CALCULATION GUIDE

Valuing HVAC Matched to Occupancy

The steps and examples below will walk you through a process for estimating the potential energy cost savings from matching HVAC to occupancy. The first calculation demonstrates how to calculate savings when electricity is used for both heating and cooling. The second provides an adapted calculation for use when natural gas is used for heating. We will use the example of a hypothetical multi-tenant office building in which we want to reduce HVAC runtime on one floor a total of 18 hours per week, assuming the HVAC system is zoned or equipped to provide floor-by-floor adjustments.

Key Variables

The following are variables typically used in valuing matching HVAC to occupancy:

Building space: square feet

Occupancy periods: hours per week

Electricity usage: kilowatts (kW) and kilowatt-hours (kWh)

Natural gas usage: therms

Energy costs and savings: dollars ($)

Savings Calculation (Electric Heating and Cooling)

Step 1: Review Current Building Space and Energy Use

Gather information about your facility's space and HVAC system configuration and operation. Floor plans, blueprints, and HVAC zone maps will be helpful for this step.

You will need to know your building's total square footage as well as the square footage of space that would be targeted for a potential HVAC runtime reduction – whether a section of one floor, an entire floor, multiple floors, or an entire building. Use floor plans or take physical measurements to determine the size of this *targeted space*.

Next, review HVAC system information to determine how conditioned air is supplied to the targeted space. For example, is the targeted space served by a dedicated air handler or one shared with other spaces within the building?

When you have isolated the equipment serving the targeted space, review the equipment's current weekly *operating hours*. This will provide the baseline for calculating the potential savings from better matching the HVAC runtime to the targeted space's actual occupancy.

We will use the following details and assumptions for our sample building:

- *Building square footage = 10,000 sq. ft.*
- *Targeted space for runtime reduction: 4,500 square feet*
- *Current HVAC operating hours:*
  - *14 hours a day, Monday–Saturday*
  - *Turned off on Sundays*

Your turn:

Building square footage: _____ square feet

Targeted space for HVAC runtime reduction: _____ square feet

Current HVAC operations:

Mon.–Fri. _____ hours

Sat. _____ hours

Sun. _____ hours

Total current weekly HVAC operating hours: _____ hours

Step 2: Obtain Energy Usage and Cost Information

Find your facility's electricity costs by reviewing your monthly or annual electricity bill. You will need to know your facility's annual *total electricity usage* (in kWH) and *total electricity cost* (in $). Electricity rates can vary regionally; in the Pacific Northwest, an average cost for electricity for commercial facilities is $0.08/kWh.

Following are the electricity usage and cost figures for our sample building:

- *Annual building electricity usage = 205,100 kWh*
- *Annual electric bill = $16,408 (at an average price of $0.08 per kWh)*

Once you have your building's energy usage and cost data, you will need to determine what percent of that usage is dedicated to running the HVAC system. As this can be challenging to determine or calculate, it may be simpler to use a benchmark or rule of thumb for this *HVAC percent of use*. For example, in the Pacific Northwest, HVAC systems consume about 40 percent of a commercial building's energy use, assuming electricity is used for both heating and cooling (see chart).

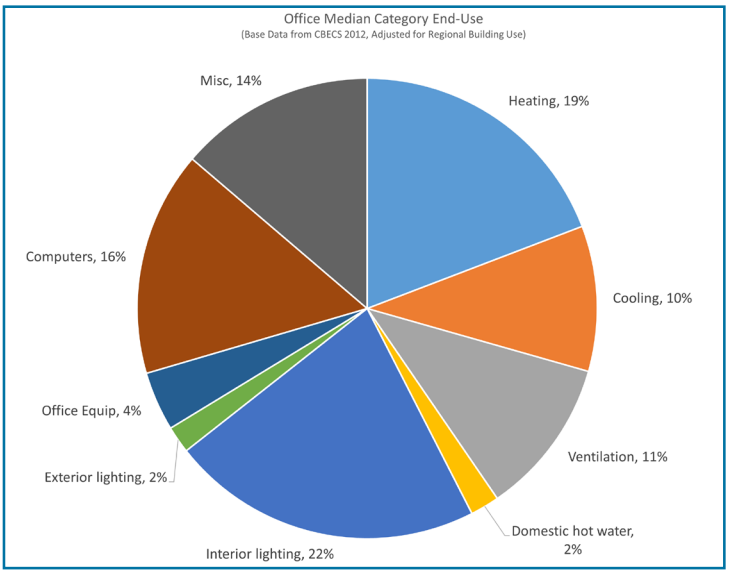

Image source: Strategic Energy Group

Next, determine the percent of your facility's space that would be affected by the runtime reduction by using your total and targeted space measurements. For example, if 4,500 square feet of a 10,000 square foot building are targeted for HVAC runtime reductions, then the *percent of space affected* would be 45 percent.

Your turn:

Annual building electricity usage: _____ kWh

Annual building electric bill: $ _____ (at $_____ /kWh)

HVAC percent of use: _____ percent (or use benchmark)

Percent of space affected: _____ percent

Step 3: Estimate Runtime Reduction in Targeted Space

Based on occupancy information gathered from conversations with occupants or tenants of the targeted space or through other means, identify a new HVAC operating schedule with reductions from the baseline you identified in Step 1. Compare the old and new operating schedules and calculate the resulting *schedule savings percentage*.

With our sample building, the current runtime schedule for our targeted space totals 84 hours a week. We can potentially reduce that to 66 hours a week by better matching runtime to the occupancy of the space as follows:

- *New proposed HVAC operations:*
    - *Mon.–Fri.: 12 hours per day*
    - *Sat.: six hours*
    - *Sun.: off*

This represents a schedule savings of 21.4 percent from the old runtime schedule, since *(84-66) / 84 = 21.4 percent*.

Your turn:
New HVAC operations:

Mon.–Fri. _____ hours

Sat. _____ hours

Sun. _____ hours

New weekly HVAC operating hours: _____ hours

Schedule savings percentage: _____ percent

Step 4: Calculate Estimated Annual Savings

Plug the data collected in the previous steps into the following formula to calculate estimated savings:

Estimated savings = Total electricity use (kWh) x HVAC percent of use x Percent of space affected x Schedule savings percentage x Electricity cost ($/kWh)

Here's how this looks for our sample building, based on our previous calculations and benchmarks:

Estimated savings = 205,100 kWh x .40 x .45 x .214 x $0.08/kWh

Estimated savings = $632.04

Your turn:
Total electricity use: _____ kWh

HVAC percent of use: _____ percent (or use benchmark)

Percent of space affected: _____ percent

Schedule savings percentage: _____ percent

Electricity cost: $ _____ /kWh

Estimated savings = Total electricity use (kWh) x HVAC percent of use x Percent of space affected x Schedule savings percentage x Electricity cost ($/kWh)

Estimated savings = _____ kWh x _____ percent
x _____ percent x _____ percent
x $_____/kWh

Your estimated savings: $ _____

Savings Calculation (Natural Gas Heating)

When natural gas is used as a heating source, it becomes necessary to allocate the electricity and heating energy usage by fuel type to estimate potential savings from matching HVAC to occupancy. In most cases, this involves simply evaluating the natural gas billing history to determine how much natural gas is used for space heating and allocating electricity usage to cooling and ventilation fans.

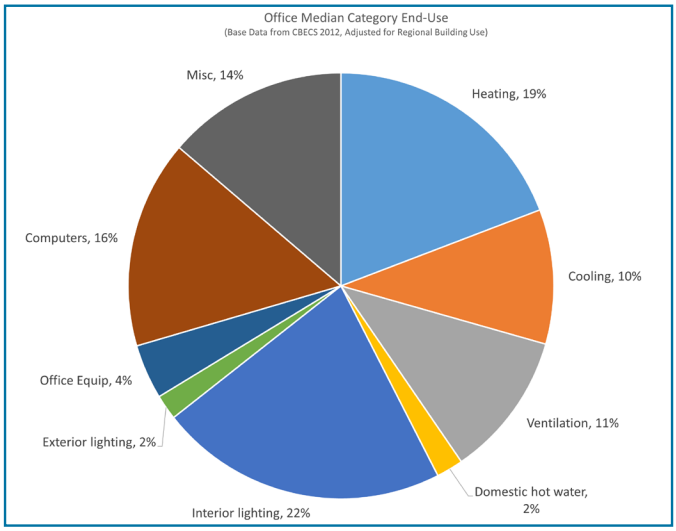

Image source: Strategic Energy Group

Things can get complicated if you have a combination of gas and electric heating, but for the purposes of this sample calculation, we will simplify and assume 100 percent natural gas heat. The two charts shown here illustrate typical energy uses in an office building west of the Cascade Mountains in the Pacific Northwest. The first categorizes typical office energy uses, and the second shows a sample natural gas use monthly billing history. From these we can see that HVAC uses about 40% of the building's energy, with heating representing 19 percent.

We can use the data in these two charts to evaluate the same 10,000 square foot office building used in the previous (all-electric) calculation, except now let's assume natural gas is used for heating and domestic hot water.

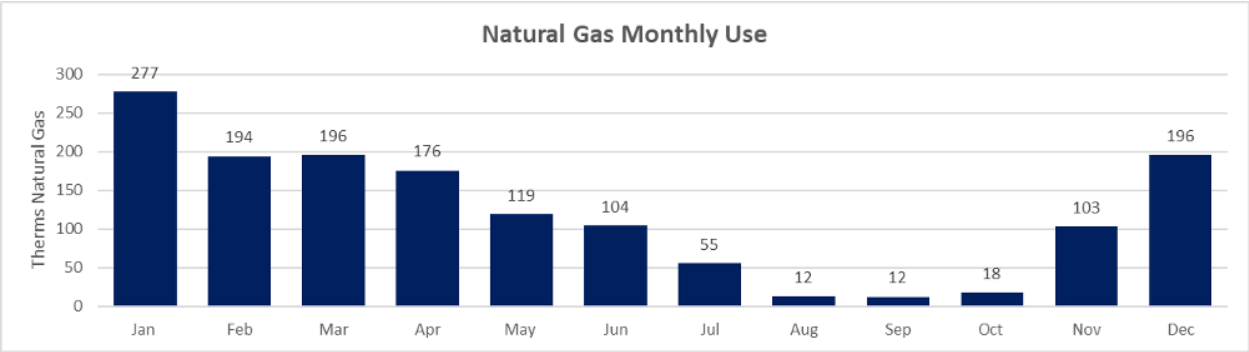

Image source: Strategic Energy Group

We can use the data in these two charts to evaluate the same 10,000 square foot office building used in the previous (all-electric) calculation, except now let's assume natural gas is used for heating and domestic hot water. There are fewer steps in this section because we will reuse calculations, assumptions, and benchmarks used in the all-electric calculation above (so be sure to review that calculation first to see how those numbers were derived).

Step 1: Review Current Building Space and Energy Use

We will use the following building space and HVAC operations assumptions from the all-electric calculation:

- *Building size: 10,000 square feet*
- *Targeted space: 4,500 square feet*
- *HVAC percent of use: 40 percent*
- *Percent of space affected: 45 percent*
- *Schedule savings percentage: 21.4 percent*

Step 2: Obtain Energy Usage and Cost Information

Reviewing our building's annual electric and gas bills, we learn the following about our building's energy usage that will be used in the next step (energy costs are regional averages for commercial customers in the Pacific Northwest):

- *Annual electricity consumption: 153,825 kWh*
- *Average electricity cost: $.08/kWh*
- *Annual natural gas consumption: 1,463 therms*
- *Average natural gas cost: $.90/therm*

Since natural gas is primarily a heating source, we would expect little natural gas use in the summer cooling months. The natural gas monthly use in the chart above shows very low usage but greater than zero, and larger than you would expect from a pilot. What is the usage? Domestic hot water (DHW) heating. With that, calculating natural gas used for space heating becomes easier.

If no heating is required during the summer months, then any usage indicates how much natural gas is used for DHW. Both August and September have the very lowest consumption at 12 therms each. We will assume, then, that 12 therms per month is required for DHW and any other natural gas usage is for space heating.

The calculation simply becomes the sum of the total annual natural gas used minus the sum of the DHW natural gas uses, which is 12 therms per month or 12 x 12 therms = 144 therms.

Therms for natural gas space heating = Total therms - natural gas DHW heating

Therms for natural gas space heating = 1,463 therms - 144 therms = 1,319 therms

Now we can take the figure for natural gas used for space heating and multiply it by the percentage of building space affected by our proposed change in HVAC runtime to determine how much natural gas is used to heat the targeted space.

Natural gas use of targeted space = 1,319 therms x 45 percent = 593.55 therms

Step 3: Calculate Estimated Annual Savings

We can only save the reduction in run hours, and while time of day can impact natural gas usage, a rough estimate for savings is equal to the percent change in hours.

Estimated savings = 593.55 therms x 21.4 percent x $.90/therm = $114.32

Our natural gas savings is $114.32 per year. Now we need to calculate the electric savings.

We know from the energy-use chart that HVAC is about 40 percent of the energy consumed in an office building in the Pacific Northwest, with heating accounting for 19 percent. Natural gas is used for heating, so we can subtract out 19 percent for heating and two percent for DHW heating, for a total of 21 percent. That means electricity is 79 percent of the total energy consumed (natural gas and electricity combined) is electricity.

With heating removed, HVAC end-use consumption is about 21% (40% - 19%) of the total combined electricity and natural gas use. Now we need to know the percent of electricity consumed by HVAC. To accurate apply that against electricity, we simply divide the 21 percent HVAC electricity use by the electric portion of the entire energy consumed of (79 percent) to get how much of the total electricity consumption is HVAC.

HVAC Electricity Use = 21 percent / 79 percent x
Annual Electricity Consumption = 40,890 kWh

Just like with the natural gas, we are reducing run hours by 21.4 percent, so:

Electricity savings = 21.4 percent x 40,890 x $0.08 kWh = $700.04

Adding up the savings, we get:

Total savings = electric + natural gas

Total savings = $700.04 + $114.32 = $814.36 saved annually

Additional Resources

NEEA Resources

Other SEM Hub tutorials. Check out other tutorials on the SEM Hub website that can help you learn and apply SEM at your facility and calculate their estimated savings. In particular, you may wish to view the tutorials on:

- How to Get and Record Energy Data
- How to Perform an Energy Audit
- How to Estimate Costs for Energy Projects
- How to Convert Measurements to Common Units

Toolbox Talk cards. Print-ready talk cards outlining a variety of strategic energy management (SEM) tools, approaches and methods for both industrial and commercial facilities.

Other Resources

Your utility or energy efficiency program provider. Check with utility or program representatives for any assistance, solutions, or incentives they offer for measuring and reducing HVAC system energy usage and implementing other O&M best practices that support energy-efficiency goals.

American Society of Heating, Refrigerating and Air-Conditioning Engineers. This association for engineers, architects, contractors, building owners and others concerned with the design, operation and maintenance of HVAC systems in buildings funds research projects, offers continuing education programs and publishes technical standards.

Smart Buildings Center. This Seattle-based regional energy efficiency solutions provider offers education, training and resources for building engineers, managers and operators, including a lending library of measurement and diagnostic tools for energy efficiency and demand-reduction projects.