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A primer on whole-building electrification - by Hall and Alpert

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What is building electrification? Electrification is the process of transitioning building systems, processes, and components to be powered by electricity rather than by various fossil fuels like oil or natural gas and can be a critical component in efforts to reduce carbon emissions. Currently, there are many building systems and components that could be powered by electricity but are not. This transition is supported by state governments, local governments, and various utilities throughout New England. Besides reduced carbon emissions, the benefits of electrification include increased operational controls and quieter operation. Electrification can also make the integration of building energy management programs easier. This would have the added benefit of allowing building and facilities managers to better control overall electricity use through advanced lighting and HVAC controls and realize energy cost savings. There are several options available to electrify building systems and components for commercial buildings in the Northeast.

Air-to-Water Heat Pumps:
Air-to-water heat pumps (AWHP) extract heat or cooling from the ambient air and convert the temperature differential into a liquid. They use only a minimal amount of electricity to carry and deliver the required amount of heat to a space. AWHPs are suitable for both heating and cooling for both retrofitting existing buildings and for new construction. Since this is one possible solution to electrify HVAC systems, the infrastructure associated with the electrical panels and service needs to be reviewed by an electrical engineer to ensure that enough capacity is available both on the customer and the utility side.

In general, AWHPs are best suited for larger commercial spaces, over about 10,000 s/f, that have an existing hydronic loop or boiler for space heating. Ideally, this could be for moderate or cold climate applications as long as enough redundancy and/or backup is available. This would also be the preferred solution for older buildings due to the limited duct work requirements, saving space on large air ducts compared to forced hot air or air-to-air heat pump systems.

One example of a modular AWHP system that has been proposed is in the town hall in a Boston

suburb. The town has explored the feasibility of installing a 100+ ton, 8-module AWHP system to provide 100% of the heating load and to cool the 28,000 s/f building, completely displacing natural gas for heating. The net gas savings are expected to be in the range of 15,000 therms, however there is an associated electric penalty for the project of 159,500 kWh due to the increased electric load. The total estimated cost for the proposed retrofit is $6 million, so any energy efficiency program contribution would highly impact the feasibility of installation.

Building electrification systems, like this VRF heat pump unit, can be a critical component in efforts to reduce carbon emissions from building heating and cooling.

Variable Refrigerant Flow:
Variable refrigerant flow (VRF) applications are ideal when the customer desires features like:

• Customizable temperature settings for simultaneous heating and cooling needs,

• A high-capacity large scale HVAC system,

• Limited space ductless solutions,

• Relatively easy installation,

• Noise sensitivity issues,

• Energy efficiency, or

• Electrification considerations.

The power consumption for an air-sourced heat recovery VRF system can be 20-30% less than conventional air-sourced chillers and VAV (variable air volume) terminal units due to better energy efficiency.

A 92,000 s/f school building in New England proposed VRF as one of the options to remedy the lack of sufficient ventilation, musty environment in the lower level, and poor air quality in general. Fan coil units (FCUs) would provide heating and cooling. As a result, an additional 367,000 kWh of electricity would be consumed, with the expected heating oil savings amounting to 47,000 gallons. The total stipulated project cost would be around $8 million while the annual cost savings would be around $14,000 compared to the existing fuel-oil-fired scenario.

Ductless Mini Splits:
Ductless mini splits are best suited for smaller commercial applications due to their independent zone temperature control requirements, minimal sound impacts, and easy installation, along with low

maintenance needs. The ductless mini split solution has superior efficiency over traditional window air conditioners and central air conditioning systems with much lower energy bills. Some mini splits have a seasonal energy efficiency ratio (SEER) ranging from 16 to 38. The upfront costs are relatively high, but they offer greater energy and cost savings in the long run, especially in climates where there are significant cooling needs, including central and southern New England.

Ground Source Heat Pumps:
Ground source heat pumps (GSHP) are considered the best long-term solution when the goal is to reduce carbon emissions and increase the energy efficiency of a building's HVAC system. They are well-suited for cold climates like New England due to the efficiency gains and cost reductions increase when both space heating and cooling benefits are realized. GSHPs can reduce energy bills by up to 65% as compared to traditional HVAC systems, making the payback period shorter and far more practical. However, the biggest issue to installing these types of systems is the significant upfront capital cost required.

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Other Information Resources:

HPAC Magazine - A look at air-to-water heat pump systems

Energy Star - 2019-2020 Air-to-Water Heat Pumps

Fergusion.com - What Is VRF in HVAC?

Consulting-Specifying Engineer (csemag.com) - Regulating HVAC with VRF systems

AlpineHomeAir.com - Ductless Mini-Split Systems: AC & Heat

NED (newenglandductless.com) - Are Mini-Splits Energy Efficient?

Which? - Ground Source Heat Pumps Explained

US Department of Energy - 5 Things You Should Know about Geothermal Heat Pumps

US Department of Energy - Geothermal Heat Pumps

Building America Solution Center (pnnl.gov) - Ground-Source Heat Pumps