CUSHMAN & WAKEFIELD

GOING GREEN

Passive Houses

Tbilisi, Georgia

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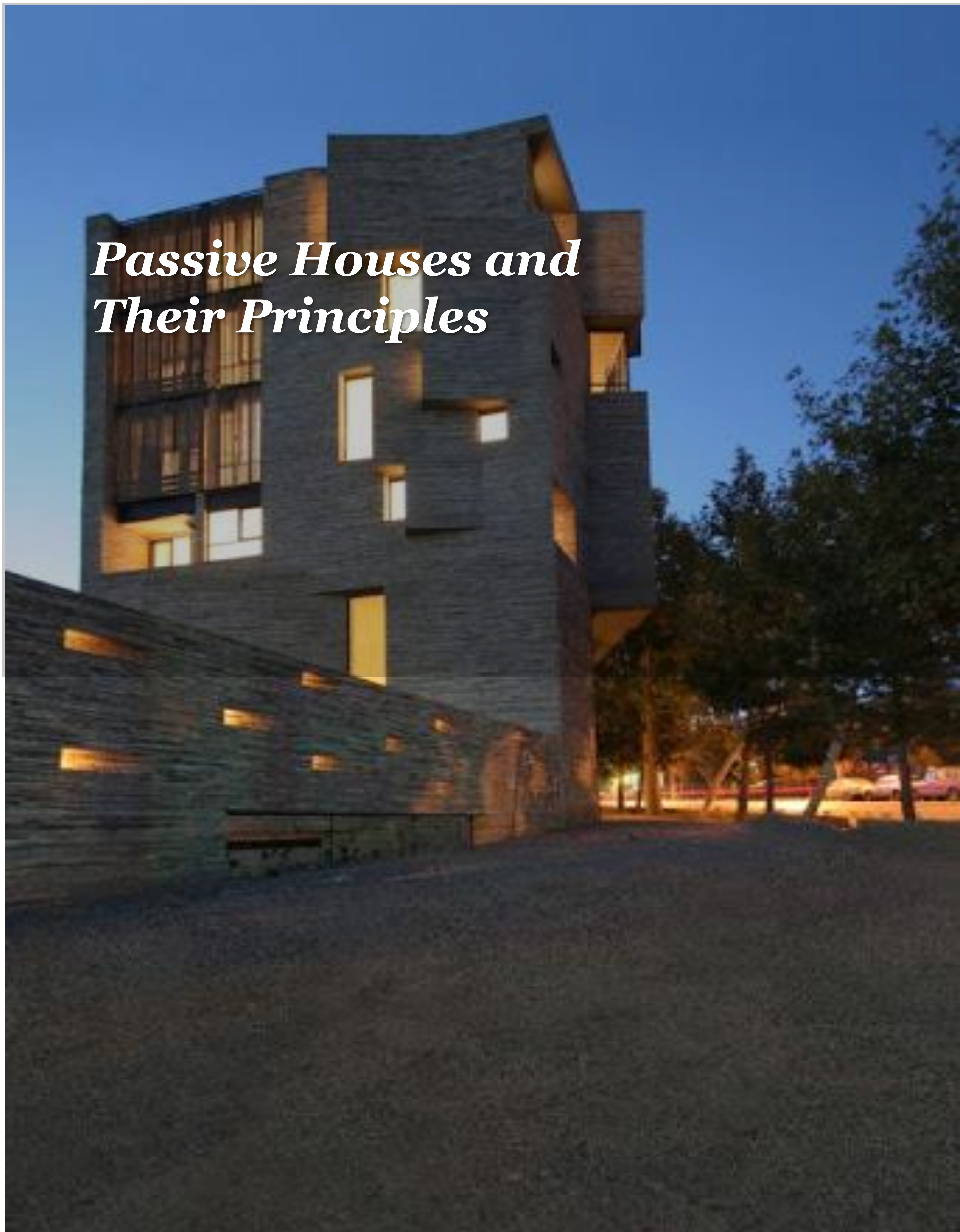
In line with ongoing sustainability activism and the leading role that real estate can play contributing to environmental conservation, we are offering a series of articles, in which we will be reviewing the importance of greener orientation and sustainability in Real Estate, green buildings, sustainable materials and practices, financial benefits of eco-friendly buildings, and lastly we will be touching upon greenness trends in Georgia to assess where real estate stands in the country on the road to sustainability.

In our previous articles we explained the importance of sustainability and green buildings, and introduced LEED system. We explained how to get LEED certificate, and reviewed its assessment areas and sustainable building materials. We also showed LEED from investors' perspective - financial gains associated with it and other monetary impetus for going green.

In this article we will introduce energy efficient, ecological, affordable, and comfortable construction concept - Passive House, as well as its guiding principles and advantages. We will briefly explain Passive House Planning Package and certification, followed by financial incentives of passive buildings and two case studies.

Passive Houses and Their Principles



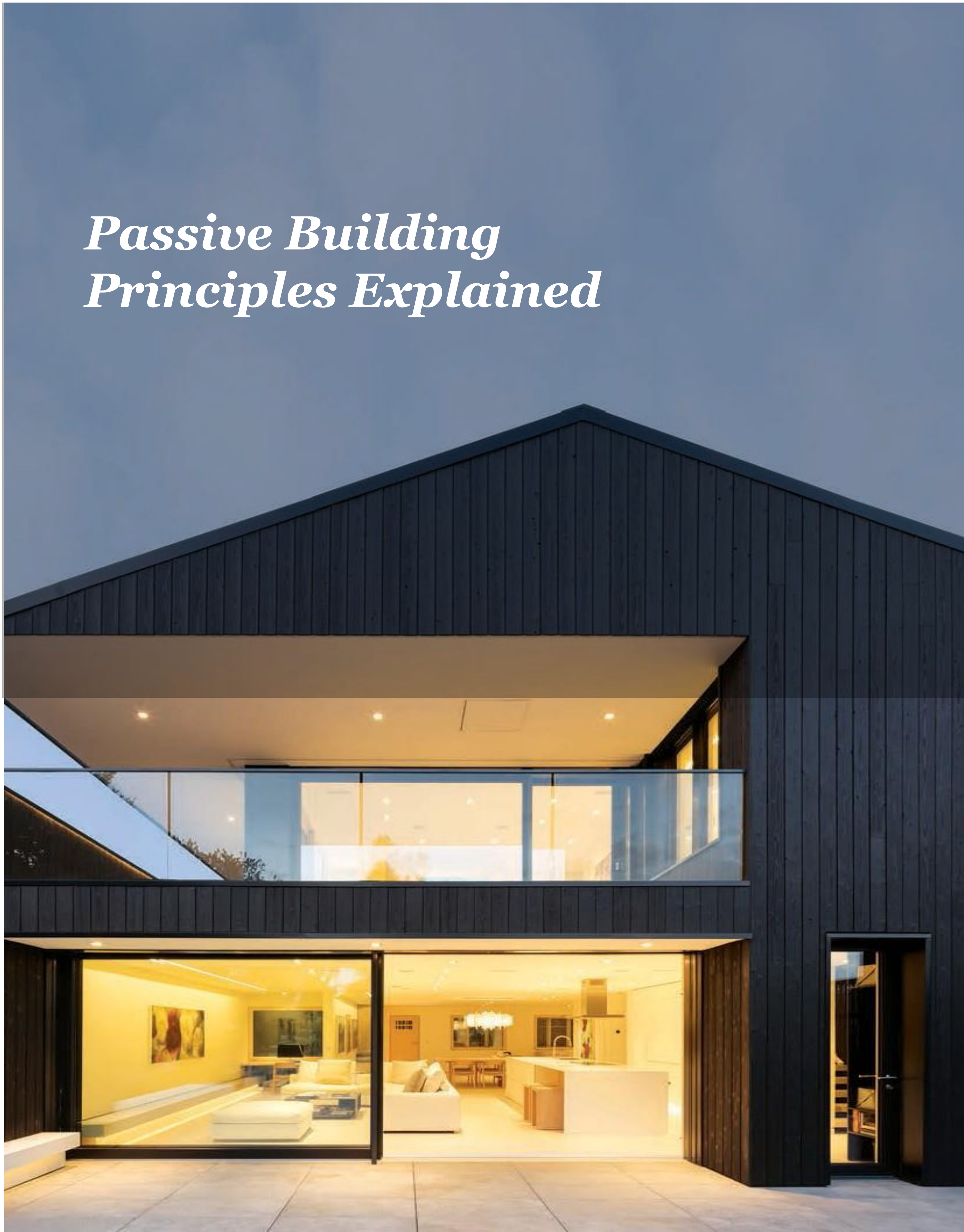
One of the most environmentally friendly and affordable types of buildings are the so called "passive buildings". North American building scientists and the Canadian government were the first to pioneer passive building principles in the 1970s. Later in the 1980s the German Passivhaus Institut (PHI) was created which developed the principles and performance standards that work especially well in case of the Central Europe. The concept of building low-energy houses has as of today become the leading building standard for private as well as multifamily and in some case commercial structures.

Passive building is a building standard and a construction concept that entails energy efficiency, eco-consciousness, affordability and comfort. One may well inquire as to why the name references passivity. This is because ***thermal comfort and equilibrium in these buildings is achieved through passive measures, such as insulation, heat recovery, passive use of solar energy and internal heat sources.***

To that end, passive buildings with their design ensure quantifiable and rigorous energy efficiency levels, and are driven by five main principles:

- *Minimal space conditioning system;*
- *Airtight construction - preventing loss of conditioned air and infiltration of outside air;*
- *Mechanical ventilation with heat recovery, balanced heat;*
- *Superior windows - high-performance double or triple-paned windows and doors, ensuring solar gain in the heating season and minimal overheating in the cooling season;*
- *Continuous quality insulation - no thermal bridging.*

Passive Building Principles Explained



Passive buildings are constructed to optimize thermal gain and reduce heat losses, and as such, enable heating and cooling related energy savings of up to 90% compared to typical buildings. They use limited amount of primary energy while energy required for construction is insignificant compared to the amount of energy saved up later on. This is possible due to specific energy efficient building components and a quality ventilation system.

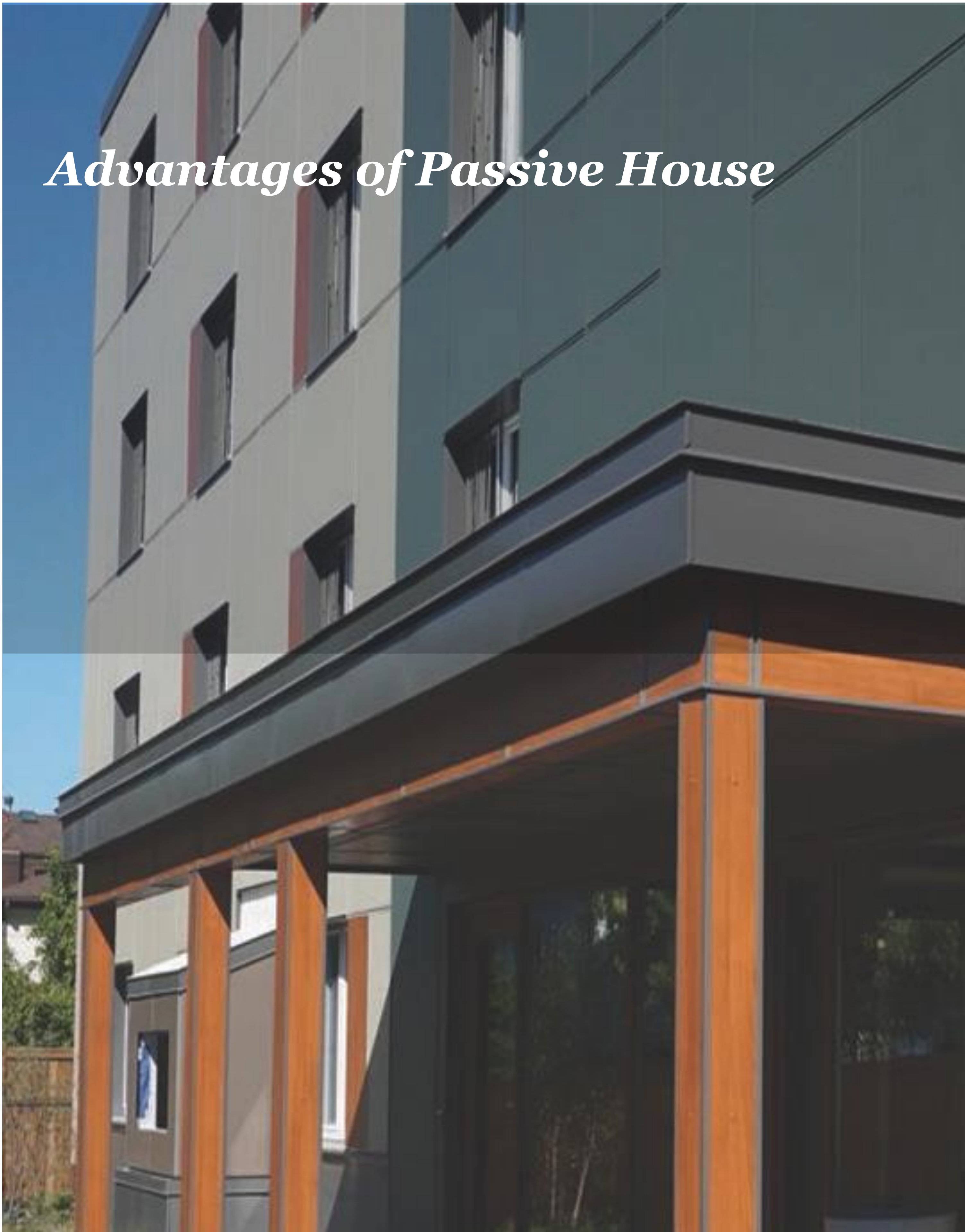
Passive buildings are perceived to be highly comfortable, as they use energy sources inside the building such as body heat from the residents or solar heat entering the building, making heating easier and rendering conventional heating systems (e.g., boilers), unnecessary throughout even the coldest months. Additionally, a highly efficient heat recovery unit allows for the heat contained in the exhaust air to be re-used. On the other hand, during warmer months, passive houses make use of passive cooling techniques such as strategic shading to keep the buildings comfortably cool.

Numerically, passive houses require less than 15 kWh/(m²a) (kilowatt-hour/square meters per annum) energy for heating or cooling (as relating to the living space), which is only about 10% of the energy used in conventional buildings.

Typically, for a building to be low-energy, it needs to be airtight. Airtight building itself requires an efficient ventilation system – one of the features of a passive house. Passive houses prevent loss or infiltration of air, thereby ensuring that throughout both the heating and cooling seasons the building has comfortable and consistent indoor temperature. Moreover, a ventilation system consistently supplies fresh air, which guarantees superior air quality in the building, resulting in improved living conditions for the inhabitants.

Using fresh ventilation air for heating without additional heating system can only work in buildings with very low net heat losses. This requires a high-quality insulation of the building envelope, in cold climates - to keep the desired warmth inside the building, and in hot climates - to keep undesirable heat out. So passive houses are appropriately insulated to maintain efficient heat recovery system. This is called “thermal bridge free design”, meaning that the insulation is applied to the whole building without “weak spots” and there are no cold corners or excessive heat losses. This again makes passive houses comfortable as there are little changes for moisture build up and damage. Notably, passive house buildings usually employ high-quality insulation methods like stone wool.

Advantages of Passive House



Passive houses, much like many other eco-friendly, sustainably built structures require a higher upfront investment but are affordable to maintain and live in in the long term. However, even at the building stage, initial capital can be redistributed away from conventional heating and cooling systems, which are unnecessary, and towards better insulation and ventilation systems. Data from Germany shows that on average, a passive house will require 3 to 8% cost premium. This cost differential will be higher in countries where materials and components required for a passive house are not readily available. However, historically, proliferation of the passive house concept has increased market supply of necessary materials as well, which has in turn exerted downward pressure on the prices.

Vis a vis the construction materials, proliferation of the passive house concept can benefit regional manufacturers of insulation materials, or structural materials as wool, straw, wood fibers, paper, mineral wool, several types of plastics, foamed calcium silicate, and foamed glass as demand on these rises.

*Total primary energy demand can be lowered by as much as 70% in passive buildings compared to their ordinary counterparts. Energy needed to heat water can be reduced by as much as 75% given than water pipes are insulated and solar collector - a device for solar hot water heating – is used in typical passive houses. Usage of efficient electrical appliances in passive houses, as well as effective control and energy-efficient lighting, makes it is possible to reduce the electricity consumption by more than 50%. Whatever demand there is for primary energy can be compensated by regionally available renewable energy sources that are environmentally-friendly and more sustainable. Due to their ability to require about one tenth of the energy used by a typical house, passive houses are sometimes referred to as "**factor 10 house**". It should be apparent, that apart from the environmental benefits, lower energy consumption translates into lower utility costs. This is why some suggest that passive houses demonstrate sustainable affordability.*

Passive House Planning Package

PHPP - The Passive House Planning Package, developed in 1997, is a tool used to design a property functioning as a passive house. It helps architects and designers to professionally plan and optimize passive house design. PHPP determines an energy balance and calculates the annual energy demand of the building based on the user input relating to the building's characteristics. PHPP explicitly looks at the location and local climate, particularly temperature and solar radiation, and determines a monthly heating or cooling demand for the entered building. Then the tool gives details about the property:

- *The annual heating demand and maximum heating load;*
- *Cooling demand and maximum cooling load, active cooling and passive cooling periods;*
- *Annual primary energy demand for the whole building.*

The sample PHPP form is shown below.

Specific building demands with reference to the treated floor area					
	Treated floor area	156,0	m^2	Requirements	Fulfilled?*
Space heating	Heating demand	14	kWh/(m²a)	15 kWh/(m²a)	yes
	Heating load	10	W/m²	10 W/m²	yes
Space cooling	Overall specif. space cooling demand		kWh/(m²a)	-	-
	Cooling load		W/m²	-	-
	Frequency of overheating (> 25 °C)	1,6	%	-	-
Primary energy	Heating, cooling, auxiliary electricity, dehumidification, DHW, lighting, electrical appliances	60	kWh/(m²a)	120 kWh/(m²a)	yes
	DHW, space heating and auxiliary electricity	33	kWh/(m²a)	-	-
	Specific primary energy reduction through solar electricity	25	kWh/(m²a)	-	-
Airtightness	Pressurization test result n_{50}	0,2	1/h	0,6 1/h	yes

* empty field: data missing; '-': no requirement

Notably, this PHPP version is best fit for the Northern Hemisphere, and the manual must be adopted to be used in the Southern Hemisphere too. We should note that on-size-fits-all approach may not be efficient, as some principles and standards may not work well in certain climate zones, and following the standards blindly may increase costs more. In an attempt to incorporate different climate and market conditions, passive building principles continuously go through changes and updates. The newest version of guiding principles was released in 2018 to reflect changing market, materials, and climate factors.

The PHPP forms the basis for ***quality assurance and certification*** of a building as a Passive House.

Certification

The PHI acts as an independent testing and certification center for buildings and building components, such as wall and construction systems, windows, doors, connections, and ventilation systems. Notably, the same program in the US is known as the PHIUS+ Certification Program, the leading, largest and fastest-growing passive building certification in North America.

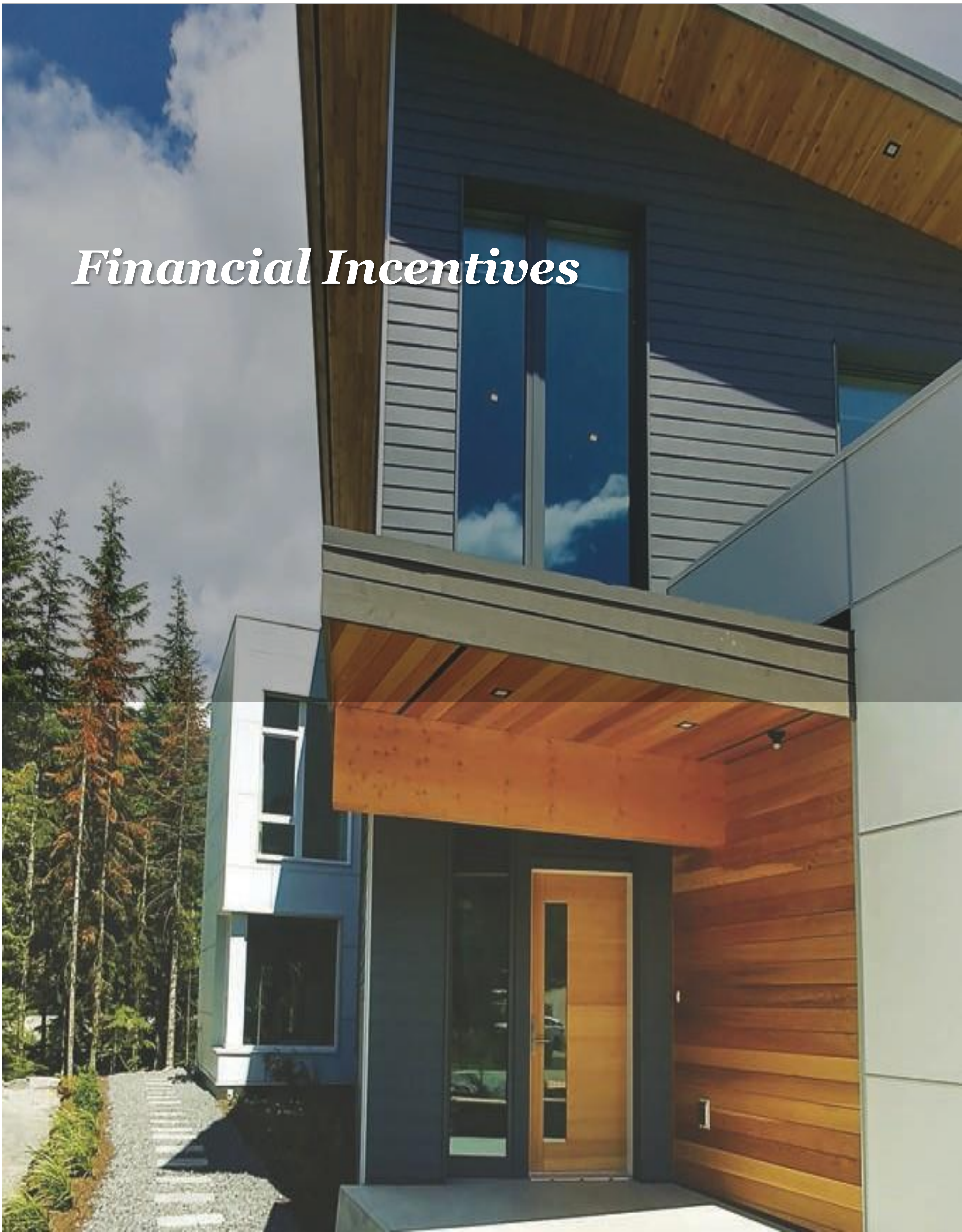
Energy-relevant planning documents and technical data of the construction products will be submitted to the institution before the start of construction, which carefully checks all data and gives recommendations what needs to be improved. After completion of the construction, adjustments to the building's energy usage will be checked again during the final inspection. Thus, certification process combines passive house verification procedure with quality assurance and control program, which is performed onsite by highly skilled and specialized raters and verifiers. The on-site inspections and testing help to assure the Institute and the project teams that the buildings can perform as designed. The certification team is made up of most experienced passive house professionals who thoroughly review projects at the design stage, identify problems, and work with project designers to help them achieve performance targets. At the end if all needed criteria are met, passive house certification is issued after completion of the building.

Since 2015 the PHI developed new – Premium, Plus and Classic levels of certification for passive houses when they achieve certain levels of renewable energy generation and renewable primary energy demand.

Certification Level	Premium	Plus	Classic
Renewable Energy Generation	≥120 kWh/(m²a)	≥60 kWh/(m²a)	
Renewable Primary Energy Demand	≤30 kWh/(m²a)	≤45 kWh/(m²a)	≤60 kWh/(m²a

If a building owner wants to upgrade only specific building component to the passive house standard instead of a complete renovation, it is also possible to get a passive house component certificate.

Financial Incentives



As green buildings are becoming more and more demanded and preferred for combatting the environmental issues, more countries are offering financial support for building low energy buildings. Different authorities incentivize constructing eco-friendly houses and 'passive' projects promoting energy optimization. Notably, passive houses get financial funding or other types of incentives usually for Energy Efficient Construction or Energy Efficient Retrofits, increasing the attractiveness of passive house construction even more.

For example, the Portuguese government decided to design a 4.5-million worth non-refundable grants for supporting energy improvement works and making buildings more passive in Portugal by the end of 2021. The authorities define several categories through which energy optimization can be achieved: windows, thermal insulation, heating/cooling and hot water systems, renewable energy production equipment, better water management and integration of biomaterials, recycled materials, green covers and bioclimatic architectural solutions. Grants comprise maximum €15 000 per owner and €7 500 per building or unit.

Portugal also provides loans on favorable terms for those who improve the environmental performance of their private housing and make them passive. This so called "Casa Eficiente 2020" program focuses on improvements in energy and water efficiency and urban waste management, which can be achieved by using high-performance windows, thermal insulation materials, installation of heat recovery systems and rainwater reuse systems. Importantly, these interventions must be carried out by authorized companies.

Moreover, some other countries have started setting up mechanisms to promote passive house standards. For instance, passive house verification, as PHPP form can be submitted for various subsidy programs. In Italy, in the municipality of Muzzan buildings that carry the passive house certificate are entitled to a 60% reduction in building permit fees with a maximum reduction of €20,000 for each building.

In the US Fannie Mae, the US Federal National Mortgage Association is offering new lower interest rates for green building certified multifamily properties, including the passive house standard. Mortgage is given to finance energy and water efficiency incentives in the properties. They also offer loans for energy and water efficiency retrofits.

CASE 1: A TERRACED HOUSE

Location: Greece

A terraced house complex in Greece, at the edge of the coastal port city of Volos, is a first building to meet the Passive House standard criteria in the country. The building was built in 2012 but then it was renovated, proving that the Passive House Standard can also be achieved in retrofits using passive house components. The local engineering firm X-G lab+development constructed 3 houses, with a total area of 477m^2.

For estimating heat requirement of a building usually utilized materials and average climatic data are taken into account. Despite the challenges for energy efficient construction in this specific region of Mediterranean with a warm climate, the constructors managed to develop a low energy passive building.

The passive building uses high quality ventilation units with heat recovery for each house, also subsoil heat exchanger, "Daikin" air conditioning system, and improved flat plate solar collector for sourcing renewable energy. Its windows have a wooden frame, and there are wooden doors with isolation all built in a local factory, highlighting the selection of locally produced resources and benefits to regional manufacturers.

The PHPP planning tool estimated the heating demand - 12 kWh/(m^{2}a) - and the cooling demand - 6 kWh/(m^{2}a) - are significantly lower than the same figures for conventional buildings.

Human resources centre in Turkey, Gaziantep city is another successful example of eco-friendly building. Several international firms participated in the design and construction process of this 310m^2 structure. EG Architecture developed the concept, while collaborating with Turkish consultancy EKHO Architecture to achieve the PassivHaus standards.

Its light-colored walls and green roofs are well-suited against heat and the sun in the area. Moreover, the building achieved its energy efficiency targets with the heat-recovery ventilation system; Depending on the weather conditions, air in the ventilation system is preheated or precooled as needed with the help of a ground heat exchanger. Superior insulation reduces heat transfers; A photovoltaic system in the garden ensures the demanded energy is generated.

Furthermore, the LED lighting system minimizes energy consumption, and the smart architectural design enables natural light to reach the interior.

Location: Turkey

CASE 2: HUMAN RESOURCES CENTRE

World map of certified buildings

Looking Ahead:

Besides LEED framework and Passive House standards, there are other third-party certifications that validate green features of green buildings. Our next article will briefly introduce some most popular certifications recognizing green elements in buildings.

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