POLYTECHNIC OF MEĐIMURJE IN ČAKOVEC
SUSTAINABLE DEVELOPMENT

DENIS PAUL PAUNA

PASSIVE HOUSES IN THE UNITED KINGDOM

FINAL PAPER

ČAKOVEC, 2019
DENIS PAUL PAUNA

PASSIVE HOUSES IN THE UNITED KINGDOM
PASIVNE KUĆE U UJEDINJENOM KRALJEVSTVU

ZAVRŠNI RAD

Mentor:
Martina Sobočan, prof.eng.i njem.jez.i knj., v.pred

Komentor:
Jasmina Ovčar, mag.ing.arh.i urb., v.pred.

ČAKOVEC, 2019.
Abstract

The aim of this paper is to provide an overview of the origin of the passive house, the community who came up with the idea, the first examples of this type of building, the characteristics of passive houses that make them so different from conventional houses, and to describe a passive house construction in the United Kingdom by giving examples and descriptions of the selected houses.

For some countries, building of passive houses is still in its beginnings, therefore it is necessary to deal with this matter, to get to know it better and to emphasize its significance in order to easily understand, but also possibly motivate passive building. There is a need to think differently when it comes to construction. In the present, we are faced with enormous energy consumption, even in households, which also includes (either directly or indirectly) burning of fossil fuels. It is evident that the damage fossil fuels are causing to our environment is irreparable. But there is still time to conserve what we have left and also, other sources of energy are needed. Apart from the fact that a passive house gives some very effective solutions, it also helps its owner reduce a great extent of household expenses.

The main feature and also the key of what defines the passive house is its insulation thickness, resulting in no need for cooling/heating. All of the elements (windows, doors, cold bridges, etc.) must be processed and installed properly within the Passive House demand standards.

This type of construction should be implemented. People have to look forward to lowering the energy consumption - it brings most benefits. The only concern is primary investment, but it is worth it. Passive houses can even produce energy. One important feature is sun energy storage which can be used when needed. By construction in the proper way, all costs can be greatly reduced.

KEY WORDS: heat-recovery, insulation, low-cost energy, passive house, the United Kingdom (the UK),
## CONTENTS

Abstract

1. INTRODUCTION ........................................................................................................6

2. ORIGINS OF PASSIVE HOUSES ..............................................................................7
   2.1. Wolfgang Feist ......................................................................................................8
   2.2. The pilot passive house building ......................................................................9
   2.3. Contemporary passive construction ................................................................10

3. KEY ELEMENTS OF THE PASSIVE HOUSE STANDARD ........................................14
   3.1. Orientation and thermal zone ...........................................................................15
   3.2. The shape of building .......................................................................................16
   3.3. Insulation ...........................................................................................................17
   3.4. High performance windows and doors. ............................................................17
   3.5. Heat recovery ventilation ..................................................................................18
   3.6. Recuperation ......................................................................................................19
   3.7. Sun energy storage ............................................................................................20
   3.8. Construction without thermal bridging .............................................................21

4. PASSIVE HOUSES IN THE UNITED KINGDOM ..................................................22
   4.1. The passive houses in the United Kingdom nowadays .......................................22
   4.2. The Passivhaus Trust ......................................................................................23
   4.3. A step forward for passive houses in the United Kingdom ...............................24
   4.4. Examples of passive houses in the United Kingdom ........................................25
       4.4.1. Crossway ....................................................................................................26
       4.4.2. Camden - London .....................................................................................27
       4.4.3. Bushbury Hill Primary School ...................................................................28
       4.4.4. Mayville Community Centre .....................................................................29
       4.4.5. Exmouth Market .......................................................................................30
ACKNOWLEDGEMENT

I would like to thank my mentors Martina Sobočan and Jasmina Ovčar for their generous help, patience, affability and various expert advice which helped me finish this final paper.

I would like to thank my professors for helping me in the knowledge acquisition, and my colleagues and friends with whom I exchanged and acquired knowledge and experience.
1. INTRODUCTION
The main focus of this paper is the passive house. It is therefore necessary to answer the question what the passive house is, because, even though passive houses are not a novelty, they are still not that common as one might expect. The passive house is a building that achieves a pleasant atmosphere without a separate heating and air conditioning system. The maximum spending of a passive home, meeting the primary energy needs including hot water and electricity, should not exceed 20 kWh / m² per year. Passive houses typically spend about 15 kWh / m² and up to 80-90% less energy than a classical low-energy house, thanks to the basic principles behind the passive house energy balance: eliminating heat losses and maximizing free gain energy. [1]

The passive house offers a lot of comfort and very low energy costs by means of insulation. As for ventilation, there are several ways to build it; draught free and heat recovery - ventilation that is crucial for providing fresh air in the winter, when the windows are closed. This means that energy will not be lost due to cold wind blowing through the building. A common building also extracts the exhaust air directly from the outside, losing all the heat contained in the air. In a passive house, the exhausted air gives most of its heat to the fresh air supply. Supplying healthy amounts of fresh air without energy loss is sometimes described as ventilation hygiene. Winter heat is partially secured by passive use of solar energy, and partly by using internal heat sources such as people and devices. Passive house buildings provide great conditions for living, such as comfort, healthy and cheap living, with minimal energy requirements and demands, no matter of the weather outside. [1]

There are new window inventions, heat-recovery ventilation products and other manufactured products which have been stimulated by the comprehension of the passive house methods across Europe. There is only a matter of time before suitable high-quality products from local manufactures appear, supporting and regenerating the local economy. [1]

The passive house method has been successfully applied and tested in all European climates, USA, Canada and even in warm Asian climates where there is a need for cooling. Indeed,
with some regional variations in design techniques, the method has proved to be applicable almost worldwide. [1]

2. ORIGINS OF PASSIVE HOUSES

After deforestation in Europe for agriculture and firewood, Europeans turned to coal for fuel as the Industrial Revolution started. But where coal was not available, other ideas emerged. For example, Icelandic people turned to burning peat in their turf-walled and turf-roofed houses. For stability the walls were very thick, and these walls of turf were found to have good insulating qualities so that hardly any heating fuel was required. [1]

It is evident therefore that scarce energy resources are not a problem of our time. From the time of Industrial revolution until now, the energy resources have only become more scarce and an alternative not only to fossil fuels, but an alternative way of building that would be more sustainable, is a must.

During the 1960s in Sweden, an engineer named Bo Adamson did a research on highly insulated buildings. Also, he built the first prototype development to test his new ideas at Alhem (Figure 1). [1]

![Project of 32 houses in Alhem, by Bo Adamson](image)

Figure 1 shows the beginning of energy efficient houses, which later evolved into passive houses. Bo Adamson built 32 houses which were his test projects, where he measured energy consumption on various objects, encouraged by his wish and ambition to find a way of no required heating in the building.

When the oil crisis occurred in 1973, Swedish buildings were relatively energy efficient compared to buildings in most of Europe. In mid 1980’s low energy design had become a rightful requirement for new buildings in Sweden and Denmark. [1]

“At the same time, he was working on further insulation development, thermal (cold) bridging, efficient insulated glazing, hermetic space and controlled ventilation. Adamson’s wish and ambition was to find a way of no required heating in the building. By his assumption, temperature would be allowed to drop to 17°C in a Swedish winter.”[1]

It can be seen that Adamson noticed the main passive house issues such as thermal bridges, heat leaking through the gaps of the openings and walls, so he searched for solutions. After numerous researches, he later teamed up with Wolfgang Feist with whom he managed to solve these problems and achieve the standard of passive houses.

2.1 Wolfgang Feist

There were other parts of Europe where an alternative to classic building was sought for. During the eighties, a young German physicist, Wofang Feist, was involved in the research of civil engineering; with the way of finding methods for creating very passive buildings with low energy. Also, these buildings were planned to change wear on warm interior temperatures and the general comfort that people in Europe are accustomed to. He wanted to maintain everyone's comfort, which was essential if people were to be convinced of the energy saving proposal. Feist determined the amount of energy losses in the building, which he wanted to minimize, but also to determine the amount of energy requirements produced. The main goal was to maintain 20°C inside the building. [1]
Feist and Adamson were working together on the idea of the passive house: “Feist visited Sweden frequently throughout the 1980s to share his ideas with Adamson. This was an exciting time for the two of them. They systematically and urgently laid the foundations of the Passive House concept. Feist’s work entangled computer simulation of the heat balance of a building, hour by hour during a typical year.” He was looking for a vigorous methodology to enforce all forms of building, where he guaranteed the highest level of comfort while using only little amounts of energy. Wolfgang Feist turned up as the father of the passive house, because he developed the scientific foundations of the standard and then went on to form the “Passivhaus Institut”. Feist, more than anyone, tirelessly worked both scientifically and politically to explain the clear social and economic benefits of the standard in a way that can be understood by everyone. [1]

2.2 The pilot passive house building

After the necessary research, the idea needed to me materialised. So, in 1989, Dr. Feist gathered a team of three private individuals and an executive architect to test the practical feasibility of a passive house concept using a pilot passive house in Darmstadt Kranichstein, Germany (Figure 2). [1]
Figure 2 shows the world’s first passive house. This project was launched by Feist in 1988 with Adamson, who was specialised in building construction, which resulted in a building without thermal bridging.

A scientific research group was created and the research involved the development of an efficient ventilation unit for heat recovery, new specially insulated window frames and shades, structural details for joining building components and solar heating technology and the concept for recovering heat from wastewater. The house had exceptionally good insulation and efficient ventilation for heating. Energy tracking results showed that the strategies were very successful. [1]

2.3 Contemporary passive construction

Contemporary architecture is sustainability oriented. It is both a necessity and a condition of modern construction. Uncompromising use of non-renewable energy sources, as well as environmental pollution, have reached their upper limit, threatening not only individual cities, regions, but the planet Earth as a whole. The construction industry takes a large part of the responsibility for this kind of behaviour and therefore the pressure on construction is extremely high. The answers to the question of sustainability have already been given in pilot projects, but there is a need for a broad approach to sustainable design and sustainable construction.

The share of low-energy buildings in the world is increasing rapidly year by year, especially in developed countries. This is a consequence of economic opportunities, because investing in low-energy construction requires higher initial investment. In Europe and beyond, on the American and Australian continents, passive construction is becoming imperative and is legally regulated by the minimum required for newly constructed buildings, as well as the energy renovation obligations of "big consumer" buildings.

Every quality construction, including a passive house, comes from a high-standard, comprehensive and well-designed architectural design solution. Therefore, the awareness of
investors and architects of contemporary construction needs is the basis for quality and affordable construction.

When focusing on Europe, there are countries where passive houses have become quite common (Austria, Germany, the United Kingdom, Scandinavian area, etc.), but there are many countries, where passive houses have not become a standard in construction, as for example in Croatia, Bosnia and Herzegovina, Hungary, Romania etc. For example, European countries are paying great attention to encouraging investors to this type of construction, and so far, hundreds of thousands of low-energy homes have been built in Germany, while in Austria there are more than 5,000 passive houses, which are leading the way in Europe. Austria is a great and applicable example in comparison to Croatia. [2] As said by the Austrian government “the Austrian state has contributed to the expansion of passive construction by incentives of around € 200/m² for anyone who decides to renovate or build on the principles of passive construction. “In order for the passive construction to include as many new ones as possible and the rehabilitation of old buildings, the state provides the above mentioned incentives.” [2]

In the year of 2006, 4% of the volume of new construction was performed according to the standards of passive construction. It was anticipated that by 2010, 28% of the volume of new construction would be carried out according to passive construction standards. In 2014, 98% of the volume of new construction could be performed according to passive construction standards. [2]

Passive houses are widely known for their comfort, frugality and contemporary look and also the function. They achieve a very high level of energy savings and less costs. Still, there are some unexplored ways to achieve better results, but every new built passive house is researched and monitored, so the method is always improving.

The standard of a passive house regime can be applied to all types of buildings (schools, offices, shopping malls, even future prisons are planned to be built). More and more people are striving to build passive houses and various buildings, residential and commercial: “The
European parliament has set for all new buildings to be nearly zero energy buildings by 2020.” [3]

There is a great example of a passive house built in Germany, an excellent representation of contemporary appearance. The architects Anja and Jochen Engelshove from Neuenkirchen wanted their whole family to live together under one roof, which was their dream and it was successfully revived by creating a home for a family of four, plus parents. The ground floor is inhabited by older generation, because of its easier accessibility. There is enough space on the first floor for the family including the children. The concept of keeping families close to one another while maintaining privacy in accordance with the different needs of all was a concept that was incorporated into the design from the beginning. [3]

The materials for the project were carefully selected to create the clean and timeless look the architects envisioned: a house loved by all generations and generations to come. The facade of anthracite paint on the entrance, terrace and interior spaces matches aluminum windows and exterior shutters in the same color. The contemporary look is primarily achieved by the use of long-form clay bricks. Light gray, tinted and built with very thin masonry bearings; the brick facing creates an elegant and durable building. [3]

Figure 3 An example of a contemporary passive house, located in Germany
Source: https://www.architectum.com/contemporary-and-timeless-passive-house/
In Figure 3 the contemporary construction of a passive house can be seen. Also, it is evident that careful selection of quality materials can result in a modern look. Every item in this house is well organized and has an associated function; big glass surfaces which result in a great amount of light in the interior, absorbing sun energy and creating a more natural enviroment.

But what is more, the house is energy-efficient: “In addition to insulating clay materials with triple-glazed windows, controlled ventilation with heat recovery, and economical underfloor heating in all rooms, the owners benefit from low operating costs. So they are saving money in the long term, with a clever investment in an attractive home – an environment that fosters wellbeing for all generations.” [3]

It can be concluded that the passive house trend is rising in Europe and in the rest of the world, too. However, there are still some countries that have not driven it to the full swing, like countries like Austria or Germany have. As mentioned above, Austria has made a great move by encouraging the citizens to build new passive houses with 200 euros per square meter, the move that created much more availability and prevalence of passive building.

A wide variety of modern and long-life materials have never been so accessible. There are plenty of them, for everyone’s taste such as cement panels, which are divided by texture, additional and finish coating. Moreover, there are metal panels with built-in foam insulation, which are pretty popular in the industry use such as halls and storage rooms and not so much in residential building. Therefore, wood use is infallible. There are many ways of processing it so there are countless divisions. The most popular are wooden panels and combination with classic materials such as bricks, cement panels, etc. Wooden facades can also be made with the combination of insulation, which then become ventilated façades.

All these materials give the building a modern and contemporary appearance. The accent is on combining them with modern windows and big glazing surfaces. Building shape is also relevant to achieve the modern note in today’s standards.
3. KEY ELEMENTS OF THE PASSIVE HOUSE STANDARD

In order to get a full understanding how a passive house differs from a conventional house, the key elements of the passive house are provided and described in this chapter. There are some key elements for gaining the energy efficiency of the passive house, which means that every item has to be installed properly and connected to each other. The purpose of energy efficiency is to achieve the ultimate passivity, which includes comfort and quality lifestyle in the house, little or no heating or cooling costs. A list of key elements is shown in Figure 4. [4]

![Key Elements of a Passive House](http://cellulose.org/GreenestInsulation/wp-content/uploads/2014/07/Passive-House-SevenFactorsGraphic-CIMA.png)

These are the main needed conditions to fulfill the passive house requirements. Thick insulation, properly sealed doors/windows and no thermal bridges are the most important elements for acquiring the ‘’passivhaus’’ status. Furthermore, the mentioned elements are reinforced with sun energy storage, which includes absorbing the heat through windows into the floor/furniture and storing the sun energy into the solar panels (water heating, additional electricity source, etc.).
### 3.1 Orientation and thermal zone

The Passive House Standard is sometimes confused with the passive approach to solar energy design, especially when it comes to solar orientation. This often means that people assume that solar orientation is as critical to a passive house as it is to a passive solar design. On the other hand, sometimes, those who especially favour the passive solar approach assume the exact opposite, i.e. that solar orientation is not at all relevant to the passive house, and solar orientation is not listed as one of the key methods or principles. The key to a passive house is an integrated approach to design. Solar orientation is important for a passive house, but this may not be the driving factor. [5]

It is no surprise that the solar orientation of a building, particularly the windows, impacts on the solar gain. The general advice for designing passive house buildings is to orientate the building and the majority of the windows facing the equator whenever possible. However, this is not so much about maximising solar gain as it is about optimising the building design and ensuring comfort. [5]

Regardless of the cause, buildings with higher internal heat gains are likely to be more sensitive to overheating. These types of buildings may even be reliant on cooling for comfort rather than heating. [5]

In all building types with higher internal heat gains, solar heat gain is less desirable and needs to be managed carefully. Shading can be used to do this or it can be achieved by solar orientation. However, in an optimised building, solar orientation may actually mean facing the building away from the sun, or it may mean facing particular rooms and spaces away from the sun. [5]

To conclude, solar orientation is often falsely considered to be one of the main requirements for the passive house building. It is important but must be adapted to the type of building and to the climate. Besides that, one of the most important things is to choose the right parcel which includes the amount of shading (trees, other buildings) and climatic zone. It is important to correctly arrange the house space, which means that highly glazed walls and rooms (such as living room, working room, etc.) must utilize as most of the sun energy as
possible (sun energy storage, lighting, heating). Places like bedrooms should be shaded most of the time during the day, because the advised temperature for a bedroom is around 18°C which results in a better sleep.

3.2 The shape of building

The more compact a building is, the easier it is to meet an energy-efficiency standard. The surface-area-to-volume ratio (S/V ratio) has a considerable influence on a building's energy requirement. The S/V ratio indicates how large the surface area S (such as wall, ceiling, roof and window surface areas) is in relation to the building volume V, and thus to the living space provided. The larger this ratio, i.e. the higher the S/V value, the greater the thermal energy requirement per m² living space/usable space is for a given set of energy-efficiency measures. The more compact a building is made, the more cost-efficiently it can be constructed, partly because the requirements applying to insulation thickness are then less strict. [6]

Larger buildings have a lower and therefore more favourable S/V ratio than smaller buildings. Buildings with a simple geometrical shape, such as cuboids or cubes, have less surface area in relation to their volume and thus a better S/V ratio than the buildings with numerous protrusions, oriel or dormers. [6]

The following sketches in Figure 5 show different (building) shapes and their degree of compactness in terms of surface-area-to-volume ratio (S/V ratio). [6]

![Figure 5 Spherical form – On the left: spherical form (< 0.3); in the centre: cube (approx. 0.5), on the right: large surface area (> 0.8) (source: Stefan Prokupek, GrAT)](https://www.egenius.at/fileadmin/user_upload/energieeffizientes_gebaeude/en/web/what_shape_is_particularly_advantageous_for_a_passive_house.html)
It can be seen in Figure 5 that passive houses have better energy-efficiency standards if built in a compact way. There are various types of shapes, but cubes and cuboid shapes seem to be the best and most practical options to be in accordance with passive house standards.

### 3.3 Insulation

Passive houses include high standards of insulation. In this way, heat loss decreases to a very low level: “When these very high standards of insulation are reached, the purpose required for heating, even in the coldest days, is reduced to a minimum and there it is possible to adequately heat the apartment by heating the fresh air entering the rooms.” [7]

Using good insulation materials, the rational thickness of the components can be achieved. The passive house can also be isolated by a combination of different materials, which is also suitable, for example: a concrete wall with an outer insulation or a monolithic wall made of porous concrete and a mineral foam insulation panel. [7] The technology, which is used for a passive house construction, costs more than for a conventional home. To build a new, adequately insulated passive house or reconstruct the current house, superb materials, careful design and contractors with knowledge and comprehension in things like air-tightness and thermal bridging is required. [7]

### 3.4 High-performance windows and doors

To accomplish the high energy performance, window configurations must contain low-E coatings, selective transmission films and gas fill between the glazing layers. The effect of these measures is to reduce the U-value. [8]
Windows, doors and overall sealings are one of the most important things to consider (along with thermal bridges) in planning and building of the passive house. There are few main things which reduce the heat loss such as triple glazing, multi-chamber frames, gases between glass surfaces and triple frame sealing.

Gases like argon or krypton could be used as a replacement for the air between panes (those gases are denser regarding common air). Conduction and convection are reduced by using those gases and it only brings thermal benefits by filling the enclosed air space. [8]

3.5 Heat recovery ventilation

Heat is in the process of heat distillation delivered to the heater and to a reboiler. The overhead current is cooled on the condenser. Almost all of the heat supplied to the reboiler in a conventional distillation process is discarded in a capacitor above the head. Conventional energy savings, distillation processes are fundamentally achieved as a result of heat recovery in a heating plant with maximized use of lower-temperature heat, which allows the speed of steam or hot oil to the heaters to be reduced. [9]
3.6 Recuperation

Air recuperation is the process of changing the "spent" living air with fresh air from the outside environment in the device called the air recuperator, in such a way that the "exhausted" warm air passes through the recuperator, which uses the warmth of the “exhausted” air to warm the cool air coming from the outside. [10]

The result is that the hot air is poured into the space, while in the classical way of changing the air, for example, by opening the windows into the space, the fresh air comes inside - but cold. Recuperation reduces the energy required for space heating.

The recuperator can also cool the space. Exhausted air-conditioned air from the space during its passage through the recuperator cools the warm air coming from the outside, and such fresh, cooled air enters the living space. The warm air passes through the heat exchanger (one of the recuperator’s elements), so the air becomes colder. The recuperation function can sometimes be combined with air conditioner, but that’s not the goal of the passive house building. [10]

The result is that the fresh air that enters the the space is cooled, while in the classical way of changing the air, for example, by opening the windows into the space, the fresh air comes in - but warm. This reduces the energy needed to cool the space. [10]

![Figure 7 Example of a recuperator function](http://www.mcsolar.hr/rekuperacija-zraka.php)
Recuperator is the indispensable device in passive houses. It carries a significant role by letting out the stale air, while the heat remains inside and mixes with the fresh air, thus losing the need for windows and door opening – ventilation. The device itself seems to be expensive at the start, but it pays off by the time and provides continual home comfort.

3.7 Sun energy storage

Major purpose of heat storage is the possibility of its later usage, when there is no sun radiation. Thereby, sun energy is used in a better and more efficient way. Also, the need for heat energy is reduced. [11]

The most important building element is floor. A big part of the floor is heated immediately, at south orientation. Good materials for efficient sun energy consumption are massive and heavy materials with big heat capacity [11], for example, thick oak parquet with longer and wider dimensions. Stone is also a great material. For example, marble and granite are one of the best materials, because of their durability and long heat absorption. However, since they are expensive, most of the people will rather apply wooder materials. Marble is less used for flooring because of its porosity, which results in scratches, stains and fraying.

Figure 8 Storage of sun energy; which penetrates through glass
Source: https://ecodesignadvisor.org.nz/passive-solar-design/passive-solar-house/
There are a few interesting and smart ways to absorb and store the sun energy and its warmth, but also to cover from the unpleasant summer heat. In the winter, the sun rays penetrate at a sharper angle, so in that way the rays can absorb in the floor and furniture in an easier way, which is the key. During the day, the window blinds have to be lifted up to achieve this absorption. After the sunset, these blinds have to be released down in order to keep the absorbed heat as long as possible and to avoid the additional heat gains.

In summer, the sun rays are much higher and have to be blocked by certain requirements which prevent overheating of the interior. That includes the roof extensions (shown in the Figure above), released window blinds during the day (just opposite of the winter method) and temporary ventilation by opening windows.

### 3.8 Construction without thermal bridging

Thermal bridges, also known as cold bridges, are local fenced areas on the building element, where the heat transfer rises in relation to other elements. They appear on the outer envelope of the building. The cause of thermal bridges poses errors in design and construction. The building can lose a lot of heat energy through inadequate insulated parts. [12]

![ Thermal bridge of balconies](http://elrondburrell.com/blog/passivhaus-thermal-bridge-free-construction/)

Figure 9 *Thermal bridge of balconies*

Source: [elrondburrell.com/blog/passivhaus-thermal-bridge-free-construction/](http://elrondburrell.com/blog/passivhaus-thermal-bridge-free-construction/)
Thermal bridges are passive enemies of the heat loss and those must be solved and correctly prevented at the early building phase. There are many house elements which need to be researched and sealed properly like wall/floor/ceiling joints, balconies, connection of windows and walls etc.

4. PASSIVE HOUSES IN THE UNITED KINGDOM

Since there were only few trained British builders who could construct passive houses, the community was motivated by German plans and their style and started to build passive houses.

The beginnings of passive houses in the United Kingdom (hereinafter referred to as “the UK”) are dating back to 2009 when Justin Bere, a British architect, was the first one to adopt the passive house building standard. The first passive house was built in Camden by the investors Fiona and Malcolm Terry. They wanted to build a brick house in the area of large detached houses, but, initially, their planning request was denied, due to the problems with land dimensions. However, they have seen the potential of that parcel and sought for the solution. With independent access on the road, it was the dream place where they decided to build their retirement home. [13]

Malcolm knew of Justin Bere's determination to build Britain's first passive house. Camden was interested in this, so when the Terrys hired Bere to design a passive house there, the approval was obtained. [13]

4.1. Passive houses in the United Kingdom nowadays

Passive houses in the UK nowadays are following the path of constant building and extending the knowledge. The Passive House Institute (PHI, an independent research institute passive house standard) is not well known in the island country. However, a multi layered evaluation system has been developed that really puts sustainability at the heart of its name.
The extremely complex CSH certification examines all possible aspects of the environment and comfort. [14]

There are four requirements that each home must meet in order to receive any CSH certificate, containing the environmental impact of incorporated materials, which must not exceed a critical level, surface drainage must be provided, separate storage facilities should be provided for recovery and non-recoverable waste, proper management of construction and demolition waste should be ensured. [14]

“The other two requirements (emission rate in a residential unit and indoor water consumption) become more stringent with the number of stars. In a one-star apartment, daily water consumption can be 120 liters per person, while in a six-star apartment it is only 80 liters per person.” [14]

4.2. The Passivhaus Trust

The Passivhaus Trust is an independent, non-profit organisation that provides leadership in the UK for the adoption of the Passive House Standard and methodology. Passivhaus is the leading international low energy, design standard. Over 65,000 buildings have been designed, built and tested to this standard worldwide. [15]

The Trust aims to promote a passive house as a highly effective way of providing high standards of occupant comfort and health as well as reducing energy use and carbon emissions from buildings in the UK. [15]

The Passivhaus Trust gives the recommendations for the best way of ensuring the quality assurance, certified by a registered Passivhaus Certifier. It is reasonable to claim that a non-certified passive house building is certified, provided it still meets the requirements of the norm. [16]
For achieving the standard of Passivhaus in the UK it includes designing and modelling through the PHPP (Passive House Planning Package), thick insulation, airtightness, high performance doors and windows, construction without thermal bridges and a recuperation system. [16]

“Passivhaus buildings achieve a 75% reduction in space heating requirements, compared to standard practice for the UK new build. The Passivhaus Standard therefore gives a robust method to help the industry achieve the 80% carbon reductions that are set as a legislative target for the UK Government. Passivhaus also applies to retrofit projects, achieving similar savings in space heating requirements.” [16]

Evidence and feedback show that passive house buildings behave as standard, which is crucial, given that the gap between design tendencies and performance built, for many new UK buildings can go as high as 50 to 100%. [16]

It can be seen that a lot of companies tend to support the passive house building and their number is rising. It seems like people are aware of nowadays financial standard and environmental status so they want to go a few steps above – and passive building fulfils everyone’s needs with its benefits.

### 4.3 A step forward for passive houses in the United Kingdom

England has voluntarily gone a step further, and since 2016 it has introduced a directive whereby all new buildings that have been built since then will have to have a zero emission of gas, and at EU level in 2018 will follow the new law enforcement. In nine years, all new buildings will need to produce enough energy for their own needs with a view to reducing energy consumption and gas emissions by 20 percent by 2020 and increasing renewable sources by 20 percent. [17]
This map (Figure 10) shows the Passivhaus projects in the UK. Every year there are thousands of new passive houses. Everyone seems to understand the concept and benefits of it.

4.4 Examples of passive houses in the United Kingdom

What follows are some examples of passive houses in the United Kingdom, some residential, some non-residential. These buildings show the various possibilities and building styles and use different building materials. Some of them are even half-buried into the ground and have achieved the passive house standard in that way – using inspiration from primitive dwellings.

4.4.1 Crossway

Crossway is a home with incredible design based in Kent (UK). This passive solar house is the first in the UK to receive the Passivhaus certification due to exceptional energy savings. [18]
What makes this house characteristic is a 20-meter-long roof, only 120 mm thin, made of hand-made tiles of clay. About 26,000 clay tiles naturally regulate air humidity and the entire roof acts as a huge thermal mass that regulates the temperature inside the house. Also, 20 tons of gravel, 40 tons of soil were added to it and vegetation was planted for even better thermal insulation. Although they spent an astounding 85,000 pounds for the roof, they got a house of unique design. [18]

![Image of Crossway – First PH in England]

In Figure 11 it can be seen that the house building plan was to merge with nature, with the accent on regular materials like brick and wood, which are followed up by large glass areas and windows.

£ 43,000 was spent on windows with triple glazing. In addition to the fact that these windows are extremely expensive, they represent another advantage in isolation, and between the second and third glazing there are blinds that, during hot summer days, are lowered to prevent overheating of the house. [18]

In order to provide constant fresh air, a ventilation system (explained below) is installed, which extracts the contents in the warm air inside the house and replaces it with fresh air. For the production of electricity, solar panels are connected to the distribution network of...
electricity, and for the heating of biomass water 11 kV. Waste treatment system and rainwater collection are additional advantages. [18]

‘‘A total of £445,000 was spent on the construction of the first Passivhaus home in the UK. The owner says that life in her is perfect. It's never cold because the temperatures do not fall below 16 ° C even in the coldest winter days, and relative humidity is regulated to 51%.’’ [18]

With significant energy savings and sales of excess electricity generated by solar panels to the electricity distribution network, this house, which makes it very interesting and special, instead of expensive bills at the end of the year is producing energy for about 1,800 £. [12]

4.4.2. Camden – London

This wooden house, surrounded by 118 m2, a two-storey house first certified by Passivhaus in London, set a benchmark for energy-efficient design combined with comfort, high quality indoor air and other benefits that improve health and are anti-asthmatics. [19]

‘‘The primary goal of the project was to achieve a comfortable home for the younger family of the client, while at the same time reducing energy consumption. The house was built with a firmly insulated wooden frame placed inside walls of 3 m and dressed in European larch. It works inexpensively, achieves a savings of 90% compared to existing flats, low carbon emissions, and bright and airy, with a sliding door on the terrace facing the south.’’ [19]
Figure 12 shows that the house is rotated to the south-west, which is the best option. This pretty modern house requires minimal energy consumption. The material selection gives the fantastic classy spice to this dwelling and the automated solar blinds provide the solar shading. It even has a rainwater tank for garden purpose.

4.4.3 Bushbury Hill Primary School

Bushbury Hill Elementary School has been designed as a standard school education school. The design includes the construction of a low-carbon wood construction with local brick, linoleum and recycled rubber floors, as well as organic and non-toxic colors and stains. [20] The ventilation and heating strategy was simple, integrating complete mechanical ventilation of heat for winter work and a simplified heating system emits only one boiler that supplies heat when needed to radiators. [20]

“‘The building was built according to the Passivhaus ventilation standard. In summer, the building is mostly flowing through the open windows, and the rooms are fully occupied in winter by a heat recovery system with a thermal efficiency of 80%.’” [20]
The cuboid shape of this building provides a decent S/V ratio and has the Passive House Standard requirements. The design is pretty simple, but the wooden façade gives a slight modern tone.

“The school was designed according to the Passive House Standard within the allocated budget of the local government. Without additional means for certain measures with low carbon and energy efficiency, this required a high degree of innovation in maintaining a high level of architectural quality.” [20]

By eliminating unnecessary complexities, ensuring that through each step of the construction process, the building ultimately makes it difficult to achieve low operating costs and eliminates the need for expensive additives as a measure of energy reduction. [20]

4.4.4 Mayville Community Centre

As said by the Centre for Social Activities, Mayville is the first remarkable energy centre in the UK, the Passivhaus retrofit (currently undergoing full PHI certification): “it will help demonstrate how deep retrofit of existing buildings rather than demolition, is an achievable and viable solution for much of the UK’s existing building stock.” [21]
“When complete, the Mayville Community Centre will be the first ultra low energy Passivhaus retrofit community centre in the UK. Built in circa 1890, the centre is located within the Mayville estate in Islington, London. Ranked in the top 10% most deprived areas in London, the centre provides a focal point for the local residents as a valuable community resource.” [21]

Figure 14: Mayville Community Centre

Source: http://www.passivhausprojekte.de/index.php?lang=en#d_1874m

Figure 14 shows that the most of the roof surface is covered with solar panels. A lot of sun energy is saved and stored, which is later used for various needs. Its very thick insulation provides a very low amount of U-value.

4.4.5 Exmouth Market

This five-story low-energy house was designed in 2007-2008 as it has developed access to the passive house method. It was completed in 2014. [22]

This is part of the facade retention, but the height of the Exmouth market is made up of new, traditionally bonded London brick walls with large woolen plasters. The two-story penthouse on the top of the complex is clad in zinc. [22]
Along with the design requirements for traditional windows, development could never reach the full performance of the passive house, but the building will be comfortable, healthy and economical. [22]

“It was necessary to turn the panel from a glass to the triple-glazed traditional wing on the first and second floors and the modern windows in the penthouse. All brick walls were insulated and thermally cracked, and the build test had excellent airtightness.” [22]

The interesting fact is that this building does not meet full Passivhaus requirements, but it provides an economical, healthy and comfortable style. Its antique brick façade and windows give the building a retrofit look. The most impressive thing is the combination of the building style with a green garden rooftop, which is merging with the higher building floors.

### 4.4.6 Underhill House

The house is designed according to the Passive House Standard - the German standard which has resulted in a 90% reduction in carbon emissions compared to the average home. This project was actually the first passive house certified in England. [23]
The construction style of this house is something similar to Crossway (mentioned above) – the one half is a regular building and the other one is buried in the ground. It has the cuboid L-shape, big glass surface so it can absorb big amounts of sun energy (its location on the open field provides that condition).

4.4.7 Hitchambury Farm

The town of Hitchambury Farm near Taplow for most of the past decade was occupied by obsolete economic buildings and overgrown vegetation. After maximizing the ecological potential, ecological sustainability was at the heart of the clients who were aiming of moving beyond the Passive House Standard. [24]

‘Located at a distance from the residential district of Taplow, the proposed apartment is rated under the strict new National Policy Plan for Protection (NPPF), which refers to the exceptional design quality of new homes in the village. At the beginning, the permission was denied, but the request was terminated and permission was granted in September 2014.’ [24]
The design of this house is modern and the shape is complex cuboid, with a lot of breaks. It has around 40% of glass surface which results in decent amount of sunlight and a closer contact with nature.

4.4.8. Passive house, Frays Island

This beautiful wooded island, part of the green chain that travels through the built Uxbridge (West London), inspires the place for the proposed zero carbon passivhaus. The shape is purposefully simple and compact, heat loss is directly related to the volume and surface ratio. [25]

‘’In the south there is plenty of glass, including shade and roof overhang, to take advantage of the low winter sun for a passive solar period, preventing overheating from a high summer sun. High-level windows on the south side of the room on the first floor use photovoltaic glazing, and solar hot water panels will also be included.’’ [25]

There is a complete system of mechanical ventilation system with heat recovery and there is no need for traditional boiler or central heating. [25]
Living in nature has a lot of benefits, especially if the passive house standards are followed. On these 3D models it can be seen that they are surrounded by forest. There is prescribed value of how much space is needed between the house and vegetation, since there must be a balance of shading and collecting sunlight.
5. CONCLUSION

A passive house is a right decision because a person feels comfortable in it, and the home budget is low and acceptable. Passive houses have walls, roofs, foundations, windows and doors, such as ordinary houses, but these elements are constructed to a different standard.

Because of the specific concept of building a passive house, the buildings without an active heating or air conditioning system achieve a pleasant temperature of space in the summer and winter period of the year.

Energy efficiency is very important, and in the future it will be even more important. In order to achieve its efficiency, we need to adapt to new energy sources and new ways of saving it. Energy efficient homes are just one part of global energy efficiency.

There are currently a very small number of energy-efficient houses and buildings in the world, but each new efficient house collects the experience that is needed to build more efficient houses. This knowledge will be increasingly used and with the help of construction laws all new construction will in the future have to respect the principles of energy-efficient homes.

In the UK, the passive house trend is on the increase. People are constantly searching for energy efficiency and consume it in the best way possible. There are many types and shapes, every architect has his vision, but all of them have a thing in common or two and that is the sustainable development, finding the method of solar gains and storing.

When designing passive houses, people use the benefits of the nature and the Crossway and Underhill passive houses described in this paper are an excellent example of objects that seem to be a part of the nature because of their appearance, but not only that, they use nature, the soil, as additional insulation.
It is interesting how one person can change the world with only one idea and the right team can make passive building a modern trend.
6. REFERENCES


[12] The blog of Elrond Burrell. What is thermal bridge free construction?
http://elrondburrell.com/blog/passivhaus-thermal-bridge-free-construction/ (visited on 8 September 2017)

[13] Inside the UK’s first passive house in Camden: super energy-efficient with fuel bills less than £100 a year

http://www.csaladihaztervezes.hu/blog/hol-tart-europa-passzivhazak-kulfoldon-7-resz (visited on 5 September 2019)

http://www.passivhaustrust.org.uk (visited on 5 September 2019)

[16] What is Passivhaus?
http://passivhaustrust.org.uk/what_is_passivhaus.php (visited on 3 September 2019)

http://gorila.jutarnji.hr/vijestigorila/gorilopedija/lifestyle/moj_dom/pasivna_kuca_cijena/ (visited on 15 September 2017)


http://www.bere.co.uk/projects/65-exmouth-market-low-energy-passivhaus-techniques

http://www.seymoursmith.co.uk/hitchambury.php (visited on 14 November 2017)

LIST OF FIGURES

Figure 1 Project of 32 houses in Alhem, by Bo Adamson .............................................. 7
Figure 2 The pilot Passive House building, Darmstadt Kranichstein, 1991 ...................... 9
Figure 3 An example of a contemporary passive house, located in Germany .......... 12
Figure 4 Key elements of a Passive House ....................................................................... 14
Figure 5 Spherical form ........................................................................................................ 16
Figure 6 Window constructions with air gaps ................................................................. 18
Figure 7 Example of an recuperator function ..................................................................... 19
Figure 8 Storage of sun energy; which penetrates through glass ..................................... 20
Figure 9 Thermal bridge of balconies ............................................................................... 21
Figure 10 Passive Houses in the UK territory .................................................................. 25
Figure 11 Crossway – First PH in the UK ....................................................................... 26
Figure 12 Ranulf Road house, London ........................................................................... 28
Figure 13 Bushbury Hill Primary School ......................................................................... 29
Figure 14 Mayville Community Centre .......................................................................... 30
Figure 15 Exmouth Market ............................................................................................. 31
Figure 16 Underhill passive house .................................................................................. 32
Figure 17 3D model of the Hatchambury Farm .............................................................. 33
Figure 18 3D model of the Frays Island passive house ................................................... 34
Figure 19 A closer view of the Frays Island house .......................................................... 34