# Training Workshop on High Performance Buildings



Session 1: Passive House Fundamentals / Refresher

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Speaker: Edward Lowes, Passive House Institute

# Overview

- What is a Passive House?
- Passive House in Numbers
- The first Passive Houses
- Step-by-step retrofit
- PER: Primary Energy Renewable
- The role of the Passive House Institute
- Basic Passive Principles
  - Insulation
  - Thermal bridges
  - Windows
  - Ventilation
  - Airtightness
- Results and Examples
- Policy Uptake Examples

# What is a Passive House?


A building with an annual heating demand less 15 kWh/(m²a)
With an overall energy consumption less 60 $kWh_{PER}$/(m²a).

# The Efficiency Revolution

Passive House Institute

## ≥ 90% Reduction of Heating Energy Demand

Average existing buildings: fossile fuel

*200 kWh/(m²a)*

*15 kWh/(m²a)*


Energy efficient

Comfortable

Affordable

Sustainable

≥ 90%

PH

# Passive House – in numbers

| | | criteria | or alternative criteria | |
|---|---|---|---|---|
| Heating demand | ≤ | 15 | - | $kWh/m^2a$ |
| Heating load | ≤ | - | 10 | $W/m^2$ |
| Cooling demand | ≤ | 15 + dehumidification allowance | climate dependent | $kWh/m^2a$ |
| Cooling load | ≤ | - | 10 | $W/m^2$ |
| Airtightness | ≤ | 0.6 | | $ACH_{50}$ |
| Primary energy | ≤ | 60 | renewable energy rating Classic \| Plus \| Premium | $kWh/m^2a$ |

The complete Passive House criteria is available in the website of the Passive House Institute.

# Passive House – in numbers

| | | criteria | or alternative criteria | |
|---|---|---|---|---|
| Heating demand | ≤ | 25 | - | $kWh/m^2a$ |
| Heating load | ≤ | - | - | $W/m^2$ |
| Cooling demand | ≤ | 25 + dehumidification allowance | climate dependent | $kWh/m^2a$ |
| Cooling load | ≤ | - | - | $W/m^2$ |
| Airtightness | ≤ | 1,0 | | $ACH_{50}$ |
| Primary energy | ≤ | climate dependent | renewable energy rating Classic \| Plus \| Premium | $kWh/m^2a$ |

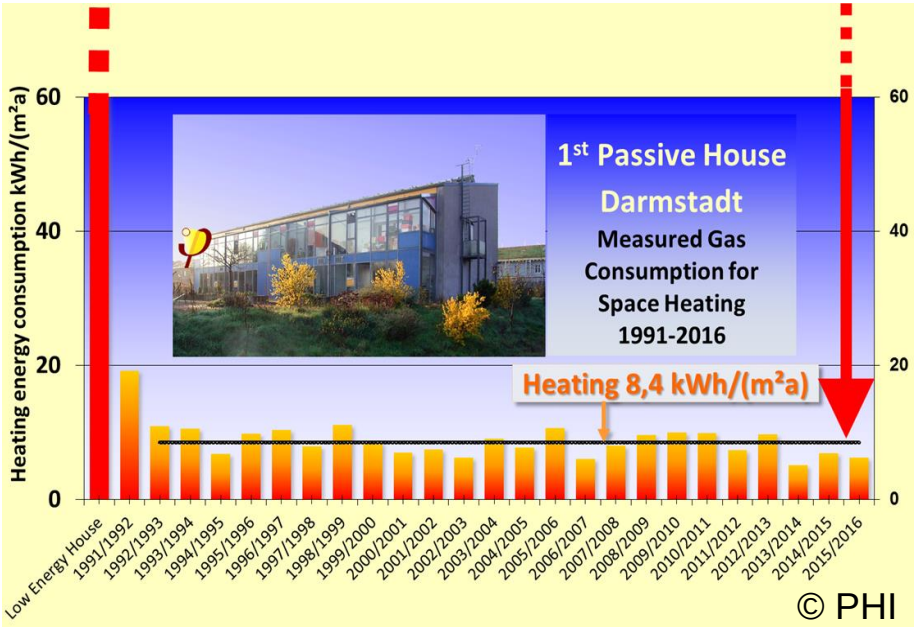
The complete Passive House criteria is available in the website of the Passive House Institute.

# Passive House Darmstadt – 25 Years

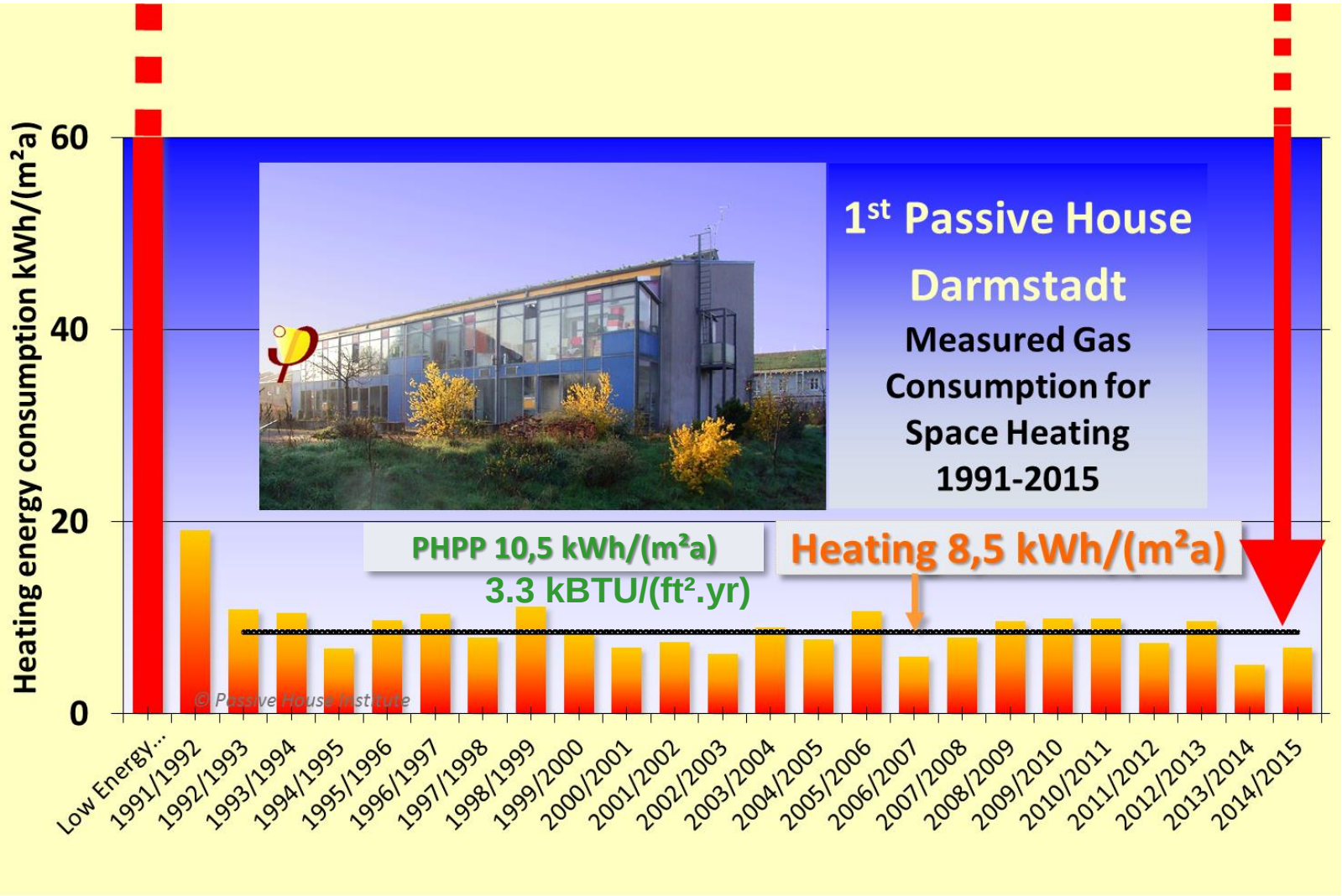

Architects: Bott, Ridder, Westermeyer
Privately financed, with funding (50%) of the additional costs by the federal state of Hesse.

**1988: Research**
**1989: Research & Design**
**1990: Construction**
**1991: Four families move in**
**2016: Still performing**

Superinsulated, airtight, high-quality windows, heat recovery ventilation
The building served also as a research project monitored in detail for many years

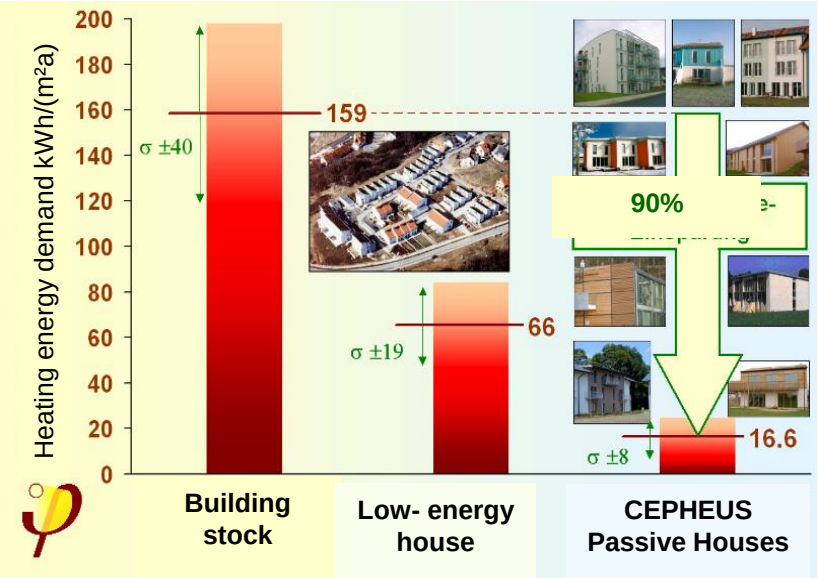


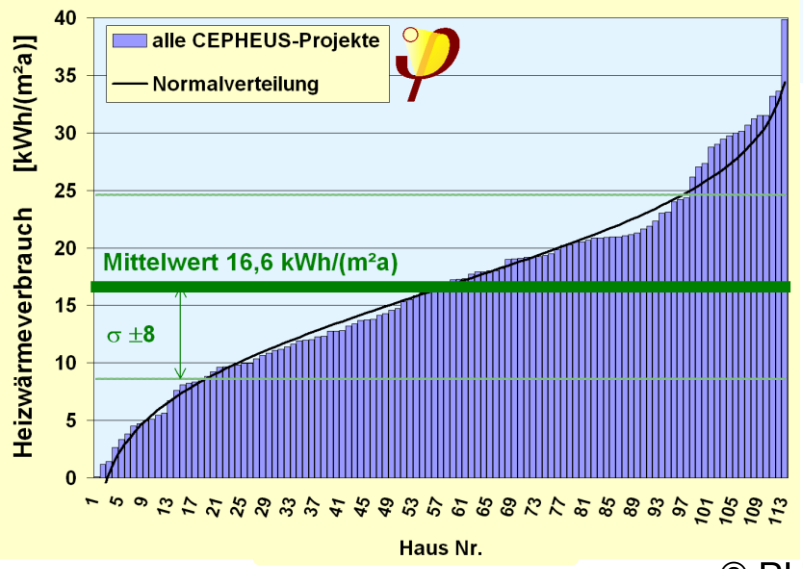
# Still performing as predicted ¼ century later



# Passive Houses in Europe

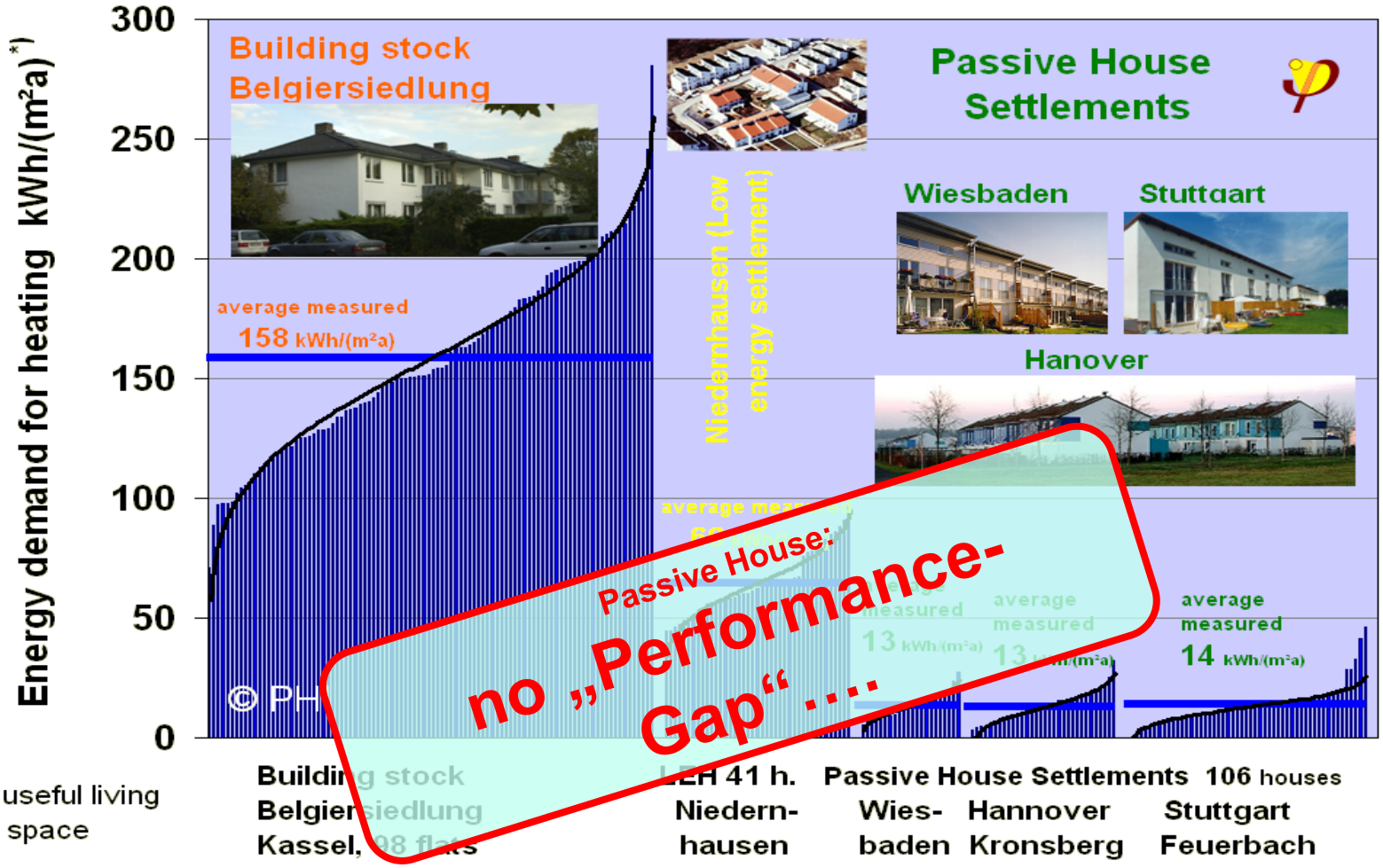
Passive House Institute


© PHI

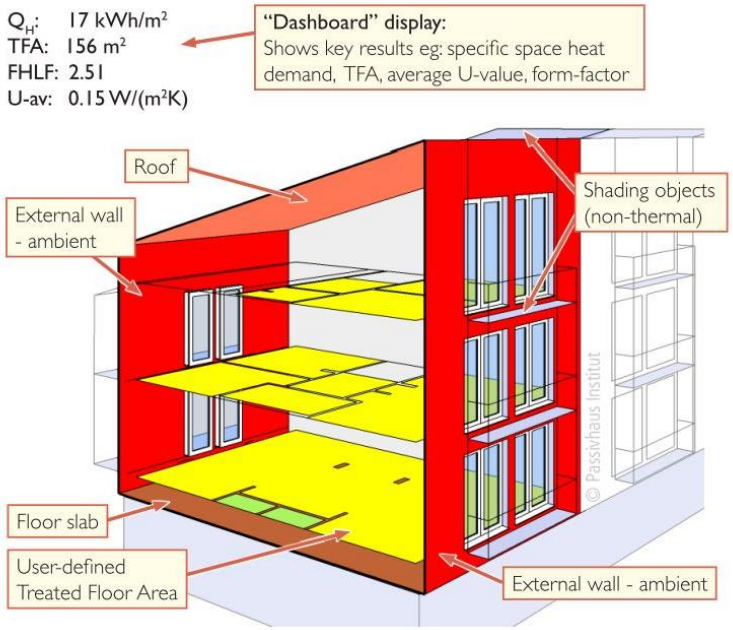
# The Passive House concept…




*) useful living space

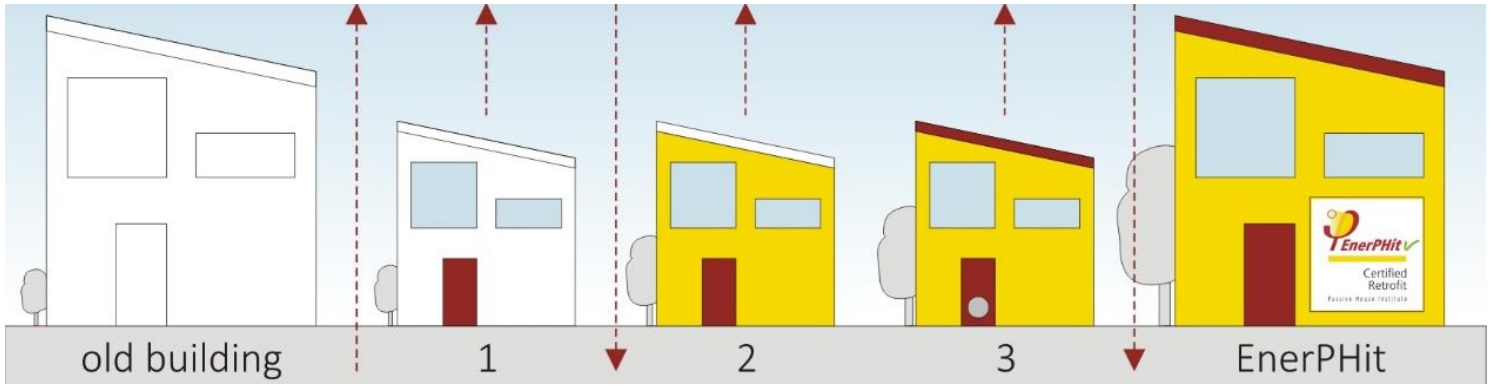
# Appropriate design for the local climate

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.

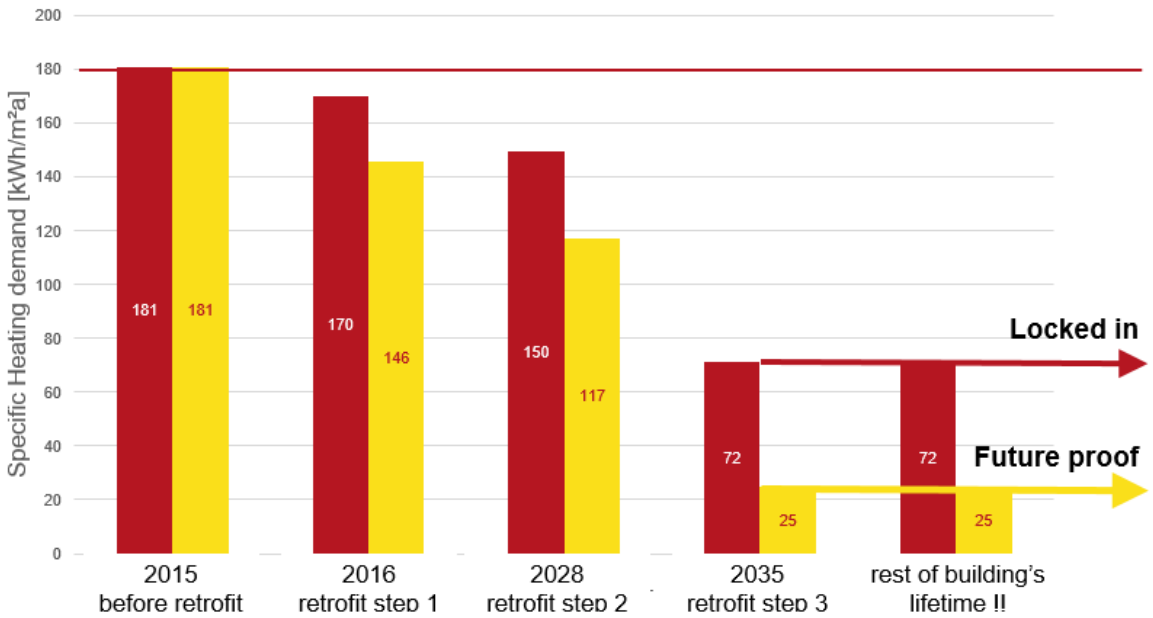

Want to know more? Check more features of PHPP and DesignPH here.

# EnerPHit Retrofit Plan to prevent „lock-in“




EuroPHit

www.europhit.eu

# Passive House + Renewables

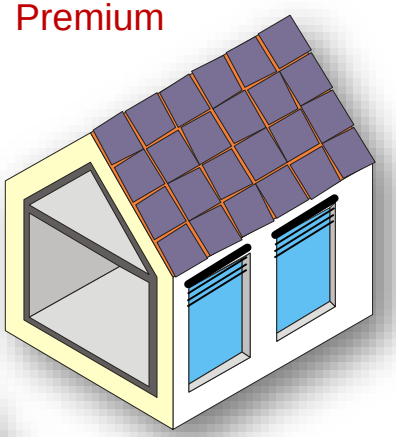
Passive House Institute

≥ 120

Renewable energy generation [$kWh_{PER}/(m^2_{projected}*a)$]

≥ 60

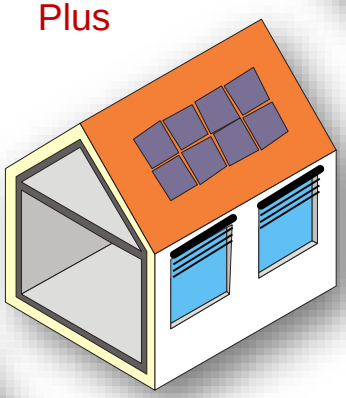
Premium



Certified Passive House
Passive House Institute
| classic | plus | premium |

≤ 30

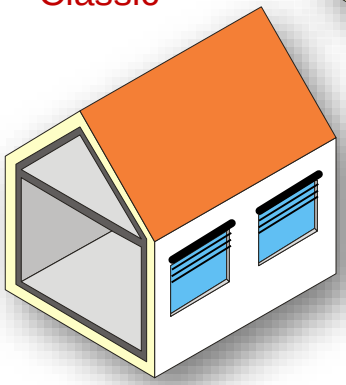
Plus



Certified Passive House
Passive House Institute
| classic | plus | premium |

≤ 45

Classic



Certified Passive House
Passive House Institute
| classic | plus | premium |

Renewable primary energy demand [$kWh_{PER}/(m^2_{TFA}*a)$]

≤ 60

Renewable Primary Energy Demand: Heating, DHW, auxiliary and appliances

# Primary Energy Rating: From PE to PER

Energy supply structure worldwide is transitioning

fossil fuels → renewables

Consequence: (non-renewable) PE factors change

**not sustainable, insolvable issues**

**sustainable, solvable challenges**

PE = **non-renewable** primary energy

PER = **renewable** primary energy

# Research, capacity building and QA


Founded in 1996 as an independent institute to bridge the gap between researchers and building professionals

# Quality is the Key to Success

Passive House Institute

PHPP

designPH

Software tools PHPP and designPH including LCCa

CERTIFIED COMPONENT
Passive House Institute

passivehousecomponents.org

CERTIFIED PASSIVE HOUSE TRADESPERSON

TRADESPERSON

passivehouse-trades.org

DESIGNER

CERTIFIED PASSIVE HOUSE DESIGNER

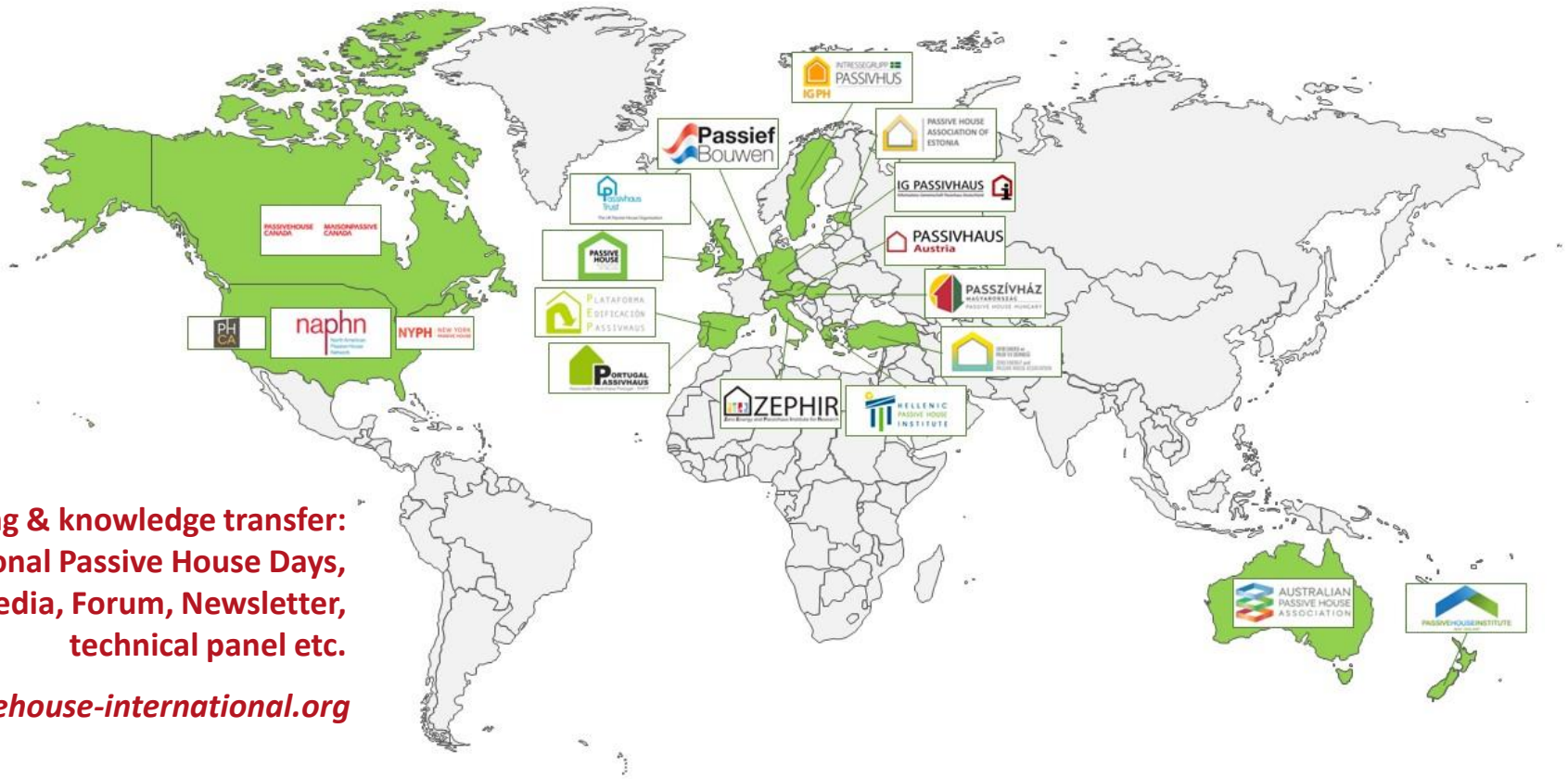
passivehouse-designer.org


Passive House Certifier
Passive House Institute accredited

passivehouse.com

# It’s a team sport!

Passive House Institute ⟷ International PASSIVE HOUSE Association iPHA




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

***www.passivehouse-international.org***

# Passive House – well defined open standard

## The Passive House is open to all

- No patents
- Not trademarked
- All criteria and rules are published
- Everybody may build Passive Houses

## Passive House is not arbitrary

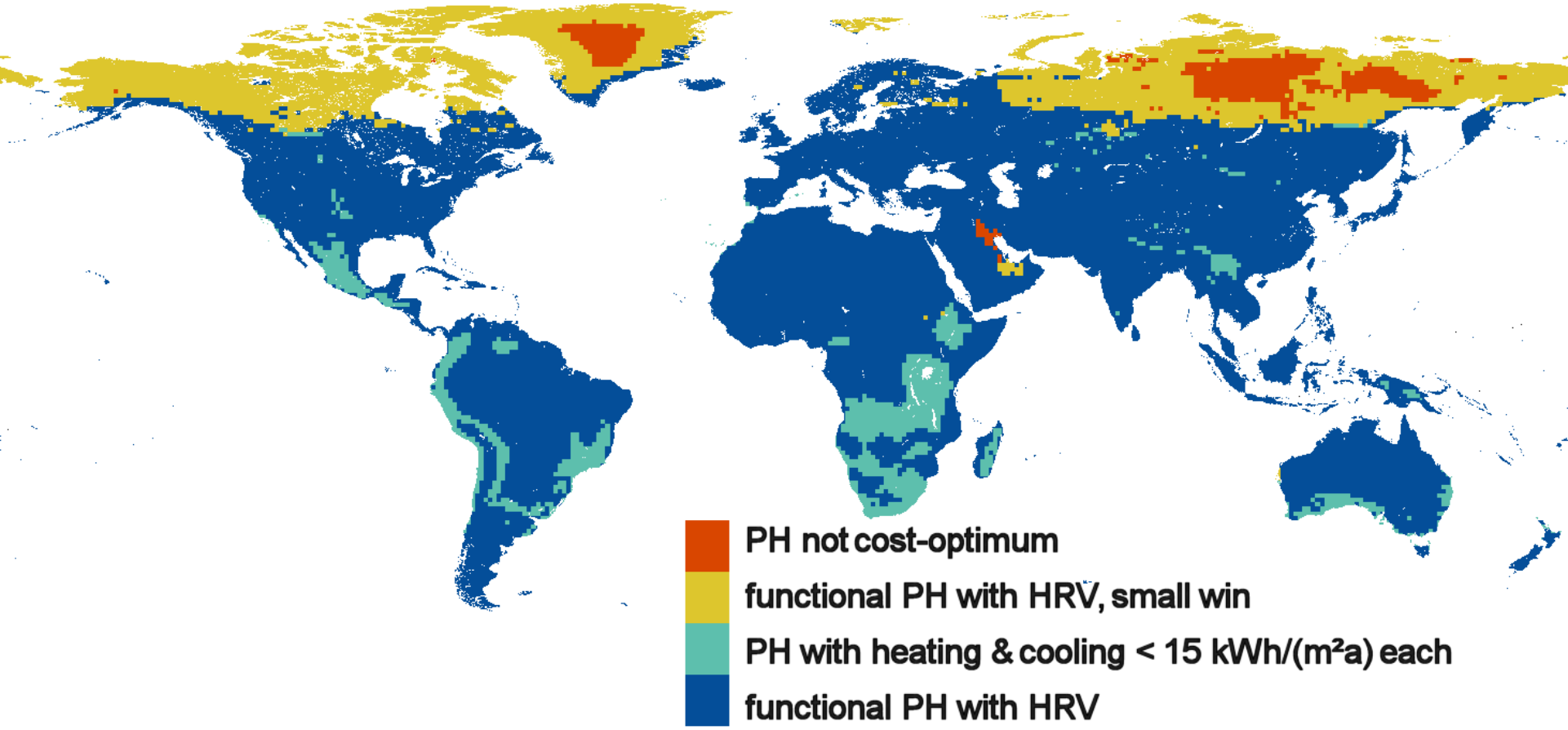
- Passive House has a functional, climate-independent definition
- Criteria are well-defined and publically available
- Quality is key: Independent quality assurance and certification available
- When Passive House is offered, Passive House has to be delivered!

## Common International Passive House definition

A Passive House is a building in which thermal comfort can be guaranteed by post-heating or post-cooling the fresh-air mass flow required for good indoor air quality.

- Climate-independent
- Concept and strategy to find adapted and affordable solutions

# Passive House – a global optimum?

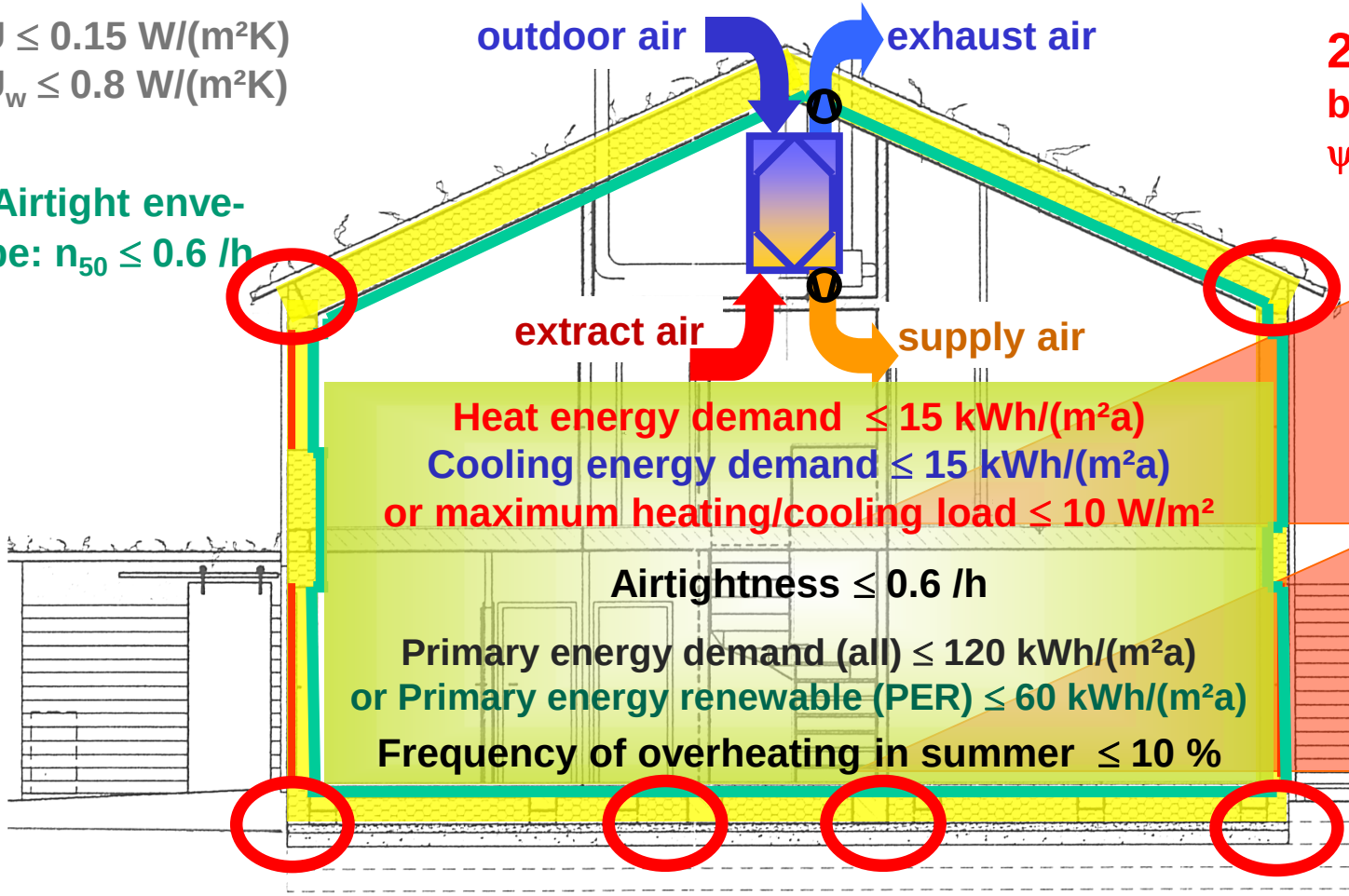


# Basic Principles of Passive House

## and Certification Criteria

**1 Thermal insulation:**
$U \leq 0.15$ W/(m²K)
$U_w \leq 0.8$ W/(m²K)

**5 Mechanical ventilation system with heat recovery $\eta \geq 75\%$**




**2 Avoid thermal bridge effects**
$\psi_a \leq 0.01$ W/(mK)

**4 Airtight envelope: $n_{50} \leq 0.6$ /h**

**Heat energy demand $\leq$ 15 kWh/(m²a)**
**Cooling energy demand $\leq$ 15 kWh/(m²a)**
**or maximum heating/cooling load $\leq$ 10 W/m²**

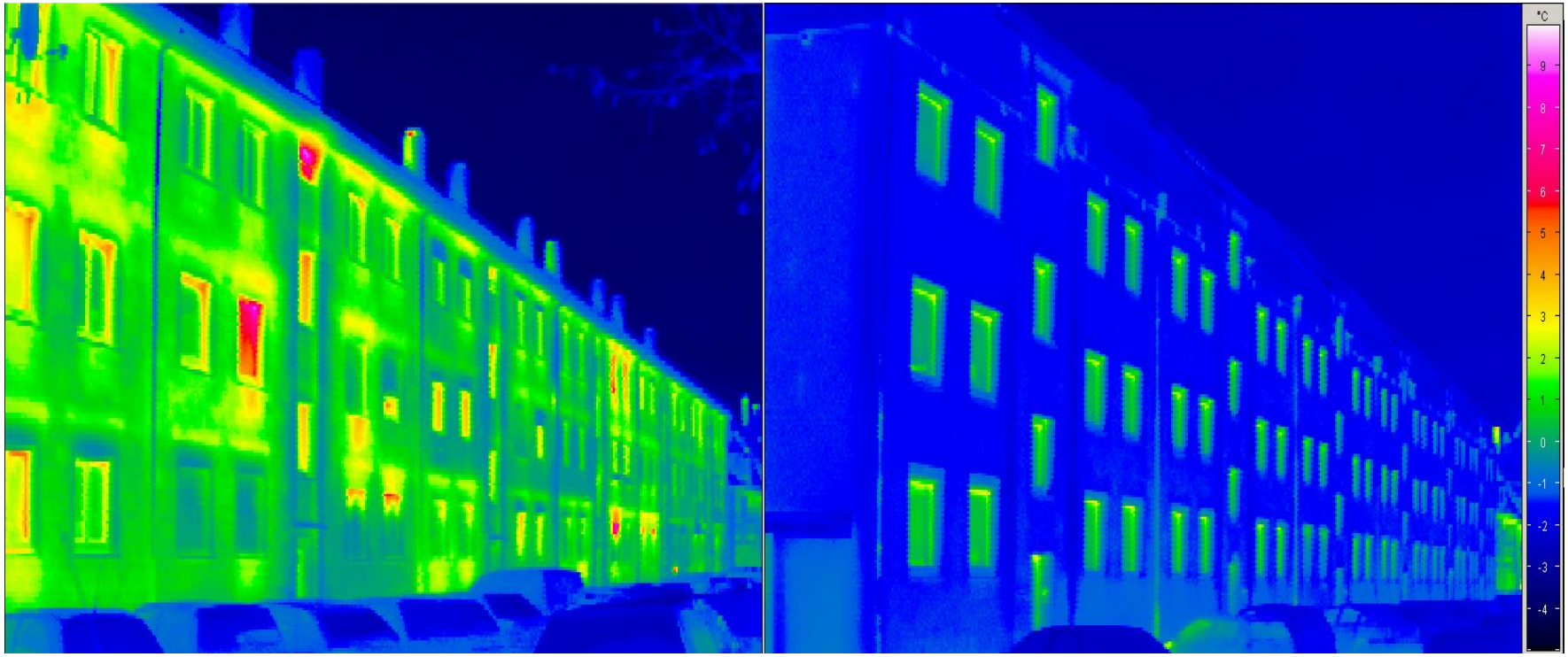
**Airtightness $\leq$ 0.6 /h**

**Primary energy demand (all) $\leq$ 120 kWh/(m²a)**
**or Primary energy renewable (PER) $\leq$ 60 kWh/(m²a)**

**Frequency of overheating in summer $\leq$ 10 %**

**3 Triple-pane glazings:**
$U_g \leq 0.8$ W/(m²K)
$g = 0.50 \ldots 0.55$

# Essential #1 – Thermal insulation



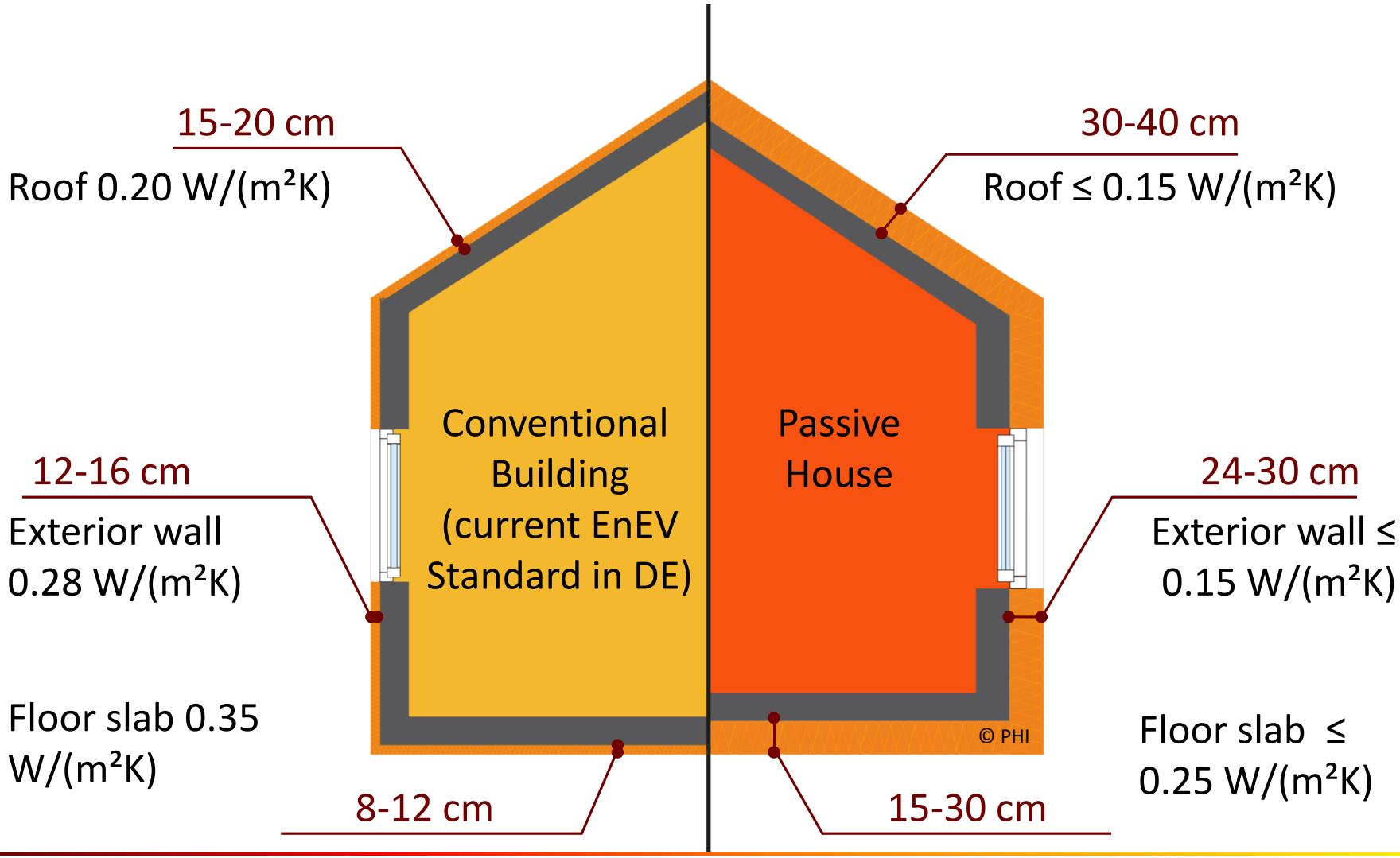

Before:
290 kWh/(m²a)

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 (e.g. Armenia)



# Essential #1 – Thermal insulation

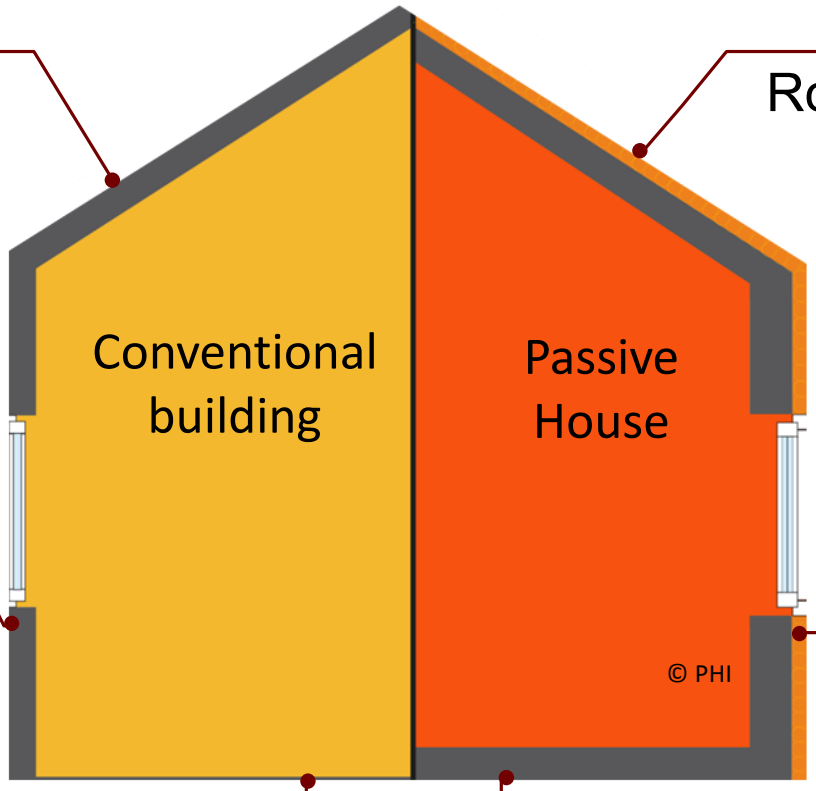
Typical values PH in temperate climates (e.g. Mediterranean):

No insulation

Roof ~ 4.5 W/(m²K)

5 – 20 cm

Roof ≤ 0.55 W/(m²K)




No insulation

Exterior wall ~ 4.5 W/(m²K)

5 -20 cm

Exterior wall ≤ 0.55 W/(m²K)

Floor slab ≤ 0.55 W/(m²K)

Floor slab ~ 4.5 W/(m²K)

No insulation

0 – 10 cm

# Essential #1 – Thermal insulation

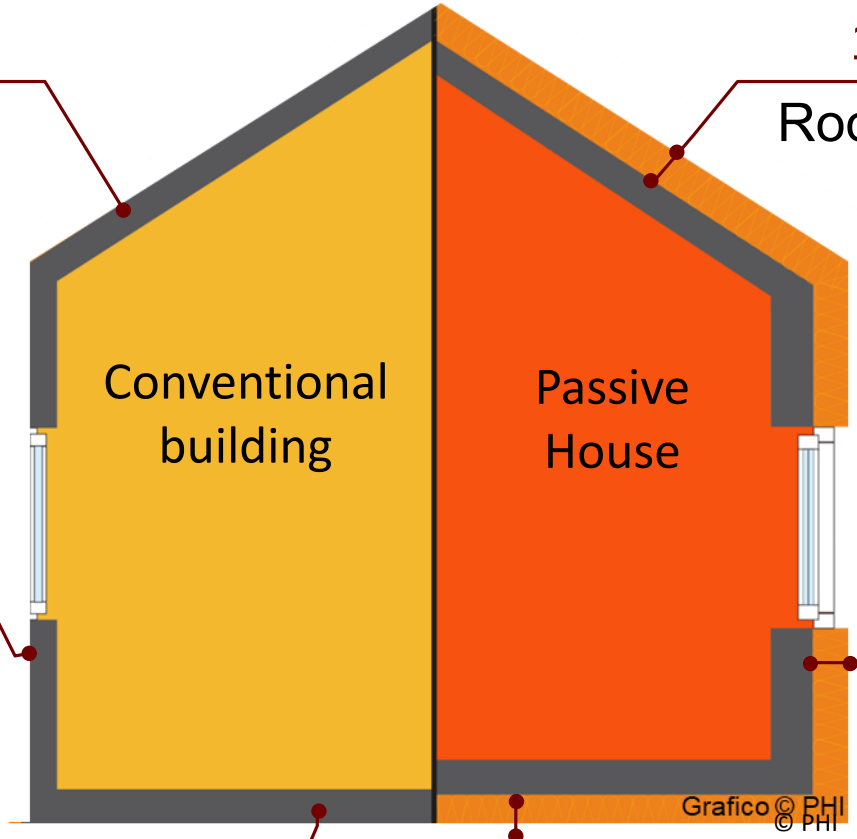
## Typical values PH in hot climates (e.g. North Africa):

No insulation

Roof ~ 4.5 W/(m²K)

15 - 20 cm

Roof ≤ 0.25 W/(m²K)




No insulation

Exterior wall ~ 4.5 W/(m²K)

20-25 cm

Exterior wall ≤ 0.25 W/(m²K)

Floor slab ≤ 0.25 W/(m²K)

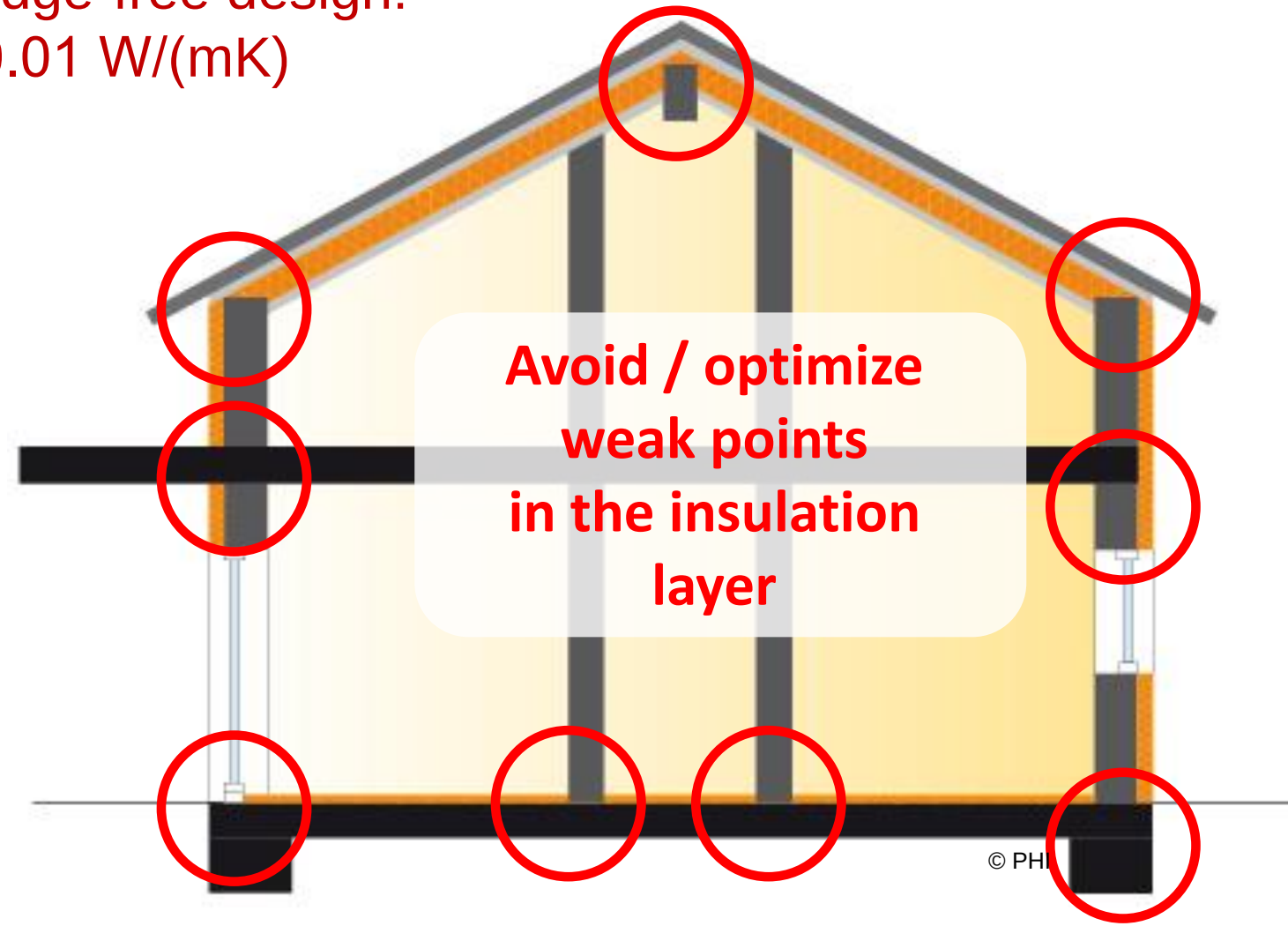
Floor slab ~ 4.5 W/(m²K)

No insulation

7.5 - 20 cm

# Essential #2 – Thermal bridges

Thermal-bridge-free design:
$\Psi_e \leq 0.01$ W/(mK)

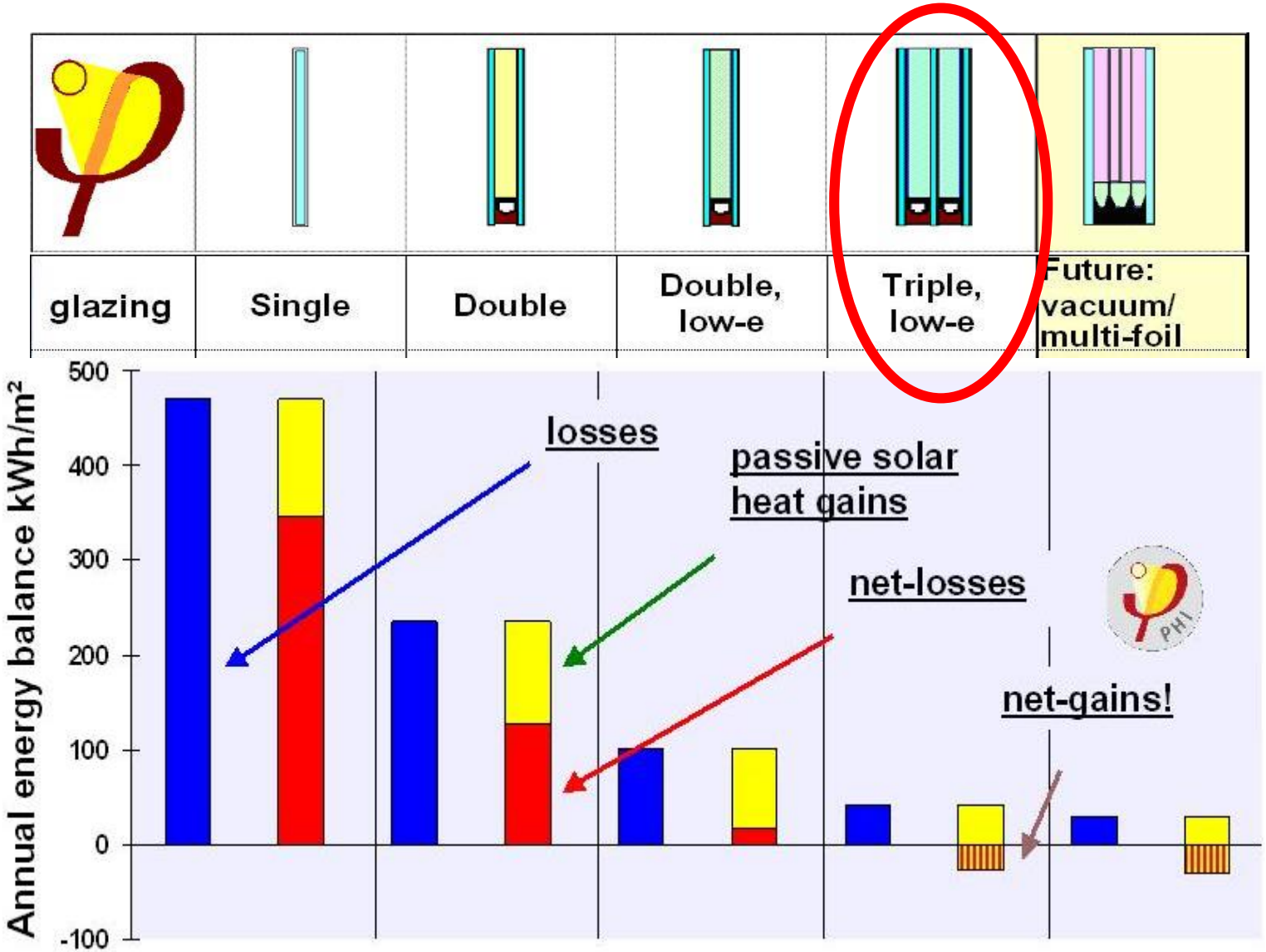


# Essential #2 – Thermal bridges


# Essential #3 – Appropriate windows

Passive House Institute

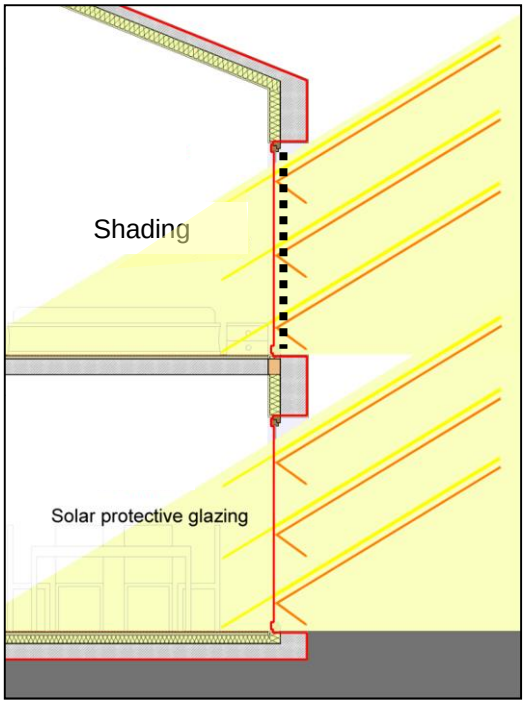
Winter Let the sunshine in



# Essential #3 – Appropriate windows

Passive House Institute

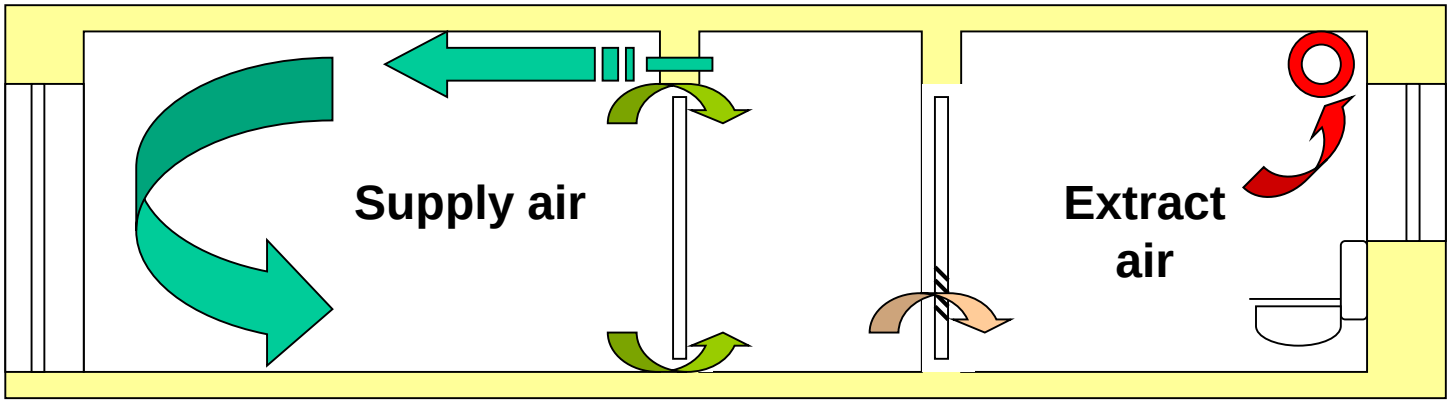
Summer Keep the solar load out




- Suitable window size & orientation
  (Also important in winter)
- Exterior shading
  fixed elements and/or blinds
  → daylight redirection

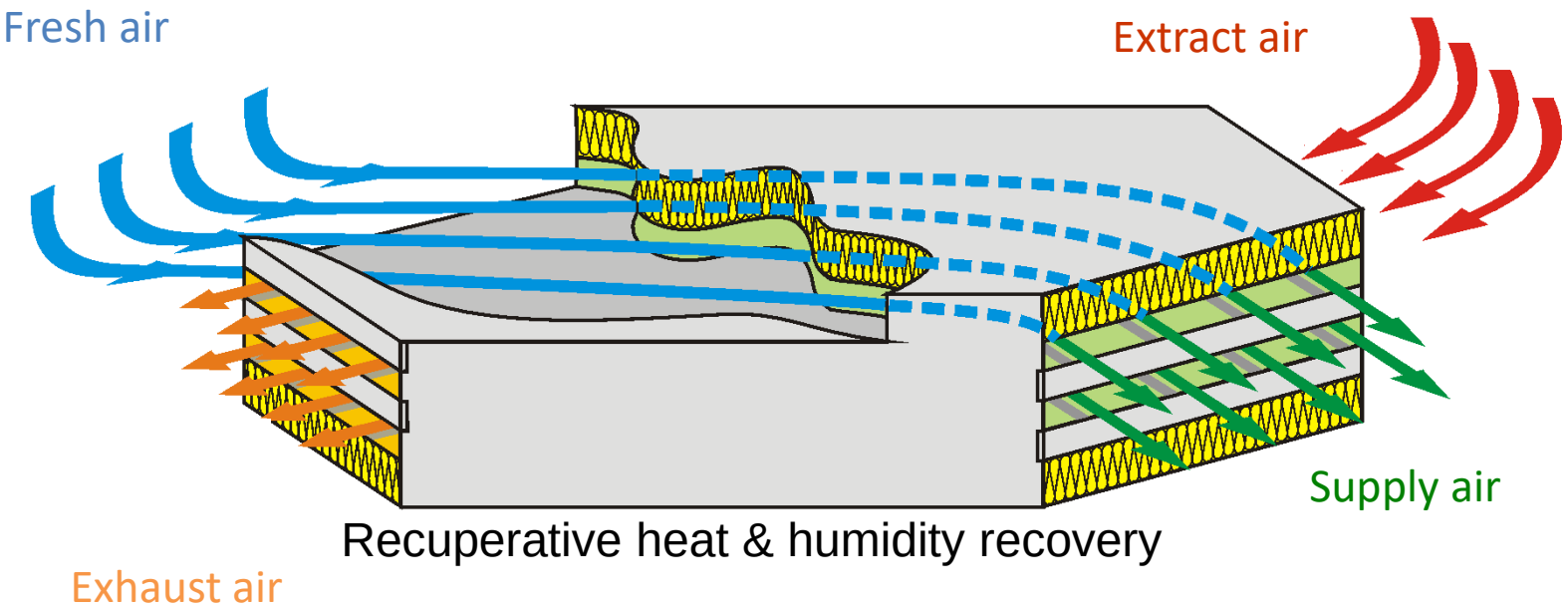
# Essential #4 – Controlled ventilation

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



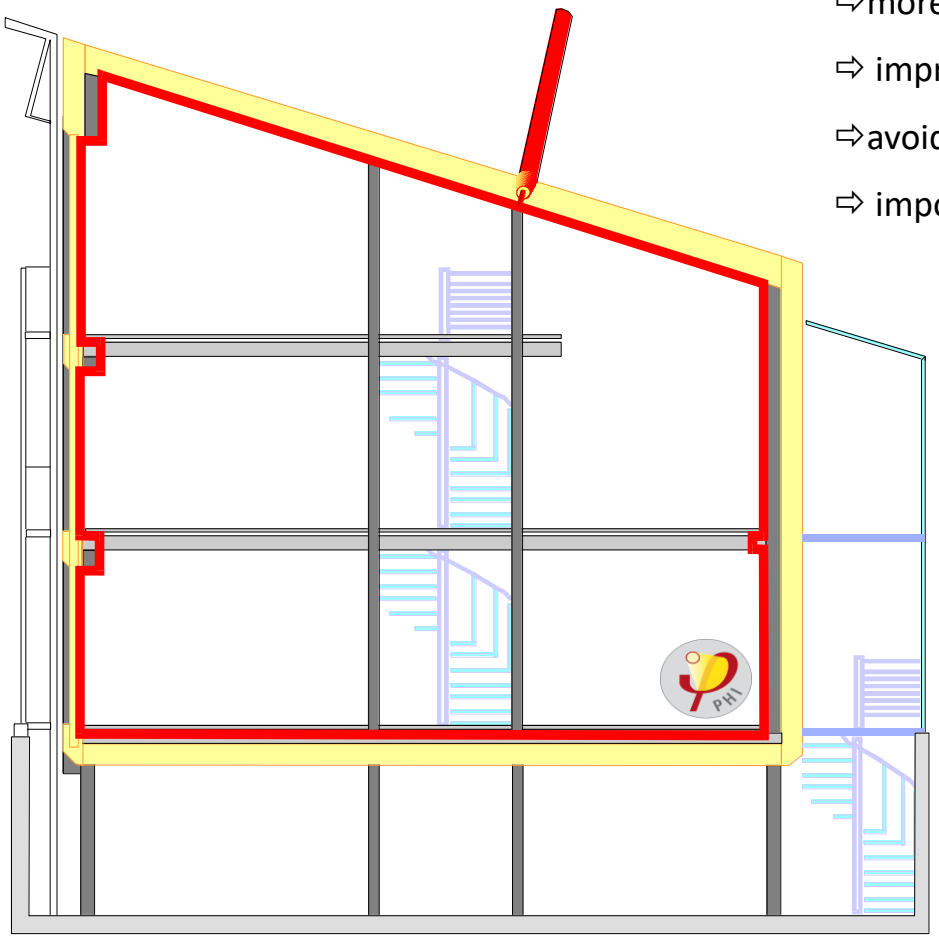

Division into zones:
High air quality in every room: Supply, transfer and extraction – each with <u>suitable airflow rate</u>.

# Essential #4 – Controlled ventilation




**Reduce ventilation heat losses**
**with highly efficient heat / energy recovery !**

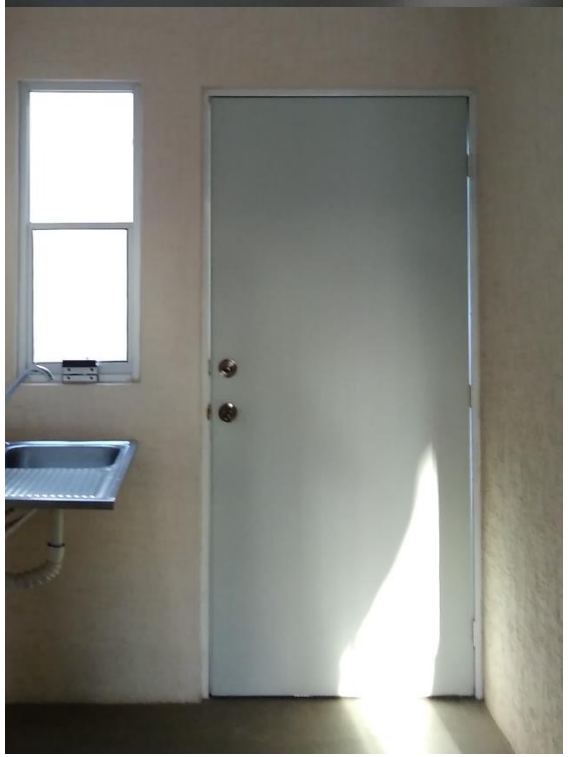
# Essential #5 – Airtightness



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

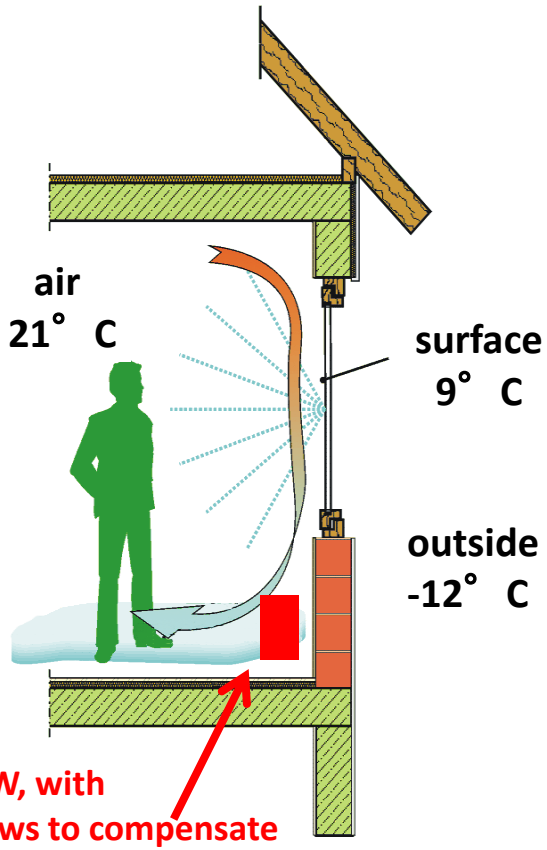
$n_{50}$ max. 0.60 $h^{-1}$

# Essential #5 – Airtightness



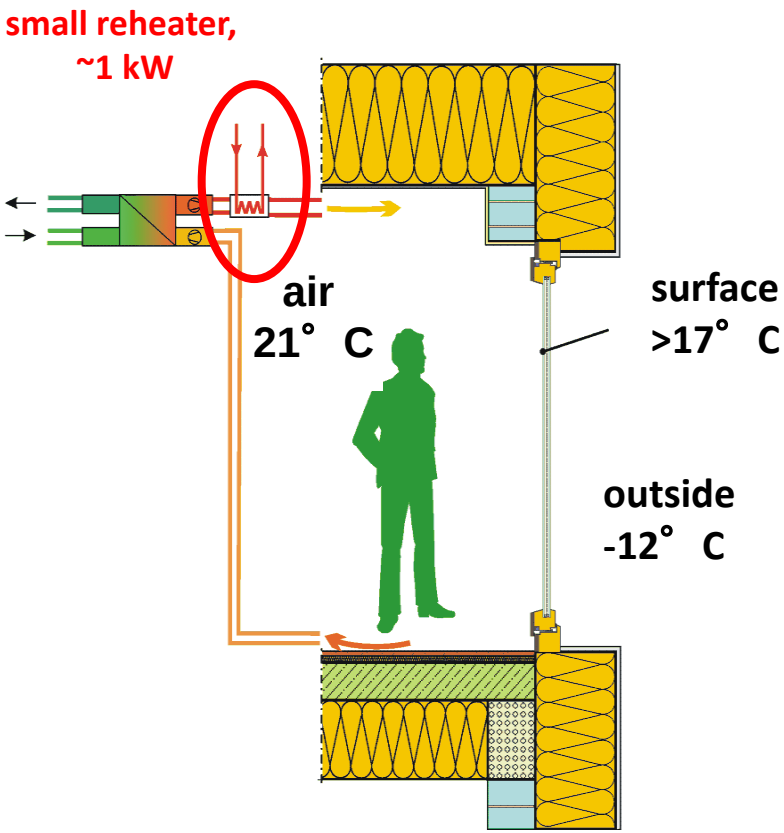

# Results: Heating

Building stock:



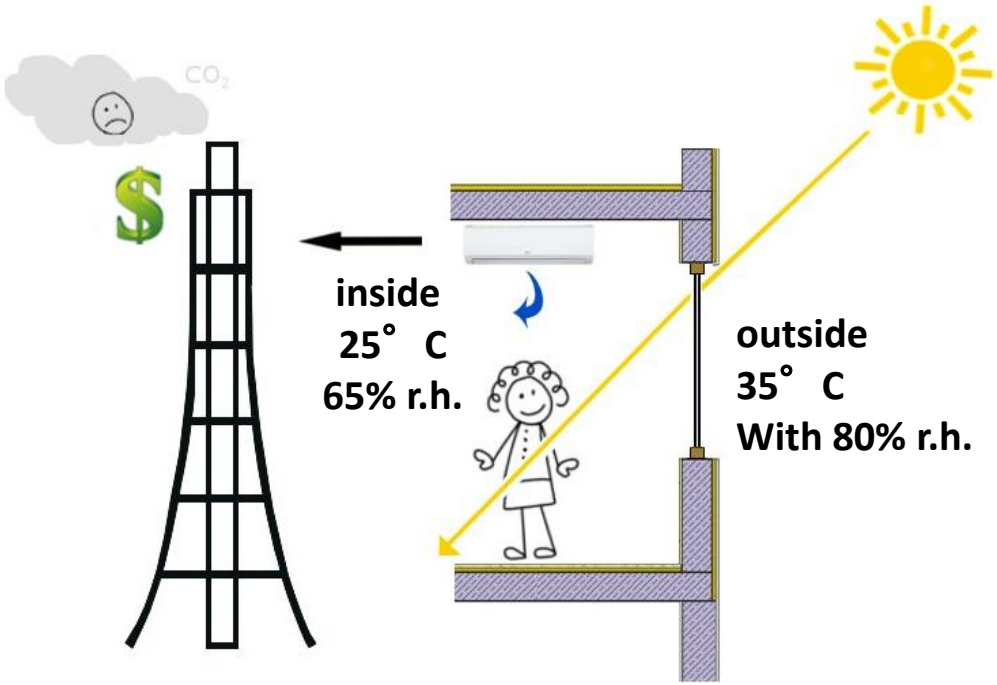

heating system, ~10 kW, with radiators under windows to compensate cold drafts

Passive House:

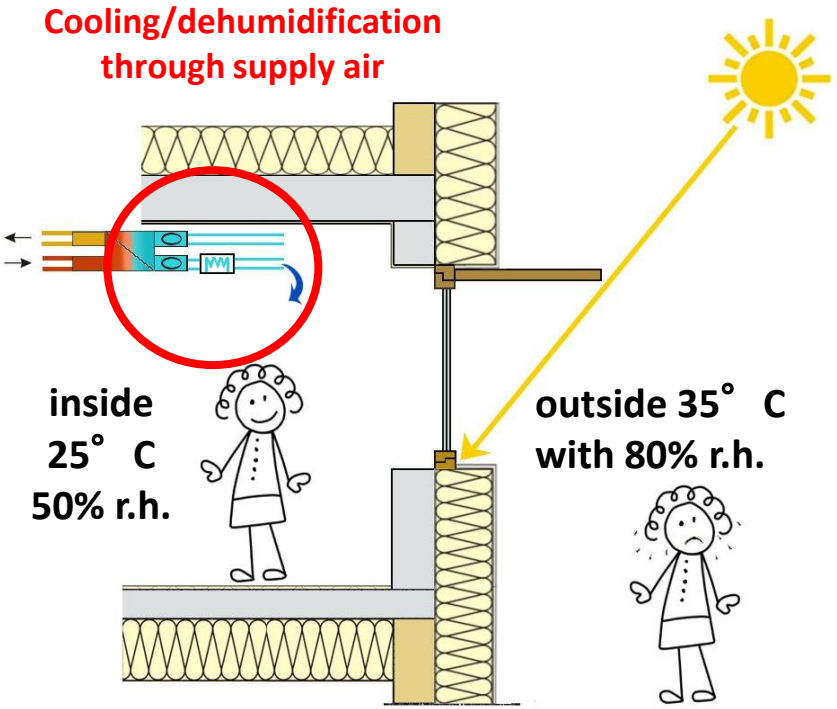


# Results: Cooling

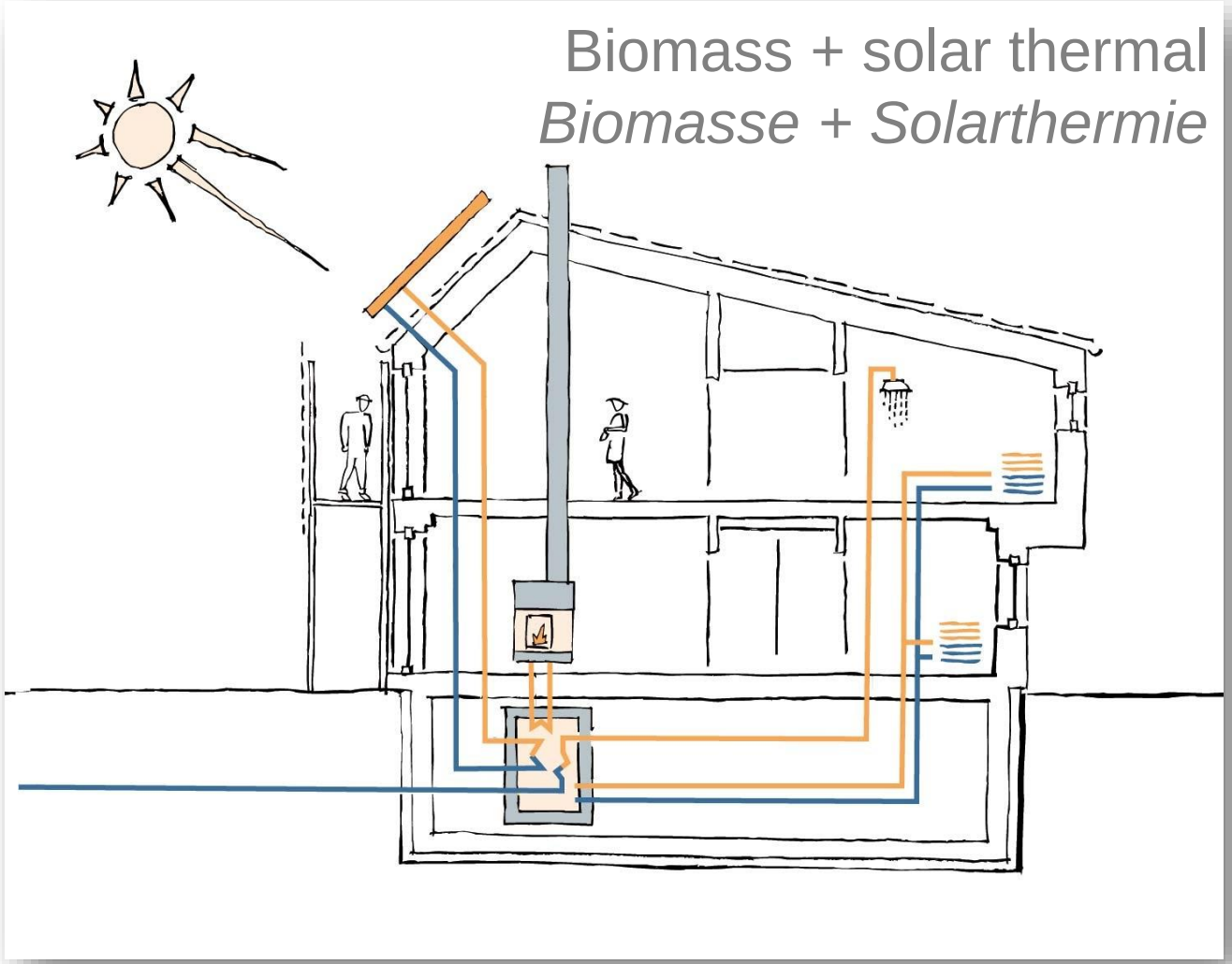
Building stock:



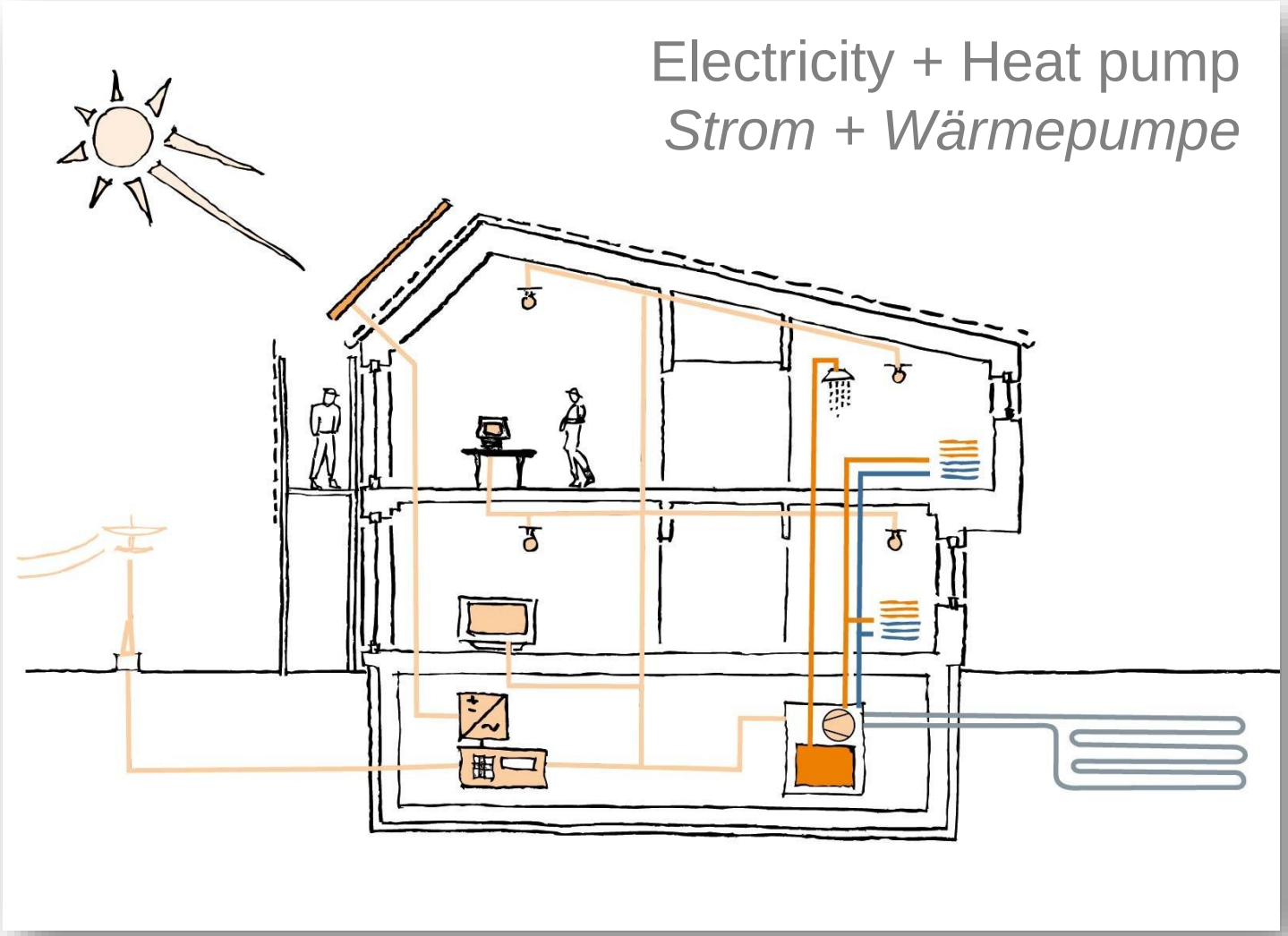

Passive House:



# Sustainable Supply Strategies

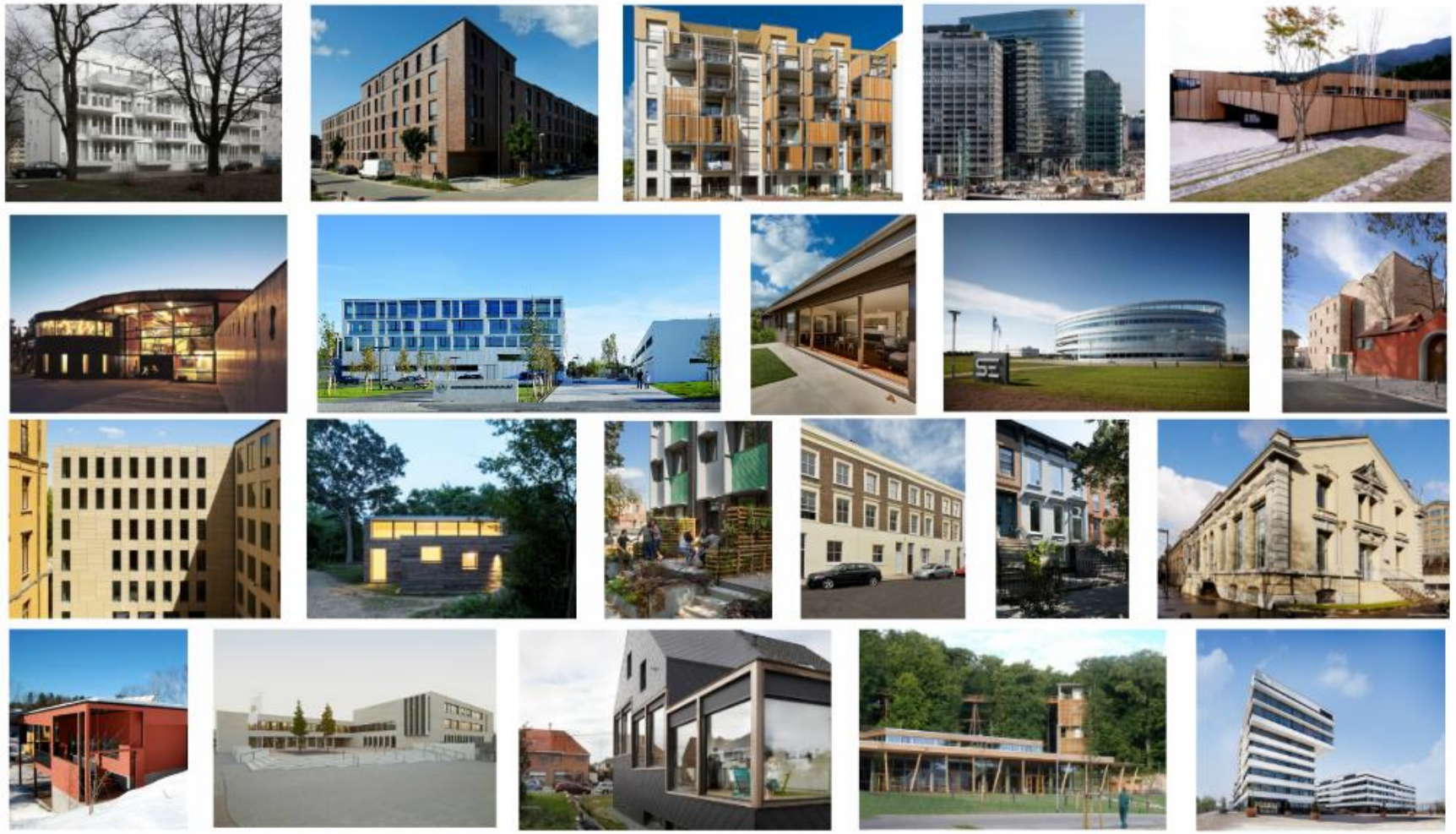



# Sustainable Supply Strategies




# 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

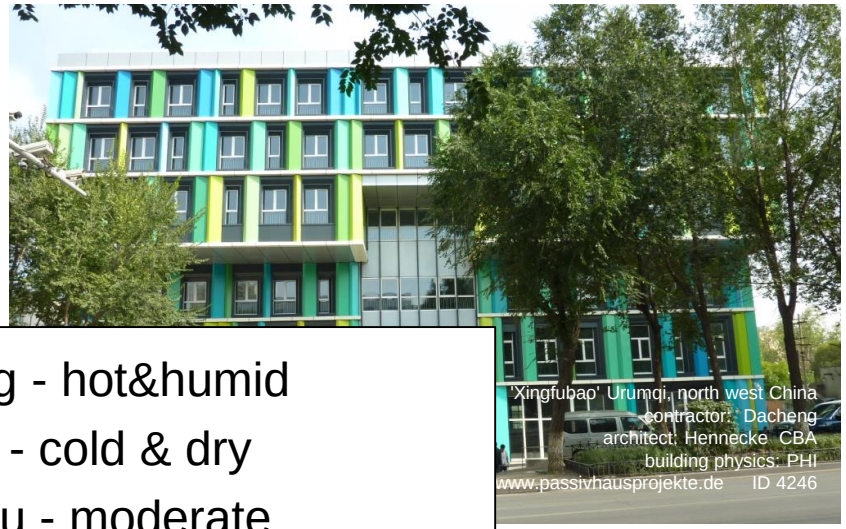
2015, TFA = 8.488 m²
Student residence, Vienna
ID: 4452

# … hotels, schools, supermarkets, archives …



# … in various climate zones


'Bruck' PH building, Changxing, south China
contractor: Landsea
architect: Ruge
building physics: PHI
more information www.passivhausprojekte.de


'Xingfubao' Urumqi, north west China
contractor: Dacheng
architect: Hennecke CBA
building physics: PHI
www.passivhausprojekte.de ID 4246

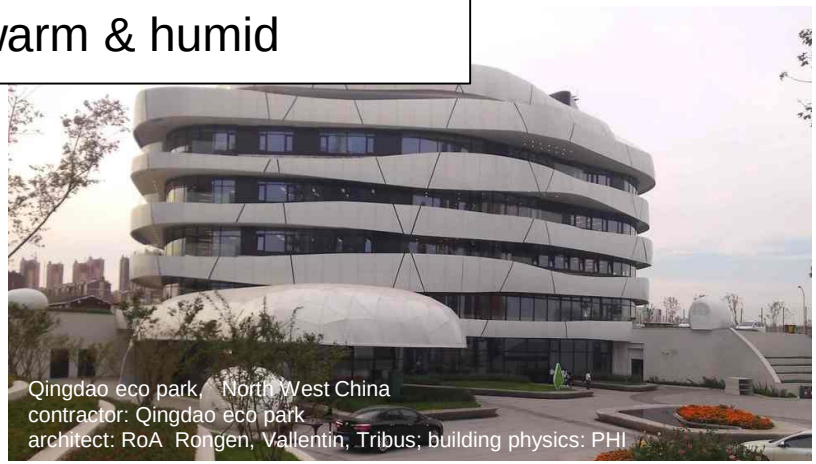
Changxing - hot&humid

Urumqi, - cold & dry

ZhuoZhou - moderate

Qingdao - warm & humid

'ZhuoZhou' Hebei Central China
Contractor: Hebei Xinhua Curtain Wall Co. Ltd.
building physics: Dawid Michulec www.schoeberlpoell.at and PHI


Qingdao eco park, North West China
contractor: Qingdao eco park
architect: RoA Rongen, Vallentin, Tribus; building physics: PHI

# … in the Black Sea region

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

Kindergarden, 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-familiy house, Passive House Plus in Romania
ID: 4893

# … in the Baltic Sea region

## EnerPHit – Latvian School

- This Soviet era school in Latvia was retrofit to the EnerPHit standard in 2014.
- The building was constructed from concrete and the walls, roof and floor were insulated. A Passive House certified ventilation system with heat recovery was installed and the building was made airtight to the Passive House standard.
- Additional heating to the building was provided by a ground source heat pump.

# … in the Baltic Sea region

## EnerPHit – Latvian School

- The results of the EnerPHit retrofit saw a significant reduction in heating demand for the building.

| | |
|---|---|
| Pre Retrofit: | 278 kWh/($m^2$a) |
| Post Retrofit: | 25 kWh/($m^2$a) |

- This results in an overall reduction in heating for the building of **524,722 kWh** per year.
- This results in an annual reduction of **72.5 tonnes** of CO2 from the atmosphere

# … at varying heights

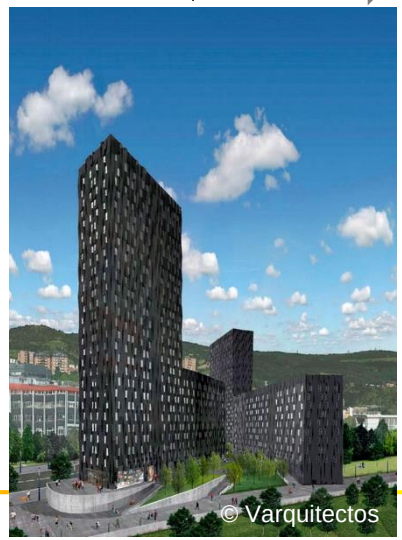

2010
Freiburg, DE
Residential retrofit
16 floors
58 m

2017
New York, US
Student residents
26 floors

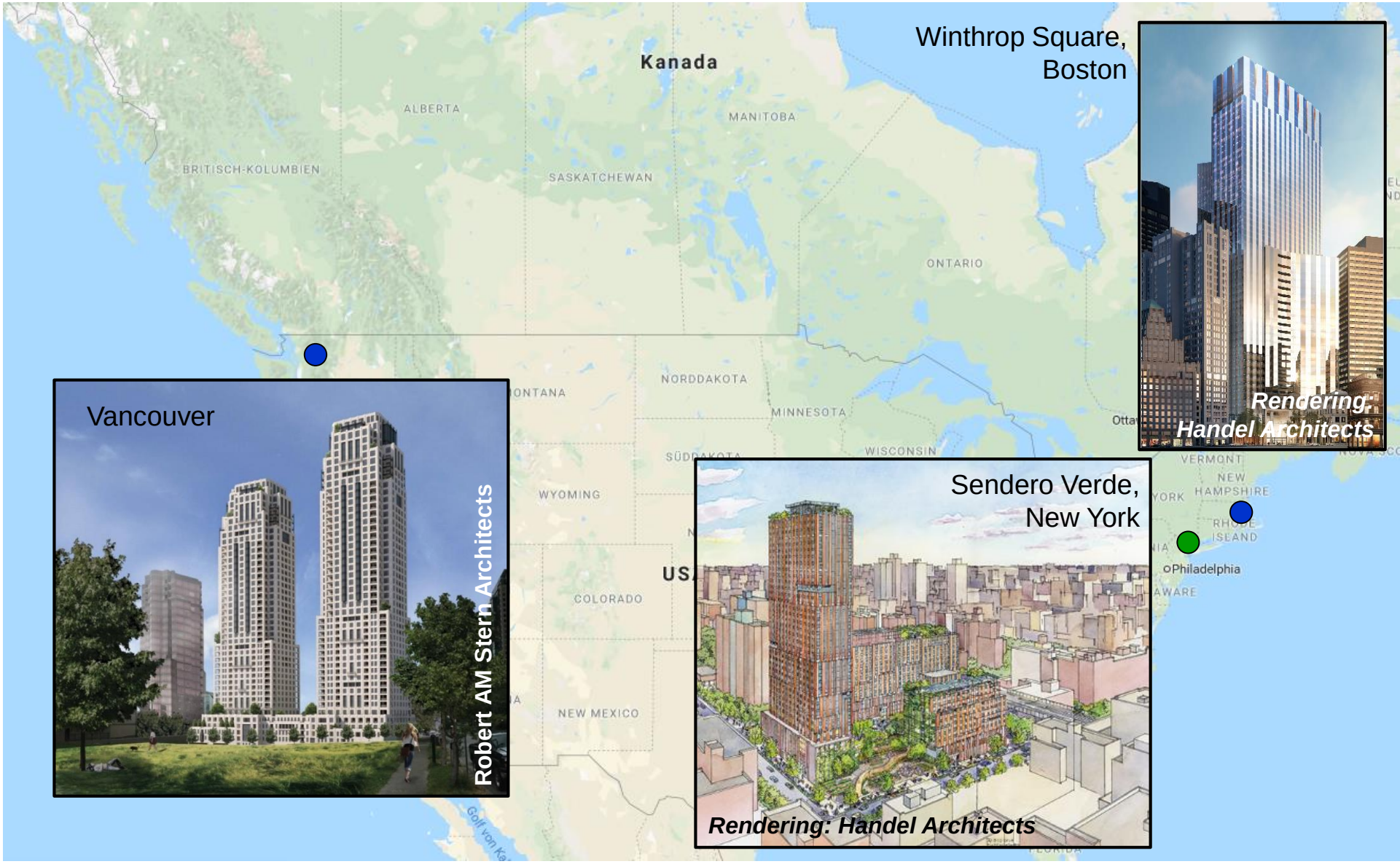

2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018

2012
Vienna, AT
Office building
23 floors
77 m


2018
Bilbao, ES
Residential
28 floors



# … at varying heights



# … at varying heights

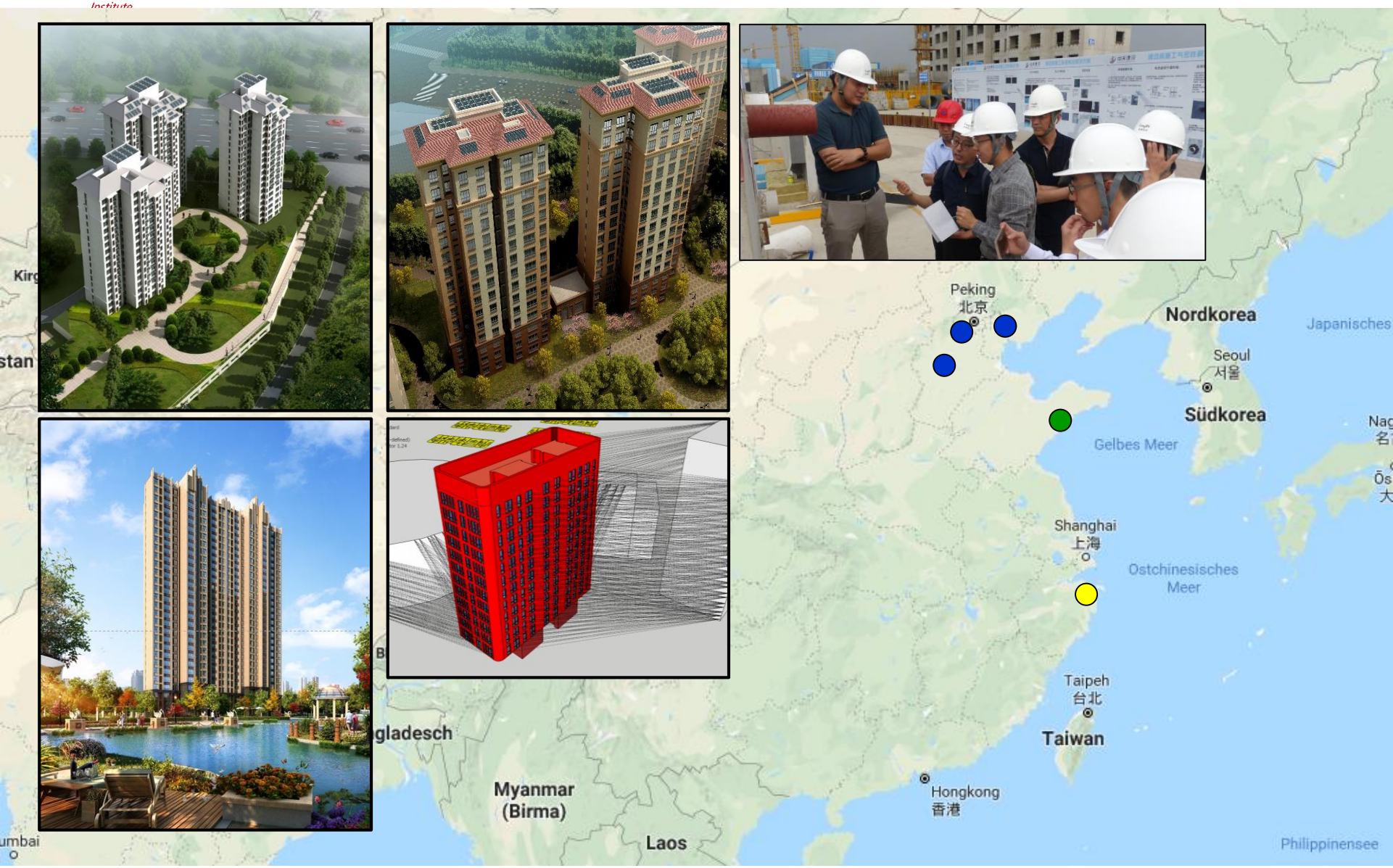




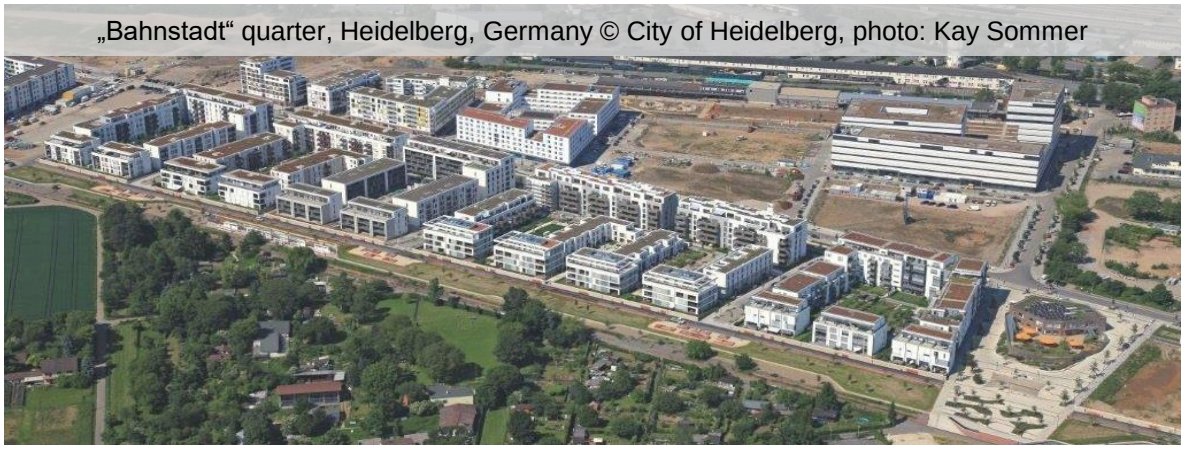








# … at different densities

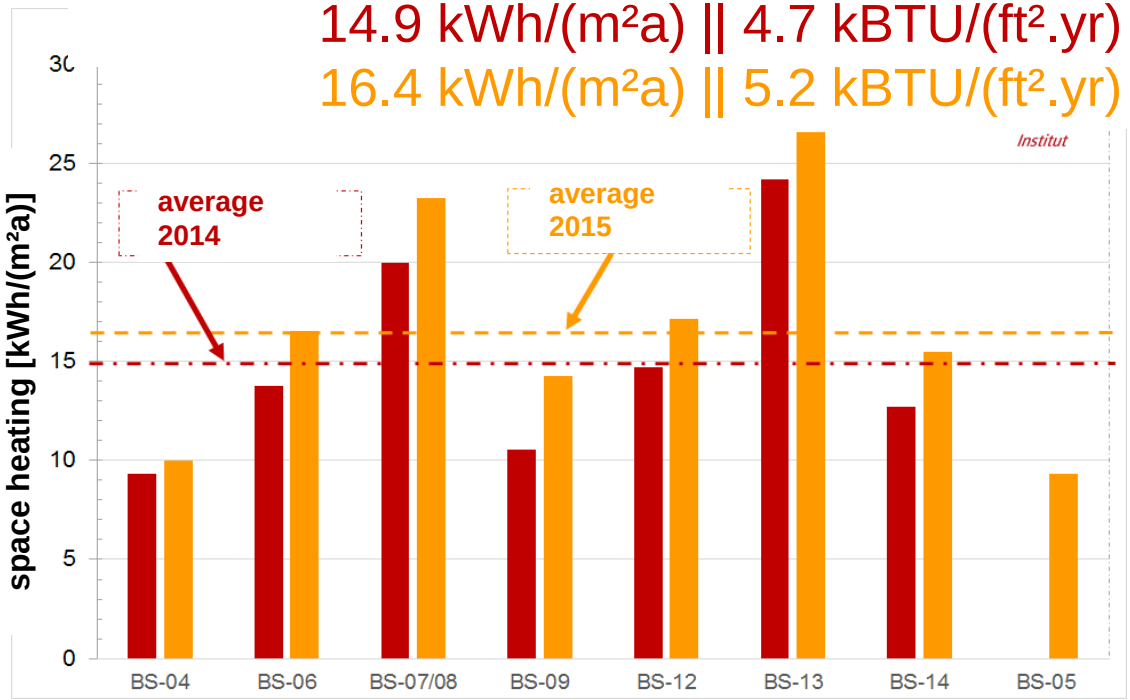

„Bahnstadt“ quarter, Heidelberg, Germany © City of Heidelberg, photo: Kay Sommer

Monitoring:
~ **900 000 ft²**
~ **1 400** appartments

Success due to good quality assurance process:

**PHPP**

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



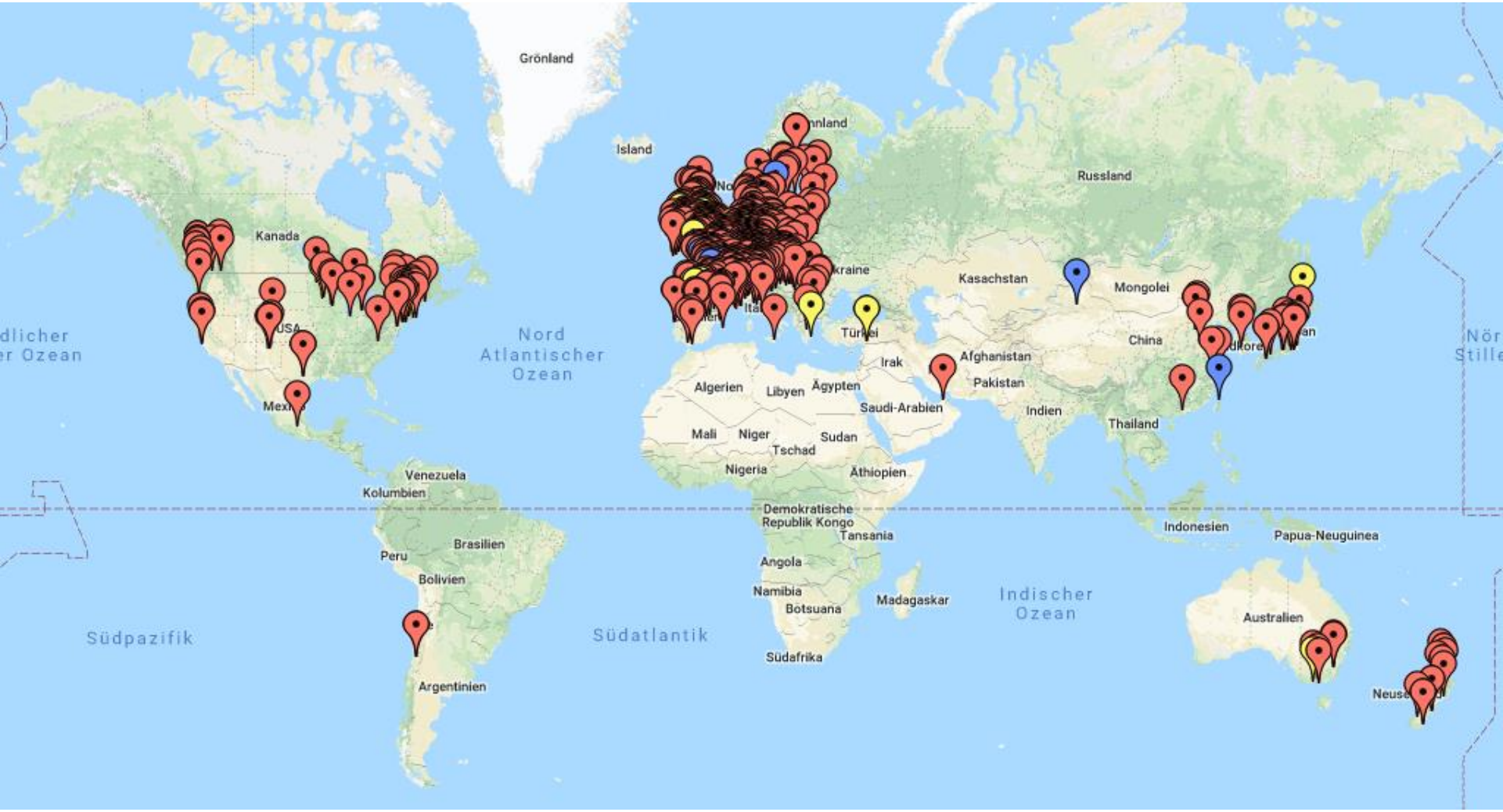
# … at different densities

**Bahnstadt Heidelberg**

**Railway City Gaobeidian**

# … and worldwide

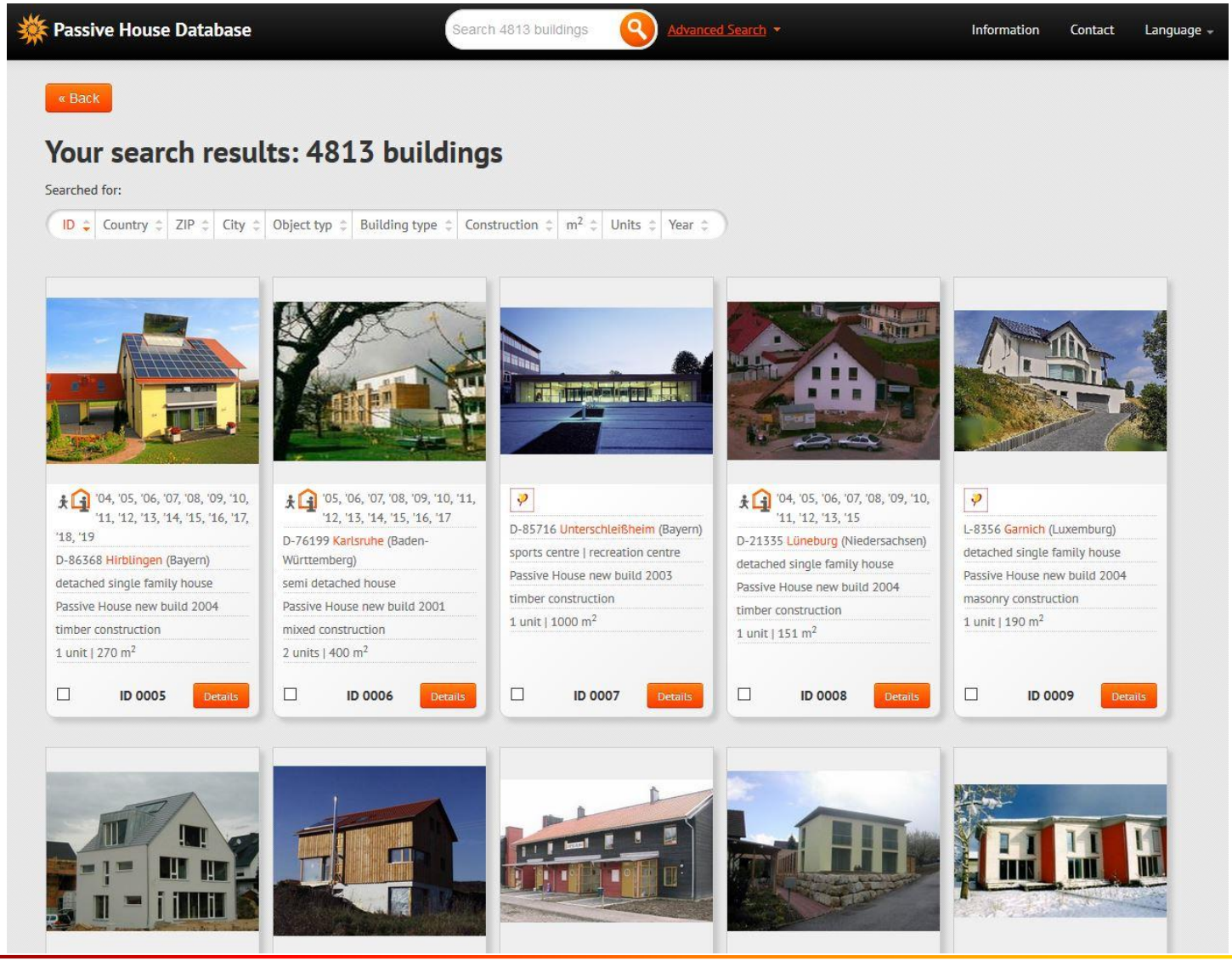
## approx. 1.8 Mio m² TFA of *certified* Passive House projects worldwide




Open the map here.

# Get inspired from projects worldwide

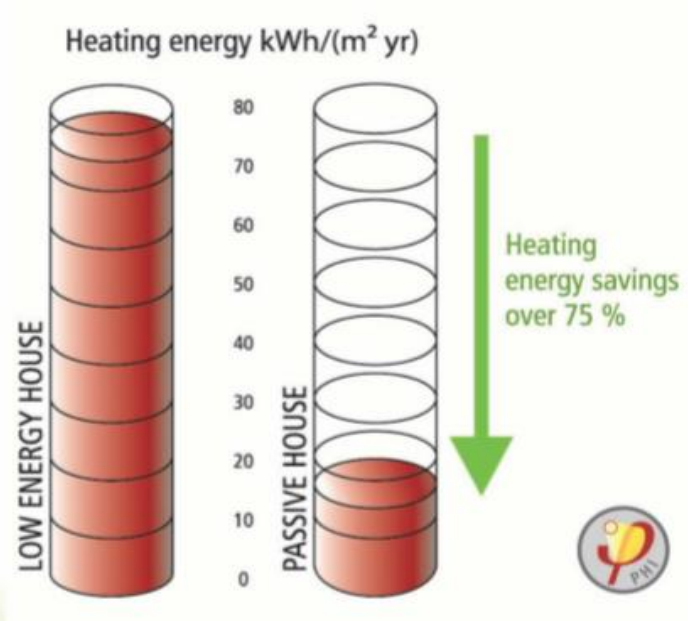
www.passivehouse-database.com



# Public Awareness of the Benefits

The public is more often interested in the emotional and/or soft benefits of energy efficiency including:

1. High levels of comfort
2. Consistent fresh air throughout the building
3. Structural longevity: mould-free buildings with a highly reduced risk of moisture related damage
4. Extremely low heating/cooling costs; despite rising energy costs
5. Passive House buildings benefit regional manufacturers



# Policy uptake

www.passivehouse-international.org

PASSIVE HOUSE INSTITUTE | iPHA | IG PASSIVHAUS | PASSIVE HOUSE DESIGNER | PASSIPEDIA | PASSIVE HOUSE TRADESPERSON

International PASSIVE HOUSE Association

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iPHA | AFFILIATES | INFO MATERIAL | EVENTS | NEWS | HANDS ON | KEY PLAYERS | PROJECTS | PASSIVE HOUSE

Advantages | Certified Passive Houses | The Difference | Criteria | Certification | Guidelines | PHPP & DesignPH | Legislation & Funding

## 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

PASSIPEDIA

A wealth of Passive House knowledge.

FORUM

Where Passive House stakeholders meet.

BECOME A MEMBER

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Member Search

Member Area Login

UPCOMING EVENTS

Upcoming Events

Int'l Passive House Conference
22—23 April 2016

# Summing up of 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.

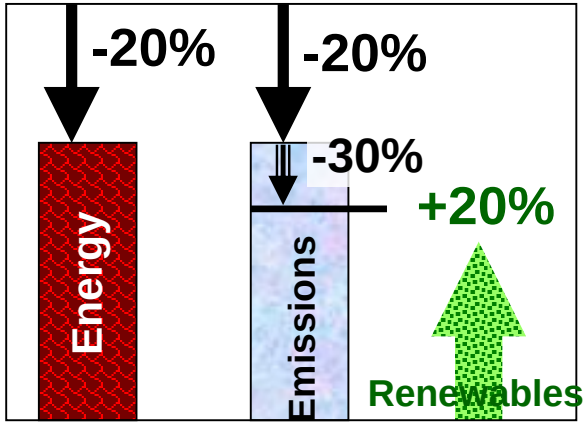
→ **Luxembourg:** subsidies to buildings built to the Passive House standard

→ **Mexico:** concept for the gradual increase of requirements for energy efficiency, tools for the performance evaluation system

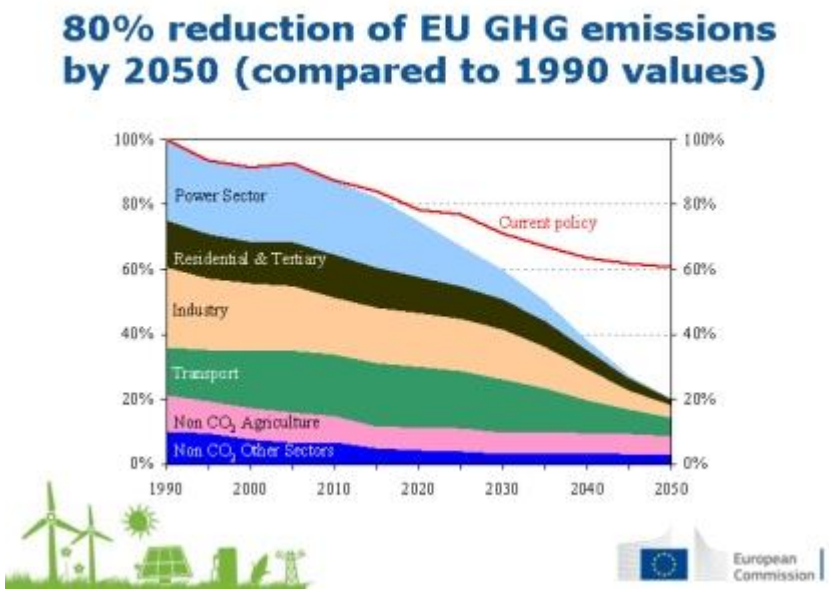
# Europe Climate Policy

## 20-20-20 Goals of the European Commission

- Until 2020
  - 20% higher efficiency
  - - 20% greenhouse gases (GHG) emissions
  - 20% share of renewables

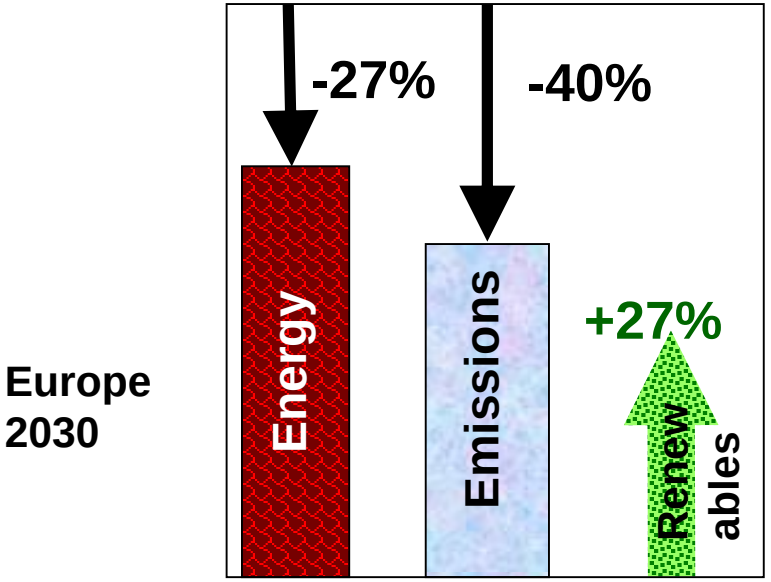



Source: EU Commission, annual report




Source: https://ec.europa.eu/clima/policies/strategies/2050/

## 2030 Climate & Energy Framework



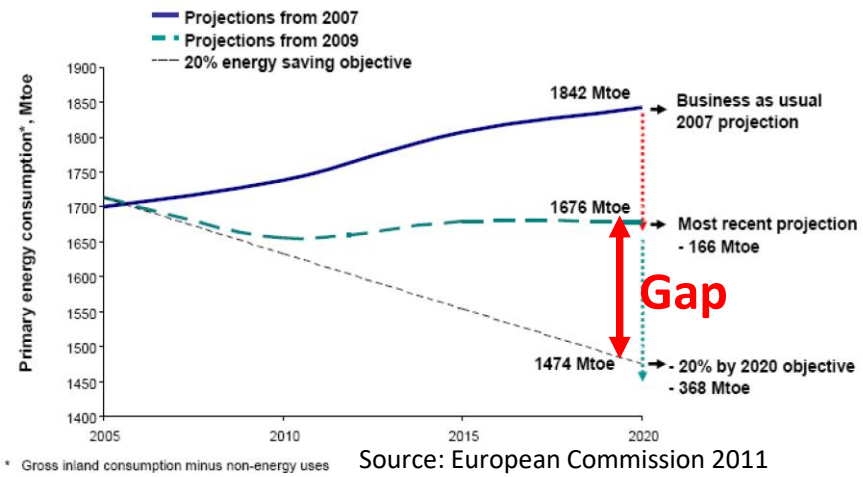

Europe 2030

# EU: Related directives and acts

## Related Directives and Acts

- European Emissions Trading Scheme
- EU Energy-Efficiency Directive
- EU CHP Directive
- EU Buildings Directive (EPBD)
- EU Delegated Act
- EU Directive on Renewable Energy
- EU EcoDesign Directive

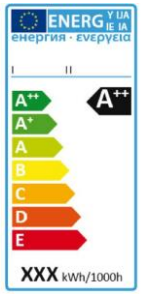
## EU Energy Efficiency Directive




Source: European Commission 2011

Cause: Gap to energy- efficiency goals of the EU

## EU EcoDesign Directive




Framework directive (2005/2009): Principles and criteria for ecological requirements on energy-using / energy-related products (ErP).

# Energy Performance of Buildings Directive

## EPBD (2002), Recast 2010:

Directive 2010/31/EU on the energy performance of buildings (19 May 2010):

- From 31 Dec 2020 onwards, all new buildings are **"Nearly zero energy buildings"** (Art. 9)
  - For all public buildings this applies from 31 Dec 2018
  - Member states shall implement measures to increase the number of "Nearly Zero Energy Buildings", and define targets (Art. 10)
- Member States are responsible for setting minimum requirements (Art. 4)
  - Have to meet at least cost optimum with respect to lifecycle costs (new buildings and building components)
- The commission is responsible for framework regulations (Art. 5)
  - "Delegated act" (Jan 2012)
  - Standardisation Mandate M 480 of the European Commission to the European Committee for Standardisation (CEN)
- Member States are responsible for the implementation

# EPBD: The Nearly Zero Energy Building

## Efficiency first!

- The Nearly Zero Energy Building is **a "building that has a very high energy performance…"**
- "The nearly zero or very low amount of energy required should to a very significant extent be covered by energy from renewable sources, including renewable energy produced on-site or nearby." (Def Article 2, (2))
- Indicators for Energy Performance and Primary energy (Art 3, App. 1)
- No accounting of efficiency and renewables
- Minimum requirements for energy performance have to meet at least cost optimum with respect to lifecycle costs

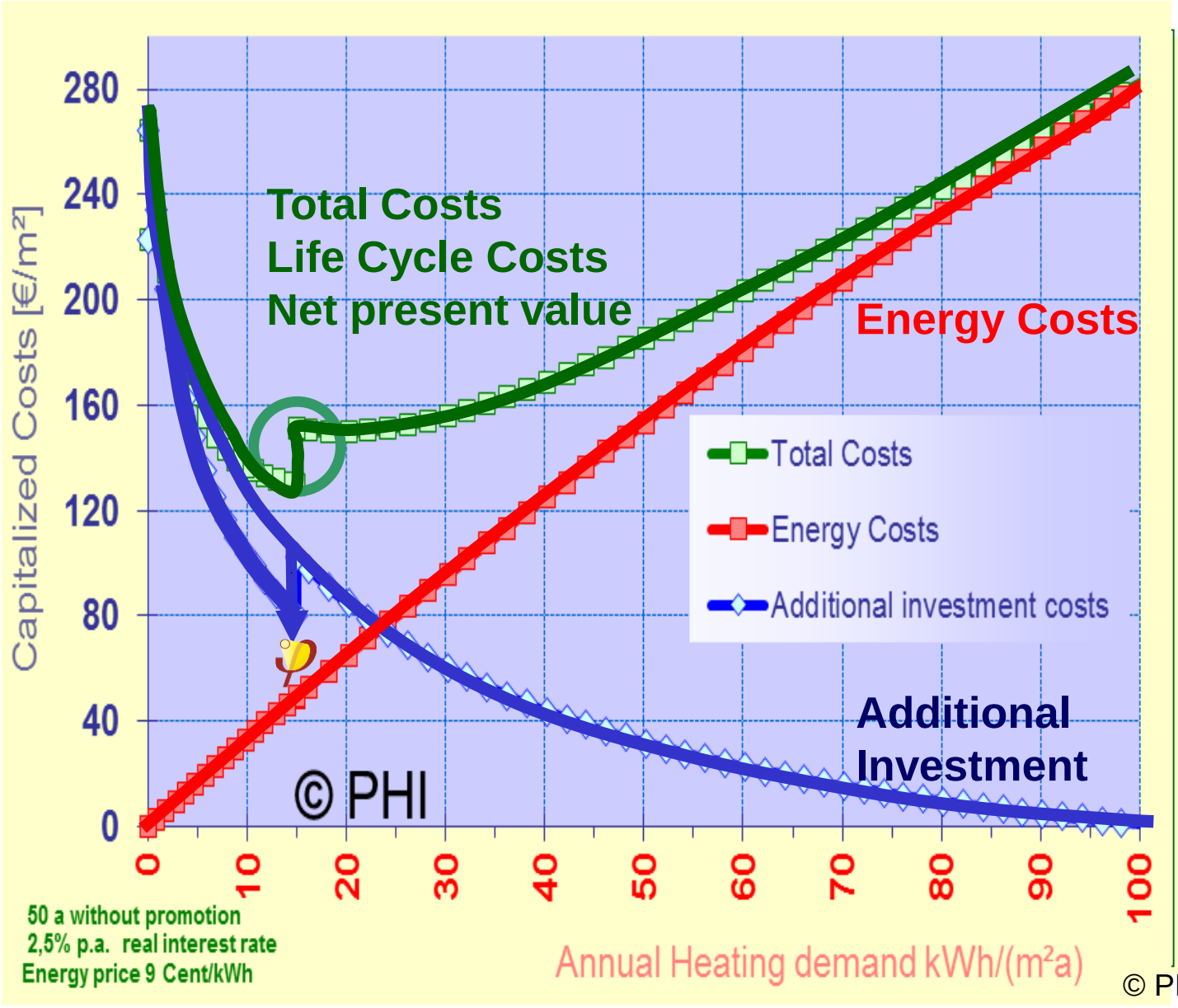
**"Cost-optimal level" - with respect to lifecycle**

# NZEB and Passive House: Cost optimum

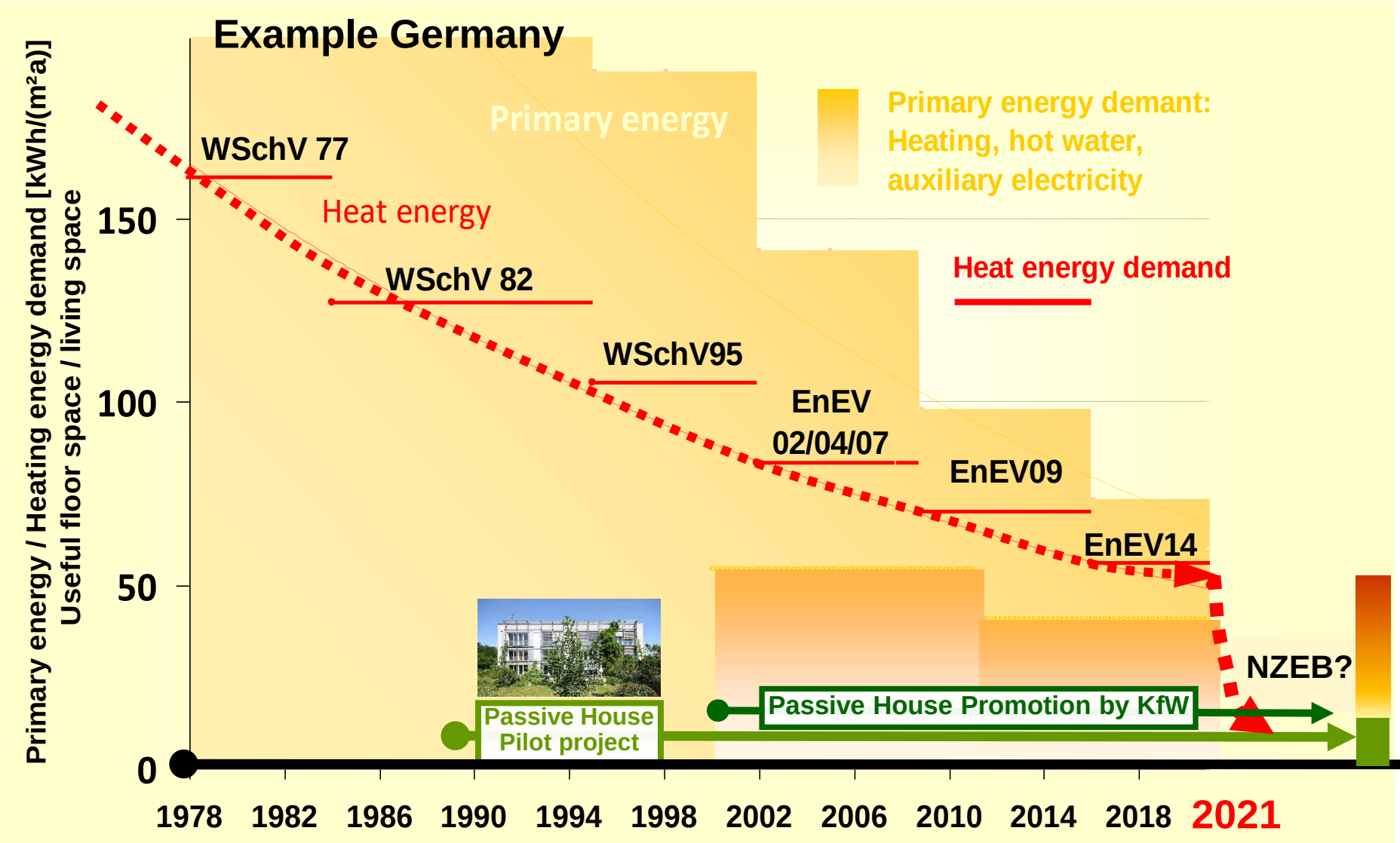
**EPBD:**
**"...** requirements should be set with a view to achieving the cost-optimal balance between the investments involved and the energy costs saved throughout the lifecycle of the building**, ...**"

**NZEB:**
**Member States are responsible**

**Passive House:**
**International prototype for NZEB**



# Building Energy Performance Standards

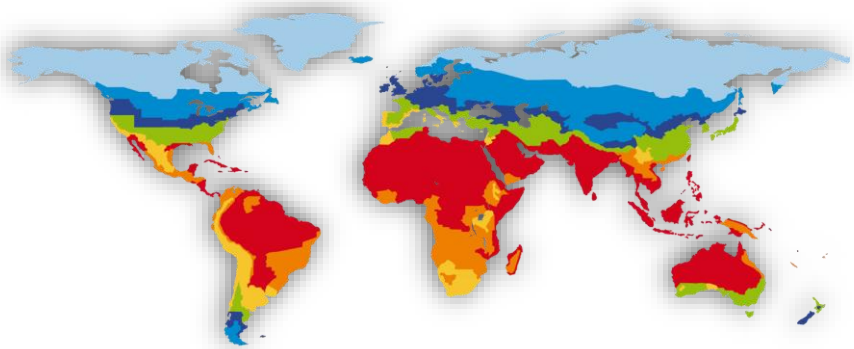


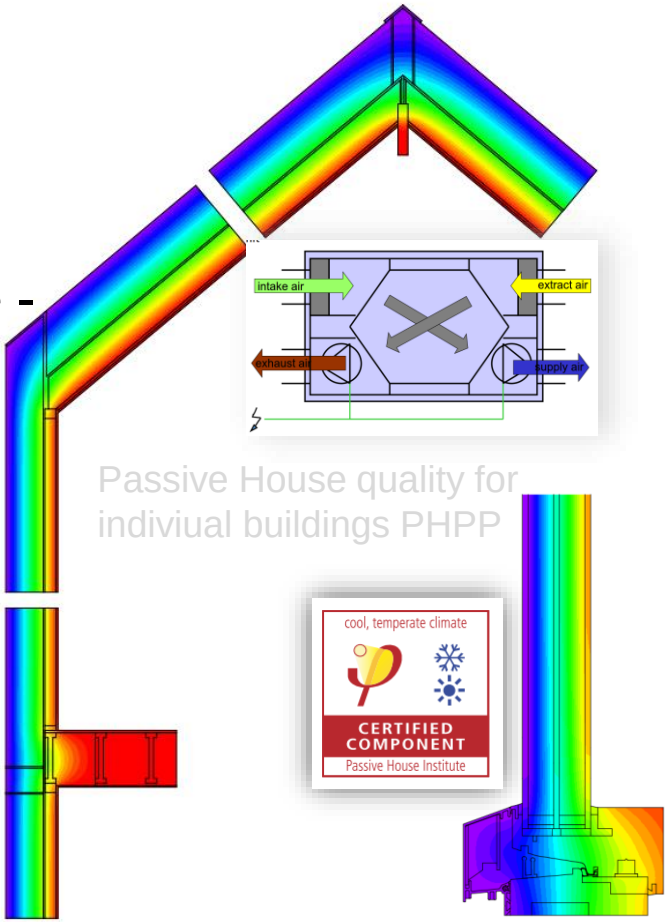

Source: Pixabay

# Predictable Design needs Reliable Products

## Product Certification

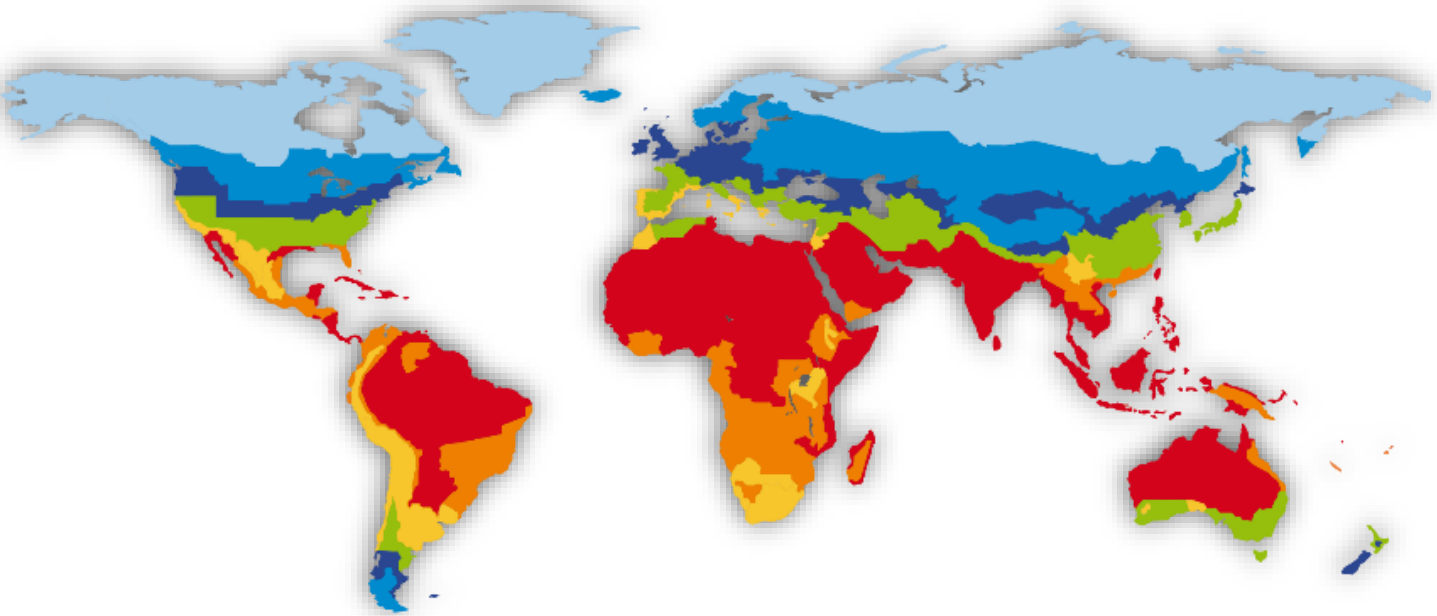
- Values for design
- Integrated in PHPP
  → directly available for energy balance - worldwide
- + component database






Make it Simple, Efficient, Cost-effective

# Components in Different Climate Zones



**The values of all certified components are available in the component database and in PHPP**

| Cli-mate | No | Region | Wall- U-Value [W/(m²K)] | Window- U-Value (built.) [W/(m²K)] | Ventilation |
|---|---|---|---|---|---|
| Heating Climate | 1 | Arctic | 0,09 | 0,45 | HRV, hum recovery, frost prot. |
| | 2 | Cold | 0,12 | 0,65 | HRV,hum. recovery, frost prot. |
| | 3 | Cool temperate | 0,15 | 0,85 | HRV, frost protection |
| | 4 | Warm temperate | 0,30 | 1,05 | HRV |
| | 5 | Warm | 0,50 | 1,25 | --- |
| Cooling Climate | 6 | Hot | 0,50 | 1,25 | HRV, humidity rec in humid cl. |
| | 7 | Very hot | 0,25 | 1,05 | HRV, humidity rec in humid cl. |

# Component Database

English

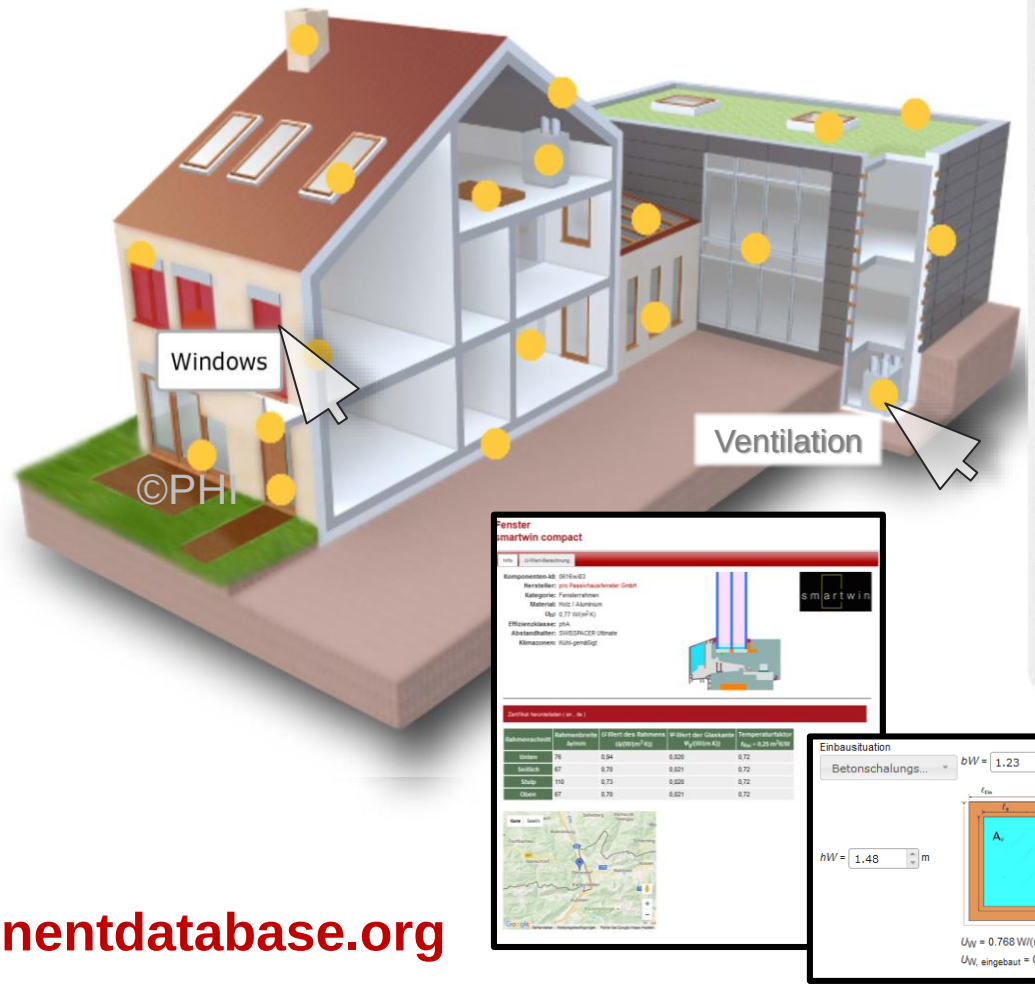
## Opaque building envelope

- Wall and construction systems
- Façade anchors
- Floor slabs
- ICF for roof parapets
- Flue systems
- Balcony connections
- Attic staircases

## Building services

- Compact heat pump units
- Ventilation systems (capacity < 600 m³/h)
- Ventilation systems (capacity > 600 m³/h)
- Drain water heat recovery

Explore the house and find the links or
☑ let the hotspots show up




## Transparent building envelope

- Windows
- Roof windows
- Skylights
- Curtain wall systems
- Glass roofs
- Openable glass roof elements
- Shutters
- Entry doors
- Sliding doors
- Glazing
- Spacers


**www.componentdatabase.org**

www.passivehouseconference.org

# Call for Papers

*Application close 2nd March 2020*

## 24TH INTERNATIONAL PASSIVE HOUSE CONFERENCE 2020

Brandenburger Tor Berlin © *VisitBerlin*, Photo: Wolfgang Scholvien

Organiser: Passive House Institute | Rheinstraße 44/46 | 64283 Darmstadt | Germany

**Berlin**
*20 / 21 September 2020*

Passive House Institute

International PASSIVE HOUSE Association IPHA

Under the patronage of the Federal Ministry for Economic Affairs and Energy

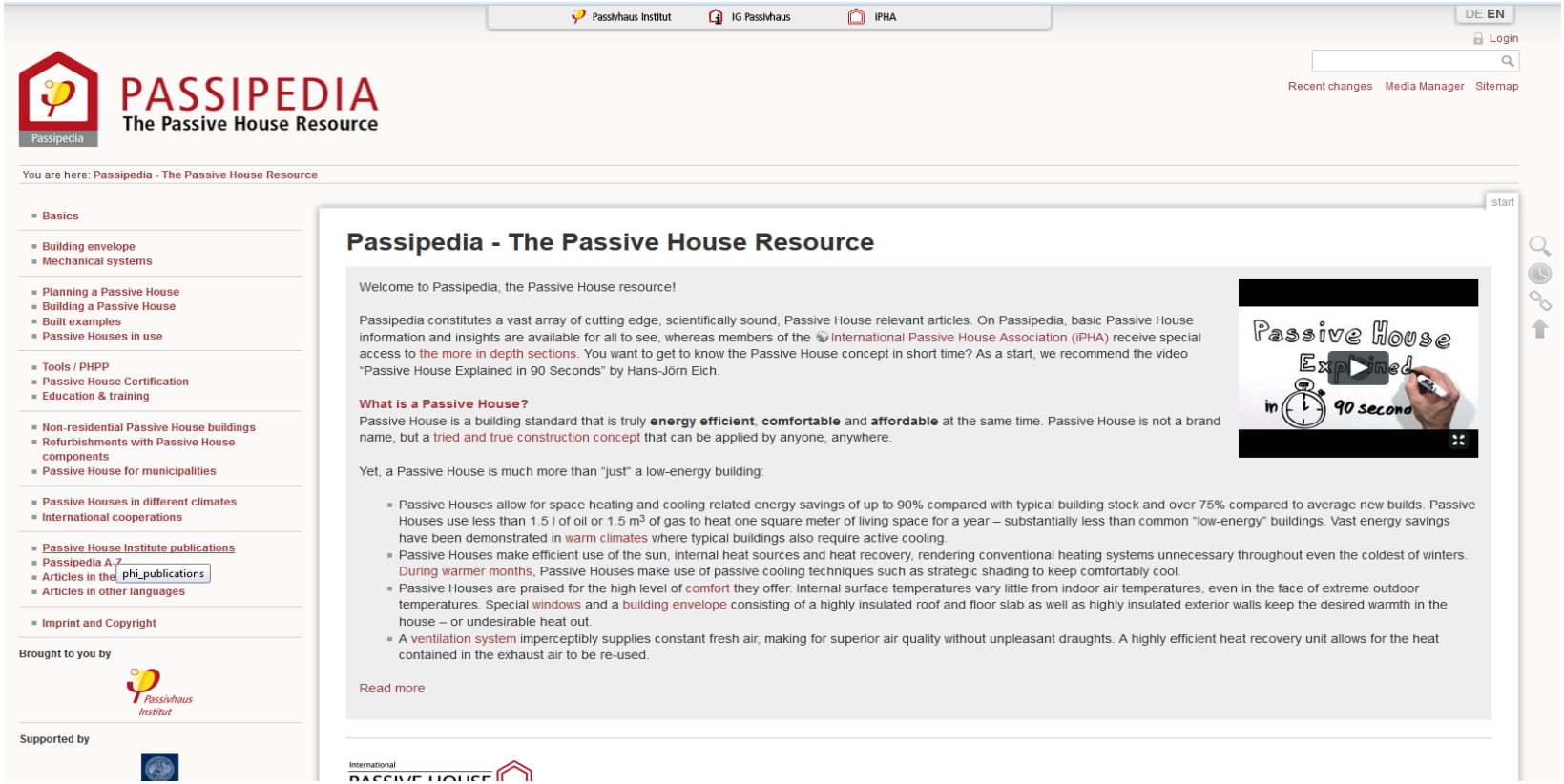
DBU Deutsche Bundesstiftung Umwelt

# www.passivehouseconference.org

# Online learning…


**www.elearning.passivehouse.com**

# Online resources…

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