Micro-CHP: A Home Energy Solution?

Replacing Conventional Home Heating with Natural Gas Combined Heat and Power

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INTRODUCTION

Natural gas furnaces and electrical power plants currently meet the energy demands of homes in Alberta. Albertan homes produced 12.9 Mt CO_2 in 2016, in part due to our inefficient electrical grid. Combined heat and power offers the potential to improve the fuel use efficiency of Alberta's electrical grid.

Micro-CHP systems were found to reduce home emissions by 47% in a Belgium case study [1]. Our model evaluates whether similar reductions can be achieved in Alberta, and whether the technology makes an economic case for homeowners.

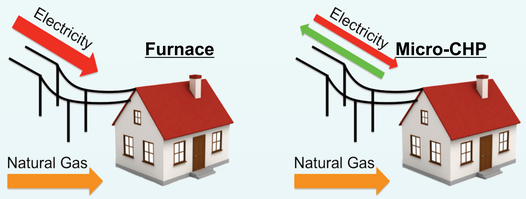


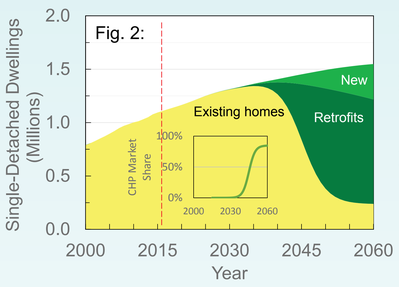
Fig. 1: Conventional Furnace vs. Micro CHP home

METHODS

We modelled future home energy consumption using projected CanESS data [2]. Our analysis focused on single-family detached homes. A Japanese 1.5kWe ICE unit with a heat to power ratio of 2.46:1 [3] is used for our analysis. Some of the major model parameters are shown below.

Natural Gas Higher Heating Value (MJ/m^3)	41.4 [4]
Micro-CHP Combined Efficiency (%)	81.1
Micro-CHP GHG Emission Intensity(kgCO_2e/kWh)	0.223

Two scenarios contribute to the adoption of Micro-CHP technology: new homes built with a Micro-CHP unit and retrofitting existing dwellings. After one year, new homes are eligible for a retrofit.

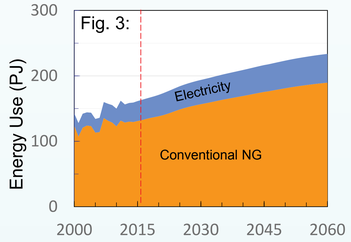


- Micro-CHP slowly introduced in 2016
- Significant implementation by 2040
- 85% market penetration by 2060 (~1 MM dwellings)

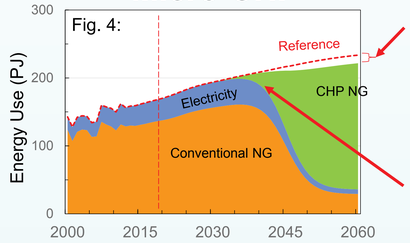
RESULTS

A. Residential Natural Gas vs. Electricity use

Business as Usual



Micro-CHP

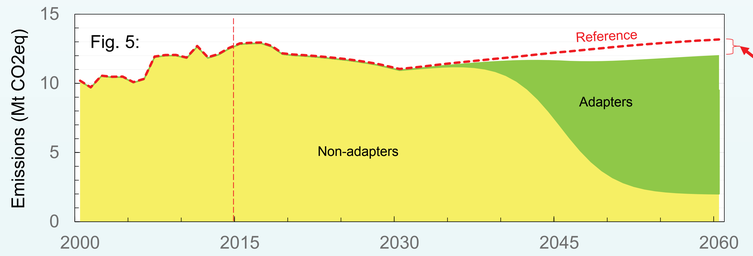


NOTE:

11.9 PJ decrease in energy demand stemming from higher efficiency of the CHP

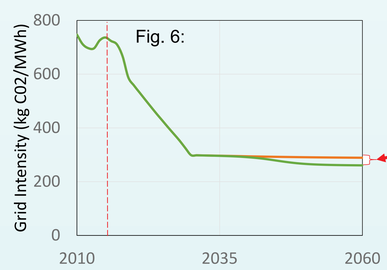
Implementation starts in 2016, but effects are minimal before ~2035

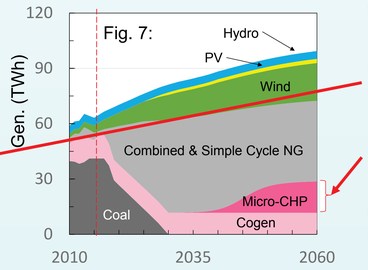
B. Residential GHG Emissions



Household perspective: annual reduction of 1.1 Mt CO_2eq. in 2060

C. AB Electricity Grid



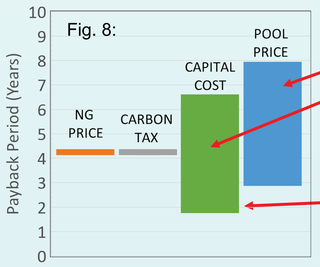


Grid perspective: Implementation dec reases grid intensity by 10%

Micro-CHP provides 17% of public grid demand (17 TWh) by 2060

D. Economic Sensitivity Analysis

Year 2040	Low Price	Med. Price	High Price
Capital Cost	$ 1,500	$ 3,500	$ 5,500
NG Price ($/GJ)	$ 3.30	$ 4.30	$ 5.30
Pool Price ($/kWh)	$ 0.04	$ 0.07	$ 0.10
Carbon Tax ($/t$Co_2$)	$ 30.00	$ 50.00	$ 70.00



Economics of Micro-CHP most sensitive to changes in capital cost and pool price

Payback period drops below 2 years if capital cost reduced to $1500

Lower capital cost, lower natural gas price, higher pool price, and higher carbon tax improve the economics of Micro-CHP for homeowners

DISCUSSION

Emissions – Household Perspective

- Today (2016): 38% reduction in annual home GHG emissions .
- Future (2060): 10% reduction in annual home emissions

With a cleaner electricity grid, Micro-CHP technology becomes less effective in reducing emissions.

Emissions – Alberta Grid Perspective

- Today (2016): Slow initial implementation means a negligible impact on the grid for the next 20 years
- Future (2060): Micro-CHP can help offset generation lost by coal phase-out, especially in the winter when home heat demand is high

Economics – Household Perspective

- Today (2016): High capital cost of Micro-CHP installation is a concern (~$5500)
- Future (2060): Economies of scale will reducing the price of a Micro-CHP unit if widespread implementation occurs

Higher electricity prices for Micro-CHP users also greatly improve the economics of this technology.

CONCLUSIONS

By 2060, the implementation of Micro-CHP in Alberta single detached dwellings could lower annual household emissions by 1.1 Mt CO_2 eq. This technology could produce enough energy in ~1 MM dwellings in order to supply 17% of Alberta's public electricity demand.

Although there are opportunities for significant cost savings to homeowners, Micro-CHP implementation lacks the magnitude in emission reduction needed to be part of a transformative energy systems strategy. This technology will not significantly advance Alberta towards the Paris 2015 Agreement of limiting the global temperature rise to 2℃.

REFERENCES

[1] M. De Paepe, P.D'Herdt, and D. Mertens, "Micro-CHP systems for residentail applications," [Online] http://www.sciencedirect.com/science/article/pii/S0196890406000124

[2] whatIf? Technologies Inc., 2014. Canadian Energy Systems Simulator (CanESS) - version 6, reference scenario. www.caness.ca

[3] Micro-Turbine Specifications provided via email by Greg Caldwell of ATCO Pipelines and Liquids, Oct. 7, 2016

[4] "Heat content values," in *Fortis BC*, 2016. [Online]. Available: https://www.fortisbc.com/NaturalGas/Business/PriceAndMarketInformation/Pages/Heat-content-values.aspx. Accessed: Oct. 31, 2016.

ACKNOWLEDGEMENTS

- Dr. David Layzell and Dr. Bastiaan Straatman for their advice and support throughout the Fall term.
- whatIf? Technologies for the use of the CanESS model data.
- Greg Caldwell of ATCO for providing insight into the technology.

This poster produced as part of University of Calgary course Scie529 in Fall 2016. For info: dlayzell@ucalgary.ca