WHERE’S THE CARBON FOOTPRINT?

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CHANGES ARE COMING TO THE “ENERGY AT A GLANCE” SIDEBAR INCLUDED IN EACH HIGH PERFORMING BUILDINGS CASE STUDY. TO SHOW A FACILITY’S CLIMATE IMPACT, ANNUAL CARBON DIOXIDE (CO₂) EMISSIONS WILL SOON ALSO BE QUANTIFIED.
While counting energy (e.g., kWhs, therms) consumed on site may tell us how efficiently a building is running, it doesn’t tell us anything about the atmospheric carbon emissions that result from its operation. When comparing buildings, a higher energy use intensity (EUI), i.e., annual Btu/ft²-year, may mean more CO₂ emissions, but how much is unclear.

The mix of energy forms used to produce a building’s electricity (e.g., coal versus gas versus solar) may also affect the climate impact, as may the choice of fuels used on site. Counting CO₂ emissions (generated on site and at off-site power plants) that stem from a facility’s operation will focus attention on how we may reduce its climate impact.

**How Do We Get From Energy To Emissions?**

When calculating a building’s energy efficiency, we look at site and source energy use. Site use is straightforward: It’s developed from fuel bills and standard conversion factors (e.g., 1 therm = 100,000 Btu).

To account for energy coming from an off-site source (e.g., power plant or grid), however, involves factors addressing that source’s efficiency of production and delivery. To do so, HPB currently relies on the methodology and conversion factors developed by the U.S. Environmental Protection Agency.

For electricity, HPB uses a national average factor of 3.34: Multiply site kWh use (converted into Btus) by 3.34 to determine power plant Btu consumption. Similar (but much lower) factors are applied to natural gas, fuel oil, etc., to reflect losses in their processing and delivery. When summed, total source energy is derived.

A similar approach may be taken with regard to CO₂ emissions. Following international standards for calculating greenhouse gas (GHG) emissions, many facilities have determined their “carbon footprints.”

**Opposite, clockwise from top**

**The National Renewable Energy Laboratory’s Research Support Facility (RSF)** in Golden, Colo., is designed to serve as a blueprint for net zero energy performance. Photovoltaic arrays totaling more than 1.6 MW are expected to meet the RSF’s energy needs and are located on the roof, over the visitor parking lot in the form of shade canopies and over the staff parking structure.

**The Great River Energy Headquarters** in Maple Grove, Minn., reduces its carbon footprint through a combination of an energy-efficient building design, on-site renewable energy production via a 200 kW wind turbine and a 72 kW photovoltaic array, and the purchase of renewable energy credits.

**Daylighting is one of several design strategies** used to reduce Richardsville Elementary School’s energy use to an annual EUI of 18.2 kBTu/ft². The low EUI made it economically feasible to produce an equivalent amount of electricity on an annual basis via on-site photovoltaic panels. Clerestory windows admit natural light to this central hallway that ends with a large window overlooking the gymnasium/cafeteria.

**The visitor’s parking lot** adjacent to the National Renewable Energy Laboratory’s Research Support Facility (RSF) in Golden, Colo., is shaded with a sawtooth roof supporting one of the facility’s photovoltaic systems.

**The Power House**, built in 1928, once provided steam to a dozen buildings in downtown St. Louis and now houses the Cannon Design Regional Offices. The firm purchases renewable energy credits to offset 35% of the building’s energy consumption.

**The Tyson Living Learning Center** in Eureka, Mo., serves as the environmental field station for Washington University. The facility’s on-site solar arrays are intended to produce more energy than the building consumes on a net annual basis. In addition to the rooftop array, two pole-mounted dual-axis solar arrays that move with the sun’s position were added in spring 2010.

**Spring 2013 HIGH PERFORMING BUILDINGS**
Reducing the Carbon Footprint
The buildings in the photos below highlight some of the ways building designers can reduce the carbon footprint.

An on-site biomass gasification plant provides carbon-neutral power to Dockside Green, a development of 1.3 million square feet of mixed residential, office, retail and industrial space in Victoria, BC, Canada. The plant converts locally sourced wood waste into a clean burning syngas (syngas), which is used to produce heat and hot water.

Large windows in the 400-seat assembly room (chapels) at Holy Wisdom Monastery ensure that all areas receive ample natural light during the day. The Benedictine Sisters’ mission of prayer, hospitality, justice and care for the earth guided the design of energy-efficient systems and selection of sustainable materials for their new monastery.

Holy Wisdom Monastery’s rooftop solar panels provide 8% of the facility’s energy needs. The system can be expanded to eventually provide all energy requirements on a net basis. The monastery in Middleton, Wis., purchases 100% renewable electricity to meet its electricity demand beyond what is supplied by the PV array.

As part of the $500 million Empire State ReBuilding program, owners sought to boost planned capital improvements by asking a team of experts to recommend sustainability measures that could be incorporated as part of planned renovations. The renovations let building owners offer state-of-the-art office amenities in a historic building while reducing energy use and carbon emissions.

Those standards divide carbon emissions into three “Scopes”: On-site CO₂ emissions are Scope 1, while CO₂ emitted at an off-site source (e.g., power plant) is Scope 2. Scope 3 covers emissions from sources not directly related to energy use, such as leaked refrigerants and vapors from industrial solvents. (See For More Information sidebar on Page 57.)

The main GHG resulting from running buildings is CO₂ from burning fossil fuels, both on site and at power plants. Because of the complexities involved with Scope 3 determinations, HPB will follow EPA’s lead on this issue and ask those submitting articles for only their Scope 1 and 2 emissions. Together, they typically cover 95% of CO₂ due to building operations. Future articles will show a building’s annual CO₂ emissions per square foot, much as EUI is presently provided. That number will appear in the “Energy at a Glance” section of each article.

Factors exist for converting on-site energy units to pounds of Scope 1 CO₂. Burning enough coal to generate 1 million Btu, for example, releases about 210 lbs of CO₂, while burning natural gas to generate the same amount of energy produces about half that amount.

The dominant source of Scope 2 emissions is CO₂ at power plants, whose emission rates (in lb/MWh) vary widely. A MWh (i.e., 1,000 kWh) produced in California (dominated by nuclear, hydro, and gas-fired generation) may release about 560 lbs of CO₂, while producing a MWh in Colorado (where 63% of power comes from coal-fired plants) would send over 1,700 lbs of CO₂ into the atmosphere.
A facility's emission rate can be found by entering its zip code at EPA's Power Profiler Web page. (See For More Information sidebar on Page 57.) ASHRAE Standard 105 (Standard Methods of Measuring, Expressing and Comparing Building Energy Performance), currently under review, proposes a similar approach.

How May CO₂ Emissions Impact Building Design?
Designing a building with only Btus and/or dollars in mind, without concern for its CO₂ climate impact, defeats one of the main reasons for making a building more energy efficient. In Canada and many European countries, CO₂ emissions have a price. As occurs with the incremental cost for a more efficient piece of HVAC equipment, the cost of CO₂ then becomes part of the financial analysis of a building's design.

In most of the US, however, releasing CO₂ into the atmosphere has no direct cost to a building, but such cost may be indirectly charged via its electric bills. In California, however, that state's 2013 cap-and-trade program directly charges large facilities (those annually emitting over 25,000 metric tons of carbon on site) for their emissions. Because many power plants fall into that category, other facilities see that impact via their electric bills. In some other states, various programs may add emission-related charges to their electric bills.

If we were charged for disposal of CO₂ emissions in the same ways we incur maintenance and replacement costs (e.g., to properly dispose of linear fluorescent lamps), that cost would be factored into a design's economics, possibly altering one's equipment choices. For example: An electric heat pump system powered from a grid heavily dependent on coal may cause more source CO₂ to be emitted than a high-efficiency natural gas boiler would emit on site.

Because of its overall higher thermal efficiency, an on-site gas-fired

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A wind turbine at Great River Energy Headquarters generates approximately 5% to 10% of the building’s annual energy needs, while the rooftop photovoltaic array generates approximately 2% to 6% of the building’s electricity needs. Great River Energy obtained a 15-year-old wind turbine that was previously used in Denmark. It was converted to a single-speed machine to fit the lower wind speed of the Great River Energy site.

ARE RECS OR OFFSETS “EQUIVALENT” TO ON-SITE RENEWABLE CONTRIBUTIONS?
Some argue that purchasing RECs or offsets is an easy “out” to avoid what might be done more ambitiously through deeper efficiency or on-site renewables. Unlike the easily metered clean kWh generated on site by a PV system owned and controlled by a facility, the tons of GHG avoided by RECs and offsets are based on unseen and likely nonconcurrent activities outside the control of those facilities.

While REC and offset markets are well regulated in the U.S., there have been high profile cases overseas where offsets were found to not provide the intended “additionality” (i.e., would not have resulted without the purchase of the REC). Even in the U.S., some unscrupulous sellers of fake offsets (lacking appropriate certification) have been brought up on fraud charges. This is an area where policy makers are closely watching developments and there will likely be more changes in the coming years.

BOUNDARY ISSUES FOR ON-SITE RENEWABLE ENERGY
In many cases, it may cost less to buy RECs or offsets to cut a building's carbon footprint than to install on-site renewable energy sources. The critical decision for designers and owners is how far the energy consumption can be cost-effectively cut with efficiency and conservation measures, and then what could be made up with renewable sources.

The building, or site “boundary,” becomes critical. For many buildings, insufficient space exists on them for PV panels, but nearby parking, or other ground-mounted, structures may allow for enough PV or other renewable resources to generate all electricity needed for the building. In the revision to ASHRAE Standard 105, and other related projects, much debate has gone into where one draws the boundary for what can be considered on-site generation. An important decision point for building design teams is whether to strive toward securing all energy from on-site renewables, or reduce the carbon footprint by also purchasing RECs and/or offsets.
The Alliance Center, built in 1908 as a warehouse, is owned and operated as a multi-tenant nonprofit center by the nonprofit Alliance for Sustainable Colorado in Denver. Annual energy use dropped from 56 kBTU/r2 to 42 kBTU/r2 after a 2004 renovation, which implemented various conservation measures. Carbon emissions associated with the all-electric building’s energy consumption are offset by the purchase of Green-e certified wind energy credits.

One of Adobe Systems Inc.’s latest energy-efficiency projects involves remodeling office spaces, removing most office walls and placing desks in open layout “neighborhoods.” Lamps, HVAC and plug load turn off automatically when no motion is detected. The open-plan layout takes advantage of daylighting, reducing the need for artificial light. This project has reduced energy use by 65% on the renovated floors, further reducing Adobe’s carbon footprint.

The Alliance Center’s tenants, largely environmentally focused organizations, are partners in making the building sustainable. A brainstorming session involving tenants and Alliance staff identified ways to make the building work better for them. Some measures that have already been implemented include an eGo Car Share option and setting up a building “green team.”

The Alliance for Sustainable Colorado seeks to use the Alliance Center to demonstrate the potential for high resource efficiency in existing buildings. Plans for an upcoming deep renovation aim to further improve energy performance, while showing how such improvements can improve tenant well-being and satisfaction, and the building’s financial performance and asset value.

cogeneration plant producing heat and power may yield lower overall CO2 emissions than electricity taken from a relatively clean gas-fired utility power plant.

Renewable Energy and Carbon Offsets: On-Site vs. Off-Site Options

On-site renewable energy systems, e.g. photovoltaic (PV) panels, are part of a building’s infrastructure and the owner’s investment (though sometimes installed and operated by a third party). Their energy output directly reduces electricity purchased for the facility.

Off-site renewable energy is usually procured through a contract to purchase zero- or low-carbon electricity. That cleaner energy is deemed to have “environmental attributes” in addition to its energy. Those attributes may be purchased separately from the electricity through renewable energy certificates (RECs).

Just as a building may purchase equipment and fuels that minimize its on-site CO2 emissions, so may it buy RECs to counter its off-site emissions. Those payments go to those generating the clean power that displaces dirty power elsewhere on the grid. Since all CO2 emissions go into the same global atmosphere, reducing them anywhere has the same climate impact as reducing them on site.

ACCOUNTING ISSUES WITH RECS: AVOIDING DOUBLE COUNTING

RECs are a tradable commodity. When a facility generates its own renewable power (e.g., from solar panels), it owns the RECs related to those kWhs. If it does not sell them, it may count them against the emissions from its own total power consumption. If it sells them, however, it cannot take carbon credit for its on-site use of solar power.

If the panels are instead owned by a third-party developer selling that power to a host facility, the RECs from that renewable power may belong to the developer, not the facility. Those RECs, therefore, cannot be counted against the facility’s own emissions.

For the RECs to really reduce a building’s carbon footprint, it is critical that the building team submitting an article to HPB review its REC and/or offset contract and show how many units were being annually purchased and for how long from the date of article submission. Doing so minimizes the likelihood of buying a one-year supply and then ceasing shortly thereafter, merely as a way to look good in its submission. If using solar or wind power, a submitter should indicate that its RECs belong to it (not a third-party developer), thereby allowing it to count power from such systems as having zero carbon impact.
By definition, a single REC represents the environmental attributes—the reduced emissions of CO₂, sulfur oxide (SO₂) and nitrogen oxides (NOₓ)—of one MWh of electricity generated by renewable power sources. That renewable power need not be received at or even near a facility, and is typically generated within 18 months of the date of purchase.

Independent verification processes exist to certify that RECs are related to actual or soon-to-be generated renewable power. For details, see www.green-e.org. Many colleges, universities, corporations, and cities now buy RECs covering 15–25% (or more) of their power.

The amount of avoided CO₂ from a REC varies depending on the location of its renewable power source. A REC based on a wind farm in New York, for example, that feeds its renewable power into a relatively low-carbon grid (less than 585 lb/MWh), does not displace as much CO₂ as one based on a wind farm in Wyoming where most power is generated by coal (yielding over a ton of CO₂ per MWh). The source point for RECs may therefore impact the amount of CO₂ that is avoided by them.

The Alliance Center, which is operated as a multi-tenant nonprofit center by the Alliance for Sustainable Colorado in Denver, provides an excellent example for applying RECs. An all-electric building, it buys enough RECs to fully offset the
Top left: Conservation and in-house energy generation combined have reduced or avoided carbon dioxide emissions for Adobe Systems Inc’s headquarters facilities in San Jose, Calif., by 56%. Adobe makes up the difference by purchasing renewable energy certificates/credits (RECs) and verifiable emissions reduction credits (VERs). Adobe’s energy and carbon credits subsidize energy from wind farms in Massachusetts and the burning of biogas from dairies in California to produce electricity for the energy grid.

Top right: A 140-kW crystalline PV array mounted on a parking shade structure and a 208-kW thin-film array mounted on the roof provide more energy than Richardville (K1) Elementary consumes on a net annual basis.

Bottom left: Kiowa County Schools uses simple and passive building systems, such as daylighting in the library and throughout the facility, to maximize efficiency and reduce energy use and costs. The result is a school that uses less than half the energy used by a school built to code.

Bottom right: Richardville Elementary School is the first full-scale net zero energy school in the United States. To reduce energy consumption, the school uses laptop computers, alternative methods to prepare lunches and building strategies such as dedicated outdoor air systems with dynamic reset.

emissions of the coal-fired plants that provide most of its power. Its carbon impact is therefore zero, regardless of its Btu consumption.

Unlike the RECs that counter emissions from power plant electricity, “carbon offsets” may be used to counter emissions from other carbon sources, such as boilers. Like RECs, offsets represent reductions in emissions and are publicly traded, but differ from RECs in three important ways:

- By definition, one offset represents one metric ton (2,204 lbs) of CO₂; its carbon impact is therefore irrespective of the location of its origin.
- Offsets do not relate to power production; instead, they result from a variety of carbon avoidance or absorption methods.
- Offsets cannot be counted against any emissions other than carbon (e.g., NO₂ or SO₂).

Carbon offsets may be generated by planting trees that absorb CO₂, capping landfills that would otherwise release methane (a GHG 20+ times worse than CO₂), or using other methods to keep GHGs from entering the atmosphere.

Offsets are generally used to counter carbon emissions from...
on-site consumption of fossil fuels. For example, to negate the carbon impact of burning natural gas in a boiler, a facility may buy “green” natural gas that includes sufficient carbon offsets to achieve that result off site.

The increase in energy cost for RECs or offsets varies with market forces and the base costs of electricity and natural gas, but is typically 5—10%. Many see it as a small contribution toward reducing a facility’s climate impact. In the case of the Alliance Center, the extra cost was about half a penny per kWh.

The Net Result
Choosing high-efficiency HVAC equipment may cut a facility’s energy use and cost, and generating some of its power on site with solar panels further reduces its climate impact. Following those actions by purchasing RECs and/or offsets may further cut—or, as some maintain, even eliminate—its remaining climate impact.

Watch as future issues of HPB document how buildings go that extra mile toward cutting their climate and energy impacts.