NEARLY ZERO ENERGY BUILDING CONSTRUCTIONS

ARCHITECTURAL AND CONSTRUCTIONAL STRATEGIES FOR NEARLY ZERO ENERGY BUILDINGS

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Module 2, Chapter 2.4

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Structure and content of the presentation

1. Wider context of building design
2. Definition of nZEBs
3. Basic strategies of nZEBs design
4. Urban and architectural strategies
5. Envelopes of nZEBs
6. Environmental technology of nZEBs
7. Conclusions

WIDER CONTEXT OF BUILDING DESIGN

Wider context of creating sustainable buildings

1
Wider context of building design

The design of nZEB needs to be seen in a broader context:

- **Environmental,**
- **Social,**
- **Financial,**
- **Ecological, etc.**

„Energy needs“ or „total primary energy use“ is only a part of principles, strategies, and concepts of sustainable building design.

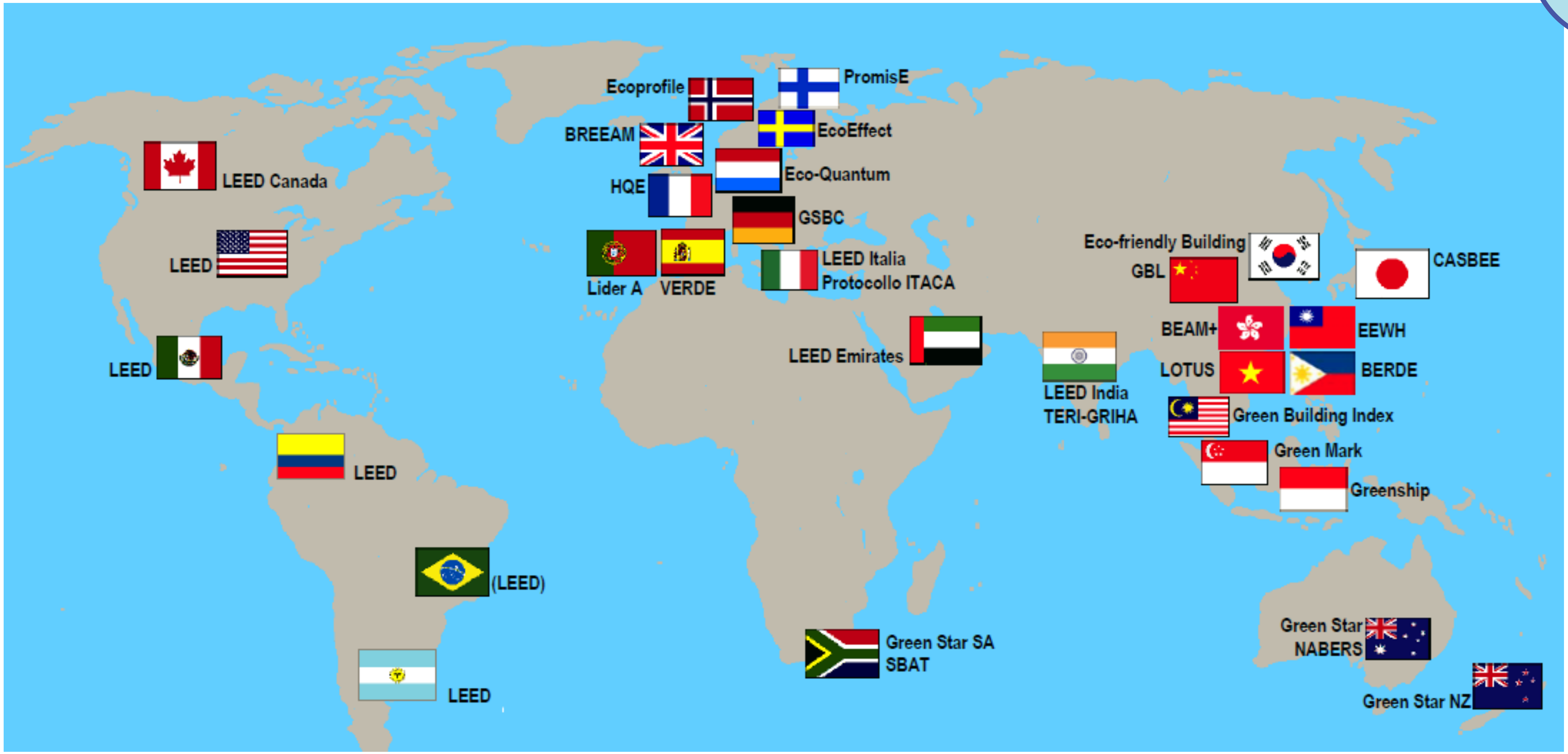
Currently, there are a number of rating systems that attempt to comprehensively assess the quality of buildings LEED, BREEAM, Nabers, HQE, DGNB (in English GSBC), VERDE, etc.

Building evaluation and certification are based on performance-based design and a building's life-cycle.

Although energy efficiency of buildings is an important part of certification, it is not dominant in rating systems of sustainable buildings.

Rating systems for sustainable buildings around the world

1
Wider context of building design



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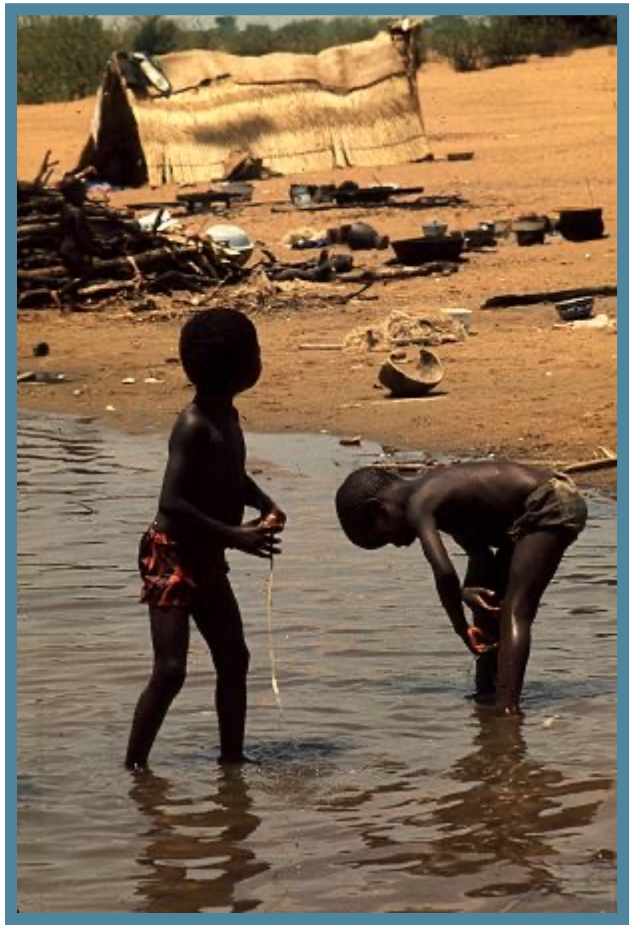
Categories of several sustainable building rating systems

1
Wider context of building design

BREEAM (U. K.)	LEED (USA)	CASBEE (Japan)	DGNB (Germany)
since 1990	since 1996 (draft)	since 2002	since 2007
Management Health & wellbeing **Energy** Transport Water Materials Waste Land use and ecology Pollution Innovation	Sustainable sites Water efficiency **Energy**& atmosphere Materials & resources Indoor environmental quality Innovation in design Regional priority credit	Q – Environmental quality Q1 – Indoor environment Q2 – Quality of service Q3 – Outdoor environment on-site L – Environmental loadings L1 – **Energy** L2 – Resources and materials L3 – Off-site environment	Environmental quality Economic quality Sociocultural and functional quality Technical quality (**building envelope quality belongs here**) Process quality Site quality

Which of the two buildings is sustainable?

1
Wider context of building design



LEED rating system answers to the question:
Hearst tower

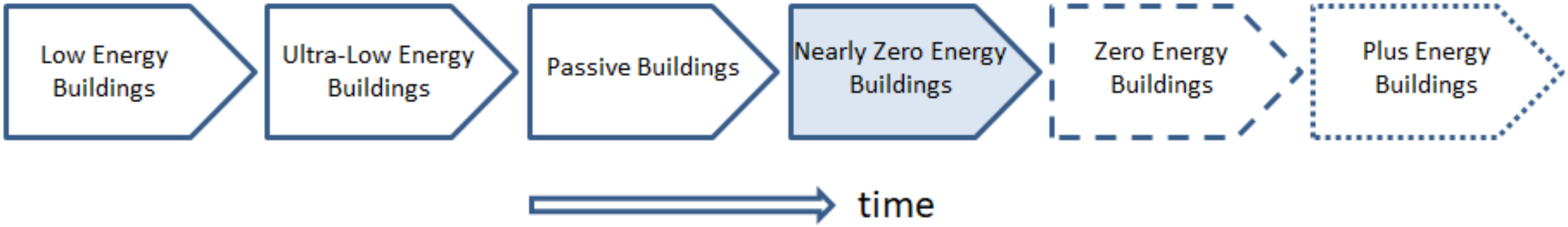
Hearst tower v NYC
Arch. Foster and Partners

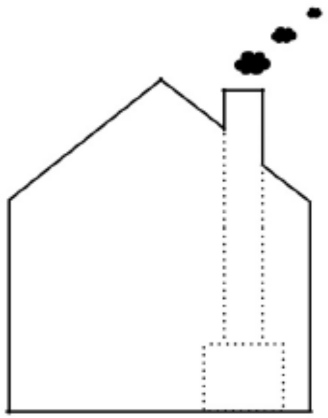
Low-tech or high-tech?

The question of whether we should prefer a low-tech approach or a high-tech approach when designing buildings seems to have been resolved. The main trend supported by all means is high-tech.

DEFINITION OF NEARLY ZERO ENERGY BUILDINGS

From low energy buildings to plus energy buildings

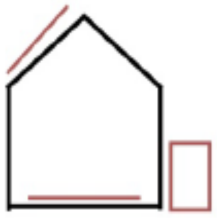




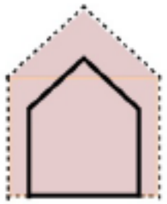
"Traditional" house

There are still many "traditional" buildings in the EU.

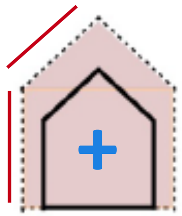
Passive house



Active house

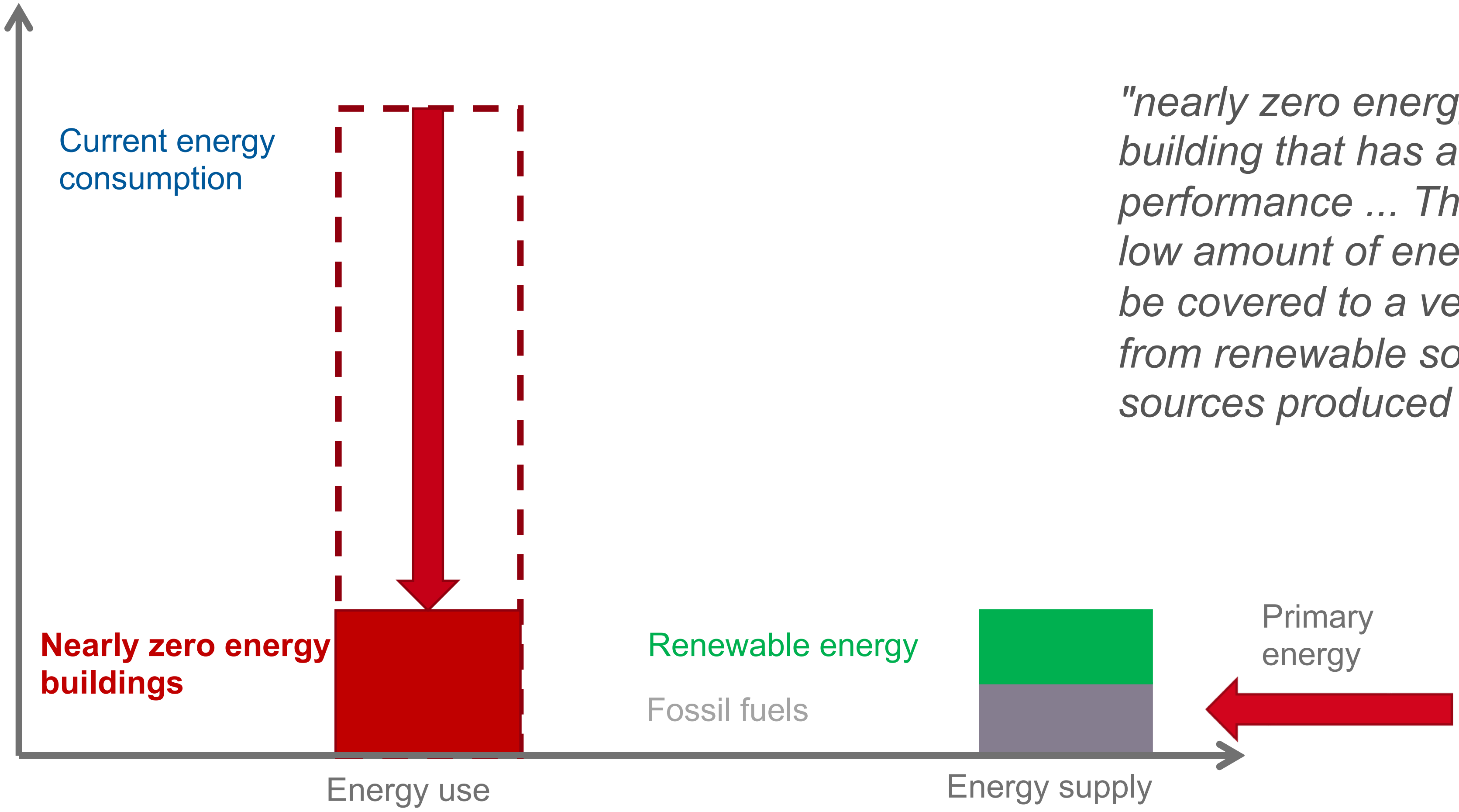


„Zero“ house



„Plus zero“ house

Definition of nearly zero energy buildings



"nearly zero energy building" means a building that has a very high energy performance ... The nearly zero or very low amount of energy required should be covered to a very significant extent from renewable sources, including sources produced on-site or nearby.

Basic principles of nearly zero energy buildings (nZEBs) design

2
Definition of nZEBs

Principle	Very low energy demand	Use of renewable energy	Primary energy and low CO_2 emissions
Characteristics of the principle	The energy demand for heating, ventilation, cooling, hot water and artificial lighting and possibly other equipment (e.g. lifts, emergency lighting) must meet the highest standards.	**Renewable energy should cover at least 50% of the total energy consumption.** Renewable energy systems must be located on or in buildings, or close to them. In perspective, renewable energy sources should cover up to 90% of the energy consumption of buildings.	The energy demand for the operation of buildings is expressed by primary energy, while it is necessary to quantify the CO_2 emissions of individual energy carriers by the factors of primary energy. Prospectively, CO_2 emissions should be lower than 3 $kgCO_2$ / (m^2.year)

Building envelope

Conventional

High thermal insulation

Very high thermal insulation + renewable energy = nZEBs

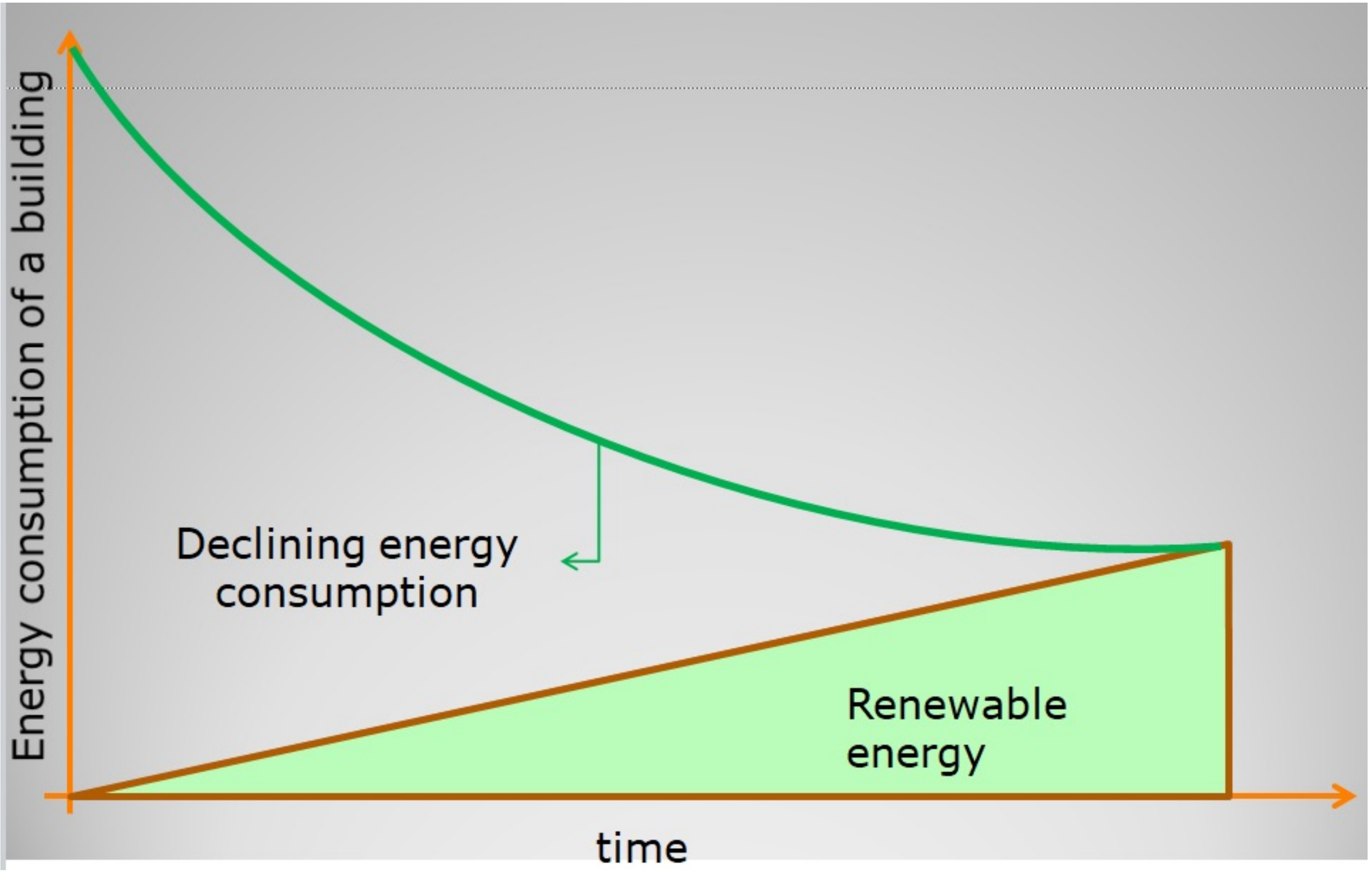
Range of energy classes of the global indicator expressed in primary energy in kWh/(m^2.a) in Slovakia (Decree 324/2016) – A0 = nZEB

Global indicator - primary energy

Categories of buildings	Energy efficiency classes of buildings							
	A0	A1	B	C	D	E	F	G
family houses	≤ 54	55-108	109-216	217-324	325-432	433-540	541-648	> 648
apartment houses	≤ 32	33-63	64-126	127-189	190-252	253-315	316-378	> 378
office buildings	≤ 61	62-122	123-255	256-383	384-511	512-639	640-766	> 766
school buildings and school facilities	≤ 34	35-68	69-136	137-204	205-272	273-340	341-408	> 408
hospital buildings	≤ 98	99-197	198-393	394-590	591-786	787-982	983-1179	> 1179
hotel and restaurant buildings	≤ 82	83-164	165-328	329-492	493-656	657-820	821-984	> 984
sports halls and sports buildings	≤ 46	47-92	93-181	182-272	273-362	363-453	454-543	> 543
buildings for wholesale and retail	≤ 107	108-213	214-425	426-638	639-850	851-1062	852-1275	> 1275

Decree 324/2016

Definition of zero energy buildings



- A zero energy building (ZEB) produces enough renewable energy to meet its own annual energy consumption requirements, thereby reducing the use of nonrenewable energy in the building sector.
- Although the definition of ZEB still lacks a national building code and international standards, number of ZEB projects is increasing worldwide.

The first „zero house“ in the EU, Lyngby, Denmark, 1975

prof. Vagn Korsgaard – Technical University of Denmark

Experience from its construction and operation has been used in the development of passive houses.

BASIC STRATEGIES OF NEARLY ZERO ENERGY BUILDINGS DESIGN

3 steps to nearly zero energy buildings

Passive strategies

- Architectural and urban means (density of development, orientation and shaping of buildings, layout, size of glazing, solar shading ...)
- Thermal insulation of building envelope
- Natural ventilation
- Daylighting
- Materiality
- ....

Energy effective technologies

- Heating, ventilation, cooling systems
- Domestic hot water
- Heat storage and recovery technologies
- Combined heat and power systems
- Advanced artificial lighting systems
- Appliances
- Efficient operation technologies
- ....

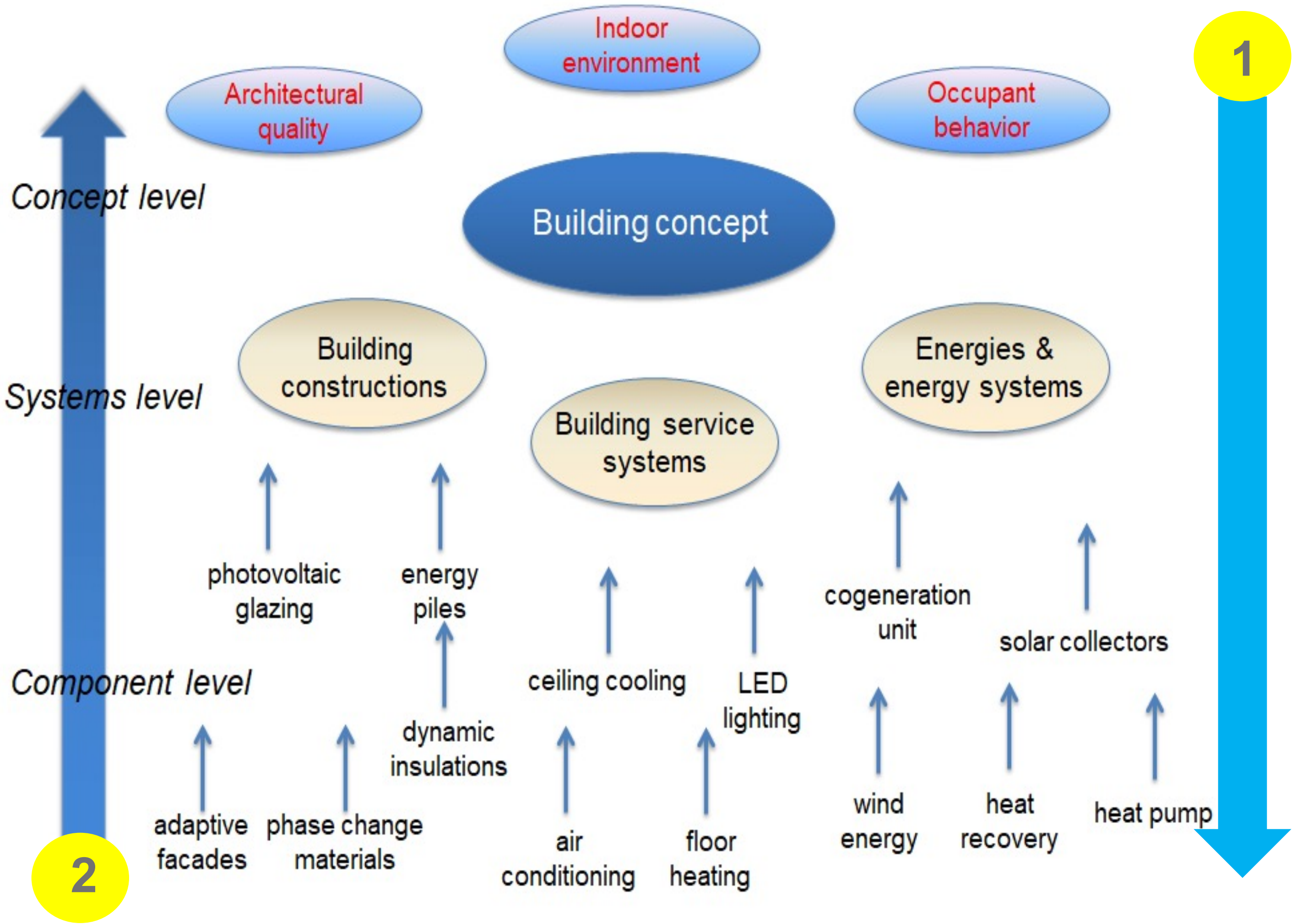
Renewable energy

- Solar thermal (including solar hot water, solar cooling and solar ventilation air preheating)
- Solar electric (photovoltaic systems)
- Wind (wind turbines)
- Geothermal energy
- Bioenergy (biomass systems)

Most importantly

- perfectly thermally insulated and airtightness building envelope,
- advanced window shading system,
- well controllable heating and cooling,
- controlled ventilation and lighting,
- 50% of energy needs is covered by renewable energy.

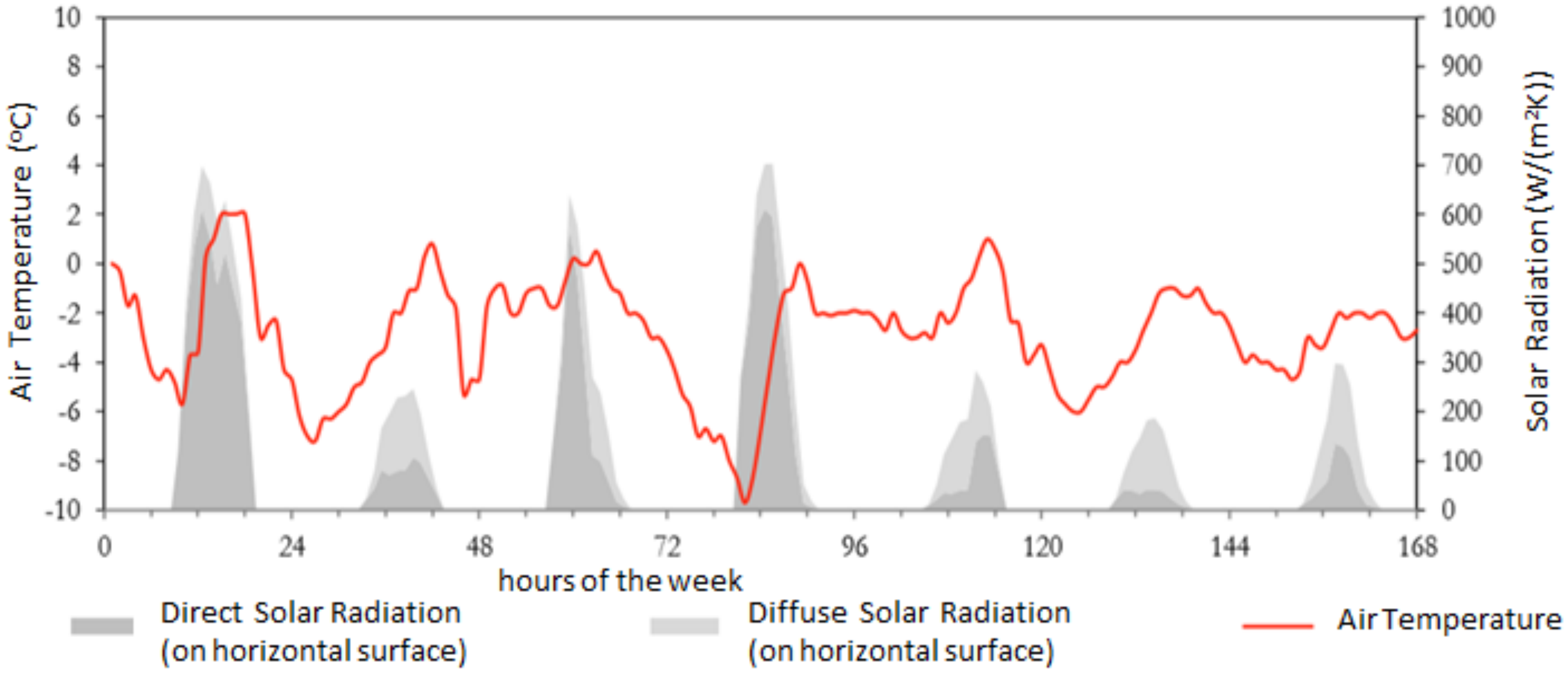
From the building concept level to component level and vice versa – with the aim of a balanced whole



The "integrated" design approach asks all the members of the building stakeholder community, and the technical planning, design, and construction team to look at the project objectives, and building materials, systems, and assemblies from many different perspectives.

This approach is a deviation from the typical planning and design process of relying on the expertise of specialists who work in their respective specialties somewhat isolated from each other.

Typical changes in air temperatures and solar radiation in January in the Central Europe



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3
Basic strategies of nZEBs design

Dynamic climate – dynamic building facade

A **dynamic /responsive/smart/adaptive ... building facade** can change in response to its surrounding environment to maximize its performance.

In this way, the building envelope is not static, but **dynamic** and is to be transformed according to requirements.

It is not a new idea, but current trends in the design of sustainable and energy-efficient buildings and the high level of technical development of civilization create a suitable space for applications of dynamic building skin.

PASSIVE URBAN AND ARCHITECTURAL STRATEGIES - THE FIRST AND ESSENTIAL STEP TOWARDS DESIGNING OF NZEBS

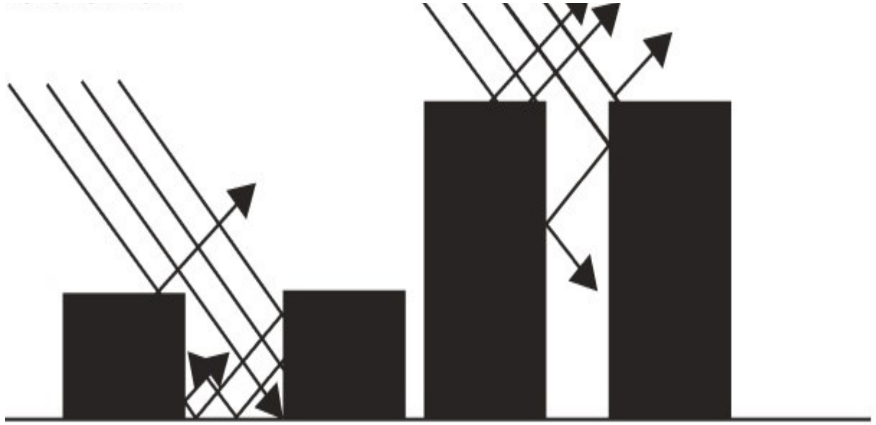
Basic passive strategies towards designing of nZEBs

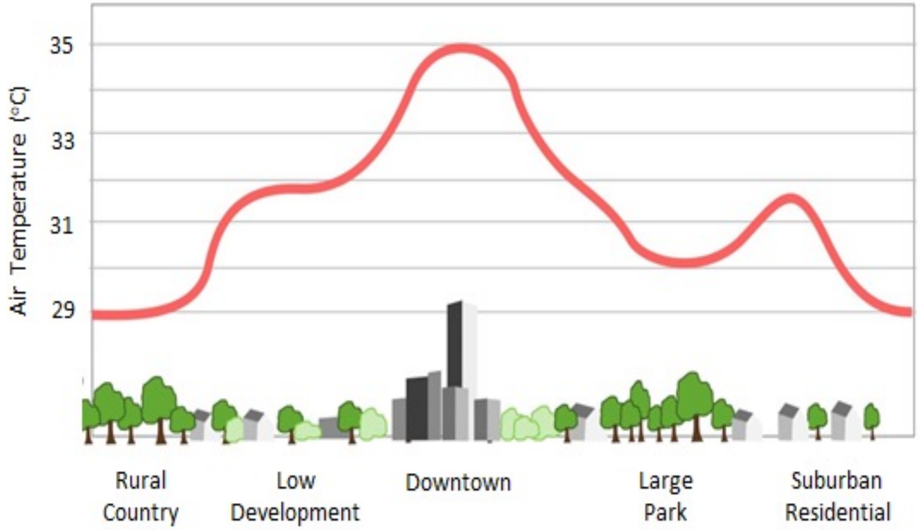
4
Urban and architectural strategies

URBAN	ARCHITECTURAL AND CONSTRUCTIONAL				TECHNICAL
site planning	building form and layout	building skin	building structure	building finish	(integrated) building services

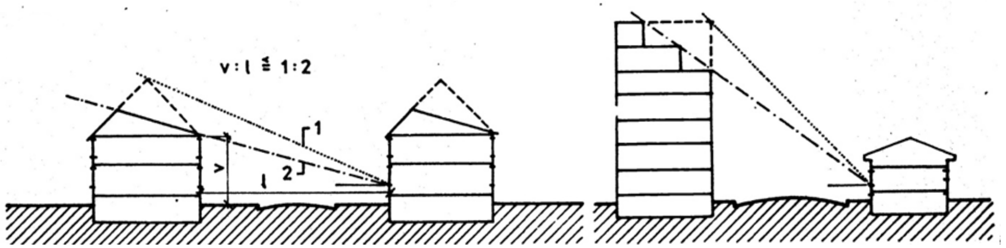
promotion	prevention	accumulation	buffering	distribution	recovery	storage

Urban strategies of nearly zero energy buildings design





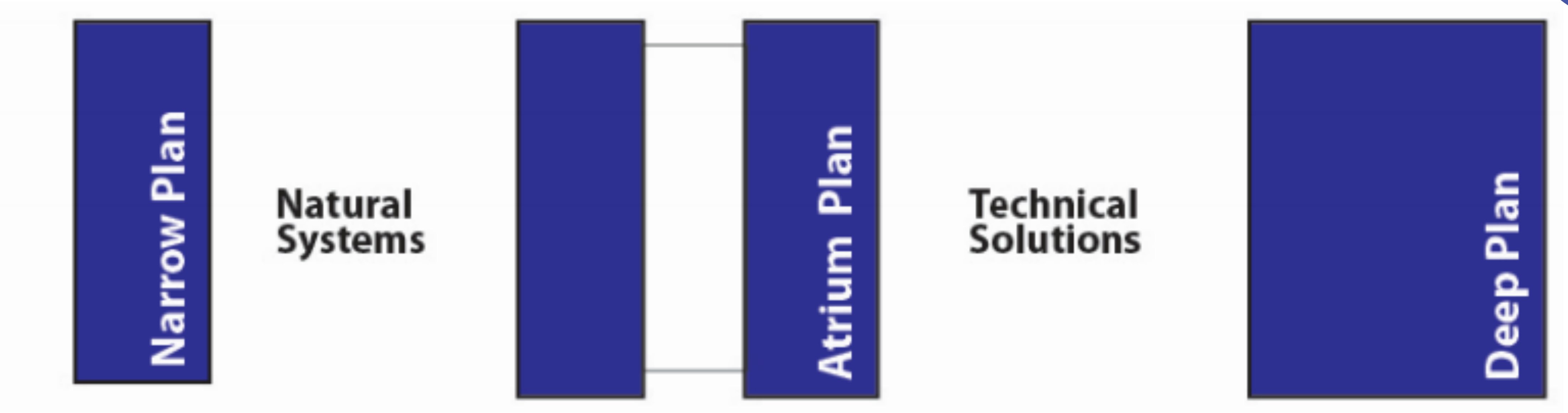
Dense development reduces the availability of solar energy in buildings and contributes to the formation of an urban heat island



Examples of shaping new buildings that improve the availability of solar energy and daylight in neighboring buildings

Architectural strategies of nZEB design – building form and layout

4
Urban and architectural strategies

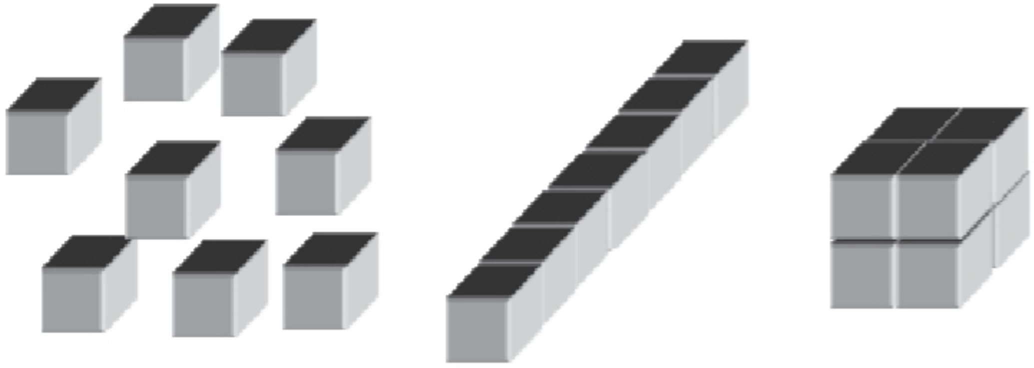


Traditional building design – daylighting and natural ventilation limit depth of residential and similar buildings at around 12 – 13 m.

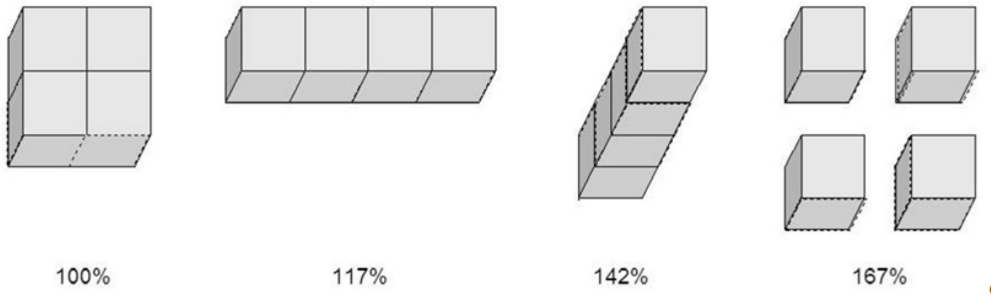
Deeper buildings are ventilated and partially naturally lit through atriums. Such a solution tends to use night time cooling and double skin facades.

Deep plans require air condition, central control, heat recovery, highly glazed facades, sophisticated shading devices.

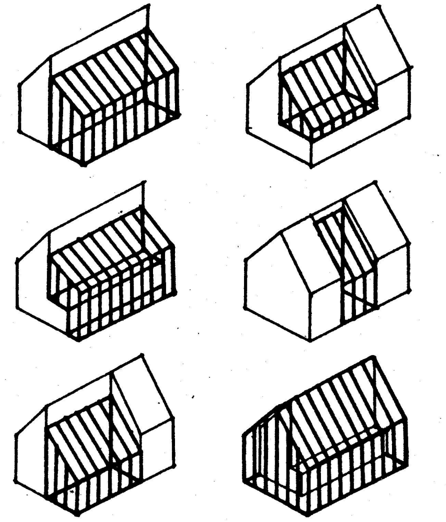
Architectural strategies of nZEBs design – building form and layout



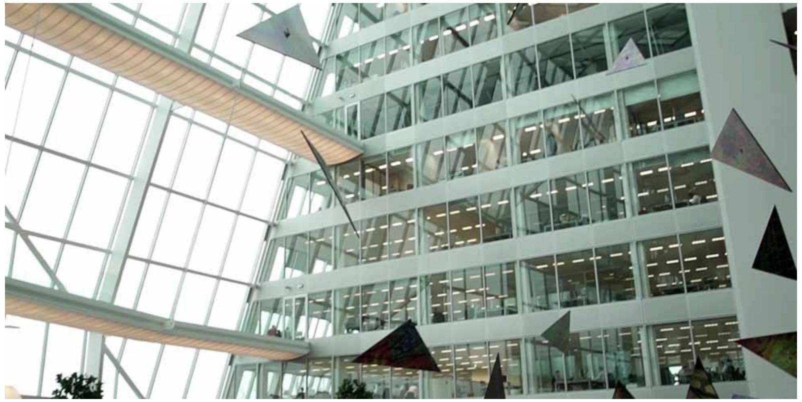
Compactness of buildings



Percentage change of the heat demand due to compactness of buildings.



Examples of glazed spaces in buildings



The geometric metrics of the architectural form related to energy performance

1. Compactness Index (C) is a measure of the building's internal volume-to-exterior surface area (V/S), with the higher number being the most compact. It is the inverse of the Shape Coefficient below
2. Shape Coefficient (Cf) (or Shape Factor) is the ratio of surface area-to-volume (S/V), where (S) is the sum of all surface areas in contact with the outside air and the building's enclosed internal volume (V)
3. Relative Compactness (RC) is the ratio of a building's compactness index (Ci) to the compactness index of a reference building, with the reference building being the more compact
4. Window-to-Wall Ratio (WWR)
5. Window-to-Floor Ratio (WFR)
6. Window-to-Surface Ratio (WSR)
7. Floor Area-to-Enclosure (F/E)
8. Exterior Wall-to-Floor Area (EW/F)
9. South Exposure Coefficient (Cs) is the southern-facing wall-to-volume ratio (Ss/V)
10. Shape Factor or Aspect Ratio (AR) is the ratio of the building's length to depth
11. Above-Grade Surface Area (S) is the surface area of the building, walls, and roof
12. Building Internal Volume (V) is the building volume enclosed by the ground floor, walls, and roof

The most common metric is Shape Factor.
The geometric metrics are beneficial to early design.

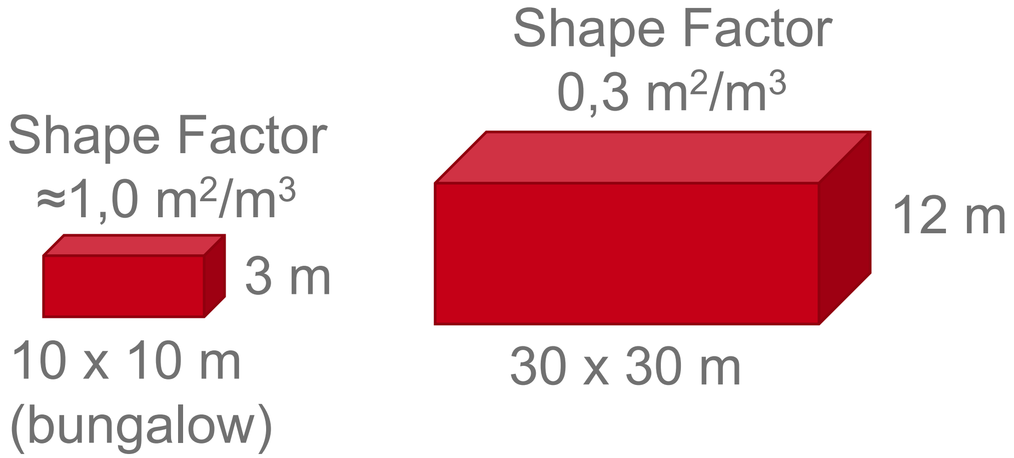
The unwanted paradox of the building Shape Factor

4
Urban and architectural strategies

The Shape Factor (SF) of a building is the ratio between its envelope area and its volume.

The smaller the building, the larger the shape factor.

The higher the value of the shape factor, the greater the requirements for thermal protection of buildings.



Heat demand for nZEBs heating according Shape Factors in STN 73 0540-2:

SF ≤ 0.3 → 25.0 kWh/(m².a)
SF = 1.0 → 50.0 kWh/(m².a)

Ratio of shape factors:
0.3/1.0 = 0.3

Ratio of prescribed heat demands:
25/50 = 0.5

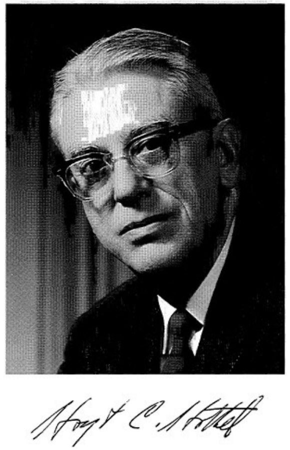
The Shape Factor of the bungalow is three times bigger compared to a larger building of the same shape. The increase in energy demand for heating is only twofold. The bungalow requires extremely thermal protection, which cannot be considered a sustainable approach to construction..

The paradox is that smaller buildings generally consume less energy and are more sustainable, but energy standards discriminate their construction.

Briefly from the history of passive houses

- 1939 - experiments with solar houses in the USA, MIT - prof. Hottel – first „active“ solar house
- The passive house standard was created in 1988
- The first passive house is considered to be the one built in 1990 in the German city of Darmstadt
- In 1996 Dr.-Ing. W. Feist founded the Passivhauss-Institut, which promotes, develops and controls passive houses

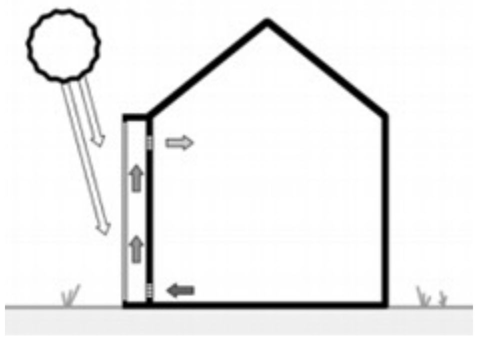
Hoyt C. Hottel



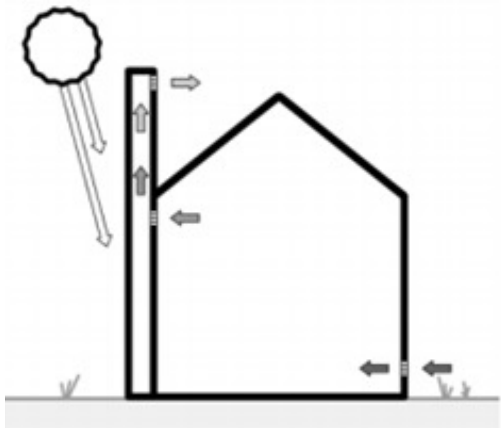
Wolfgang Feist

Historical approach to the design of passive buildings

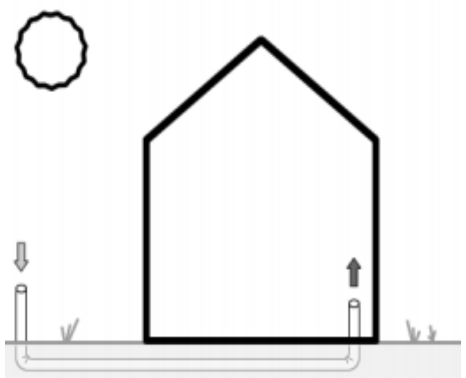
4
Urban and architectural strategies



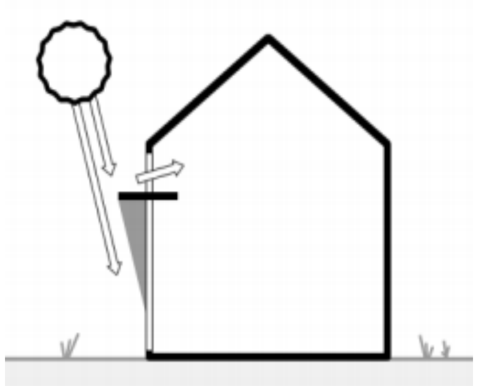
Trombe wall



Solar chimney



Earth tubes , which support heating and cooling



Daylight control by light shelves

- Fundamental strategy - maximizing heat gains from solar radiation
- Less attention was paid to reduce heat loss, which was <u>a fundamental overlook </u>in the beginnings of the design of passive buildings

Professor Hottel's skepticism

4
Urban and architectural strategies

"When we started we had high enthusiasm. But we slowly came to realize that while there were uses of the sun, they were not as promising as we all thought they would be." (Prof. Hottel in 1976)

"If you wish to lose the least money, get fifty percent of your heat from the sun. If you wish to lose no money, don't get any." (Prof. Hottel in 1976)

Here Prof. Hottel is reacting to the times; by the mid-1970s there was considerable public enthusiasm for the solar house concept, but an inexperienced industry did not meet this need.

MIT Solar House 1 (1939)

Solar House 2 (1948)

Solar House 3 (1949)

Solar House 4 (1959)

Solar House 5 (1978)

Solar House 6 (1948) PCM

Prof. HOTTEL

Dr. M. TELKES

Passive buildings – basic starting point for nearly zero energy buildings design

4
Urban and architectural strategies

A passive building design strategy in Central Europe means:

- high thermal resistances of the building envelope,
- windows with very high thermal insulation parameters,
- elimination of all thermal bridges,
- high tightness of building envelope,
- air exchange with heat recovery during the winter.

Southern view of the first passive house in Darmstadt from 1991

Northern view of the first passive house in Darmstadt

Feist and Bott, 2007

Physical criteria for designing passive buildings

Parameter	Criterion value
Primary energy demand	< 120 kWh/(m^2.a)
Net heating and cooling energy demand	< 15 kWh/(m^2.a)
Maximum heating load	< 10 W/(m^2.K)
Thermal transmittance of facade, U_{facade}	< 0.15 W/(m^2.K)
Thermal transmittance of roof, U_{roof}	< 0.10 W/(m^2.K)
Thermal transmittance of whole window, U_{window}	< 0.75 W/(m^2.K)
Linear thermal bridge transmittance, ψ	< 0.01 W/(m.K)
Efficiency of mechanical ventilation with heat recovery	> 80 %
Specific input of a fan, P*	< 0.4 W/(m^3/h)
Airtightness of building envelope, n (at 50 Pascal underpressure)	n_{50} < 0.6 / h
Limit of the internal comfort in summer	< 10% of the year air temperatures can be higher than 25 °C

Note:

P* is the specific fan input, which is the ratio between the effective input (in W) and the reference flow (in m^3 / h).

nZEBs and overheating – shading technique is necessary

- The high thermal resistances of the envelope of passive buildings, the large fenestration on the sunny sides and the high tightness increase the tendency for overheating.
- The problem of overheating of passive houses is not only during the peak summer, but can also occur during the transitional seasons when the days are sunny.
- In passive houses, it is highly recommended to design effective shading devices.

A risk of summer overheating can be shortened:

- by designing heat storage building structures that are in direct contact with indoor air,
- night cross ventilation,
- minimal ventilation during the day,
- not using equipment that generate much heat and the like.

Daylighting of nearly zero energy buildings

4
Urban and architectural strategies

- Daylight means efficient use of natural renewable energy and has a number of positive health benefits.
- Well-designed daylighting of the building leads to significant energy savings (using solar energy, saving energy for artificial lighting, saving energy for mechanical ventilation ...)
- Extreme shading negates the availability of daylight in the indoor environment of buildings.

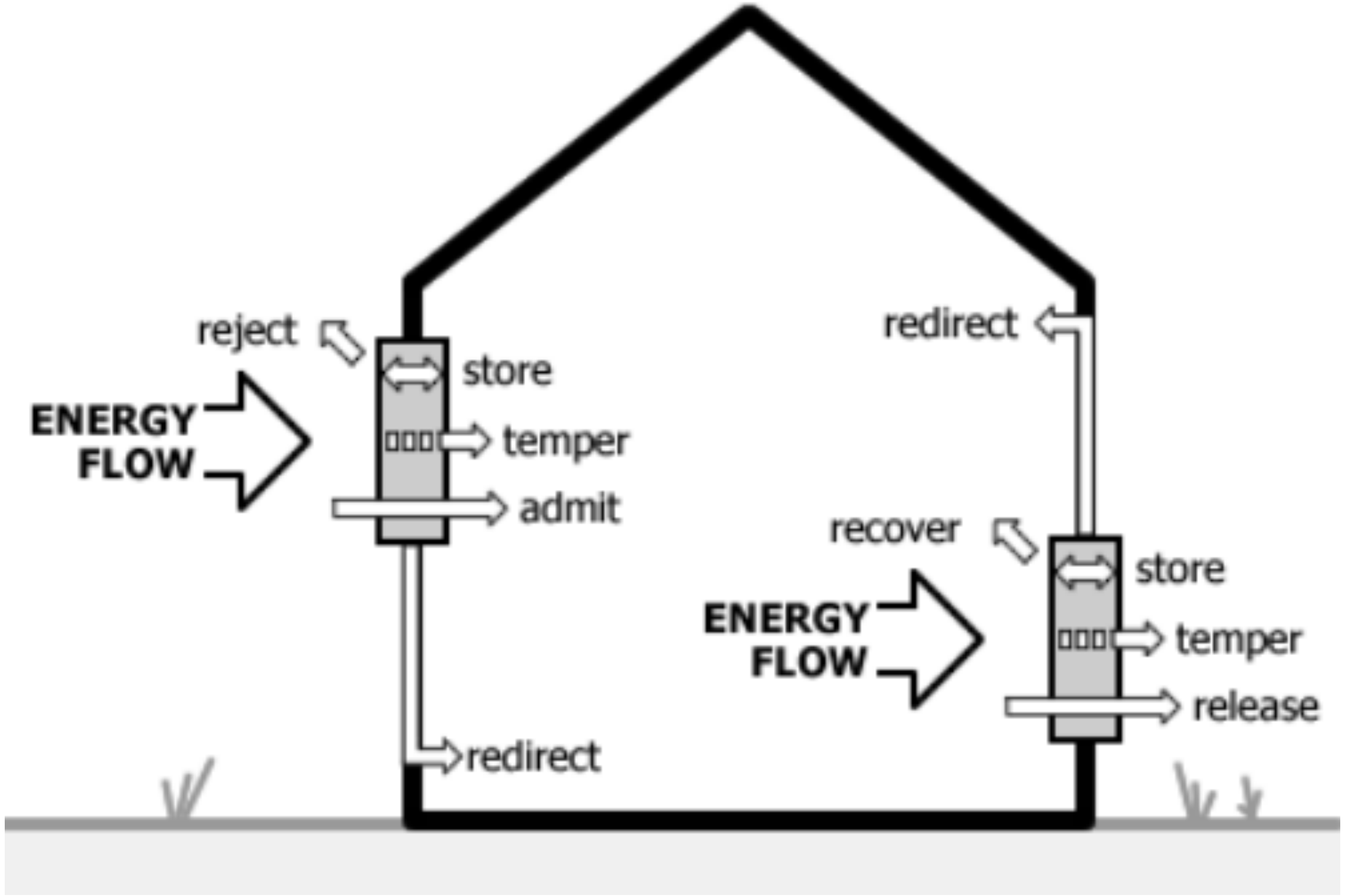
Other daylighting's benefits:

- Daylight openings provide views and connection to the outside and contribute to the psychological well-being of occupants.
- A daylight opening can also provide exposure to sunlight indoors, which is important, for example, in dwellings, hospital wards and nurseries.

ENVELOPES OF NEARLY ZERO ENERGY BUILDINGS

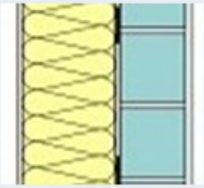
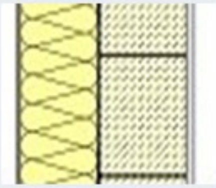
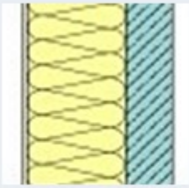
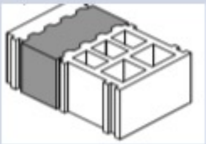
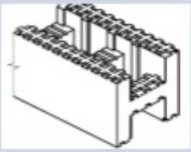
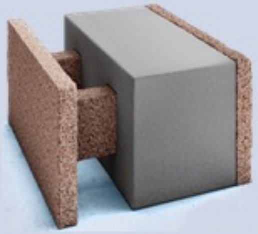
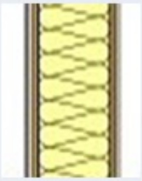
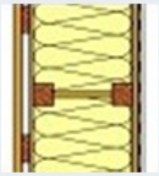
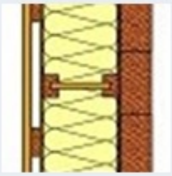
Constructional and physical strategies of nZEBs design

5
Envelopes of nZEBs



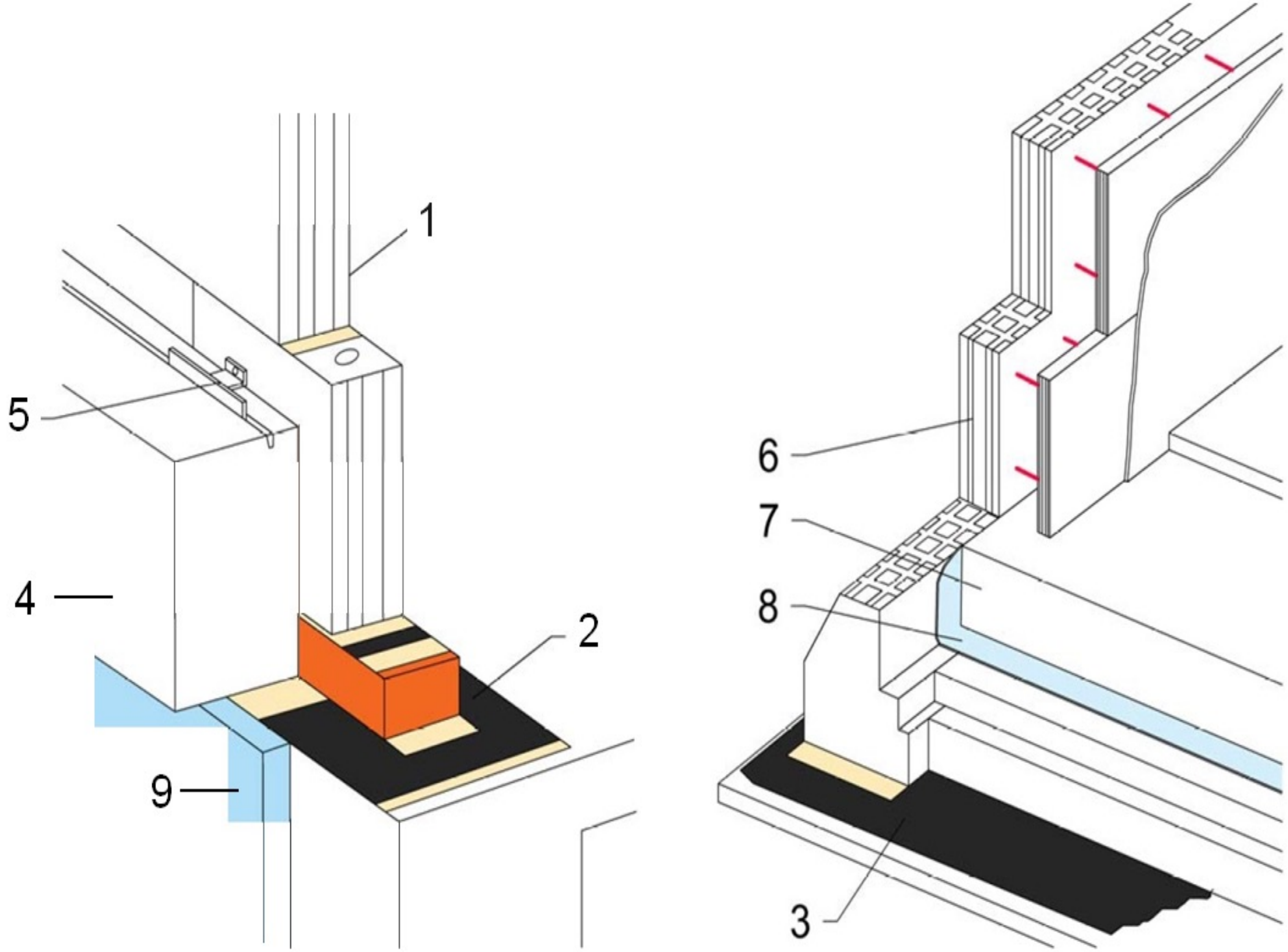
- Energy is transferred through the envelopes of buildings in both directions - from the interior to the exterior and vice versa.
- Heat flows through building envelopes affect several of their physical properties - thermal insulation, heat accumulation, homogeneity, airtightness, transparency, surface properties, etc.
- Several measures can make the thermal protection of buildings more effective in winter and summer.

Types of external walls suitable for nearly zero energy buildings

Type of wall	Schematic example			Example of a wall
Masonry walls to full thickness				
Load-bearing wall with contact thermal insulation				
Walls with „lost“ thermal insulation formwork				
Lightweight walls				

Examples of external walls suitable for nearly zero energy buildings

5
Envelopes of nZEBs



1 - wall made of cement sand bricks,

2 - foam glass (red color),

3 - waterproofing,

4 - thermal insulation (e.g. expanded polystyrene),

5 - thermal insulation clip,

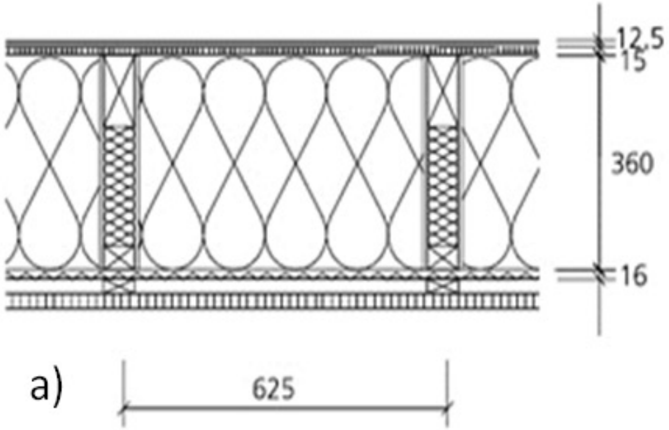
6 - formwork fittings made of expanded polystyrene,

7 - floor support layer,

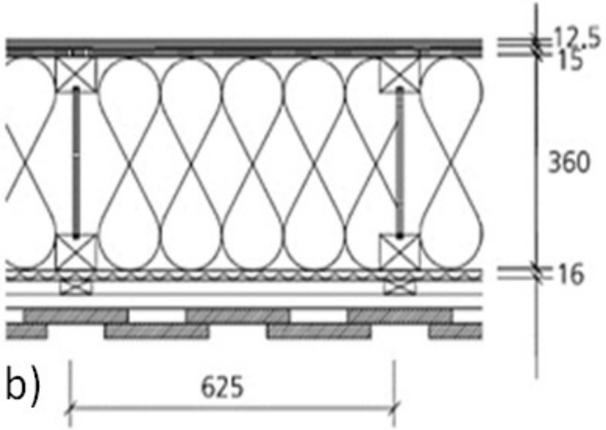
8 - separation layer,

9 - thermal insulation (e.g. made of extruded polystyrene)

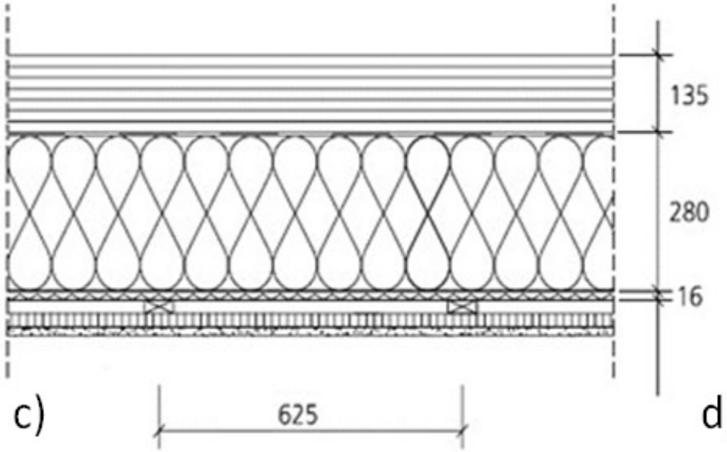
External walls of wooden houses suitable for nZEB



a)



b)



c)

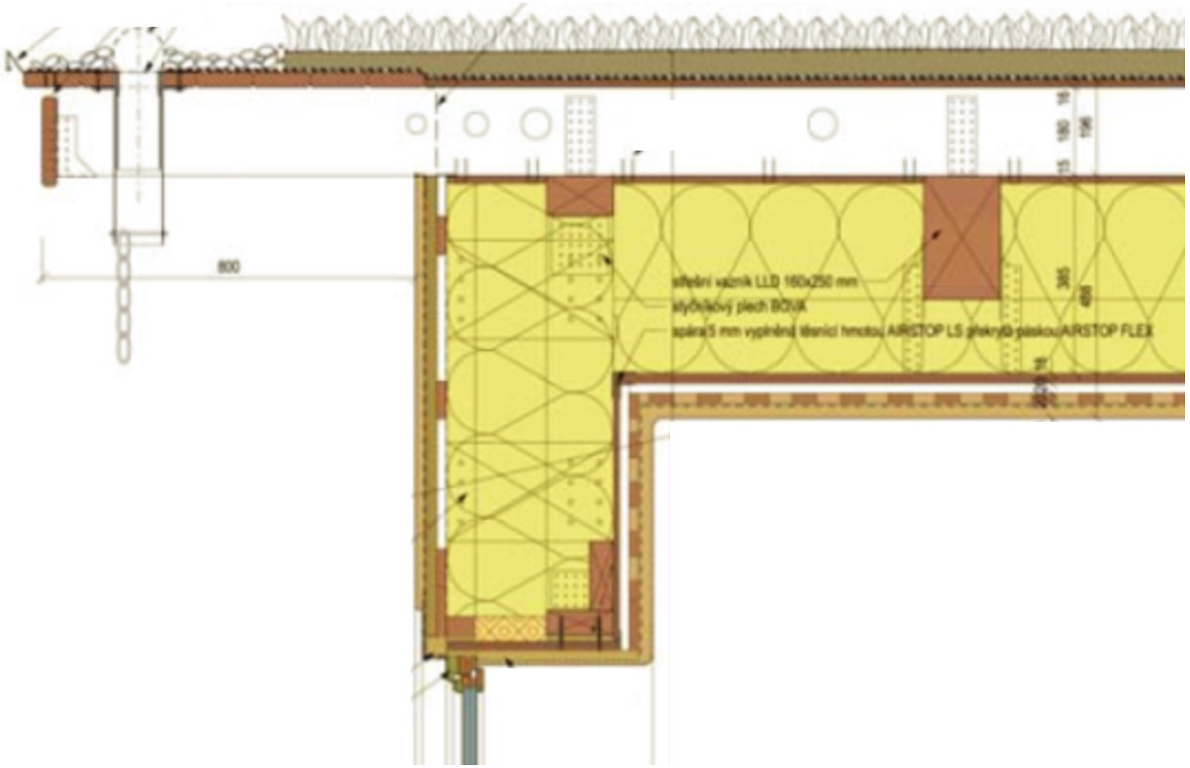
d)

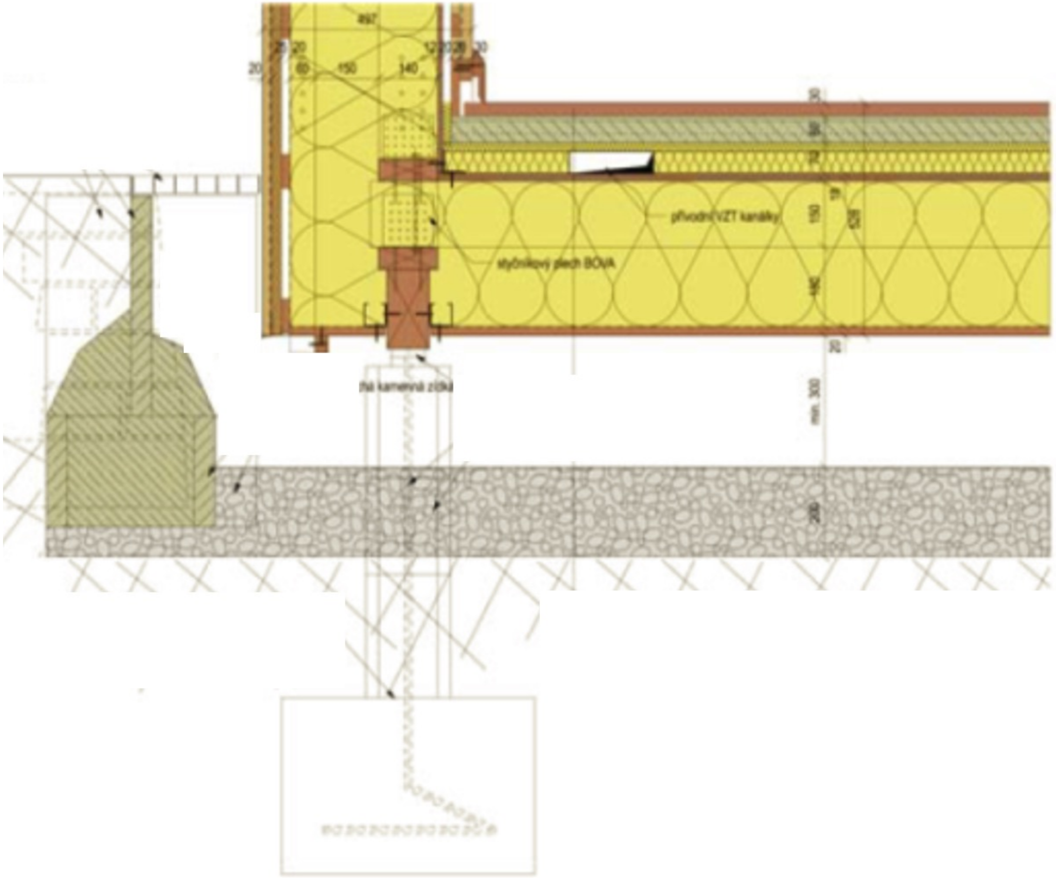
a) *wall post construction,*
b) *wall post with the use of I-shaped posts,*
c) *wall with a load bearing layer of glued laminated wood,*
d) *example of a wall with a load bearing layer of glued laminated wood*

Bebej and Sedlák, 2011

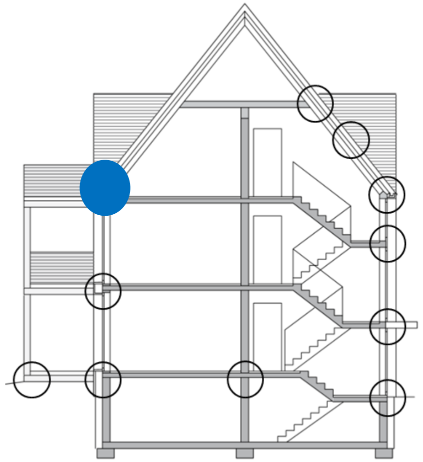
Examples of carefully designed details in envelope of nearly zero energy wooden buildings

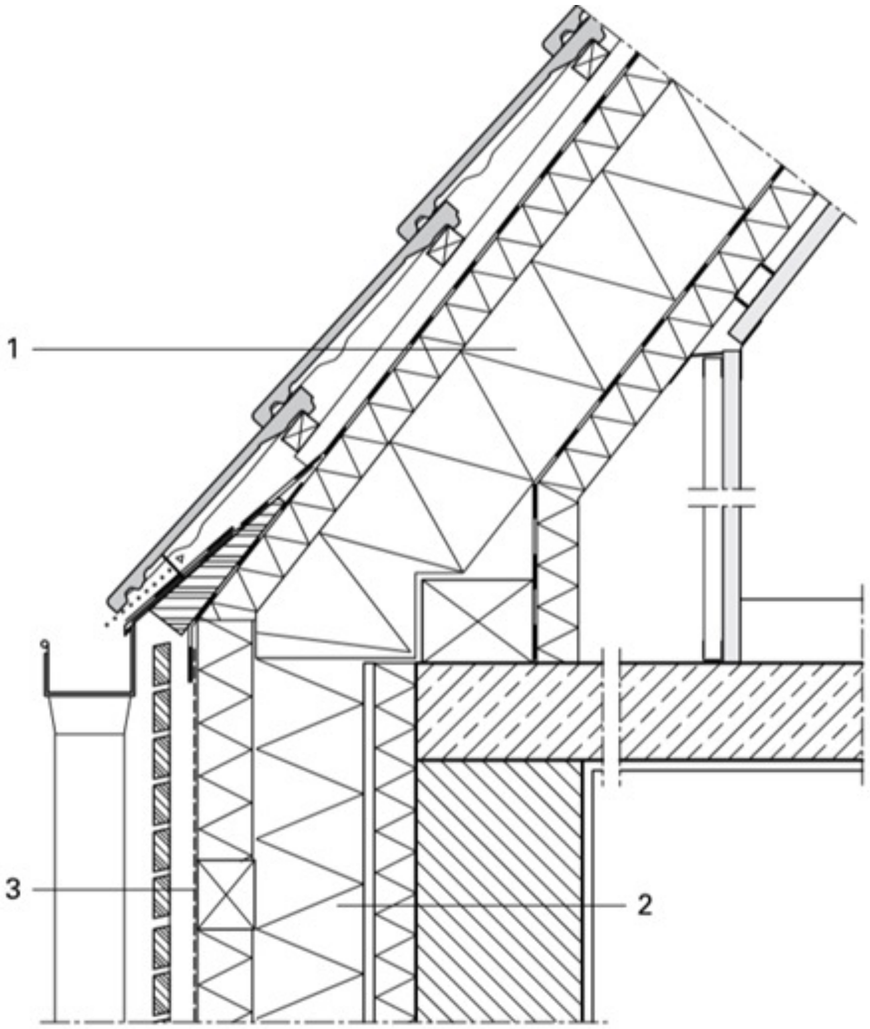
5
Envelopes of nZEBs





Example of carefully designed detail in envelope of nearly zero energy buildings





1 - thermal insulation

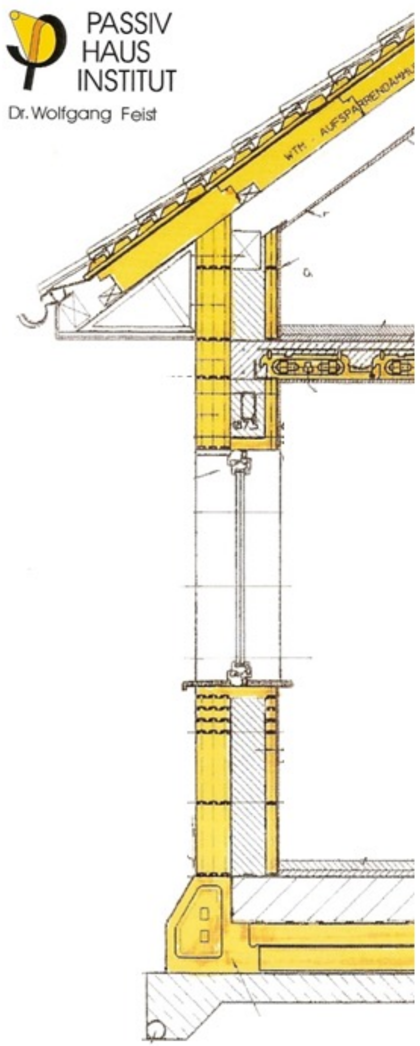
between rafters,

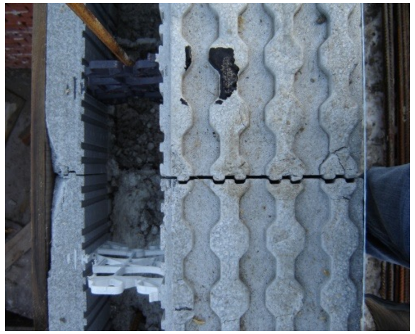
2 - thermal insulation of the

wall between lathes,

3 – vapor permeable foil

Examples of carefully designed details in envelope of nZEBs





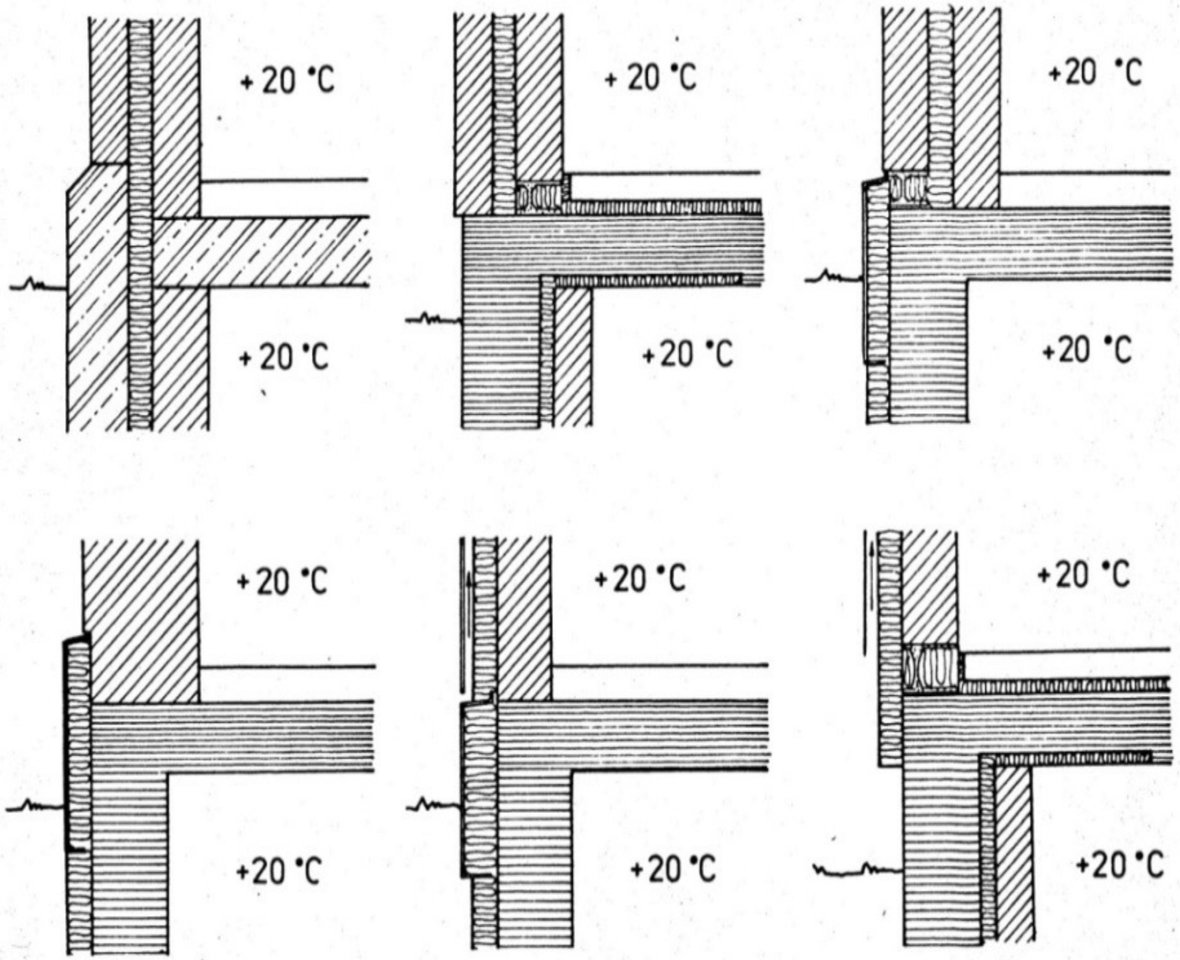
The pictures on the left show the Innovativbau Thermomodul building system, which was certified by the Passivhaus Institute.

The Thermomodul system is characterized by consistent thermal insulation of envelope of a passive building with consistent removal of thermal bridges and high airtightness of a building envelope.

Examples of elimination of thermal bridges at massive external walls in the contact with a heated underground floor

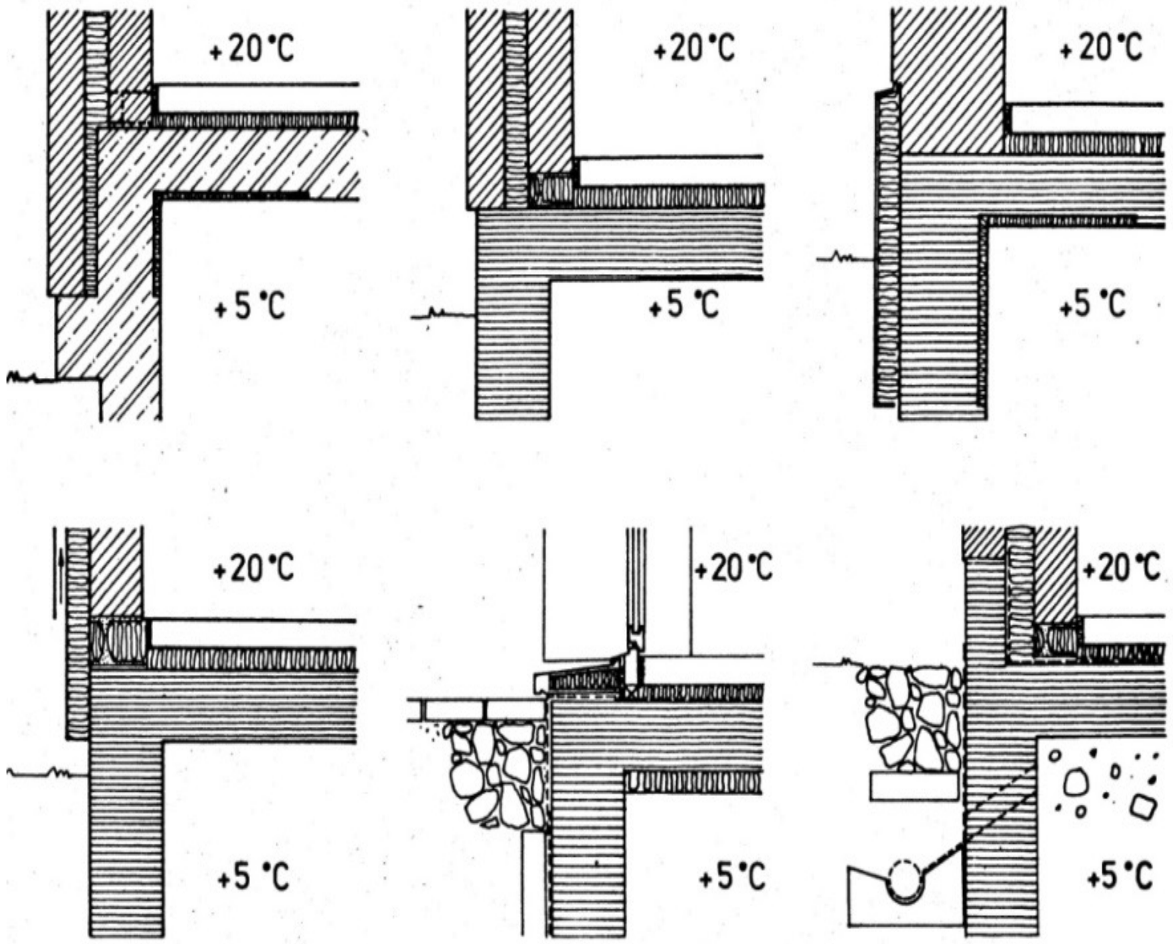
Thermal bridges need to be eliminated with particular care in the case of nZEBs envelope. In the case of highly thermally insulated envelopes of nZEBs buildings, insufficiently designed thermal bridges can increase heat losses by up to 30%.

Figures on the right indicate several possibilities of elimination of thermal bridges in the case of masonry external walls in contacts with heated basements.

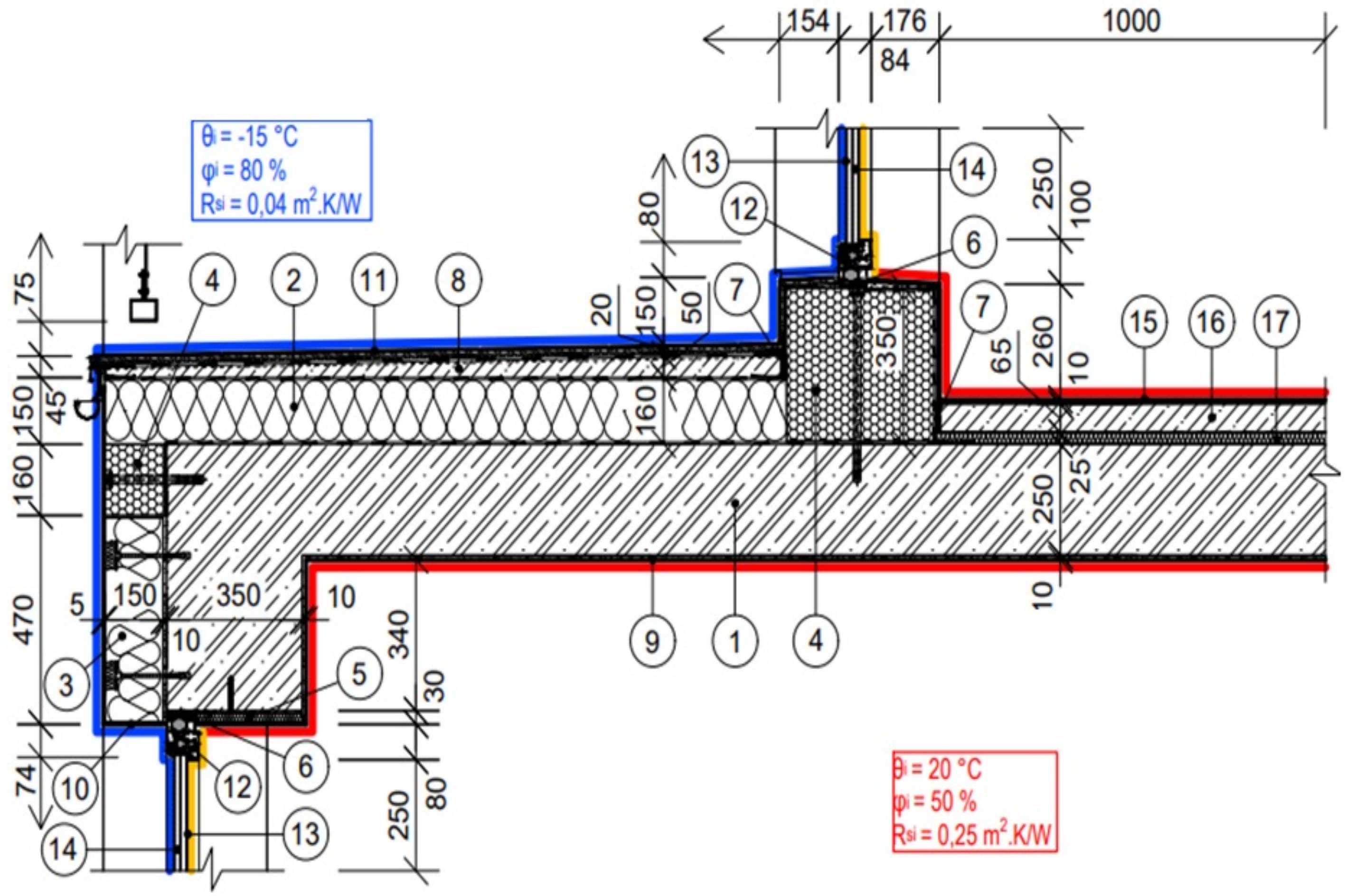


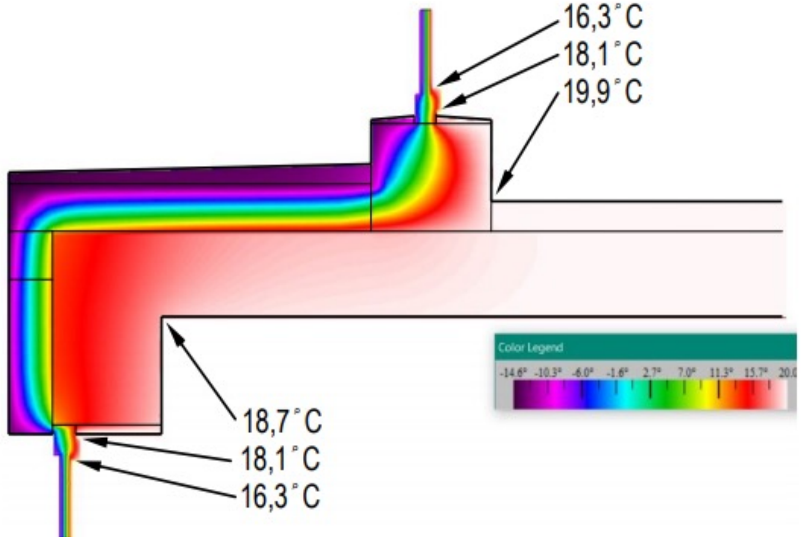
Examples of elimination of thermal bridges at massive external walls in the contact with unheated underground floor or in contact with the subsoil

Figures on the right indicate several possibilities of elimination of thermal bridges in the case of masonry external walls in contacts with non-heated basements or with subsoil.

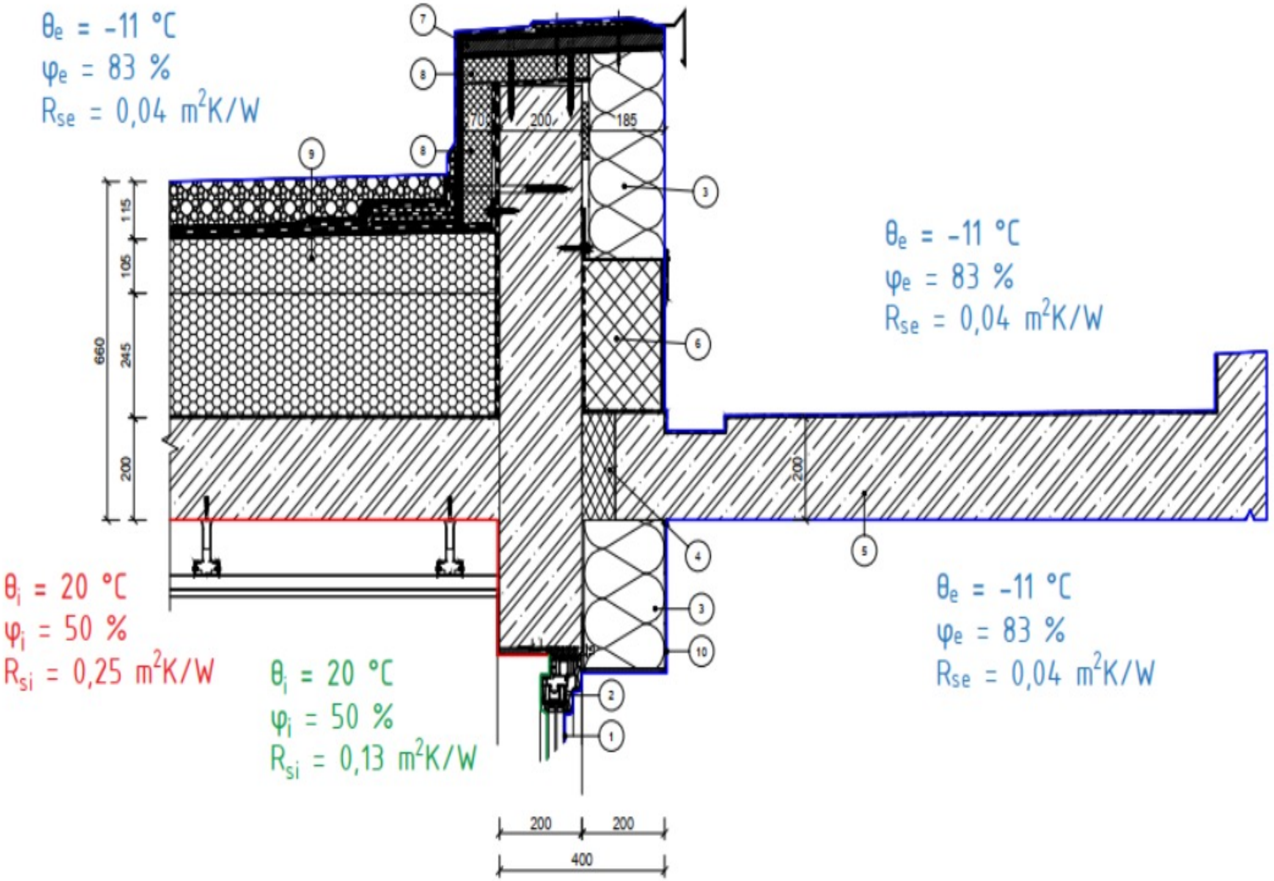


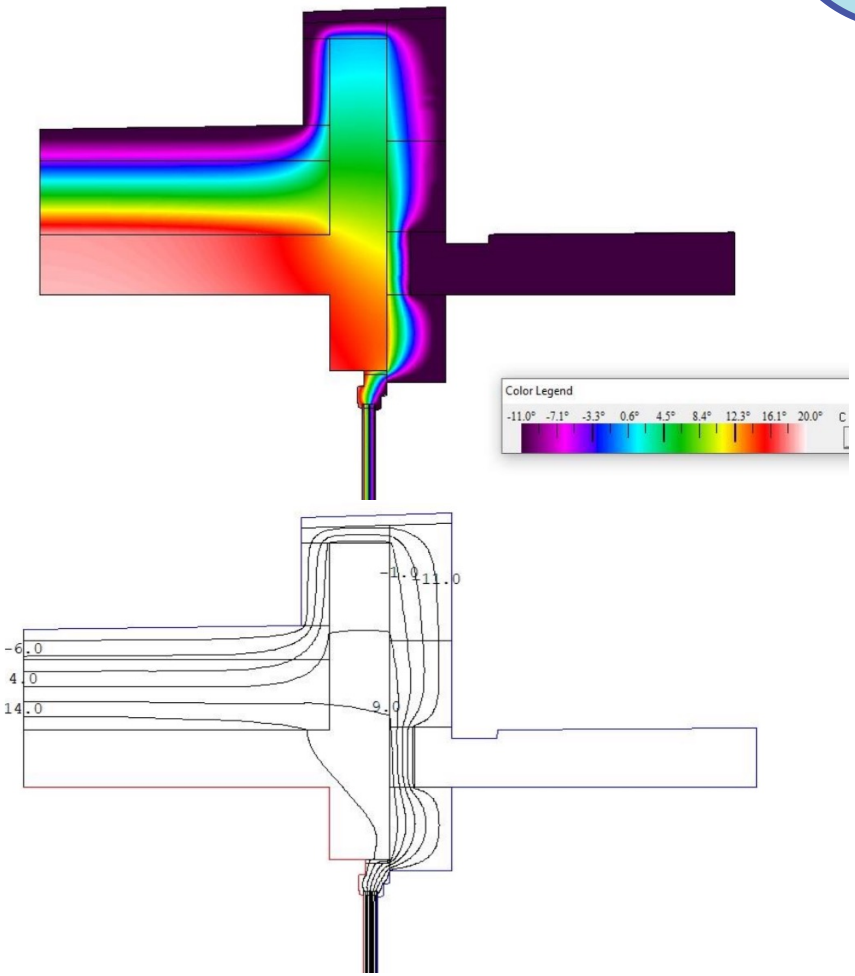
Temperature field in the place of the balcony of a residential building



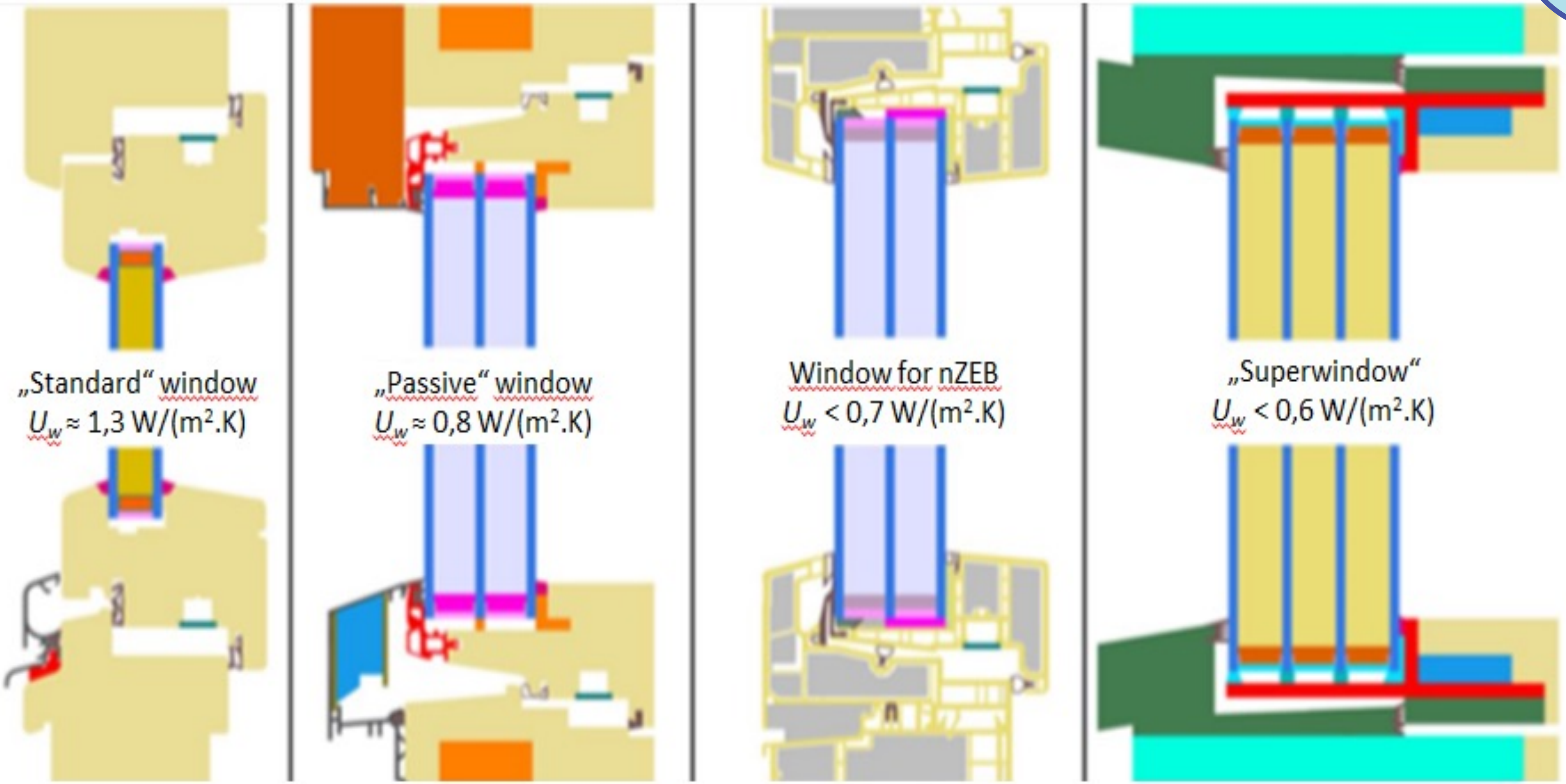


Temperature field at the end of the roof and external wall of a residential building



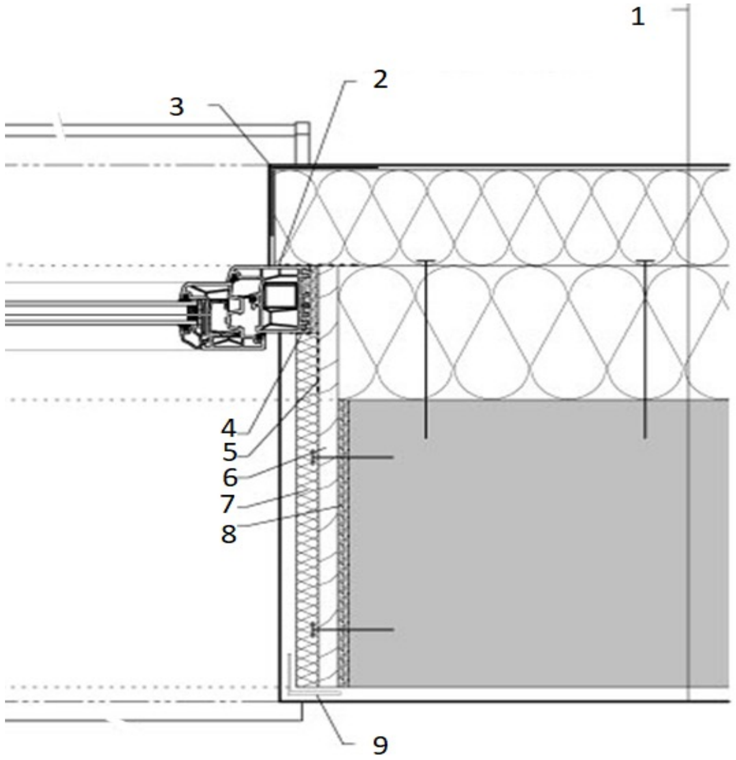


Examples of windows that meet the standards of passive and nearly zero energy buildings

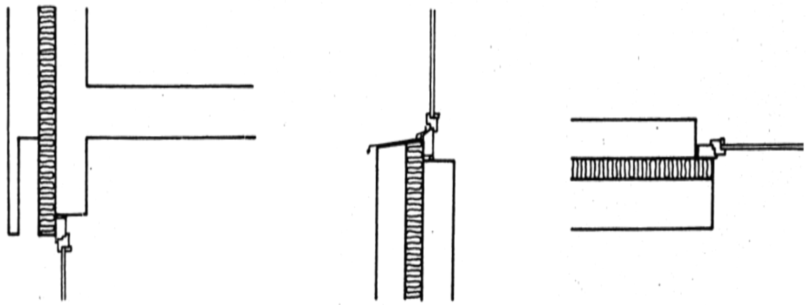


Goldstein et al., 2016

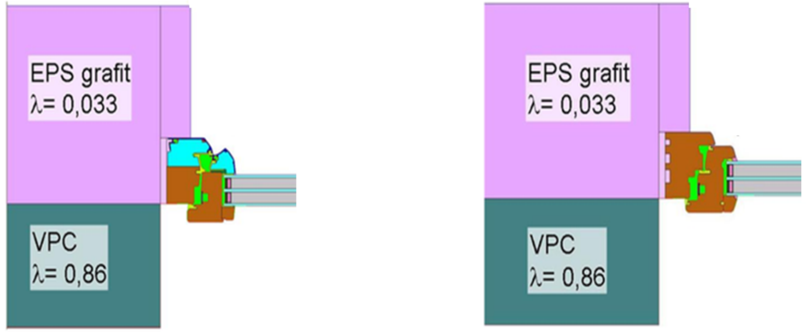
Details of the window installation in the nZEB lining



1 - thermally insulated wall, 2 - outer vapor permeable foil, 3 - corner strip, 4 - polyurethane foam, 5 - inner vapor barrier foil, 6 - OSB board, 7 - thermal insulation, 8 - polyurethane foam, 9 - corner profile



Example of elimination of thermal bridges in window linings



Windows installed in the plane of thermal insulation of the wall

Window frames can create significant thermal bridges

5
Envelopes of nZEBs

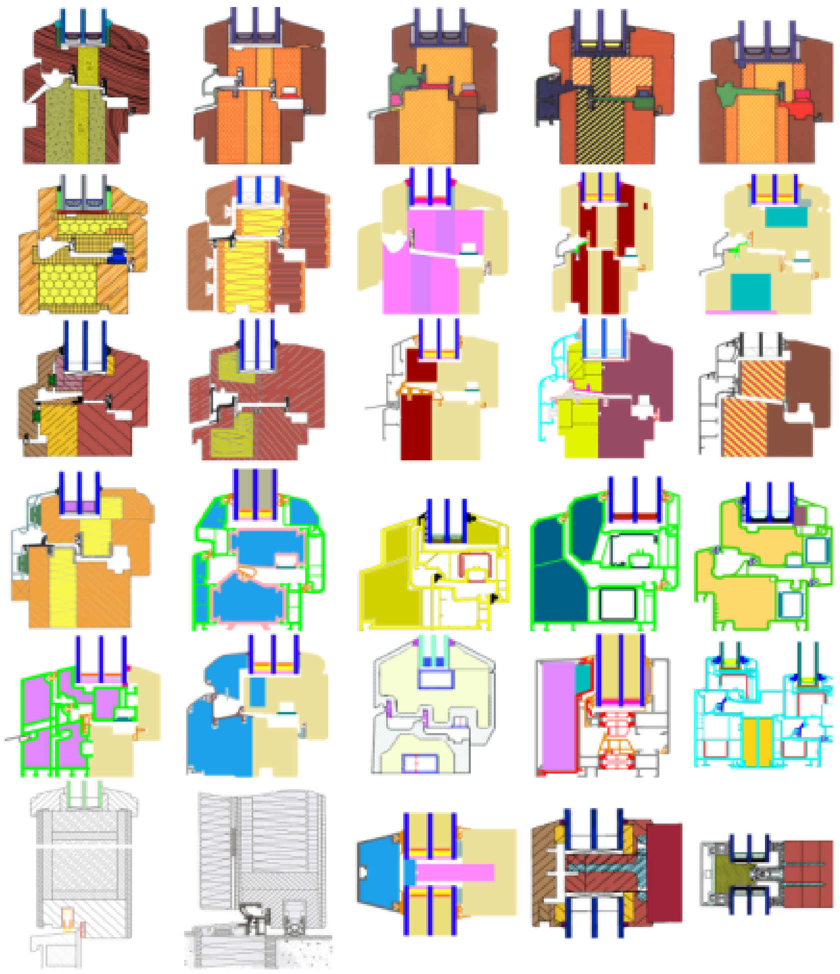
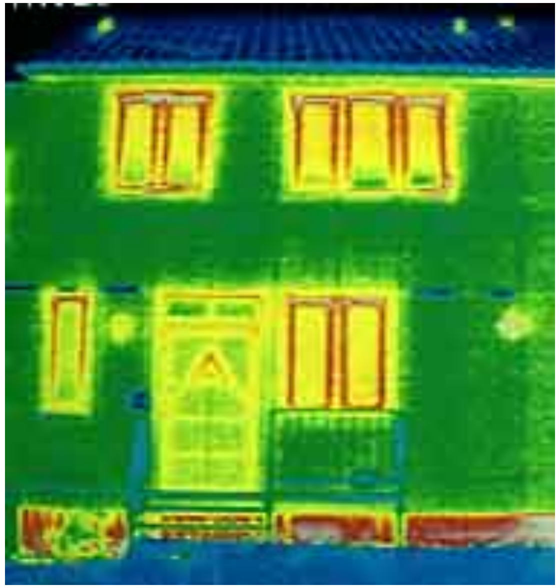


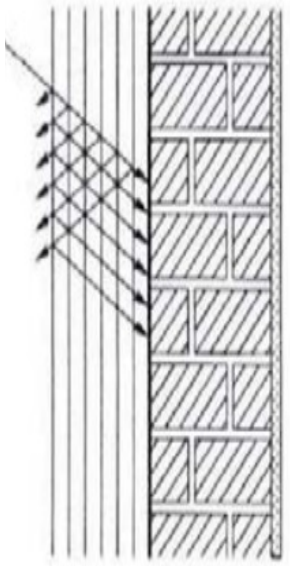
Photo of the facade



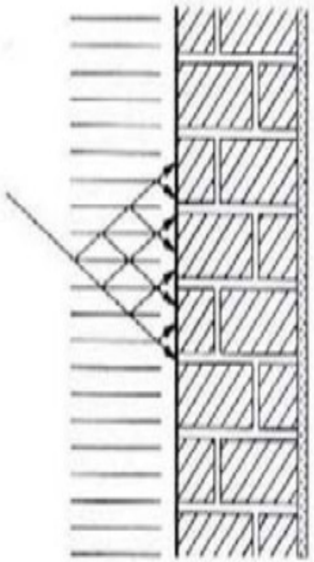
Thermovision image

Enhanced types of window frames of nZEBs

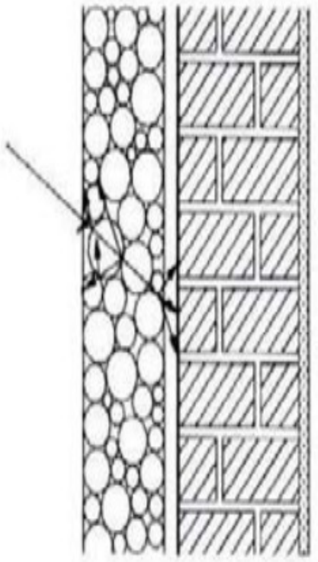
External walls with transparent thermal insulation



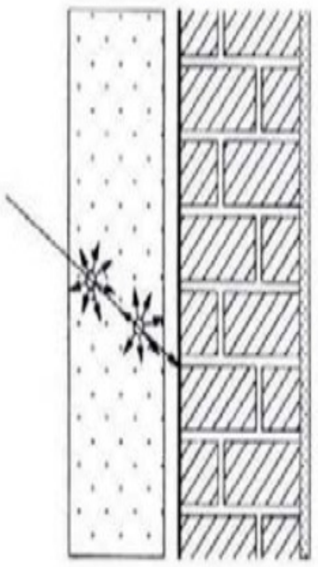
Multiple transparent sheets



Honeycombs or capillaries



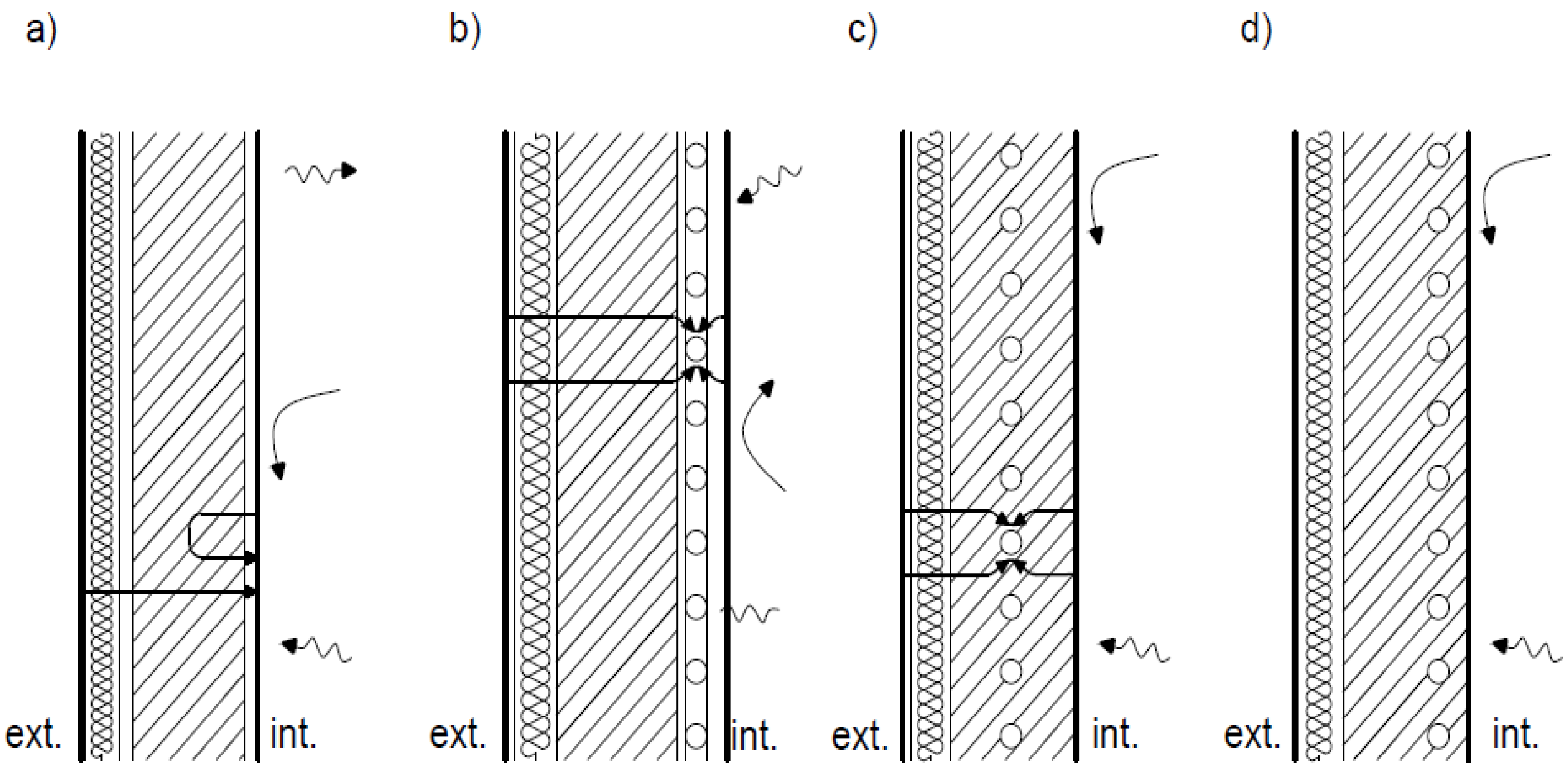
Cavity structures (eg. foam)



Aerogels or xerogels

Application example

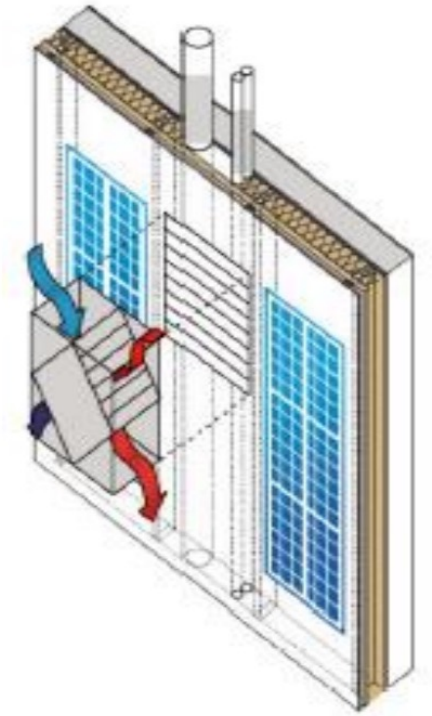
Walls of buildings in the function of radiators or coolers

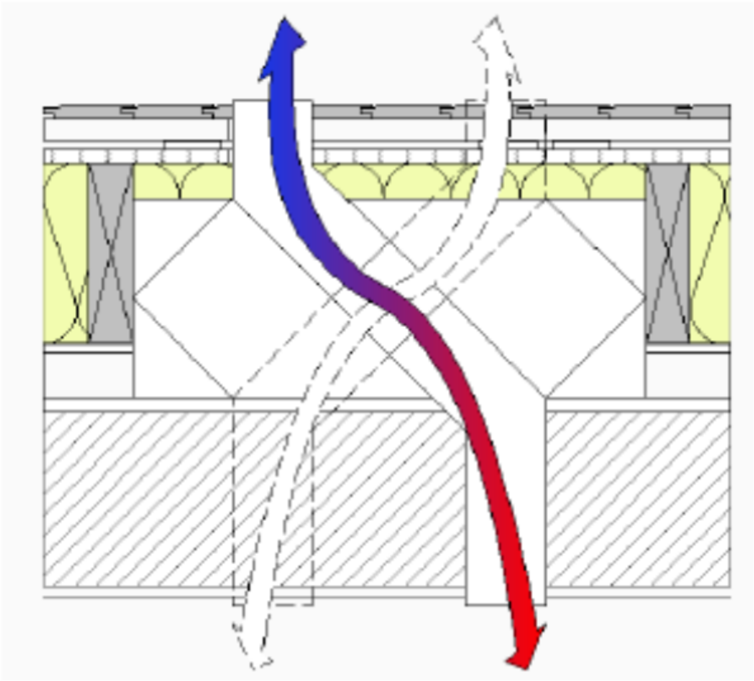


a) capillary mats in plaster, b) pipes in plaster or behind cladding, c) pipes in the core of the solid wall, d) pipes at the inner surface of the solid wall

TES energy facade (with integrated environmental technology)

5
Envelopes of nZEBs



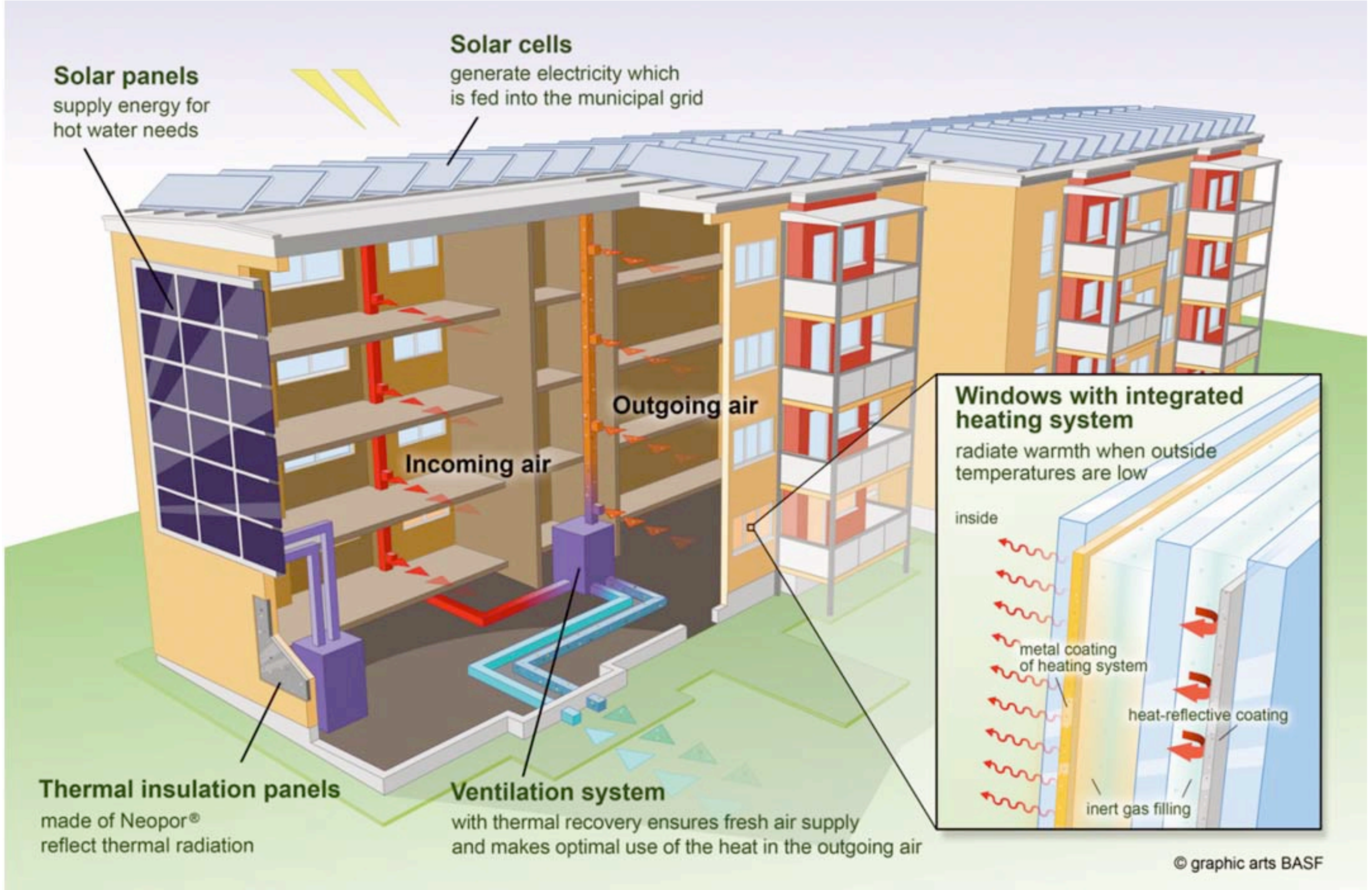


Insulated wall with integrated ventilation unit with heat recovery

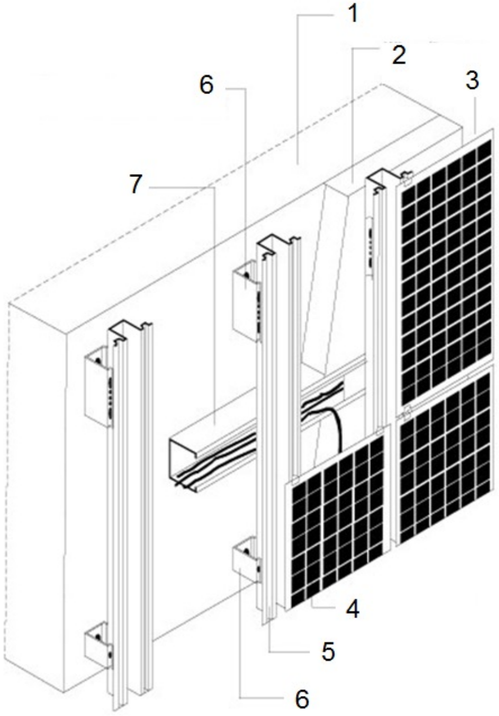
A larger number of timber-based element system (TES) energy facade variants is proposed - e.g. with integrated small heat pumps, with ventilation units, photovoltaic panels, solar thermal collectors, and heat pipes.

TES EnergyFaçade (2009). TES EnergyFaçade manual. Final project report. PDF.
Available: http://tesenergyfaçade.com/downloads/TES_Manual-ebookFINAL.pdf

An example of application of building integrated and added solar elements



Solar and PV panels may be added to building envelope or can be incorporated within façades, shading devices, and glass assembly.

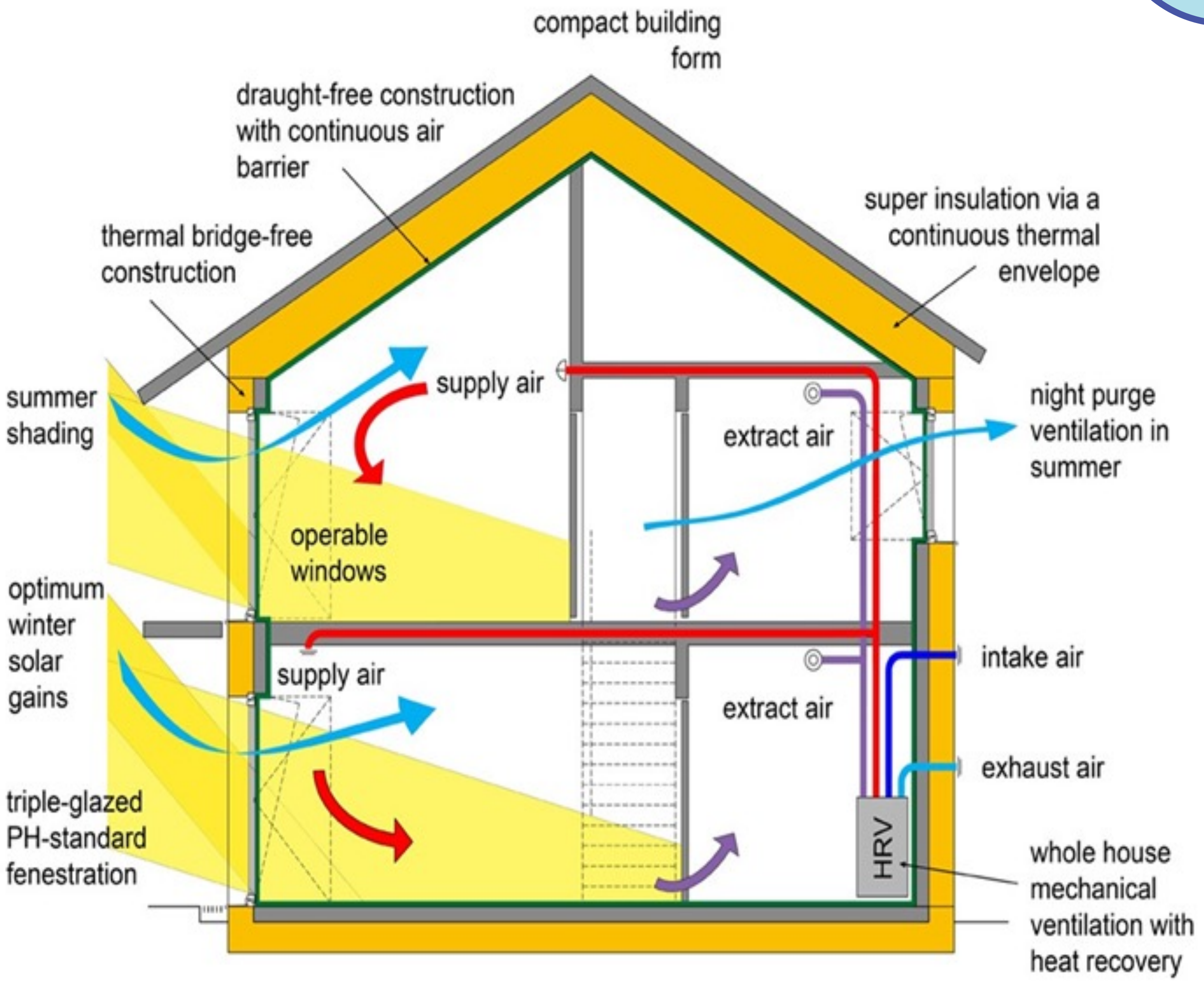


1 - solid wall, 2 - thermal insulation, 3 - ventilated air layer, 4 - photovoltaic panel, 5 - vertical anchoring element, 6 - anchoring bracket, 7 - cable duct

TYPICAL ENVIRONMENTAL TECHNOLOGY OF NEARLY ZERO ENERGY HAUSES

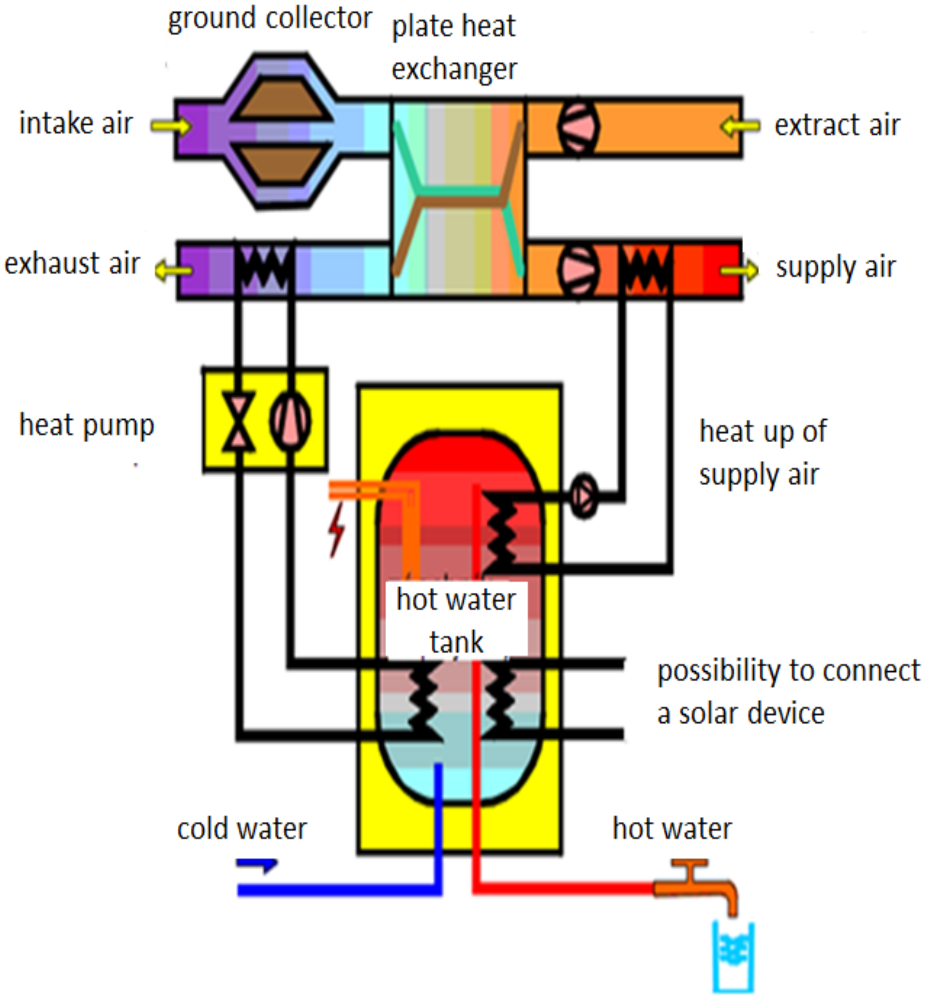
Typical nearly zero energy house ventilation system with heat recovery

- Heat losses due to natural ventilation of buildings cause energy losses of 20 to 30 kWh/(m^2.year).
- By mechanical ventilation with heat recovery these energy losses can be reduced to values of 2 to 7 kWh/(m^2.year). Mechanical ventilation cannot function reliably and efficiently without high airtightness of the building envelope.
- Mechanical ventilation of passive buildings is standardly solved with heat recovery.
- Heat recovery efficiency of at least 80% is required.



Bátora and Baloga, 2015

Nearly zero energy house ventilation system in combination with heat pump and hot water preparation



A more complex solution of mechanical ventilation with heat recovery in combination with a heat pump and hot water preparation increases the energy efficiency of the ventilation system.

Ground/air heat exchanger, photovoltaic and solar thermal devices increase the energy efficiency of the system and at the same time increase its economic intensity.

CONCLUSIONS

Conclusions

The urban and architectural aspects of building design have considerable impact on energy performance of buildings in any climate regions.

Architectural and sustainable strategy must go hand in hand in the design of the facades of buildings (both passive and active design thinking) and with environmental technology.

The strategy to minimize the energy demand stands in several improvements of the building shape form, its thermal mass or envelope insulation.

Post occupancy testing of nearly zero energy buildings is urgent and results should be published in order to help improve practice.

Different design configurations of nZEBs should identify the so-called cost-optimal level that represents the energy performance level which leads to the lowest cost during the economic building lifecycle.

From an energy point of view, it would be appropriate to redefine heat demand limits for small buildings with a high shape factor in a more acceptable way.

EPILOGUE

The Jevons Paradox and energy efficiency policies

The Jevons Paradox states that:

Technologies make it possible to use resources more efficiently, while at the same time leading to higher consumption and faster depletion of resources.

The nature of the Jevons Paradox is called „rebound effect“, which is an increase in energy consumption following an energy efficiency improvement.

Rebound effects produced by reduction in costs of energy services have not been generally taken into account in policy making.

It is necessary to address the rebound effect through behavioral, legal and economic instruments.

Wiliam Stanley Jevons
(1835 – 1882)

„Rebound effect“ – theoretical assumptions and real energy consumption in a deep renovation dwellings in the nZEBs standard in Belgium

In analyzed nZEBs apartments the influence of the user behavior appears to become dominant in relation to the building envelope performance.

The results of the study are not in line with the assumption, confirmed by the calculations, that the ratio of domestic hot water (DHW) in energy-efficient dwellings is becoming increasingly dominant compared to space heating (SH). Energy for DHW was much smaller than the theoretical assumptions.

On the other hand, the energy use for SH was in analyzed nZEBs apartments strongly underestimated. 71% of all apartments had SH that was at least twice as high as their corresponding theoretical figure.

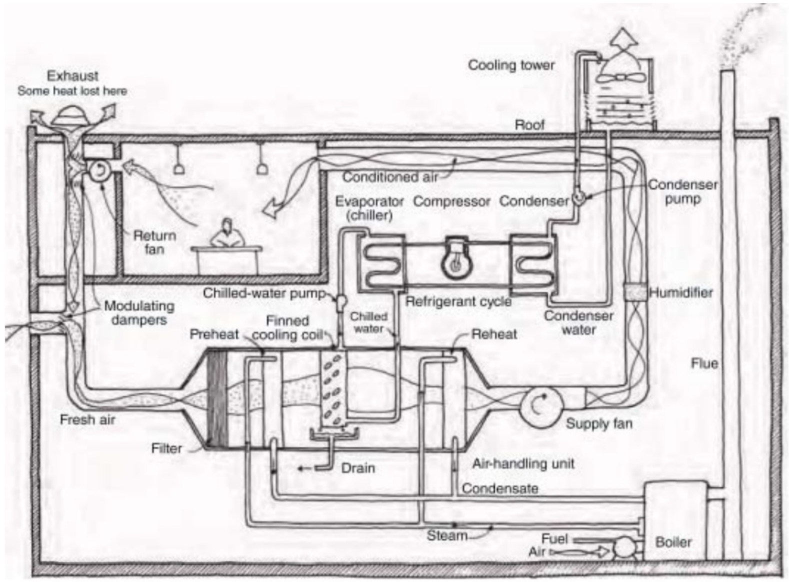
A certain rebound effect has been recorded: the potential energy savings are in the first place used to increase the living comfort.

The reduction in energy demand associated with better building performance levels has been proved to be less than assumed. This is a typical conclusion of similar studies that have been conducted in different countries.

https://www.buildup.eu/sites/default/files/content/e3sconf_nsb2020_22007.pdf

Thank You

For Your Attention!



Advanced office room

Obsolete office room

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