Passive House standard and its practical applications

Elena Reyes Bernal
elena.reyes@passiv.de

Passive House Institute
www.passivehouse.com | www.passipedia.org

A presentation for
Training Seminar on High-Performance Energy Efficiency Standards in Buildings in the UNECE Region
September 6, 2018, St. Petersburg
1. What is “Passive House”
2. History and current trends
3. Policy uptake
4. The role of the Passive House Institute
What is “Passive House”?
Passive House - in words

A performance based standard for highly energy efficient buildings.

→ Optimize the building components to the extent that you can:
→ Use simple & robust heating / cooling systems

Want to know more? Check out our Passipedia article on the Passive House definition.
### Passive House – in numbers

#### Criteria or Alternative Criteria

<table>
<thead>
<tr>
<th></th>
<th>Criteria</th>
<th>Alternative Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Heating demand</strong></td>
<td>≤ 15</td>
<td>-</td>
</tr>
<tr>
<td><strong>Heating load</strong></td>
<td>≤ -</td>
<td>10</td>
</tr>
<tr>
<td><strong>Cooling demand</strong></td>
<td>≤ 15</td>
<td>climate dependent</td>
</tr>
<tr>
<td></td>
<td>+ dehumidification allowance</td>
<td></td>
</tr>
<tr>
<td><strong>Cooling load</strong></td>
<td>≤ -</td>
<td>10</td>
</tr>
<tr>
<td><strong>Airtightness</strong></td>
<td>≤ 0.6</td>
<td></td>
</tr>
<tr>
<td><strong>Primary energy</strong></td>
<td>≤ 120</td>
<td>renewable energy rating</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Classic</td>
</tr>
<tr>
<td></td>
<td></td>
<td>kWh/m²a</td>
</tr>
</tbody>
</table>

The complete Passive House criteria is available in the [website](http://www.passivhaus.org) of the Passive House Institute.
Passive House – measured performance

Read more about CEPHEUS and other EU-Projects [here](#).
The main Passive House principles

Find more details about how a Passive House works.
Essential #1 – Thermal insulation

What is “passive” about the Passive House?

- High quality envelope
- Permanent energy supply

passive active

Photograph: PHI

Read more about insulation and insulating materials in Passipedia.
Essential #1 – Thermal insulation

Before:
290 kWh/(m²a)

After:
17 kWh/(m²a)

Refurbishment project Tevesstraße FF/M; Client: ABG Frankfurt Holding; Architects: faktor10, Darmstadt
Scientific Monitoring: Passivhaus Institut, Darmstadt
Financial support: Hessisches Ministerium für Wirtschaft, Verkehr und Landesentwicklung, Wiesbaden
Essential #1 – Thermal insulation

Typical values PH in cool-temperate climates (Central Europe)

- Roof: 15-20 cm, 0.20 W/(m²K)
- Roof: 30-40 cm, ≤ 0.15 W/(m²K)
- Exterior wall: 12-16 cm, 0.28 W/(m²K)
- Exterior wall: 24-30 cm, ≤ 0.15 W/(m²K)
- Floor slab: 8-12 cm, 0.35 W/(m²K)
- Floor slab: 15-30 cm, ≤ 0.25 W/(m²K)
Essential #1 – Thermal insulation

Typical values PH in hot climates:

- **No insulation**
  - Roof: \(~ 4.5 \text{ W/(m}^2\text{K)}\)
  - Exterior wall: \(~ 4.5 \text{ W/(m}^2\text{K)}\)
  - Floor slab: \(~ 4.5 \text{ W/(m}^2\text{K)}\)

- **Conventional building**
  - Roof: \(~ 15 - 20 \text{ cm}\)
  - Exterior wall: \(~ 20 - 25 \text{ cm}\)
  - Floor slab: \(~ 7.5 - 20 \text{ cm}\)

- **Passive House**
  - Roof: \(~ \leq 0.25 \text{ W/(m}^2\text{K)}\)
  - Exterior wall: \(~ \leq 0.25 \text{ W/(m}^2\text{K)}\)
  - Floor slab: \(~ \leq 0.25 \text{ W/(m}^2\text{K)}\)

Example: Cancún and Hermosillo, Mexico
Essential #1 – Thermal insulation

Typical values PH in temperate (milder) climates:

- **Roof**: ~ 4.5 W/(m²K)
  - No insulation
  - 5 – 20 cm
  - Roof ≤ 0.55 W/(m²K)

- **Exterior wall**: ~ 4.5 W/(m²K)
  - No insulation
  - 5 – 20 cm
  - Exterior wall ≤ 0.55 W/(m²K)

- **Floor slab**: ~ 4.5 W/(m²K)
  - No insulation
  - 0 – 10 cm
  - Floor slab ≤ 0.55 W/(m²K)

Example: Guadalajara, Mexico

© PHI
Essential #2 – Thermal bridges

Thermal-bridge-free design:

\[ \Psi_e \leq 0.01 \text{ W/(mK)} \]
Essential #2 – Thermal bridges
**Essential #3 – Appropriate windows**

<table>
<thead>
<tr>
<th>glazing</th>
<th>Single</th>
<th>Double</th>
<th>Double, low-e</th>
<th>Triple, low-e</th>
<th>Future: vacuum/multi-foil</th>
</tr>
</thead>
</table>

**Winter**

Let the sunshine in

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**Diagram:**
- **Y-axis:** Annual energy balance kWh/m²
- **X-axis:**
  - **Losses:**
  - **Passive solar heat gains:**
  - **Net-losses**
  - **Net-gains!**
Essential #3 – Appropriate windows

- Suitable window size & orientation (Also important in winter)
- Exterior shading fixed elements and/or blinds → daylight redirection
Essential #4 – Controlled ventilation

High air quality: 30 m³/h per person [DIN 1946]

Division into zones:
High air quality in every room: Supply, transfer and extraction – each with suitable airflow rate.
Essential #4 – Controlled ventilation

Reduce ventilation heat losses with highly efficient heat / energy recovery!
Essential #5 – Airtightness

- energy saving
- more comfort: no drafts
- improved sound insulation
- avoid humidity related damage to the construction
- important for controlled ventilation to work effectively

$n_{50}$ max. 0.60 h$^{-1}$
Essential #5 – Airtightness
Results: Heating

Building stock:
- Air: 21°C
- Surface: 9°C
- Outside: -12°C

heating system, ~10 kW, with radiators under windows to compensate cold drafts

Passive House:
- Small re heater, ~1 kW
- Surface: >17°C
- Outside: -12°C
Results: Cooling

Building stock:
- Inside: 25°C, 65% r.h.
- Outside: 35°C, with 80% r.h.

Passive House:
- Inside: 25°C, 50% r.h.
- Outside: 35°C, with 80% r.h.
- Cooling/dehumidification through supply air
Appropriate design for the local climate

**Design** – it’s too late to try to implement the concept on the building site if you don’t have a well-planned and well-documented design.

Want to know more? Check more features of PHPP and DesignPH here.
Appropriate design for the local climate

→ Climate zones for initial component recommendations
Appropriate design for the local climate

- Climate zones for initial component recommendations
- Actual design optimization through energy modelling with Passive House Planning Package: PHPP
Appropriate design for the local climate

- Climate zones for initial component recommendations
- Actual design optimization through energy modelling with Passive House Planning Package: PHPP

**Selection of climate data**

<table>
<thead>
<tr>
<th>Country</th>
<th>BG-Bulgaria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Region</td>
<td>All</td>
</tr>
<tr>
<td>1-Sortierung</td>
<td>Alphabetisch</td>
</tr>
<tr>
<td>Climate data set</td>
<td>BG0001a-Varna</td>
</tr>
<tr>
<td>Climate zone</td>
<td>4: Warm-temperate</td>
</tr>
</tbody>
</table>

**PHPP climate datasets and corresponding climate zones (September 2017)**

- Map © 2016 Google, INEGI, ORION-ME
... and it pays off
The Passive House Standard:

→ Affordable solution for long-term sustainable high quality buildings

→ Achieved with simple yet effective and reliable technologies for Energy Efficiency

→ Comfortable and versatile, performance-based standard applicable all around the world
History & current trends
Passive House: From a research project ...
Still performing as predicted ¼ century later

1st Passive House
Darmstadt
Measured Gas Consumption for Space Heating
1991-2015

PHPP 10.5 kWh/(m²a)
3.3 kBTU/(ft².yr)

Heating 8.5 kWh/(m²a)
Passive House: From a research project …

… to an international journey
From single family to larger projects

- Offices,
- Apartment buildings

2015, TFA = 14.824 m²
Office building, Frankfurt
ID: 4524

2015, TFA = 8.488 m²
Student residence, Vienna
ID: 4452
... hotels, schools, supermarkets, archives ...
... in various climate zones

Changxing - hot & humid
Urumqi, - cold & dry
ZhuoZhou - moderate
Qingdao - warm & humid
... in the Black Sea region

Holiday villa, EnerPHit Retrofit in Bansko, BG
EKSA art, SolAir Architects, HES Bulgaria Ltd.
ID: 2087

Kindergarten, Passive House in Calarasi, Moldovia
Axis Mundi S.R.L. / RoA RONGEN ARCHITEKTEN PartG mbB
ID: 5361

Apartment building, PH Low-energy building in Volos, Greece
ID: 4992

Administration building, Passive House in Anatolia, Turkey
Gaziantep Metropolitan Municipality
ID: 4976

Single-family house, Passive House Plus in Romania
ID: 4893
approx. 1.8 Mio m² TFA of *certified* Passive House projects worldwide
Get inspired from projects worldwide

www.passivehouse-database.com
Hot topic: Retrofitting

Renovation with Passive House components = EnerPHit
EnerPHit Retrofit Plan to prevent „lock-in“

Old building: 1, 2, 3, EnerPHit

Specific Heating demand (kWh/m²a)

- 2015 before retrofit: 161
- 2016 retrofit step 1: 176
- 2028 retrofit step 2: 150
- 2035 retrofit step 3: 72
- Rest of building's lifetime: 25

Locked in - Future proof

www.europhit.eu
Hot topic: Integration of renewables

Energy efficiency + Renewables = Dream Team

The low energy demand of a PH can easily be covered by on-site or nearby renewables

Required PV area (German climate)
Net-zero = 32 m²
PER-zero = 40 m²
Net-zero / net-plus energy often misleading

\[\text{e.g. multistory buildings are discriminated despite their advantages}\]

PH approach: Independent rating of RE and efficiency.

\[\rightarrow \text{Building’s footprint area as a reference for renewables.}\]
\[\rightarrow \text{Take off-site production into account.}\]
Passive House + Renewables

Basic requirement: Efficiency first
→ PH performance criteria: very low heating and cooling demand

classic

plus

premium

+ Renewable energy generation (PER supply)
+ increased overall efficiency (PER demand)
### Hot topic: The tallest!

<table>
<thead>
<tr>
<th>Year</th>
<th>Location</th>
<th>Type</th>
<th>Floors</th>
<th>Height</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>Freiburg, DE</td>
<td>Residential retrofit</td>
<td>16</td>
<td>58 m</td>
</tr>
<tr>
<td>2012</td>
<td>Vienna, AT</td>
<td>Office building</td>
<td>23</td>
<td>77 m</td>
</tr>
<tr>
<td>2017</td>
<td>New York, US</td>
<td>Student residents</td>
<td>26</td>
<td></td>
</tr>
<tr>
<td>2018</td>
<td>Bilbao, ES</td>
<td>Residential</td>
<td>28</td>
<td></td>
</tr>
</tbody>
</table>

**Source:**
- © LENZ Ingenieur-Büro
- © Field Condition & Pavel Bendov
- © PHI
- © Varquitectos
... and more to come

Vancouver
Robert AM Stern Architects

Winthrop Square, Boston
Rendering: Handel Architects

Sendero Verde, New York
Rendering: Handel Architects
... and more to come
Hot topic: Passive House districts

Success due to good quality assurance process:

PHPP

Monitoring:

~ 900 000 ft²
~ 1 400 appartments

14.9 kWh/(m²a) || 4.7 kBTU/(ft².yr)
16.4 kWh/(m²a) || 5.2 kBTU/(ft².yr)

Source: [Peper 2016]
Bahnstadt
Heidelberg

Railway City
Gaobeidian
The hot topics / trends:

→ Retrofits: EnerPHit + EnerPHit Retrofit Plan

→ Renewables: efficiency first, then renewables, considering when and where

→ Larger scale: whether tall buildings or entire districts, it’s possible!
Policy uptake
Hot topic: Policy uptake

www.passivehouse-international.org

Passive House Legislation & Funding

In the following section you will find a list of cities and administrative districts that already stipulate the Passive House standard in their building regulations. This list is always growing. If you know of any further cities or regions that are implementing the Passive House Standard in their building regulations, please let us know by sending an email with a link to: info@passivehouse-international.org.

10 point plan
The Passive House Institute has also published a position paper with recommendations detailing how cities and communities can take their commitment forward in an effective way.

iPHA does not take any liability for the correctness of the information below.

AT | BE | DE | ES | LU | NO | US
Policy examples: Frankfurt

- **Level:** local, city
- **Type:** building code
- **Targets:** public buildings
- **Basis:** EU Energy Performance Buildings Directive

**2003 -** School buildings to be built to Passive House standard.

**2005 -** Wrote PH into the building code

**2005 -** Guidelines for Economical Construction were developed for the City of Frankfurt. Passive House is recommended as one possibility for economical construction.

**2007 -** all municipal buildings must be built to much stricter energy requirements than those under federal law to anticipate the EU EPBD

**Present -** 79 new construction projects have been built to Passive House Standard and 8 refurbished using Passive House certified components. 16 projects are currently in the planning phase or under construction.
Policy examples: Vancouver

→ Level: local, city
→ Type: non-financial incentives, code improvement
→ Targets: all buildings
→ Basis: Vancouver’s Greenest City Action Plan

- Inspiration: Lost Lake House built for the Winter Olympics in 2010
- Removing barriers for Passive Houses:
  - extra floor area, height and depth;
  - openness to resolving code compliance issues
  - Fee reductions
  - Bringing the code closer to the Passive House standard
  - Rezoning policy favoring Passive Houses
- Quality assurance aligned to Passive House:
  - using PHPP and Passive House plans to apply for a development permit
  - a PHI Building Certifier approved “Passive House Commissioning Plan”
  - applying for Passive House certification once the building is complete.
Policy examples: Vancouver

Moving forward

- Next steps: training and code improvements to include a retrofit policy
- UNECE launched one of its (Zero Emissions Buildings) Centers of Excellence in Vancouver.
- Passive House has also spread to further provincial governments such as Toronto and has resulted in Passive House projects for First Nation people in Southwestern British Colombia (B.C.).
- In B.C. at large, the BC Step Code 5 has been brought closer in line with the Passive House Standard.
Policy examples: Brussels

→ Level: local, city
→ Type: building code, capacity building, financial incentives
→ Targets: all buildings

- as of 1 January 2015 the “Brussels” Passive requirements apply to new buildings and any major renovation in housing, offices or schools
- Accelerating Passive House uptake:
  - Public outreach and education campaigns,
  - free consulting services from the Brussels Passive House Platform
  - financial incentives (100€/m² for residential - max. 15 000€, 50€/m² for non-residential)
  - “Exemplary Buildings” call for projects in 2007 offering selected projects +100€/m² in subsidies
  - Training programmes for stakeholders
  - Employment-Environment Alliance to promote engagement with and in the sustainable construction sector and share industry expertise.
  - Energy fund: electricity supplier gives back 1.95% of the consumption revenue and offers a tax break.
Policy examples: Luxembourg

→ Level: national
→ Type: building code, subsidies
→ Targets: all buildings

- After an implementation process of 8 years, as of January of 2017 all new buildings must be constructed to the modified Luxembourg Passive House standard
- Subsidy for buildings with additional sustainability features such as ecological materials and end-of-life-cycle management
- Training courses were devised by energieagence and the IFSB, Luxembourg’s association for training in the construction sector, on behalf of the Chamber of Trades. Courses available in French, German and Portuguese
- Construction sector was involved in the development of regulations
- Carrot and stick policy: incremental requirements and incentives
Policy examples: Mexico

- Level: national
- Type: policy concept, measurement tools
- Targets: residential buildings
- Basis: Mexico’s mitigation commitment

Source: Original and updated NAMA for sustainable housing in Mexico, Passivhaus Institut for GiZ

The Technical Annex of the NAMA is available online.
Policy examples: Mexico

Source: NAMA for sustainable housing in Mexico, Passivhaus Institut for GiZ
Summing up the policy examples

→ **Frankfurt**: PH into the building code, starting 2007 all public buildings must be Passive Houses.

→ **Vancouver**: started by removing barriers through incentives and improving the building code, has resulted into the Center of Excellence and the inclusion of Passive House into the code of BC and other provincial governments.

→ **Brussels**: dissemination, free consulting, exemplary projects, training programmes, energy fund and buildings to Brussel’s passive code.

→ **Luxembourg**: subsidies to buildings built to the Passive House standard.

→ **Mexico**: concept for the gradual increase of requirements for energy efficiency, tools for the performance evaluation system.
The role of the Passive House Institute (PHI)
Founded in 1996 as an independent institute to bridge the gap between researchers and building professionals
Passive House – an open standard

Not a brand but an open concept.
Certification schemes as means of quality assurance.

1 700 000 m² certified (2017)

56% Residential
40% Non-Residential
4% Mixed use
It’s a team sport!

Networking & knowledge transfer:
International Passive House Days, Passipedia, Forum, Newsletter, technical panel etc.

www.passivehouse-international.org
International outreach
Welcome to Passipedia, the Passive House resource!

Passipedia constitutes a vast array of cutting edge, scientifically sound, Passive House relevant articles. On Passipedia, basic Passive House information and insights are available for all to see, whereas members of the International Passive House Association (IPHA) receive special access to the more in-depth sections. You want to get to know the Passive House concept in short time? As a start, we recommend the video "Passive House Explained in 90 Seconds" by Hans-Joern Iech.

What is a Passive House?
Passive House is a building standard that is truly energy efficient, comfortable and affordable at the same time. Passive House is not a brand name, but a tried and true construction concept that can be applied by anyone, anywhere.

Yet, a Passive House is much more than "just" a low-energy building:
- Passive Houses allow for space heating and cooling related energy savings of up to 90% compared to typical building stock and over 75% compared to average new builds. Passive Houses use less than 1.51 of oil or 1.5 m² of gas to heat one square meter of living space for a year – substantially less than common "low-energy" buildings. Vast energy savings have been demonstrated in warm climates where typical buildings also require active cooling.
- Passive Houses make efficient use of the sun, internal heat sources and heat recovery, rendering conventional heating systems unnecessary throughout even the coldest of winters. During warmer months, Passive Houses make use of passive cooling techniques such as strategic shading to keep comfortably cool.
- Passive Houses are praised for the high level of comfort they offer. Internal surface temperatures vary little from indoor air temperatures, even in the face of extreme outdoor temperatures. Special windows and a building envelope consisting of a highly insulated roof and floor slab as well as highly insulated exterior walls keep the desired warmth in the house – or undesirable heat out.
- A ventilation system imperceptibly supplies constant fresh air, making for superior air quality without unpleasant draughts. A highly efficient heat recovery unit allows for the heat contained in the exhaust air to be re-used.

Read more
Experience the comfort for yourself!

International Passive House Open Days
PASSIVE HOUSE BUILDINGS WORLDWIDE OPEN THEIR DOORS

Doing more with less:
- Superior comfort with minimal heating and cooling costs
- Fresh air around the clock
- Easily combined with renewable energy
- For new builds and retrofits alike

Learn directly from residents and construction professionals

9 - 11 November 2018

Please visit www.passivehouse-international.org for further information. Participating buildings will be listed as of September on www.passivehouse-database.org
### The necessary infrastructure

<table>
<thead>
<tr>
<th>Category</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality Assurance</td>
<td>Availability of planning tools</td>
</tr>
<tr>
<td></td>
<td>Certification of components and buildings</td>
</tr>
<tr>
<td>Education / Knowledge transfer</td>
<td>Training for designers and tradesmen--</td>
</tr>
<tr>
<td></td>
<td>Accreditation of certifiers</td>
</tr>
<tr>
<td>Events</td>
<td>Exchange experience</td>
</tr>
</tbody>
</table>
Passive House: Inspiring transformation

Each individual makes a difference!

The more, the higher the impact 😊

- More awareness and expertise
- More and better components
- Policy uptake
  - compliance pathway for PH projects
  - requirements towards PH efficiency levels
Thank you!

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