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ENGINEERING

SYSTEM SOLUTIONS

Our industry's customers – the people who live and work in the buildings we produce – do not measure us in "tons" or "cfm". They measure us in terms of comfort, energy efficiency (with an eye on operating cost), life cycle cost, indoor air quality and sound among others. Several of these parameters have been incorporated into the overall "Green" building movement as an integral part of creating synergy between environment, community and economy.

This issue of Engineering System Solutions discusses Green building design, more formally known as "Building Sustainability". For North America, the LEED™ program is the most popular rating system for Green building design, and we have used it as reference to explain the design considerations in developing a sustainable building. This article will help readers understand and appreciate what building sustainability is, how it fits with energy efficiency (the connection between ASHRAE Std. 90.1 and building sustainability) and how it impacts HVAC design. Further information can be found at www.ashrae.org and www.usgbc.org.

This issue was written by Carol Marriott, who among other things is LEED accredited, a voting member of ASHRAE SSPC 90.1 and McQuay's top energy analysis professional. She is available to work with customers on energy related issues. Please feel free to contact her at carol.marriott@mcquay.com.

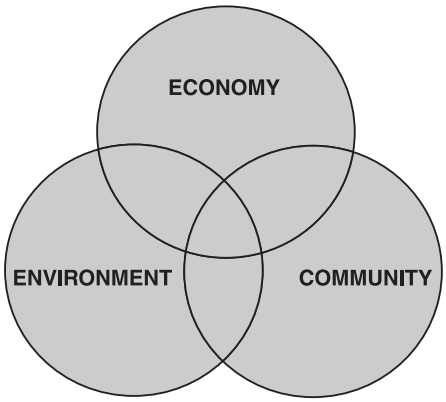
Hugh Crowther
Director of Applications
McQuay International

Building Sustainability and HVAC Systems

More and more, the term "building sustainability" is being used to describe a growing trend in the building design and construction industry, but what does it mean? According to the Oxford dictionary, "sustain" is defined as "continue, extend, keep alive, keep going, keep up, maintain, prolong." In a 1987 report, known as the Brundtland Report, the World Commission on Environment and Development defined it as "sustainable development meets the needs of the present without compromising the ability of future generations to meet their own needs." ASHRAE, in its position statement on building sustainability, "supports building sustainability as a means to provide a safe, healthy, comfortable indoor environment while simultaneously limiting the impact on the Earth's natural resources." Everyone has their own unique perspective on building sustainability, and most would agree that a sustainable building is also a "Green" building. This newsletter addresses sustainable building design as it relates to the heating, ventilation and air conditioning (HVAC) systems used in Green buildings.

LEED™ Green Building Rating System

What does a Green building look like? How much energy does it use? How would it feel to work there? How does it affect the community? How does it affect the environment? How much does it cost? All of these questions are addressed as part of the synergistic approach used in sustainable building design.



Sustainable design considerations.

One of the more popular guidelines for sustainable building design is the Leadership in Energy and Environmental Design (LEED™) Green Building Rating System. Developed by the United States Green Building Council (USGBC) as a third party verification system for Green buildings, LEED is a point-based rating system that awards points in the following categories:

- Sustainable sites
- Water efficiency
- Energy and atmosphere
- Materials and resources
- Indoor environmental quality
- Innovation and design process

Within most categories, prerequisite requirements must be met. Thereafter, up to 69 points can be awarded for meeting additional voluntary "credits" in each category. A minimum of 26 points is required for LEED certification. Four levels of certification are possible based on the total points accumulated (See Table 1).

Table 1 – LEED certification levels

LEED Certification Level	Points
Certified	26-32
Silver	33-38
Gold	39-51
Platinum	52-69

It is important to note that it is virtually impossible to acquire all 69 points, if for no other reason than it may be cost prohibitive. In addition, tradeoffs are often required between credits. The challenge for designers is to identify design concepts that create the most synergy between credits to make the best decision for the building. In this way, the LEED system provides flexibility to account for the fact that no two buildings (or building designers) are exactly alike.

The USGBC has published guidelines for its LEED Green Building Rating System that are available for download at www.usgbc.org (current Version is 2.1). In addition to describing the intent of each prerequisite or credit, the guidelines list the requirements and submittals necessary to earn points, as well as potential technologies and strategies that can be used. It is important to understand the intent of each prerequisite and credit as this is what the USGBC relies on to make an interpretation or ruling on whether or not the requirements of that prerequisite or credit have been met.

The rest of this newsletter provides a listing of the prerequisites and credits for each of the five LEED categories and a discussion of how they relate to HVAC equipment.

Site Selection

Table 2 lists the prerequisites and credits available for Site Selection.

The prerequisite and credits in this category address the location of a building, its interaction with the environment (both during and after construction), and the effect of its occupants on the environment. Favorable ratings are given when urban and/or rehabilitated sites are chosen, making use of areas where environmental disruption has already occurred and helping to reduce urban sprawl.

While there is no direct correlation to HVAC systems in this category, the credits for reducing site disturbance and heat island effects can have a positive affect on the HVAC system. The thermal gradient difference between developed and undeveloped areas is called a heat island. This can impact local habitats because native plant and animal species may not be adapted to the increased temperature. Minimizing this impact may also help reduce summer cooling loads, resulting in lower energy costs and capital cost requirements.

Water Efficiency

Table 3 lists the credits available for Water Efficiency.

In general, HVAC systems have little effect on water efficiency unless water-cooled technology such as cooling towers

Table 2– Site Selection[1]

Value	Description	Intent
Prerequisite	Erosion and sedimentation control	Control erosion to reduce negative impacts on water and air quality.
1 Point	Site selection	Avoid development of inappropriate sites and reduce environmental impact from the location of a building site.
1 Point	Development density	Channel development to urban areas with existing infrastructure, protect greenfields and preserve habitat and natural resources.
1 Point	Brownfield redevelopment	Rehabilitate damaged sites where development is complicated by real or perceived environmental contamination, reducing pressure on undeveloped land.
4 Points	Alternative transportation • Public transportation access • Bicycle storage & changing rooms • Alternative fuel vehicles • Parking capacity	Reduce pollution and land development impacts from automobile use.
2 Points	Reduce site disturbance • Protect or restore open space • Development footprint	Conserve existing natural areas and restore damaged areas to provide habitat and promote biodiversity.
1 Point	Stormwater management • Rate and quantity	Limit disruption and pollution of natural water flows by managing stormwater runoff.
1 Point	Stormwater management • Treatment	Limit disruption of natural water flows by eliminating stormwater runoff, increasing on-site infiltration and eliminating contaminants.
2 Points	Heat island effect • Non-roof • Roof	Reduce heat islands (thermal gradient differences between developed and underdeveloped areas) to minimize impact on microclimate and human and wildlife habitat.
1 Point	Light pollution reduction	Eliminate light trespass from the building and site, improve night sky access and reduce development of nocturnal environments.

and evaporative condensers are used. The advantage of water-cooled technology is that it follows wet bulb rather than dry bulb temperature, making it more efficient than air-cooled equipment. However, water-cooled equipment uses water to make up for evaporation, creating a trade-off between water efficiency and energy efficiency, or vice versa. New cooling tower technologies, such as wet/dry tower technology, offer the ability to reduce water consumption, sewage charges, and chemical water treatment at part load conditions, while still maintaining full load capabilities. This offers the best of both water and energy efficiency.

Energy And Atmosphere

Table 4 lists the prerequisites and credits available for Energy and Atmosphere.

In addition to other building systems, each of the prerequisites and credits in this category directly address the HVAC system and its impact on the environment. This includes the amount of energy it consumes, the environmental impact of generating that energy, and the ozone depletion potential of the refrigerant used in the equipment.

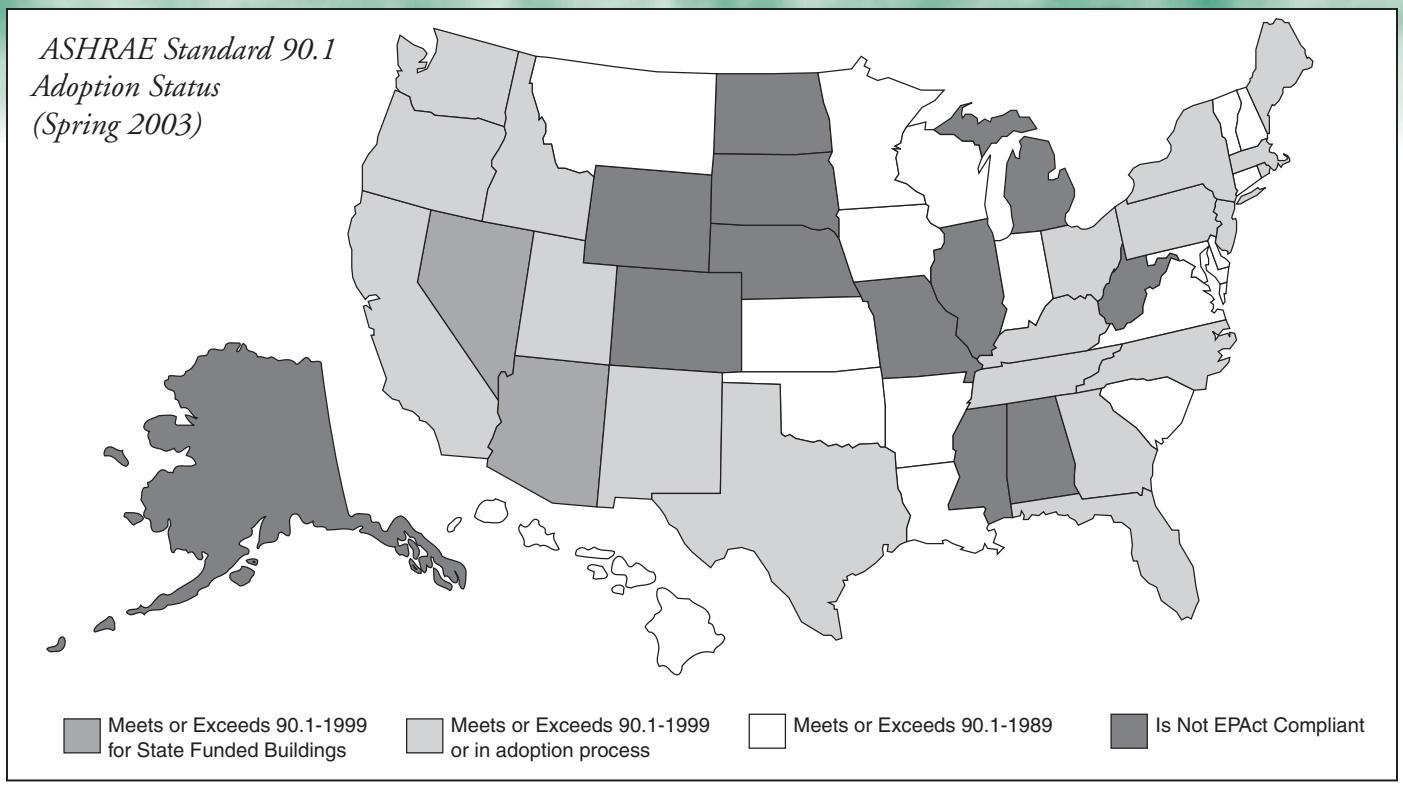
The minimum energy performance prerequisite is to meet local codes or ASHRAE Standard 90.1-1999, Energy Standard for Buildings Except Low-Rise Residential Buildings, whichever is more stringent. It is important to note that ASHRAE Standard 90.1-1999 is not the building code standard for most states (at the time of this publication). As of July 15, 2002, the U.S. Department of Energy (DOE) determined that ASHRAE Standard 90.1-1999 saved energy over the 1989 edition of the Standard. All states have until July 15, 2004 to update their local energy codes to 90.1-1999 levels, or apply for an extension of their deadline. This means that many states will be reviewing their

Table 3 – Water Efficiency[1]

Value	Description	Intent
2 Points	Water efficient landscaping • Reduce by 50% • No potable use or no irrigation	Limit or eliminate the use of potable water for landscape irrigation.
1 Point	Innovative wastewater technologies	Reduce generation of wastewater and potable water demand, while increasing the local aquifer recharge.
2 Points	Water use reduction • 20% reduction • 30% reduction	Maximize water efficiency within buildings to reduce the burden on municipal water supply and wastewater systems.

Table 4 – Energy And Atmosphere[1]

Value	Description	Intent
Prerequisite	Fundamental building systems commissioning	Verify and ensure that fundamental building elements and systems are designed, installed and calibrated to operate as intended.
Prerequisite	Minimum energy performance	Establish the minimum level of energy efficiency for the base building and systems.
Prerequisite	CFC reduction in HVAC&R equipment	Reduce ozone depletion.
10 Points	Optimize energy performance • 15% new, 5% existing = 1 • 20% new, 10% existing = 2 • 25% new, 15% existing = 3 • 30% new, 20% existing = 4 • 35% new, 25% existing = 5 • 40% new, 30% existing = 6 • 45% new, 35% existing = 7 • 50% new, 40% existing = 8 • 55% new, 45% existing = 9 • 60% new, 50% existing = 10	Achieve increasing levels of energy performance above the prerequisite standard and reduce environmental impacts associated with excessive energy use.
3 Points	Renewable Energy • 5% • 10% • 20%	Encourage and recognize increasing levels of on-site renewable energy self-supply in order to reduce environmental impacts associated with fossil fuel energy use.
1 Point	Additional commissioning	Verify and ensure that the entire building is designed, constructed and calibrated to operate as intended.
1 Point	Ozone protection	Reduce ozone depletion and support early compliance with the Montreal Protocol.
1 Point	Measurement and verification	Provide for the ongoing accountability and optimization of building energy and water consumption performance over time.
1 Point	Green power	Encourage the development and use of grid-source, renewable energy technologies on a net zero pollution basis.



building codes and updating them in the next year.

Energy performance in excess of ASHRAE Standard 90.1-1999 requirements can earn up to 10 additional points based on how much energy is conserved. Examples of energy performance in excess of ASHRAE Standard 90.1-1999 are McQuay Heat Recovery Centrifugal Chillers and Templifier™ Water Heaters. These chillers recover the waste heat generated from supplying chilled water for air conditioning and convert it to usable heat for the building or the domestic hot water supply. This reduces the consumption of fossil fuel (or other energy sources) and it lowers the cost of heating. The determination of whether or not this qualifies can be derived using the Energy Cost Budget method defined in Section 11 of ASHRAE Standard 90.1-1999, and then using computer simulation software to quantify energy performance versus a baseline building.

Another prerequisite in this category is fundamental building systems commissioning. This is done to help ensure that the building systems are designed, installed, and calibrated to function as intended. It involves a documented process with actual performance testing, and it usually includes training of the building staff to properly operate the building systems. When commissioning is properly executed, the performance and energy consumption of building systems should be optimized at start-up and all systems should be operating as intended.

Points can be earned by performing additional commissioning and ongoing measurement and verification of building systems using the DOE's International Performance Measurement and Verification Protocol (IPMVP). The additional commissioning is intended to iron out any operational issues that could only be identified when the building is occupied. The ongoing measurement and verification is intended to help identify issues early so that the performance and energy consumption of building systems are maintained over the life of the building. Since many buildings are designed for a 50-plus year life, minor energy savings can add up to significant savings over time.

The final prerequisite for LEED certification is the use of no chlorofluorocarbons (CFC) in the HVAC & R equipment used in new buildings, or a phase-out plan for an existing building. CFCs have been phased out in new HVAC equipment in North America since 1996 because of their ozone depleting properties. An additional point can be earned for using no hydrochlorofluorocarbons (HCFC-22 and HCFC-123 for example) in HVAC equipment. HCFCs are in the process of being phased out because of their ozone depleting potential. Alternative refrigerants with no ozone depleting properties include R-410A, R-407 and R-134a. Further information on these and other refrigerant choices can be found in McQuay's Refrigerants Application Guide (AG31-007) which can be downloaded from www.mcquay.com.

The remaining credits in this category address the use of renewable energy sources and Green power. While the use of these energy sources does not decrease the energy usage in a building, it can reduce the environmental impact of generating the energy used by HVAC equipment. In addition, the cost for adding renewable energy equipment (solar panels and wind turbines) has steadily decreased and the Green power market is maturing, making these alternatives very attractive versus traditional power products.

Materials and Resources

Table 5 lists the prerequisites and credits available for Materials and Resources.

This category encourages reuse and restoration of our existing building stock versus new building construction. While on the surface this may not seem to

have an impact on HVAC systems, it can have a significant impact. For example, if an older building (1970s or before) is to be restored as part of a LEED project, there is a very good chance that it will be difficult to find indoor space to accommodate more modern HVAC equipment, ductwork and ancillary equipment. Quite simply, modern HVAC systems have grown larger to meet modern ventilation requirements. A one-for-one replacement may be difficult, if not impossible, without impeding significantly on the occupied space or requiring major structural changes to accommodate larger equipment. Careful evaluation of what system is currently in the building and what system options are available (including alternative systems) can greatly simplify this process and help reduce design and installation costs, while preserving tenant space.

Indoor Environmental Quality

Table 6 lists the prerequisites and credits available for Indoor Environmental Quality.

On average, Americans spend 80% to 90% of their time indoors. As a result, the indoor environmental quality (IEQ) of the buildings we occupy can significantly influence health, productivity and quality of life. One aspect of IEQ is indoor air quality (IAQ). ASHRAE developed Standard 62.1-2001 to provide a reference for what a building should incorporate for proper IAQ. LEED requires certified buildings to adhere to Standard 62.1-2001 with amendments. LEED also requires that there is zero exposure of building occupants to Environmental Tobacco Smoke (ETS). This can be accomplished by having a designated smoking room with a dedicated ventilation system, or prohibit smoking within a certain distance of the building structure.

Two points can be earned for ventilation. One is for monitoring CO_2 concentrations in the building and maintaining indoor CO_2 levels no higher than 530 PPM above outdoor air levels. The technology relies on accurately calibrated sensors that are appropriately placed to get precise readings of space conditions. Fresh air dampers can then be adjusted to bring in sufficient outdoor air to meet ventilation requirements. This can be a very energy efficient way to deal with ventilation air as the number of occupants in a building varies throughout the day, particularly in high occupancy spaces such as schools, theatres, etc. The other ventilation point is earned by testing ventilation effectiveness and achieving 90% ventilation effectiveness (according to ASHRAE Standard 129-1997) in mechanically ventilated buildings and 95% effectiveness in naturally ventilated spaces.

Several points may be earned by taking a proactive approach to limiting pollutants in the building before, during and after construction. In addition to providing cleaner air and reducing odors upon occupation, these actions will help reduce maintenance for the HVAC system by extending filter life and reducing cleaning requirements. Up to 4 points are available for specifying low emitting materials including adhesives

Table 5 – Materials and Resources[1]

Value	Description	Intent
Prerequisite	Storage & collection of recyclables	Facilitate the reduction of waste generated by building occupants that is hauled to and disposed of in landfills.
3 Points	Building reuse • Maintain 75% of existing walls, floors and roof. • Maintain 100% of existing walls, floors and roof. • Maintain 100% of shell/ structure and 50% of non-shell/non-structure	Extend the life cycle of existing building stock, conserve resources, reduce waste and reduce environmental impacts of new buildings as they relate to materials, manufacturing and transport.
2 Points	Construction waste management • Divert 50% from landfill • Divert 75% from landfill	Divert construction, demolition and land clearing debris for landfill disposal. Redirect recyclable recovered resources back to the manufacturing process. Redirect reusable materials to appropriate sites.
2 Points	Resource reuse • 5% • 10%	Reuse building materials and products in order to reduce demand for virgin materials and to reduce waste, thereby reducing impacts associated with the extraction and processing of virgin resources.
2 Points	Recycled content • 5% (post-consumer + ½ post industrial) • 10% (post-consumer + ½ post industrial)	Increase demand for building products that incorporate recycled content materials, therefore reducing impacts resulting from extraction and processing of new virgin materials.
2 Points	Regional materials • 20% manufactured regionally • 50% extracted regionally	Increase demand for building materials and products that are extracted and manufactured within the region, thereby supporting the regional economy and reducing the environmental impacts resulting from transportation.
1 Point	Rapidly renewable materials	Reduce the use and depletion of finite raw materials and long-cycle renewable materials by replacing them with rapidly renewable materials.
1 Point	Certified wood	Encourage environmentally responsible forest management.

Table 6 – Indoor Environment Quality[1]

Value	Description	Intent
Prerequisite	Minimum IAQ performance	Establish minimum indoor air quality (IAQ) performance to prevent the development of IAQ problems in buildings, thus contributing to the comfort and well-being of the occupants.
Prerequisite	Environmental Tobacco Smoke (ETS) control	Prevent exposure of building occupants and systems to ETS.
1 Point	Carbon Dioxide (CO_2) monitoring	Provide capacity for IAQ monitoring to help sustain long-term occupant comfort and well-being.
1 Point	Ventilation effectiveness	Provide for the effective delivery and mixing of fresh air to support the safety, comfort and well-being of building occupants.
2 Points	Construction IAQ management plan • During construction • Before occupancy	Prevent indoor air quality problems resulting from the construction/renovation process in order to help sustain the comfort and well-being of construction workers and building occupants.
4 Points	Low-emitting materials • Adhesives and sealant • Paints and coatings • Carpet • Composite wood	Reduce the quantity of indoor air contaminants that are odorous, potentially irritating and/or harmful to the comfort and well-being of installers and occupants.
1 Point	Indoor chemical and pollutant source control	Avoid exposure of building occupants to potentially hazardous chemicals that adversely impact air quality.
2 Points	Controllability of systems • Perimeter spaces • Non-perimeter spaces	Provide a high level of thermal, ventilation and lighting system control by individual occupants or specific groups in multi-occupant spaces (i.e. classrooms or conference areas) to promote the productivity, comfort and well-being of building occupants.
2 Points	Thermal Comfort • Compliance with ASHRAE 55-1992 • Permanent monitoring system	Provide a thermally comfortable environment that supports the productivity and well-being of building occupants.
2 Points	Daylight and views • Daylight in 75% of spaces • Views for 90% of spaces	Provide for the building occupants a connection between indoor spaces and the outdoors through the introduction of daylight and views into regularly occupied areas of the building.

and sealants, paints and coatings, carpet and wood composites. One point may be earned for meeting the Sheet Metal and Air Conditioning National Association (SMACNA) IAQ Guideline for Occupied Buildings Under Construction (1995, Chapter 3) and ASHRAE 52.2-1999 requirements for the Minimum Efficiency Reporting Value (MERV) of filtration while construction is in progress. Prior to the building being occupied, another point can be earned by flushing out the building with 100% outdoor air for a minimum of two weeks using filtration media with an MERV of 13, or by conducting a baseline IAQ testing procedure consistent with EPA guidelines. A final point is available for capturing dirt and particulate at all high volume entryways, providing separate ventilation in areas where chemical use occurs and providing for proper drainage for liquid wastes.

The remaining LEED credits address other aspects of IEQ, including occupant comfort. While comfort is somewhat of a subjective concept, ASHRAE Standard 55 was developed to establish the design values for temperature, humidity, and air movement that provide satisfactory thermal comfort for 80% of building occupants. LEED gives one point for complying with ASHRAE Standard 55-1992 with 1995 addenda, and another point for providing permanent temperature and humidity controls designed to give operators control over thermal comfort in the building. Two additional points are available for providing zone controls for individual occupants or groups of occupants to control their own comfort in perimeter and non-perimeter spaces.

Finally, LEED gives a point for providing 2% daylight factor in 75% of all space occupied for critical visual tasks. Another point can be earned by providing a direct line of sight from 90% of all regularly occupied spaces. By providing sunlight and views to the occupants of the building, the building occupants can be connected to the outdoor environment. However, careful balancing must be done as solar heat gain is one of the largest loads on the cooling system. Conversely, this can offset some of the heating load requirements in winter months if planned correctly.

Innovation and Design Process

Table 7 lists the credits available for Innovation and Design Process.

This category encourages innovative designs that stretch the boundaries of the LEED Green Building Rating System to result in an even more positive impact on the environment, community and economy. Each innovation must be submitted in a required format. It is then interpreted by USGBC before a point is awarded.

Table 7 – Innovation and Design Process[1]

Value	Description	Intent
4 Points (one per innovative design)	In writing, identify the intent of the proposed innovation credit, the proposed requirement for compliance, the proposed submittals to demonstrate compliance, and the design approach (strategies) that might be used to meet the requirements	To provide design teams and projects the opportunity to be awarded points for exceptional performance above the requirements set by the LEED Green Building Rating System and/or innovative performance in Green Building categories not specifically addressed by the LEED Green Building System.
1 Point	LEED accredited professional	To support and encourage the design integration required by a LEED Green Building project and to streamline the application and certification process.

Innovations From McQuay To Help You With Green Building Design

Feature	McQuay Product(s)	What it does for you
HFC Refrigerants	• Enfinity™ Water Source Heat Pumps (R-410A) • Applied Rooftop Systems and Air Handlers (R-407) • Vertical Self-contained Systems (R-407) • Centrifugal, Dual Centrifugal and Reciprocating Chillers (R-134a) • Genesys™ Air-cooled chillers (R-134a)	HFC refrigerants have zero ozone depletion potential and no phase-out date.
ASHRAE 90.1 Compliance	• All applicable products	Meet or exceed local codes and LEED requirements.
Energy and Life Cycle Analysis	• McQuay Energy Analyzer™ software	Allows you to quickly evaluate the energy consumption, operating cost and life cycle analysis of a wide variety of systems to help determine which system best meets your application.
Fully Integrated Heat or Energy Recovery	• Vision™ Air Handler • Applied Rooftop Systems and Air Handlers • Templifier™ Water Heaters • Heat Recovery Centrifugal Chillers	Recycle waste heat (or heat and humidity) and generate significant energy savings.
Fully Integrated CO_2 Sensor	• AAF®-HermanNelson® Unit Ventilator	Helps maximize efficiency in delivering required ventilation.
Small or Flexible Footprints	• Vision™ Air Handler • McQuay Water Source Heat Pumps • AAF®-HermanNelson® Unit Ventilator • McQuay Centrifugal and Dual Centrifugal Chillers	Provides maximum flexibility to meet space requirements in new or replacement applications.
DesignFlow™ Outdoor Airflow Measurement System	• McQuay Applied Rooftop Systems and Air Handlers	Accurately measures outdoor air intake to within 2.5% of required levels to help maintain required ventilation amounts.
SuperMod™ 20:1 Turndown Burner	• Applied Rooftop Systems and Air Handlers	Provides low temperature rise reheat for consistent thermal comfort, particularly in VAV applications.
MicroTech II™ Controls with Protocol Selectability™ Feature	• Applied Rooftop Systems and Air Handlers • Vertical Self-Contained Systems • Chillers and Condensing Units • AAF®-HermanNelson® Unit Ventilators	Promote easy, low cost BAS integration using open, standard protocols during both initial project commissioning and as building needs evolve.
Geothermal Systems	• Water Source Heat Pumps	Very high efficiency, environmentally friendly systems that use natural sources (the ground or a body of water) for heat exchange.

Building Green Makes Sense

Many of the prerequisites and credits for the LEED Green Building Rating System are already required by local codes, or they make sense to be incorporated as part of any building designer's best practices. In many cases, it is the forethought and follow through that makes the difference in a building being certified as Green or not.

In terms of cost, it is difficult to quantify whether or not a Green building costs more. Many cities in the United States have started requiring LEED certification and have allocated a 1% to 4% increase in cost. However, if we assume that a Green building will tend to be more energy efficient, owners can recoup this investment through lower energy costs. Software programs, such as the McQuay Energy Analyzer™, can help analyze this information before the building is built to help optimize payback. Also, the increased knowledge gained from more and more people practicing Green building design should help costs and help achieve a net-zero increase.

Finally, looking back to our very first newsletter, *System Performance and ROI: Adding Value to Commercial HVAC Applications* (October 1999), we stated that "people (or employees) cost ten times as much as building operating costs, and 100 times as much as utilities." If a Green building keeps employees or tenants satisfied, it makes good economic sense and it should be of more value. When you add the risk of litigation or potential healthcare costs, it becomes even clearer. While there is not data to prove higher rental rates can be achieved with a Green building, it makes sense that landlords should be able to charge a premium for a building that has greater comfort and lower operating costs for the tenants.

For more information on Green building and the LEED Rating System, visit the USGBC website at www.usgbc.org. For more information on McQuay Products and services, contact your local McQuay Representative or visit www.mcquay.com.

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For comments or suggestions, please call or write:
Chris Sackrison, Editor
McQuay International
13600 Industrial Park Boulevard
Minneapolis, MN 55441
Phone: (763) 553-5419
E-mail: chris.sackrison@mcquay.com

For more information on McQuay products and services, or to speak with your local representative, call (800) 432-1342, or visit our web page at *www.mcquay.com.*

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