Justifying Replacement of Existing HVAC Equipment with Above-Code Higher Efficiency Equipment

By

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A growing challenge for contractors in today's price-sensitive market is the ability to provide building owners with an estimate of energy cost savings when proposing to replace existing HVAC equipment with new, more energy efficient equipment. This challenge has become increasingly acute in today's highly competitive environment where building owners demand an economic justification for the premium typically required when installing higher efficiency equipment rather than less expensive, minimally code-compliant equipment.

Traditionally, contractors have not provided estimates of energy cost savings in their equipment replacement proposals to justify the cost premium of higher efficiency equipment. There is no argument that the higher efficiency equipment can reduce utility bills for the building owner over the life of the equipment; however, providing an estimate of how much cost savings can be achieved is rarely if ever addressed.

Unfortunately, this shortcoming prohibits the building owner from evaluating the cost-benefit of alternative equipment options. As a result, the building owner is unable to make an informed decision. This proposal information deficit typically results in the selection of the lowest cost equipment that meets local energy code requirements – an "everyone loses" outcome.

Compounding the challenge is the fact that most building owners are unwilling or unable to invest the resources (time and money) to conduct an energy cost savings assessment. This is particularly challenging in the small-to-medium-sized buildings (SMB) market, i.e., buildings less than 50,000 square feet which represent most commercial buildings, where project dollar values typically do not support energy cost savings analysis.*

More than seven million commercial and multifamily buildings are in the SMB size category, representing almost 95% of all commercial and multifamily buildings (five or more units) in the country. Moreover, more than 5% of existing HVAC equipment at the end of its useful life is estimated to be replaced each year. Given the significant potential energy savings that can accrue by installing more energy efficient equipment when equipment is replaced, there is a need to equip contractors with a methodology to estimate energy savings that can flow from the installation of above-code, higher efficiency HVAC equipment.

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* According to the most recent U.S. Energy Information Administration's Commercial Building Energy Consumption Survey (CBECS), approximately 94% (5.6 million) of all non-residential commercial buildings are less than 50,000 square feet.[1] Additionally, according to the most recent Residential Energy Consumption Survey (RECS), HUD and U.S. Census Bureau data, there are approximately 1.6 million commercial multifamily buildings with five or more units that are less than 50,000 square feet.[2-4]

The potential energy savings resulting from the installation of more energy efficient equipment in this SMB market is significant and provides an "everyone wins" opportunity that should not be ignored:

- **Contractors**: have the cost-benefit information needed to differentiate their proposals resulting in sales of higher efficiency, higher margin equipment.
- **Building owners**: have the "business case" information needed to justify investment in high efficiency equipment that is eligible for rebates and yields a greater return on investment.
- **Tenants/employees**: benefit from the building's improved comfort and indoor air quality.

As such, there is a substantial market need for contractors who are routinely being asked to replace existing HVAC equipment at or beyond its useful life to have the capability to estimate energy consumption and cost savings associated with replacement equipment at various levels of energy efficiency. Such a capability will provide the building owner with the cost-benefit analysis needed to justify the cost premium required for higher efficiency equipment that often provides a superior return on investment. A contractor able to provide such cost-benefit comparisons, e.g., high efficiency, above-code versus standard efficiency, code-compliant equipment, will have a distinct advantage over contractors unable or unwilling to provide this level of analysis.

Methodology

The methodology to estimate energy cost savings that may accrue from replacing existing equipment with higher efficiency equipment involves six steps:

(1) A review of recent utility bills for a minimum of one year to determine the building's annual energy consumption and utility rate structure.
(2) Utilizing publicly available data to estimate end-use energy consumption based on the type of building and adjusting the data for the specific building location.
(3) Estimating the energy efficiency metrics of existing equipment being replaced and the building end-use(s) that will be impacted.
(4) Identifying the new replacement equipment's energy efficiency metrics.
(5) Estimating the percentage of end-use energy consumption savings based upon comparison of the energy efficiency metrics of the existing and new replacement equipment.
(6) Estimating the energy consumption savings and converting this to energy cost savings over the estimated life of the replacement equipment.

Building Energy Use

Recent historic utility billing data should be collected for electricity use and, if applicable, for fuel use such as natural gas or fuel oil. The period over which the utility bills are collected to establish the baseline whole building energy consumption should include at least one year's worth of data and represent the building's typical operation (e.g., not during times of major renovation).

End-Use Energy Consumption

The major commercial and multifamily building end-uses include:

- Space heating
- Space cooling
- Domestic hot water (DHW) heating
- Lighting
- Ventilation
- Cooking
- Refrigeration
- Office equipment
- Computers.

Building baseline end-use energy consumption data are publicly available for commercial and multifamily buildings in the U.S. from three publicly available sources.

- For commercial buildings located in the U.S. there is the U.S. Energy Information Administration's Commercial Buildings Energy Consumption Survey (CBECS).[5]
- For multifamily buildings in the U.S. there is the Energy Information Administration's Residential Energy Consumption Survey (RECS).[6]
- For commercial buildings located in California there is the California Commercial End-Use Survey (CEUS).[7]

It is important to note that using these end-use energy consumption data directly may result in significant inaccuracies stemming from how these data are presented, i.e., typically representing large geographic regions that can encompass significant variation in weather conditions (which will result in different building energy use profiles).[8] As such, the data need to be adjusted to account for building location and local climate.

Adjusting for building location and local climate is generally accomplished by making the reasonable assumption that only the space heating and cooling building end-use energy consumptions will be impacted by weather, and then adjusting the publicly available end-use energy consumptions using appropriate heating and cooling degree day data.* The methodology to accomplish this has been described in previous articles and publications.[8,9]

Once the end-use energy consumption data have been adjusted for building location and local climate, they should then be weather-normalized. Weather-normalization is performed for the space heating and cooling end-uses and involves adjusting these end-uses to better reflect long-term average heating and cooling degree days. This will allow the influence of unusual weather conditions in any one year to be removed, e.g., a warmer than normal winter or a colder than normal summer in any particular year, resulting in a more technically sound estimate from which future energy consumption savings may be determined.

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* See source of local heating and cooling degree day data: degreedays.net and weather.gov/wrh/climate.

Equipment Energy Efficiency Metrics

When estimating the energy savings associated with replacing existing equipment with new, high efficiency equipment, or comparing replacement equipment with different energy efficiencies, it is essential to have knowledge related to the energy performance of both the existing equipment (baseline) and the replacement equipment.

Estimating the energy performance of the existing equipment being replaced often requires investigation. Such equipment may, for example, no longer have an observable and readable nameplate tag, or the building owner/manager may not have access to the operating manual, original purchase order or proposal, or any other supporting documentation that might provide insight into the existing equipment's energy efficiency rating when installed. The nameplate tag on the equipment at a minimum should identify the manufacturer who can then be contacted to obtain key data. However, finding specifications for equipment that may be more than a decade old is often challenging. Furthermore, even if the equipment's original energy efficiency metrics can be identified, the equipment's current efficiency would not likely be at the same performance level as when it was first installed.

If research is unable to uncover the needed information, the existing equipment's efficiency may be estimated based upon its approximate age, the building energy code in effect when the equipment was installed, and an annual performance degradation factor (which exists over the life of the equipment). Unfortunately, the U.S. does not have a national energy code or standard, so energy codes are adopted at the state and local government level. As a result, local energy codes can vary widely; however, they generally follow the International Energy Conservation Code (IECC) or ASHRAE 90.1 Building Energy Standard. As such, it can reasonably be assumed that the equipment's energy efficiency metrics likely complied with the IECC or ASHRAE 90.1 standard in effect at the time the equipment was installed.*

Regardless of the methodology used to estimate existing equipment energy efficiency metrics, these metrics do not consider performance degradation that may have taken place since the equipment was first installed. Therefore, an estimate of equipment performance degradation over the period from the date of installation to the date of replacement needs to be made. Typical average annual performance degradation factors may be available from the manufacturer or have been published.[(8)] If they are not available, it would not be unreasonable to assume an annual performance degradation factor of 0.25% to 0.50% per year of operation.

Estimating Energy Savings

The energy efficiency metrics of the new replacement equipment should be readily available from the manufacturer. The energy consumption percentage savings can then be estimated as described in Table 1. This percentage savings would then be multiplied by the impacted end-use's weather-normalized energy consumption to estimate the energy consumption that might be saved in the first year. The energy consumption saved would degrade slightly each year going forward (based

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* See source of historic ASHRAE 90.1 standards: https://www.ashrae.org/technical-resources/standards-and-guidelines/read-only-versions-of-ashrae-standards.

on the equipment's assumed annual performance degradation) until the equipment's estimated useful life is reached. On the other hand, energy cost savings will increase each year going forward because energy costs are constantly increasing. Assuming an average annual energy cost escalation of 3-4% each year over the estimated useful life of the equipment would not be unreasonable.

The lifetime energy cost savings of replacement equipment at different energy efficiencies can then be determined. It would not be unusual to find that higher efficiency, more expensive equipment operating above-code provides a superior return on investment as compared to less expensive, minimally code-compliant equipment. Furthermore, this return on investment will typically be enhanced when considering potential utility rebates and government incentives that might be available for higher efficiency equipment. This cost-benefit information often provides building owners with the economic justification they need to purchase higher efficiency equipment even though it may have a higher first cost.

Conclusion

Most owners of commercial and multifamily buildings, particularly in the SMB market, place considerable weight on the upfront investment when making equipment replacement purchasing decisions. However, to make a more informed decision knowledge of both capital investment and operating cost information over the life of the proposed equipment is essential. While equipment with higher efficiency will typically have higher upfront costs, this may be more than offset by a lower operating cost over the life of the equipment complimented by available rebates and incentives often associated with higher efficiency equipment. Utilizing the methodology described herein to estimate energy cost savings has proven to provide a contractor with the tools to enable a building owner to make a more informed and confident decision to invest in higher efficiency equipment. At the same time, it will provide the contractor with a significant competitive advantage and result in an "everyone wins" outcome.

Third-Party Support Services

To support contractor efforts to estimate energy cost savings that may accrue from their proposed HVAC equipment replacements, third-party service providers have developed software and support services that turnkey the data collection, analysis, and calculations described herein. Contractors that prefer such third-party support to conduct these calculations and include cost-benefit analyses in their equipment replacement proposals, can benefit from partnering with a third-party provider.(10)

References

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(10) Sustainable Real Estate Solutions (SRS) is an example third-party service provider who has developed an Energy Performance Improvement Calculator (EPIC) to automate energy savings calculations for equipment replacements (refer to SRSworx.com).

Table 1. Typical Energy Savings Algorithms for Select Equipment Replacement.[8]

Equipment Being Replaced	Estimated Percentage Savings
Air Conditioning	$[1-(IEER_{Existing} / IEER_{New})] * 100$
Chiller	$[1-(IPLV_{New} / IPLV_{Existing})] * 100$
Boiler/Furnace	$[1-(\eta_{Existing} / \eta_{New})] * 100$
Heat Pump (Heating)	$[1-(COP_{Existing}/COP_{New})] *100$
DHW Heating	$[1-(EF_{Existing} /EF_{New})] * 100$

where:

IEER = Integrated Energy Efficiency Ratio, Btu cooling output/Watt-hr of electricity input
IPLV = Integrated Part Load Value, kW input/ton output
η = Average Fuel Utilization Efficiency, fraction
COP = Coefficient of Performance,
EF = Energy Factor, fraction.

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