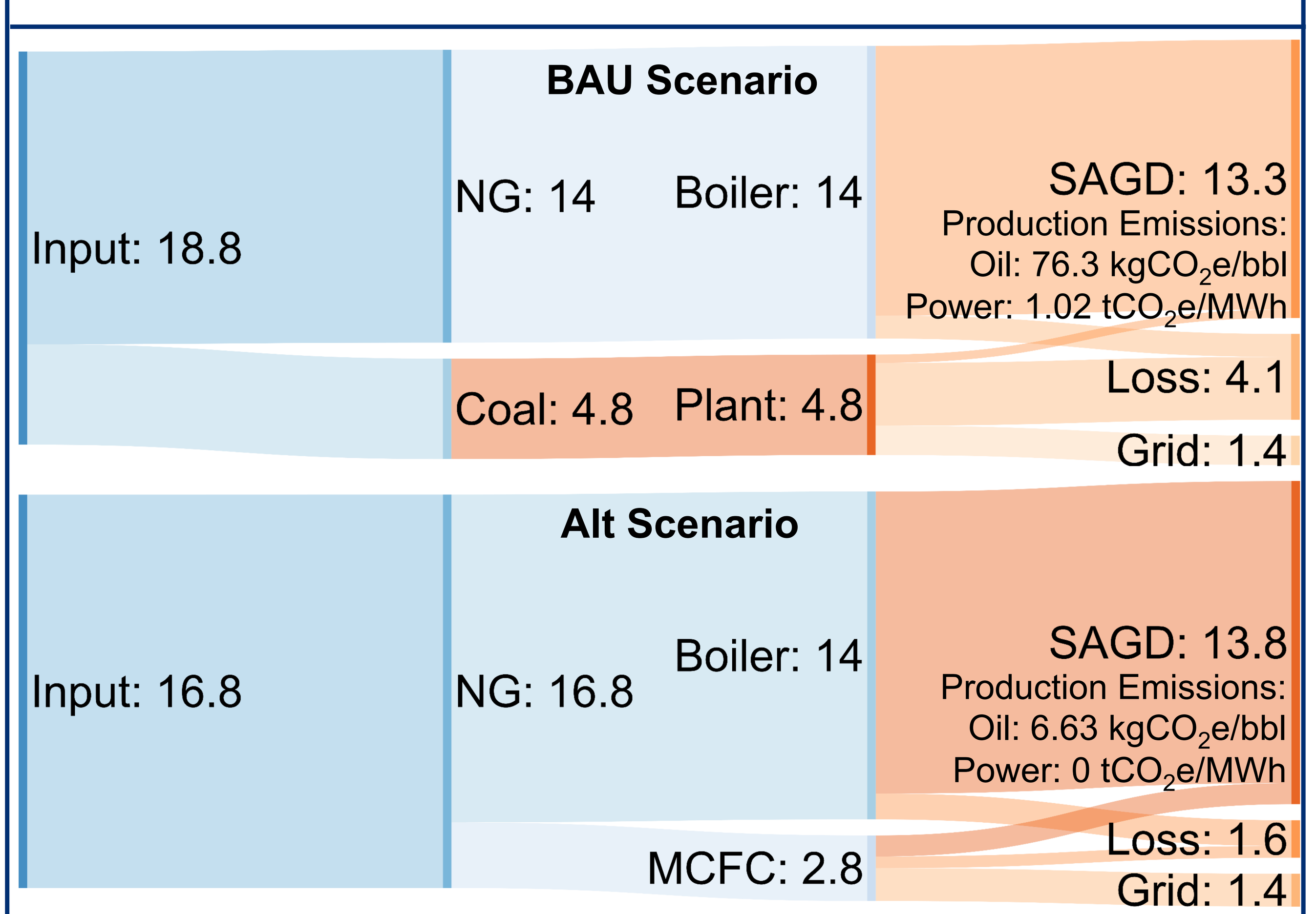


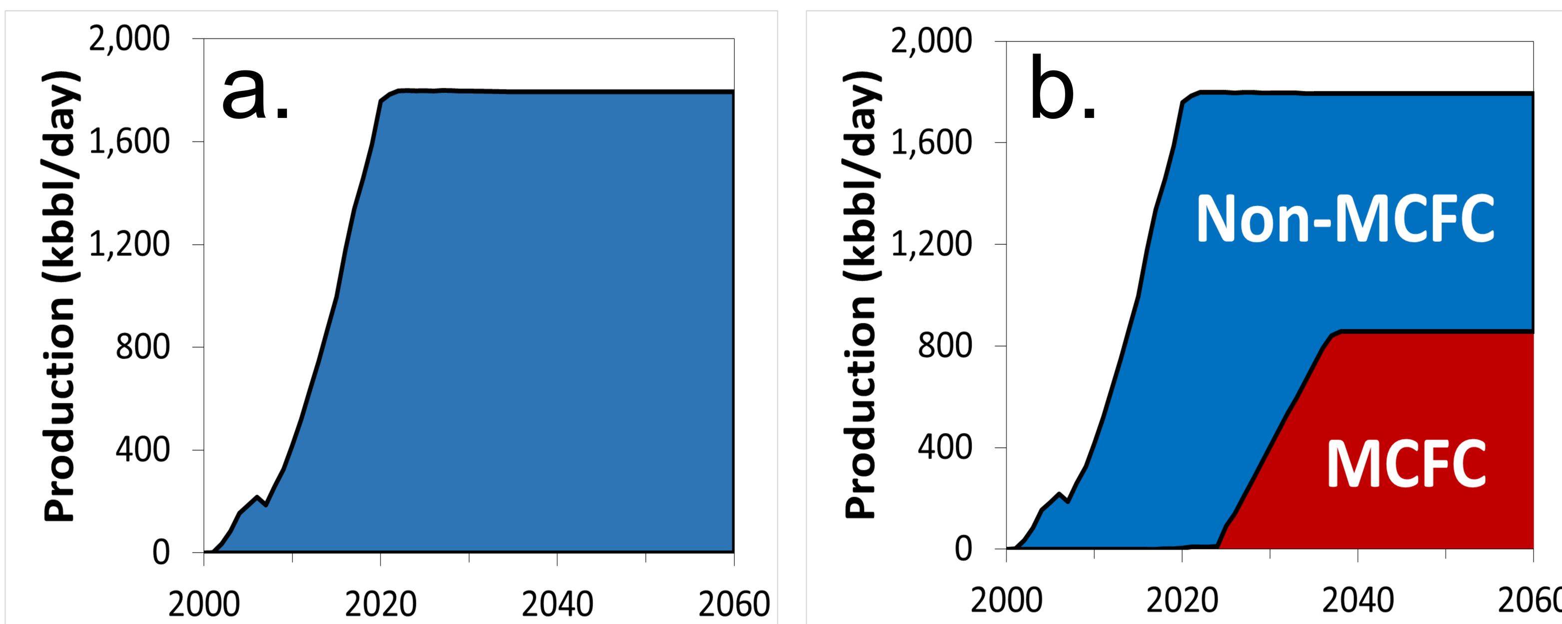
Fig 2. Energy Comparison for BAU vs. Alt Scenario, Single 33,000 bbl/day Facility, in PJ/yr

RESULTS

Business-as-Usual | **MCFC + SAGD**

Fig 3. SAGD Crude Production

SAGD Production (kbbl/day annually): MCFC-integrated facility production shown in red

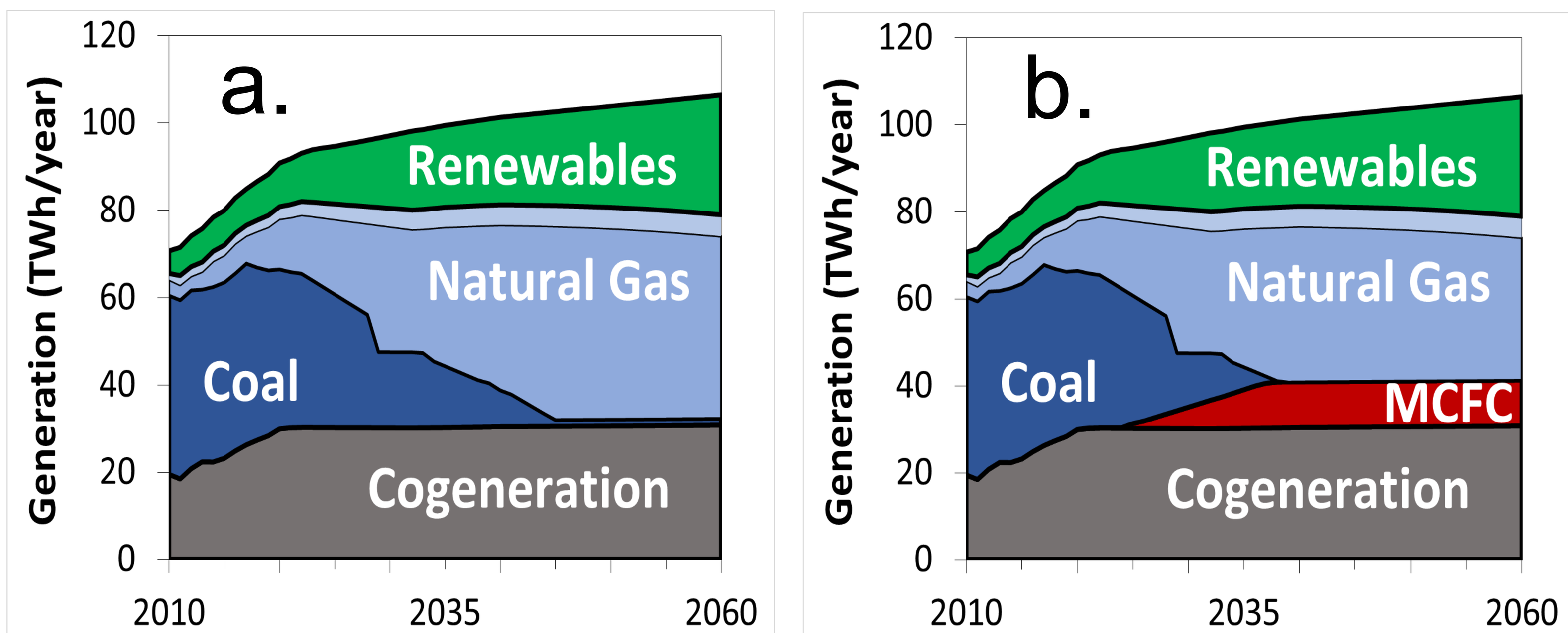


NOTE:

- MCFCs installed on 27 facilities by 2037

Fig 4. Alberta Electricity Demand

Demand generation broken down by fuel type for both scenarios

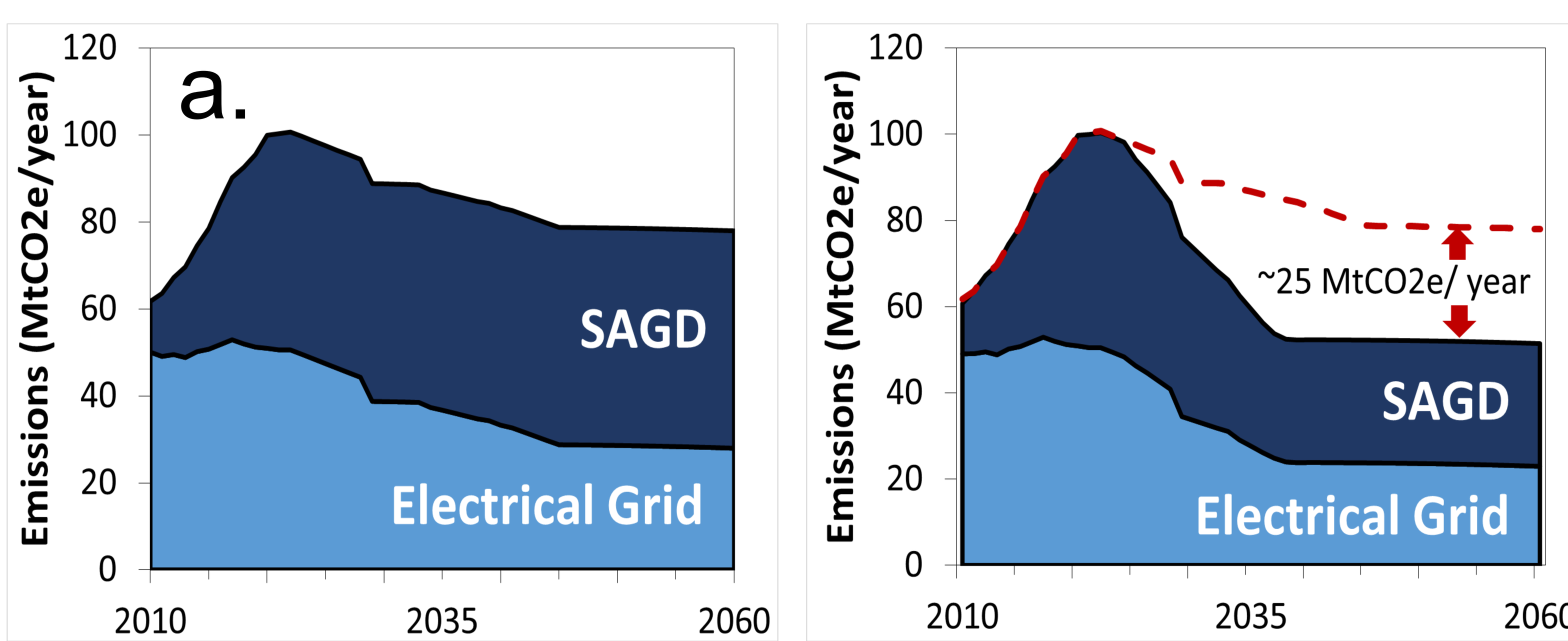


NOTE:

- MCFC Excess Power displaces coal power

Fig 5. Total Emissions Reductions

GHG Savings based on SAGD Carbon-capture with MCFCs as well as MCFC-derived electrical generation

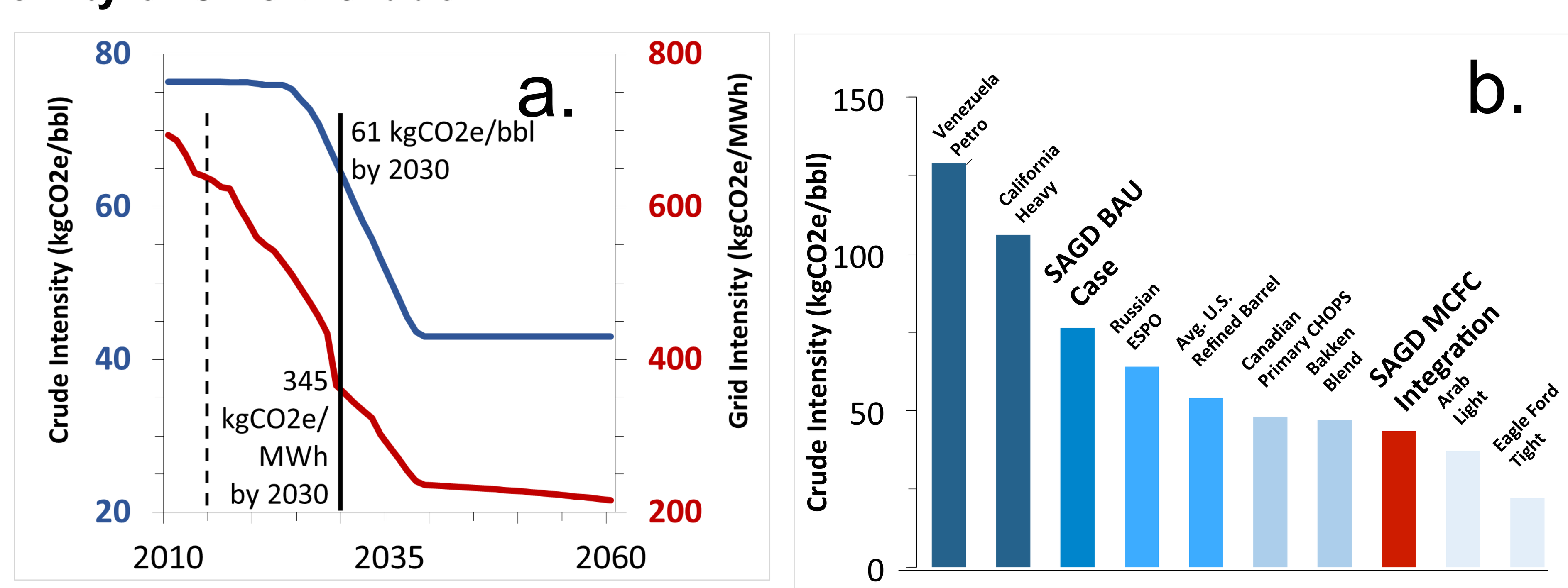


NOTE:

- Emissions decline due to SAGD CCS and coal power replacement

Fig 6. CO2 Emissivity of SAGD Crude

Emissions decline over time due to SAGD CCS and coal power replacement by net MCFC power generation.



DISCUSSION

This study investigates the emission reductions and costs associated with the integration of MCFC across the SAGD industry using scenario modelling [5, 6, 7, 8, 9, 10].

MCFCs could be retrofitted to process the OTSG flue gas from 27 SAGD standard facilities by 2037, accounting for up to 891,000 bbl/day of production. Subsequent net power generated by SAGD MCFCs would be exported to the grid to offset demand met by coal-fired power plants and combined-cycle natural gas plants, accounting for ~20 TWh/year of demand. Overall SAGD and grid emissions would be reduced by ~25 Mt CO2e/year. The resulting would be among the lowest emissivity crude in North America.

A carbon tax of $15-20/tCO2e by 2030 will account for the total costs of MCFCs and additional financial risk associated with their deployment and operation.

Limitations of study:

- Low oil sands growth model – No new facilities.
- Technology adoption and cost reductions predicted by FCE Inc. – Sole North American MCFC Manufacturer
- All SAGD facilities modelled as 'COSIA Standard'

CONCLUSIONS

Integrating MCFCs into SAGD facilities has the potential to cut SAGD and electrical grid emissions while promoting early coal-fired power plant retirement in Alberta. Following the deployment model given will reduce emissions by **865** Mt CO_2e to 2060.

This study recommends:

- Proactive **investment** in MCFC technology to set up pilot plant trials
- **Fast-tracking** of approvals and regulation process surrounding MCFC to bolster deployment
- Implementation of **carbon accounting system** allowing transfer of emissions between oil sands and electrical grid for ultra-low emissivity bitumen production

These will allow the full potential of MCFC integration in SAGD to be reached.

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