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### 2022 Fall ENGR333 Poster, Section B

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## Authors

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# Natural Gas CO2 Emissions Reduction Project

ENGR-333-B, Calvin University, Fall 2022

## Introduction

- “What would it take to eliminate Calvin’s natural gas-related net CO<sub>2</sub> emissions?”
- Former Calvin President Michael Le Roy signed the President’s Climate Commitment on Dec 6, 2017
- Pledged carbon neutrality by 2057
- Results so far have been mixed due to the COVID-19 pandemic, but gains have come from:
  - Improved lighting efficiency
  - Reduced enrollment
- Renewable electricity is already being tackled through partnerships with companies like Sun FUNDed.

## Objectives and Methods

- Class initially split up into five groups:
  - RNG – purchasing and consuming renewable natural gas
  - Air-source – heat pump technology paired with carbon free electricity
  - Ground-source – heat pump technology paired with carbon free electricity
  - Energy markets – changes in cost affecting timing and strategy for new system
  - Efficiency – reducing demand for excess heat, therefore saving cost.
- Additional groups formed during the semester:
  - Executive Board – streamlined communication and organization for entire semester
  - “Tiger Team” – calculating heating load for each building on campus
  - Console Heat Pump – smaller device that can be installed on an individual building
  - New Buildings – Aligning heating needs with Calvin Campus Master Plan

## Results

### Air Source:

- Installed from 2031-2033
- Have largest CO<sub>2</sub> reduction per dollar of any equipment implemented



### RNG:

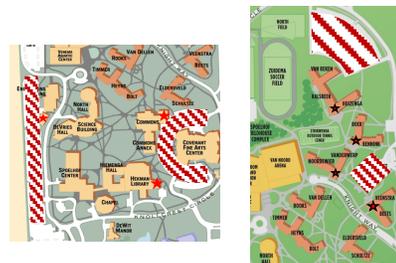
- Implemented with the construction of the new Commons Union building in 2027, powering kitchen needs.

### Ground Source:

- Installed from 2024-2026.
- 110 vertical bore holes, largest cost but largest efficiency.

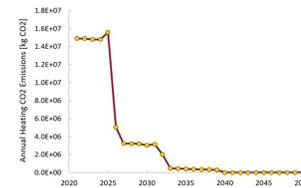
### Console Heat Pumps:

- Installed from 2025-2026
- 175 vertical bore holes, necessary to replace stream loop.



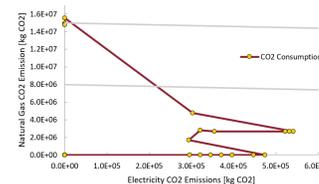
### CO<sub>2</sub> Emissions:

- Analysis of total CO<sub>2</sub> emissions vs time until 2050
- Demonstrates implementation of various heating technologies, time to implement, and construction carbon effects.



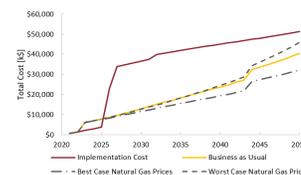
### CO<sub>2</sub> Tradeoffs:

- Analysis of Natural Gas Emissions vs Electricity Emissions
- New heating will come from electricity powered devices, with carbon free electricity from renewable resources implemented in the future.



### Cost of Implementation:

- Analysis of total consumption cost increase vs time until 2050
- After an initial high-capital investment, annual costs will taper off but will be more expensive than the current system.



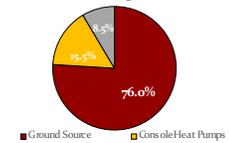
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## Conclusions

- Carbon Neutral by 2040
- Total Capital Investment: 31.33 Million'
- Estimated Annual Cost Crossover – Mid 2067

Source	Capital Cost	CO <sub>2</sub> Reduction [kg CO <sub>2</sub> /yr]	CO <sub>2</sub> Construction Cost [kg CO <sub>2</sub> ]
GSHP	\$18.5 Million	12.8 Million	17.0 Million
Console	\$8.8 Million	1.05 Million	5.68 Million
ASHP	\$1.9 Million	2.85 Million	7.01 Thousand
RNG	\$1.2 Million	0.12 Million	845
Total	\$30.4 Million	16.82 Million	22.7 Million

Total Heating Allocation



## Acknowledgements

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