Carbon Black to the Future?

Can natural gas dissociation provide a clean fuel for SAGD and a high value by-product?

UNIVERSITY OF CALGARY


Miles Alger
Chemical Engineering


Paul Dang
Natural Science


Nauman Sultan
Civil Engineering


Berkley Downey
Chemical Engineering


Nathan Thompson
Chemical Engineering

CESAR CANADIAN ENERGY SYSTEMS ANALYSIS RESEARCH

Correspondence: mralger@ucalgary.ca

INTRODUCTION

Alberta has vast reserves of natural gas (NG) that are used throughout our energy systems, including Steam Assisted Gravity Drainage (SAGD) for oil sands recovery. SAGD is projected to emit ~50 Mt of CO_2e/yr by 2020 [1]. Natural Gas Decarbonisation (NGD) via microwave plasma technologies were investigated in this study as a strategy to reduce the carbon footprint of SAGD bitumen recovery. These technologies produce H_2, a CO_2-free fuel source, and $C_{(s)}$, carbon black (CB) a potentially high value by-product. The processes by Atlantic Hydrogen (AHI) and Monolith Materials were considered [2,3].

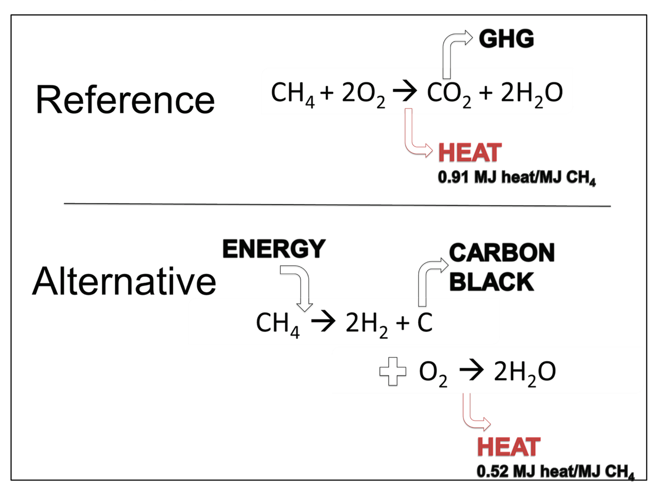


Fig. 1. BAU heat generation process, vs. methane decarbonization.

METHODS

Business as usual (BAU) and alternative scenarios (AS) were modelled for SAGD energy use and emissions in Alberta.

BAU assumed "low oil sands growth" derived from the CanESS model [1]. SAGD energy and emissions retrieved from a standardized 33 kbpd facility from COSIA [4].

The AS scaled a NGD to provide H_2 for a 33 Mbpd operation. Yields, inputs, economics and deployment were modelled off available industry data and process literature [2-6]. The scenario assumed 50% adoption by 2060.

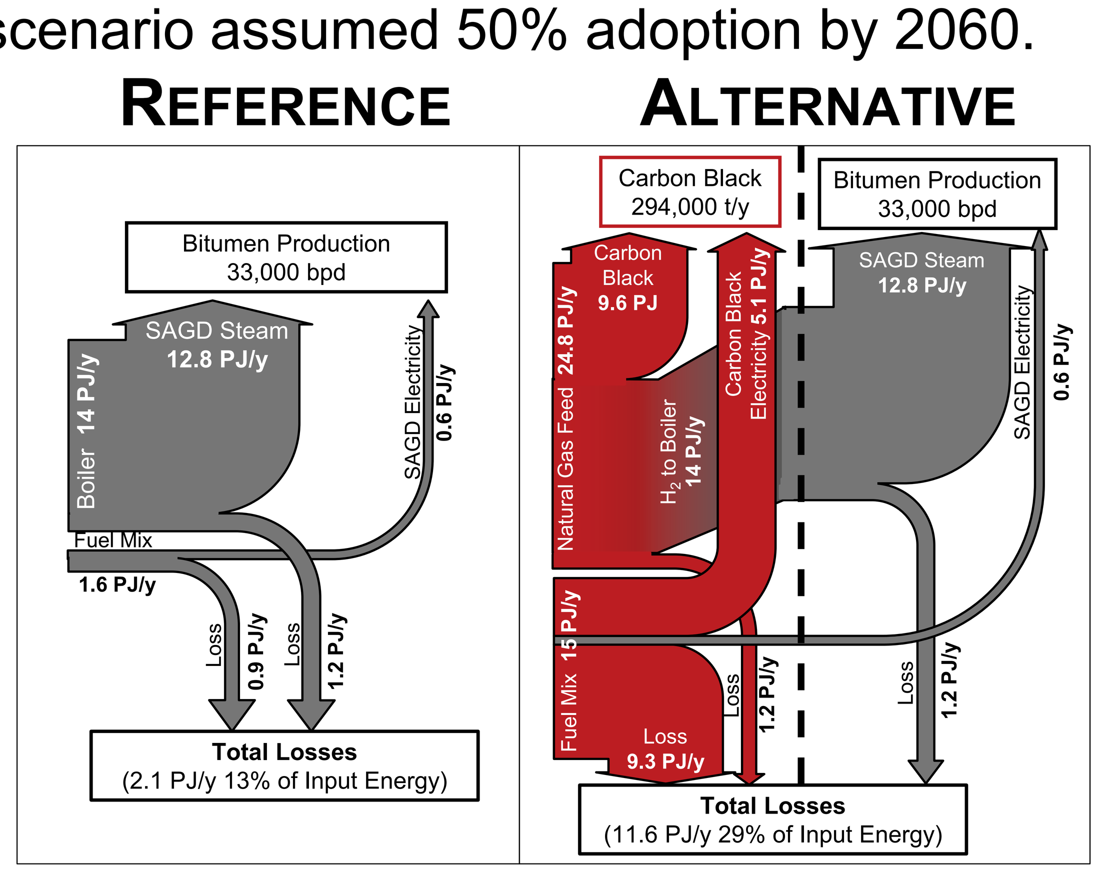
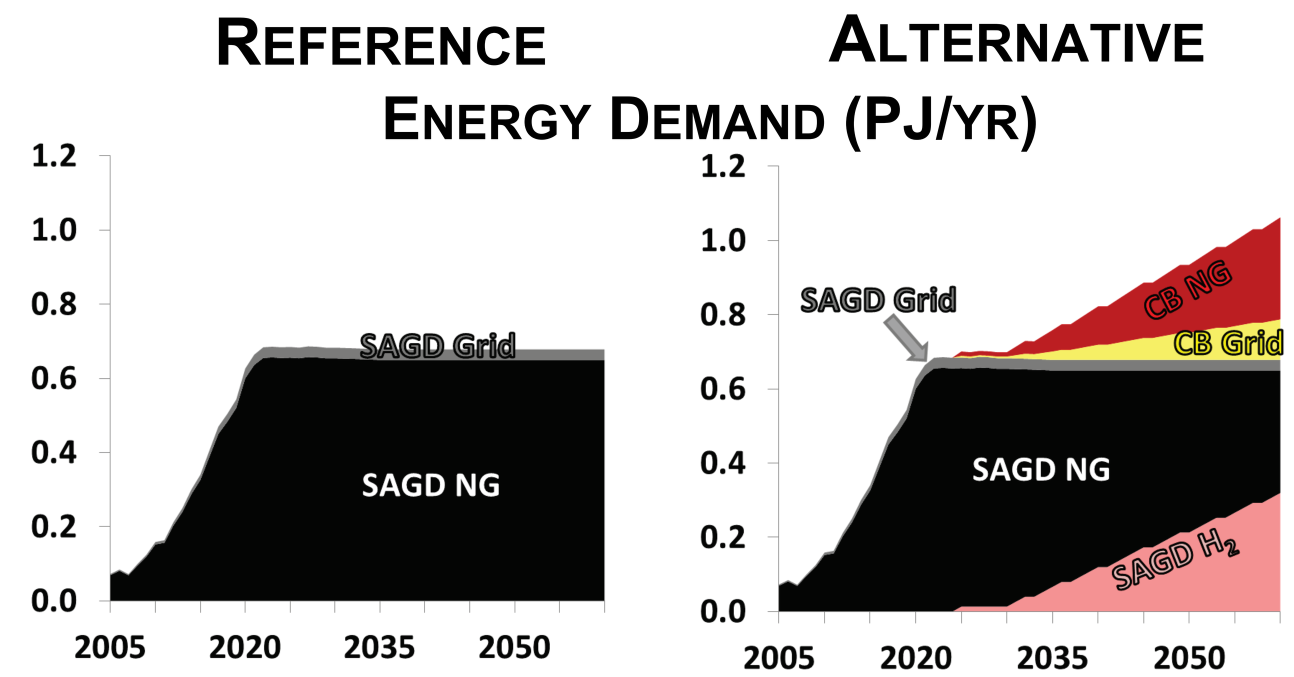


Fig. 2. Energy flow the BAU and Alternative scenario SAGD plant.

RESULTS AND DISCUSSION

A. Energy Demand Comparison

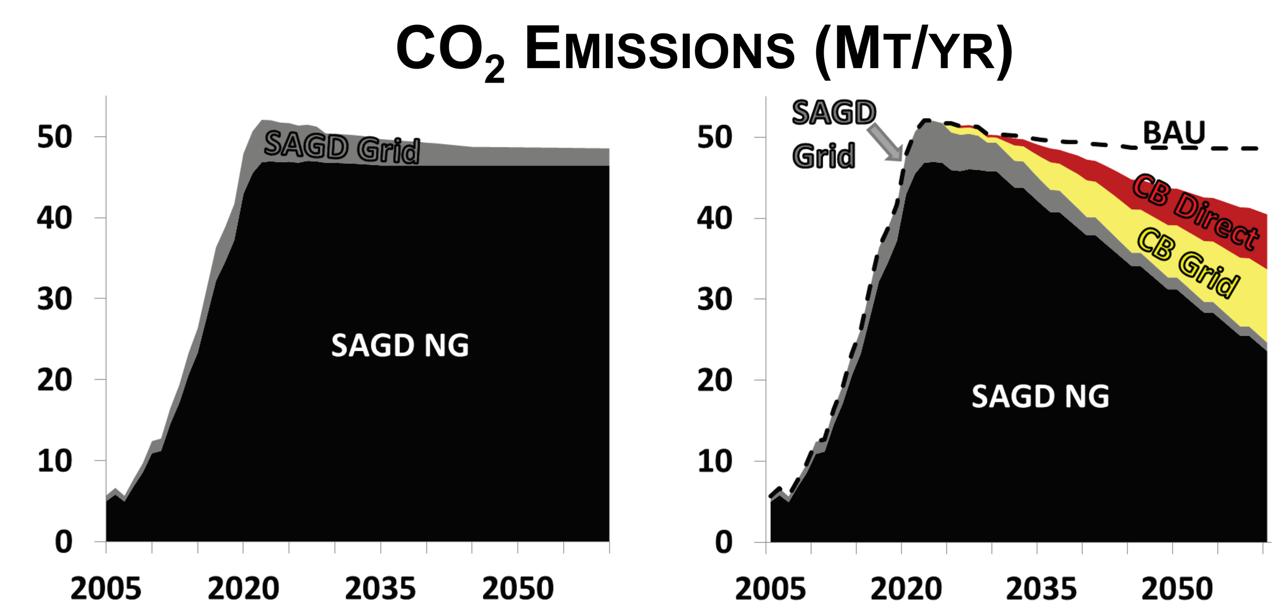
BAU SAGD energy demand compared with energy demands to run SAGD while producing Carbon Black and Hydrogen. Demonstrates total energy demand in EJ/yr.



- NGD integration would require an increased ~0.4EJ/yr
- Increase is equivalent to the yearly usage of 1.3 million people

B. CO2 Emission Comparison

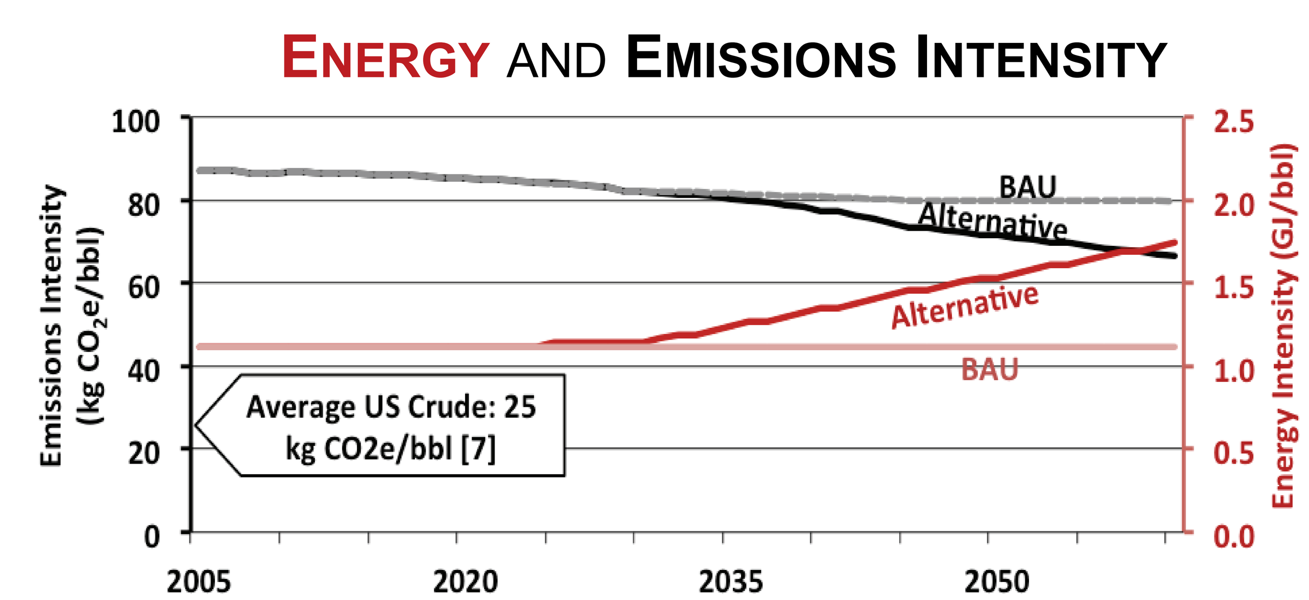
Decarbonization will reduce SAGD emissions. However the CB process emissions will limit this reduction.



- Potential for reduction of ~8 Mt/yr from BAU
- A more efficient decarbonisation technology would further lower emissions

C. CO2 Emission Intensity

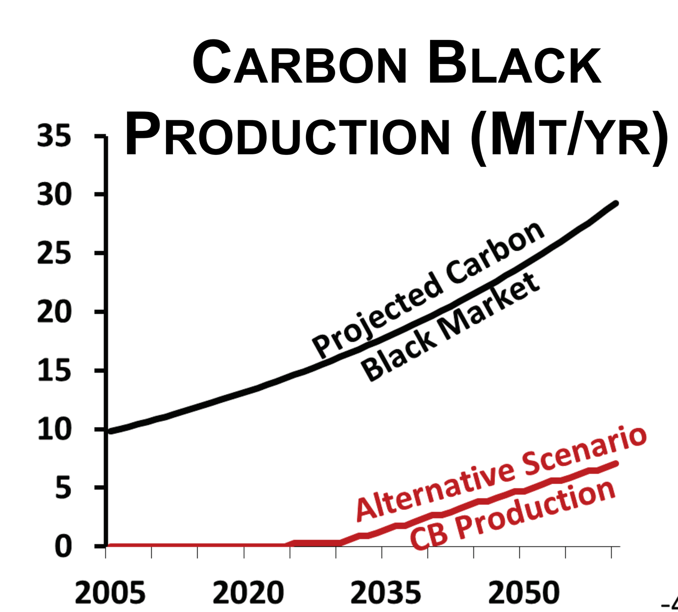
The emissions per barrel of bitumen can be greatly reduced by implementing NGD.

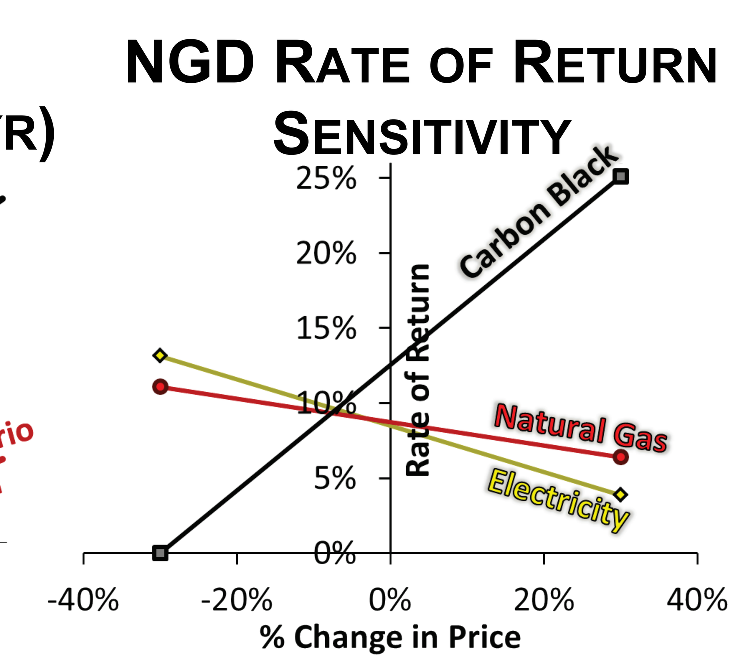


- Average Oil Sands per barrel emissions will decrease by 25%
- This decrease is still far from reaching average conventional crude emissions

D. Carbon Black Market and Economics

The market is expected to increase in the future. However economics of NGD highly sensitive to CB price.





- With 50% of SAGD creating Carbon Black, approximately ¼ of the future CB market demand would be met.

E. Other Carbon Black Markets

Carbon can be converted into other useful forms such as Graphene.

Present Carbon Black markets and Applications [8,9]	Future Carbon Black Markets and Applications [8,9]
Tires	Production of Graphene, Buckminsterfullerenes, Carbon nanotubes
Synthetic Rubber and Plastics	High Carbon Steel Production
Electrostatic Discharge (ESD) Compounds	Carbon Black in Material, Chemical and Electric Industry
High Performance Coatings	Carbon based Electric Transmission Sources, Batteries and Capacitors

- New CB markets like carbon fiber or graphene will be necessary to utilize increased CB production

CONCLUSIONS

NGD is a potentially viable pathway to significantly reduce CO_2 emissions of SAGD in Alberta. This study *indicated a 8 Mt/y reduction in CO_2 emissions for microwave plasma based NGD by 2060*. That said, the high electrical demand of this technology is a significant barrier to its adoption.

Research into the following areas should be considered:

- *Less energy intense solutions* such as those being investigated by Drs. Nduagu and Gates at the University of Calgary [10,11].
- *Developing new CB products* to expand the currently mature market
- *Evaluating the potential for large scale energy storage* by converting CB into graphene super capacitors

ACKNOWLEDGEMENTS

We would like to thank our technical advisors Experience Nduagu and David Foord (AHI) as well as Dr. Bastiaan Straatman and Dr. David Layzell for directional guidance. We would also like to thank whatIf? Technologies for access and use of the data from their CanESS energy systems model.

REFERENCES

[1] whatIf Technologies Inc., "Canada Energy Systems Simulator (CanESS)," 2014. [Online]. Available: www.caness.ca.

[2] B. Gaudernack and S. Lynum, "Hydrogen from natural gas without release of CO2 to the atmosphere," *Int. J. Hydrogen Energy*, vol. 23, no. 12, pp. 1087–1093, 1998.

[3] Boxer Industries, "Request to Approve Project for Sales and Use Tax Exclusion (STE)," Redwood City, 2013

[4] COSIA, "COSIA Challenge - Natural Gas Decarbonization," 2014. [Online]. Available: www.cosia.ca..

[5] P. L. Johnson, R. J. Hanson, and R. W. Taylor, "Integration of Plasma and Hydrogen Process with Combined Cycle Power Plant and Steam Reformers," 2015.

[6] G. Towler and R. Sinnott, Chemical Engineering Design, 2nd Edition. Elsevier Ltd, 2013.

[7] IHS Energy, "Comparing GHG Intensity of the Oil Sands and the Average US Crude Oil," Special Report, May 2014.

[8] International Carbon Black Association, "Carbon Black Uses." [Online]. Available: http://www.carbon-black.org/index.php/carbon-black-uses. [Accessed: 12-Nov-2015].

[9] A. K. Geim, "Graphene: Status and Prospects," Science, vol. 324, no. 5934, pp. 1530–1534, 2009.

[10] E. I. Nduagu and I. D. Gates, "Process analysis of a low emissions hydrogen and steam generation technology for oil sands operations," Appl. Energy, vol. 146, pp. 184–195, 2015.

[11] E. I. Nduagu and I. D. Gates, "An Ultra-low Emissions Enhanced Thermal Recovery Process for Oil Sands," Energy Procedia, vol. 63, pp. 8050–8061, 2014.

This poster produced as part of University of Calgary course Scie529 in Fall 2015. For info: dlayzell@ucalgary.ca