Cement Plant Carbon Capture and Electricity Production

Reducing Cement Plant Emission Using Molten Carbonate Fuel Cells

UNIVERSITY OF CALGARY


Cooper Husband
Civil Engineering


Qi (Jeff) Jiang
Mechanical Engineering


Changyu (Chad) Jung
Natural Science


Kyle Lemna
Mechanical Engineering


Kaitlyn Wong
Civil Engineering

CESAR CANADIAN ENERGY SYSTEMS ANALYSIS RESEARCH

Correspondence: cwhusban@ucalgary.ca

INTRODUCTION

Cement-making processes produce high emissions at low economic value relative to other industrial processes in Alberta(AB). In 2016, the AB cement industry will produce approximately 1.7Mt of cement which will result in 1.7Mt of CO_2 emissions[6].

Molten-Carbonate Fuel Cells (MCFCs) have been proposed to be implemented into cement plants (See Fig. 1) because they can capture a significant amount of CO_2 and can also produce electricity. This project will affect the emissions produced by the AB industrial and electricity production sectors.

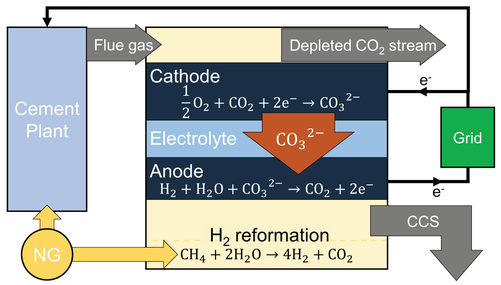


Fig. 1. *MCFC cell schematic with chemical reactions and placement in cement plant [6]*

METHODS

Assumptions:

- 90% carbon capture verified with Spinelli[1]
- Forecasted cement demand with StatsCan[2] data and tuned to match the 2016 NIR Report[3]. (See Fig. 2)
- Exshaw plant[4] characteristics are similar to the second cement plant in Alberta
- An Organic Rankine Cycle (ORC) was evaluated to capitalize the waste heat produced from the MCFC
- CO_2 exiting the MCFCs is captured and sent to either storage or enhanced oil recovery
- An economic analysis was conducted to determine the implementation year for Alternative Scenario #2.

Table 1 below shows the main differences between the reference and alternative scenarios. Figures 5 and 7 are based on the results of Alternative Scenario #2.

Reference Scenario	Alternative Scenarios
Zero carbon capture	~90% Carbon Capture of cement flue gas
~10MW electricity imported to plant	Zero electricity import Net export to the grid
No MCFCs	#1: MCFC Capacity[5] matches cement production #2: Implementation based on economic analysis #3: Total MCFC Capacity installed in first year

Table 1. Comparison of reference and alternative scenarios

RESULTS

Fig. 2

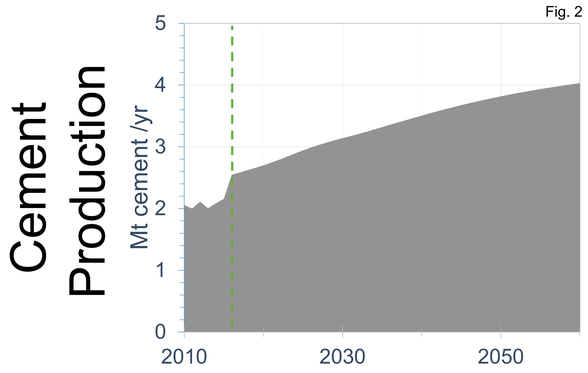
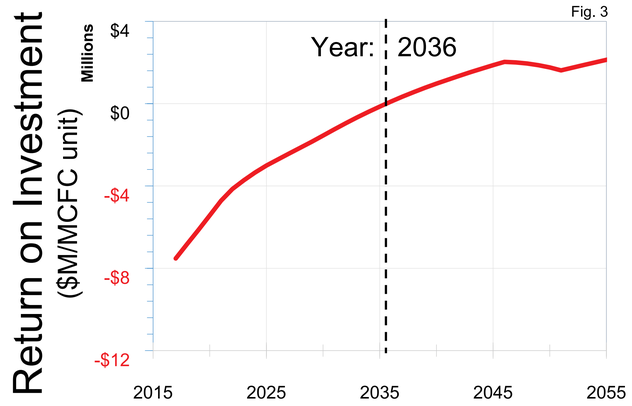


Fig. 3

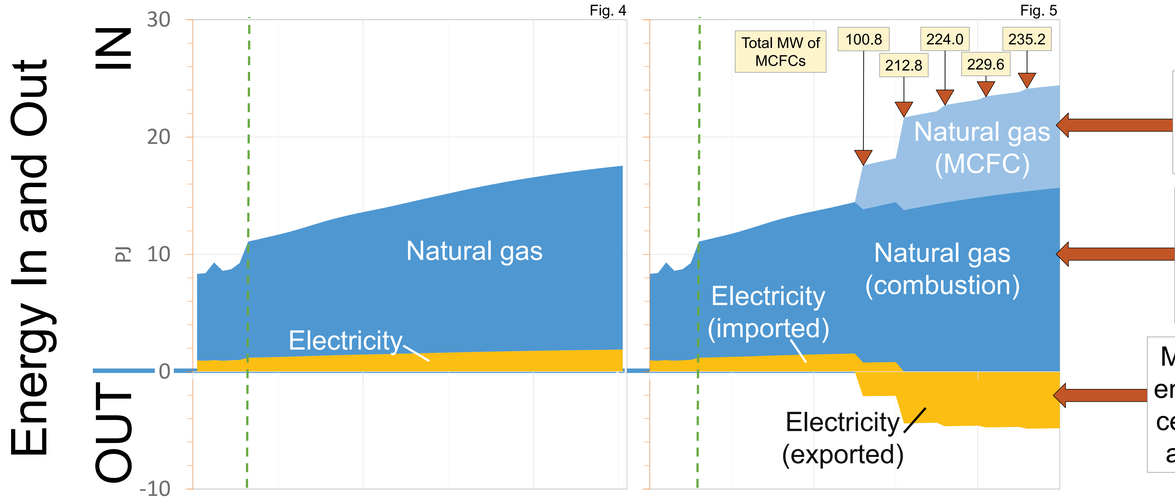


Reference Scenario

MCFC Scenario

Fig. 4

Fig. 5



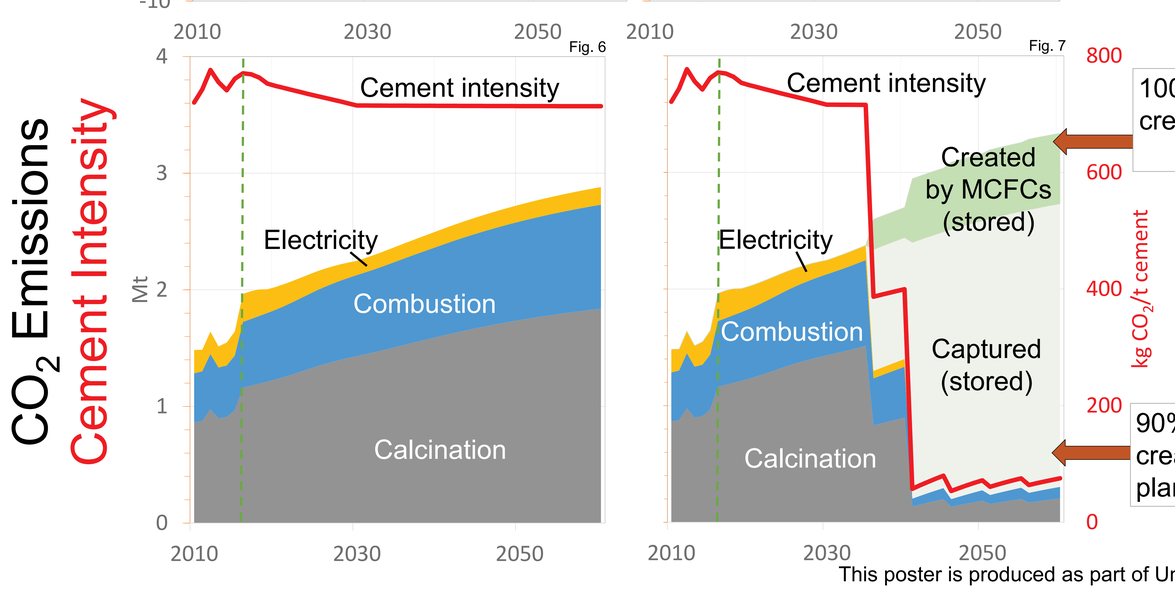
MCFCs require natural gas for operation

We assumed the natural gas contains 100% methane

MCFCs produce enough power for cement plant use and exportation

Fig. 6

Fig. 7



100% of emissions created by MCFCs are captured

Cement intensity drops abruptly as a result of installing MCFCs

90% of emissions created by cement plant are captured

DISCUSSION

Calcination of limestone and fuel combustion are key reactions in the cement-making process.

- ❖ Not possible to reduce CO_2 emissions without compromising production.

The implementation of MCFCs will result in a net export of "emissions-free" electricity to the grid.

- ❖ Create a precedent for new policies on low-emission cement and promote the use of MCFCs.

The ORC was found to produce minimal benefits in terms of electricity production relative to the MCFC. Return on investment for the MCFC was calculated to be 5 years.

CONCLUSIONS

Molten-Carbonate Fuel Cells generate a considerable amount of power and can significantly reduce CO_2 emissions depending on the installed capacity.

In this project, MCFCs reduce up to 2.43MtCO_2 by 2060, generate enough power to run the plant, and export green electricity to the grid. In comparison, the addition of an ORC to the retrofit was not deemed economically viable.

From an economics standpoint, 2020 is too early for MCFCs to be implemented. The analysis suggests that after 2036, MCFCs will likely become a more feasible carbon capture solution. New policies for the production of low-emissions cement will also aid with increasing the rate at which this technology can be adopted into common practice.

REFERENCES

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