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Be.Passive

Lessons learnt from the Belgian Passivhaus experience

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Introduction

This report was commissioned by the Centre for the Built Environment (CBE), part of the Adapt Low Carbon Group at the University of East Anglia. CBE is a centre that draws upon a cluster of expertise on low energy and sustainable construction both within and outside UEA and is responsible for delivery of the Exemplar Low Carbon Building project funded by the EU Regional Development Fund, UEA and UK Government. As part of this funding CBE provides free business support through a series of bespoke CPD accredited seminars, webinars and other support showcasing the design, build and post-occupancy of the Exemplar Low Carbon Building which is targeting BREEAM Outstanding and Passivhaus Certification.

This report aims to disseminate to the Built Environment sector in the UK how Brussels as a region may offer a guide for a city or regional approach to developing a Passivhaus standard. The National Planning Policy Framework (NPPF), the Local Enterprise Partnerships (LEP) combined with rising energy prices are all UK specific factors pointing towards a regional framework that can contribute towards a significant reduction in carbon emissions.

The region of East Anglia, particularly the area covered by the New Anglia LEP has an opportunity to be an exemplar Passivhaus region, The New Anglia LEP has been given Green Economy Pathfinder status¹ which means is the national leader on the green economy promoting, showcasing and recommending to government and businesses the work that is underway across Suffolk and Norfolk that can be implemented across the rest of the UK.

The BE.Passive report owes its name and many of its case studies to the eponymous quarterly magazine that is published by the Belgian equivalent of the Passivhaus Trust, the Passiefhuis-Platform (PHP) and Plateforme Maison Passive (PMP)

¹ New Anglia Green Pathfinder Manifesto (http://www.newanglia.co.uk/Assets/Files/Content/2012-06-01%20Final%20New_Anglia_Manifesto_2.pdf)

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Glossary

AECB	The Sustainable Building Association (formerly the Association for Environment Conscious Building) is a network of individuals and companies with a common aim of promoting sustainable building. It brings together builders, architects, designers, manufacturers, housing associations and local authorities, to develop, share and promote best practice in environmentally sustainable building. The AECB was established in 1989 to increase awareness within the construction industry of the need to respect the environment. The AECB is run by its members and is an independent, not for profit organisation.
Air tightness	The resistance of the building envelope to air leakage either inward or outward. Low airtightness leads to increase heat loss and higher energy consumption required to heat the building.
AV Ratio	The compactness of a building is indicated by the surface area to volume (AV) ratio. This ratio, between the external surface area and the internal volume of a building, has a considerable influence on the overall energy demand. Buildings with identical U-values and air change rates, and orientations could have significantly different heating demands simply as a result of their AV ratio. The size of a building also influences the AV ratio. Small buildings with an identical form have higher AV ratios than their larger counterparts. It is therefore particularly important to design small detached buildings with a very compact form, whilst larger buildings offer the designer greater freedom to explore more complex geometries. A favourable compactness ratio is considered to be one where the AV ratio $\leq 0.7\text{m}^2/\text{m}^3$. In some parts of the UK with poor winter insulation very small detached dwellings may require even lower AV ratios in order to achieve the Passivhaus specific heating demand.
BRE	Building Research Establishment. For almost ninety years, BRE has been recognised as a world leader in independent and authoritative research that advances knowledge of the built environment. BRE has over 600 staff, of which 80% are professionally trained and many are world leaders in their chosen fields.
BatEx	Brussels Exemplary Building programme.
Blower door test	A test that is carried out to determine the air tightness of a building. A temporary door housing a fan is placed in the main entrance and is used to pressurise and de-pressurise the building to determine the amount of air that leaves or enters the building.
BREEAM	Building Research Establishment Environmental Assessment Method
EPDB	Energy Performance of Buildings Directive. An EU wide directive that requires the implementation of 'nearly zero energy buildings' by 2020.

FSC	Forestry Stewardship Council. FSC is an independent, non-governmental, not for profit organization established to promote the responsible management of the world's forests.
MVHR	Mechanical Ventilation with Heat Recovery
NPPF	National Planning Policy Framework
PEFC	Programme for the Endorsement of Forest Certification. Promotes an internationally credible framework for forest certification schemes and initiatives in European countries.
PHP	Passiefhuis-Platform. The PHP is a non-profit Belgian sister organisation to PMP, working in Flanders, the Dutch speaking part of Belgium. Set up in 2002 and composed of leading individuals and institutions in the construction world. They show commitment to energy conservation and sustainable technological development. PHP is an independent organisation that is neutral and not tied to suppliers or other groups.
PHPP	Passivhaus Planning Package. This is the Excel spreadsheet that is used to model buildings to determine their performance in accordance with the Passivhaus certification requirements.
PMP	Plateforme Maison Passive. Set up in 2006 PMP is a non-profit sister organisation to PHP which aims to encourage the construction of Passivhaus buildings in the French speaking part of Belgium. PMP helped promote the Passivhaus concept in Brussels.

Executive Summary

Under the recast EU Energy Performance of Buildings Directive (EPBD), 2010, all EU countries are required to regulate for zero energy buildings by 2020. Pursuant to this, in the UK, all new dwellings must be 'zero carbon' from 2016, while all new non-domestic buildings must achieve the same from 2019.

The realisation that the energy performance of buildings in Brussels was ranked among the worst in Europe² - lower than the UK - and new build standards were a long way from the nearly zero energy buildings required by the EPBD in 2020 prompted the Brussels-Capital region to consider how to meet its EU obligations. This report focuses on the Brussels-Capital experience.

In 2011, the regional government, Brussels-Capital, passed the Passivhaus Law. This law committed to an energy standard that would make Brussels the largest city in Europe to adopt the one of the most stringent energy standard for buildings. This was achieved in a relatively short period of time, with a high level of political consensus and minimal commercial concern starting from building regulations that were less stringent than the UK.

There a number of key lessons for the UK and its regions that can drawn from this report:

First, in order to fulfil the recast EU Energy Performance of Buildings Directive (EPBD) and to regulate for zero energy buildings by 2020, Passivhaus offers a solution to meet these requirements. In the UK, all new dwellings must be 'zero carbon' from 2016, while all new non-domestic buildings must achieve the same from 2019. Currently, the plans for the UK zero carbon approach assumes a minimum energy requirement that is three times higher than Passivhaus with carbon emissions being offset by renewable energy or allowable solutions.

Regions outside Germany are adopting the standard as a way of significantly reducing carbon emissions from buildings. The Brussels-Capital Region started with energy standards that were amongst the worst in Europe – and less stringent than the UK - before committing to the Passivhaus law that starts in 2015.

Secondly progress towards the Passivhaus Law was supported and funded by two key initiatives: the BatEx subsidy which stimulated the market for energy efficiency; and the elevation of sustainable design and construction with the appointment of a Master Architect and key advisors to train and assist industry.

The Exemplary Building (BatEx) programme provides a subsidy to buildings recognised as meeting an exemplary energy and environmental performance standard. It is an open competition, and during each round applications are invited to receive funding and those buildings meeting the highest standards receiving a subsidy of €100 per m².

With high level political commitment, the Master Architect is able to gain the support of a number of experienced professionals with expertise in various areas of sustainable

² BRUSSELS from eco-building to sustainable city, Environment, Energy and Urban Renewal of the Brussels-Capital Region

construction to act as advisors for BatEx projects. Working alongside a project's design team, the advisors provide advice free of charge to encourage best practice in the design and implementation, management or refurbishment of Passivhaus buildings. A key aim is to disseminate knowledge to design team members that they can use on their future projects.

Third, whilst initially the supply chain faced stiff competition from Passivhaus imports, local businesses including a number of SMEs were able to develop certified products and compete effectively in the market. In 2012, BatEx accounted for more than 16% of construction annually generating a 319 million Euro turnover and creating an additional 1250 jobs.

Finally, the combination of legislation and funded support led to a rapid increase in the number of Passivhaus buildings from practically zero in 2007 to more than 80,000 m² built or planned in 2009 and over 250,000m² by 2011³. At the same time energy consumption per head fell by 17% which the Brussels-Capital Region claims is entirely down to the programme.

The successful adoption of Passivhaus in Brussels Central Region suggests that a regional approach to Passivhaus may result in quicker uptake within the UK with concomitant energy and carbon reductions. The National Planning Policy Framework (NPPF) may offer an opportunity as the framework contains a presumption in favour of sustainable development but does not explicitly define sustainable development, thereby enabling it to be defined at local level.

In order to develop a Passivhaus region in the UK, it is recommended the following regional players would need to be aligned:

- Local Enterprise Partnership – to provide the political will and surety. To administer a subsidy if funds permit, and to help engage the supply chain
- Planning authority, or coalition of planning authorities to enact and enforce a Passivhaus requirement
- Centre of expertise to provide the necessary technical advice and rigour across the supply chain, and to ensure the compliance necessary for the subsidy to be provided

³ Brussels 2007-2011: from 0 to 250.000m² of Passive buildings. How is it possible? Thibaut HERMANS, Valentine FRUCHART, Bruxelles Environnement – IBGEBIM, Division Energy Presentation to the International Passivhaus Conference 2012

1 EU and UK Policy Context

Under the Climate Change Act 2008 the UK is committed to achieve a 34% reduction in carbon emissions by 2020 and an 80% reduction by 2050.

Under the recast EU Energy Performance of Buildings Directive (EPBD), 2010, all EU countries are required to regulate for zero energy buildings by 2020. Pursuant to this, in the UK all new dwellings must be 'zero carbon' from 2016, while all new non-domestic buildings must achieve the same from 2019.

Central to the National Planning Policy Framework (NPPF), March 2012 is a presumption in favour of sustainable development. The Framework states the 'guiding principles' of sustainable development, the need for the planning system to perform economic, social and environmental roles to achieve it, and sets out policies which are consistent with these. However it does not explicitly define sustainable development, thereby enabling it to be defined at local level.

It is estimated that unregulated energy use emits between a third and a half of all carbon emissions in a home built to Building Regulations, Part L 2010. Part L 2010 sets minimum fabric energy efficiency standards in respect of U-values for building components and air-tightness, but not for building energy demand (ie kWh/m²/yr).

1.1 UK Government's Approach to Zero Carbon Homes

The Code for Sustainable Homes (CSH) is the national assessment method for sustainable design and construction new homes, launched in 2006. It covers nine categories of sustainable design (energy & carbon emissions, water, materials, surface water run-off, waste, pollution, health & well-being, management and ecology) which are weighted based on environmental impact. The categories are broken down into a total of 34 issues, each with multiple criteria for which credits are available. CSH uses a six level rating system to certify overall performance.

At present CSH is not mandatory, except for the following circumstances where: (a) affordable housing is funded by the Homes and Communities Agency (HCA), which requires a minimum of Level 3, or (b) local authorities stipulate a requirement.

CSH's energy and carbon emissions performance criteria are based on Building Regulations, Part L and Carbon Compliance benchmarks (and improvement thereon). For example the following minimum standards apply:

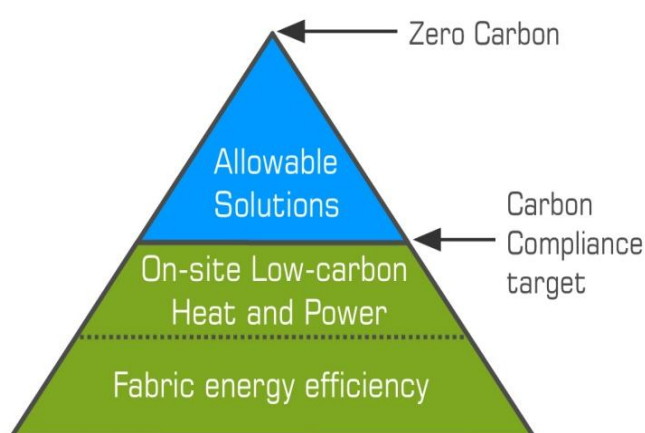
- Energy and Carbon Emissions:
 - Level 4: ≥ 25% improvement on Part L 2010 Target Emission Rate (TER)
 - Level 5: ≥ 100% improvement on TER
 - Level 6: zero net carbon emissions – ie Regulated and Unregulated – from space heating & cooling, ventilation, water heating, fans, pumps, fixed lighting, plug-in appliances and cooking.

Save where minimum standards apply, CSH is not prescriptive as to how ratings are achieved, thereby leaving scope for stakeholders to 'trade-off' credits and innovate.

The current definition of Zero Carbon based on a 100% reduction of Regulated carbon emissions is to be achieved through the following hierarchy:

1. Very high standards of fabric energy efficiency
2. On-site low/zero carbon energy and connected heating systems
3. Allowable Solutions.

Figure 1: Zero Carbon Hierarchy⁴



1.2 Moving towards a fabric first energy standard

Following consultation, the Department for Communities and Local Government (DCLG) is currently considering options for revisions to Part L which are due to come into effect in October 2013. The key proposals, intended to be an interim step towards Zero Carbon Homes standards in 2016:

The fabric energy efficiency targets sit within the carbon emissions targets. In relation to Tier 1 of the above hierarchy, the Carbon Compliance limits must be met in part by the following minimum Fabric Energy Efficiency Standards (FEES):

- $\leq 39 \text{ kWh/m}^2/\text{yr}$ for apartments and mid-terrace houses
- $\leq 46 \text{ kWh/m}^2/\text{yr}$ for end-terrace, semi-detached and detached houses.

⁴ www.zerocarbonhub.org/definition.aspx?page=4

These form the current minimum standards for fabric energy efficiency for Levels 5 & 6 of the Code for Sustainable Homes.

Moving forward, DCLG tasked the Zero Carbon Hub with assisting in the development of a new definition for Zero Carbon that would “both reflect the ambition of the 2016 target, whilst being technically achievable and cost-effective for house builders”⁵.

The Zero Carbon Hub ‘Zero Carbon Strategies report, published February 2013, sets out the approaches that may be used to achieve ‘zero carbon’ homes. The document states that Passivhaus performance is well in excess of the Fabric Energy Efficiency Standard (FEES),

In *Zero Carbon Strategies for Tomorrow’s New Homes* the ZCH gives the Standings Court, Horsham development, by Saxon Weald Homes as an example where 12 homes on the site were designed and constructed to the Passivhaus standard. In this particular case the emissions from the Passivhaus plots were sufficiently low that the UK’s zero carbon home standard could have been achieved with a one off payment of around £1600 – 1800 by the developer into an ‘Allowable Solutions’⁶ fund, showing that Passivhaus could be a cost effective, minimal risk approach for developers seeking to deliver zero carbon homes.

Another argument in favour of a fabric first approach is in its impact in reducing fuel poverty. With fuel prices continuing to rise, the low space heating demand of Passivhaus Buildings of less than 15kWh per square metre per year means that annual fuel costs are reduced by a factor of 5-10.

UK National statistics show the cost of heating most homes has approximately doubled since 1996, with the expected increase in fuel poverty to match, in spite of a slight improvement in the average SAP rating of UK homes in the same time period. In East Anglia approximately 17% of households are in fuel poverty, in spite of people in the region having the third highest average annual incomes in the UK after London and the South East.

2 What is Passivhaus?

Passivhaus was developed in Germany in the early 1990s by Professors Bo Adamson of Sweden and Wolfgang Feist of Germany and the first dwellings to be completed to the Passivhaus Standard were constructed in Darmstadt in 1991. The Passivhaus standard can be applied not only to residential dwellings but also to commercial, industrial and public buildings.

A functional definition of a Passivhaus is:

“A Passivhaus is a building, for which thermal comfort 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.” – Professor Wolfgang Feist

⁵ www.zerocarbonhub.org/definition.aspx?page=1

⁶ For a full explanation of ‘Allowable Solutions’ please see *Zero Carbon Strategies for Tomorrow’s New Homes*

Passivhaus is an international design and construction standard for domestic and non-domestic buildings which, in essence, achieves a reduction of the heating demand to the point where a traditional heating system is no longer required. This is achieved primarily through the design of the fabric based on fundamental building physics. Passivhaus buildings do not need to differ aesthetically from conventional buildings, while their typical features are as follows:

- Super-insulated
- Minimized or eliminated thermal bridging
- Extremely air-tight building envelope
- Mechanical ventilation with heat recovery (MVHR)
- Triple-glazed windows, largely south oriented
- High thermal comfort
- Windows can be opened.

Passivhaus is an energy standard as opposed to a carbon standard, with the following criteria for a central European climate:

- Space heating demand $\leq 15 \text{ kWh/m}^2/\text{yr}$, or space heating load $\leq 10 \text{ W/m}^2$
- Space cooling demand and load as above
- Primary energy demand $\leq 120 \text{ kWh/m}^2/\text{yr}$ (including space heating & cooling, hot water, fans, pumps, lighting and appliances)
- Air-tightness $\leq 0.6 \text{ ac/hr @ n50}$.

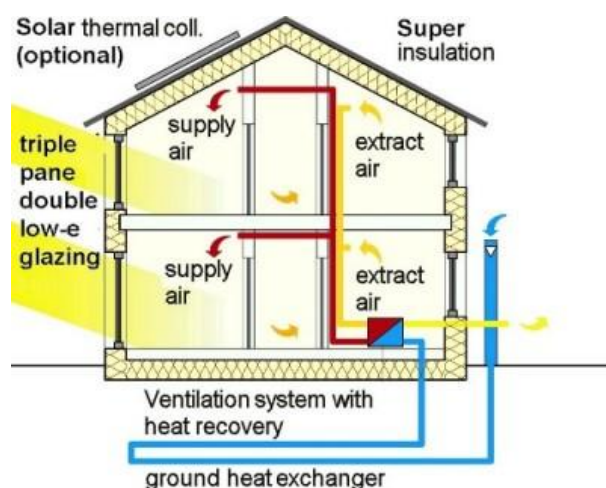
Passivhaus is not an alternative to CSH, but instead a specific fabric energy efficiency and construction quality assurance standard that is entirely compatible and complementary within CSH. Specifically, Passivhaus standards will achieve maximum credits for the CSH Fabric Energy Efficiency issue.

There is evidence that most Passivhaus dwellings will come close to achieving Carbon Compliance without renewable energy, and will achieve Carbon Compliance with minimal renewable energy⁷.

⁷ Passivhaus Trust. *Passivhaus and Zero Carbon: Technical briefing document*. April 2012.

Research indicates that there is a widespread and significant gap between design and as-built performance. Passivhaus entails rigorous quality control throughout design and construction to ensure that as-built performance meets design performance.

Figure 2: Schematic showing the key features of a Passivhaus⁸



2.1 Passivhaus as building regulations across the EU

One of the key developments about the adoption of Passivhaus across the EU is in its regional uptake. A number of regional authorities are starting to incorporate Passivhaus as a minimum building standard. Initially led by German regions, Oslo, Brussels and Tyrol of Austria have also adopted Passivhaus as a minimum standard.

State, City or District	Date of inception or regulation passed	Description of legislation or subsidy
Brussels-Capital Region	1 January 2015	All public buildings are built to the Passivhaus standard by 2015 – and where possible, to apply it in the refurbishment of existing buildings too.
City of Antwerp, Belgium	December 2008	All new school buildings of the city are built to the Passivhaus standard
City of Oslo, Norway	1 January 2014	All public buildings are built to the Passivhaus standard by 2014 – and where possible, to apply it in the refurbishment of existing buildings too.
Tyrol, Austria	1 January 2012	A financial incentive package similar to Brussels is in place. Green loans and subsidies exist for low energy buildings with Passivhaus buildings entitled to the maximum amount of subsidies available.

⁸ http://passivedia.passiv.de/passivedia_de/

Hamburg, Germany	1 January 2012	Municipal funding for new housing projects will be granted exclusively to Passivhaus'.
State of Bavaria, Germany	19 July 2011	All new build administrative buildings be constructed to the Passivhaus Standard.
Freiburg, Germany	1 January 2011	All new residential houses will be designed and built to the Passivhaus Standard
State of Hesse, Germany	1 September 2010	All public building projects must show energy performance that is equal to Passivhaus levels of energy efficiency
Walldorf, Germany	20 July 2010	All new municipal building are to be built to the Passivhaus standard
Cologne, Germany	26 April 2010	All new municipal buildings in the city of Cologne must be designed under the Passivhaus concept.
Bremen, Germany	1 January 2010	All new public buildings owned by the city of Bremen must be built according to the Passivhaus Standard
District of Darmstadt-Dieburg, Germany	1 January 2010	All new school buildings must be designed and implemented according to the Passivhaus Standard
State of Rhineland-Palatinate, Germany	1 January 2010	All new municipal building and renovations must be analysed to see whether these buildings can be feasibly constructed as Passivhaus buildings
Nuremberg, Germany	1 November 2009	All new building projects will implement the Passivhaus Standard
State of Saarland, Germany	1 November 2009	All public new builds must be built to the Passivhaus Standard whereas the Standard will serve as a guideline for all renovations of public buildings owned by the State.
Leverkusen, Germany	16 February 2009	All new buildings to be constructed must reach the Passivhaus standard
Leipzig, Germany	19 March 2008	All new buildings belonging to the city administration, municipal facilities and

		municipal enterprises, as well as all the new buildings of the “PPP-Modellen” programme in Leipzig, are built under the Passivhaus standard
Frankfurt, Germany	6 September 2007	All new buildings belonging to the city administration including municipal facilities and enterprises together with the buildings that will be constructed in as part of the “PPP-Modellen” programme in the city of Frankfurt, will be conceptualised to meet the Passivhaus Standard.

Table 1 List of regions adopting Passivhaus as building regulation standards

3 Passivhaus in Brussels: “the last shall be the first”

3.1 Introduction

The realisation that the energy performance of buildings in Brussels was ranked among the worst in Europe⁹- lower than the UK - and new build standards were a long way from the nearly zero energy buildings required by the EPBD in 2020, prompted the Brussels-Capital Region to consider how to meet its EU obligations.

In Belgium, building regulations are issued at the regional level issue within Belgium’s federal system of Government. Belgium is a federal state with all regulation split between the federal level and the three regions, Brussels-Capital, Flanders and Wallonia.

3.2 2007-2011: The move towards Passivhaus

In Belgium, political action on the regional rather than national level has enabled rapid progress in low energy policy making. The Brussels-Capital region has benefited from the strong political leadership of Evelyne Huytebroeck, Minister of the Environment, backed up with support from within the administration, provided by Grégoire Clerfayt, Director of Energy at Brussels-Capital. In December 2007 Brussels-Capital passed the Energy Performance and Indoor Climate of Buildings Order, to transpose the EPBD into Belgian law by establishing the requirements and methodology for energy performance in buildings (PEB).

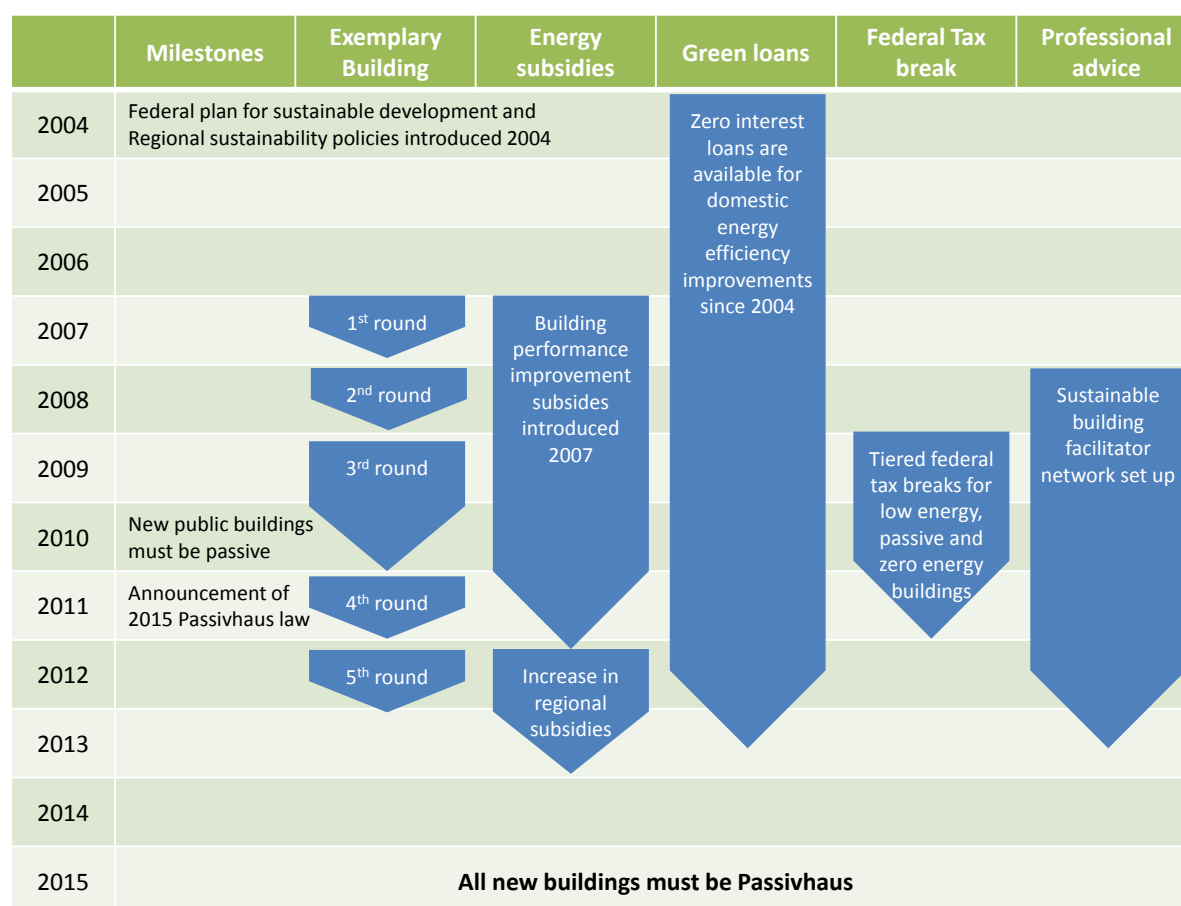
Yet by March 2011, the Brussels-Capital regional government amended the decree of December 2007 by setting the Passivhaus requirements for 2015 and modifying some of the shortcomings related to the method of calculating the PEB. From building regulations that were less stringent than the UK, the regional government passed the Passivhaus Law committing to an energy standard that would make Brussels the largest city to adopt the

⁹ Evelyne Huteybrock, Be.Passive

most stringent energy standard for buildings. This was achieved in a relatively short period of time, with a high level of political consensus and minimal commercial concern.

The move towards the Passivhaus Law by Brussels-Capital was established in three stages. First, the regional government passed an energy performance law. Second, this law was supported by a variety of subsidies to stimulate the market for energy efficiency. Third, communication, training and dissemination was deemed to be as important as the technical details of design and construction.

The timeline below shows the various schemes that contributed to the adoption of the Passivhaus Law. Each initiative is explained in detail, but the two that were the most important according to Thibaut Hermans, of the Brussels Environment administration,¹⁰ were the BatEx Programme (BatEx) and the focus on free professional advice and communication.



3.2.1 Exemplary Building Programme (BatEX)

¹⁰ Brussels 2007-2011: from 0 to 250.000m² of Passive buildings. How is it possible? Thibaut HERMANS, Valentine FRUCHART, Bruxelles Environnement – IBGEBIM, Division Energy Presentation to the International Passivhaus Conference 2012

Launched in 2007, the aim of BatEx was twofold: to stimulate demand for low energy, low environmental impact buildings, by rapidly providing a critical mass of replicable buildings that serve as examples for people to aspire to. The second aim was to stimulate the supply of such buildings, so that the market would be able to meet future demand.

The BatEx programme provides a subsidy to buildings recognised as meeting an exemplary energy and environmental performance standard. It is an open competition, organised (to date) in five rounds, with calls for BatExs having taken place in 2007, 2008, 2009, 2011 and 2012. During each round applications were invited to receive funding, and those buildings which meet the highest standards receive a subsidy of €100 per m².

Projects must be located within the Brussels-Capital region in order to be eligible to receive funding, however the BatEx programme is otherwise highly flexible, with both new building and refurbishment projects of the following types of building eligible:

- Dwellings – private or social houses and apartments
- Schools, nurseries and childcare facilities
- Commercial offices, seminar facilities
- Health care buildings
- Sports halls or other indoor sporting facilities such as swimming pools
- Exhibition halls with conditioned indoor space, cultural facilities

Prerequisites for projects applying for funding include:

- Projects should be aspirational yet achievable. Energy and environmental performance should be replicable by other teams in future; therefore projects must demonstrate simple, feasible technical solutions at reasonable cost.
- New build developments must aspire to the Passivhaus fabric performance levels and to be zero-emission buildings
- Environmental impacts must be addressed in addition to energy performance, such as the use of low impact materials, life cycle assessment and biodiversity
- As exemplars, projects must be of high architectural quality, highly visible, and yet be satisfactorily integrated into the existing building stock.

Projects bidding for funding are reviewed by technical experts and a jury who assess each application against the above prerequisites. The jury can call for additional technical feedback from the expert panel. If approved, projects must sign a contract with Brussels Environment which states both parties' commitments; these include the critical point that all funded projects must submit regular energy consumption reports to Brussels Environment for five years following occupation of the building. Buildings should be completed within four years, and upon completion buildings are inspected to evaluate their quality of implementation and assuming no problems are identified the project is officially labelled an BatEx.

The total value of the BatEx programme is €45 million from May 2007 to December 2014. The subsidies are paid upon the commencement of works, 90% to the contractor and 10% to the developer. Funding is capped for any one project at of €500k for the contractor and of €100k for the developer.

A total of 117 winning projects representing more than 265,000 m² have been selected by the Calls for Proposals for BatExs. These include hundreds of collective and individual homes, offices, schools and child care centres, a funeral home, and so forth, totalling over €18.5 million in subsidies. In 2012, BatEx accounted for more than 16 % of construction annually generating a €319 million turnover and creating an additional 1250 jobs.

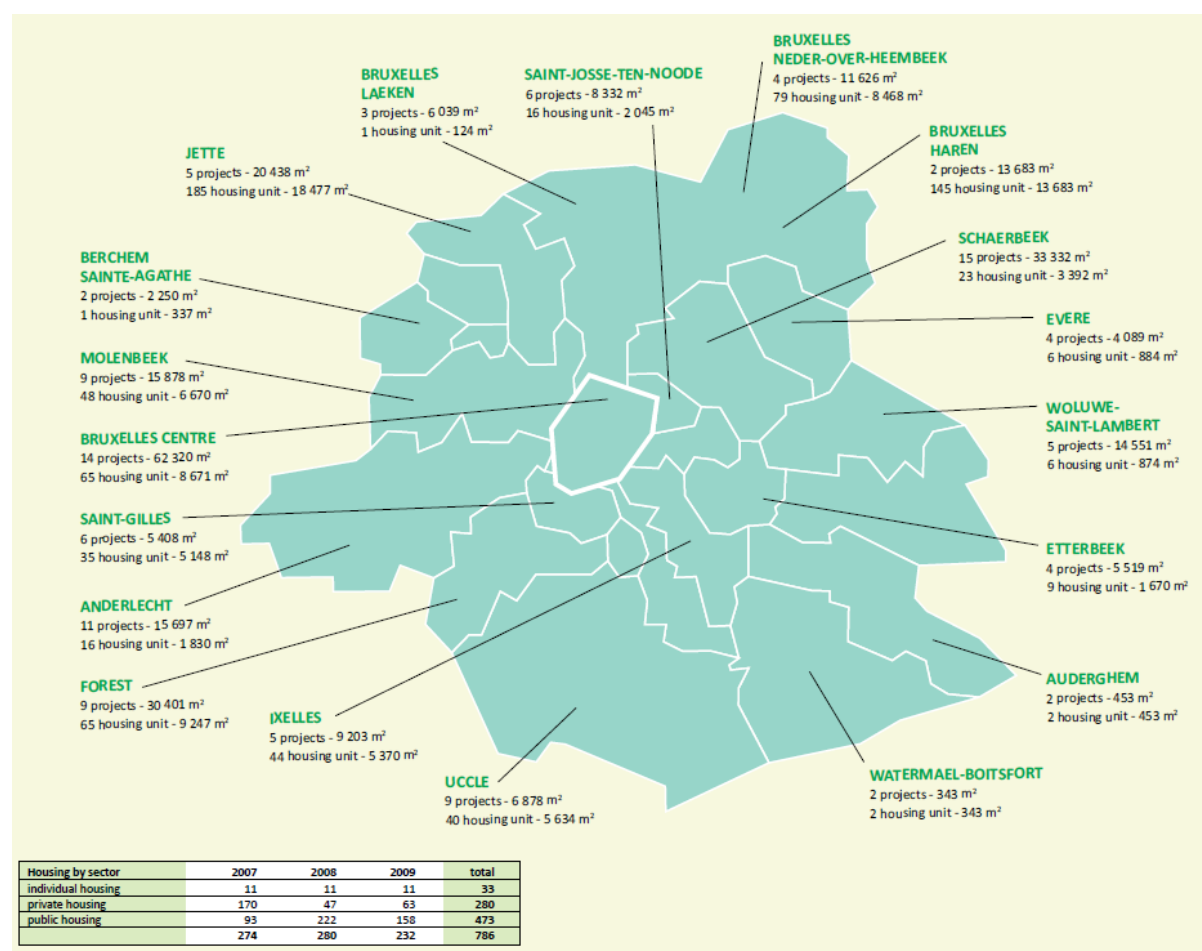


Figure 3 Map detailing various Passivhaus projects in Brussels-Capital

3.2.2 Technical Support: "A lot of people will have to learn to work differently and work better"

A major element of the BatEx and the Passivhaus Law is the network of professional advisors set up in 2008 and the establishment of a position of Master Architect ("Bouwmeester" in Flemish) of the Brussels-Capital Region for five years. The Master Architect is a function that ensures the architectural quality of institutional projects initiated by regional institutions, both in terms of procedures and results. The Master Architect is jointly funded by five ministers: Charles Piqué (Minister President), Brigitte Grouwels (Public Works), Christophe Doukeridis (Housing), Emir Kir (Planning and Public Property) and

Evelyn Huytebroeck (Environment, Energy and Urban Renewal). The professional advisor network is funded by Environment, Energy and Urban Renewal ministry.

With high level commitment, the Master Architect is able to gain the support of a number of experienced professionals with expertise in various areas of sustainable construction to act as advisors for BatEx projects. Working alongside a projects design team the advisors provide advice free of charge to encourage best practice in the design and implementation, management or refurbishment of Passivhaus buildings. A key aim is to disseminate knowledge to design team members that they can use on their future projects. The professional advisor generally offers the following:

- Information on appropriate technologies and suppliers
- Help with accessing grant funding
- Critical review of specifications and monitoring of project team members
- Assistance in developing an energy strategy
- Help in conducting energy audits
- Supervision of new build construction and renovation work
- Analysis of tenders for energy related systems installation.

The following sectors are served by specialists:

- *Social housing*
- *Tertiary sector* - the design or refurbishment of public or privately owned non domestic buildings such as hospitals, residential care homes, offices, swimming pool and schools
- *Cogeneration* to assess the financial viability and then the design and project management of cogeneration (combined heat and power) systems
- *Renewable energy* to specialise in advising on renewable energy projects, in particular offering assistance with more technically complex large installations, for example solar thermal arrays larger than 25m². Advice for smaller, more routine installations is available from the Belgian association for the promotion of renewable energy.
- *Green building* - experts in holistic sustainability in construction, advising on all areas of low environmental impact construction and buildings. They promote the range of green building tools made available by Brussels Environment and propose solutions to any obstacle that they identify may hinder a project.

3.3 Communication

Since 2009 the Belgian equivalent of the UK's Passivhaus Trust - the Passiefhuis-Platform (PHP) and Plateforme Maison Passive (PMP) – has produced a quarterly bilingual magazine: Be.Passive¹¹. BE.Passive is dedicated entirely to low energy building, with a focus on the on the Passivhaus standard targeting architects, public authorities, building

¹¹ See www.bepassive.be/splash/

societies, regional development agencies, engineers, construction manufactures and estate agents. The main goal of this magazine is to present information that is clear, concise and jargon free which is comprehensible to non-technical people that have an interest in low energy buildings.

“Joke Dockx, an engineer from the Brussels municipal environment and energy department, stressed the need to promote and “prove the legitimacy” of the standard to both the general public and also to contractors and developers.”¹²

National and regional events are pivotal in the promoting of the Passivhaus standard, currently In Belgium a Passivhaus fair has been jointly organised by PHP/PMP, thought to be the largest in the world, to showcase the latest developments and technologies in Passivhaus level energy efficient construction. In addition to the fairs PHP and PMP are also the lead organisers for an annual symposium which is a specialised event specifically targeting construction professional.



3.4 What about the Supply Chain?

Minimal consultation with the supply chain took place. There were objections from some suppliers upon the announcement that all buildings would be required to meet the Passivhaus standard by 2015. However other domestic and non-domestic competitors have embraced supplying components and materials to subsidised BatExs since 2007, along with supplying high quality components to low energy new and refurbished buildings that fall outside the BatEx programme.

¹² www.irishtimes.com

Underpinning this market is the necessary certainty that a market for higher quality products exists, as provided by the BatEx programme, which was expected at the outset to be funded until 2014. The other subsidy schemes – detailed in appendix 5.2 - that have operated in Brussels have also driven the fledgling market.

It was found at the outset of the BatEx programme some non-domestic component suppliers from central Europe would cut their prices by up to 40% in order to enter the Belgian market, but after the first couple of years would increase their prices again. By this time selected domestic manufactures were able to supply suitable components. This created a competitive situation where once non-domestic suppliers had to compete with Belgian suppliers the cost of high quality Passivhaus suitable components reduced. Again, this illustrates the market led approach used in Brussels has been successful, not just at the building level, but also at the material and component levels.

Of the companies that innovated to develop Passivhaus products many are locally based small to medium enterprises (SME).

Isoframes BVBA

Established in 2004 Isoframes is an SME that manufactures windows in Essen, Belgium, near the Dutch border. It supplies timber and aluminium clad timber window frames with insulated polyurethane cores and double seals for improved air tightness. Isoframes timber frames have a U value of 0.77 W / m² K while the aluminium clad timber version achieves a U value of 0.68 W / m² K and are marketed as suitable for use in Belgium, Holland, France and the UK.

<http://www.isoframes.eu>

Her-Win SA

Based in Mariembourg near the French border, **Her-Win SA** is another Belgian SME window manufacturer that has developed a Passivhaus window – Hermin 66 - that has been used on certified buildings. Their product is an aluminium clad timber frame window with a frame U value of 0.66 W / m² K.

<http://www.hermine66.com>

Pierret-System SA

Based in Southern Belgium, Pierret System is a family run SME that has traded for over 50 years. Adapting their traditional products, they have recently obtained PHI approval for their insulated timber frame with aluminium cladding. It is available with whole window U values ranging from 0.71 to 0.64 W / m² K and benefits from a triple sealing, double locking system for improved airtightness.

<http://www.pierret-system.com/>

Peters Alku-Bau AG

Founded in 1965, Peters Alku-Bau is a medium-sized company based in Southern Belgium that manufactures window frames and doors in aluminum and PVC.

<http://www.alku-bau.com>

BC Tech SA

BC Tech is an SME that was established in 2006 focusing on ventilation, based in East Belgium. <http://www.bctech.be>

3.5 Is it really Passivhaus?

The Passivhaus Planning Package (PHPP) is paramount in adhering to the Passivhaus standard in Belgium. However, unlike the UK, certification is not finalised by the Passivhaus Institute in Germany. Instead, the PMP/PHP controls standards and certification. There are some variations. For example Sebastian Moreno-Vacca, a leading Passivhaus designer in Belgium and head of PMP, has suggested that thermal bridges need not always be addressed to the extent advocated by the Passivhaus Institute. He argues that it is often possible to achieve Passivhaus energy performance, while using more cost effective details, or by compensating for greater losses via thermal bridging by improving other aspects of the building fabric, boosting insulation levels for example – a familiar scenario to UK designers. In certain situations this can avoid the need for expensive, proprietary products such as thermally broken façade support brackets.

This finding does however need to be taken in the Brussels context. Many of the buildings implemented as Passivhaus under the BatEx programme are apartment buildings, or non-residential; offices, schools or other commercial building types, all of which have very favourable floor AV ratios, which is beneficial in achieving a low space heating energy demand of 15kWh/m²/year.

Brussels Passivhaus Certification requirements

Specific heating demand of less than or equal to 15 kWh/m² per year

The percentage of overheating in buildings (more than 25 °C) must be less than or equal to 5% (calculated with PHPP software).

Primary energy must be less than or equal to 45 kWh / m² for dwellings or less than or equal to 90 - 2.5 x AV ratio. Annually for heating, hot water and auxiliary (PHPP calculation with the software). i.e. no appliances, lighting or small power

Overheating - the number of hours above 25 °C may not exceed 5% of working time (result obtained by dynamic simulation)

Figure 4 Brussels-Capital Passivhaus requirements

3.6 Monitoring

BatEx funding is monitored to measure the real consumption and comfort of buildings. A five year monitoring programme will commence in April 2012 monitoring the real consumption of energy and water and compared to the calculations made by the PHPP spreadsheet. According the Brussels Ministry of Environment¹³, a survey similar to a Building in Use Study (BUS) Survey has been undertaken in order to learn about user comfort in a BatEx building. Of the responses received from 11 different buildings the results are good with high levels of satisfaction about indoor temperature, ventilation, air quality, humidity and comfort.

Further details are expected in a book that was to be edited in June 2012 and it is hoped that evidence of energy performance will be available in English. Further research is required to make it publically available.

3.7 Costs

The cost of the BatEx Programme winners of course varies, both in land and construction cost, according to the location, in Brussels as anywhere else. The average construction costs of individual dwellings benefiting from the programme is €1,503/m² compared to €1,514/m² for non-Passivhaus homes, i.e. less than a 1% increase in costs. The figures for apartment buildings are €1,350/m² for Passivhaus homes compared to €1,494/m² for non-Passivhaus homes, meaning that building to the Passivhaus standard actually provided a 9% cost saving.

When refurbishing any type of building however, to go the extra mile and achieve the Passivhaus performance levels, costs more than a 'regular' refurbishment, with average costs for Passivhaus BatEx refurbishment being €1,565m² against €1,492m² for non-Passivhaus refurbishments, representing an increase in costs of 5%.

When looking at commercial buildings, again the cost of Passivhaus buildings is greater than 'regular' buildings, however the payback time is within the acceptable time frame for many businesses. The Aeropolis II project was constructed for €1,300m² (excluding VAT and fees), which is 4-5% more than the cost of constructing to the Brussels-Capital region regulatory minimum standard. It equates to a payback time of 5 years in energy cost reduction¹⁴.

The cost findings in Brussels indicate that when trying to establish the costs of building to the Passivhaus Standard we cannot look only to Germany for an answer. The cost premium of building Passivhaus in Germany is 3-8%¹⁵ which appears to be higher than the cost in Brussels. The UK may therefore also be able to achieve Passivhaus performance at a lower cost than Germany.

¹³ Brussels 2007-2011: from 0 to 250.000m² of Passive buildings. How is it possible? Thibaut HERMANS, Valentine FRUCHART, Bruxelles Environnement – IBGEBIM, Division Energy Presentation to the International Passivhaus Conference 2012

¹⁴ Exemplary Buildings Success Stories, Brussels Environment

¹⁵ NHBCF, NF 47: Lessons from Germany's Passivhaus Experience

Brussels therefore is driving the demand for Passivhaus building using a significant financial incentive, in a similar manner to Germany, which offers repayment grants and discounted interest rate loans from the publicly owned KfW Bank. The UK on the other hand offers no such support to new build projects¹⁶

¹⁶ NHBCF, NF 47: Lessons from Germany's Passivhaus Experience

3.8 Did it work?

The table below shows the number of standard buildings constructed in Brussels compared to the number of Passivhaus buildings from 2004 and projected to 2015 when the law comes into force. It can be seen that with the introduction of the subsidies and financing programs in 2007 there was a slow start to the increase in Passivhaus buildings. As the financing program became more prominent a sharp increase was seen which resulted in a total of 358 Passivhaus buildings by 2012 – an impressive increase from only 1 three years previously. In terms of floor area Brussels has progressed from zero Passivhaus buildings in 2007 to more than 80,000 m² built or planned in 2009 and over 250,000 m² by 2011¹⁷.

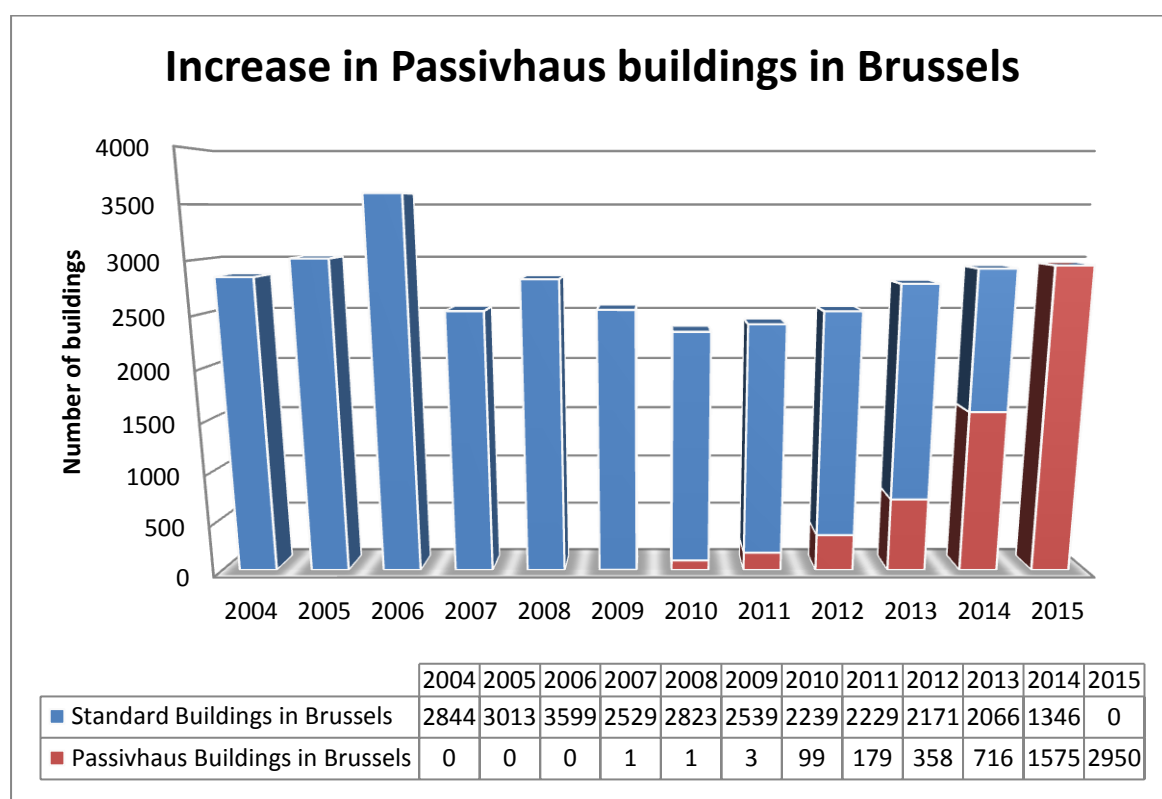


Figure 5 Number of Passivhaus projects in Brussels

The figure¹⁸ below shows the impact of the overarching CO₂ emissions reduction program of which the Passivhaus Law was part of. During the early 2000's Brussels inhabitants had one of the worst CO₂ emissions and energy consumption per person in Europe. This was the main driver for the implementation of a programme to reduce the inhabitant's impact on the environment and Minister Huytebroeck was responsible for bringing in the initiative. The

¹⁷ Brussels 2007-2011: from 0 to 250.000m² of Passive buildings. How is it possible? Thibaut HERMANS, Valentine FRUCHART, Bruxelles Environnement – IBGEBIM, Division Energy Presentation to the International Passivhaus Conference 2012

¹⁸ Ismael Daoud, presentation at the UK Passivhaus Conference 2011

graph¹⁹ shows a dramatic fall in the CO₂ emissions and energy consumption and this can be entirely attributed to the success of the programme.

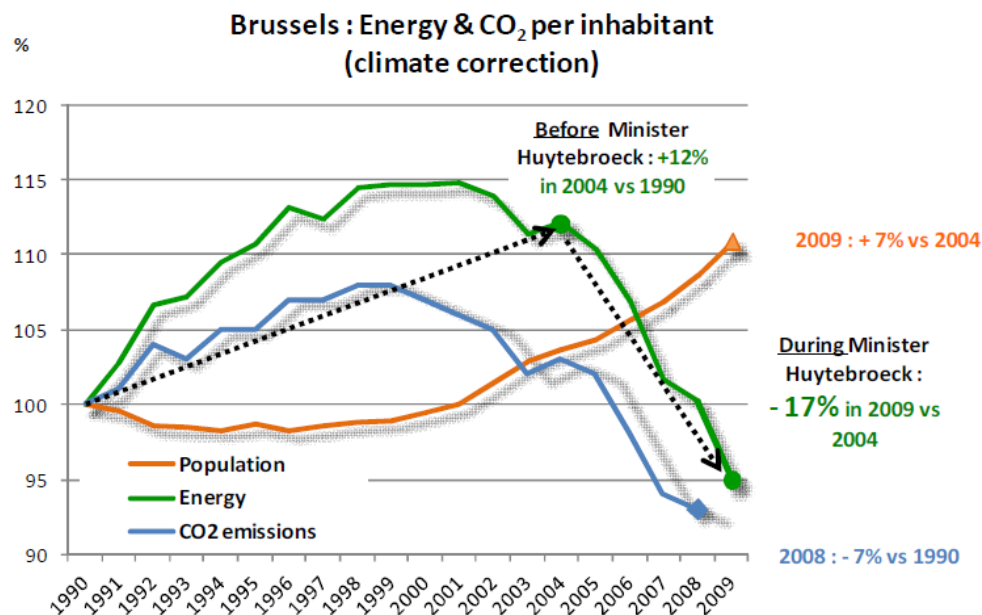


Figure 6 Energy and CO₂ per inhabitant in Brussels

Other significant benefits include the BatEx participation of public housing associations with 473 units in the scheme by 2009 accounting for 60% of the project. Unlike Germany, Brussels-Capital has similar levels of social housing to the UK – 11% of housing is public – with 32,000 households on waiting lists. According to estimates²⁰, almost 60,000 housing units must be provided in the next ten years.

¹⁹ From Ismaël Daoud's presentation at the 2011 UK Passivhaus conference

²⁰ BRUSSELS from eco-building to sustainable city, Environment, Energy and Urban Renewal of the Brussels-Capital Region

3.9 Brussels-Capital Region Case Studies

3.9.1 ELIA 2 Building, Quai Leon Monnoyer 3, 1000 Brussels



Figure 7 Elia 2²¹

This is ELIA's (the operator of Belgium's national Electricity transmission grid), second building to benefit from the BatEx programme. Due for completion in September 2013, it will be both constructed to the Passivhaus certification and certified under BREEAM. It is a cast in situ concrete frame structure with prefabricated timber framed wall panels. The building clad in a bronze coloured aluminium certain walling system.

Client	Elia Asset
Architect	Architectes Associés www.architectesassocies.be
Service engineer	Arcadis
Contractor	CFE Brabant
Floor Area	9,939 m ²
Space heating energy demand	13 kWh/m ² /year
BatEx grant	€ 286.71/m ²
U of walls and windows	0.13 W/m ² .K
Systems:	Cellulose insulation, night cooling system, solar shading and 4000m ² PV
Cost before subsidy:	€ 1,474 m ²

²¹ Picture courtesy of Architectes Associés

Reference: 11-141 QUAI-LEON-MONNOYER_INFOTICHE_BATIMENT_EXEMPLAIRE_FR2011.doc from <http://www.bruxellesenvironnement.be/Templates/Home.aspx>

3.9.2 Aeropolis II, Avenue Britsiers, 1030 Schaerbeek



Figure 8 Aeropolis II²²

Despite not originally being envisaged as a Passivhaus building, after a design modification, Aeropolis II won funding in the first round of the BatEx programme, and became Brussels largest Passivhaus office building at the time it was initiated in 2007²³. The project benefits from a highly airtight and well insulated curtain wall façade.

Client	Groep Arco - KWB - KAV - KAJ
Architect	Architectes Associés www.architectesassocies.be
Service engineer	Ingenieursbureau Stockman www.istockman.be
Contractor	Jacques Delens www.jacquesdelens.be
Floor Area	7,388 m ²
Space heating energy demand	8 kWh/m ² /year
BatEx grant	€ 100/m ²
U of walls and windows	wall: 0.09 à 0.14 W/m ² .K; floor: 0.15 W/m ² .K; roof: 0.15 W/m ² .K; Uf : 1.5 W/m ² K; Ug: 0.6 W/m ² K
Systems:	Mechanical ventilation with heat recovery; ground air heat exchanger
Cost before subsidy:	€11,500,000 excl. VAT, excluding fees Or €1315/m ²

²² Picture courtesy of Architectes Associés

²³ 07-40 AEROPOLIS II INFOFICHE_BATIMENT EXEMPLAIRE_FR2007.doc (from <http://www.bruxellesenvironnement.be/Templates/Home.aspx>)

3.9.3 14 Terraced Houses, Rue Fin Molenbeek-Saint-Jean



Figure 9 Bonnevie, du Cire, de la commune de Molenbeek-Saint-Jean²⁴

In collaboration with the Municipality of Molenbeek (which provided a plot of land) and the Housing Fund for the Brussels-Capital Region (which will provide project management before selling the homes to members of the association), the families set up workshops to define their needs, train themselves up regarding energy issues, meet professionals and organise an architectural competition and a "design and implementation" tender. The 14 duplex apartments, ranging from 2 to 5 bedrooms and 100 to 150m² were delivered to their owners in March 2010 and were won the "Exemplary Buildings" scheme in 2008.

Client	Fonds du Logement Brussels Region www.fondsdulogement.be
Architect	Damien Carnoy www.carnoy-crayon.be
Service engineer	MK engineering www.mkengineering.eu
Contractor	Degraeve www.degraeve.be
Floor Area	1 833 m ²
Space heating energy demand	15 kWh/m ² /year
BatEx grant	€ 100/m ²
Average walls U value	0.26 W/m ² .K
Systems:	Heat exchanger; extensive green roofs; rainwater tank; natural materials; FSC wood, cellulose, etc.
Cost before subsidy:	1 150 €/m ²

²⁴ Picture and details courtesy of BE.Passive

Reference: 08-60 L'ESPOIR INFOFICHE_BATIMENT EXEMPLAIRE_FR2008.DOC - 02/03/2010 (from <http://www.bruxellesenvironnement.be/Templates/Home.aspx>)

3.9.4 79 Social Houses, Rue Bruyn, 1 1120 Neder-Over-Heembeek Brussels



Figure 10 79 Social Houses, Rue Bruyn, 1 1120 Neder-Over-Heembeek Brussels²⁵

Bruyn East account for 330 new homes with the second phase – Bruyn West to be built with 79 Passivhaus units. Bruyn West was in 2009 one of the winners "exemplary buildings" Region Brussels. Bruyn West buildings are constructed using a traditional masonry block with a layer of external insulation. Compactness was key to reduce airtightness and insulation issues.

Client	CPAS de Bruxelles
Architect	Pierre Blondel architects www.pblondel.be
Service engineer	MK Engineering www.mkengineering.be
Contractor	AM Galère & CEI De Meyer www.galere.be www.cei-demeyer.be
Floor Area	9 100 m ²
Space heating energy demand	Average : 12 kWh/m ² .an; Max : 15 kWh/m ² .an; Min : 6 kWh/m ² .an
BatEx grant	€ 100/m ²
Average walls U value	Walls: 0.15 W / m ² . K; Floor: 0.09 W / m ² . K; Roofing: 0.07 W / m ² . K
Systems:	double flow ventilation centralized heat recovery and individual control zones; production of hot water from renewable sources with solar thermal; management of rainwater infiltration and creation of a wetland; efficient lighting and lighting control based on common areas and user controls
Cost before subsidy:	€ 11.27 million (excluding VAT and fees)

²⁵ Picture and details courtesy of BE.Passive

Reference: 09-100-BRUYN OUEST_INFOFICHE_BATIMENT EXEMPLAIRE.doc (from <http://www.bruxellesenvironnement.be/Templates/Home.aspx>)

4 Conclusions and recommendations

There are a number of key lessons for the UK and its regions that can be drawn from this report:

First, in order to fulfil the recast EU Energy Performance of Buildings Directive (EPBD) and to regulate for zero energy buildings by 2020, Passivhaus offers a solution to meet these requirements. Currently, the plans for the UK “zero carbon” approach assumes a minimum energy requirement that is three times higher than Passivhaus with carbon emissions being offset by renewable energy or allowable solutions.

Regions outside Germany are adopting the standard as a way of significantly reducing carbon emissions from buildings. The Brussels-Capital region started with energy standards that were amongst the worst in Europe – and less stringent than the UK - before committing to the Passivhaus law that starts in 2015.

Second, given that there were very few Passivhaus buildings in Belgium or Brussels in 2007 the Passivhaus Law was supported and funded by two key initiatives: the BatEx subsidy which stimulated the market for energy efficiency; and the elevation of sustainable design and construction with the appointment of a Master Architect and key advisors to train and assist industry.

Third, initially the supply chain faced stiff competition from Passivhaus imports local businesses including a number of SMEs were able to develop certified products and compete effectively in the market.

Finally, the combination of legislation and funded support led to a rapid increase in the adopting of Passivhaus buildings from zero buildings in 2007 to more than 80,000 m² built or planned in 2009 and over 250,000 m² by 2011²⁶. At the same time energy consumption per head fell by 17% which the Brussels-Capital Region claims is entirely down to the programme.

The successful adoption of Passivhaus in Brussels Central Region suggests that a regional approach to Passivhaus may result in quicker uptake within the UK. The National Planning Policy Framework (NPPF) may offer an opportunity as the framework contains a presumption in favour of sustainable development but does not explicitly define sustainable development, thereby enabling it to be defined at local level.

In order to develop a Passivhaus region in the UK, it is recommended that the following regional players would need to be aligned: a centre of expertise to provide the necessary technical advice and rigor, the Local Enterprise Partnership to help engage the supply chain and administer a subsidy if funds permit, and a planning authority, or coalition of planning authorities to enact and enforce a Passivhaus requirement.

²⁶ Brussels 2007-2011: from 0 to 250,000m² of Passive buildings. How is it possible? Thibaut HERMANS, Valentine FRUCHART, Bruxelles Environment – IBGEBIM, Division Energy Presentation to the International Passivhaus Conference 2012

5 Appendix

5.1 The key players

The following people were instrumental in making the Brussels Passivhaus Law successful, whether it was in relation to policy making, Passivhaus design or publicity and dissemination of information to the public and construction industry.

Christophe Marrecau

General-Coordinator of Passiefhuis-Platform (<http://www.passiefhuisplatform.be/>)

Christophe Marrecau leads Passiefhuis-Platform (PHP). Established in 2002 to introduce the Passivhaus concept in the Flanders Region, PHP has been instrumental in delivering Passivhaus buildings prior to discussions on the possibility of introducing the 2015 Passivhaus law. Christophe also sits on the board of editors of the *be.passive* magazine

Benoit Quevrin

General-Coordinator of Plateforme Maison Passive (www.maisonpassive.be/)

Benoit Quevrin leads Plateforme Maison Passive (PMP), the sister organization of PHP introduce the Passivhaus concept into the French speaking regions of Belgium. Benoit is a former student of the Faculty of Engineering (FP) of the University of Mons, has contributed to the organisations information publications such as a book on thermal bridging and is part of the editorial team of *be.passive*

As leads of their respective organisations Christophe Marrecau and Benoit Quevrin were active in promoting the Passivhaus idea before its widespread uptake in Brussels and thus inspiring the Brussels Minister Huytebroeck, and advisers Daoud and Clerfayt, and giving ideas to many other people working in the field. They also contributed to the writing of the 2015 law. They are part of the experienced professionals, conduct a lot of Passivhaus oriented research and deliver a wide set of tools and knowledge to the market (at low or no cost at all).

Sebastian Moreno-Vacca



President of the board of Directors, PMP and Managing Partner of a2m

Architect, awarded diploma with high honour at ISA Saint-Luc Brussels. In 2000 he founded and manages his own practice A2M sprl. In 2006 he contributed to setting up PMP with colleagues. Sebastian is currently president of the board of directors of PMP and since 2007 professor at University of Architecture ULB-LaCambreHorta. As of 2007, all the projects of A2M are either passive, or zero energy for new construction and for refurbishment. He regularly participates as speaker in seminars and symposiums in the field of Passivhaus standard.

In 2009, Sebastian launched a quarterly magazine called “be.passive”, the online edition of which can be found at the PMP website: <http://www.bepassive.eu>

Evelyne Huytebroeck²⁷



Brussels Minister of Environment, Energy, Urban Regeneration and Aid to people
(<http://evelyne.huytebroeck.be>)

After working a Brussels MP and leader of the group ECOLO for fifteen years (1989 to 2002), she then became co-president of the party Ecolo (2002 to 2004), in 2004 she became the first female government minister in Brussels representing the party Ecolo.

²⁷ Info from <http://evelyne.huytebroeck.be>

She has been an Environmental activist since 1982, elected to Parliament in Brussels since 1989, she has always fought for a greener region and solidarity. Her goal is to make Brussels a city-region which combines sustainable economic development and job creation, protection of environment and social justice, but also revitalizing neighbourhoods and citizen participation.

Evelyne was responsible for implementing the Brussels Passivhaus law and ensuring that it formed part of the regions political policies.

Ismaël Daoud



Brussels Ministry of Environment, Sustainability and Energy (<http://evelyne.huytebroeck.be>)

Since the new term of Parliament began (June 2009), Ismaël Daoud, a civil engineer by trade who specialises in energy, has been part of Brussels Minister Evelyne Huytebroeck's team of Political Advisers. His technical contribution and practical, down-to-earth nature constitutes a decisive asset when it comes to offering optimum advice to the Minister for the Environment, Energy and Urban Regeneration.

He is responsible for all aspects of the energy performance of buildings (EPB), including the preparation of the construction sector for compliance with the "Passive 2015" EPB requirement, together with the materials that affect energy production, eco-construction, the exemplariness of the public authorities, the BatExs Call for Projects, energy incentives, the training and technical tools deployed by Brussels Environment, the implementation of a Belgian sustainable building label, not forgetting the provision of technical support to the other Cabinet Advisers.

Sabine Leribaux



Managing Partner, Architectes Associes (<http://www.architectesassocies.be>)

Sabine Leribaux is managing partner of Brussels-based practice Architectes Associes since its creation in 2000. With her partners M. Lacour, M. Desmedt, and D. Van Cauwenberghe, focus has always been on bringing to life flexible solutions based on the solid hands-on experience of the team members. Synergies and collaborations with other essential members of the building process are systematically encouraged thereby better reflecting the reality and complexity of today's society.

Born and raised in the US, Sabine studied architecture in Brussels. She has worked with Marc Lacour since 1991 designing both public and private projects, many award-winning for example the Belgian National Theatre (Venice Biennale 2002), the Maisin Center (Horta Award 2005), Belmont Court (Mipim Award 2007), and more recently Aeropolis II (7500sqm of offices, IBGE BatEx 2009) representing one of Europe's largest Passivhaus office buildings so far. Sabine is also heavily involved in the new SBK for ELIA (10000sqm of Passivhaus offices, BREEAM certified).

5.2 Subsidies

5.2.1 Energy Subsidies

In line with the BatEx subsidy program discussed above an additional financial incentive program was introduced. These subsidies were introduced to encourage the widespread take up of passive and sustainable products and solutions.

The aim of this program was to ensure that everybody in the region had an opportunity to benefit from a financial incentive and to not only focus on exemplar buildings. The program was designed to further develop the supply chain and availability of sustainable products and services, thereby reducing the cost as take up and demand increased. The subsidies available within this program are very varied and cover a wide range of products and solutions. They range from individual products such as insulation or solar thermal panels to

energy audits and feasibility studies. This again helps the program reach a wider audience as possible providing something for everyone.

A summary of the subsidies are outline below and are split into 3 categories: privately owned/rented dwellings, multiple occupancy housing (apartment blocks, etc. or organisations equivalent to Registered Social Landlords) and tertiary and industrial sector buildings. The subsidies that are available in the privately owned/rented dwellings category are only available for the purchase and installation of products rather than energy audits or feasibility studies. This enables individuals that may not have extensive knowledge of low energy construction to benefit from tangible products and help raise the profile of such products. Over three quarters of the subsidies have been allocated to individuals, but groups and businesses that are also eligible for funds. The subsidies have proved to be very popular over 6 years more than 110,000 subsidies have been allocated for a total amount of over €65 million, 80 % of this going to individuals. The subsidies are means-tested so that families on a low-income are eligible for increased financial assistance.

From the table²⁸ below it can be see that there is a strong emphasis on designing and building to Passivhaus levels, with the subsidies available being numerous and larger than those available for lower levels of energy efficient construction. The subsidies make it a very attractive option to build a Passivhaus; the amount available is likely to cover the current extra-over capital cost of building a Passivhaus compared to a conventional dwelling. As the program became more established the success meant that the extra-over cost reduced and will continue reducing until a Passivhaus could be built for the same price as a conventional dwelling.

Under subsidy B10 an average sized dwelling of 120m² built to Passivhaus standards for a family on a low-income would qualify for a subsidy of €15,600 (using an exchange rate of 0.86 this equates to £13,416). Recent studies have shown that a Passivhaus currently costs between 0.5 and 8% extra to build. Taking recent examples of Passivhaus built in the UK, a cost £1500/m² can be used for comparison purposes. This equates to a total cost of £180,000 for an average size UK dwelling. In this example the subsidy would reduce the total cost by 7.4%. The subsidy rate set by the Brussels law covers this increase and makes building a Passivhaus cost neutral compared to building a conventional dwelling. On top of this additional subsidies for products such as renewable energy sources, energy efficient heating systems and external shading could also be applied for. If natural insulation materials are used in a Passivhaus building then extra subsidies are available. Another interesting subsidy is the payment for 100% of the cost for a blower door test. An airtightness test is mandatory for a Passivhaus to confirm that the as-built building meets the Passivhaus air-tightness requirement of 0.6 air changes per hour at 50 Pa. This bonus subsidy further assists in promoting Passivhaus as an very attractive option for building energy efficient buildings and helps to make a Passivhaus cost neutral compared to a conventional building. The blower door test is itself a good example of how the program can assist in creating local business and enterprise. By encouraging designers, buyers and specifiers to build Passivhaus buildings a demand is created for specialist services and products that would otherwise not be considered. This then has a positive knock-on effect of creating local employment opportunities and boosting local economy.

²⁸ <http://www.bruxellesenvironnement.be/Templates/Particuliers/informer.aspx?id=12103>

5.2.2 Green Loans

As part of the subsidy program a loan was made available for low-income families who wanted to refurbish their homes. The loan is interest free and was available to cover either the costs of insulation the home or replacing the heating system. Special consideration was given to encouraging low-income families to refurbish their homes as the cost of improving the home is likely to have been low priority. Lengthy pay-back periods would have provide further disincentives for families to invest money into insulating their homes or replacing the heating system. The value of the loan that the home owner or leaseholder could apply for was between €500 and €20,000.

5.2.3 Government tax breaks for energy efficient construction

In 2009 the Belgian central government introduced a reduced tax rate for energy efficient buildings. The reduction depended on the level of energy efficiency achieved by the building. The reduction was applied annually over 10 years and provided a strong incentive to construct energy efficient buildings. There were three levels of energy efficient buildings that qualified for varying reductions:

A low energy building - defined as having heat demand of less than 30 kWh/m²/yr,

A Passivhaus building,

A zero-energy building defined as a Passivhaus where the remaining energy demand is met through the use of renewable energy.

The low energy category qualified for a reduction of €420 per year, the Passivhaus category was eligible for a reduction of €850 per year and the zero energy category qualified for a reduction of €1,700 per year for 10 years.

Unfortunately as part of a government-wide cost cutting strategy the tax break was withdrawn, however, to compensate for this the Brussels-Capital region increased some of the Energy Subsidies discussed previously.

5.2.4 Energy audits and studies subsidies

	Subsidy Description	Amount
A1	Energy audit	€400 per individual dwelling or €3,000 for collective housing
A2	Feasibility Study - Designing energy (feasibility study is not accessible to individual housing)	50% of eligible costs of the invoice
A5	Blower Door test	Individual accommodation: €500 / dwelling unit Other: €1,500 per building + €0.6 / m ² to 1000 m ² and above

5.2.5 Insulation and ventilation subsidies

	Subsidy Description	Amount
B10	New construction to Passivhaus levels	<p>Base level: €80 / m² to 100 m² and €40 / m² beyond</p> <p>Average income: €100 / m² to 100 m² and €50 / m² beyond</p> <p>Low income: €120 / m² up 100 m² and €60 / m² beyond</p>
	Refurbishment to low energy levels (= need for heating ≤ 60 kWh / m ² . year	<p>Base Level: €110 / m² up to 100m² and €70 / m² beyond</p> <p>Middle income : €130 / m² to 100 m² and €80 / m² beyond</p> <p>Low income : €150 / m² to 100 m² and €90 / m² beyond</p>
	Renovation to very low energy levels (= need for heating ≤ 30 kWh / m ² . annually)	<p>Base Level: €140 / m² to 100 m² and €100 / m² beyond</p> <p>Average income: €160 / m² to 100 m² and €110 / m² beyond</p> <p>Low income: €180 / m² to 100 m² and €120 / m² beyond</p>
	Refurbishment to Passivhaus levels (= need for heating / cooling ≤ 15 kWh / m ² . annually)	<p>Base Level: €170 / m² to 100 m² and €100 / m² to €130 / m² beyond</p> <p>Average income: €190 / m² to 100 m² and €140 / m² beyond</p> <p>Low Income : €210 / m² to 100 m² and €150 / m² beyond</p>
	NOTE: The subsidies shown above cannot be used in conjunction with B1, B2, B3, B4 and B7	
	<p>The B10 is combined with following bonus subsidies:</p> <ul style="list-style-type: none"> • new wood frame labelled FSC or PEFC (€50 / m² glass) • new wood frame non FSC or PEFC certified (€5 / m² glass) • natural insulating material (€10 / m² insulated) • Blower door test (100% of the invoice and max €500 / housing) 	

	Subsidy Description	Amount
B1	Roof insulation (with a U value of 0.25 W/m ² K)	Base Level: €15 / m ² insulated roof Average income: €20 / m ² roof insulated Low income: €25 / m ² insulated roof
	Bonus if using a natural insulating material	+ €10 / m ² insulated roof
	Bonus if using a Passivhaus type roof (0.11 W/m ² K)	+ €10 / m ² insulated roof
B2	Internal Insulation (with a U value of 0.5 W/m ² K)	Base Level: €20 / m ² of insulated wall Average income: €25 / m ² of insulated wall Low income: €30 / m ² of insulated wall
	External Insulation (with a U value of 0.29 W/m ² K)	Base Level: €80 / m ² of insulated wall Average income: €90 / m ² of insulated wall Low income: €100 / m ² of insulated wall
	Cavity wall insulation (with a U value of 1 W/m ² K)	Base Level: €8 / m ² of insulated wall Average income: €10 / m ² of insulated wall Low income: €12 / m ² of insulated wall
	Bonus if using a natural insulating material	+ €10 / m ² of insulated wall
B3	Floor insulation (with a U value of 0.5 W/m ² K)	Base Level: €20 / m ² floor or ground isolated Average income: €25 / m ² floor or ground isolated Low income: €30 / m ² floor or ground isolated
	Bonus if using a natural insulating material	+ €10 / m ² floor or ground isolated
B4	Super insulating glazing (with a U value of ≤ 1.1 W/m ² K or ≤ 1.2 W/m ² K frame if available)	Base Level: €45 / m ² glazing Average income: €50 / m ² glazing Low income: €55 / m ² glass
	Bonus if using thermally enhanced glazing spacer	+ €15 / m ² glass
	Bonus if glazing 0.6 W/m ² K < U _g ≤ 1.0 W/m ² K or 0.6 W/m ² K < U _g ≤ 1.1 W/m ² K if existing frame	+ €15 / m ² glass

	Subsidy Description	Amount
	Bonus if glazing $U \leq 0.6$ W/m ² K	+ €30 / m ² glass
	Bonus if new wood frame labelled FSC or PEFC	+ €50 / m ² glass
	Bonus if new wood frame NON FSC or PEFC certified	+ €5 / m ² glass
B5	Green roof (with a U value of 0.25 W/m ² K)	Base Level: €20 / m ² Average income: €30 / m ² Low income: €40 / m ²
	Bonus if intensive green roof	+ €30 / m ² intensive green roof insulated
B6	External Shading ($g < 0.3$)	Base Level: €25 / m ² glass surface equipped with sunshade Average income: €30 / m ² of glass equipped with sunshade Low income: €35 / m ² of glass equipped with sunshade
	Bonus if certified wood FSC or PEFC	+ €50 / m ² visor certified wood
B7	Passivhaus certified MVHR unit	Base Level: €2,500 / System Average income: €3,000 / System Low income: €3,500 / system
	Centralised demand-controlled extract ventilation	Base Level: €1,250 / System Average income: €1,500 / System Low income: €1,750 / system
	Local demand-controlled extract ventilation	Base Level: €50 / System Average income: €100 / system Low income: €150 / system

5.2.6 Efficient Heating Subsidies

	Subsidy Description	Amount
C1	Gas condensing boiler	Base Level: €1,200 up to 40 kW then €10 / kW additional

	Subsidy Description	Amount
		Average income: €1,400 up to 40 kW then €10 / kW Extra Low income: €1,600 up to 40 kW then €10 / kW additional
C1b	Bonus "boiler room renovation" (only for district heating or shared boiler systems)	+ 20% of the aggregate amount of premiums C1, C3 (or E6), E2 and E5
C2	Instantaneous gas water heater	Base Level: €125 / Installation Average income: €250 / installation Low income: €500 / installation
C3	Thermal	
	Room thermostat or optimiser	Base Level: €25 / thermostat or optimizer Average income: €50 / thermostat or optimizer Low income: €100 / thermostat or optimizer
	Thermostatic radiator valves	Base Level: €10 / valve Average income: €20 / valve Low income: €30 / valve
C4	Heat pump (not reversible)	Base Level: €4,250 / housing Average income: €4,500 / housing Low income: €4,750 / housing

5.2.7 Renewable energy

	Subsidy Description	Amount
D1	Solar thermal (per dwelling unit)	Base Level: €2,500 / m ² up to 4 / dwelling unit + €200 / m ² beyond 4 m ² Average income: €3,000 / m ² up to 4 / dwelling unit + €200 / m ² than 4 m ² Low income: €3,500 / m ² up to 4 / dwelling unit + €200 / m ² beyond 4 m ²
D2	Photovoltaic system (if the new building or refurbished to Passivhaus levels)	Base Level: €0.25 / Wp Average income: €0.5 / Wp Low income: €1 / Wp

5.2.8 Energy efficient investment

	Subsidy Description	Amount
E1	District heating network	Base Level: 25% of the invoice Average income: 27.5% of the invoice Low income: 30% of the invoice
E2	Combine heat and power plant	Base Level: €3,500 x square root of the electric power (kW) Average income: €4,000 x square root of the

	Subsidy Description	Amount
		electric power (kW) Low income: €4,500 x square root of the electric power (kW)
E4	Lighting and relighting optimisation (only for communal areas)	Base Level: 25% of the invoice Average income: 27.5% of the invoice Low income: 30% of the invoice
E5	All Accommodation	
	If electrical power <100 W	Base Level: €50 / Installation Average income: € 75 / installation Low income: € 100 / installation
	Multiple occupancy housing (apartment blocks)	
	If electrical power ≤ 100 W <300 W	Base Level: €150 / Installation Average income: €200 / installation Low income: €250 / installation
	If electrical power ≤ 300 W <500 W	Base Level: €300 / Installation Average income: €350 / installation Low income: €400 / installation
	If electrical power ≤ 500 W <1000 W	Base Level: €400 / Installation Average income: €450 / installation Low income: €500 / installation
E6	Any equipment or system that improves energy efficiency of a building (only for communal areas)	Base Level: 25% of the invoice Average income: 27.5% of the invoice Low income: 30% of the invoice

5.2.9 Efficient appliances

	Subsidy Description	Amount
F	Fridge/freezer A + + or A tumble dryer	Base Level: €50 / Installation Average income: €100 / installation Low income: €200 / installation (+ €100 bonus / installation where 4 people live in a low income household)
	Bonus A + + + fridge or electric dryer A + +	Base Level: €100 / Installation Average income: €150 / installation Low income: €200 / installation



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