Cambridge Air Solutions
White Paper

Electric vs. Gas Heat

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Introduction

Large spaces such as warehouses can be efficiently heated with natural gas. High efficiency direct gas fired heating equipment (92% efficient) is highly practical for these spaces - particularly those with high heat demands - as the high heat content per CFM of outside air that can be delivered results in relatively few units being required to meet a building's heat load.

Recently, some localities and states have implemented or are considering legislation or building code changes that prohibit or severely restrict natural gas usage, requiring electrification as a means of carbon footprint reduction. However noble these pursuits may be, they neglect the practicality of electrical infrastructure capacity constraints and the steep increase in electrical service requirements that result from natural gas / propane prohibitions. The purpose of this paper is not to debate whether natural gas should be prohibited, but rather to discuss the practical implications of heating large spaces with electric instead of natural gas and to submit that gas fired heating equipment is a historically reliable and effective means of decarbonization.

To understand the implications of using electric heat in lieu of natural gas fired equipment, a sample 1.1M square foot warehouse located in Kelso, Washington with characteristics shown in Attachment 1 will be considered. With the following design conditions, the subject building has a total heat load of 6,615 MBH (detailed calculations are shown in Attachment 2).

Freeze protection inside design temperature.......40°F
Outside design temperature.................................18°F
ASHRAE 62.1 minimum ventilation........................120,000 CFM
Total Building Heat Load............................6,615 MBH = 1,939 kW [1]

This heat load represents 5.6 BTU per square foot for the subject building. Electrical service of 460V/3PH is common for these types of buildings and is assumed for this analysis. At 1,939 kW, the building requires 2,433 amps of electrical service for heating alone.

$$I = \frac{P}{V \times \sqrt{3}} = \frac{1{,}939kW}{460V \times \sqrt{3}} \times \frac{1000VA}{1kW} = 2{,}433\ Amps$$

where $I = current\ (amps), P = power\ (kW), V = voltage\ (volts)$

The actual building requirement will exceed this after accounting for lighting, blower fans, conveyors, process equipment, and other necessary building systems or newly legislated electrified components.

Building owners and engineers can use this information to determine the practicality of electrical service requirements when initially specifying a building and the type of heating equipment. Other considerations include the relatively fewer number of natural gas units required to heat a building.

For the subject building, an average of six direct fired natural gas Cambridge units could meet both the building's ventilation and heat load whereas a minimum of thirty two 60kW electric unit heaters would be required to similarly meet the building's heat load.

[1] At 3.412 MBH per 1 kW

Some engineers use an additional 10-20% more unit heaters than necessary to meet the heat load to overcome unit heater system inefficiencies and destratification limitations. Additionally, other equipment would be needed to address the outside air ventilation requirement. It should not be discounted the environmental impact and cost of manufacturing, transporting, installing, and maintaining this extra equipment simply for the sake of not using natural gas. Ongoing utility costs for electric heat are over double what they are for a functionally equivalent natural gas heating system (for the above scenario at the design condition, electric and natural gas costs would be $233 and $99 per hour respectively)[2].

Even more disconcerting is that every equivalent unit of heat produced by an electric heater emits 58% more carbon dioxide than does natural gas after factoring in local emission rates for electricity generation in Kelso, WA.

According to the Environmental Protection Agency:

- Electricity in Kelso, Washington has a CO_2 emission rate[3] of 634 lbs / MWh
- Natural gas has a CO_2 emission rate[4] of 11.7 lbs / therm of natural gas

Put in equivalent terms with a conversion of 34.1 therms per 1 MWh:

- Electricity in Kelso, Washington has a CO_2 emission rate of 634 lbs / MWh
- Natural gas has a CO_2 emission rate of 399 lbs / MWh

The above analysis considers a modest outside design temperature and the minimum possible inside design temperature (i.e., freeze protection applications) – additional heating requirements will only worsen the situation. Furthermore, outside design conditions can be significantly lower in other locations. For example, Spokane's winter design temperature is 6.1°F, but many engineers design for 0°F to include safety factor and global temperature fluctuations. Furthermore, certain inventory and equipment can require higher minimum indoor design temperatures. Perhaps more importantly, the health and wellbeing of employees (and the corresponding attrition resulting from poor working conditions) can justify comfort heating applications in which indoor design temperatures can exceed 60°F.

[2] Assuming electric cost of $0.12 / kWhr and natural gas cost of $1.5 / therm
[3] https://www.epa.gov/egrid/power-profiler#/NWPP
[4] https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator#results

Using the same method and building as shown above but instead located in Spokane, the electrical service requirement for heating alone is shown below:

Inside design temperature..40°F
Outside design temperature....................................0°F
<u>ASHRAE 62.1 minimum ventilation..........................120,000 CFM</u>
Total Building Heat Load..............................12,027 MBH = 3,525 kW[5]
Electric Heat Amperage Requirement........4,424 amps

Similarly, for a comfort heated building in Kelso:

Inside design temperature..65°F
Outside design temperature....................................18°F
<u>ASHRAE 62.1 minimum ventilation..........................120,000 CFM</u>
Total Building Heat Load..............................14,132 MBH = 4,142 kW[6]
Electric Heat Amperage Requirement........5,198 amps

And lastly, for a comfort heated building in Spokane:

Inside design temperature..65°F
Outside design temperature....................................0°F
<u>ASHRAE 62.1 minimum ventilation..........................120,000 CFM</u>
Total Building Heat Load..............................19,544 MBH = 5,728 kW[7]
Electric Heat Amperage Requirement........7,189 amps

[5] Equals 10.2 BTU / sqft for the subject building
[6] Equals 12.0 BTU / sqft for the subject building
[7] Equals 16.6 BTU / sqft for the subject building

The electrical amperage requirement at any given heat load can be quickly estimated using the chart below in Figure 1. For buildings with large heat load requirements resulting in heat inputs exceeding 8 BTU / square foot, other factors such as increased insulation or reduced minimum ventilation must be considered to meet semi-heated space restrictions, where applicable.

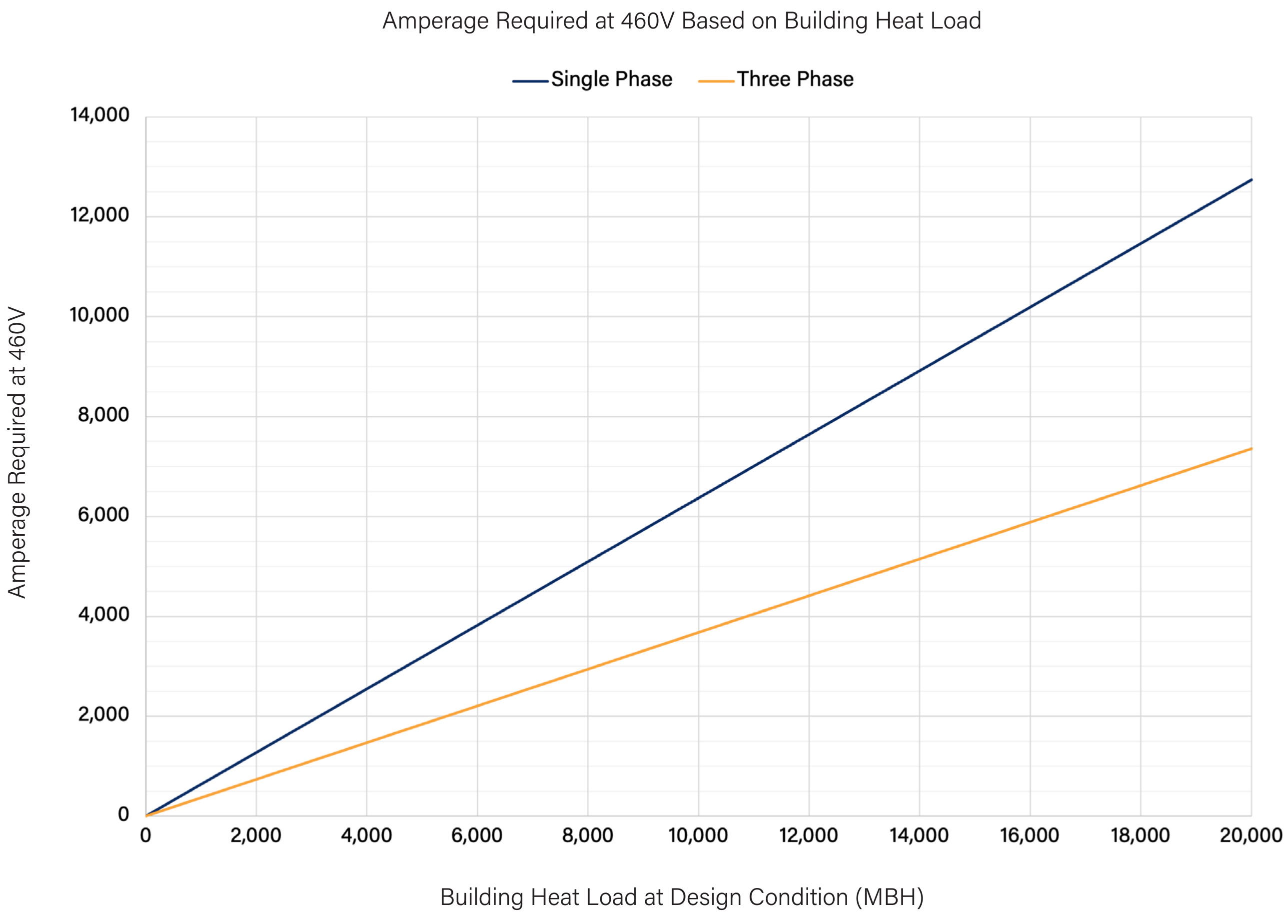

Figure 1: Estimated building amperage requirement at various building heat loads

These results show the exceedingly high electric service requirement that results from a decision to use electric heat instead of natural gas and how the requirement varies depending on where a building is located and the associated design conditions. The practical implications of electrical heat vary greatly based on design temperature difference and are exacerbated by the relatively greater number of electric heating equipment required to simply heat a space.

Highly efficient direct gas fired heating equipment is more practical than electric heating equipment and serves as a means of decarbonization given its 92% efficiency rating.

While in some cases electric heating may indeed be appropriate, its use is not suitable for all applications and natural gas prohibitions should not be indiscriminately implemented without considering the large building heating and ventilating nuances discussed herein.

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For nearly 60 years, Cambridge has enriched the lives of its people, customers and suppliers through the design, manufacture and application of HTHV (high temperature heating and ventilation) space heating, ventilation and evaporative cooling products for commercial, industrial and manufacturing facilities.

Cambridge team members and their network of 550+ sales representatives help leaders in manufacturing and warehousing create healthy work environments by creating thermal comfort and improved indoor air quality so that workers can thrive. With more than 55,000 system installations and 3 billion square feet of buildings served. Deeply rooted in a continuous improvement (lean) culture, Cambridge is able to create superior products based on quality, effectiveness and the overall customer experience. This mindset is shared openly and freely with like-minded leaders looking to find ways to engage their employees.

Cambridge is headquartered in Chesterfield, Missouri with its expansion facility located in Wentzville, Missouri. **www.cambridgeair.com**

Attachment 1

Project: Washington Warehouse
Location: Kelso, Washington

Design Temperatures

Indoor	Outdoor
40 °F	18 °F

Physical Conditions

Building Dimensions

Height	Length	Width	**Total Heated Space**
40′ flat roof	1,200′	980′	**1,176,000 ft^2**

Building Materials

Roof	Wall
R-41.8	R -1.6

Skylights

Quantity	Length	Width	Pane
80	4′	4′	Plastic

Dock Door 1

Quantity	Size	Seals	Open
100	10′ x 9′	Sealed	10.0%

Operating Conditions

Ventilation

ASHRAE 62.1 minimum fresh air ventilation: 120,000 CFM

Attachment 2

Project: Washington Warehouse
Location: Kelso, Washington

Design Temperatures

40 °F Indoor Design Temperature
-18 °F Outdoor Design Temperature

22 °F Design Temperature Difference (DTD)

Base Heat Load

Conduction Load *(Net Area [ft²] x U-Value [Btu/(hr°Fft²)] x DTD[°F] ÷ 1000[Btuh/MBH] = MBH)*

Roof	R=41.81,200'L x 980'W	1,174,720 ft² x 0.0239 x 22 = 618 MBH
Walls	R=1.64,360 'L x 40'H	174,400 ft² x 0.6250 x 22 = 2,398 MBH
Skylights R=0.9	4'L x 4'W	1280²ft x 1.2 x 22 = 32 MBH

Subtotals:	Roof Load:		618 MBH
	Wall Load:	+	2,398 MBH
	Skylight Load:	+	32 MBH
	Total Conduction Load:		**3,049 MBH**

Infiltration Load *(Volume[ft³] ÷ 60[min/hr] x ACH[1/hr] = Airflow[CFM])*

(Airflow[CFM] x Heat Transmission Factor [Btu/hr°Fft²] x DTD[°F] ÷ [1000BTUh/MBH] = MBH

Infiltration Airflow 47,040,000 ft³ ÷ 60 min/hr x 0.15/hr = 117,600 CFM

Infiltration Load 117,600 CFM x 1.19 Btu/hr°Fft² x 22°F ÷ 1000 BTUh/MBH = 3,084 MBH

Total Infiltration Load: 3,084 MBH

Operating Heat Load

Open Door Load *(Quantity of Doors x MBH/Door x %Open = MBH)*
(100 x 22 x 10.0%) = 220 MBH

Process Gains or Losses
Additional ventilation required to meet ASHRAE 62.1 minimum + 262 MBH

Total Operating Heat Load: **482 MBH**

Total Heat Load: 6,615 MBH