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Introduction

With over 30% of all energy consumed in developed countries occurring in the built environment, it is not a surprise there are multiple performance rating systems for commercial and residential buildings. The USGBC Leadership in Energy and Environmental Design (LEED) is one of the most popular. It covers 8 areas for sustainable buildings of which energy is one area. The EPA's Energy Plus program has been used on over 400,000 buildings and focuses on energy only. ASHRAE's Building Energy Quotient (bEQ) programs covers energy both as *designed and as operated*. The as *operated* or asset rating can help building owners with programs to improve their real building performance.

Recently a new rating system, Passive House, has gained a foothold in North America. This paper will discuss the basis of Passive House and how you can learn more.

Passive House Europe

Figure 1 – Certified Passive House Nursery School with Swegon GOLD DOAS units, Skvode, Sweden

Passive House Institute was created in 1988 by Wolfgang Feist and Bo Adamson. It focused on ultra-low energy buildings particularly residential homes based on initial work developed in the United States and Canada in the early 1880s. Today there over 50,000 buildings that have followed the Passive House approach all over the world.

In German *PassivHaus* means passive building. While the original projects were mostly residential spaces, the program is now used for all types of buildings in all climate zones.

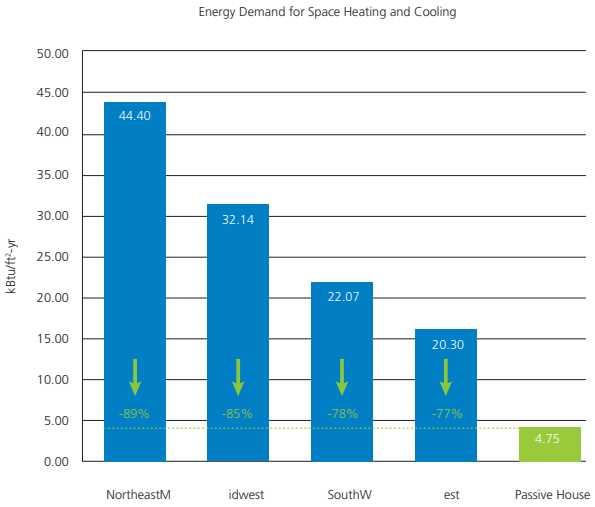
The Passive House program is focused on energy performance while being mindful on maintaining indoor Air Quality and thermal comfort. It uses a performance based approach (as opposed to a prescriptive approach more common in North America) which gives the designer more freedom on the path to compliance.

"A Passive House is a building, for which thermal comfort (ISO 7730) can be achieved solely by post-heating or post-cooling of the fresh air mass, which is required to achieve sufficient indoor air quality conditions – without the need for additional recirculation of air."[1]

Thermal comfort is achieved for the most part through passive measures such as insulation, very high grade windows, shading techniques and air tightness.

[1] Definition of Passive House from www.passiv.de

Figure 2 – Energy Demand for Space Heating and Cooling in Residential Buildings.[2]



As well as setting ultra low energy performance targets (see Figure 2), the program also covers certifying designers and equipment used to achieve a Passive House certification.

PASSIVE HOUSE EUROPE

Passive House Institute (passiv.de) is headquartered in Germany and is most prevalent in central Europe and the Nordic countries.

The certification program has three levels – Classic, Plus and Premium. A Classic rating is near net zero energy. Plus and Premium ratings have on site power generation that will meet or exceed net zero energy. A Classic Passive House Europe certified building must meet the following (see Table 1);

- Space heating demand not exceed 15 kWh/m²-yr (4.75 kBtu/ft²-yr) or 10 W/m² (3.2 Btu/ft²) of usable living space.
- Total primary (source) energy of less than 120 kWh/m²-yr (38 kBtu/ft²-yr)
- 0.6 Air changes/hr @ 50 Pa (0.6 ACH @ 0.2 inches w.c.)

Passive House certification is performance based so the designer has the freedom to choose the best method to achieve the result. Passive House design has the following pillars to help guide the designer to achieve the result;

- Insulation
- Thermal Bridge Free Design
- Air Tight Construction
- Heat Recovery Ventilation
- Highly Insulating Windows

		Criteria			Alternate Criteria
Heating					
Heating Demand	kBtu/ft²-yr	≤ 4.75			
Heat Load	Btu/ft²				≤ 3.2
Cooling					
Cooling + Dehumidification Demand	kBtu/ft²-yr	≤ 4.75 + dehumidification			Variable limit value
Cooling Load	Btu/ft²				≤ 3.2
Airtightness					
Pressurization Test	ACH	≤ 0.6 ACH @ 0.2 in w.c.			
Renewable Primary Energy					
Renewable Primary Energy Demand	kBtu/ft²-yr	≤19	≤14.3	≤9.5	± 4.75 bBtu/ft²-yr deviation from criteria with compensation different amount of generation
Renewable Energy Generation	kBtu/ft²-yr		≥19	≥38	

Table 1 – Passive House Criteria [3]

The heating performance goal is to improve the building envelope to the point where any remaining heat load can be met by just heating the ventilation air. Thus there is no other mechanical heating system other than the ventilation unit. In principle the removal of a distributed heating system offsets the increased cost in the building envelope.

PASSIVE HOUSE CERTIFIED PROFESSIONALS

In addition to building certification, Passive House also certifies both designers and tradesmen on the Passive House program.

PASSIVE HOUSE CERTIFIED PRODUCTS

Passive House institute also certifies key components used in building construction (http://database.passivehouse.com/en/components) including windows, compact heatpumps, drain water recovery and energy recovery ventilation (DOAS) units.

[2] USA, 2005, Source: Department of Energy

[3] Criteria for the Passive House, EnerPHIT and PHI Energy Building Standard

Table 2- EnerPHIT Criteria for Building Components

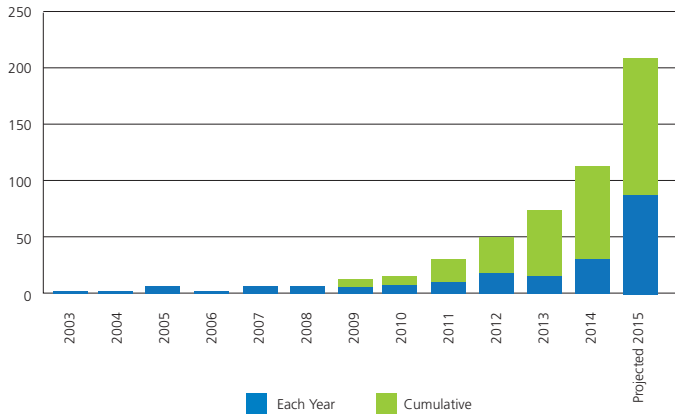
	Opaque Envelope Against...				Windows (including exterior doors)					Ventilation	
	Ground	Ambient Air			Overall			Glazing	Solar Load	Min. heat recovery	Min. humidity recovery
	Insulation	Ext. Insulation	Int. Insulation	Ext. Paint	Max. Heat transfer coefficient			Solar heat gain coefficient			
	R Value (h·ft²·°F/Btu)			Cool Colours	Btu/h·ft²·°F			g unit	kBtu/ft²-yr		
					Wall	Pitched Roof	Flat Roof			%	%
Arctic	Determined in PHPP from project specific heating and cooling degree days against ground	63	23	-	0.08	0.14	0.11	U_g-g·0.7≤0	32	80	-
Cold		41	19	-	0.11	0.12	0.14	U_g-g·1.0.≤0	32	80	-
Cool-Temperate		38	16	-	0.15	0.18	0.19	U_g-g·1.6≤0	32	75	-
Warm - Temperate		19	11	-	0.18	0.19	0.21	U_g-g·2.8≤0	32	75	-
Warm		11	8	-	0.22	0.23	0.25	-	32	-	-
Hot		11	8	Yes	0.22	0.23	0.25	-	32	-	60
Very Hot		23	13	Yes	0.18	0.19	0.21	-	32	-	60

Passive House USA and Canada

Passive House Institute US

In North America, Passive House is represented by Passive House Institute US (PHIUS) (phius.org) and Canadian Passive House Institute (CanPHI) (passivehouse.ca)

Figure 3 – US Passive House Certified Projects



While Passive House has been well known in Europe for the last two decades, it is a relative newcomer to North America. In the last few years interest in the high performance standard has grown both in residential and commercial projects (see Figure 3).

Passive House Canada follows the European performance targets. PHIUS follows the intent and pillars of the Euro version but has modified the goals for the USA. In 2015 it introduced PHIUS + 2015 which includes climate specific performance targets (The European version has one set of targets for all building types and locations). The change is based extensive research conducted with a DOE grant with NREL (National renewable Energy Lab). The key result is the new program provides performance criteria based on climate zone. This was found to be necessary when considering the wide range of climate zones found in North America compared with central and Northern Europe. The PHIUS website contains local performance targets for over 1000 locations in the US. The new standard qualifies for the DOE Zero Energy Ready Home program.

SWEGON AND PASSIVE HOUSE

Figure 4 – Swegon Passive House Certified Ventilation (DOAS) Unit

Swegon has a long history with Passive House though its Nordic roots. The Swegon GOLD energy recovery ventilating (DOAS) unit is Passive House certified. In addition, the integral unit controller has the necessary control algorithms to not only control ventilation but provide heating and cooling control through the

ventilation air (the definition of a Passive House Building). These units are now being manufactured in North America.

GOLD AIR HANDLING UNIT

Widely-recognized in Europe, Swegon's innovative technology is now in North America. The GOLD DOAS unit enables designers to re-think system design to improve comfort, reduce operational costs, and maximize usable space. GOLD has the lowest overall sound power levels and smallest footprint of any unit in its class. In healthcare, office, and institutional markets, GOLD helps promote employee effectiveness and attendance by improving indoor air quality and thermal comfort. The comfort revolution begins now.

Certified Efficiency

To achieve PHI certification, Swegon air handlers must comply with strict operating efficiency requirements. This assures Passive House building owners of predictably low energy consumption and a comfortable environment for the occupants. Swegon GOLD meets or exceeds the following PHI criteria:

Table 3 – Passive House Commercial DOAS Unit Performance Requirements

Parameter	Criteria
Thermal Comfort	T_{SA} >= 62°F When T_{OA} = 14°F
Effective heat recovery	>75%
Specific Fan Power	<0.77 W/cfm
Performance Number[i]	≥ 10
Leakage, exhaust to supply air	<3%
Leakage, casing	<3%
Automated airflow balancing	required
Filtration, return	MERV 9
Filtration, supply	MERV 13
Frost protection	not required at T_{OA}>5°F

[i]Performance number refers to the ratio of energy saved to energy consumed.

Figure 5 – Hogasskolan School, Certified Passive House with Swegon GOLD DOAS units, Knivsta, Sweden. (http://www.swegonairacademy.com/case-studies/hogasskolan-in-knivsta/)

The Swegon Air Academy is a platform for objective information and knowledge conveyance in the ventilation, indoor climate and energy issues. There is extensive information on projects as well as design and construction considerations. (swegonairacademy.com)

Additional Information

www.passiv.de
www.PHIUS.org
www.passivehouse.ca
www.passipdeia.org
www.swegonairacademy.com
www.swegon.com

Please feel free to contact us if you would like more information on chilled beam systems, GOLD or to schedule a training session.