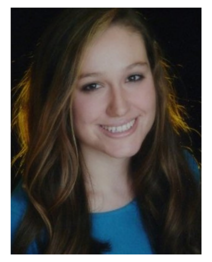
Renewable Natural Gas for Industrial Heat:

Potential Sources and Carbon Emissions Reductions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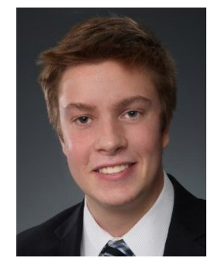
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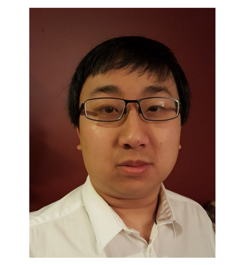
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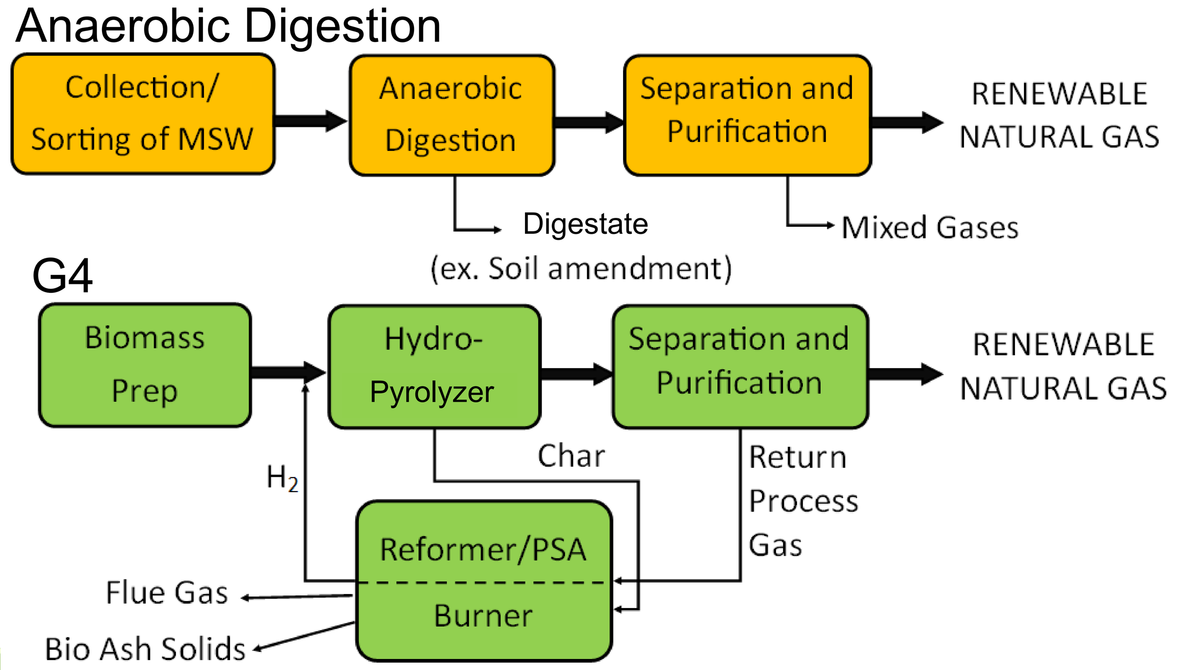
INTRODUCTION

The Canadian industrial sector currently requires 624 PJ/year of natural gas for heating. Demand is expected to exceed 850PJ/year by 2060, creating over 60Mt CO_2e [1].

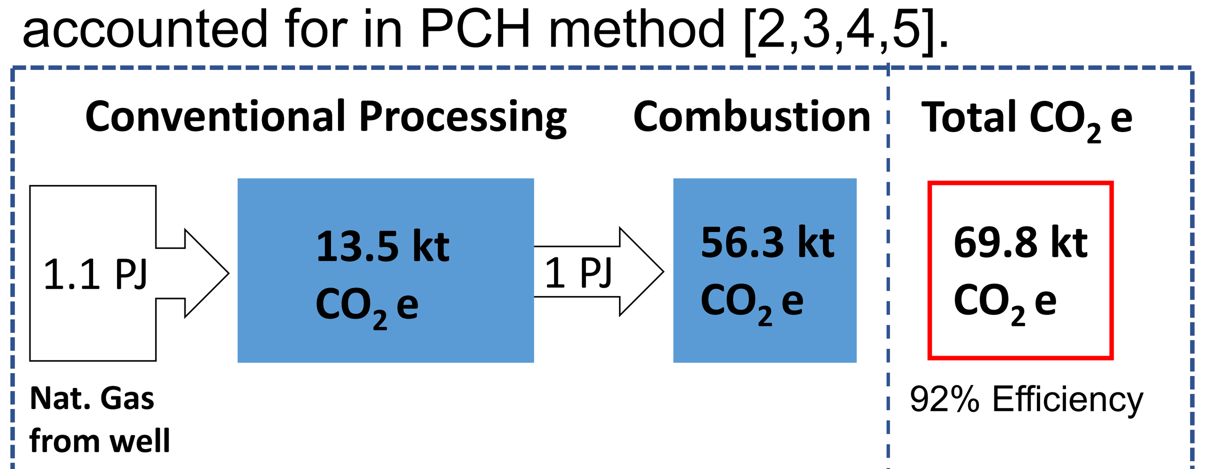
Two technologies for producing renewable natural gas (RNG) are anaerobic digestion (AD) using municipal solid waste (MSW) [2] and a G4 technology (pyro-catalytic hydrogenation) using forestry biomass [3], [4].

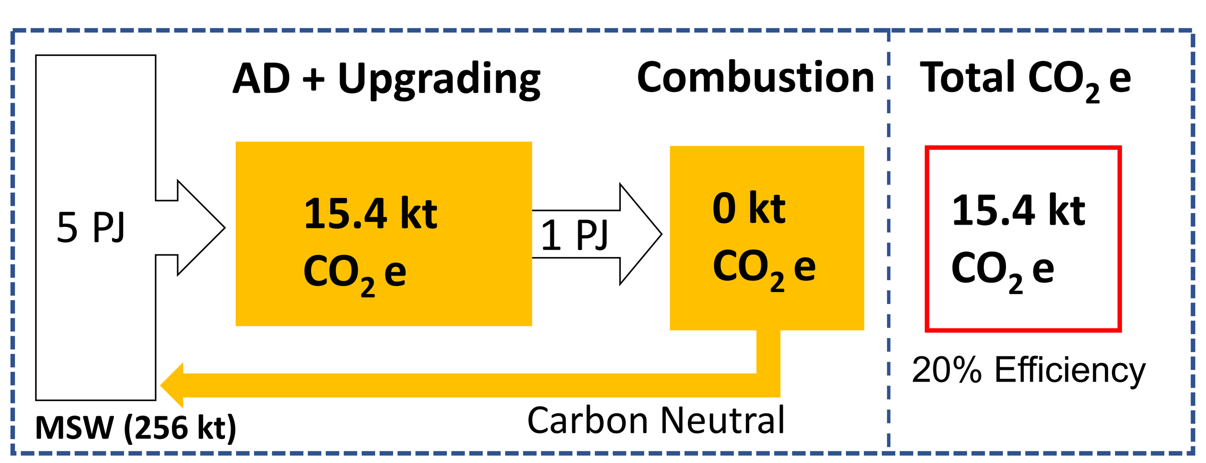


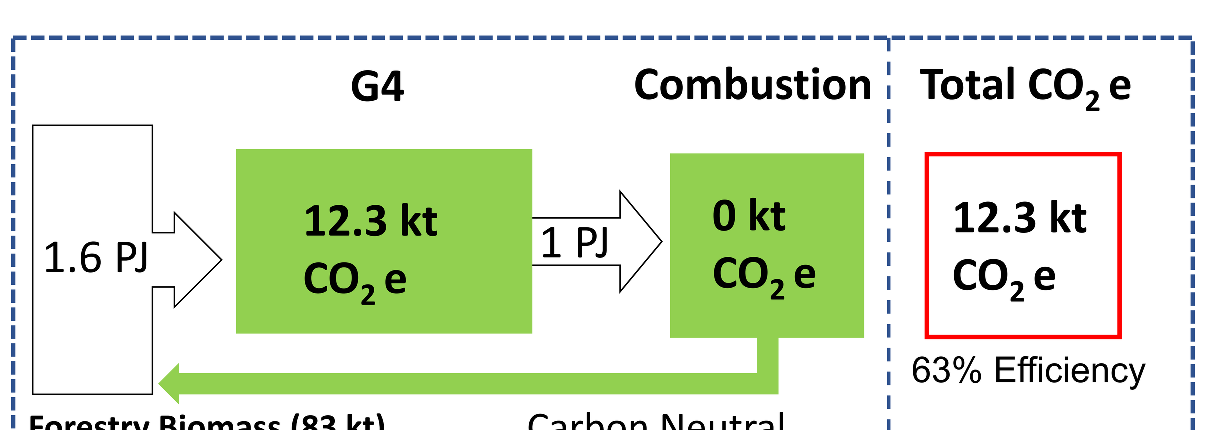
METHODS

Models were created to evaluate the energy conversion efficiency and total emissions emitted by the 3 scenarios to produce 1PJ of energy.

Critical Assumption: No carbon retention accounted for in PCH method [2,3,4,5].





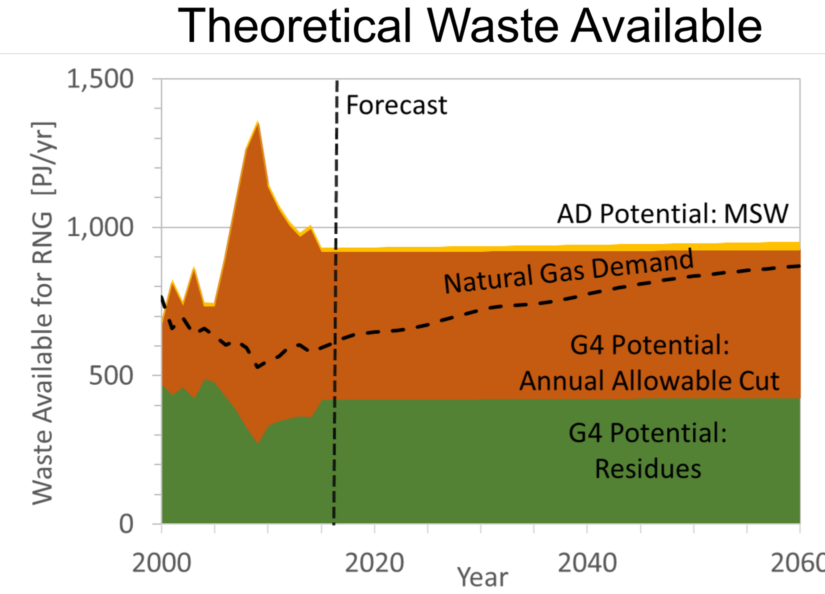


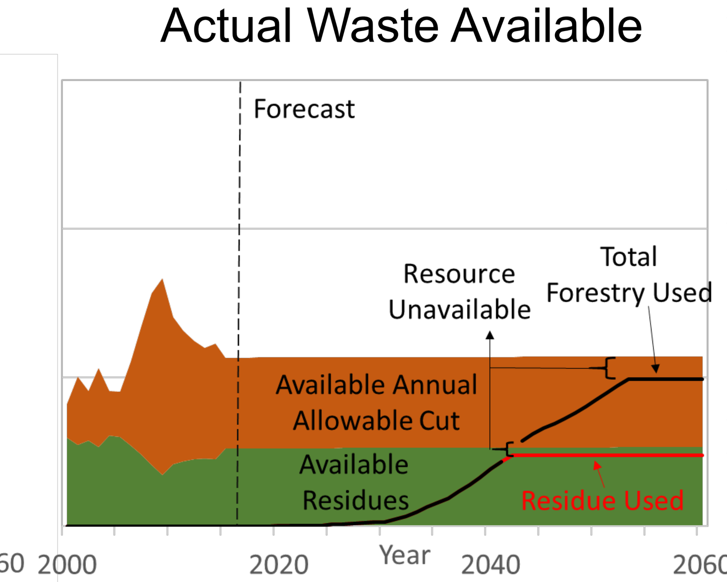
RESULTS

Reference
Theoretical Waste Available

Alternative
Actual Waste Available

Production Capacity
Amount of RNG that could be produced. Max RNG Potential reached in 2052 [1], [2], [3].

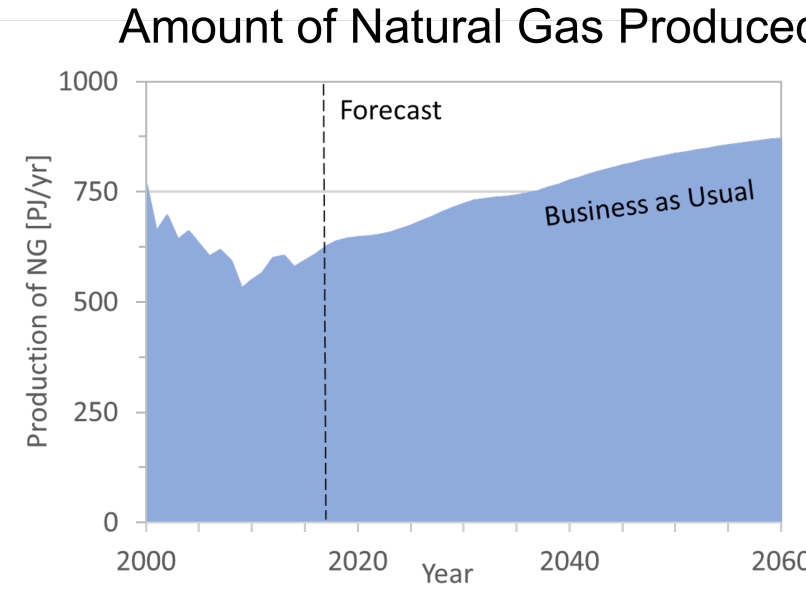




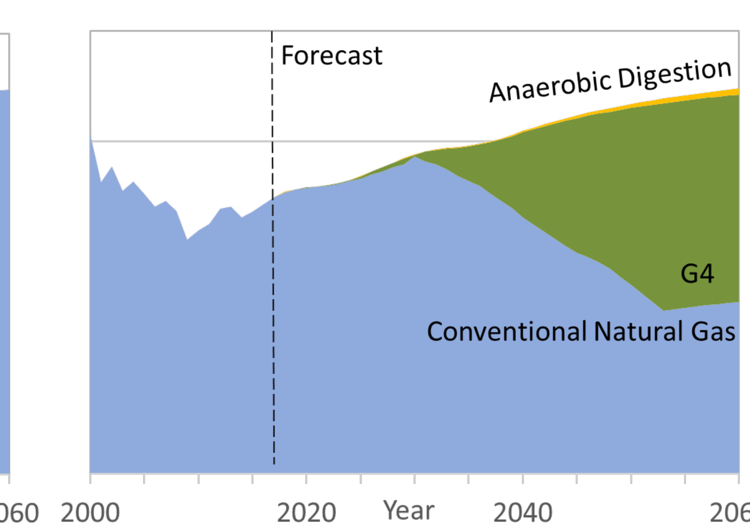
- Process efficiency included in actual waste graph
- Collected residues: 90% Collected Unused AAC: 75%
- In 2052, max available feedstock is reached

Market Penetration
Ramp-up or RNG entering the natural gas market compared to demand. G4 contributes a lot more RNG than AD [1], [2], [3].

Amount of Natural Gas Produced



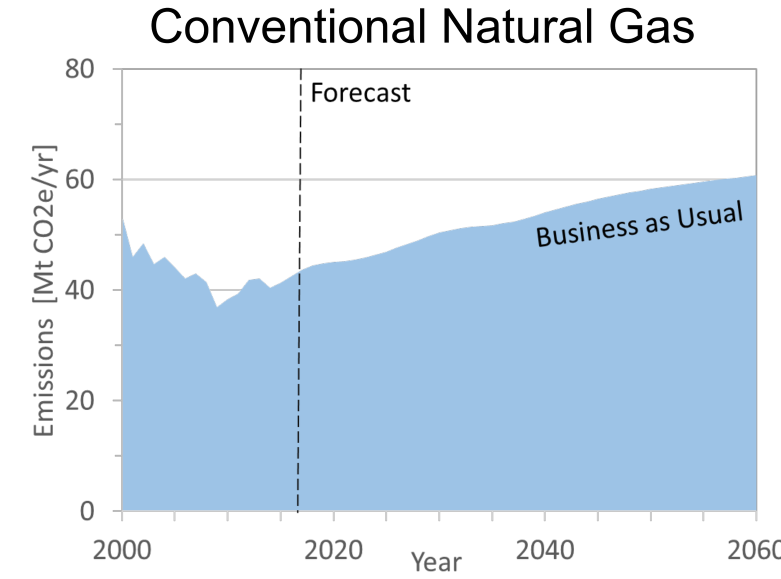
Market Share of RNG



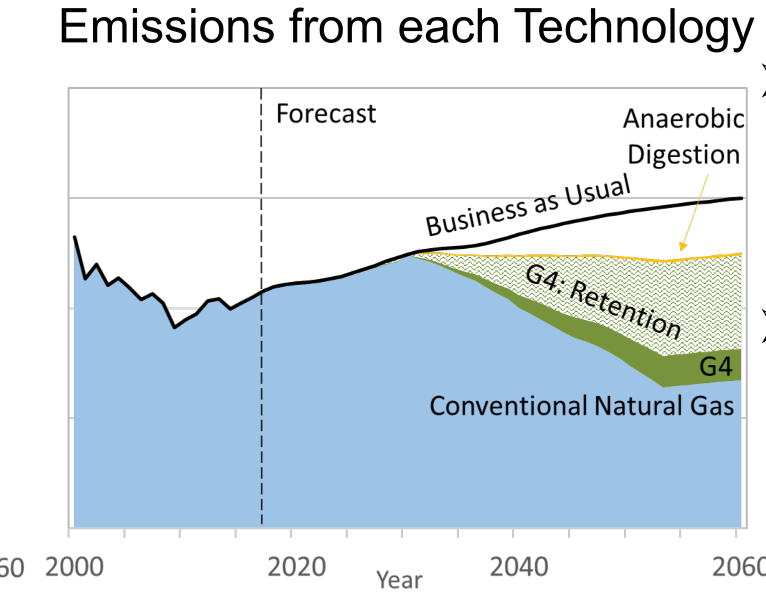
- G4 can produce 27 times more NG than AD
- 2034 marks inflection point of G4 technology
- RNG production can displace 54% of the NG used in industrial heating

Carbon Emissions
Carbon emissions per year based on market share curve. Life cycle assessment and carbon debt is considered [1], [2], [3], [4].

Emissions from Conventional Natural Gas



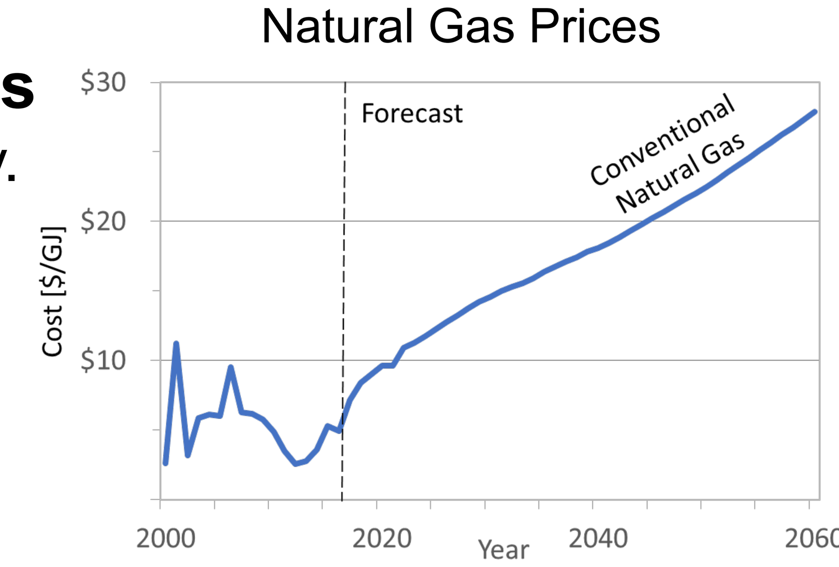
Emissions from each Technology



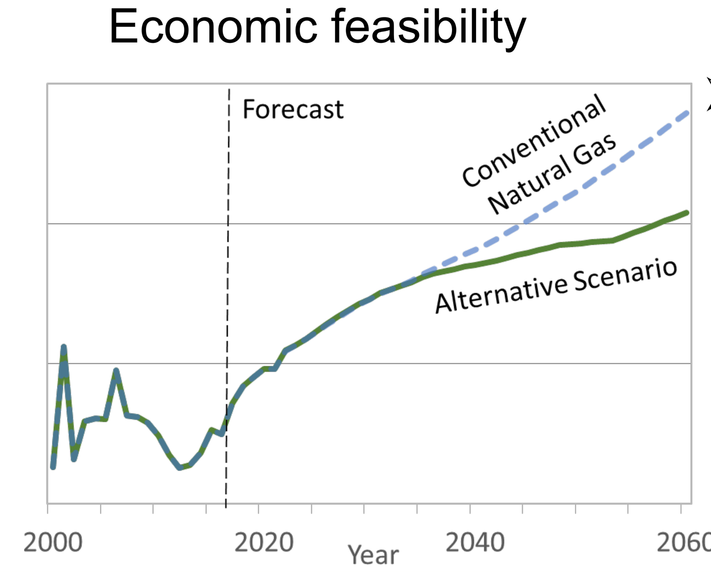
- Life cycle emissions from AD and G4 are minimal
- G4 Retention: includes the residence time of the carbon in the atmosphere before it is sequestered

Cost of Natural Gas
Cost per GJ of energy. Carbon tax plans are considered [6]. G4 becomes feasible in 2034 and AD in 2053.

Natural Gas Prices



Economic feasibility



- Economics based on EIA energy outlook and carbon levy increase of \$5/tCO_2e per year past 2030

DISCUSSION

AD and G4 can displace 54% of the NG demand for the industrial heating sector by 2060. The lack of available feedstock limits greater production. G4 and AD become economically viable after 2034 and 2053, respectively.

For "G4 Retention", the atmospheric carbon debt was considered for G4's pyrolysis process. While the combustion process is ultimately carbon neutral, temporal effects of CO_2 due to carbon retention result in a carbon discount rate of only 43%, rather than 100%. [7]

CONCLUSIONS

G4's PCH process is an attractive alternative for conventional natural gas combustion, with the potential to reduce carbon intensity by 80%. The technology is still in the pilot stage, and will likely take root between 2030-2040 [4].

Anaerobic digestion is a readily available technology which can be employed immediately. However, due to limited MSW, AD can only displace 3-4% of industrial heating NG demand.

G4 and AD technologies can be expected to be rapidly adopted once rising carbon prices make these processes competitive (\$110/tCO_2e for G4, \$210/tCO_2e for AD).

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