

ET Summit 2024

Presented by



Energy Modeling and Analysis of Dual Fuel Heating Systems in Single-family Homes

Gas Emerging Technologies Program (GET)



Saurabh Shekhar

Energy Engineer

ICF/GET



Cristalle Mauleon

Engineering Manager

Lincus/GET



Our Team



Saurabh Shekhadar,
CEM, EIT, CDCP
Energy Engineer, ICF



Steven Long, P.E.
Director of
Engineering, ICF



Nicholas Fette
Senior Energy
Engineer, Lincus



Cristalle Mauleon
Engineering
Manager, Lincus

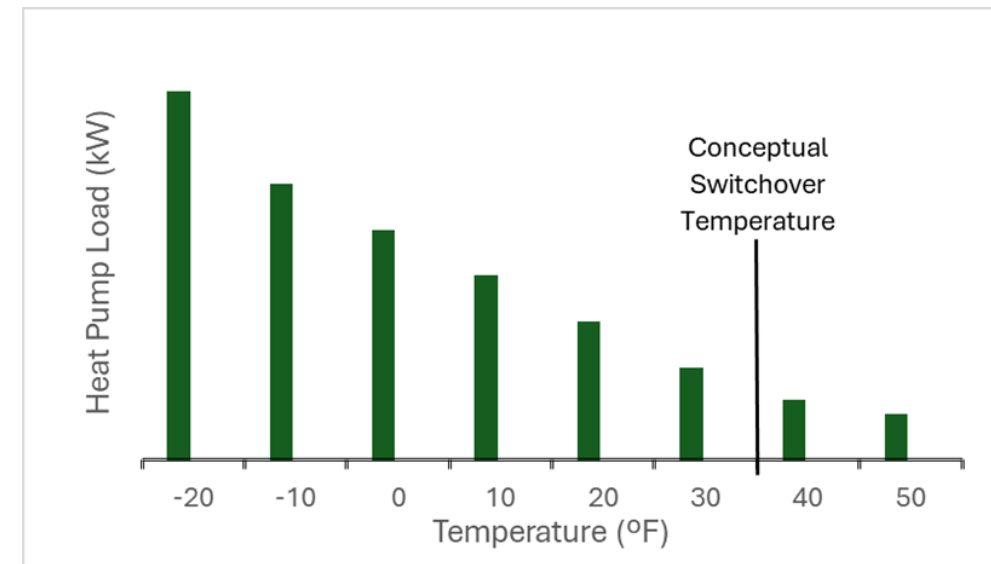
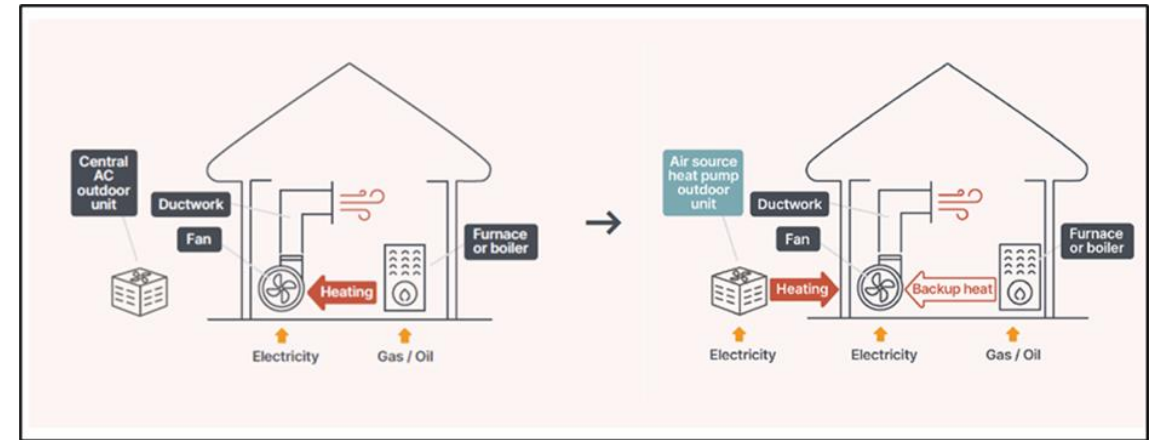
Agenda

- Introduction
- Research objectives
- Literature review and subject matter expert interview findings
- Energy models and methodology
- Annual operating cost vs emissions trade-off
- Simulation results: Hourly trends
- Parametric analyses
- Key parameter correlations
- Findings

Introduction

Dual fuel heating technology and configurations

- Introduction to dual fuel heating systems
- Configurations
- Switchover temperature and associated factors
- Emissions and economic balance point



[1] Combating High Fuel Prices with Hybrid Heating, Report by CLASP and RAP, July 2022.

Research Objectives

- To determine the technical feasibility of dual fuel heating technology for single-family homes using EnergyPlus and spreadsheet analysis
- To determine the potential for emissions reduction from dual fuel space heating in single-family homes in California
- To analyze the impact of switchover temperature on total energy consumption and operating costs
- To determine the cost effectiveness of installing dual fuel heating system based on TRC and TSB tests (Metrics of cost effectiveness in CA)

Literature Review and Subject Matter Expert Interview Findings

- About 47% of the U.S. homes are good candidates for retrofit of AC with a heat pump.
- About 62% of the total homes in California have natural gas furnaces as their main heating equipment.
- Stronger market demand for dual fuel technology in residential sector. (NEEA Study 2023)
- Adoption of dual fuel heating systems is common in Northeast and Mid-Atlantic regions.
- Potential barriers of adoption of dual fuel technology.
- Pre-qualifications required for installing dual fuel heating systems.

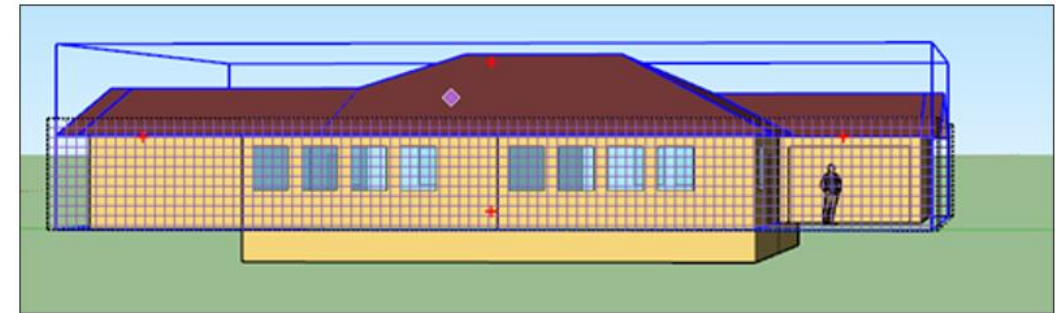
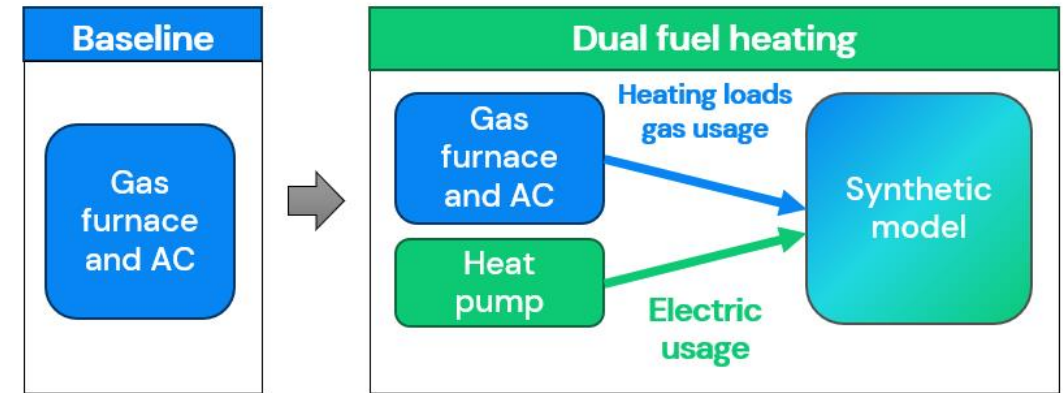
[1] CLASP and RAP Report, July 2022.

[2] RECS Survey, 2020.

Energy Models and Methodology

- Synthetic model for dual fuel heating combines two otherwise identical models for gas furnace and heat pump
- Calculations are end-use specific, using time series outputs for heating and fans during heating mode

Model assumption	Value
Building energy model	DEER EnergyPlus Single Family
Vintage	Median existing (circa 1975/1985 building energy code)
Size	Small (1-story / 1,400 ft ²)
Gas furnace efficiency	95% AFUE
Heat pump efficiency	15.2 SEER2 / 16 SEER 7.7 HSPF2 / 9.0 HSPF
Simulation time step	10 minutes
Cost and emissions calculation granularity	Hourly
Emissions sources	California Avoided Cost Calculator (ACC 2022)



Climate zone	Gas tariff	Electric tariff for flat-rate analysis	Electric tariff for TOU analysis
CZ 16	SCG GR	SCE D	SCE TOU-D-4-9PM
CZ 11	PG&E G-1	PG&E E-1	PG&E E-TOU-C

Climate Zone Screening: Emissions Savings and Cost Increase

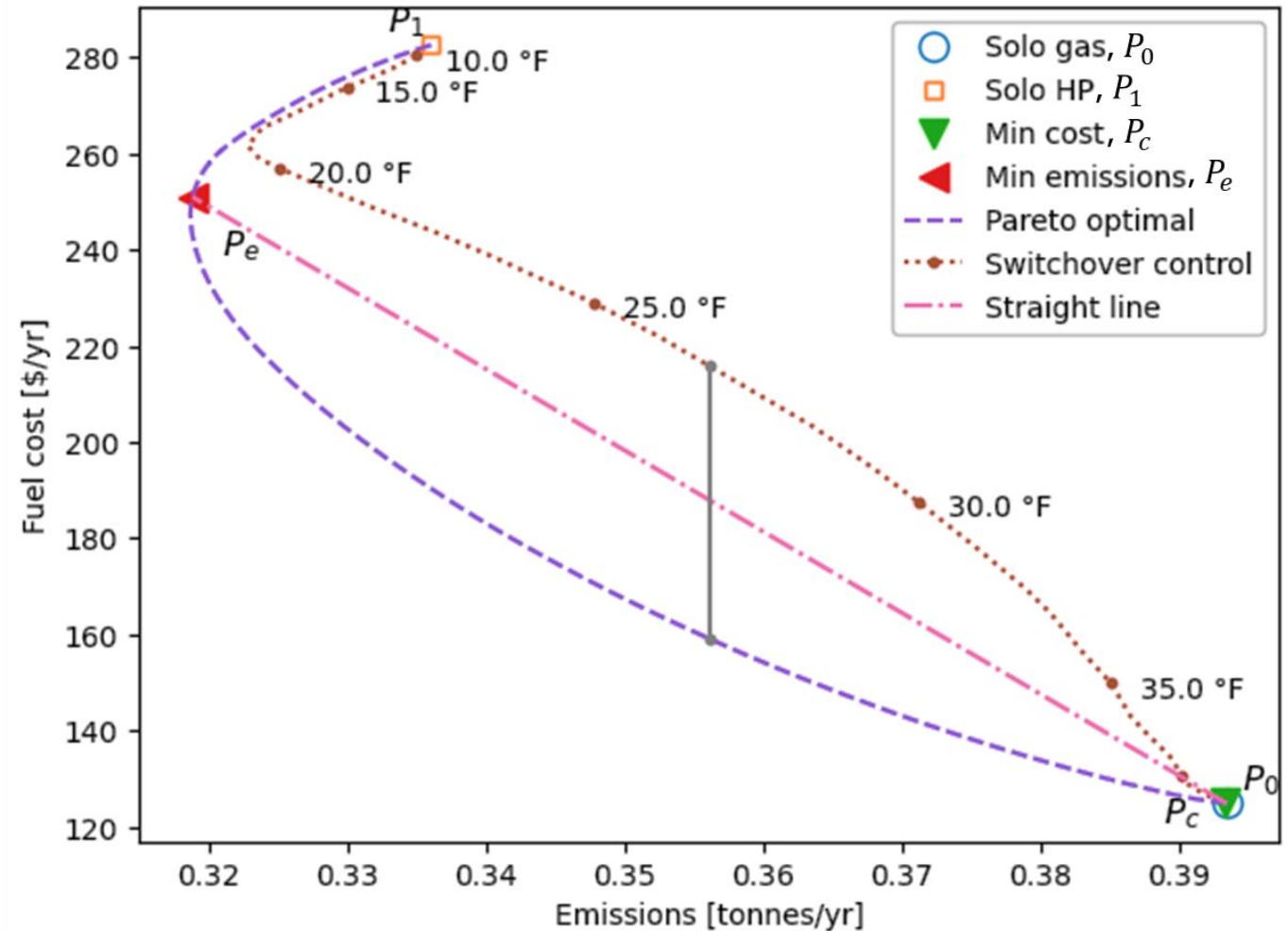
Climate Zone	Annual HVAC Fuel Cost ² [\$]				Annual HVAC Emissions [tonnes CO ₂]		
	Gas Furnace	Heat Pump	Preferred System for Minimum Cost	Preferred System for Minimum Emissions	Gas Furnace	Heat Pump	Preferred System for Minimum Emissions
1	\$166.28	\$446.25	\$166.26	\$405.20	0.497	0.414	0.408
2	\$317.68	\$728.43	\$317.67	\$709.34	0.918	0.708	0.705
3	\$249.01	\$543.89	\$249.01	\$540.91	0.701	0.509	0.509
4	\$222.76	\$485.60	\$222.76	\$482.07	0.631	0.470	0.470
5	\$263.16	\$587.02	\$263.16	\$584.98	0.745	0.547	0.546
6	\$145.37	\$268.53	\$145.37	\$268.01	0.434	0.310	0.310
7	\$214.19	\$360.88	\$214.19	\$360.64	0.425	0.287	0.287
8	\$147.95	\$250.76	\$147.87	\$249.64	0.427	0.287	0.286
9	\$163.66	\$294.76	\$163.66	\$294.43	0.493	0.348	0.348
10	\$89.24	\$205.47	\$89.24	\$186.16	0.281	0.248	0.244
11	\$222.63	\$518.13	\$222.62	\$462.14	0.620	0.523	0.514
12	\$221.58	\$521.02	\$221.57	\$475.46	0.620	0.527	0.519
13	\$229.93	\$501.86	\$229.93	\$480.80	0.627	0.510	0.506
14	\$233.61	\$458.06	\$233.57	\$441.93	0.698	0.541	0.539
15	\$73.07	\$134.03	\$73.04	\$126.23	0.219	0.165	0.162
16	\$124.83	\$282.56	\$124.81	\$247.45	0.393	0.336	0.319

Emissions Savings and Cost Increase, Continued

Climate Zone	Emissions Savings: Dual Fuel Over heat Pump (MT CO ₂)	Emission Savings as percent of Heat Pump Emissions (MT CO ₂)	Cost Savings: Dual Fuel Over Heat Pump	Cost Savings (% of Heat pump Cost)	Cost Increase: Dual Fuel Over Gas Furnace	Cost increase (% of Gas Furnace Cost)
01	0.0062	2%	\$41.05	9%	\$238.92	144%
02	0.0035	0%	\$19.09	3%	\$391.66	123%
03	0.0006	0%	\$2.98	1%	\$291.90	117%
04	0.0007	0%	\$3.54	1%	\$259.31	116%
05	0.0004	0%	\$2.03	0%	\$321.82	122%
06	0.0002	0%	\$0.52	0%	\$122.64	84%
07	0.0000	0%	\$0.24	0%	\$146.46	68%
08	0.0002	0%	\$1.12	0%	\$101.69	69%
09	0.0001	0%	\$0.33	0%	\$130.77	80%
10	0.0036	1%	\$19.31	9%	\$96.91	109%
11	0.0099	2%	\$55.99	11%	\$239.52	108%
12	0.0084	2%	\$45.56	9%	\$253.88	115%
13	0.0045	1%	\$21.06	4%	\$250.88	109%
14	0.0024	0%	\$16.13	4%	\$208.32	89%
15	0.0034	2%	\$7.80	6%	\$53.16	73%
16	0.0174	5%	\$35.11	12%	\$122.63	98%

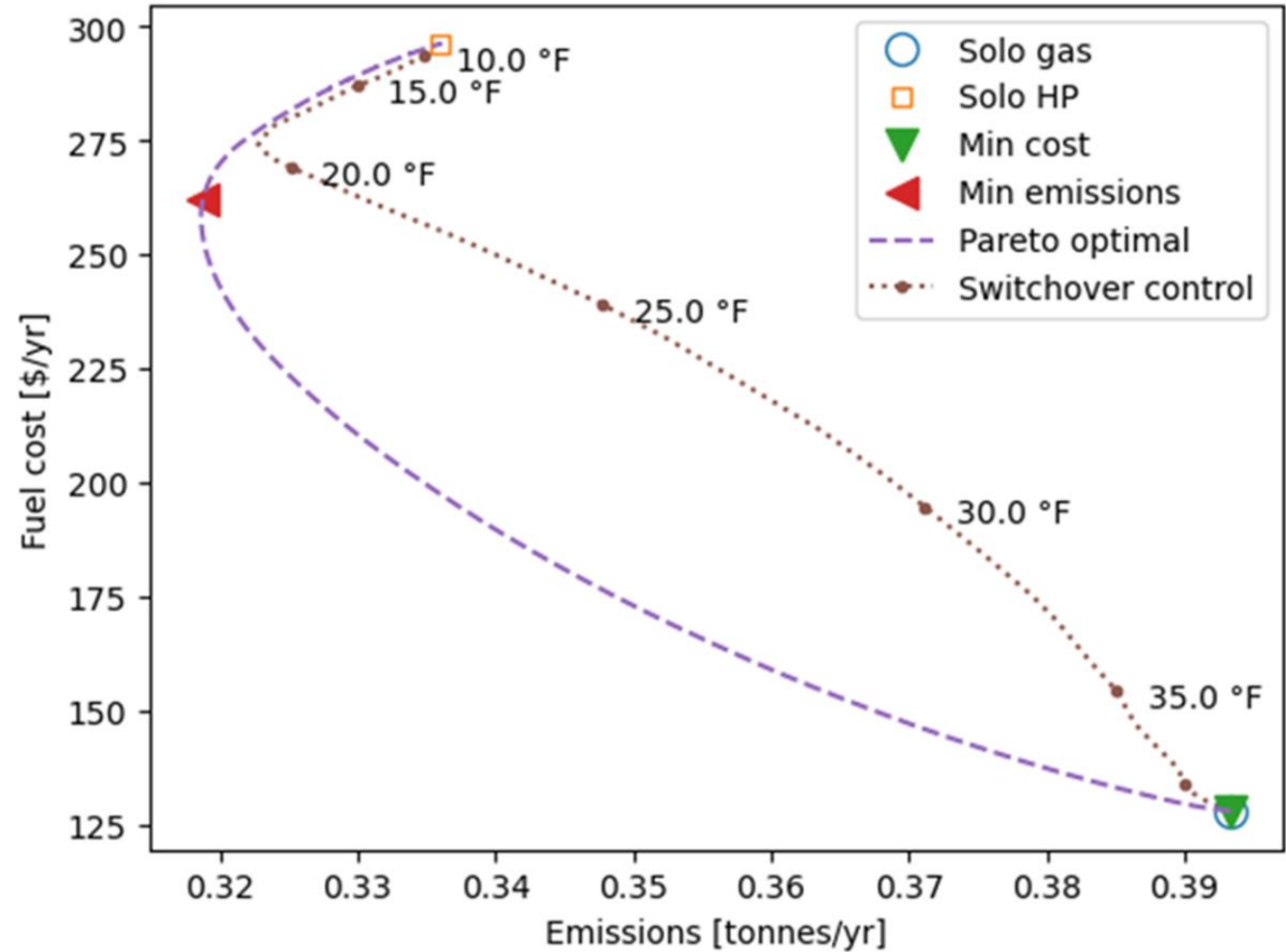
Annual Operating Cost vs Emissions Trade-off

Pareto optimal front,
CEC climate zone 16,
flat rate electric tariff



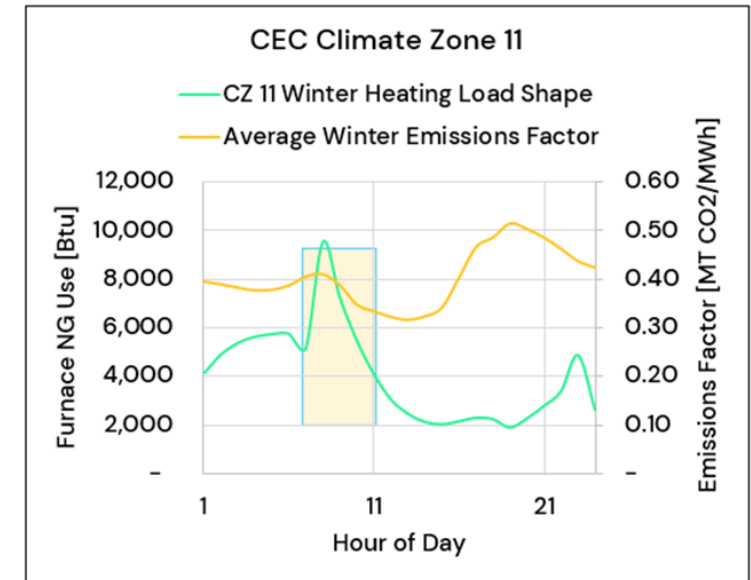
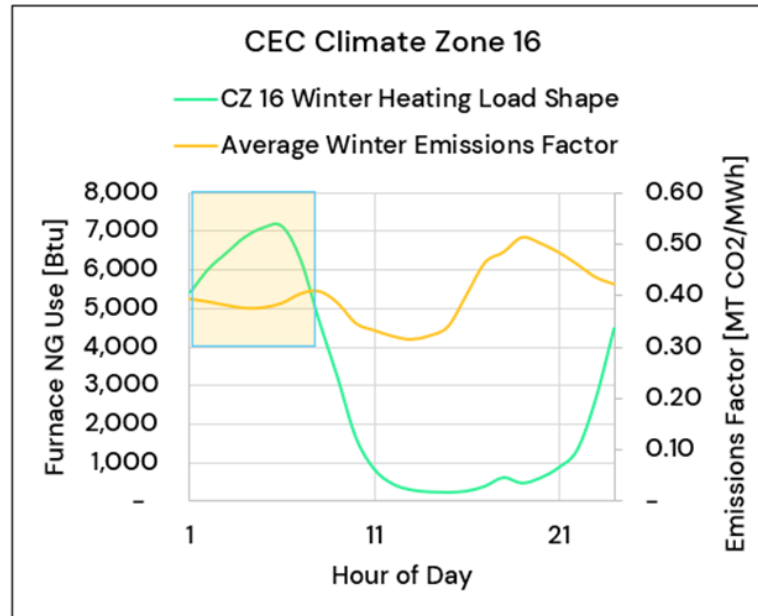
Annual Operating Cost vs Emissions Trade-off

Pareto optimal front,
CEC climate zone 11,
flat rate electric tariff



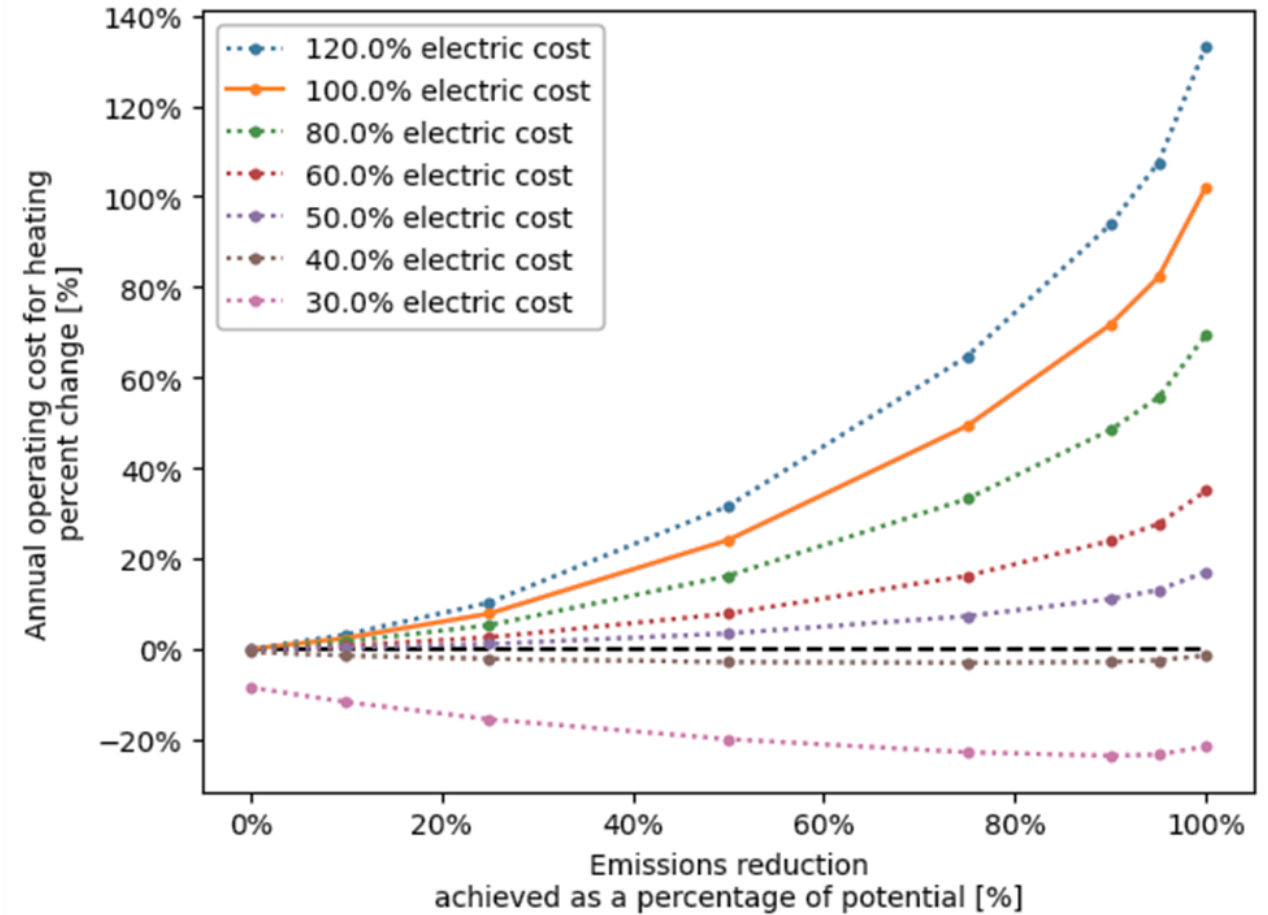
Simulation Results: Hourly Trends

- Heating load peaks in winter mornings
- Emissions are at their secondary peaks for both climate zones
- Potential electric grid constraints in winter morning hours as more homes electrify



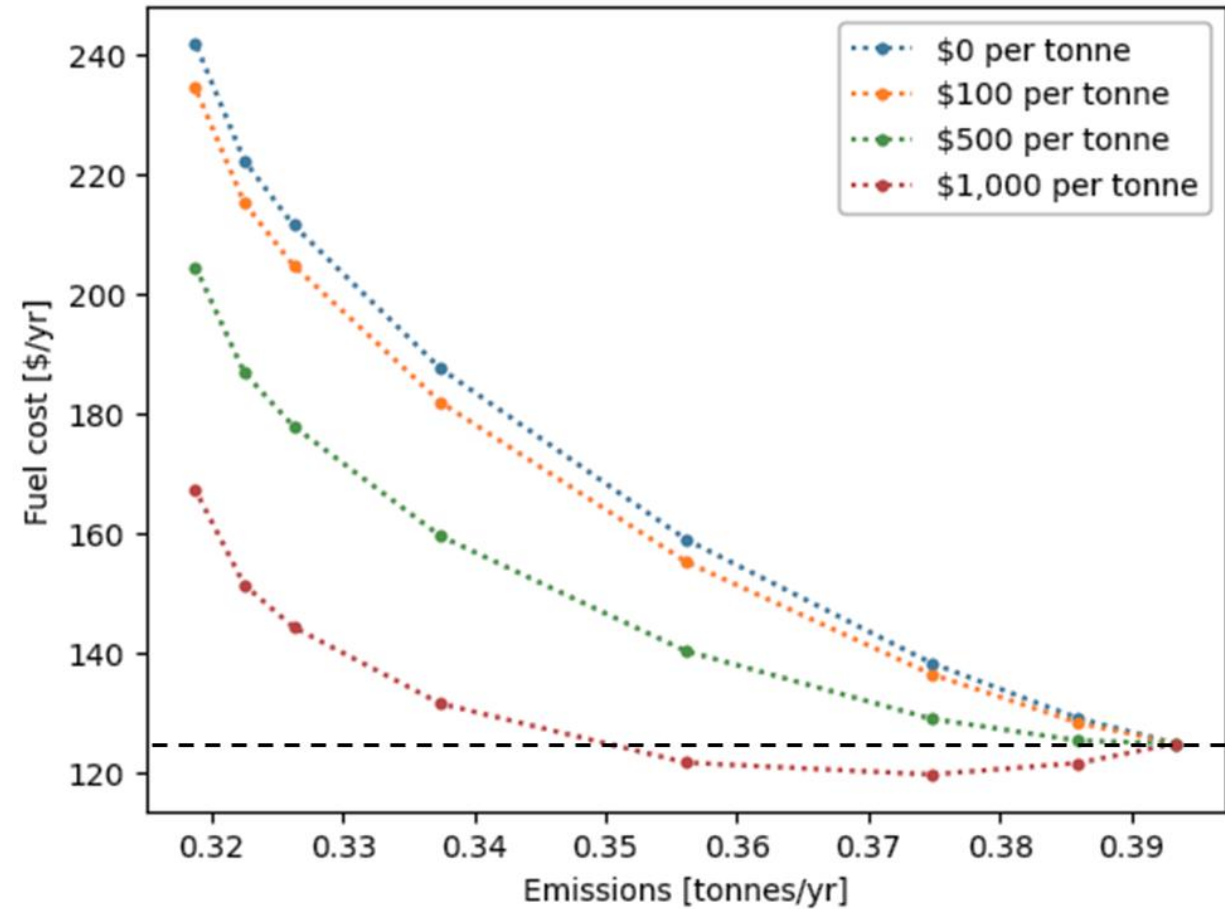
Parametric Analyses

- Scenario 1 : Customer electric cost varies from default assumption (equivalently, vary electric-to-gas cost ratio ([$\$/\text{kWh}$] / [$\$/\text{therm}$]))
- Percent change results for parametric variation of electric costs, CZ 11, flat rate electric tariff



Parametric Analyses

- Scenario 2 : Emissions reduction credit
- Parametric variation of emissions reduction credit, CZ 16, flat rate electric tariff



Findings

- In California, there is no “emissions balance point” and “economic balance point”.
- Heating peak in winter mornings could lead to potential electric grid constraints as more homes electrify.
- Under California electric and gas rates considered in the study, the cost to operate the heating system in heat pump mode is nearly double when compared to solo gas furnace.
- CZ 11 - The current rate ratio would need to be reduced by 55% to achieve 100% emissions reduction
- Significance of rate ratio and emissions credit (\$/tonne) in making dual fuel systems cost effective
- Limited benefits of using static switchover temperature control strategy
- Cost effectiveness ranges in California (TRC/TSB)

This project was conducted through the ICF implemented, SoCalGas administered California Statewide Gas Emerging Technologies Program.

For more information, contact
get@caenergyprograms.com

Saurabh Shekhar

Energy Engineer
ICF/GET

Saurabh.nageshshekhar@icf.com

Cristalle Mauleon

Engineering Manager
Lincus/GET

cmauleon@lincus.com

