Dual-Fuel Gas Furnace + Heat Pump System Control Analysis

Larson Energy Research

Presented by

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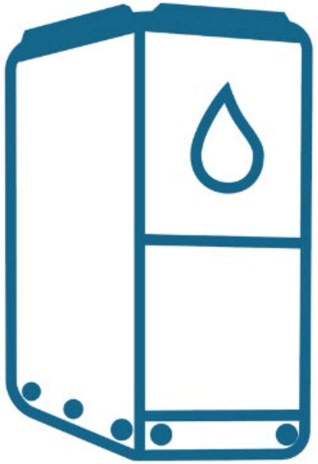
10 March 2026

Dual-Fuel Heat Pump Systems Analysis

Full project report:

https://neea.org/resource/dual-fuel-heat-pump-systems-analysis/



Gas furnace

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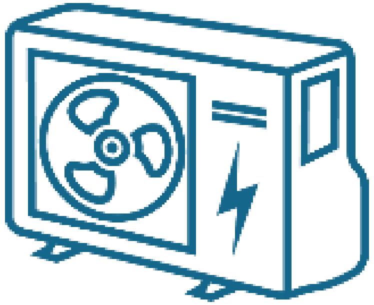

Air source heat pump

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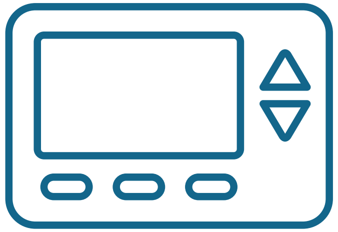
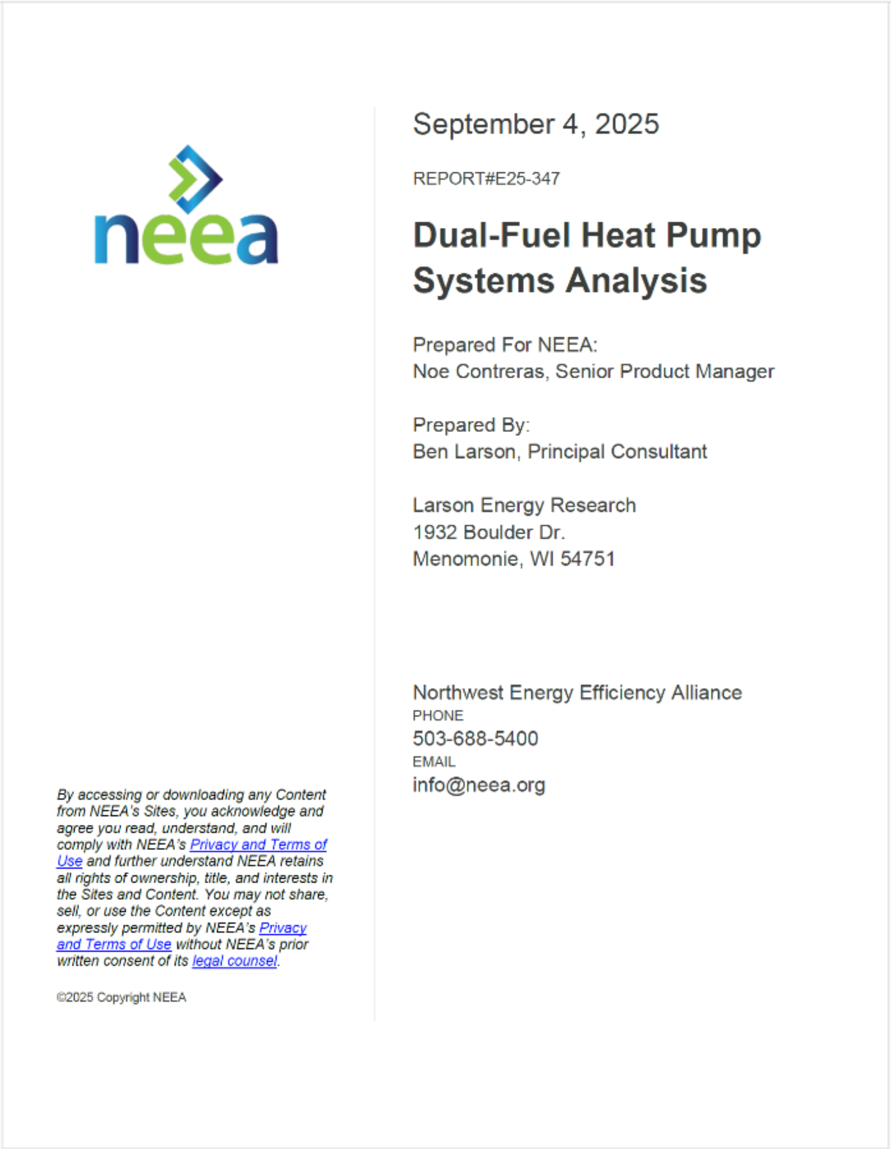


Thermostat



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Dual-Fuel Heat Pump Systems Analysis

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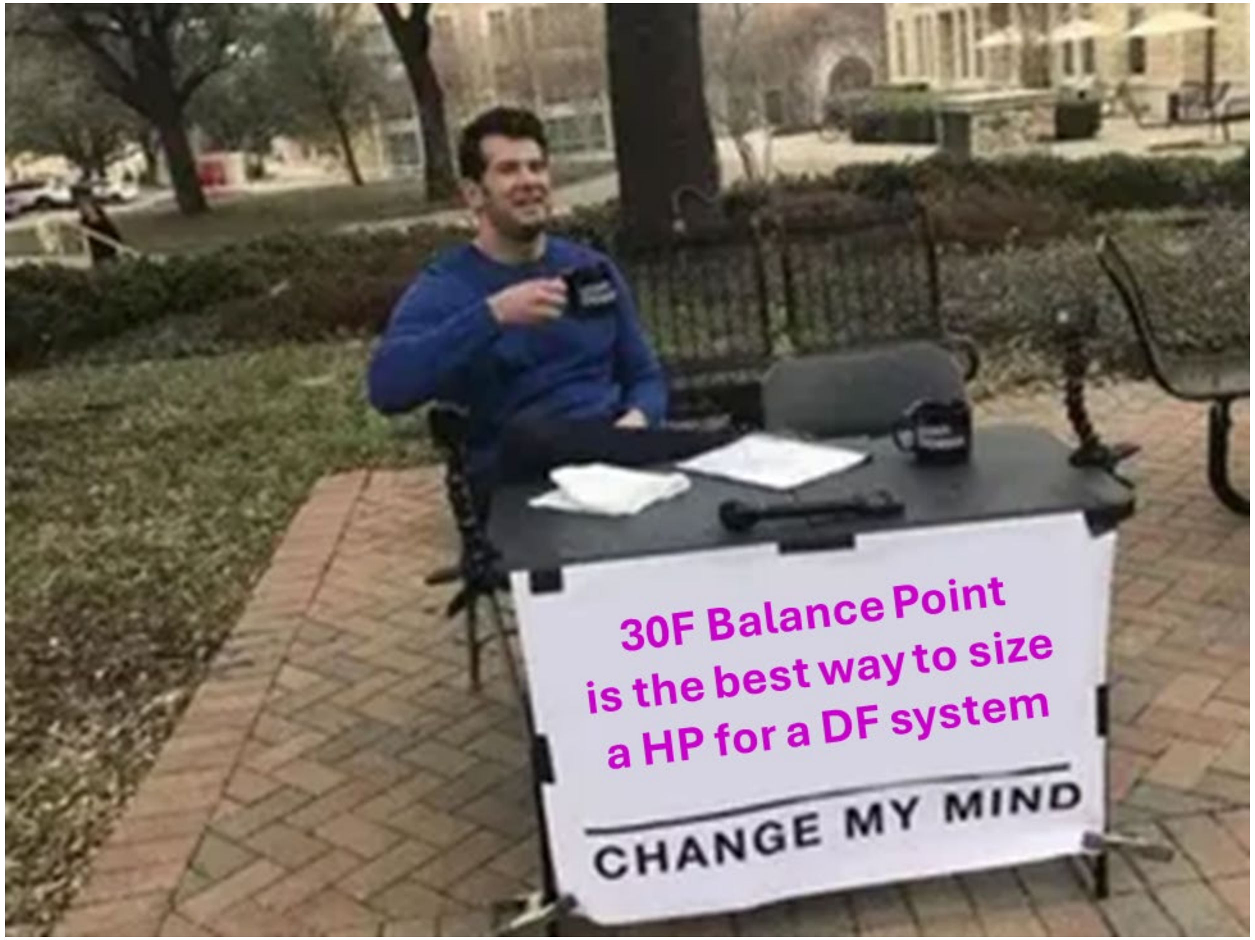


Definitions

- **Balance Point** – temperature at which heat pump output capacity equals house heating need
- **Switchover** – temperature at which system switches from heat pump to gas furnace heating
- **Supplemental** – equipment design that simultaneously operates both systems: heat pump as primary, gas furnace as secondary, supplement

High Level Findings

- Natural Gas Use Impacts
  - Gas use will decrease with any DF system
  - Switchover temperature is the largest lever
- Heat Pump Sizing
  - Set switchover close to the heat pump balance point
  - The cooling need sets a minimum required size
  - Gains diminish below 30F balance point size
- Electric vs Gas Rates Matter
  - Value proposition in WA and OR on utility costs.
  - Not as clear in ID and MT (except propane).
- Heat Pump Type Matters
  - All heat pumps saved in WA and OR. Some products saved more.
  - Better performing heat pumps can save in ID and MT where single-speed cannot.

Quick Method Review

- **Base case** is a gas furnace (95 AFUE) and air conditioning system
- All analysis for an RBSA average house with **heat loss rate (UA) of 640 Btu/hr °F**
  - Analysis results are illustrative. Relative differences are most telling.
- **Rates**. Based on 2023 data from EIA.

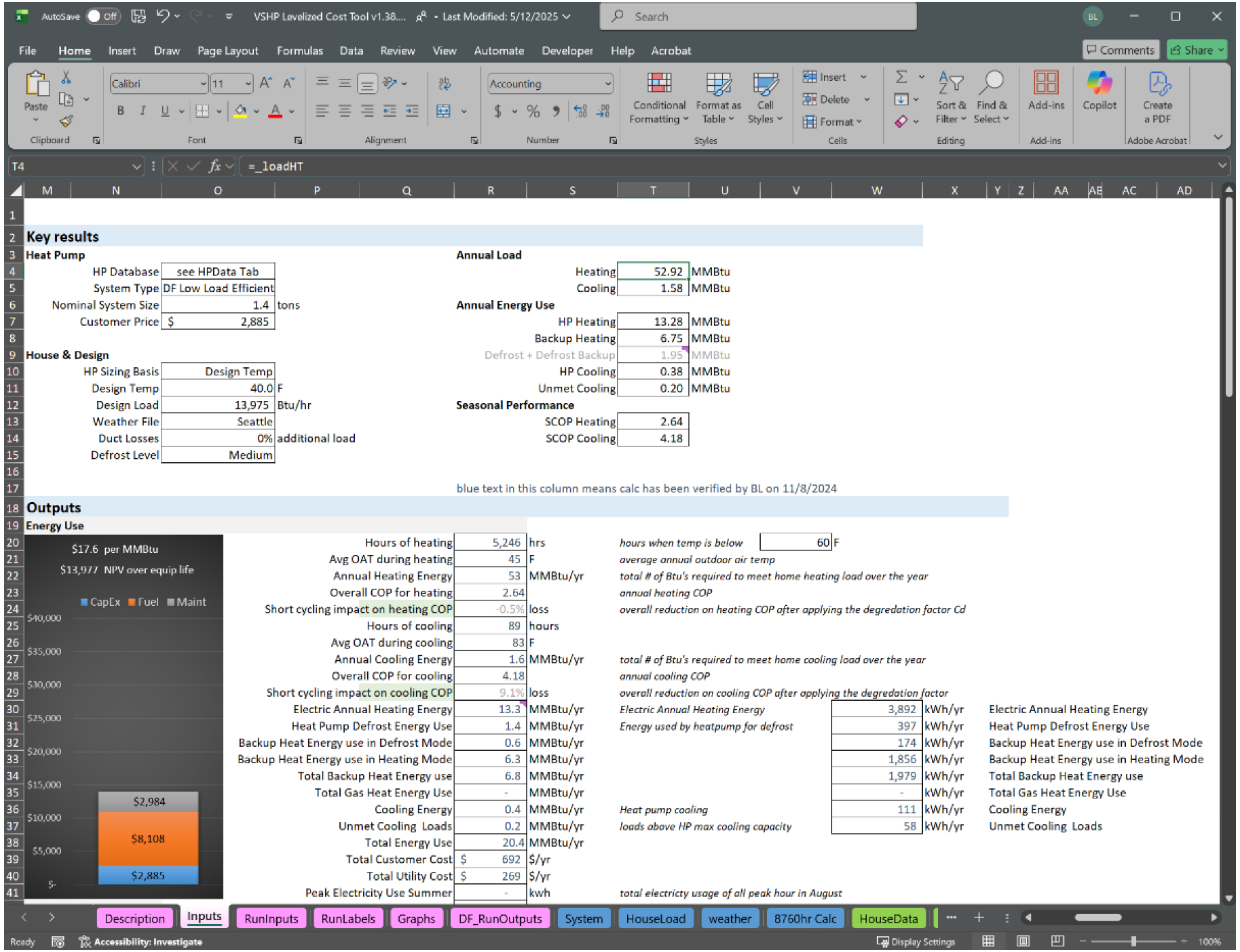
Location	Electricity	Gas	Propane
	$/kWh	$/Therm	$/gallon
WA, OR	0.1157	1.507	-
ID, MT	0.1161	0.953	2.21

- **GHG** emissions for electricity, gas, and propane. (EIA data)
  - 1 lb CO_2/kWh, 293 lbs per MMBtu @ site (PNW electric grid average)
  - 11.7 lbs CO_2/therm, 117 lbs per MMBtu (piped natural gas)
  - 12.7 lbs CO_2/gallon, 139 lbs per MMBtu (delivered propane)

Equipment install costs. Definitive costs beyond study scope.
ROM: Incremental costs are multiple thousands of $.

Calculation Tool

- Variable Capacity Heat Pump (VCHP) Levelized Cost Tool
  - Spreadsheet original created by Center for Energy and Environment (CEE)
  - Hourly calculations of house heating/cooling loads and energy input of the equipment needed to meet those loads. “8760” tool
  - Weather inputs from TMY files
  - Calculations account for house conductive heat loss, solar heat gains, internal heat gains, infiltration, thermal mass, and duct losses
  - Multiple heat pump types
  - Calculations with nighttime setbacks. Morning recovery uses 100% gas unless outside temperature above 40 °F.



What the Tool Can Do

Graphs of Daily Energy Use

Example graphs of daily energy use follow for three scenarios.

- Heat Pump always sized to 30F outdoor balance point
  - Single speed heat pump with “good EER”
    - A very basic heat pump
  - *Portland* climate
  - Size is 3.3 tons
- **Switchover** to Gas @ 40F.
- **Switchover** to Gas @ 35F.
- **Supplement** with Gas at any temperature below 40F.
  - This is the TWH+ AHU system where the hydronic coil is located after the heat pump coil in the air handler.
  - It is also how a well-behaved electric only system, with resistance auxiliary will perform.

Note this is daily summary data and calculations are hourly so, within a day, it can be both above and below the switchover temperature leading to both heat pump and gas system operation in the same day but never the same hour.

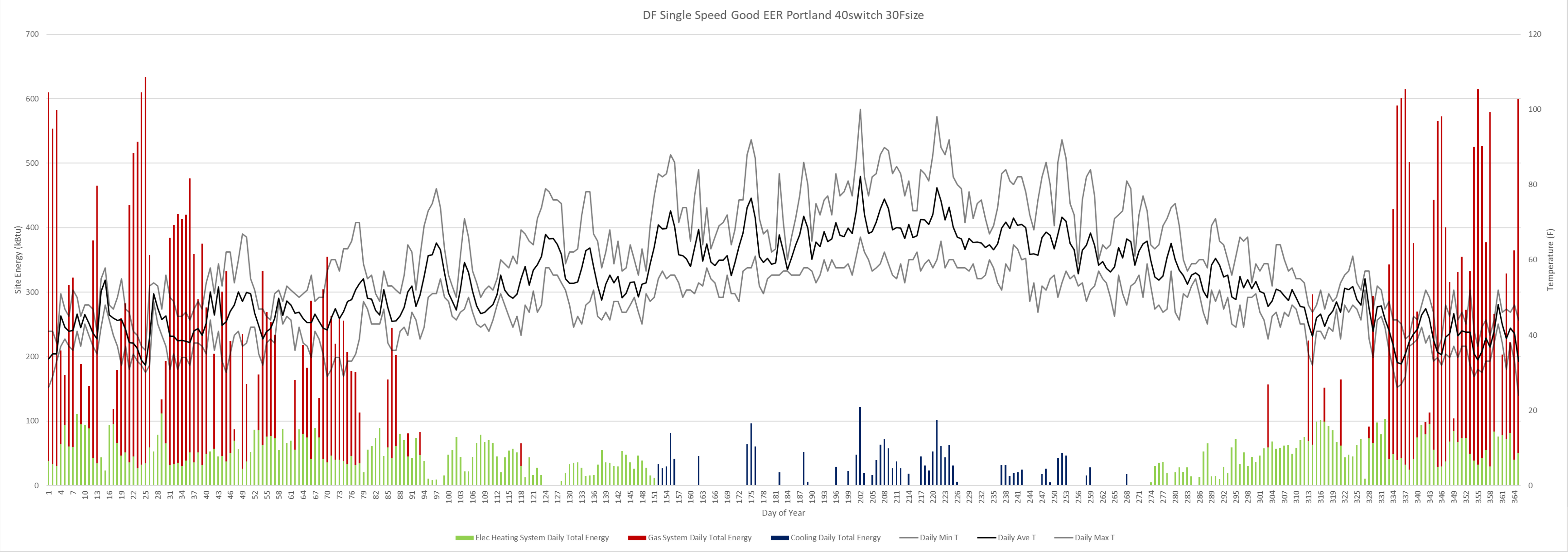
Switchover @ 40F. Size 30F.

Switchover @ 40F
- Gas use in **red**
- Heat pump heating in **green**
- Cooling in **blue**

Annual plot by day

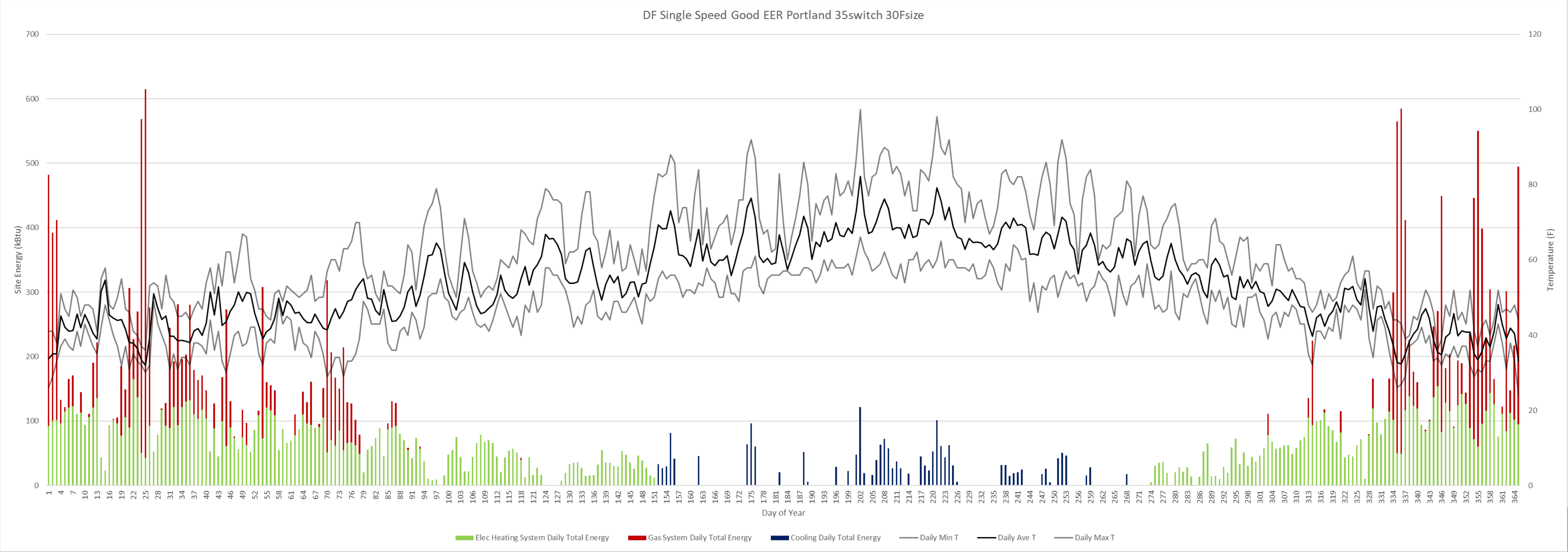
Site energy in kBtu/day

Outdoor temperature in F (black and gray)



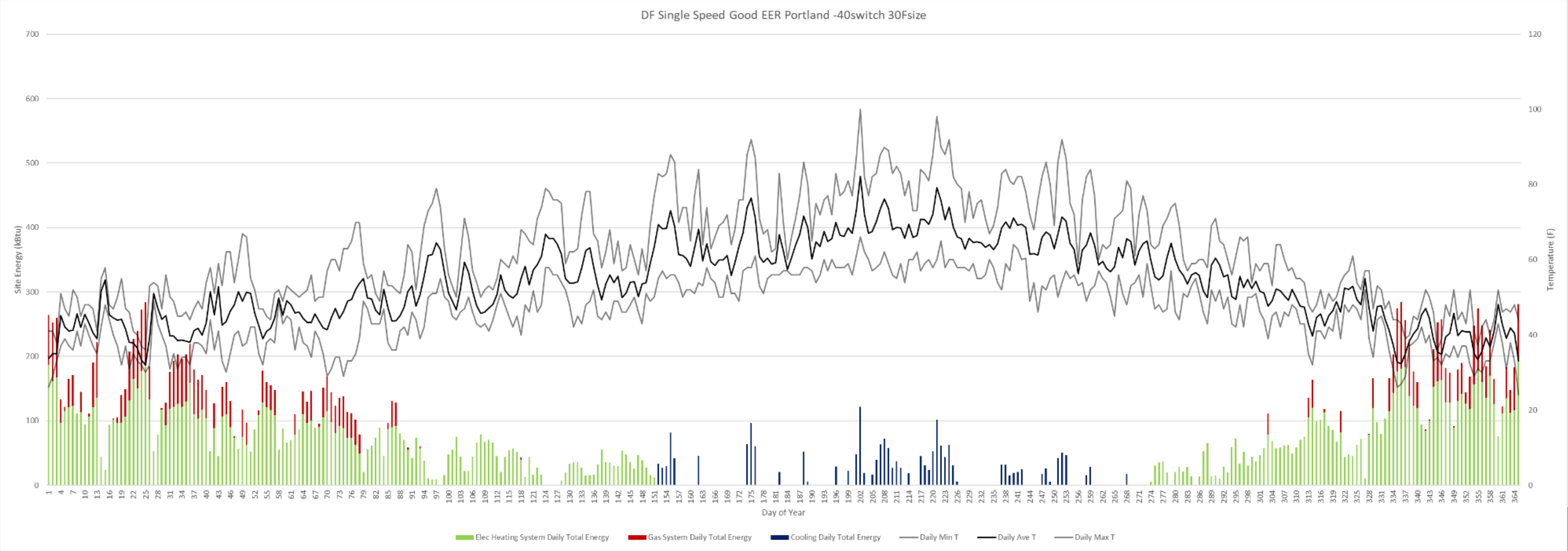
Switchover @ 35F Size 30F

Less gas use with lower switchover temperature



Supplement: 30F HP size

The supplement control minimizes gas. Uses gas furnace only when heat pump output capacity cannot meet 100% of the heating load.



Questions about base case, methods, tools?

Calculation Findings

Fundamental Results Case

Portland Climate

Heating System*	Control	Gas therms/yr	Electricity kWh/yr	GHG lbs. CO_2 / yr	Annual Operating Cost†
Furnace		631	668	8,127	$1,093
Furnace, Single Speed HP	30F Switchover	105	5,178	4,699	$821
Furnace, Single Speed HP	35F Switchover	154	4,726	4,994	$842
Furnace, Single Speed HP	40F Switchover	309	3,310	5,953	$912

*Heat pump sizes to 30 ºF balance point in all cases which equates to 3 tons. Air conditioner also 3 tons.

†Includes cooling cost of $65/yr

What if I live in a cold climate? Go bigger?

- Operating costs increase (or gains diminish) as HP balance point and switchover temperature decrease

- Bonus: staying at 30 F size means duct system large enough to handle air flow

- Notes
  - Single speed heat pump
  - Switchover at balance point.

Equipment Switchover (F) and Size (tons)		Heating Electricity MMBtu / yr	Heating Gas MMBtu / yr	Annual Operating Cost	GHG Emissions lbs CO_2 / yr
Spokane					
Furnace	-	2.4	115.3	$1,916	14,423
20 °F	4.5	32.1	28.8	$1,626	9,613
30 °F	2.7	18.7	61.9	$1,657	11,034
Bozeman					
Furnace	-	2.1	153.3	$1,645	18,892
20 °F	4.5	30.4	70.4	$1,832	14,299
30 °F	2.7	15.8	108.2	$1,669	15,989

Why not smaller than a 30 °F balance point size?

- Higher balance points (smaller sizes) do not have enough cooling capacity to meet cooling load
- Size for cooling in most Northwest climates and you get close to the 30F point for heating
  - *Boise is an exception

Climate	Cooling Need MMBtu / yr	Cooling Energy MMBtu / yr	Unmet need at 40 °F Size MMBtu / yr	Unmet need at 30 °F Size MMBtu / yr
Portland	5.0	1.7	1.1	0.0
Boise	15.1	5.3	5.8	0.7
Bozeman	8.7	3.0	2.9	0.2
Seattle	1.5	0.5	0.3	0.0
Redmond	7.4	2.5	2.2	0.1
Missoula	8.1	2.8	2.6	0.1
Idaho Falls	7.0	2.4	2.3	0.1

Takeaway:
Cooling load sizing sets the minimum size and it is, coincidentally, big enough for dual-fuel heating

What if I want the latest, greatest Heat Pump?

- Heat pumps with good low-load efficiency pair best with dual-fuel systems

System	Heat Pump COP	Annual Operating Cost
Portland		
Furnace with AC		$1,093
Furnace, Single Speed HP Good EER	3.1	$842
Furnace, Average Variable Speed HP	3.7	$768
Furnace, Low Load Efficient HP	4.6	$688
Furnace, Cold Climate HP	4.2	$731
Bozeman		
Furnace, AC		$1,645
Furnace, Single Speed HP Good EER	3.1	$1,652
Furnace, Average Variable Speed HP	3.5	$1,579
Furnace, Low Load Efficient HP	4.4	$1,521
Furnace, Cold Climate HP	3.9	$1,549

Heat Pump Type Definitions Used in Calculations

- **Single Speed Normal EER.** Meets the federal minimum for SEER2, 13.4, EER2, 9.0, and HSPF2, 7.5.
- **Single Speed "Good" EER**. A federal minimum compliant heat pump for hot climates. Has an EER2 of 11.2. Otherwise same heating performance as the other single speed heat pump.
- **Average Variable Speed HP**. A heat pump with a variable speed compressor. It is meant to reflect the market average. It is the same as the "Average One" archetype from the 2022 variables speed heat pump study.
- **Low-Load Efficient HP**. A variable speed heat pump that has relatively higher efficiency at low part load. This product will perform well in mild heating conditions of ~30F and above. At colder temperatures, it does not maintain its heating output capacity as well as a cold climate heat pump would. Patterned after the Daikin Fit product line.
- **Cold Climate HP**. A variable speed heat pump that maintains output capacity at colder conditions, especially down to 5F. This comes at the expense of relatively poor low load efficiency. Patterned after the Mitsubishi Hyper M-Series product line.

Questions about sizing and switchover findings?

Fuel Costs, Ratios, & Breakeven COP

Electric vs Gas vs Propane Rates Matter

- Customer value proposition depends on gas and electric rates
  - There is a compelling value for dual-fuel systems in WA and OR.
  - Less so in ID and MT because gas is less costly there.

Location	Electricity	Gas	Propane
	$/MMBtu (site)	$/MMBtu (site)	$/MMBtu (site)
WA, OR	33.9	15.1	-
ID, MT	34.0	9.5	24.2
Translation to Efficiency			
	Given this site combustion efficiency…	**…Breakeven Electric COP Is**	
WA, OR	0.95	2.1	-
ID, MT	0.95	3.4	1.3

If the site cost of energy ratio is 34 / 9.5, Elec:Gas, and your onsite combustion efficiency is 0.95, you need an electric onsite COP of 3.4 to breakeven.

For propane ratio 34 / 24.2, Elec:Propane, the breakeven point is only 1.3

Rates Matter: Same HP Efficiency, Different Outcome

Heating System	Heat Pump COP	Operating Cost Savings	Emissions reductions lbs CO_2 / yr
Portland – Furnace, single speed HP, switch at 35F	3.1	$251	3,133
Missoula – Furnace, single speed HP, switch at 35F	3.1	-$14	2,293

Compared to gas furnace and AC in base case

What if I have delivered Propane and not Piped Gas?

Heating System	Balance Point and Switchover (F)	Heat Pump Size (tons)	Heat Pump COP	Operating Cost Piped Gas ($/yr)	Operating Cost Propane ($/yr)
Missoula					
Furnace		3.0		$1,420	$3,324
Furnace, Single Speed HP	20 F	4.5	2.9	$1,619	$2,294
Furnace, Single Speed HP	30 F	2.7	3.1	$1,454	$2,642
Furnace, Single Speed HP	40 F	1.4	3.4	$1,374	$3,233

- Missoula climate
- Single speed heat pump
- Remember: breakeven COP for propane is only 1.3
- 2.9 COP is still way above 1.3

Takeaway:
You changed my mind. For propane fuel costs, go to 20F balance point or lower.

What if I want to minimize electric grid peak impacts?

Dual-fuel systems, with switchover temperatures at 30F, inherently minimize the peak grid impact. All PNW winter peaks occur when temperatures below 30F. The heat pump will not be running.

Future scenarios with flex load, communicating products could receive signals to switch between electric and gas heating.

Review

- Size to ~30F balance point
- Set switchover temperature a few degrees above balance point
  - Any higher is a wasted investment in HP equipment.
- Customer value proposition depends on fuel cost ratios
  - Natural Gas
    - Oregon and Washington ratios offer compelling case
    - Idaho and Montana ratios far less compelling
  - Delivered Propane
    - Substantial operating cost savings. Highly compelling.
- Dual-Fuel is never a bad choice relative to baseline
  - There is always something to be gained
    - Lower operating costs or lower GHG emissions
- Which heat pump type?
  - Single speed heat pumps work
  - Variable speed and low-load efficient heat pumps offer additional benefits
  - Low temperature performance, < 30° F, is not important because gas heating will run then

Discussion

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Extras

More on supplemental equipment

- Operationally, when does it make sense?
  - When heat pump efficiency above the breakeven COP but outdoor temperatures below the balance point.
    - Heat pump runs at max capacity, meeting partial load. Then gas system adds missing capacity.
- Simultaneous gas heating and heat pump heating only possible with special system designs. Not yet commonplace in the market.
- Supplemental heating / simultaneous operation can offer further gas energy use reductions, operational flexibility, and, in some cases, further operational cost savings.

Operating Cost Summary

Portland Climate with 30F balance point heat pump

System	HP Size 30F Balance Point (tons)	Control	Annual Operating Cost	18-year Value @ 3% Discount
Furnace		na	$1,093	---
Furnace, Single Speed HP	3.0	35F Switchover	$842	$3,452
Furnace, Low Load Efficient HP	3.0	35F Switchover	$688	$5,570
TWH+AHU, Single Speed HP	3.0	Supplement	$806	$3,947
TWH+AHU, Low Load Efficient HP	3.0	Supplement	$645	$6,162

- Even single speed HP offers savings
- Low-Load Efficient HP offers more but will cost more
- Supplemental/Simultaneous:
  - Tankless Water Heater + Air Handler Unit (TWH+AHU) offers marginally more savings

A Glimpse Into the Future: SDFS

Smart Dual-Fuel Switching (SDFS)

Time-of-Use Rate Optimization

To optimize cost, the controller shifts heating load from electric to gas during electricity rate peaks. As a result, TOU-optimized operation uses more gas than standard controls.

Table 13. TOU-Optimized Fuel Switching Results

	Annual Heating Operating Cost		Electric share of heating input energy	
	Standard Control	TOU Control	Standard Control	TOU Control
Furnace with AC	$1,078		3%	
Furnace, Single Speed HP Good EER	$765	$640	51%	44%
Furnace, Low Load Efficient HP	$635	$552	44%	37%
TWH+AHU, Single Speed HP Good EER	$717	$608	70%	49%
TWH+AHU, Low Load Efficient HP	$581	$515	64%	43%

SDFS: GHG Emissions Optimization

Smart Dual-Fuel Switching (SDFS)

Table 14 shows the results of the GHG-optimized control for the same equipment and climate. Interestingly, this control had no significant effect on the operation of the TWH+AHU systems. This is because the standard controls for those systems are already effectively optimized for emissions reductions by maximizing heat pump use.

For the gas furnace systems, the GHG-optimized control shifts some of the heating load from gas to electric. In both cases this led to an 11% decrease in GHG emissions.

Table 14.GHG-Optimized Fuel Switching Results

	Annual Heating Emissions lbs. CO_2		Electric share of heating input energy	
	Standard Control	GHG Control	Standard Control	GHG Control
Furnace with AC	7,996		3%	
Furnace, Single Speed HP Good EER	3,593	3,215	51%	61%
Furnace, Low Load Efficient HP	3,152	2,794	44%	53%
TWH+AHU, Single Speed HP Good EER	2,892	2,905	70%	70%
TWH+AHU, Low Load Efficient HP	2,439	2,444	64%	64%