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TECHNICAL ARTICLE

The 'Right' Way to Approach Building System Electrification

Four-part Technical Series on Buildings & Carbon-Neutrality
Part 3 – The 'Right' Way to Approach Building System Electrification

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With Parts 1 & 2 of our four-part series on buildings and carbon neutrality published, we can now discuss the 'right' way to approach building system electrification a little. In particular, we believe the conversation should be economically grounded as, of course, the dollars and cents of a decision are usually one of the most determinant factors. Let us continue to use NYC as our test case here although commentary for other locales is included below:

Historically the price of electricity in NYC has been on the order of 4-4.5x the price of natural gas. At $0.18/KWH and $1.20/therm the ratio is 4.39 to put today's pricing into context. To begin to understand the economics of electrification, we should discuss electric and gas-fired equipment efficiencies. Let us speak in terms of heating equipment as this is most readily approachable.

A gas-fired boiler or furnace might typically have a thermal efficiency on the order of 85-95% noting lower efficiencies are certainly possible for older or poorly tuned equipment. In contrast, a heat pump for space heating would have an efficiency expressed as a Coefficient of Performance (COP) and a typical air-source heat pump COP in NYC might be say 3 to 3.5, plus or minus.

Now, fossil based equipment creates energy by combusting fuel for heating and energy is lost in the process, hence the less than 100% efficiency. Heat pumps in contrast simply move energy and the COP is the ratio of energy needed to do so. With a heat pump, if we need 300 BTUs of heat in a space and the COP is 3, we need 100 BTUs of electrical energy to get that to happen. An air-source heat would take this energy from the air whereas a water-source heat pump would take this energy from a water source.

This really starts to get interesting when we begin to compare systems:

If we compare the operating cost of a gas-fired system at a 90% efficiency to a heat-pump based system with a COP of 3.5, we can see on first order that the break point pricing-wise in support of building system electrification in this example exists when electricity costs no more that 3.89x the price of gas because 3.5 divided by 0.9 is 3.89. This is very oversimplified because a number of operational factors like pumping/fan energy for fossil-based systems are neglected among many other things. Thus, in many cases the operational economics of heat-pump based systems in NYC can be superior to that of fossil-based systems even ignoring any applicable carbon tax liability that may be looming under LL97 (see Part 2 of our series).

Things get more complicated from here as air-source and water heat pump efficiencies are very sensitive to air and water temperatures. Thus, the industry has coined the termed cold-climate air-source heat pumps (ccASHPs) as one front of technological advancement in this arena has revolved around improving heat pump efficiencies at low source temperatures.

To add some context for non-NYC geographies, the ratio of the cost of electricity to gas in other domestic jurisdictions is typically less than 4x. This would clearly benefit the economics of electrification

noting in particularly cold climates one must be very mindful of low temperature de-rate. (We discussed this extensively on a multi-building project in Detroit, MI for example). In say a mid-Atlantic or Southern region increasingly higher COPs can be accessed for same domestic hot water heating while simultaneously accessing a lower electricity-to-fossil cost ratio and electrification can be a 'home-run'.

All of this to say that while there are clearly many complexities involved, including many not mentioned herein, proper building system electrification can be very economically grounded particularly when considering carbon taxes, third party incentives (e.g., NYSERDA, ConEd, etc. coming home to NY) and otherwise. Keeping an eye on electrical system 'COP' as the prize is the key as is associated systematic design to maximize electrical efficiency and economic pro-forma associated.

The response to the first two parts of our ongoing series here has been fantastic, so keep it up! And we look forward to closing our series out with a discussion of what electrification means for the nation's electrical grid.

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