Passive House –
towards a sustainable future

universität innsbruck

Passivhaus Institut

Univ.-Prof. Dr. Wolfgang Feist

University of Innsbruck and Passive House Institute

Portland/Maine September 2014

Passive House is 27 years old

1987:

Bo Adamson

„Passive Houses in South-West China"

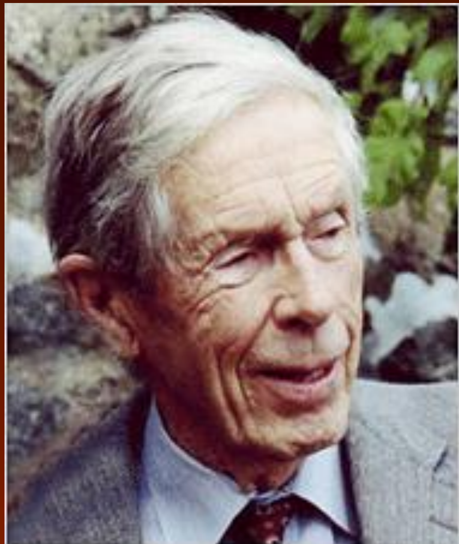
Passivhaus Institut

Lund university, September 2014

"Sustainable Building Award "

Bo Adamson and Wolfgang Feist

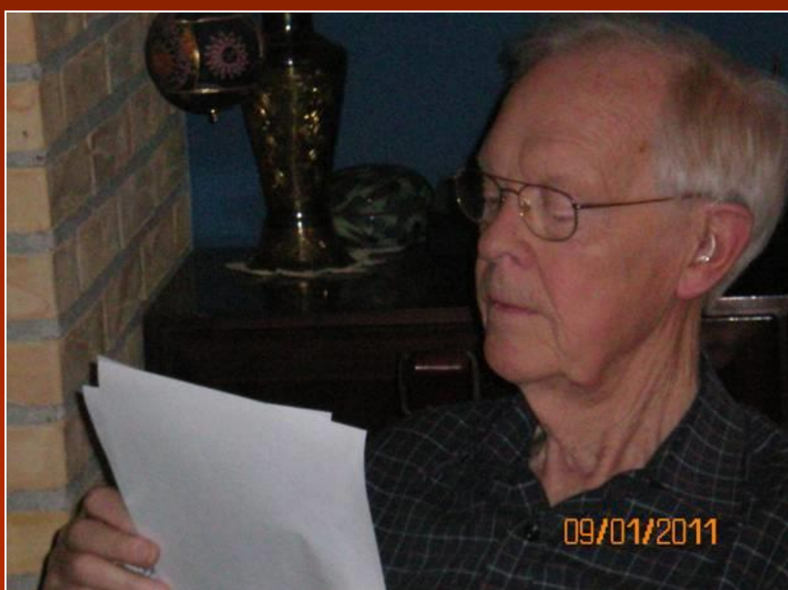
Passivhaus Institut



William Shurcliff

Arne Elmroth

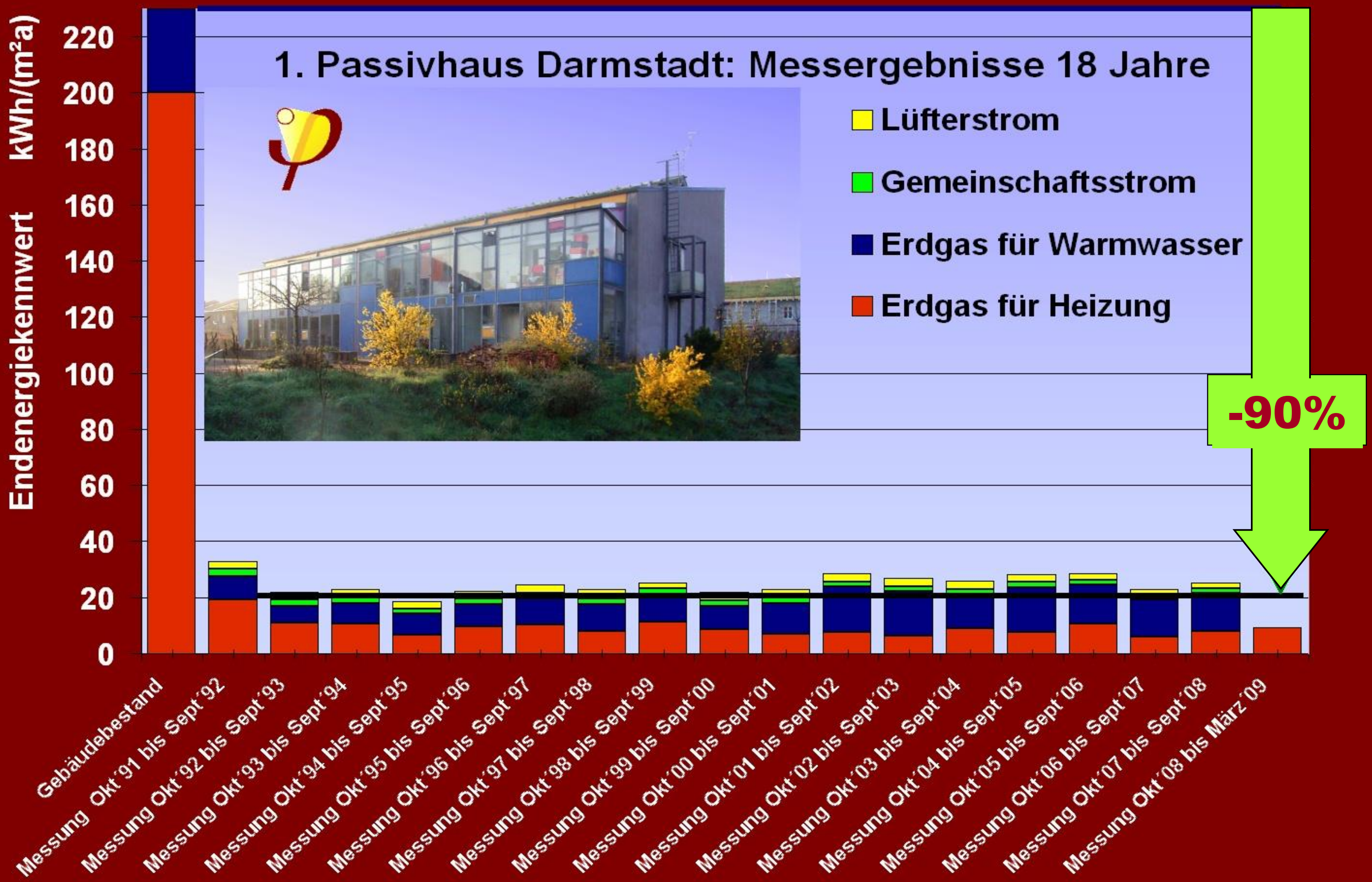
Bernd Steinmüller



Vang Korsgaard

Claes Bankvall

Long term tried and tested:
Passivhaus Darmstadt Kranichstein 1991…2014



Long term stable „nearly zero energy“

Passive Houses for Different Tasks

School

Social Housing

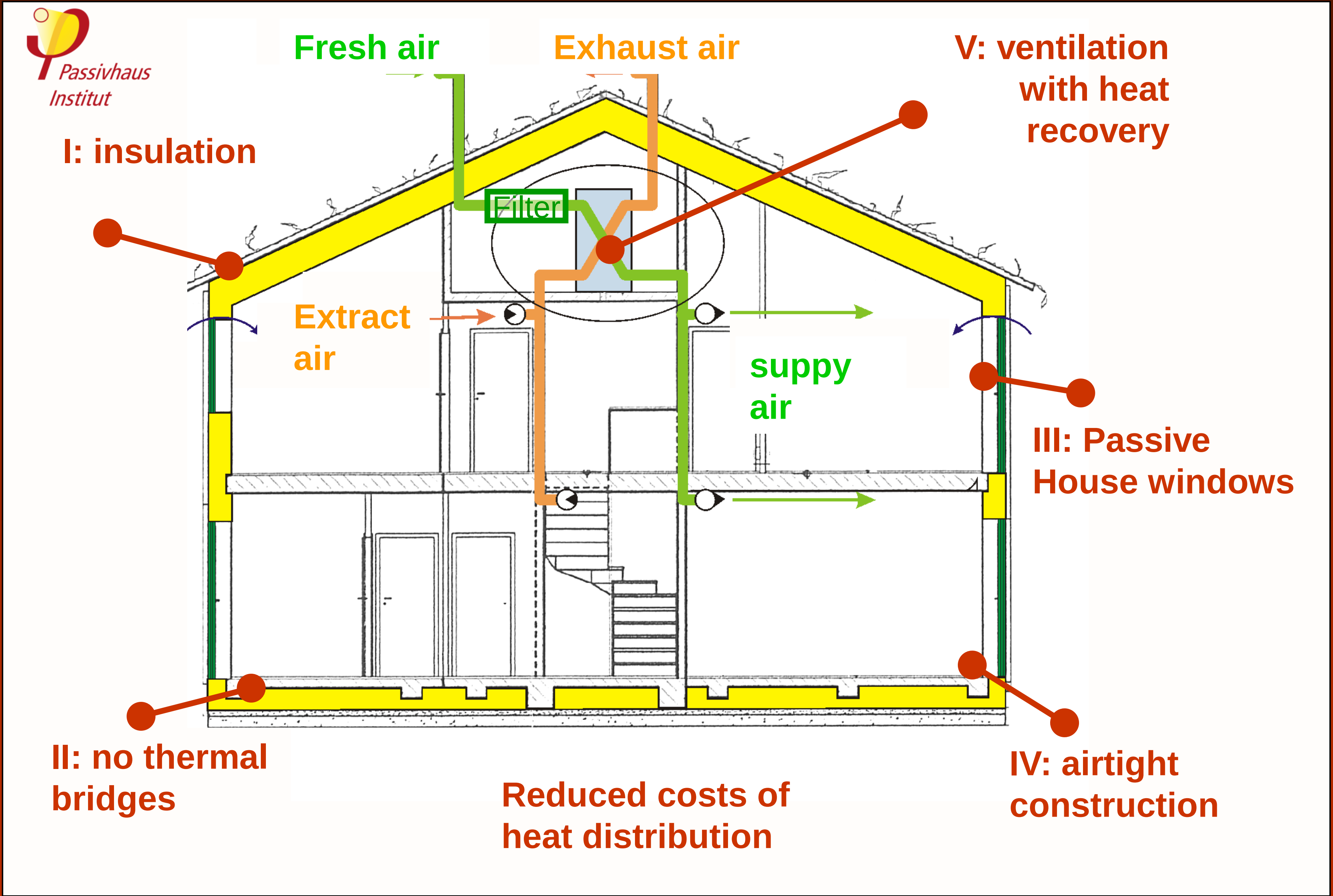
Office Buildings

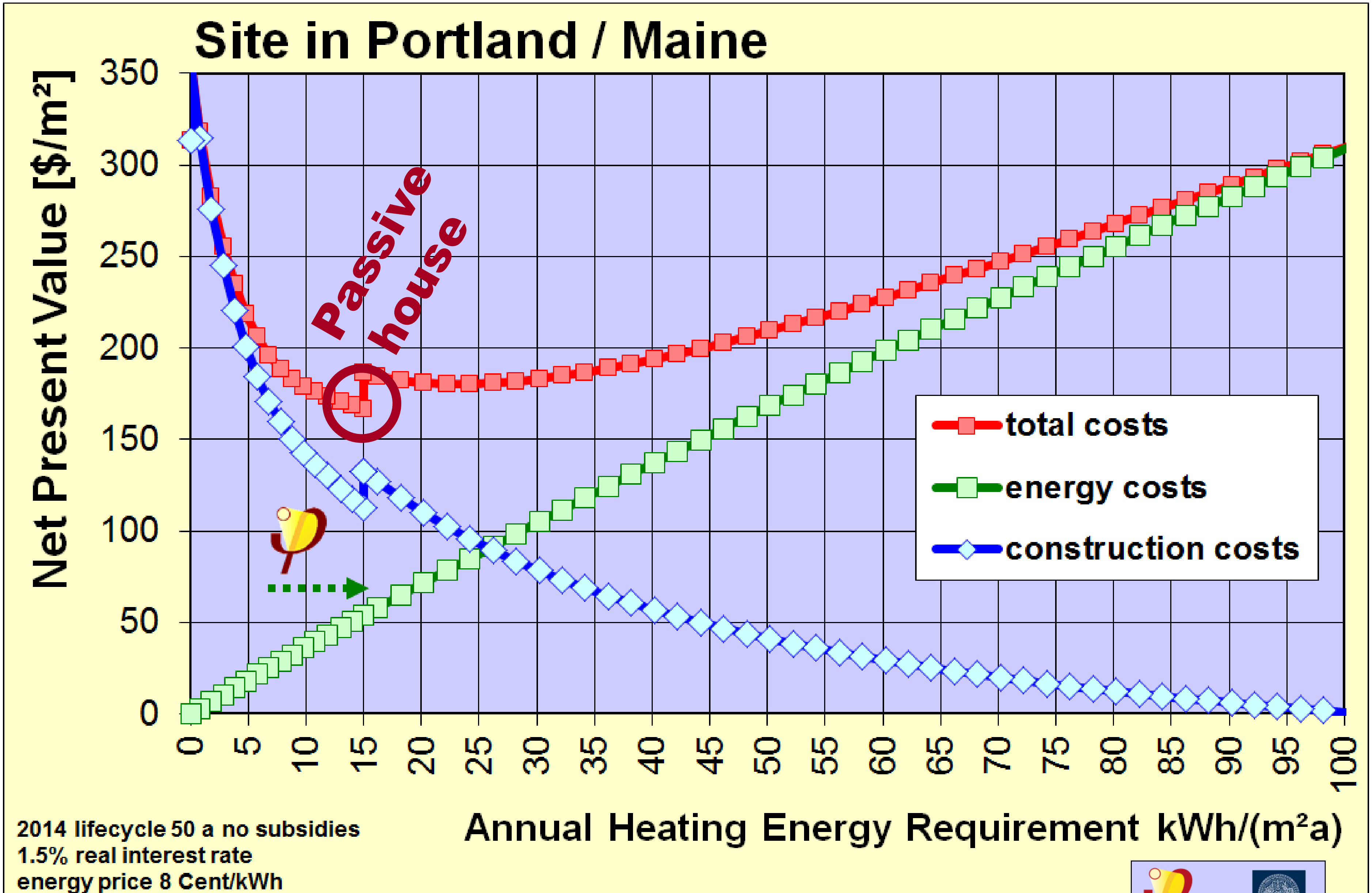
Passivhaus Institut

Swimming Hall

Kindergarten

Passive House – Sustainability becomes affordable all components needed anyhow





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Passive House – most economic standard

Wall-Systems

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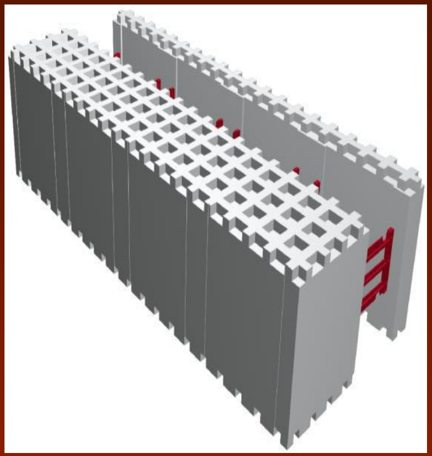
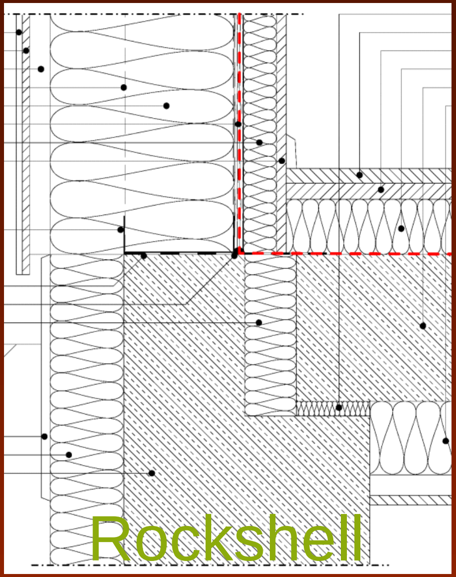
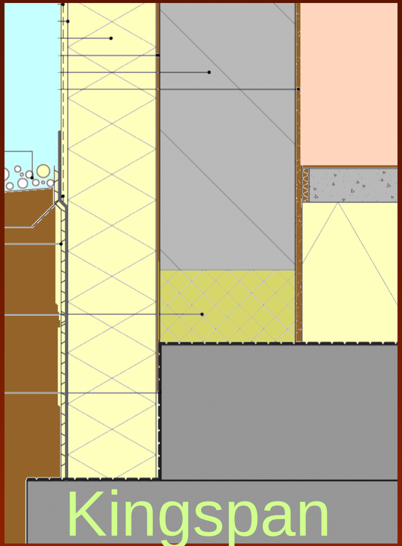
Hotblok



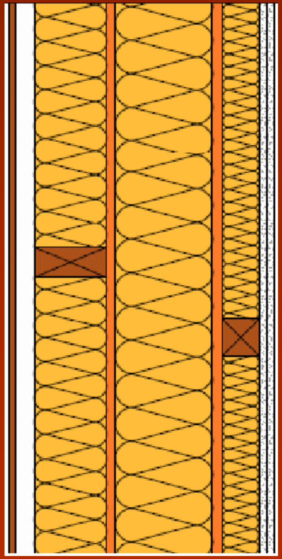
IsoteQ



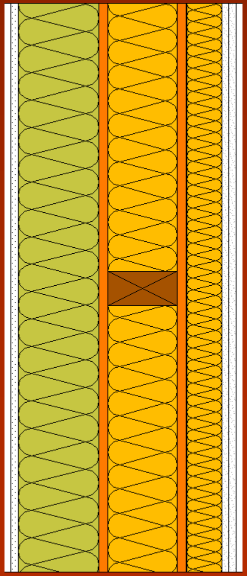
Rockshell



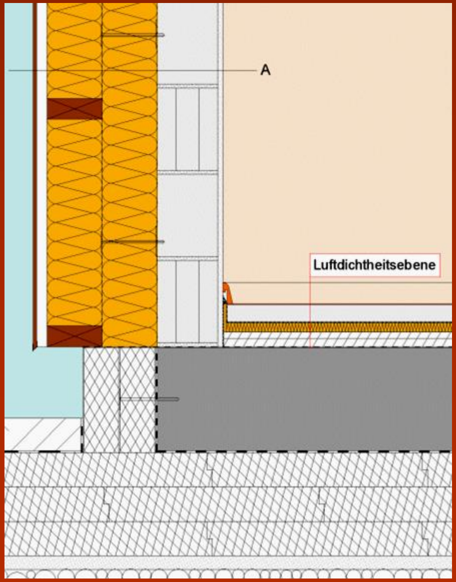
Kingspan



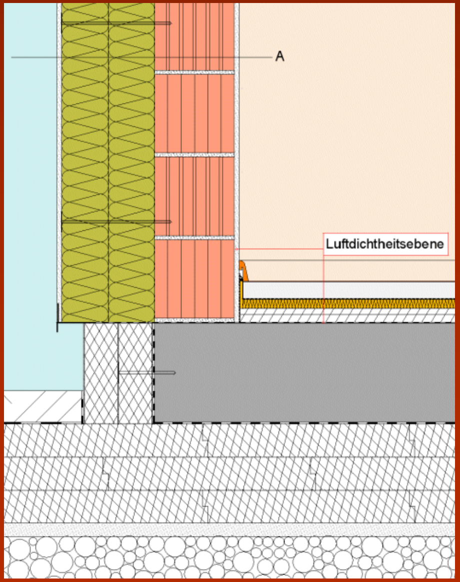
Isover-HLF



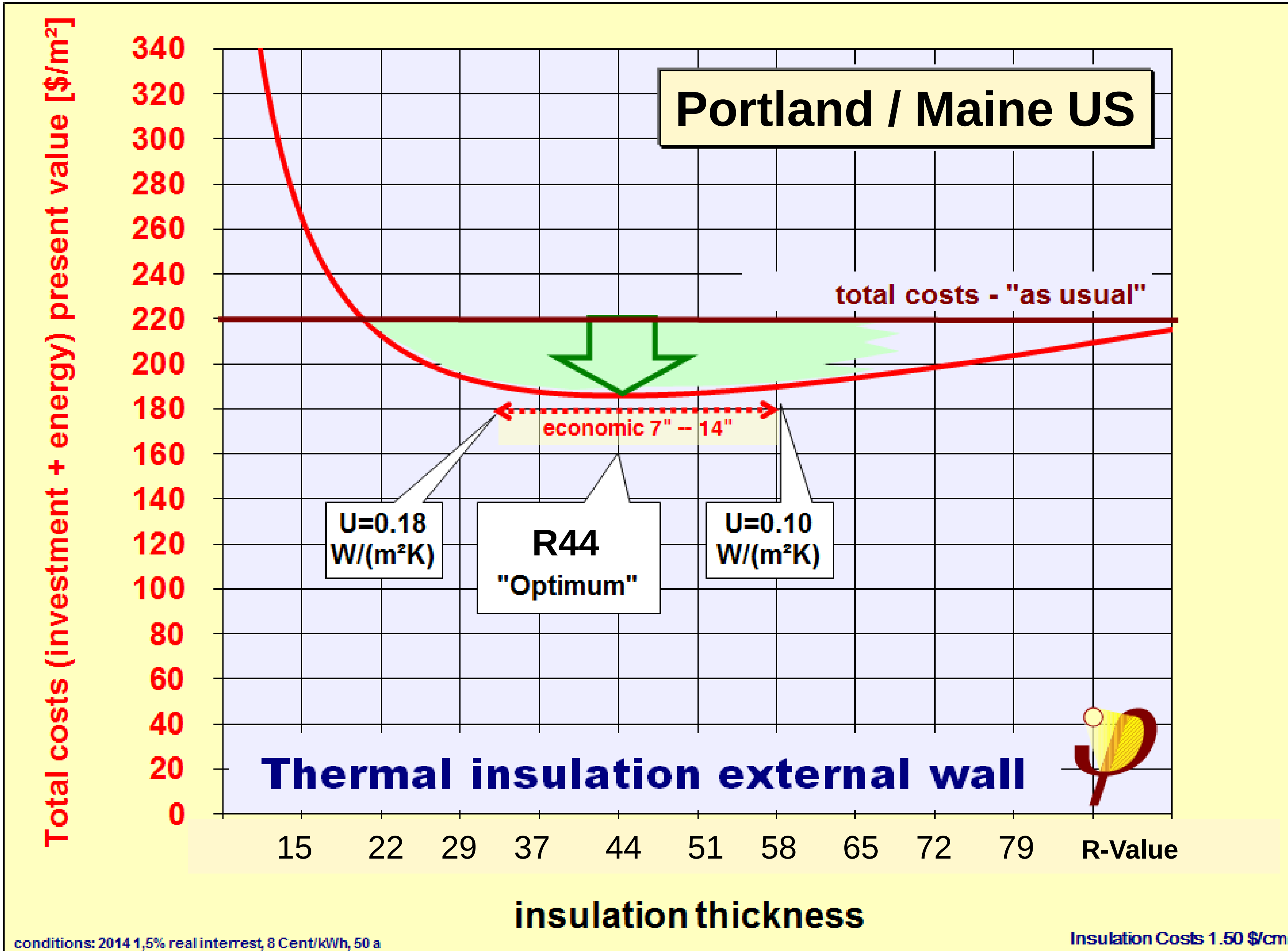
Isover-WdVS



Isover-massivHLF



Isover-massiv-WdVS



Passive House – most economic standard

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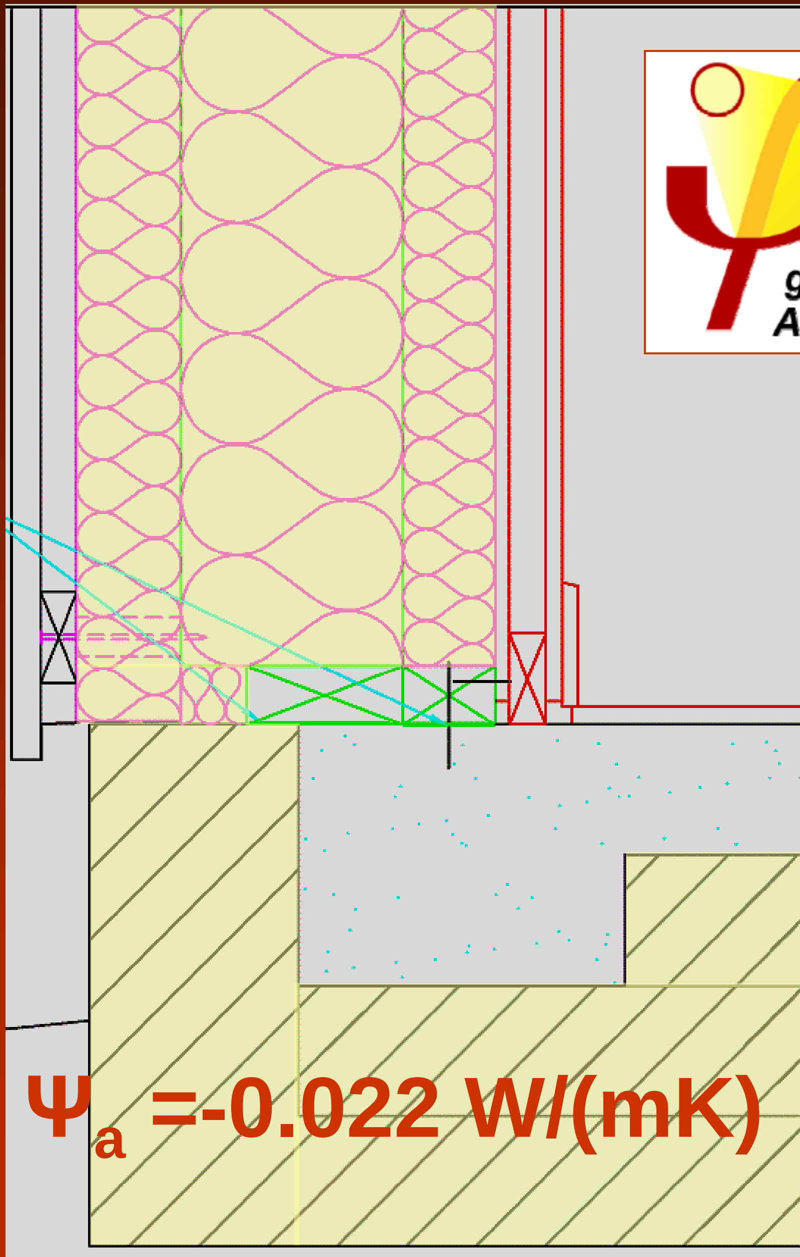
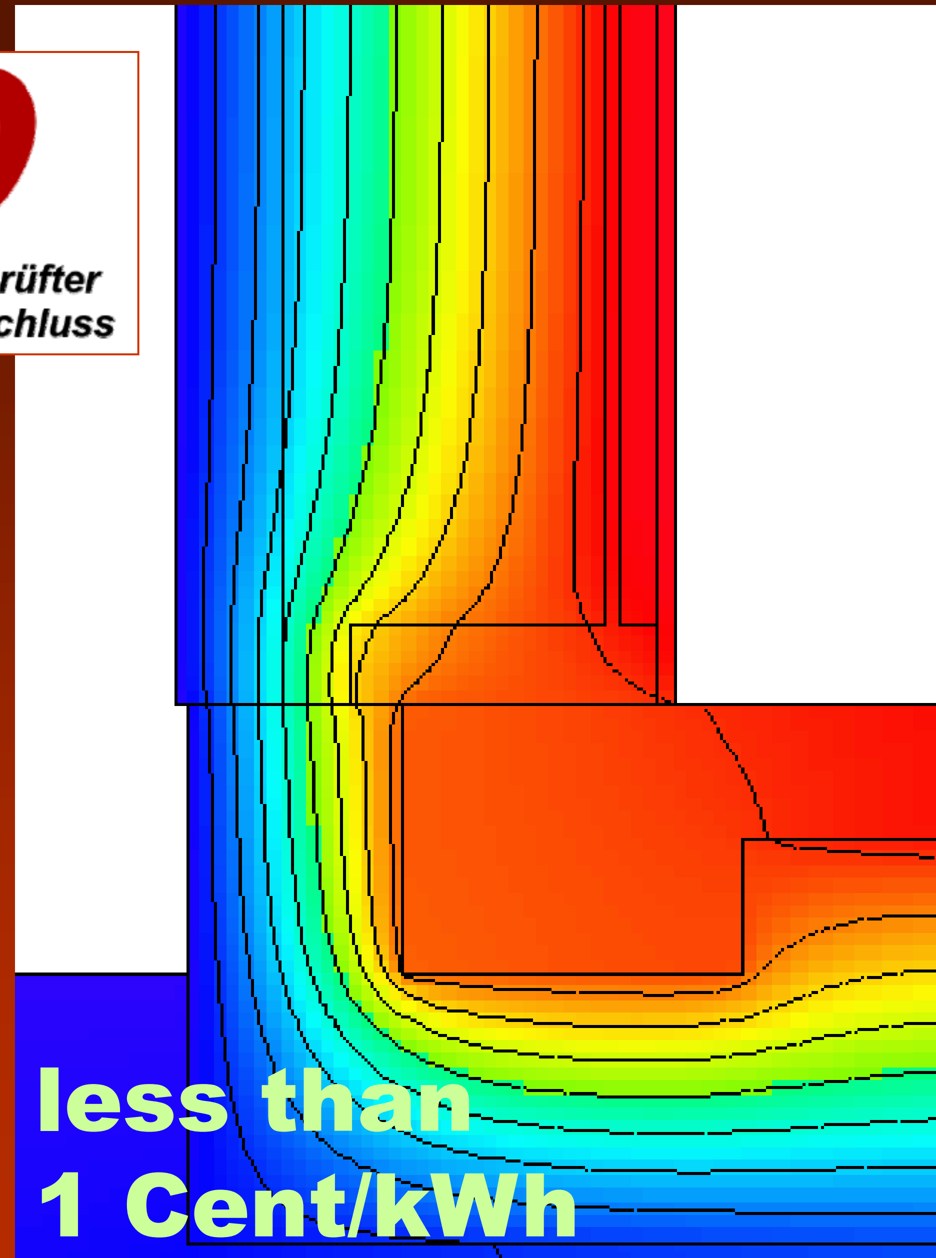
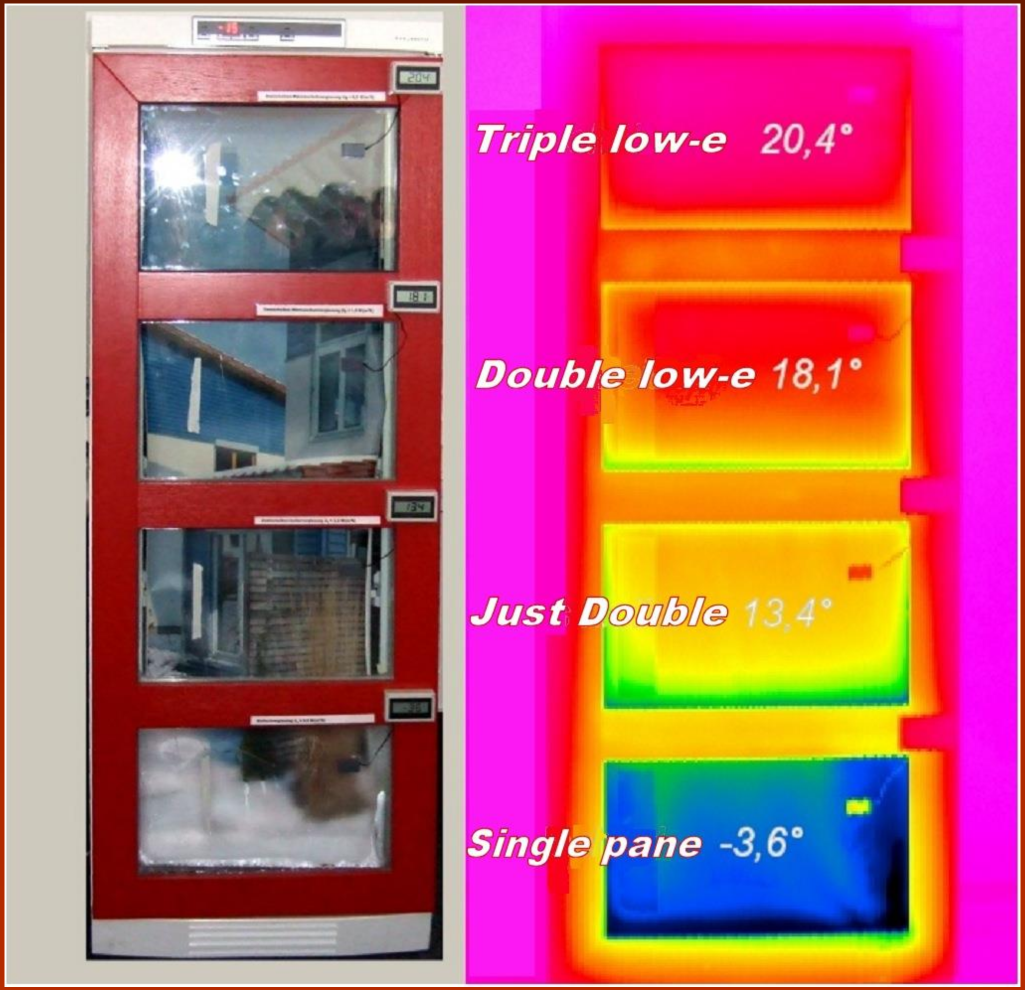
Thermal Bridge free Details





High efficient low-e glazing:

Energy-gain-glasing



Advantages, not just energy savings:

- high surface temp.
- best thermal comfort
- no condensation
- no cold drafts
- better protection of the construction

Glazing:
2 to 3 Cent/kWh

Sustainable Solution:

Energy-Plus-Window

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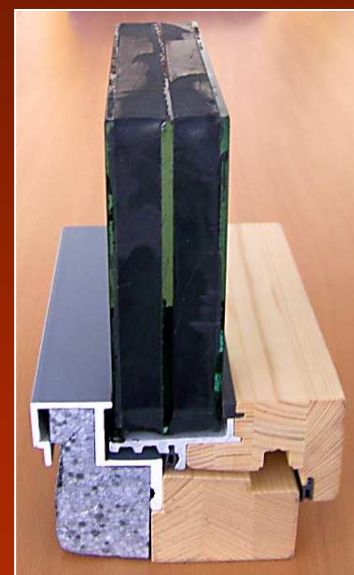
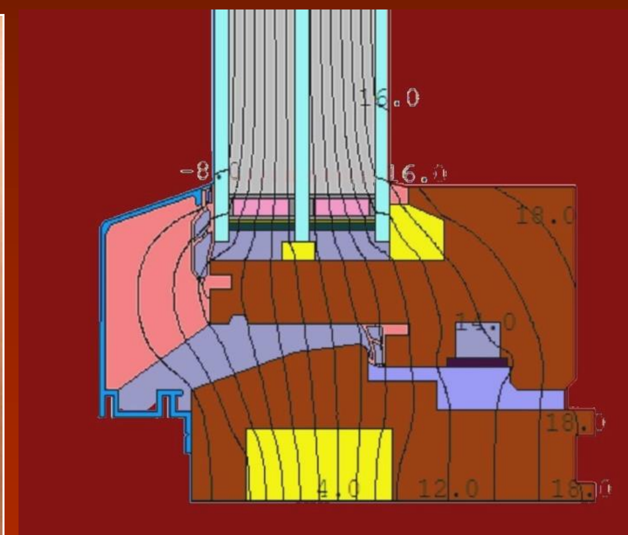
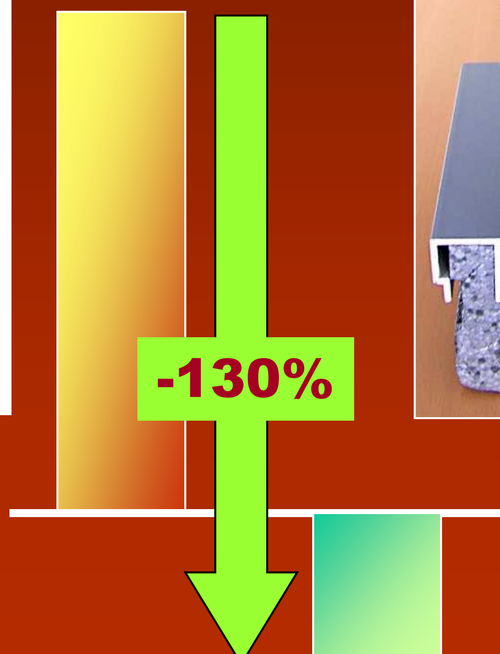
Contemporary Window

Passive House – Window

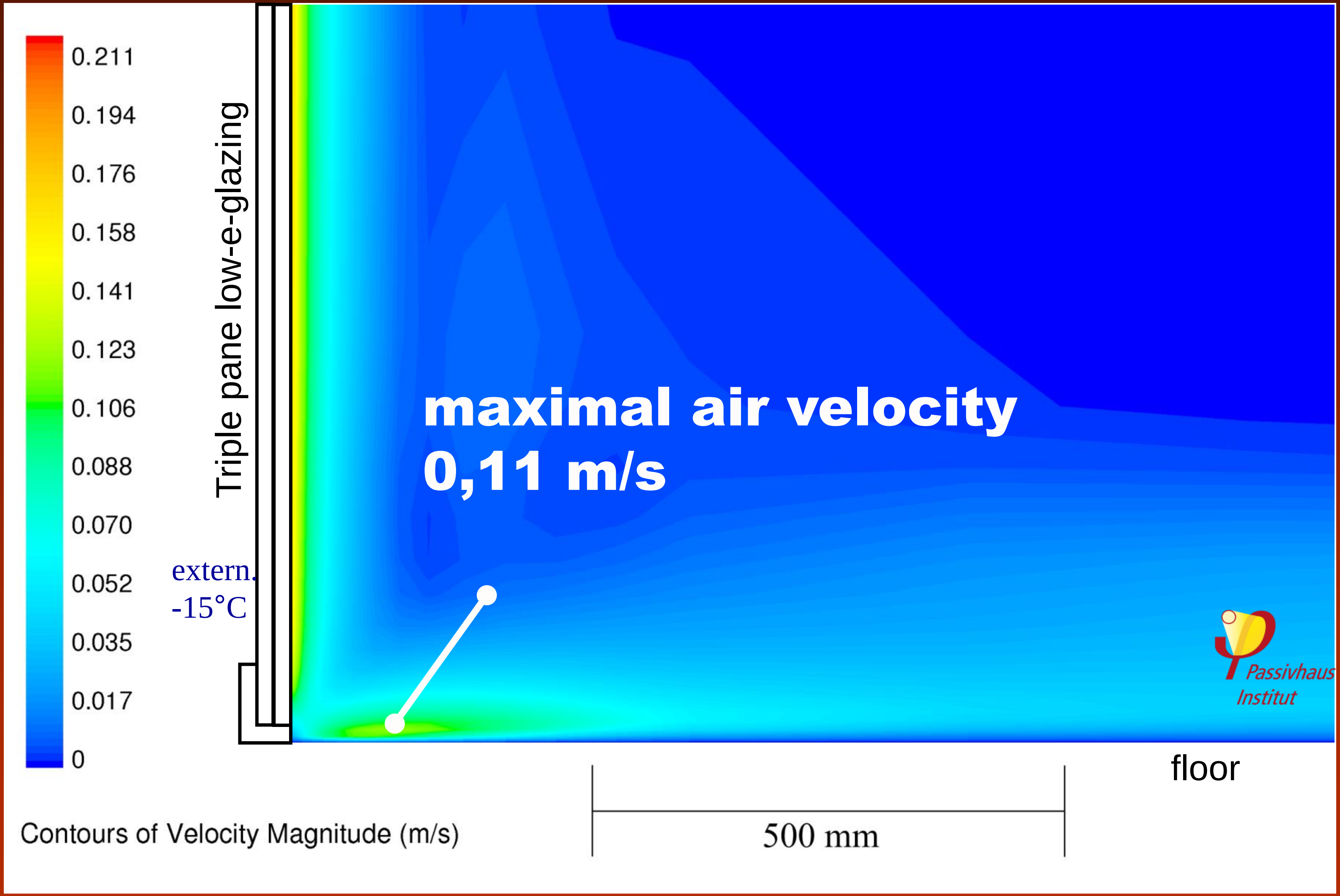






4,5 Cent/kWh

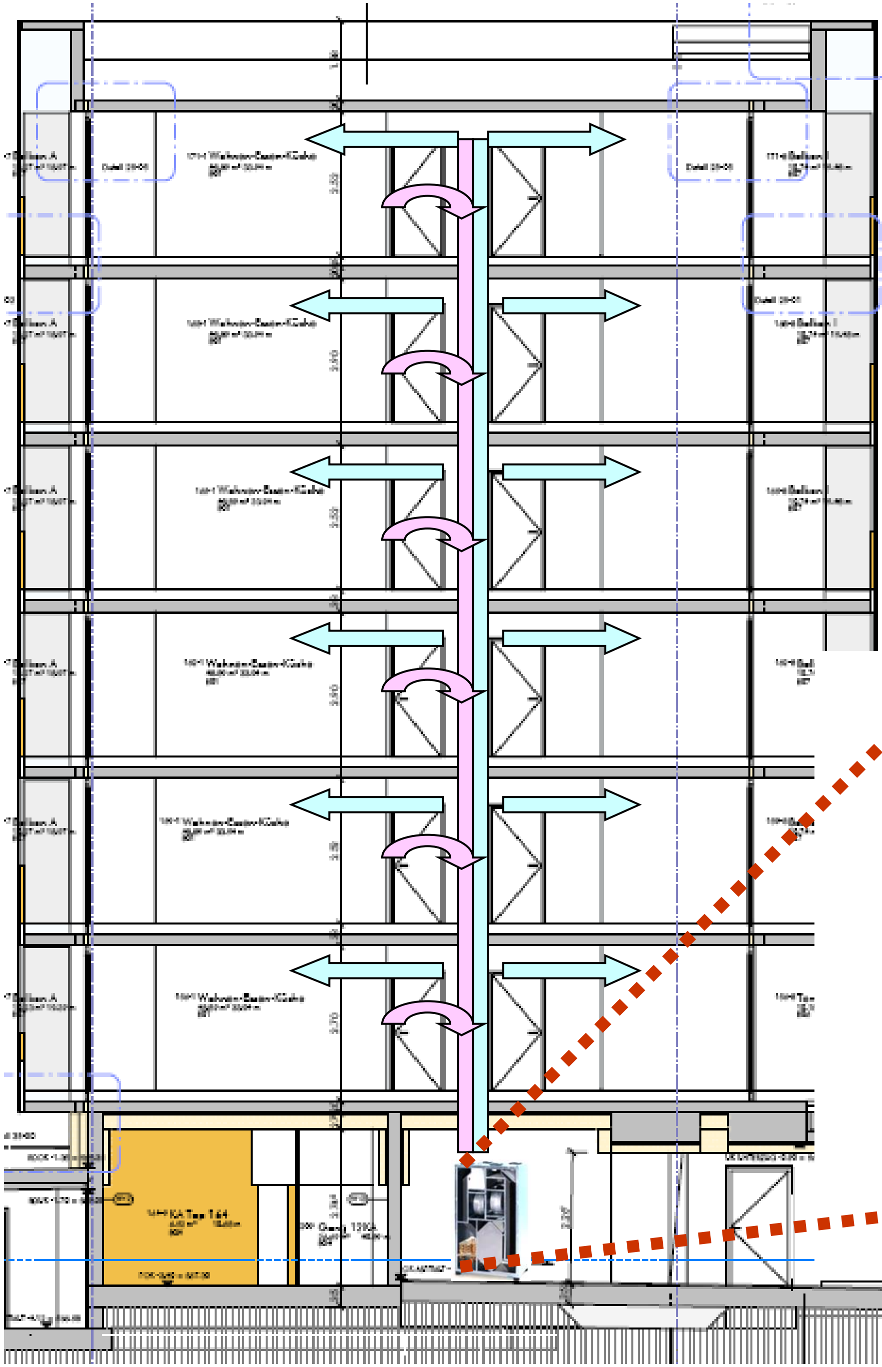
Best Possible Comfort – air flow at base of the window

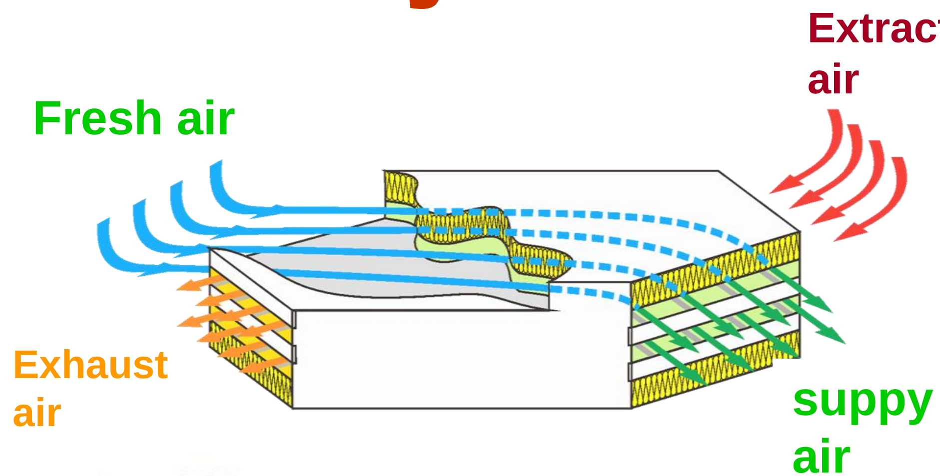


CFD-simulation of the air movement with a Passive House window (U = 0,85 W/m²/K) .

Boundary cond.: free convection
air temp. external -15°C
air temp. internal 20°C
(controlled)

heat-recovery





advantages –

- good IAQ
- best comfort
- no drafts
- better protection of the building

10 Cent/kWh

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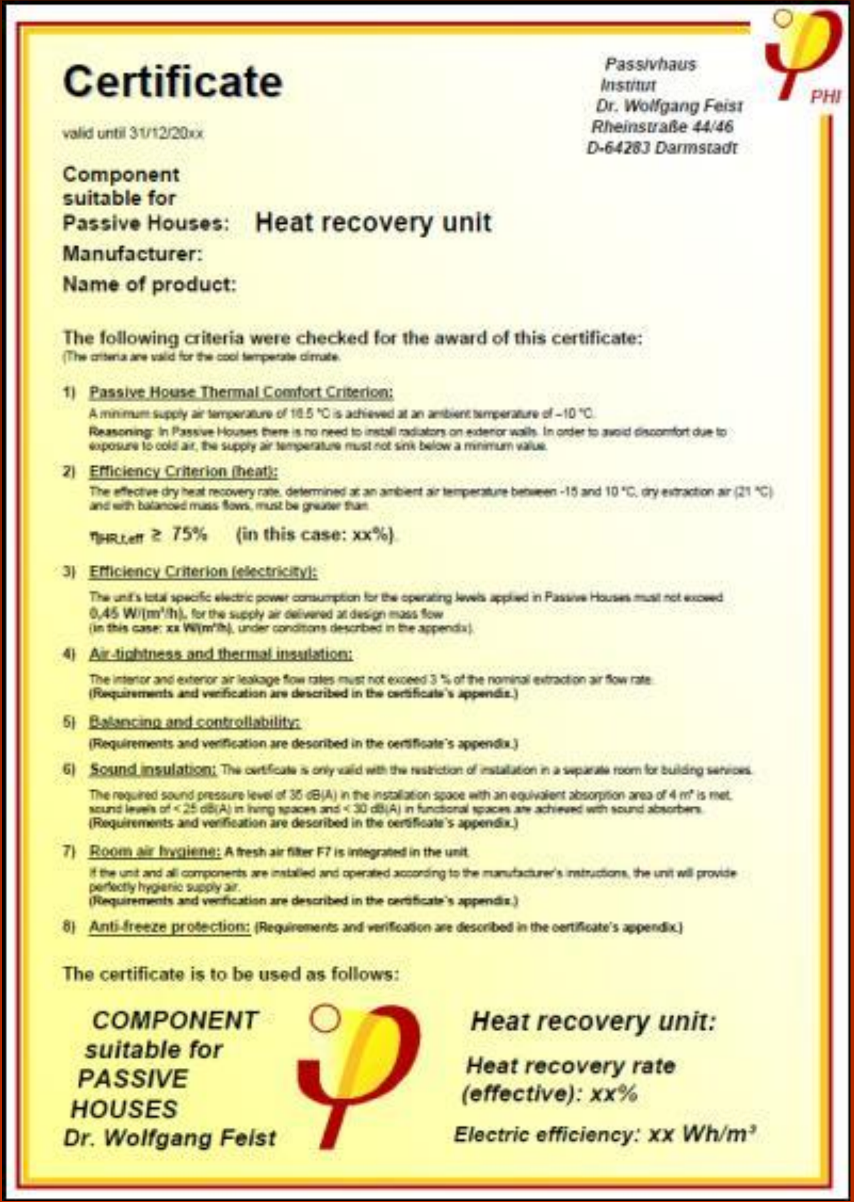
Heat Recovery Ventilation:

Criteria: Performance in the focus … should work in a real building!

- Comfortable supply air temperatures (always > 16.5° C),
- low air flow velocities
- Efficiency criterion - heat: η_{HR} > 75 %
- Efficiency criterion - electricity: max. 0.45 Wh/m³
- Good airtightness and thermal insulation
- Balance: outdoor/exhaust air
- and controlled operation (70/100/130 %)
- Noise protection: max (!) 25 dB(A) in living spaces
- Hygiene (filters)
- Frost protection



Certificate

Passivhaus Institut
Dr. Wolfgang Feist
Rheinstraße 44/46
D-64283 Darmstadt

PHI

valid until 31/12/20xx

Component suitable for Passive Houses: Heat recovery unit

Manufacturer:

Name of product:

The following criteria were checked for the award of this certificate:
(The criteria are valid for the cool temperate climate.

1) Passive House Thermal Comfort Criterion:
A minimum supply air temperature of 16.5 °C is achieved at an ambient temperature of –10 °C.
Reasoning: In Passive Houses there is no need to install radiators on exterior walls. In order to avoid discomfort due to exposure to cold air, the supply air temperature must not sink below a minimum value.

2) Efficiency Criterion (heat):
The effective dry heat recovery rate, determined at an ambient air temperature between -15 and 10 °C, dry extraction air (21 °C) and with balanced mass flows, must be greater than
$\eta_{HR,t,eff} \geq 75\%$ (in this case: xx%).

3) Efficiency Criterion (electricity):
The unit's total specific electric power consumption for the operating levels applied in Passive Houses must not exceed 0,45 W/(m³/h), for the supply air delivered at design mass flow
(in this case: xx W/(m³/h), under conditions described in the appendix).

4) Air-tightness and thermal insulation:
The interior and exterior air leakage flow rates must not exceed 3 % of the nominal extraction air flow rate.
(Requirements and verification are described in the certificate's appendix.)

5) Balancing and controllability:
(Requirements and verification are described in the certificate's appendix.)

6) Sound insulation: The certificate is only valid with the restriction of installation in a separate room for building services.
The required sound pressure level of 35 dB(A) in the installation space with an equivalent absorption area of 4 m² is met, sound levels of < 25 dB(A) in living spaces and < 30 dB(A) in functional spaces are achieved with sound absorbers.
(Requirements and verification are described in the certificate's appendix.)

7) Room air hygiene: A fresh air filter F7 is integrated in the unit.
If the unit and all components are installed and operated according to the manufacturer's instructions, the unit will provide perfectly hygienic supply air.
(Requirements and verification are described in the certificate's appendix.)

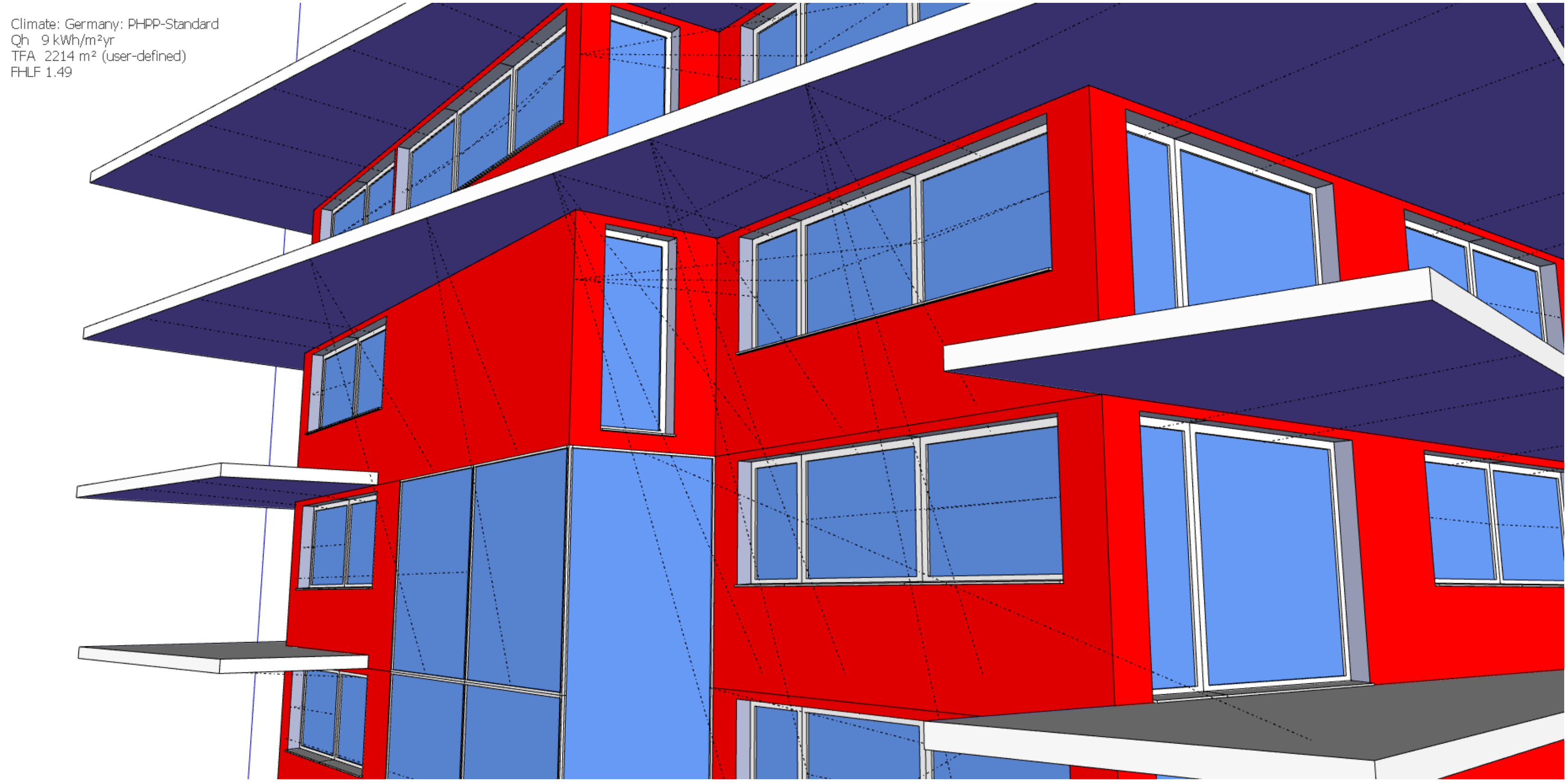
8) Anti-freeze protection: (Requirements and verification are described in the certificate's appendix.)

The certificate is to be used as follows:

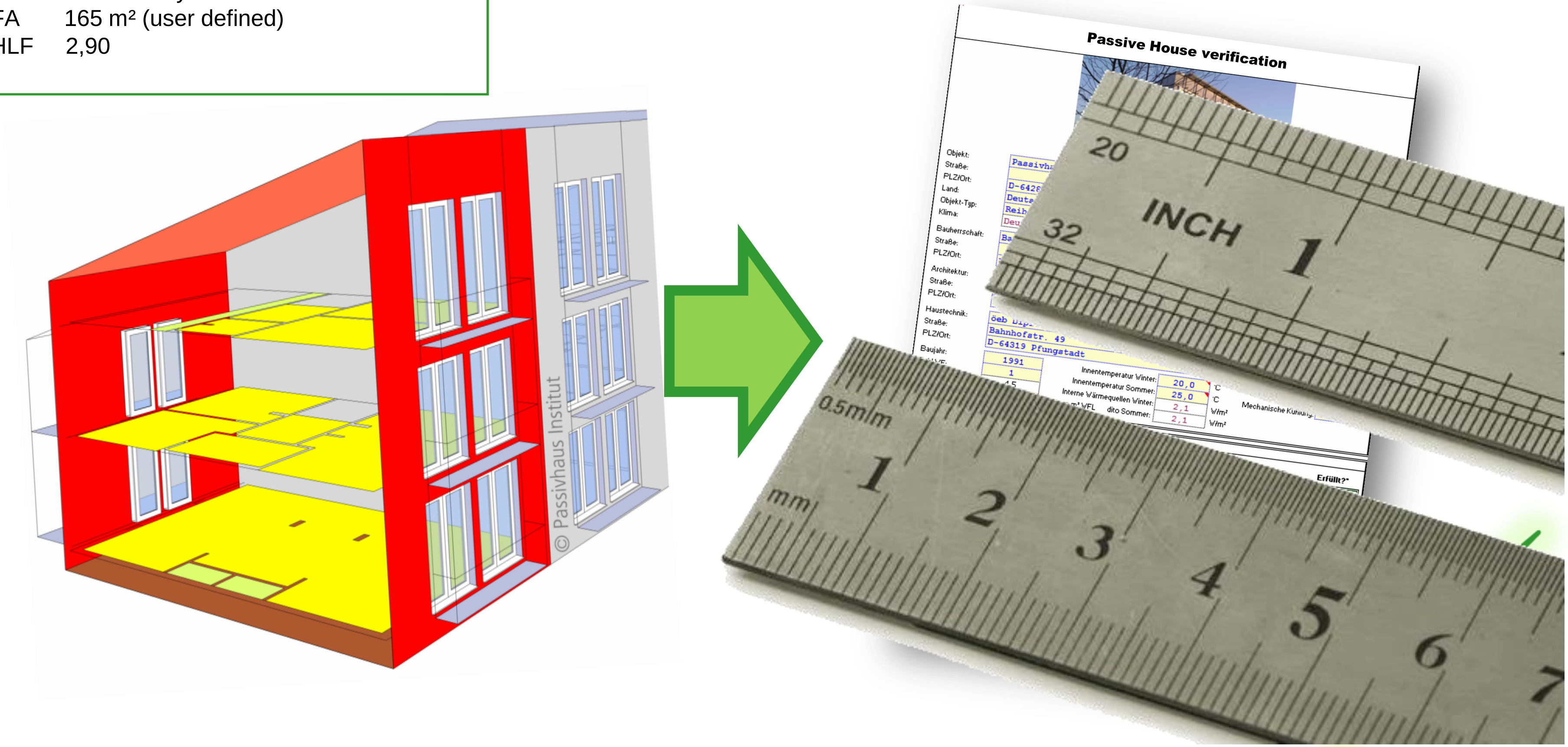
COMPONENT suitable for PASSIVE HOUSES
Dr. Wolfgang Feist

Heat recovery unit:
Heat recovery rate (effective): xx%
Electric efficiency: xx Wh/m³

***design*PH is a plugin for Trimble Sketchup which allows to design Passive House projects in 3D and import the model into PHPP**



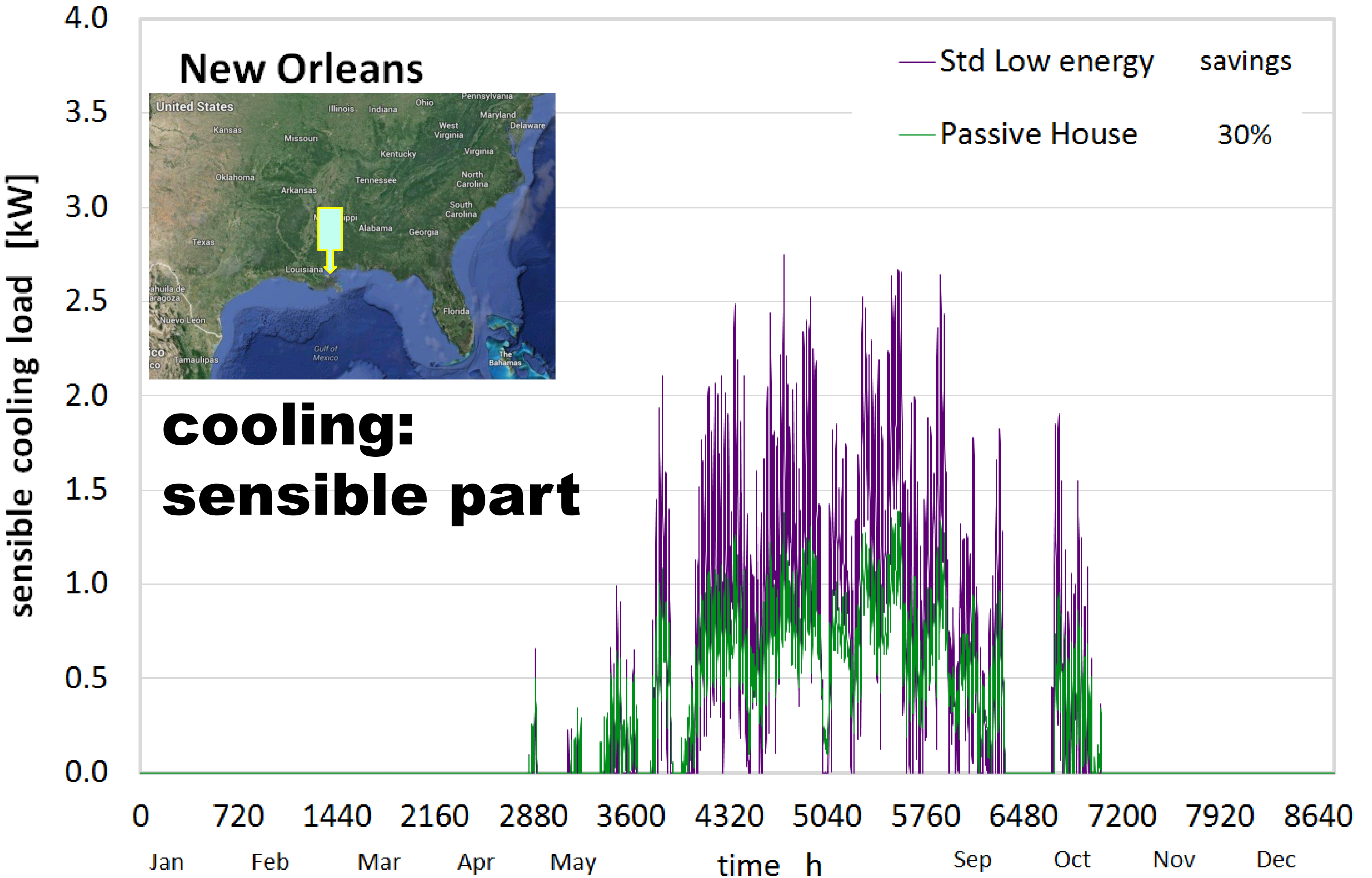
Climate: Germany: PHPP-Standard
Qh 15 kWh/m²yr
TFA 165 m² (user defined)
FHLF 2,90



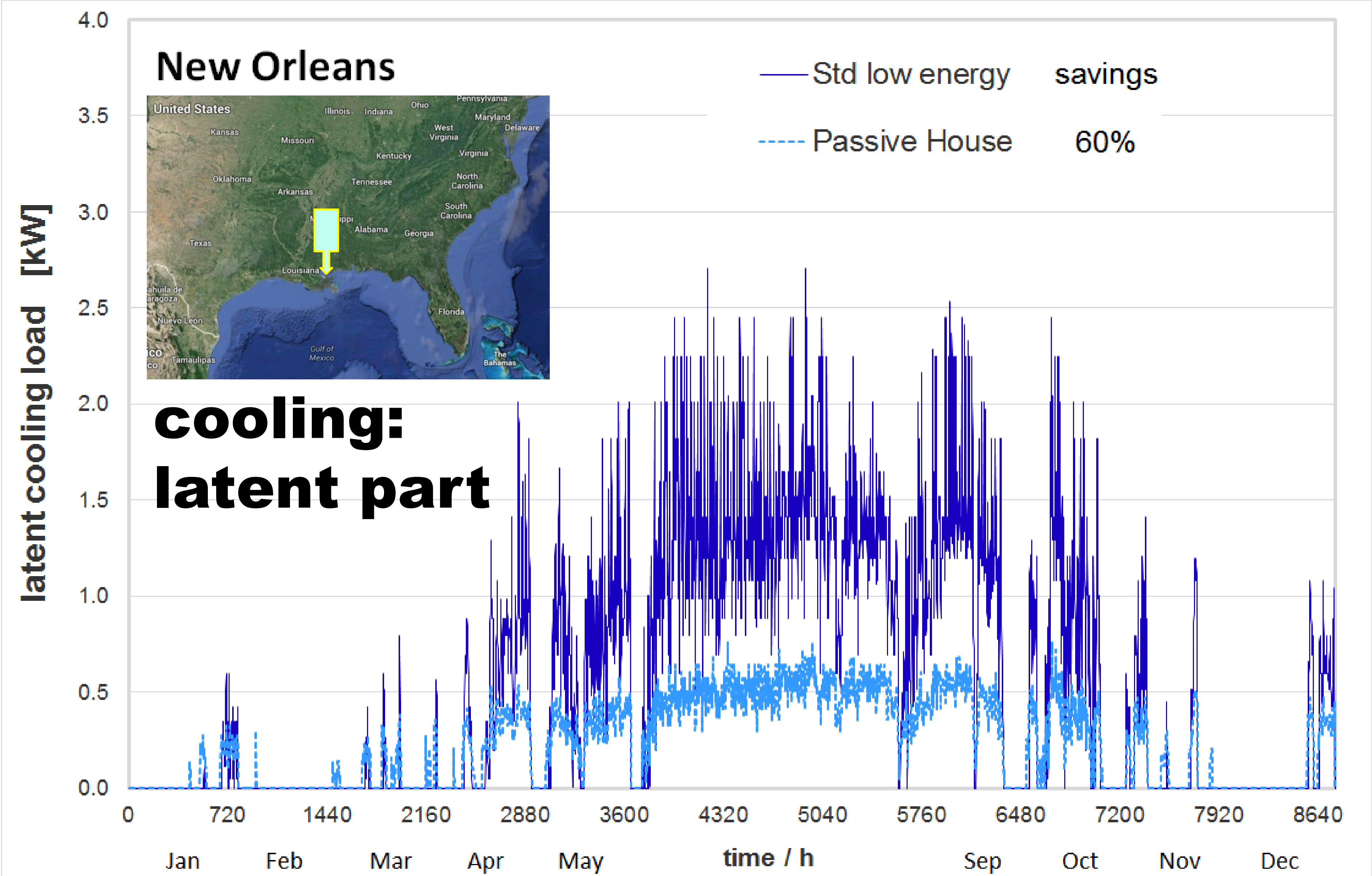
it's the helping hand for implementing good passive house projects

www.designph.org

Looking at different climates

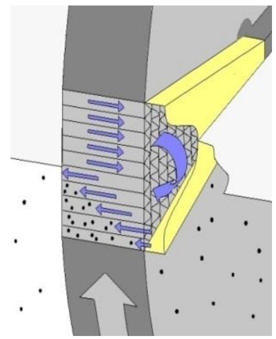


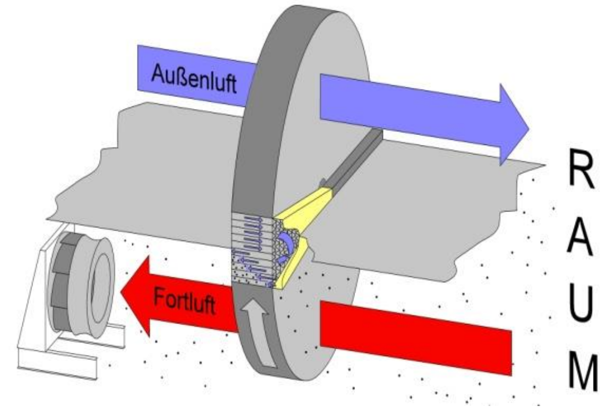
Cooling „latent part“: Dehumidification



Humidity recovery the other way: keep the humdity out!

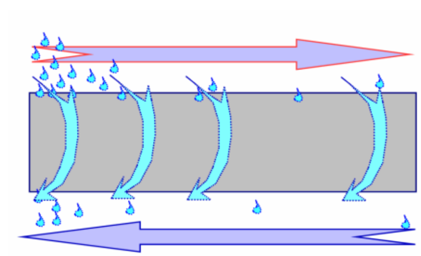
sorption wheel

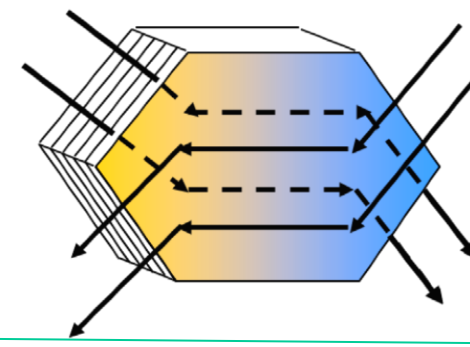




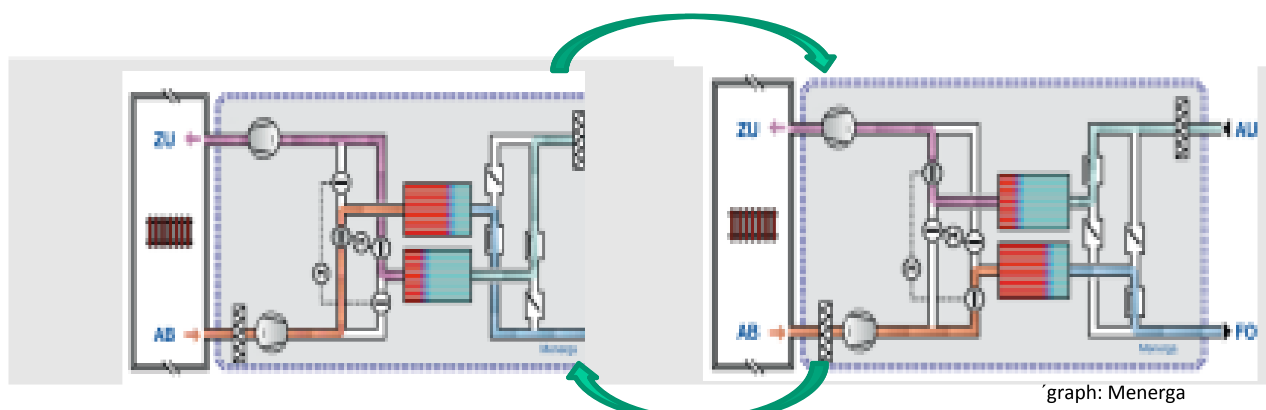
graph: Lautner

humidity-transfer-membrane





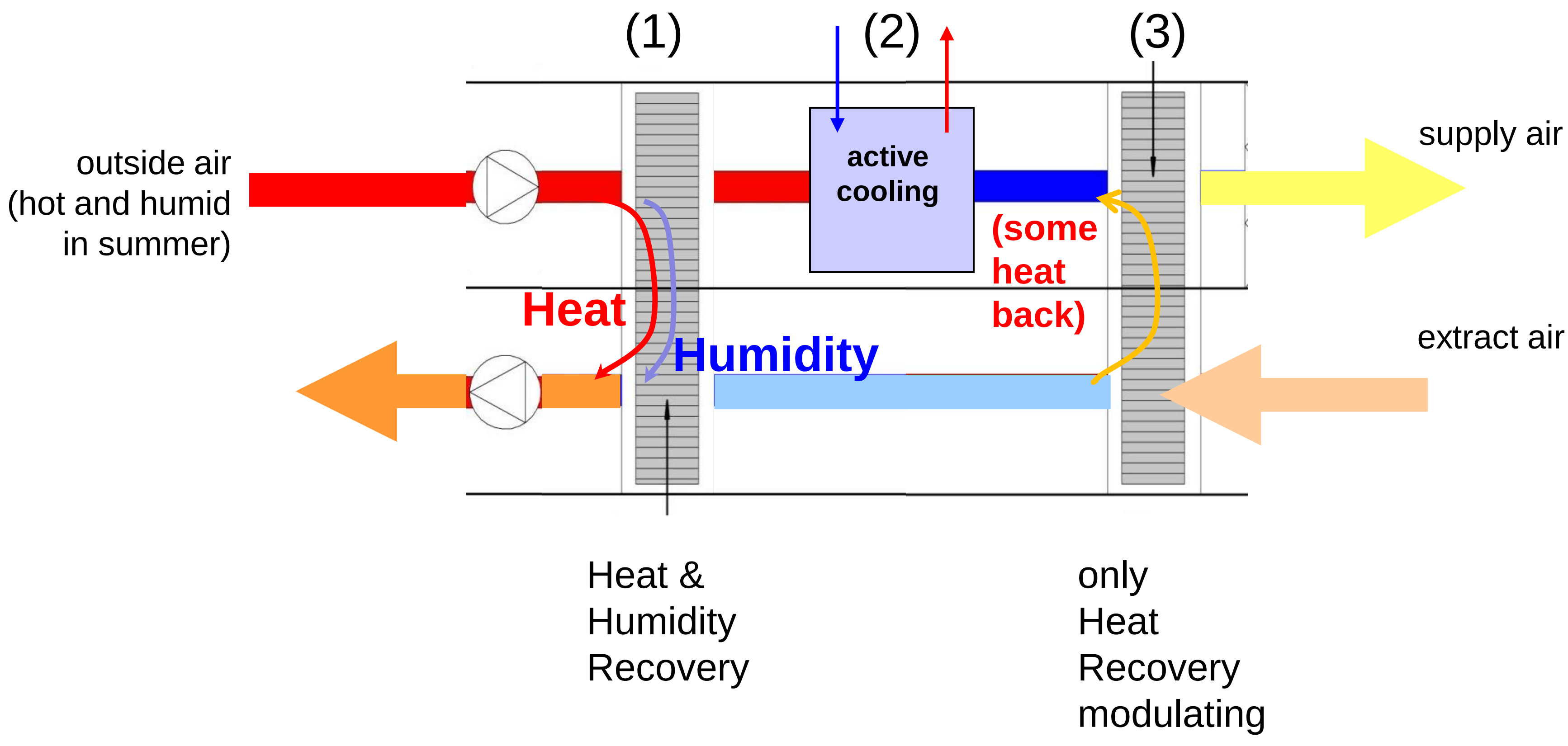
flap controlled counterflow



´graph: Menerga

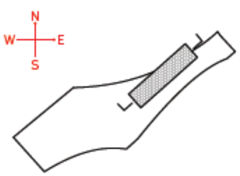
Solution: cooling &dehumidification supported by heat &humidity recovery

- Humidity recovery system (wheel, mebrane, switching, …) (1)
- active cooling coil – reaching comfort zone humidity (2)
- cooled air (humidity <12 g/kg) sometimes reheated by ordinary HRV (3)
- always appropriate cooling and dehumidification is possible



Example: hotel building near Shanghai, China

- used as a hotel, therefor high internal loads (that's challenging!)
- 2200 m² (TFA)   hotel: 20 m² each dwelling (1 Person)
- compact design (+)
- shading by architectual design (+)

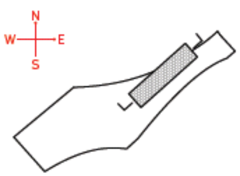


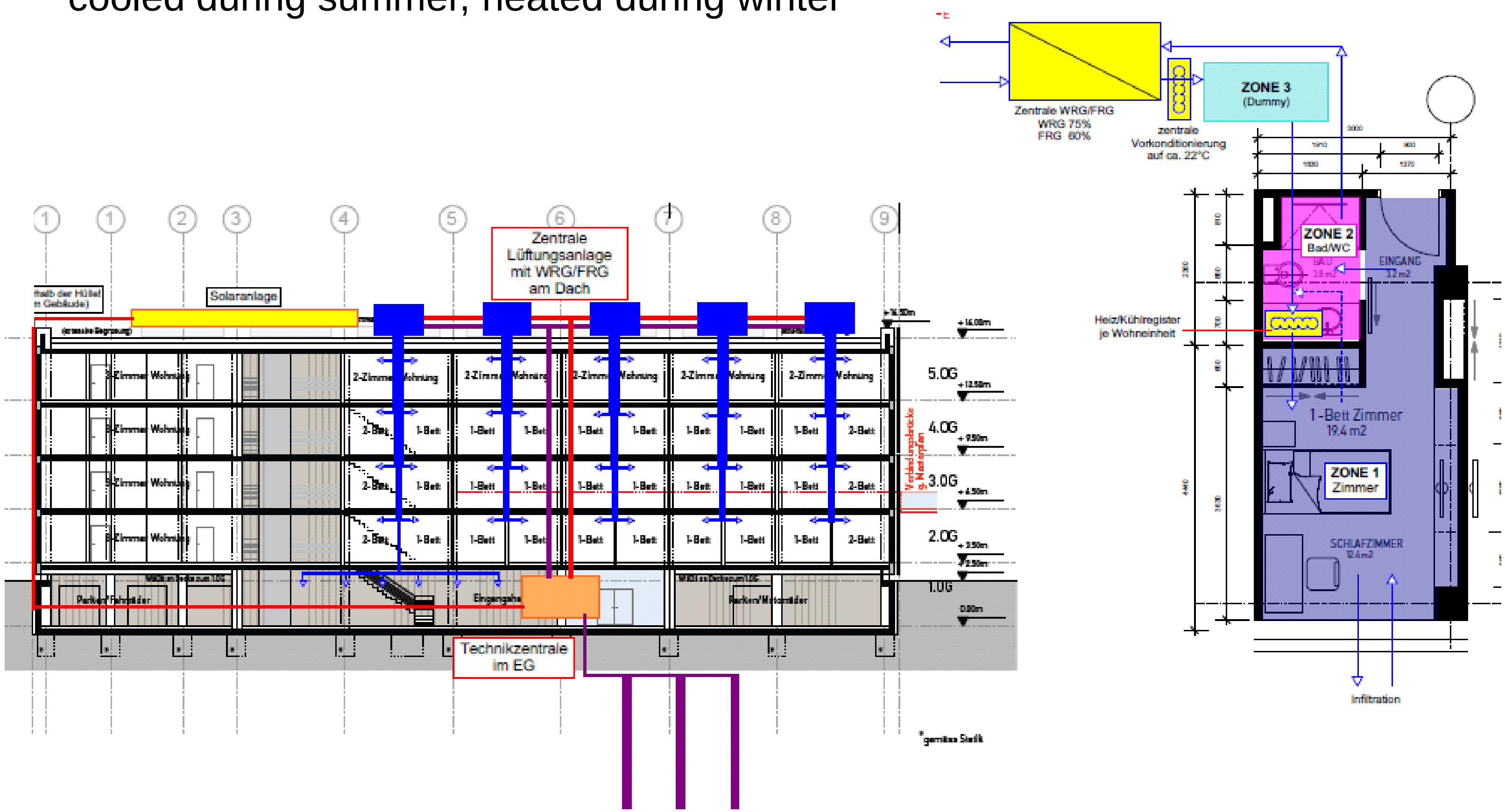
view from south east   **Architect: PeterRuge, Berlin**   **Contractor: Landsea, Shanghai, China**

LANDSEA CHANGXING BRUCK PASSIVE HOUSE

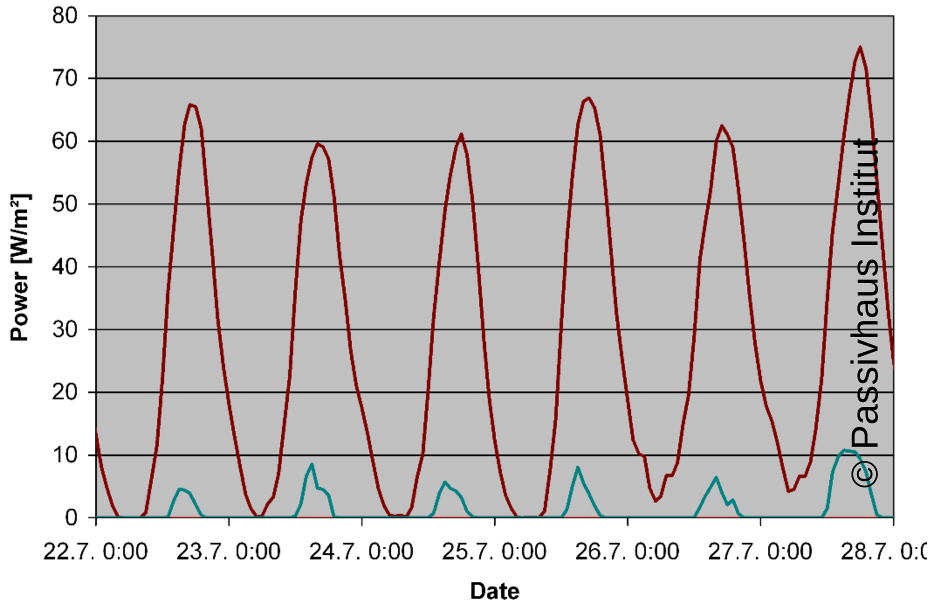
example: concept for cooling and dehumidification

- centralized preconditioning of air (MVHR)
  combined with dehumification to 12 g/kg   on roof
- decentral heating or cooling to adjust comfortable air temperatures
  with small circulation air heater/cooler in each dwelling (ach: 2/h)
- heat and cold source by water circle:
  cooled during summer, heated during winter

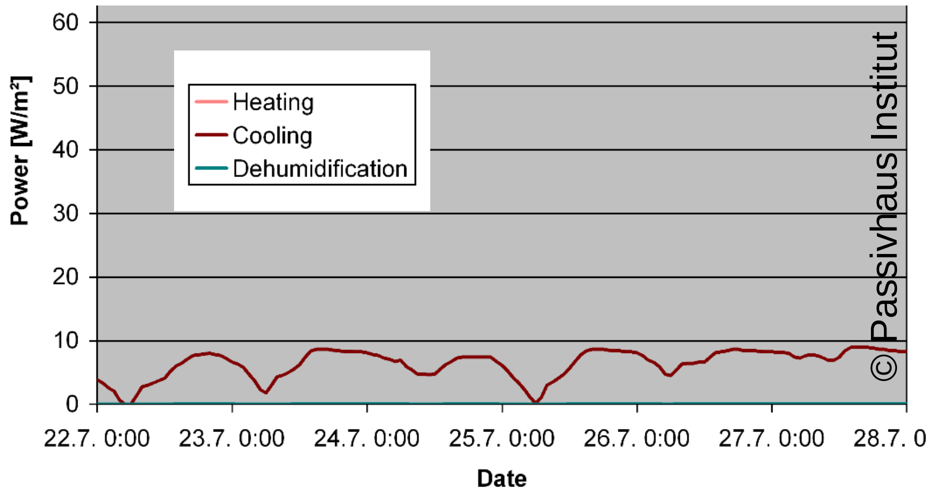




if active cooling needed in PH: no more cooling peak power problem



Existing old standard building: needs very <u>high cooling power</u>



Passive House: only <u>low cooling power</u> needed

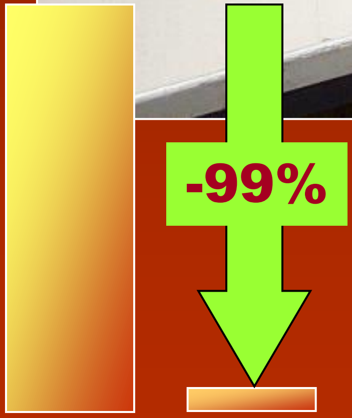
no electric peak power problem

Office A.S.S.A. Santa Croce, Italy
Arch: Silvia Mazzetti, Building Physics: Günther Gantioler

for more information see www.passipedia.org

Sustainable Solution – high Efficiency:
„electronic ink“

… and also in colour



76 Watt

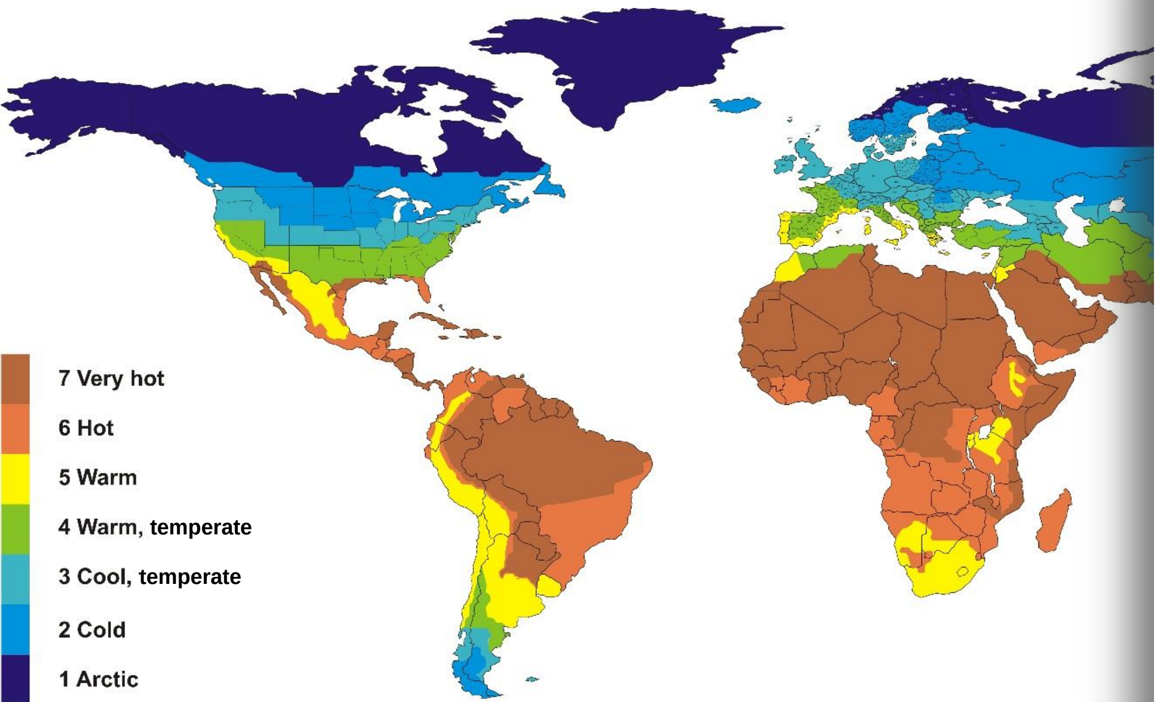
unter 1 Watt

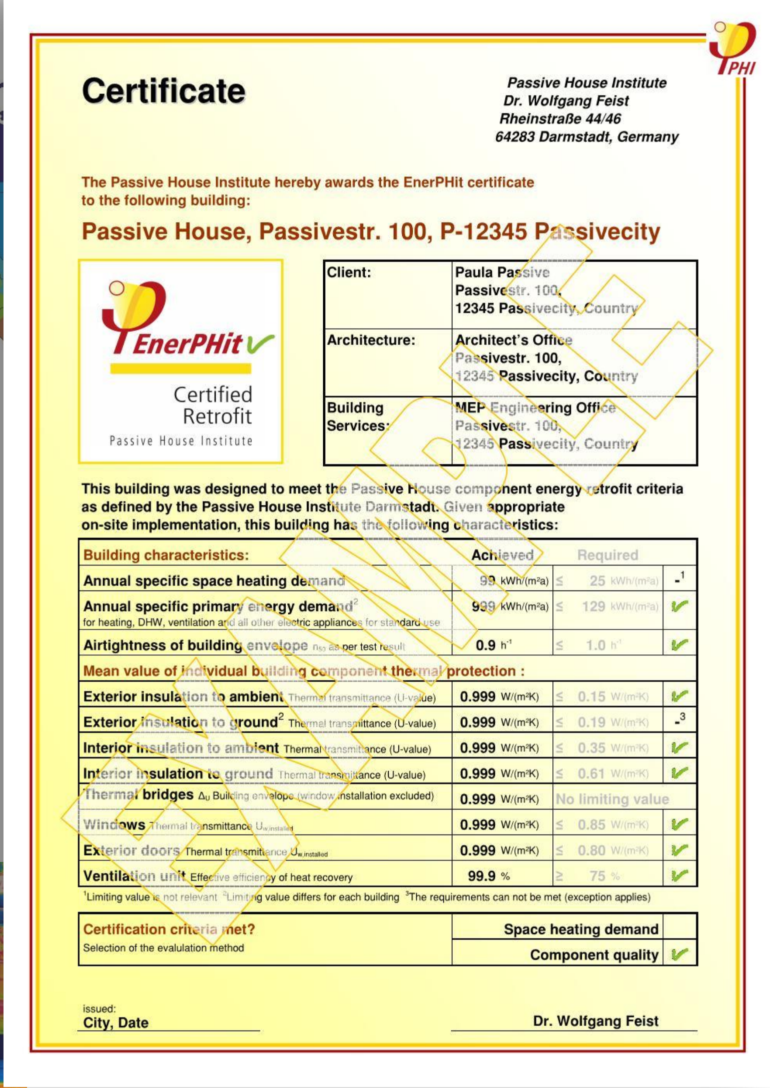
Energy efficiency is very cost efficient

EnerPHit standard for energy retrofit with PH components

International criteria available from end of 2014

Including sets of component requirements
for 7 climate zones





Certificate

Passive House Institute
Dr. Wolfgang Feist
Rheinstraße 44/46
64283 Darmstadt, Germany

The Passive House Institute hereby awards the EnerPHit certificate
to the following building:

Passive House, Passivestr. 100, P-12345 Passivecity

EnerPHit
Certified Retrofit
Passive House Institute

Client:	Paula Passive Passivestr. 100, 12345 Passivecity, Country
Architecture:	Architect's Office Passivestr. 100, 12345 Passivecity, Country
Building Services:	MEP Engineering Office Passivestr. 100, 12345 Passivecity, Country

This building was designed to meet the Passive House component energy retrofit criteria as defined by the Passive House Institute Darmstadt. Given appropriate on-site implementation, this building has the following characteristics:

Building characteristics:	Achieved		Required	
Annual specific space heating demand	99 kWh/(m²a)	≤	25 kWh/(m²a)	-[1]
Annual specific primary energy demand[2] for heating, DHW, ventilation and all other electric appliances for standard use	999 kWh/(m²a)	≤	129 kWh/(m²a)	✔
Airtightness of building envelope n_{50} as per test result	0.9 h^{-1}	≤	1.0 h^{-1}	✔
Mean value of individual building component thermal protection :				
Exterior insulation to ambient Thermal transmittance (U-value)	0.999 W/(m²K)	≤	0.15 W/(m²K)	✔
Exterior insulation to ground[2] Thermal transmittance (U-value)	0.999 W/(m²K)	≤	0.19 W/(m²K)	-[3]
Interior insulation to ambient Thermal transmittance (U-value)	0.999 W/(m²K)	≤	0.35 W/(m²K)	✔
Interior insulation to ground Thermal transmittance (U-value)	0.999 W/(m²K)	≤	0.61 W/(m²K)	✔
Thermal bridges Δ_U Building envelope (window installation excluded)	0.999 W/(m²K)	No limiting value		
Windows Thermal transmittance $U_{w,installed}$	0.999 W/(m²K)	≤	0.85 W/(m²K)	✔
Exterior doors Thermal transmittance $U_{w,installed}$	0.999 W/(m²K)	≤	0.80 W/(m²K)	✔
Ventilation unit Effective efficiency of heat recovery	99.9 %	≥	75 %	✔

[1]Limiting value is not relevant [2]Limiting value differs for each building [3]The requirements can not be met (exception applies)

Certification criteria met? Selection of the evalulation method	Space heating demand	
	Component quality	✔

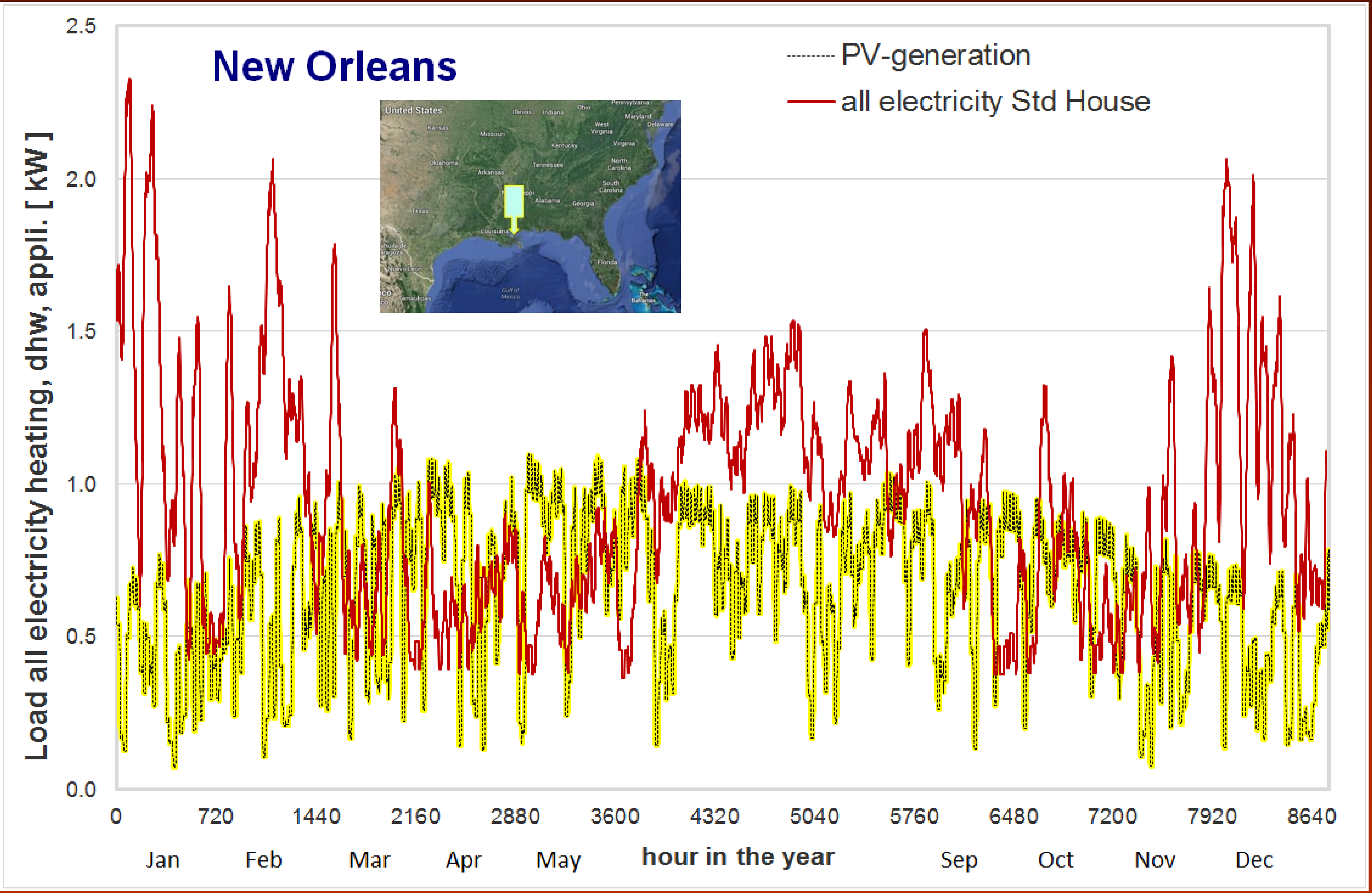
issued:
City, Date

Dr. Wolfgang Feist

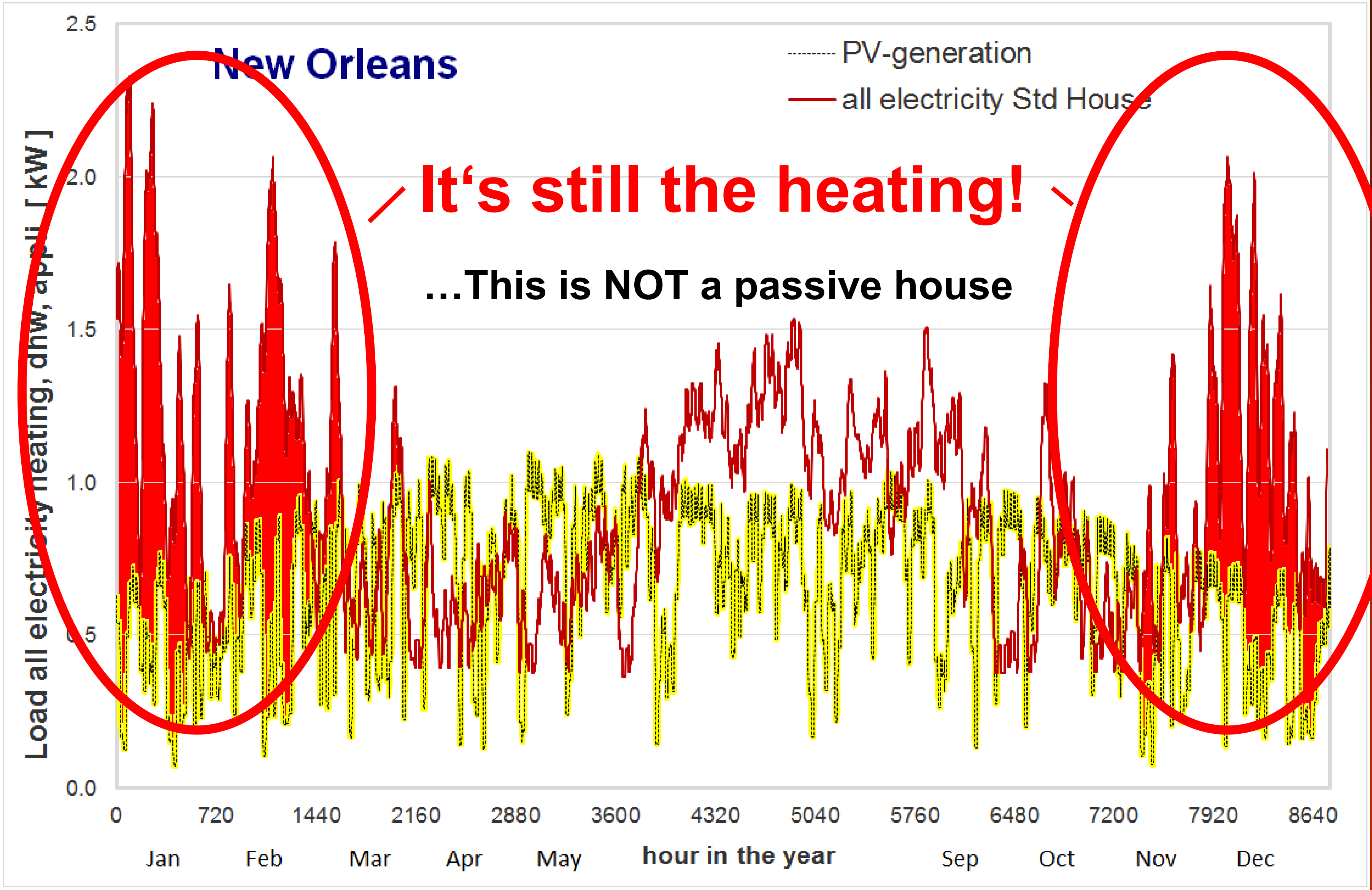
Tighthouse - Fabrica 718 J Torres Moskovitz, Thermal Image by Sam McAfee

Renewable Supply

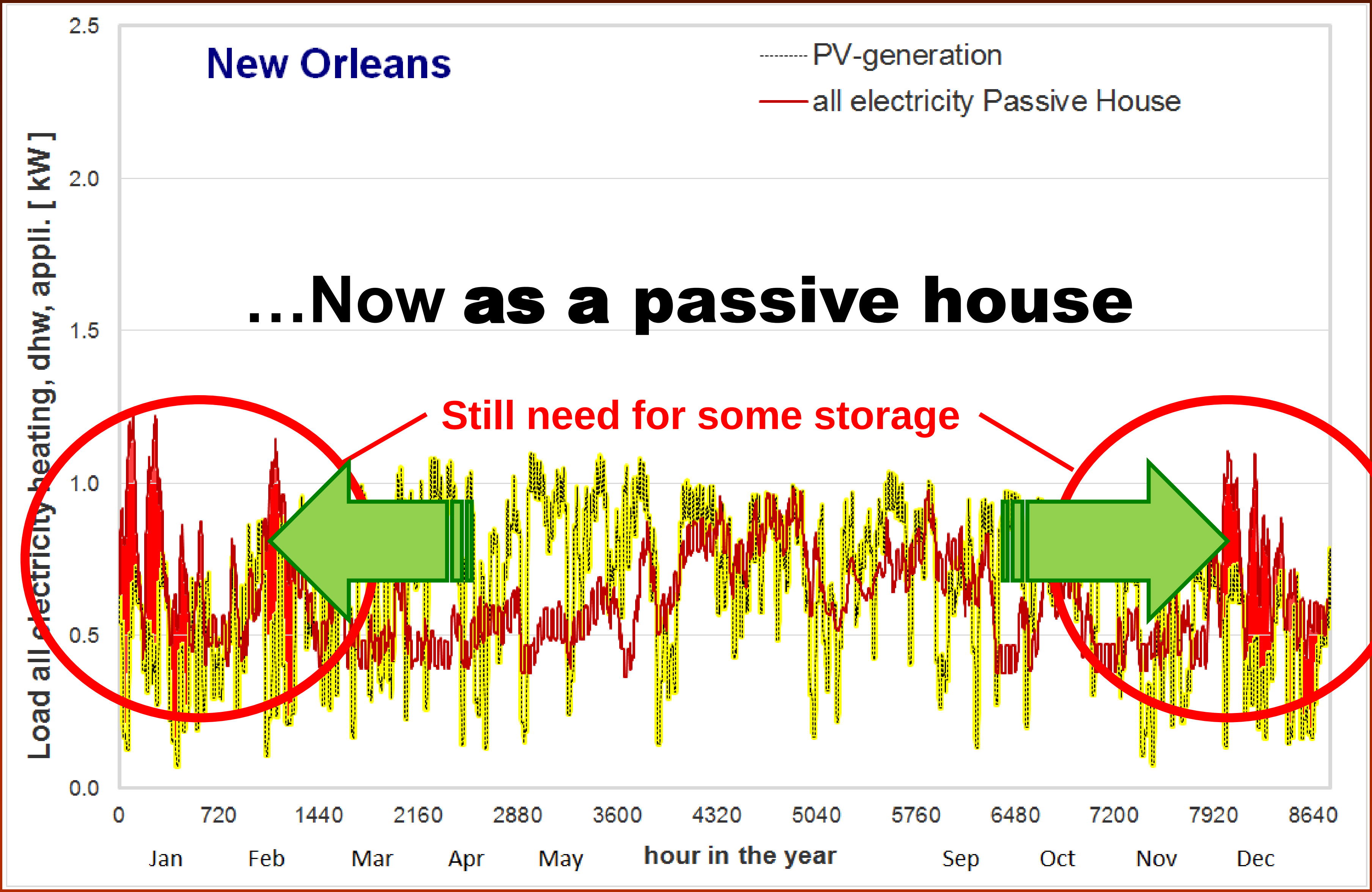
Renewable Supply and Load for all electricity



Renewable Supply and Load for all electricity

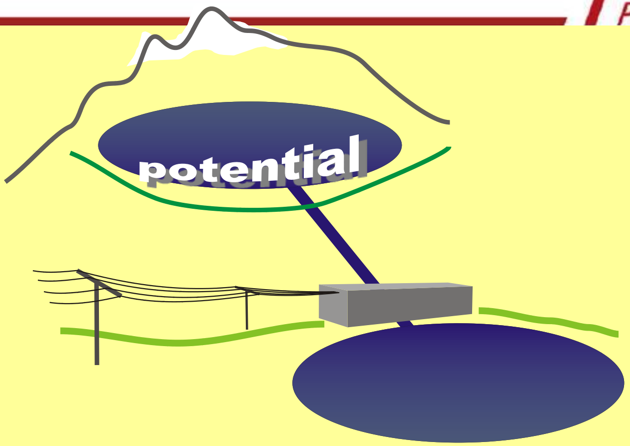


Renewable Supply and Load for all electricity



Energy Storage

Passive House



Storage technology

Flywheel
pump storage

mechanical

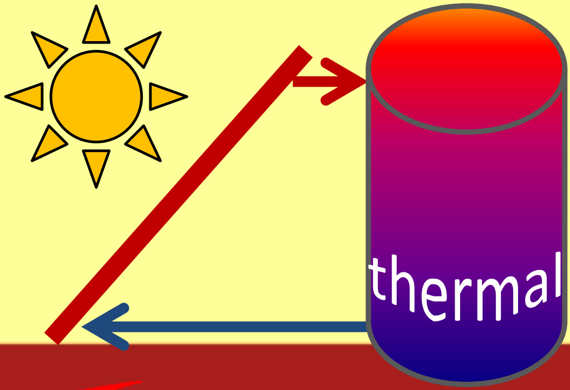
Battery
RES H_2
RES CH_4

chemical

High Temperature storage
Low Temperature storage
H_2O
LT storage soil

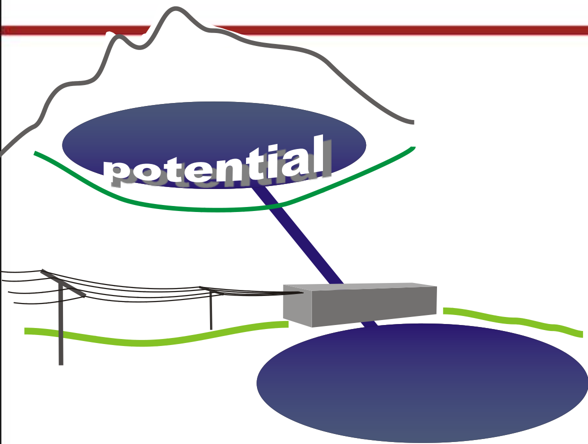
LT storage PCM

thermal



~~electromagnetic~~ ~~nuclear~~

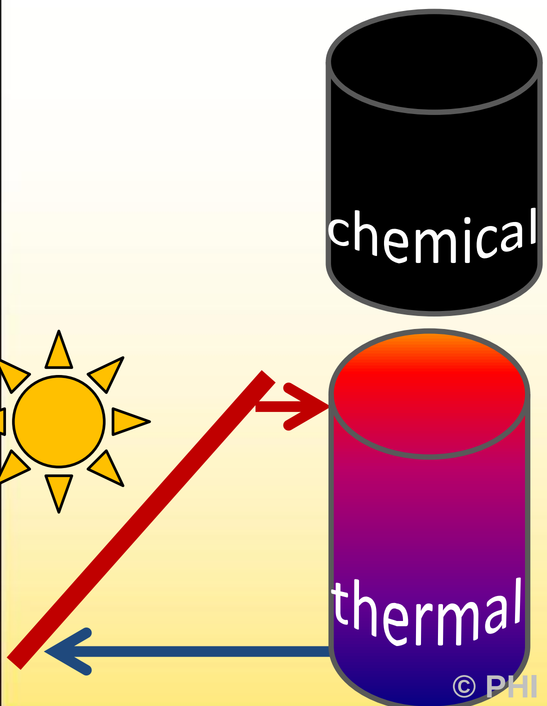
Energy Storage

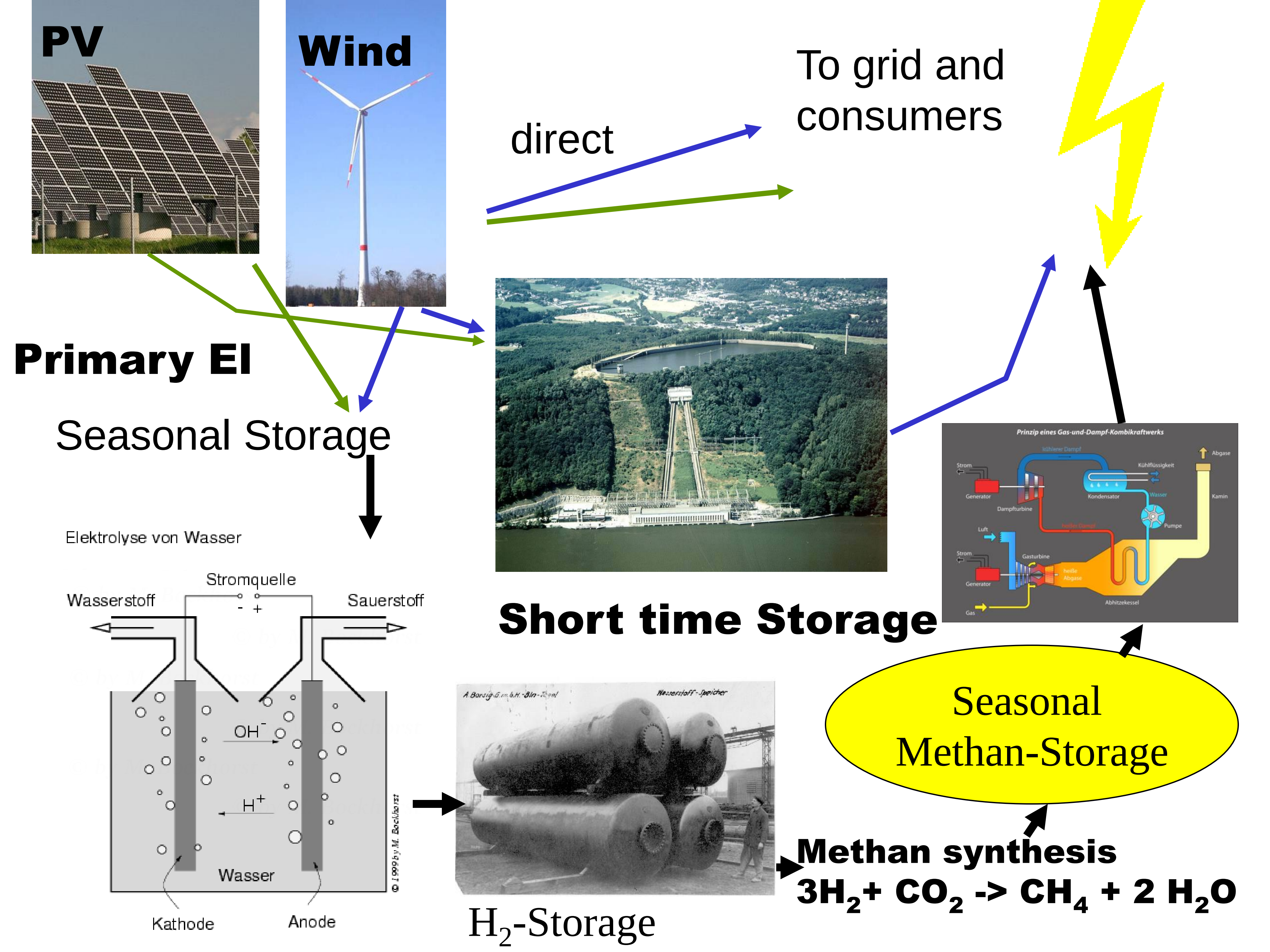


Storage technology	Efficiency [%]	*Daily cycle* *Storage costs* *[€/kWh]*	**Annual cycle** **costs per kWh @ 5 €cent/kWh source [€/kWh]**
Flywheel	95	*0.153*	22.20
Pump storage	75	*0.008*	2.60
Battery			
RES H_2	48		
RES CH_4 (Methan)	36		
High Temperature storage	45	*0.016*	5.00
Low Temperature storage H_2O	40	*0*	
LT storage soil			
LT storage PCM	50	*0.007*	**2.70**

25-39 Cent/kWh

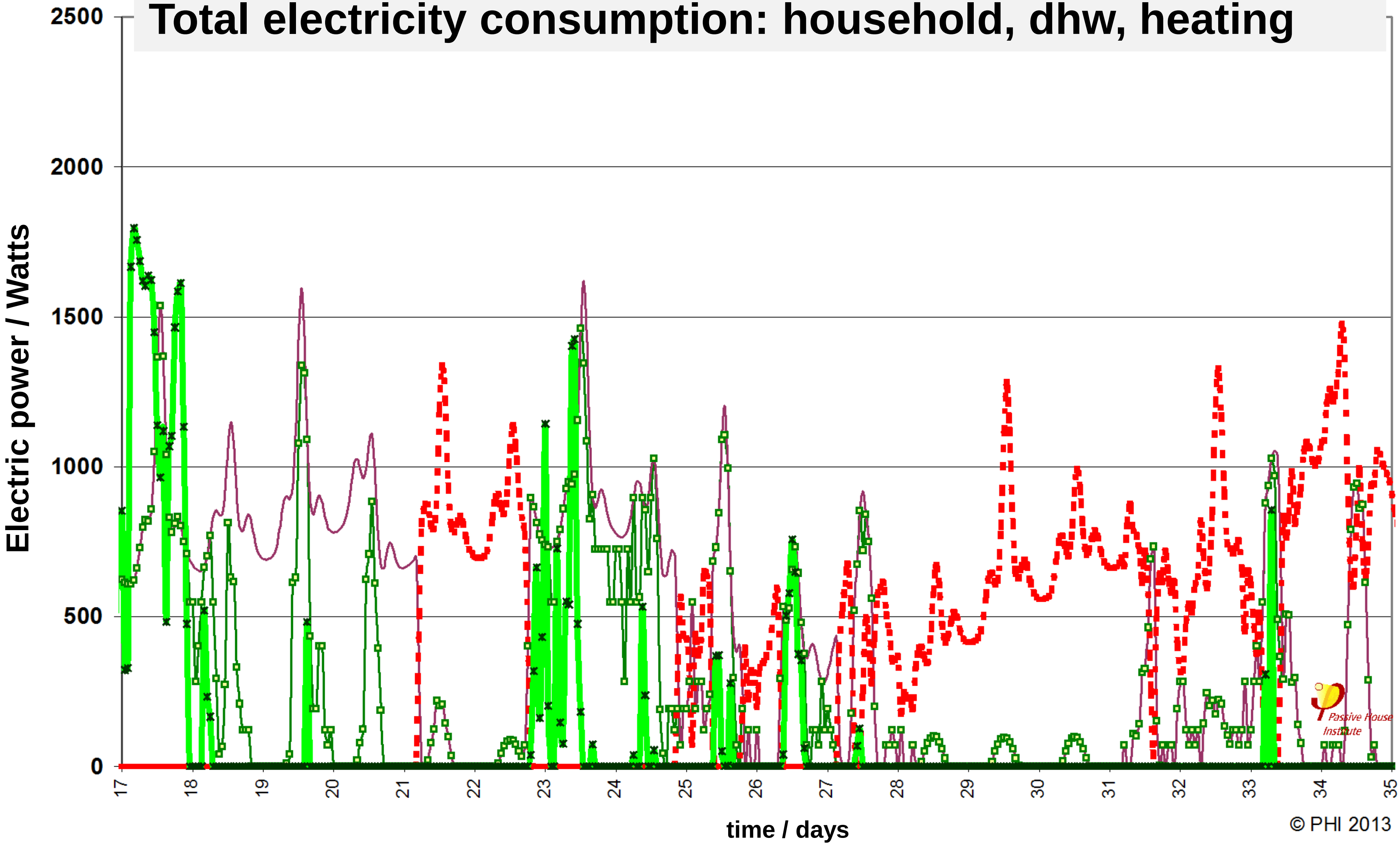
25-70 Cent/kWh





PV
Wind
direct
To grid and consumers
Primary El
Seasonal Storage
Short time Storage
Elektrolyse von Wasser
Stromquelle
Wasserstoff
Sauerstoff
- +
OH⁻
H⁺
Wasser
Kathode
Anode
© 1999 by M. Bockhorst
A Borsig G.m.b.H.-Bln-Tegel
Wasserstoff-Speicher
H_2-Storage
Prinzip eines Gas-und-Dampf-Kombikraftwerks
Seasonal Methan-Storage
Methan synthesis
$3H_2 + CO_2 \rightarrow CH_4 + 2\,H_2O$

Total electricity consumption: household, dhw, heating



Domestic electricity: total delivery by Primary Electricity (circles), from short time storage (violett) and seasonal storage using RES-Methan, (red dotted). &Energy for storage (light green)

Prof. Dr. Wolfgang Feist
University of Innsbruck and Passive House Institute

Primary Energy Renewable PER

Will be dependent on the application – especially the time-development of the requirements

$$PER = \frac{E_{dir} + E_{MS} / \eta_{MS} + E_{SS} / \eta_{SS} + E_{DL}}{E_{dir} + E_{MS} + E_{SS}}$$

E_{dir} in time directly generated electricity by RES

E_{MS} electricity from short/medium time storage

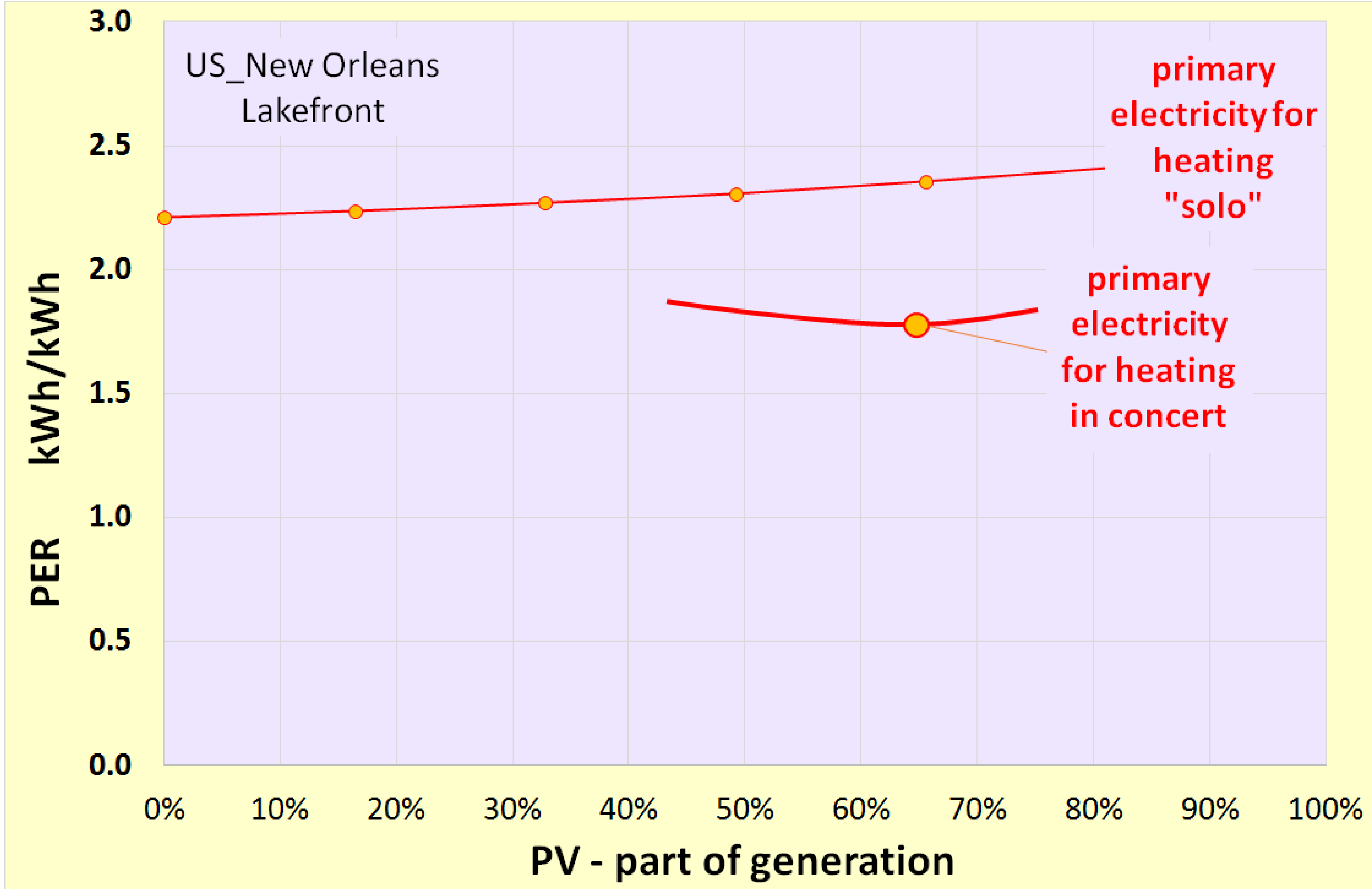
E_{SS} electricity generated from energy in seasonal storage

E_{DL} distribution and other losses

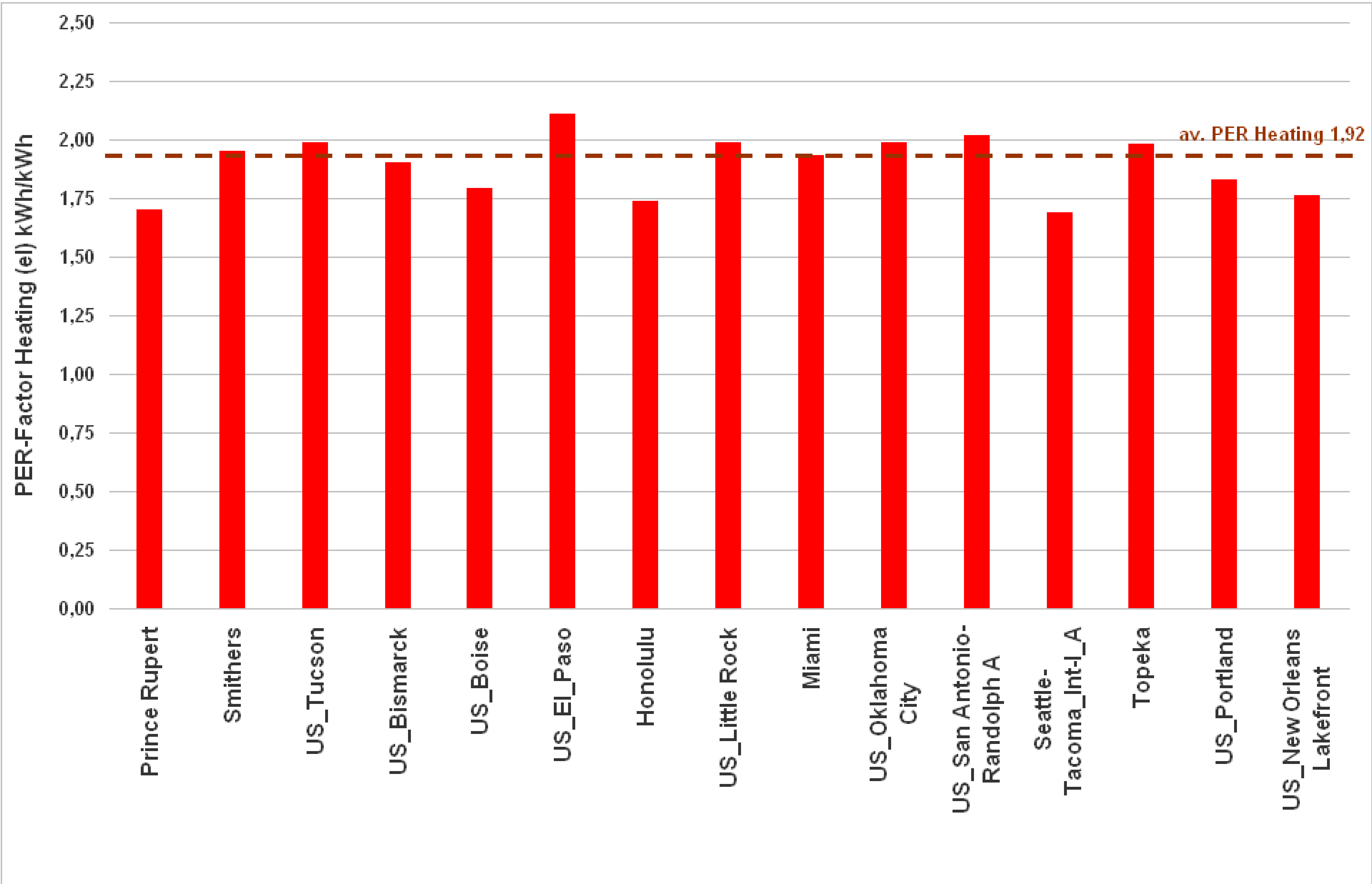
η_{MS} and η_{SS} efficiencies of storage processes (whole chain)

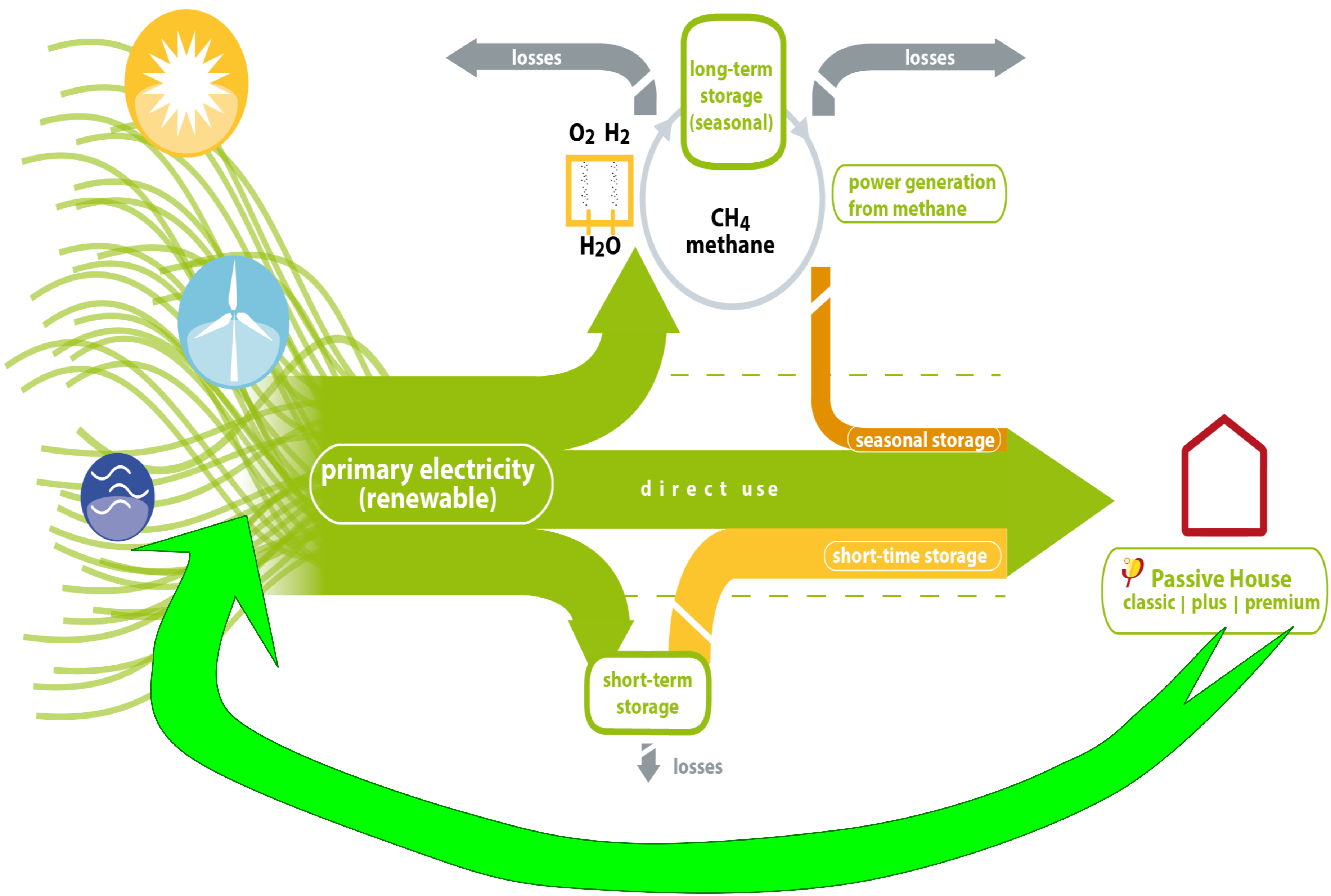
Prof. Dr. Wolfgang Feist
Universität Innsbruck und Passivhaus

Primary Energy Renewable for Heating PER



Primary Energy Renewable for Heating PER US





losses
long-term
storage
(seasonal)
losses
O_2 H_2
H_2O
CH_4
methane
power generation
from methane
seasonal storage
primary electricity
(renewable)
direct use
short-time storage
Passive House
classic | plus | premium
short-term
storage
losses

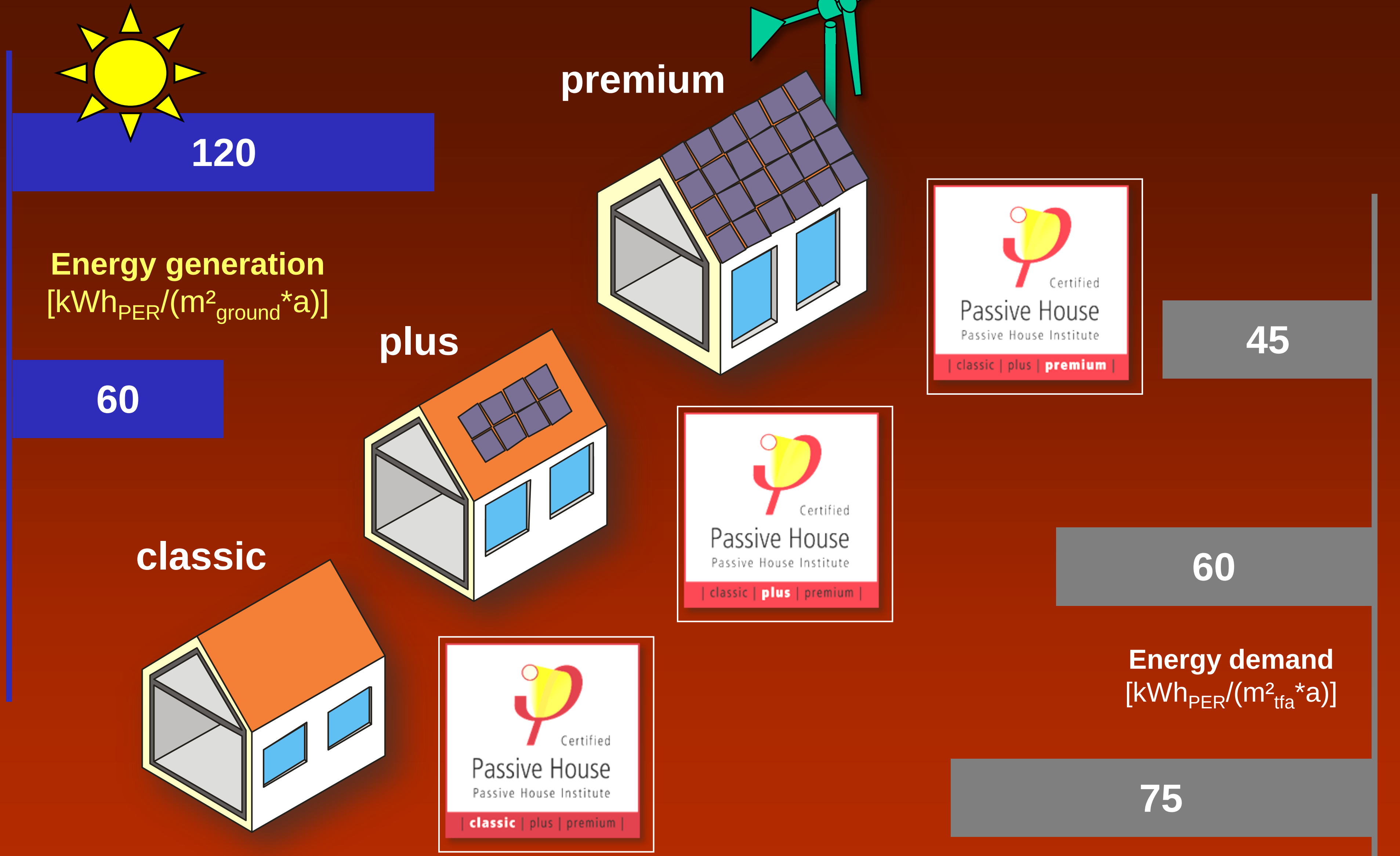
Primary Energy Renewable PER

Application	Final Energy	PER	A_{PV}
Appliances, light,..	electricity	1.25	**23**
dhw (via heatpump)	electricity	1.19	**4**
heating by heatpump	electricity	1.76	**4**
cooling (el. comp)	electricity	1	**3 + 3**
heating (gas boiler)	RES-Methan	1.75	
heating (gas boiler)	Bio-gas **(Bugdet 20 kWh/m²)**	1.1	
District heating	CHP 90%	1.1	
District heating	CHP 70%	1.5	

Equivalent PV-aerea / m² per dwelling (sum 37)

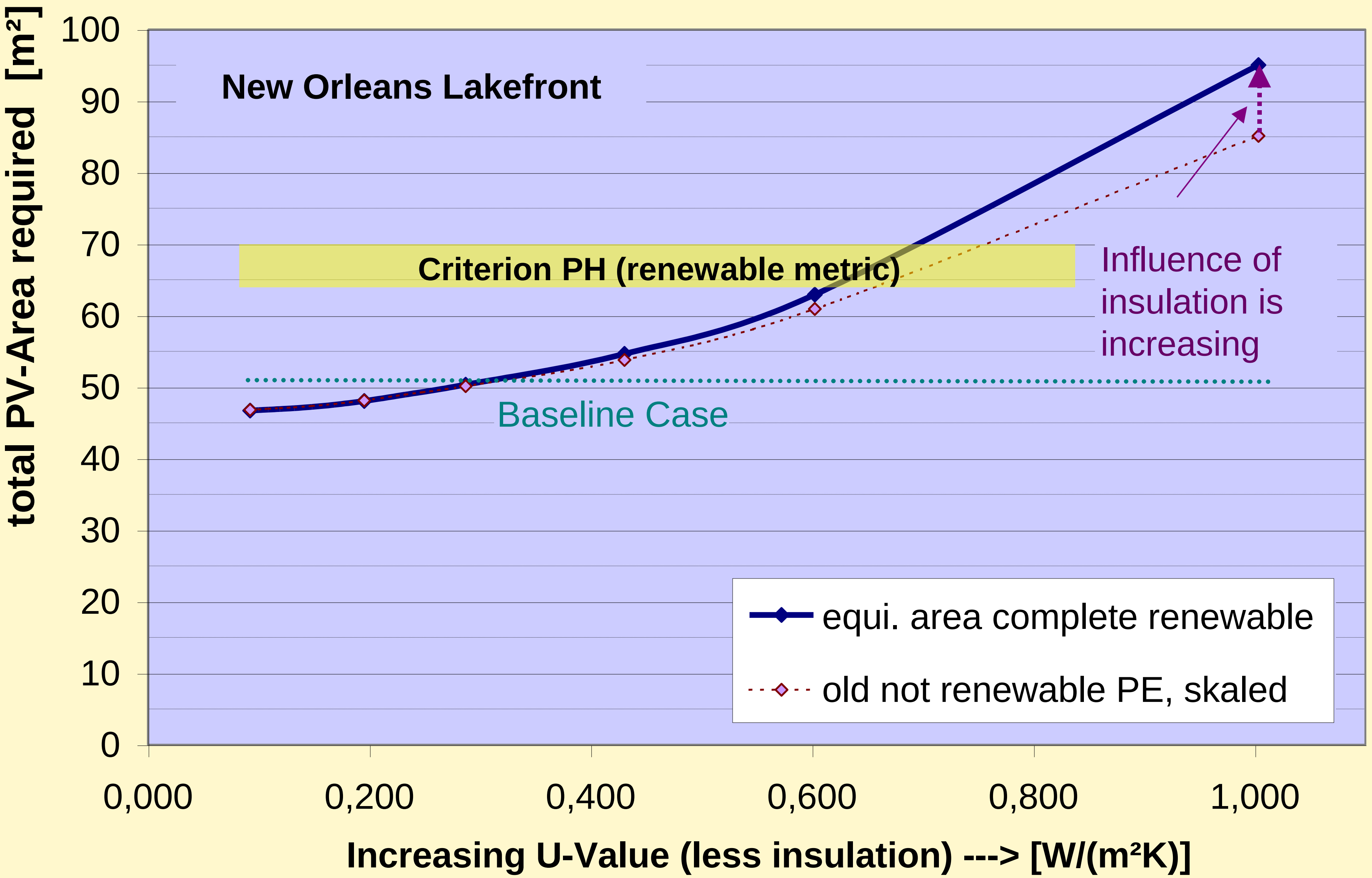
Site: New Orleans / preliminary results / will be further developed to regional figures

The new Passive House Classes

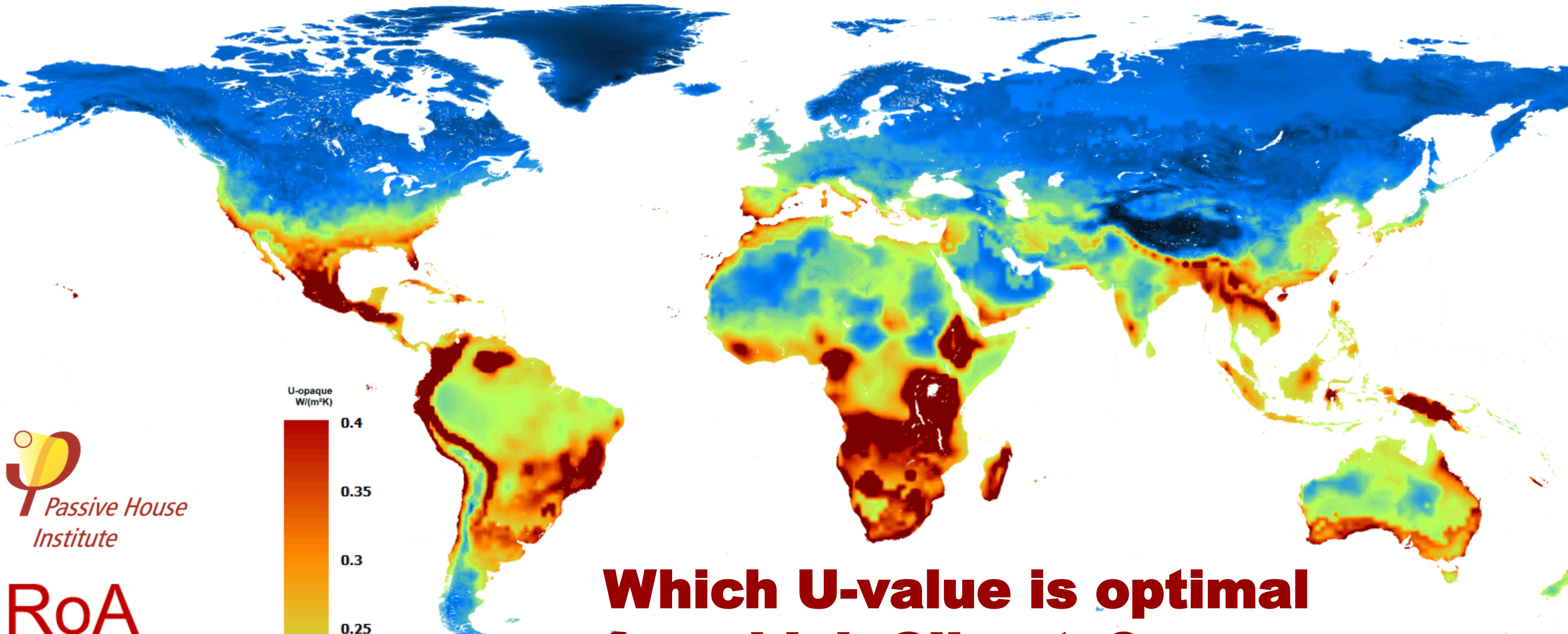


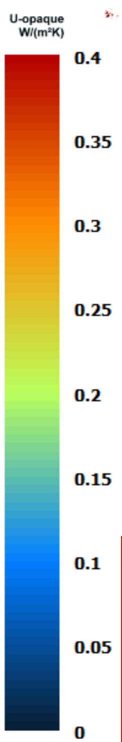
Energy efficiency and renewable energy generation – The Dream Team

Primary Energy Renewable for everything



Climate – Climatic Conditions





Passive House Institute

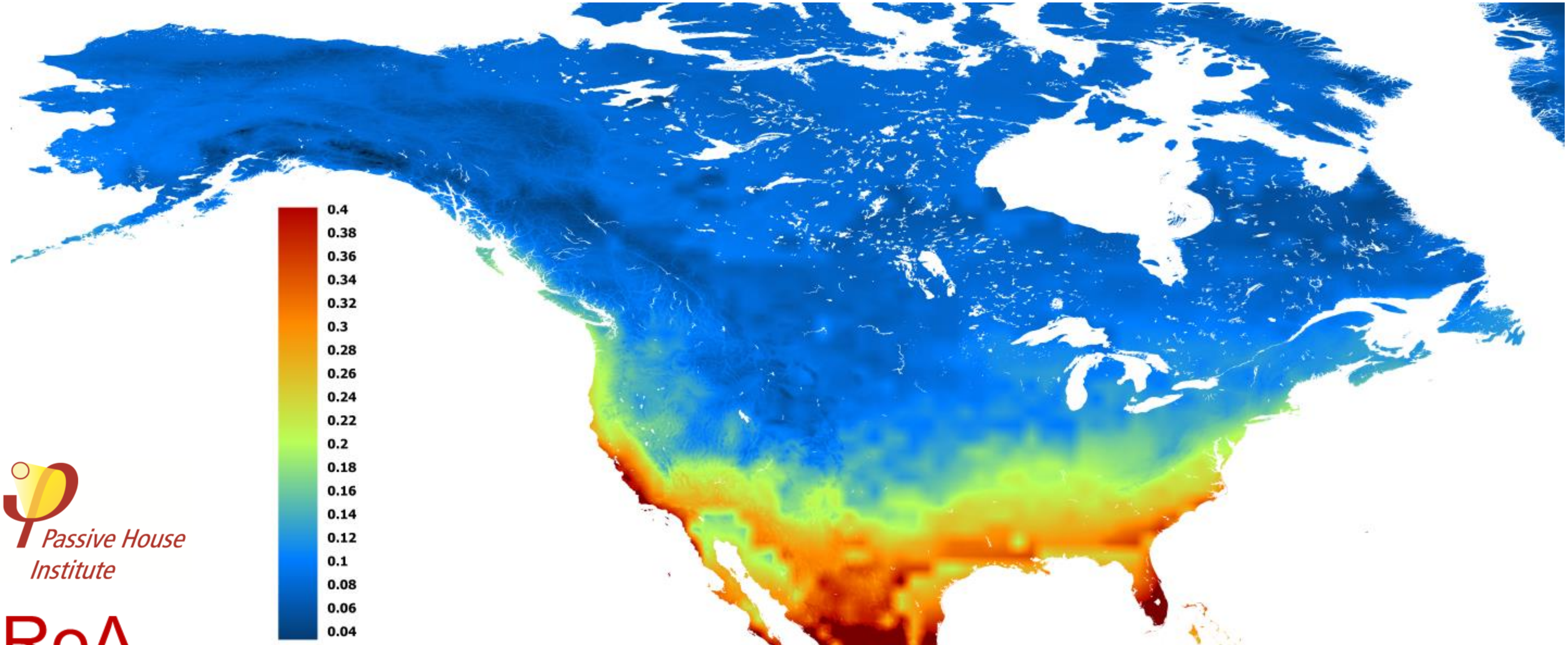
RoA

Which U-value is optimal for which Climate?

Schnieders / Feist / Rongen

Which window-type?
Which ventilation mode?

Climatic Conditions



Passive House Institute

RoA

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Passivhaus Institut

Passive Houses around the globe

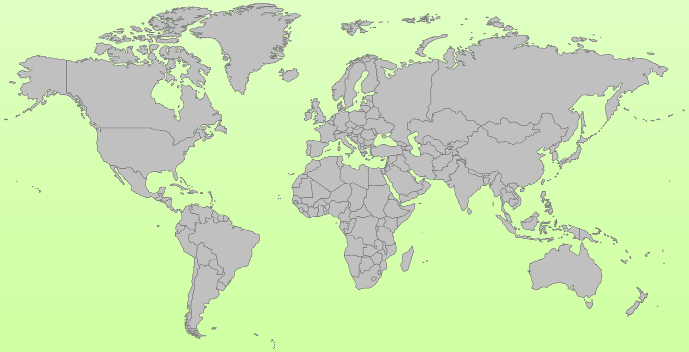
International

PASSIVE HOUSE

Association

iPHA

The international network for Passive House knowledge
Promoting the Passive House Standard worldwide



www.passivehouse-international.org

passipedia

Part 1: general information for the public

Part 2: information and tools for members

19TH INTERNATIONAL PASSIVE HOUSE CONFERENCE 2015

Congress-Center Leipzig

17-18 April, 2015

with exhibition and framework programme

(15 – 19 April 2015)

Passivhaus Institut

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