GREEN BUILDING

HVAC Resource Guide

for green building design

Healthy buildings are vital to the world's economic and social development. Unfortunately, high energy and other resource use means they create a significant environmental impact. Trane has been a leader in this field, promoting more sustainable alternatives to conventional building design and equipment. This practical guidebook to energy efficient and green HVAC design will make an important contribution to reducing the environmental impact of energy use in buildings, while making them healthier and more productive places to live and work.

Rob Watson
Founding Chairman
LEED Green Building Rating System
Board Member, US Green Building Council

As the environmental impact of buildings becomes more apparent, a new field called green building is gaining momentum. Green or sustainable building is the practice of creating healthier and more resource-efficient models of construction, renovation, operation, maintenance, and demolition. Research and experience increasingly demonstrate that when buildings are designed and operated with their lifecycle impacts in mind, they can provide great environmental, economic, and social benefits.

U.S. Environmental Protection Agency
www.epa.gov/greenbuilding

PREFACE

Trane values guide us in our commitment to corporate social responsibility. We are driven by customers; we recognize the importance of our people; we operate with integrity; we strive for excellence; we deliver on our promises. By following these values - by living them every day - we get closer to our goal of being a model corporate citizen in the communities where we work and a responsible resident of the planet where we all live. Since 2004, Trane has published an annual global citizenship report to substantiate our commitment and desire to be measured not only by our financial performance, but also by our environmental stewardship and social responsibility.

As a worldwide leader in the HVAC industry, Trane helps create environmentally responsible building solutions that deliver energy performance, reduce power consumption, and save lifecycle cost. We execute programs to reduce our own impact on global climate change and help others do the same. And, we support green building initiatives by investing resources in the various industry committees and expertise in designing and manufacturing energy-efficient systems for buildings. Whether it is designing, operating or maintaining high-performance buildings, Trane can help.

This pocket guide is intended to provide quick reference on various HVAC design practices and technologies so that building professionals can make sound decisions in meeting or exceeding the technical requirements of a green building. Green options are provided along with the corresponding criteria and benefits. References for further reading can also be found at the end of the guide. Since system performance ties closely with individual components and the integration among them, when combining various system strategies or applications to achieve a desired outcome, please consult your local Trane professionals.

Trane compiled this publication with care and made every effort to ensure the accuracy of information and data provided herein. However, this offers no guarantee of being error free. Trane shall not assume any risk of the use of any information in this publication; nor shall Trane bear any legal liability or responsibility of the subsequent engineering design practice.

CONTENTS

CHILLED-WATER SYSTEMS (CWS)

	green options	green criteria	reference
1	Reduce water-flow rate in chilled-water loop (12-20˚F, or 6.7-11.1˚C∆T) condenser water loop (12-18˚F or 6.7-10˚C∆T)	• Increase efficiency of chilled-water plant so that pumps and cooling towers consume less energy • Reduce building materials (smaller pump, cooling tower, fan) • Reduce water pipe sizes, save cost and material	(1) (2)
2	Variable flow chilled-water systems Vary the water flow rate through the chiller evaporators during system operation	Reduce system materials required, using fewer pumps than the common primary-secondary system; for example, reduced • piping connections • strainers • electrical connections • valves and specialties • pump starters • space required Improve system efficiency modestly by reducing pumping energy.	(3) (4) (5) (6) (7)
3	System optimization controls Condenser water temperature reset and optimization	• Improve system efficiency • Optimize the condenser water system by balancing the chiller and tower power • Iterate for the best condenser water temperature to minimize the combined chiller-tower energy use at all time	(8) (9)
4	Pumping pressure-speed reset	• Reset the pump operating pressure to ensure that the control valve needing the highest pressure is about 90% open • Save pump energy	(10)
5	Refrigerant charge per ton	Select systems that require less refrigerant charge to operate • Less refrigerant means less impact on the environment in case refrigerant leaks from the system • Use ASHRAE Standard 147 to further minimize leakage or overall refrigerant emissions	(11)

	green options	green criteria	reference
6	Heat recovery	Recover heat from the condenser of a water-cooled chiller • to reheat air (for humidity control) • to preheat outdoor air • to heat make-up water entering a building ASHRAE 90.1-2004 requires heat recovery for service water heating when • The facility operates 24 hours per day • The total heat rejection capacity of the system exceeds 6,000,000 Btu/h of heat rejection (about a 450-ton chiller) • The design servicewater heating load exceeds 1,000,000 Btu/h (293 kW)	(12)
7	Series chillers chilled-water loop only, 15˚F or 8.3˚C ∆T	• maximum 2 chillers in series • place heat recovery or more efficient chiller upstream • reduce water flow rate, lower chiller-pump system energy	(40) (41)
8	Series-series counter-flow chilled-water loop, 20˚F or 11.1˚C ∆T condenser-water loop, 20˚F or 11.1˚C ∆T	• lower life-cycle cost for larger plant • chilled-water-leaving end is condenser-water-entering end, i.e. counter-flow the chiller and tower power • reduce water flow rate, half of ARI standard rating conditions • Equal lift for each chiller	(41) (42)
9	Ice storage	• load shift, create source energy savings and reduce emissions • standby capacity for non-regular peaks • reduce overall energy cost	(43) (44) (45) (46)

AIR-HANDLING SYSTEMS

	green options	green criteria	reference
1	Low temp. air • high-efficiency centrifugal chiller, 45˚F(7.2˚C) • screw chiller, 48˚F(8.9˚C) • rooftop/VAV, 52˚F(11.1˚C)	• Reduce fan energy • Improve indoor humidity control • Reduce air duct materials	(47) (48) (49)
2	Add an air-to-air heat exchanger for exhaust-air energy recovery	• Permits downsizing of cooling and heating equipment • Reduces cooling and heating energy use	(19)
3	Variable-air volume	• Provide appropriate system-level ventilation • Adequately protect the coils from freezing • Control space humidity over a wide range of loads • Control building pressure	(17) (23) (32) (49)
4	Parallel,fan-powered VAV terminals for those zones that require heat	• Reduces heating energy • Increases air motion during heating season	(49)
5	Series desiccant wheel (Trane CDQ™)	• Improve the dehumidification ability of a cold coil • Humidity control 24/7, 365 days per year • Use standard air conditioning equipment • Reduce energy cost of dehumidification	(63) (64)
6	High efficiency fans	• Energy efficiency improvement • Reduce operating time for boiler	(16)
7	Factory-mounted and factory-commissioned controls	• Reduce the human error and amount of time spent installing and commissioning the system	
8	Brushless DC motor (ECM) for VAV boxes	• Efficiency benefit as compared to AC motors, particularly in series VAV terminals • Factory flow-rate preset reducing air balancing expense • Precise speed–torque control	(66) (49)
9	Electrically-enhanced air filters	• Reduce air pressure drop to increase energy efficiency	
10	Air filtration/purification	Particulate • 10 microns or less generally pose the greatest health hazard because they are small enough to penetrate the natural defenses of the body's respiratory system. • Min. efficiency MERV 6 and located upstream of all cooling coils Gaseous • Originated from building materials or VOC of cleaning agents • Source control: negative pressure, dilution, absorption • Disable fan operation when a dirty filter alarm is present, a dirty filter light is on, or filter media is absent.	(36) (37) (38)

WATER/GROUND-SOURCE HEAT PUMP SYSTEMS

	green options	green criteria	reference
1	Water-source heat-pump system variable water flow	At non-design load conditions, reduce water flow rate in the heat-pump system • Install two position valves at each heat pump that close when the heat pump turns off • Install a pump that can reduce its energy consumption at reduced flow rates • on large applications install a variable speed drive on the pump	(13) (14) (56)
2	Reduce the flow rates in the condenser water system	Use a flow rate of 2 gpm/ton (0.126 l/s per ton)	
3	Consider using a geothermal well field	Perform a life cycle cost analysis on a geothermal heat pump system	(15) (56)
4	Heat recovery	Recover energy from the water loop • Reduce operating time for cooling tower • Reduce operating time for boiler	(16)
5	High efficiency (Greener) products	Consider using the highest efficiency heat pumps available	
6	Deliver conditioned outdoor air cold directly to the spaces	• Permits downsizing of heat pumps • Reduces cooling energy use	(30) (56) (17)
7	Add an air-to-air heat exchanger for exhaust-air energy recovery	• Permits downsizing of cooling and heating equipment • Reduces cooling and heating energy use	(19)

DX UNITARY SYSTEMS ROOFTOP, SPLIT, SELF-CONTAINED

	green options	green criteria	reference
1	Avoid oversizing supply airflow and cooling capacity	• Improves comfort control • Improves dehumidification performance	(17)
2	Avoid using hot-gas bypass unless it is absolutely required	• Reduces overall energy use • Minimizes the risk of refrigerant leaks in a DX split system due to less field-installed refrigerant piping	(18)
3	Select high-efficiency equipment	• Reduces overall energy use	
4	Consider using an air-to-air heat pump equipment (may not be suitable for extreme cold climates)	• Reduces heating energy use during mild outdoor conditions because a heat pump is a more efficient heater than hot water, steam, gas or electric heat	
5	Include an airside economizer (or waterside)	• Reduces cooling energy use during mild non-humid outdoor conditions	(21) (49)
6	Add an air-to-air heat exchanger for exhaust-air energy recovery	• Permits downsizing of cooling and heating equipment • Reduces cooling and heating energy use	(19)
7	Use variable air volume (VAV) in a multiple-zone system	• Reduces energy use at part-load conditions • Improves part-load dehumidification performance	(17) (21) (49)
8	Directly control space humidity by overcooling and reheating supply air using refrigerant heat recovery	• Improves comfort and IAQ by allowing direct control of space humidity (below a desired upper limit) • Avoids the use of “new” energy for reheat	(17) (22)

	green options	green criteria	reference
9	Provide "powered exhaust" (**on/off** central exhaust fan) for control of building pressure in a constant-volume system with an airside economizer. Provide **modulating** central exhaust for direct control of building pressure in a VAV system with an airside economizer.	• Maximizes the benefit of the airside economizer, thereby reducing cooling energy use during mild outdoor conditions • Helps minimize risk of moisture-related problems in the occupied spaces or building envelope • Reduces fan energy use by minimizing the operation of the central exhaust fan	(23) (24)
10	Avoid using DX system for large building with low diversity or high utilization	• Area >430,000ft^2 (40,000 m^2), full air-conditioned • Area >215,000ft^2 (20,000 m^2), cooling only • Example: office, hotel, hospital	

CONTROL STRATEGIES

ENERGY MANAGEMENT, COMMISSIONING, MEASUREMENT AND VERIFICATION

	green option	green criteria	reference
1	Night setback	• Allow cooling setpoint to be set up to 90˚F (32˚C) during unoccupied times • Allow heating setpoint to be set down to 60˚F (16˚C) during unoccupied times	(25)
2	Fan pressure optimization	• Reset the fan operating pressure to ensure that the control damper needing the highest pressure is nearly wide open. • Reduce fan operating pressure and power • Required feature for DDC/VAV systems	(10) (25) (49)
3	Wider indoor temperature range	• Control deadband of 5˚F or 3˚C	(25)
4	Operable window with HVAC override	• Open windows to provide natural ventilation when outdoor conditions are appropriate • When windows are open, do not allow HVAC system to operate	(25)
5	Optimal start and stop	• Start the HVAC system as late as possible while still reaching the space setpoint when it will be occupied • Stop the system to allow space conditions to "float" prior to all occupants leaving the space • Optimal start is required for systems with air flow rate >10,000 cfm (4.72m^3/s)	(20) (25) (49) (56)
6	Water loop optimization for water-source heat-pump system	• Use system level controls to determine the optimal loop water temperature to minimize energy consumption of the water-source heat pump units and cooling towers.	(56)
7	Wireless zone sensor temperature	• enhance comfort controllability • better flexibility in space layout	
8	Auto commissioning	• use factory mounted/calibrated controllers • compatible with open, standard protocols • reduce on-site time and errors	(51) (52)

	green option	green criteria	reference
9	3D graphics	• build interactive display for visitor's center • visualize system operation	(53)
10	Measurement and verification	• trend log by the building energy consumption overtime • compare and benchmark the energy performance to the original design estimates	
11	Ventilation optimization	• Regulate the outdoor air-flow rate based on the actual need for ventilation, as indicated by (any of): • Occupancy sensors • Carbon dioxide sensors • Occupancy schedules	(20) (29) (30) (49)
12	Supply Airflow measurement	• Use factory-mounted piezometer ring to enhance the accuracy of the airflow measurement	

UNITARY HEAT PUMP EFFICIENCY

equipment	test procedure	size	cooling efficiency (green)	heating efficiency (green)	cooling eff. (greener)	heating efficiency (greener)
Air-cooled	ARI 340/ 360	≥65,000 Btu/h (19.0kW) and <135,000 Btu/h(39.6kW)	10.1 EER	3.2 COP @47˚F db and 43˚F wb (8.3˚C db, 6.1˚C wb) 2.2 COP @17˚F db and 15 ˚F wb (-8.3˚C db, -9.4˚C wb)	11.0 EER 11.4 IPLV	3.4 COP @47˚F db and 43˚F wb (8.3˚C db, 6.1˚C wb) 2.4 COP @17˚F db and 15˚F wb (-8.3˚C db, -9.4˚C wb)
		≥135,000 Btu/h (39.6kW) and <240,000 Btu/h (70.3kW)	9.3 EER	3.1 COP @47˚F db and 43˚F wb (8.3˚C db, 6.1˚C wb) 2.0 COP @17˚F db and 15˚F wb(-8.3˚C db, -9.4˚C wb)	10.8 EER 11.2 IPLV	3.3 COP @47˚F db and 43˚F wb (8.3˚C db, 6.1˚C wb) 2.2 COP@ 17˚F db and 15˚F wb (-8.3˚C db, -9.4˚C wb)
		≥240,000 Btu/h (70.3kW)	9.0 EER	3.1 COP @47˚F db and 43˚F wb (8.3˚C db, 6.1˚C wb) 2.0 COP @17˚F db and 15˚F wb(-8.3˚C db, -9.4˚C wb)	10.0 EER 10.4 IPLV	3.3 COP @47˚F db and 43˚F wb (8.3˚C db, 6.1˚C wb) 2.2 COP@ 17˚F db and 15˚F wb (-8.3˚C db, -9.4˚C wb)
Water-source	ISO-13256-1	≥17,000 Btu/h (5.0kW) and <65,000 Btu/h (19.0kW)	12.0 EER @ 86˚F (30˚C) entering water	4.2 COP @ 68˚F (20˚C) entering water	14.0 EER @ 85˚F (29.4˚C) entering water	4.6 COP @70˚F (21.1˚C) entering water
Ground-water-source	ISO-13256-1	<135,000 Btu/h (39.6kW)	16.2 EER @ 59˚F (15˚C) entering water	3.6 COP @ 50˚F (6.7˚C) entering water	N/A	N/A

equip-ment	test proce-dure	size	cooling efficiency (green)	heating efficiency (green)	cooling eff. (green-er)	heating efficiency (greener)
Ground-source	ISO-13256-1	<135,000 Btu/h (39.6kW)	13.4 EER @ 77˚F(25˚C) entering water	3.1 COP @ 32˚F (0˚C) entering water	16.0 EER @ 77˚F entering water	3.45 COP @ 32˚F entering water

UNITARY AIR CONDITIONER EFFICIENCY

equip-ment	test proce-dure	size	efficiency (green)	effi-ciency (greener)
Air-cooled	ARI 340/360	≥65,000 Btu/h (19.0kW) and <135,000 Btu/h(39.6kW)I	10.3 EER	11.0 EER 11.4 IPLV
		≥135,000 Btu/h (39.6kW) and <240,000 Btu/h(70.3kW.	9.7 EER	10.8 EER 11.2 IPLV
		≥240,000 Btu/h (70.3kW) and <760,000 Btu/h(222.7kW)	9.5 EER 9.7 IPLV	10.0 EER 10.4 IPLV
		≥760,000 Btu/h(222.7kW)	9.2 EER 9.4 IPLV	10.0 EER 10.4 IPLV
Water-cooled or evapo-ratively cooled	ARI 340/360	≥65,000 Btu/h (19.0kW) and <135,000 Btu/h(39.6kW)	11.5 EER	14.0 EER
		≥135,000 Btu/h (39.6kW) and <240,000 Btu/h(70.3kW)	11.0 EER	
		≥240,000 Btu/h	11.0 EER	

1. Notes for Unitary Air Conditioner and Heat Pump Efficiency tables:
2. Efficiency reference: (25) for green, (26) for greener
3. EER: Energy Efficiency Ratio at full-load
4. IPLV: Integrated Part-Load Value, part-load efficiency based on single unit operation conditions
5. COP: Coefficient of Performance at full-load

ELECTRIC CHILLER EFFICIENCY

equipment	size (tons)	efficiency (green)	efficiency (greener)	energy-saving options
Air-cooled, with con-denser	All	2.80 COP 3.05 IPLV	2.93 COP 3.51 IPLV	
Air-cooled, without condenser	All	3.10 COP 3.45 IPLV	3.26 COP 3.26 IPLV	
Water-cooled, positive displace-ment (screw/ scroll)	<150	4.45 COP 5.20 IPLV	4.82 COP 6.39 IPLV	• Condenser water may be used for heat recovery • Condenser water may be used for "free" cooling under certain outdoor conditions (eg. not for south Asia with warm winter)
	≥150 and <300	4.90 COP 5.60 IPLV	5.76 COP 6.89 IPLV	
	≥300	5.50 COP 6.15 IPLV	5.86 COP 7.18 IPLV	
Water-cooled, centriugal	<150	5.00 COP 5.25 IPLV	5.76 COP 5.67 IPLV	• Refrigerant migration "free" cooling (see ref. 39) • Partial sized (auxiliary) heat-recovery condenser • Variable-speed drive if the chiller experiences many hours of operation at both low load and low condenser water temperatures. This does not occur in plants with three or more chillers or in climates that remain humid most of the year (e.g. Miami, Florida, southern China, Hong Kong and Singapore)
	≥150 and <300	5.55 COP 5.90 IPLV	5.96 COP 6.28 IPLV	
	≥300 and <600	6.10 COP 6.40 IPLV	6.17 COP 6.89 IPLV	
	≥600	6.10 COP 6.40 IPLV	6.39 COP 6.89 IPLV	

Note:
1. All chillers in this table use ARI-550/590-1998 as their test procedure
2. Efficiency reference: (25) for green, (26) for greener
3. Coefficient of Performance (COP) at full-load
4. Integrated Part-Load Value (IPLV), part-load efficiency based on single operation conditions

NOTES:

refrigerant	theoretical efficiency (COP)	atmo-spheric life (years)	ozone deple-tion potential (ODP)	global warming potential (GWP)	life cycle climate perfor-mance (LCCP) [kg.CO2 equivalent]	refer-ence
R123	11.38	1.3	0.02	76	7,812,400	(27) (28)
R134a	10.89	14.0	~0	1320	8,997,000	
R410A	10.51	blend	~0	1890	8,312,900	
R407C	10.69	blend	~0	1700	N/A	

Note:
1. LCCP for 350 ton (1200 kW) chiller in Atlanta office building, 1999 efficiency level. (see p. 7-9, ref. 27)
2. R410A is a mixture (blend) of R32 and R125 with atmospheric life 4.9 and 29 years respectively.
3. R407C is a mixture (blend of R32, R125 and R134a with atmospheric life 4.9, 29 and 14 years respectively.

For refrigerant selection, consider all five environmental factors above PLUS equipment leak tightness.

An integrated environmental assessment of refrigerant selection is as follows, which has been adopted for LEED® Green Building Rating System™ starting in 2006. (ref. 31):

$$LCGWP + LCODP \times 10^5 \leq 100$$

Where:

LCODP = [ODPr x (Lr x Life +Mr) x Rc]/Life
LCGWP= [GWPr x (Lr x Life +Mr) x Rc]/Life
LCODP: Lifecycle Ozone Depletion Potential (lbCFC11/Ton-Year)
LCGWP: Lifecycle Direct Global Warming Potential (lbCO_2/Ton-Year)
GWPr: Global Warming Potential of Refrigerant (0 to 12,000 lbCO_2/lbr)
ODPr: Ozone Depletion Potential of Refrigerant (0 to 0.2 lbCFC11/lbr)
Lr: Refrigerant Leakage Rate (0.5% to 2.0%; default of 2% unless otherwise demonstrated)
Mr: End-of-life Refrigerant Loss (2% to 10%; default of 10% unless otherwise demonstrated)
Rc: Refrigerant Charge (0.5 to 5.0 lbs of refrigerant per ton of gross ARI-rated cooling capacity)
Life: Equipment Life (10 years; default based on equipment type, unless otherwise demonstrated)

For multiple equipment at a site, a weighted average of all base building level HVAC&R equipment shall be applied using the following formula:

$$[\Sigma(LCGWP + LCODP \times 10^5) \times Qunit] / Qtotal \leq 100$$

Where:

Qunit: Gross ARI-rated cooling capacity of an individual HVAC or refrigeration unit (tons)

Qtotal: Total Gross ARI-rated cooling capacity of all HVAC or refrigeration

Note: A calculation spreadsheet is available for download at www.trane.com/LEED

LEED®-NC 2.2 REFERENCE GUIDE

refrigerant	maximum refrigerant charge lb/ton, based on equipment life*			
	10 year life	15 year life	20 year life	23 year life
	(Room or window AC & heat pumps)	(Unitary, split and packaged AC and heat pumps)	(Reciprocating compressors & chillers)	(Centrifugal, screw & absorption chillers)
R22	0.57	0.64	0.69	0.71
R123	1.60	1.80	1.92	1.97 (note Trane is 5.15)**
R134a	2.52	2.80	3.03	3.10
R245fa	3.26	3.60	3.92	4.02
R407C	1.95	2.20	2.35	2.41
R410A	1.76	1.98	2.11	2.17

*Values shown are based on LEED-NC 2.2 Reference Guide EAc4, Table 2

** An official Credit Interpretation Ruling issued by the U.S. Green Building Council allows the use of a 0.5% refrigerant leakage rate for Trane HCFC-123 CenTraVac centrifugal chillers, (model numbers CVHE, CVHF, CVHG, CDHF, or CDHG), rather than the default assumption of 2%. This value is used in the calculations for achieving Energy & Atmosphere Credit 4 of LEED-NC (version 2.2). With this 0.5% leakage rate, the maximum allowable refrigerant charge for Trane HCFC-123 centrifugal chillers is 5.15 lb/ton (rather than 1.97 lb/ton, as listed in Table 2 of the LEED-NC Reference Guide).

HVAC IMPACT on LEED®

LEED FOR NEW CONSTRUCTION (NC) 2.2

LEED-NC credit	LEED points	HVAC equip-ment	building control	refer-ence
WE1.2: Water Efficient Landscaping: no potable water use or no irrigation	1	◗	◗	(57)
EAp1: Fundamental Commissioning of the Building Energy Systems	Preq.	◗	◗	(65)
EAp2: Minimum Energy Performance	Preq.	◗	◗	(20) (49) (56) (57) (58) (59) (61)
EAp3: Fundamental Refrigerant Management	Preq.	●		(57) (60)
EAc1: Optimize Energy Performance	2-10	◗	◗	(20) (49) (56) (57) (58) (59) (61) (62)
EAc3: Enhanced Commissioning	1	◗	◗	(65)
EAc4: Enhanced Refrigerant Man-agement	1	●		(57) (60)
EAc5: Measurement & Verification	1	◗	●	(68)
MRc4.1, 4.2: Recycled Content				(57)
MRc5.1, 5.2: Regional Materials				(57)
EQp1: Minimum IAQ Performance	Preq	●	●	(57)
EQp2: Environmental Tobacco Smoke (ETS) Control	Preq	◗	◗	
EQc1: Outdoor Air Delivery Monitor-ing	1	●	●	(20) (57)
EQc2: Increased Ventilation	1	●	●	(57)
EQc3.1: Construction IAQ Manage-ment Plan: During Construction	1	◗		(57)

LEED-NC credit	LEED points	HVAC equip-ment	building control	refer-ence
EQc3.2: Construction IAQ Manage-ment Plan: Before Occupancy	1		◗	
EQc5: Indoor Chemical & Pollutant Source Control	1	◗	◗	(57)
EQc6.1: Controllability of Systems: Lighting	1		●	
EQc6.2: Controllability of Systems: Thermal Comfort	1	◗	●	(37) (67)
EQc7.1: Thermal Comfort: Design	1	◗	◗	(67)
IDc1.1-1.4: Innovation in Design	4	◗	◗	(53)
IDc2: LEED Accredited Professional	1			

Note:
● Main component in gaining LEED point
◗ Assist in gaining LEED point
p: Prerequisite in LEED rating system: a must perform item without exceptions; no points for the prerequisites.
c: LEED credit

LEED-NC 2.2 POINTS THAT TRANE CAN IMPACT

LEED-NC category		LEED points	Trane assists
Sustainable Sites	SS	14	-
Water Efficiency	WE	5	1
Energy & Atmosphere	EA	17	13
Materials & Resources	MR	13	-
Indoor Environmental Quality	EQ	15	8
Innovation & Design Process	ID	5	5
	TOTAL	69	27

Certified: 26-32; Silver: 33-38; Gold: 39-51; Platinum: 52-69

LEED FOR EXISTING BUILDINGS: OPERATIONS & MAINTENANCE (EB) 2008

LEED-EB O&M credit	LEED points	HVAC equip-ment	building control	refer-ence
WEc3.1: Water Efficient Landscaping – 50% reduction	1	◗	◗	(57)
WEc4.2: Cooling Tower Water Man-agement	1	◗	◗	(57)
EAp1: Energy Efficiency Best Management Practices – Planning, Documentation, and Opportunity Assessment	req.	◗	◗	(65)
EAp2: Minimum Energy Efficiency Performance	req.	◗	◗	(20) (49) (56) (57) (58) (59) (61)
EAp3: Refrigerant Management – Ozone Protection	req.	●		(57) (60)
EAc1: Optimize Energy Efficiency Performance	2-15	◗	◗	(20) (49) (56) (57) (58) (59) (61)
EAc2.1, 2.2, 2.3: Existing Building Commissioning: Investigation and Analysis, Implementation, Ongoing Commissioning	6	◗	◗	(65)
EAc3.1, 3.2, 3.3: Performance Measurement – Building Automation System, System Level Metering	3	●	●	(65)
EAc5: Refrigerant Management	1	●		(57) (60)
EAc6: Emissions Reduction Report-ing	1		◗	
EQp1: Outdoor Air Introduction and Exhaust Systems	req.	●	●	(57)

LEED-EB O&M credit	LEED points	HVAC equip-ment	building control	refer-ence
EQp2: Environmental Tobacco Smoke (ETS) Control	req.	◗	◗	
EQc1.1~1.5: IAQ Best Management Practices: IAQ Management Program, Outdoor Air Delivery Monitoring, Increased Ventilation, Reduce Particulates in Air Distribution, Management for Facility Alterations and Additions	5	◗	◗	(57)
EQc2.2: Occupant Comfort: Occupant-Controlled Lighting	1		●	(65)
EQc2.3: Occupant Comfort: Thermal Comfort Monitoring	1	●	●	(65)
IOc1.1-1.4: Innovation in Operations	4	◗	◗	
IOc2: LEED Accredited Professional	1			

Note:
● Main component in gaining LEED point
◗ Assist in gaining LEED point
p: Prerequisite in LEED rating system: a must perform item without exceptions; no points for the prerequisites.
c: LEED credit

LEED-EB O&M POINTS THAT TRANE CAN IMPACT

LEED-EB O&M category		LEED points	Trane assists
Sustainable Sites	SS	12	-
Water Efficiency	WE	10	2
Energy & Atmosphere	EA	30	26
Materials & Resources	MR	14	-
Indoor Environmental Quality	EQ	19	7
Innovation In Operations	IO	7	5
	TOTAL	92	40

Certified: 34-42; Silver: 43-50; Gold: 51-67; Platinum: 68-92

LEED FOR CORE AND SHELL DEVELOPMENT (CS) 2.0

LEED-CS credit	LEED points	HVAC equip-ment	building control	refer-ence
WEc1.2: Water Efficient Landscap-ing – No Potable Water Use or no Irrigation	1	◗	◗	(57)
EAp1: Fundamental Commissioning of the Building Energy Systems	req.	◗	◗	(65)
EAp2: Minimum Energy Performance	req.	◗	◗	(20) (49) (56) (57) (58) (59) (61)
EAp3: Fundamental Refrigerant Management		●		(57) (60)
EAc1: Optimize Energy Performance	2-8	◗	◗	(20) (49) (56) (57) (58) (59) (61)
EAc3: Enhanced Commissioning	1	◗	◗	(65)
EAc4: Enhanced Refrigerant Man-agement	1	●		(57) (60)
EAc5.1, 5.2: Measurement & Verification – Base Building, Tenant Sub-metering	2	◗	●	(68)
MRc4.1, 4.2: Recycled Content				(57)
MRc5.1, 5.2: Regional Materials				(57)
EQp1: Minimum IAQ Performance	req.	●	●	(57)
EQp2: Environmental Tobacco Smoke (ETS) Control	req.	◗	◗	
EQc1: Outdoor Air Delivery Monitor-ing	1	●	●	(57)
EQc2: Increased Ventilation	1	●	●	(57)

LEED-CS credit	LEED points	HVAC equip-ment	building control	refer-ence
EQc3: Construction IAQ Manage-ment Plan: During Construction	1	◗		(57)
EQc5: Indoor Chemical & Pollutant Source Control	1	◗	◗	(57)
EQc6: Controllability of Systems: Thermal Comfort	1	◗	●	(37) (67)
EQc7: Thermal Comfort: Design	1	◗	◗	(67)
IDc1.1-1.4: Innovation in Design	4	◗	◗	(53)
IDc2: LEED Accredited Professional	1			

Note:
● Main component in gaining LEED point
◗ Assist in gaining LEED point
p: Prerequisite in LEED rating system: a must perform item without exceptions; no points for the prerequisites.
c: LEED credit

LEED-CS POINTS THAT TRANE CAN IMPACT

LEED-CS category		LEED points	Trane assists
Sustainable Sites	SS	15	-
Water Efficiency	WE	5	1
Energy & Atmosphere	EA	14	12
Materials & Resources	MR	11	-
Indoor Environmental Quality	EQ	11	6
Innovation In Design Process	ID	5	5
	TOTAL	61	24
Certified: 23-27; Silver: 28-33; Gold: 34-44; Platinum: 45-61			

FEATURES OF TRACE™ 700

	green option	green criteria	reference
1	Modeling functionality	• All systems listed in this guide • All control strategies listed in this guide	(61)
2	Integration	• ASHRAE Standard 90.1 equipment library • gbXML (green building XML) • Weather files and templates • ASHRAE 62.1-2004 Ventilation Rate Procedure • Building Information Modeling (BIM)and more	(61)
3	Compliance	• Complies with Appendix G for Performance Rating Method of ASHRAE Standard 90.1-2004 • Auto-building rotations for LEED baseline building • Approved by the IRS for energy-savings certification (Energy Policy Act 2005) • Compliance with ANSI/ASHRAE Standard 140–2004	(61)

MODELING STEPS FOR LEED

(Peformance Rating Method in Appendix G of ASHRAE Standard 90.1-2004)

	green option	green criteria	refer-ence
1	Model the proposed design according to Section G3	• All end-use loads • Energy-saving strategies • Actual lighting power • Energy-saving architectural features • *Not yet designed* systems as identical to the baseline design	(59)
2	Model the baseline design in according to Section G3	• Set the lighting power density to the maximum value allowed for the building type per Table 9.5.1; • Omit the economizer, as allowed by Table G3.1.2.6A; • Change the HVAC systems type and description per Table G3.1.1A and G3.1.1B, based on the building type and size; • Use the minimum efficiencies specified in Table 6.8.1A (cooling) and 6.8.1E (heating); • Oversize the cooling and heating equipment based on requirements in Section G3.1.2.2	(59)
3	Calculate the energy performance of the proposed design	• Entire year simulation required (8760 hours)	(58) (59)
4	Calculate the energy performance of the baseline design	• Cooling and heating equipment is sized at 115% and 125%, respectively. • Four orientation simulations (rotating 0°, 90°, 180°, 270°) and the average of the four results is the baseline building energy performance	(59)
5	Calculate the percentage improvement and correlate number of LEED points attained	• Apply the formula: $100 \times \frac{\text{baseline bldg perf - proposed bldg perf}}{\text{baseline bldg perf}}$ • Correlate number of LEED points gained from LEED-NC EAc1 table	(59)

TABLE G3.1.1A BASELINE SYSTEM TYPES

buidling type	fossil fuel, fossil/electric hybrid, & purchased heat	electric and other
Residential	System 1 - PTAC	System 2 - PTHP
Nonresidential & 3 floors or less & <75,000 ft^2 (7000 m^2)	System 3 - PSZ-AC	System 4- PSZ-HP
Nonresidential & 4 or 5 floors or less & <75,000 ft^2 (7000 m^2) or 5 floors or less & 75,000 ft^2 (7000 m^2) to 150,000 ft^2 (14,000 m^2)	System 5 - Packaged VAV with reheat	System 6 - Packaged VAV w/PFP boxes
Nonresidential & more than 5 floors or >150,000 ft^2 (14,000 m^2)	System 7 - VAV w/reheat	System 8 - VAV w/PFP boxes

Notes:
Residential building types include dormitory, hotel, motel, and multifamily. Residential space type include guest rooms, living quarters, private living space, and sleeping quarters. Other building and space types are considered nonresidential.

Where no heating system is to be provided or no heating energy source is specified, use the “Electric and Other” heating source classification.

Where attributes make a building eligible for more than one *baseline* system type, use the predominant condition to determine the system type for the entire building.

TABLE G3.1.1 B BASELINE SYSTEM DESCRIPTIONS

system no.	system type	fan control	cooling type	heating type
1. PTAC	Packaged terminal air conditioner	Constant volume	Direct expansion	Hot water fossil fuel boiler
2. PTHP	Packaged terminal heat pump	Constant volume	Direct expansion	Electric heat pump
3. PSZ-AC	Packaged rooftop air conditioner	Constant volume	Direct expansion	Fossil fuel furnace
4. PSZ-HP	Packaged rooftop heat pump	Constant volume	Direct expansion	Electric heat pump
5. Packaged VAV w/reheat	Packaged rooftop variable-air volume with reheat	VAV	Direct expansion	Hot water fossil fuel boiler
6. Packaged VAV w/PFP boxes	Packaged rooftop variable-air volume with reheat	VAV	Direct expansion	Electric resistance
7. VAV w/reheat	Packaged rooftop variable-air volume with reheat	VAV	Chilled water	Hot water fossil fuel boiler
8. VAV w/PFP boxes	Variable-air volume with reheat	VAV	Chilled water	Electric resistance

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NOTES:

Care about Next Generations, Think about Life-cycle Impact.

While the environmental and human health benefits of green building have been widely recognized, this comprehensive report confirms that minimal increases in upfront costs of about 2% to support green design would, on average, result in life cycle savings of 20% of total construction costs — more than ten times the initial investment.

The Costs and Financial Benefits of Green Buildings
A Report to California's Sustainable Building Task Force
www.cap-e.com/publications

Note: Electric chiller is typically the largest single energy user in the building HVAC system. To work out how much more efficient a chiller should be purchased in order to justify its energy cost savings over the lifetime (or any other span of time), a "Bid Form" can help... especially for all large chillers. (see ref. 55)

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