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Training for Renovated Energy Efficient Social housing

Intelligent Energy -Europe programme, contract n° EIE/05/110/SI2.420021

Intelligent Energy Europe

Section 1 Techniques
1.1 Insulation and Thermal Bridges

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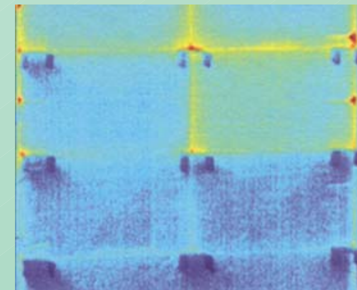
VIP – Vacuum Isolation Panels in Practice

- very low thermal conductivity → space saving (factor 5 … 10)
- application fields: floor, balcony, walls and ceilings with little scope (e. g. embrasures, dormers, connections, indoor insulation)
- high influence of thermal bridges in-between mounted elements
  → very accurate mounting
  without any gaps indispensable



- special fixing-solution: dowels (glass-fibre) clamp elements at edge
- durability: up to 50 years (at room temperature), significant reduced by permanent humidity (→ protection)
- VIPs nearly impermeable, but humidity transport via splices
- avoid punctiform pressure
- cost intensive; special handling → special-purpose solution

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Contents

- Insulation materials and their features
- Insulation-systems for (Ultra)Low-Energy-Houses
- Special-purpose solutions: Vacuum-Insulation-Panels and Transparent Insulation in practice
- Thermal bridges
- Airtightness
- Exemplary solutions

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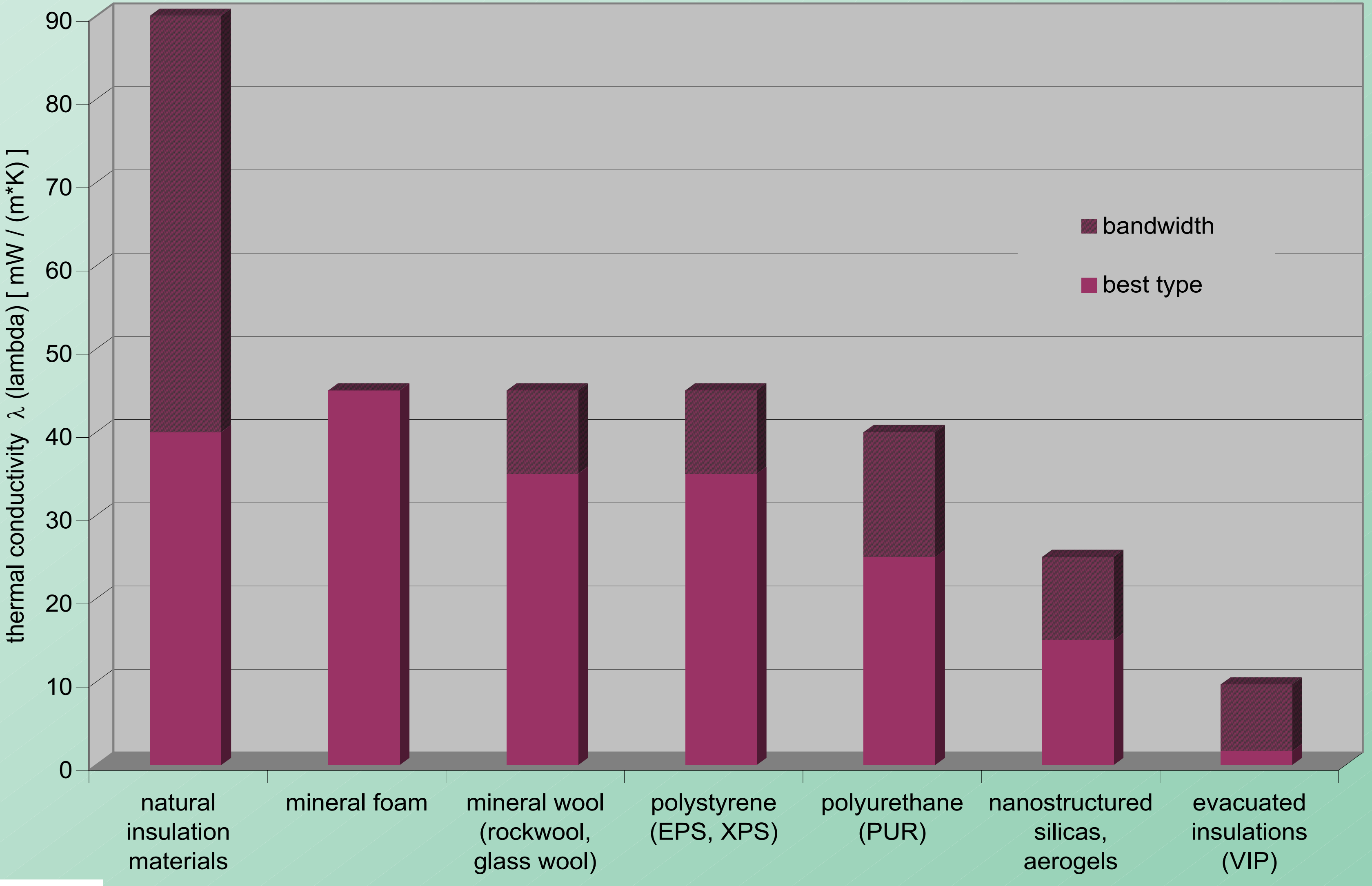
Thermal Conductivity of Insulation Materials



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Features of Synthetic Insulation Materials

Insulation Material	Thermal conductivity W / (m·K)	Density Kg / m³	Material class	Capillar Activity*	Dehumidi-fication*	Application
Rockwool, Glass wool	0.035 – 0.040 0.035 – 0.050	20-200	A1-B2	no	-	roof, ceiling, wall, floor
Mineral foam	0.045	115	A2	*no*	*hydrophobic treated*	wall
Polystyrene (expanded) EPS, Graphite modified	0.035-0.040 0.032	10-60	B1	no	-	roof, ceiling, wall, floor
Polystyrene (extruded)	0.035-0.040	20-60	B1	no	- (closed cellular)	flat roof, ceiling, cellar
Polyurethane (PUR)	0.025-0.040	15-80	B1/ B2 (foil clad)	no	- (closed cellular)	flat roof, ceiling, cellar
Nano-structured silicas, aerogels	*0.015-0.025*		*A1*			*core material for VIPs*
Evacuated Insulations Vacuum Insulation Panels (VIPs)	*(0.002)* 0.008	150-300	A2-B1	no	-	roof, ceiling, wall, floor

* see text

Features of Natural Insulation Materials

Insulation Material	Thermal conductivity W / (m·K)	Density kg / m³	Material class	Capillar Activity*	Dehumidi-fication*	Application
Cellulose (fluffs) (slabs)	0.040-0.045	30-80 (F) 60-90 (S)	B2		+	roof, ceiling, wall, floor
Cork (expanded shred)* (slabs)	0.050 (shr) 0.040-0.045 (S)	75-85 (shr) 110-120 (S)	B2			excavation fill*, rf, cl, wl, fl (S)
Wood fibre (loose) (slabs)	0.040 (L) 0.040-0.052 (S)	30-40 (L) 150-270 (S)	B2		++ (S)	rf, cl, wl, fl
Wood wool (mineral bound slabs)	0.065-0.090	330-500	B1			only for boarding; plaster base
Coco fibre	0.045	70-80	B2	yes	++	floor, stuff wool
Flax	0.040	Ca. 30	B2		++	rf, cl, wl, fl
Hemp (loose, mat)	0.050-0.055 (L) 0.040-0.050 (M)	40-60 (L) 20-45 (M)	B2		++	rf, cl, wl, fl
Perlite (fill)* (slabs)	0.050-0.055 (F) 0.055-0.060 (S)	10..90..165 150…200 (S)	B2 (F) A2/B1/ /B2 (S)	no	o	excavation fill*, flat roof (S)

* see text

Insulation-Systems: Bonded Thermal-Insulation-System

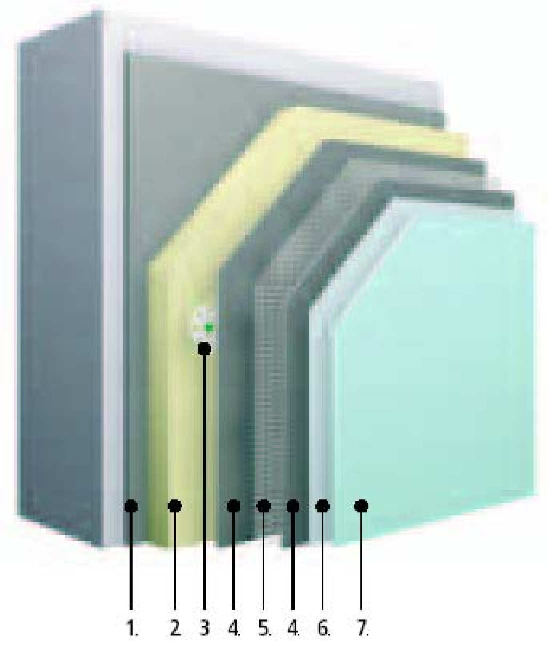

Figure: sto AG, D-Stühlingen

1	adhesion mass
2	insulation material (slabs)
3	dowelled joint
3	armoring mass
4	armoring fabric
5	*(pre-coating)*
6	plaster

- only approved as a whole system from one manufacturer
- plaster up all around each insulation slab on the back to avoid rear-ventilation with cold air

- no plaster on butt joints
- place insulation carefully without gaps
- fill voids only with insulation material (not with plaster or mortar)
- anchorage of external elements (railings, porches etc.): uncouple thermically with mounting-elements (PUR) or impregnated gluelam

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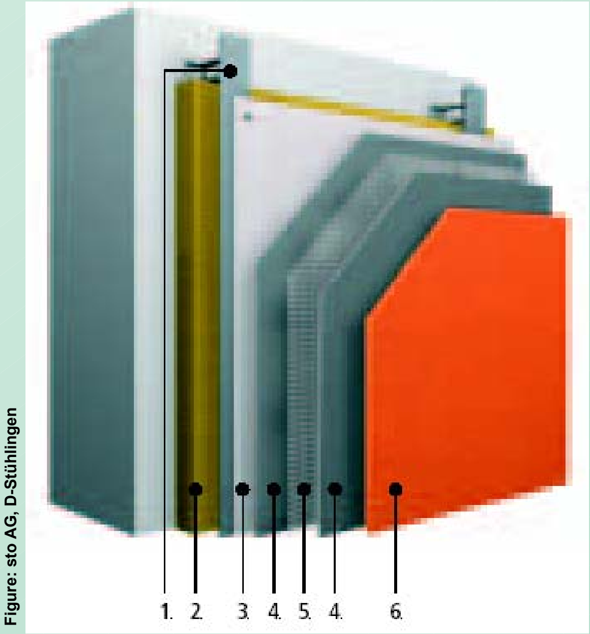
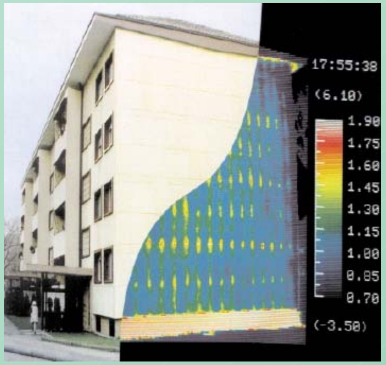
Insulation-Systems: (rear ventilated) Curtain Wall



1	Under-construction
2	Insulation material
3	Truss slab
4	Armoring mass
5	Armoring fabric
6	Plaster



- uncouple anchoring of underconstruction thermically from wall (especially in case of aluminium-structures)
- consider underconstruction in fire protection
- place insulation carefully without gaps (if recommended: slightly oversized)
- fill voids only with insulation material
- many insulation materials require a wind seal outside
- vapour-sealed facades require a rear-ventilation

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Comparison of both Insulation Systems

Bonded Thermal-Insulation System	(rear ventilated) Curtain Wall
▸ high insulation-values easy to reach (single-layer up to approx. 30 cm insulation thickness) ▸ over 34 years of proved durability ▸ recycling with passable effort ▸ wide range of different applicable materials ▸ higher fire protection needs grantable with class-A-materials (e. g. lintels, high-rise buildings) ▸ very low costs in use of EPS-slabs ▸ improved noise control also feasible with EPS by modified slab-materials	▸ insulation effect reduced up to 20%, due to thermal bridges of the necessary anchors → special solutions required ▸ recycling mostly by simple disassembling ▸ higher fire protection needs grantable with class-A-materials (e. g. lintels, high-rise buildings) ▸ higher construction costs ▸ very low maintenance (depending on covering material) ▸ noticeable improvement of noise control feasible

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Arguments for High-Insulated-Constructions

- share of costs for insulation-material is very low (ca. 1/3 of total amount)
- cost-optimised insulation-thickness rises with the energy-prices
- later added insulation is in any case uneconomical
- thermal-bridge optimised constructing is easier with high insulation-thickness
- secure prevention of mildew also at intensive habitation
  and in critical areas (e. g. corners behind gardrobes)
- docile (or ‘well tempered’) cooling-down of the building
  in case of longer heating-omission (category temperature 18…19°C)

  → social housing – assured for a good future –
  also in case of extreme (?) energy scenarios

  → ‘warmth-guarantee’ as marketing-advantage
- optimal thermal behaviour also in summer

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Insulation Materials: Amortisation of Fabrication Energy

	Insulation Material	Thermal Conductivity [W/(m·K)]	Density [kg/m^3]	Thickness for U=0.15 W/(m^{2}K) [cm]	Fabrication Energy		Amortisation Time [months]
					[kWh/m^3 Insulation Material]	[kWh/m^2 external wall]	
BTIS	Expanded Polystyrene (EPS)	0.035…0.040	15	21…24	600	130…145	13…15
	EPS, graphite modified	0.032…0.035	15…17	19…21	600...680	115…145	11…14
	Glass wool	0.035…0.040	120	21…24	700...1200	145…290	14…29
	rockwool	0.035…0.040	150	21…24	530…680	110…140	11...14
	Mineral foam	0.045	115	27	250	70	7
	Wood fibre (slabs)	0.040…0.045	180	24…27	600...1400	145…380	14…37
	Cork (slabs)	0.040…0.045	120	24…27	65...450	20…120	2...12
Curtain Wall, timber underconstruction	Glass wool	0.035…0.040	40	24…27	250...400	60…110	6...11
	rockwool	0.035…0.040	60	24…27	210…270	50…75	5...7
	Cellulose fluffs	0.04	40...60	27	45…70	15…20	2…3
	Wood fibre (loose)	0.04	100	27	300…700	80…190	8…18
	Flax	0.04	30	27	20…40	5…10	1…2
	Hemp (mat)	0.040…0.050	40	27…33	50…80	15…25	2…3

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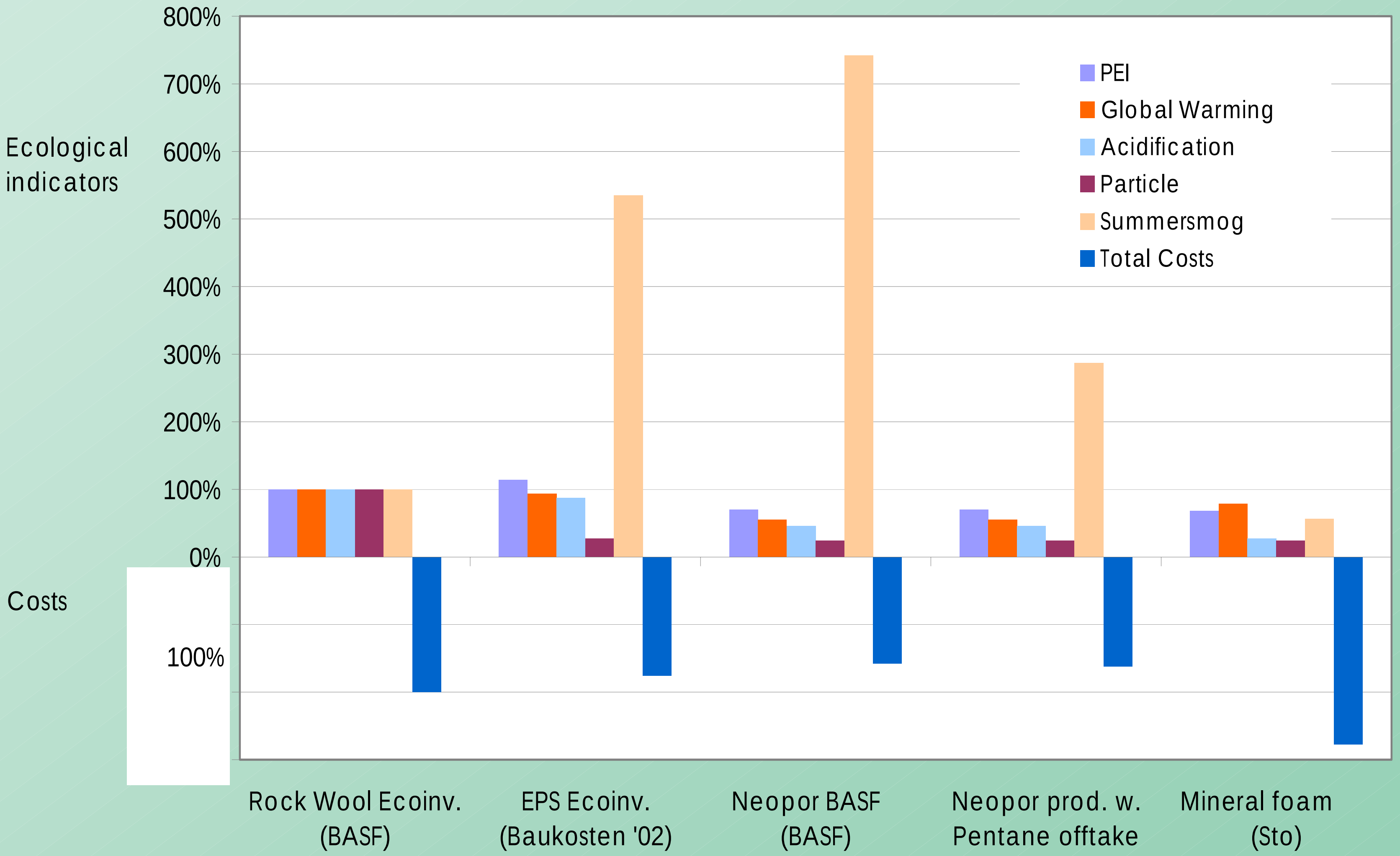
Bonded Thermal-Insulation-Systems: Ecological Effects and Costs



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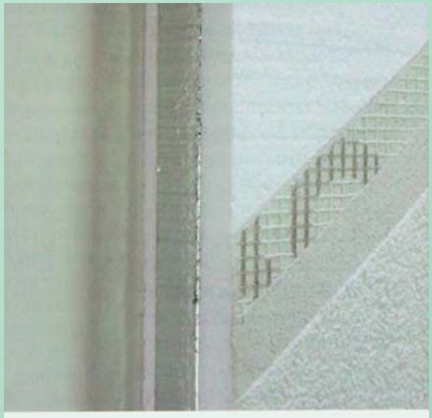
VIP – Vacuum Isolation Panels and Elements

VIP-Panels:

- \- core: pyrogenic silica
  - protective membran
  - envelope: vacuum sealed
    (impervious to diffusion)
- sensor-disc for vacuum-check

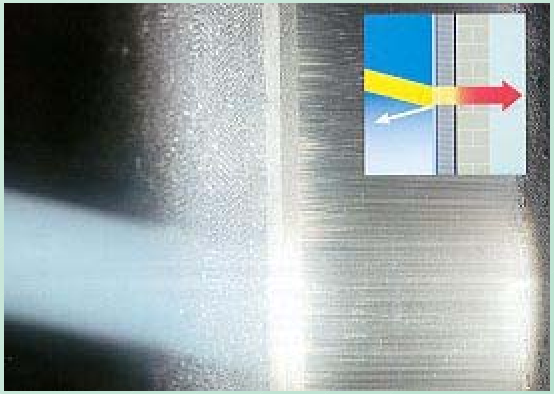


VIP-Elements = Panel + Protective Layers

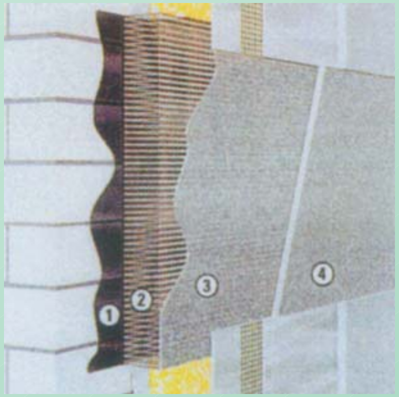
- EPS-layers
  (Bonded Thermal Insulation System)
- PUR-layers

Transparent Insulation (TI): Function and Designs

Passive-Solar Accumulating Wall

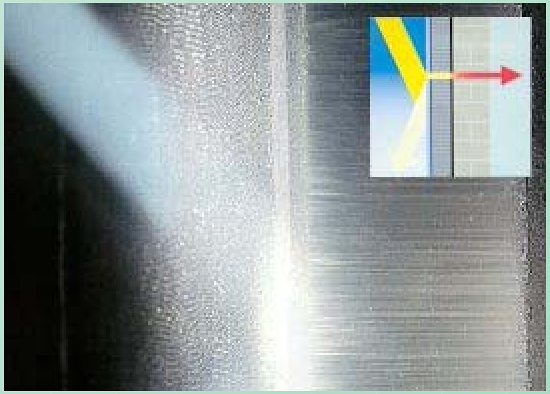


incidence angle in winter

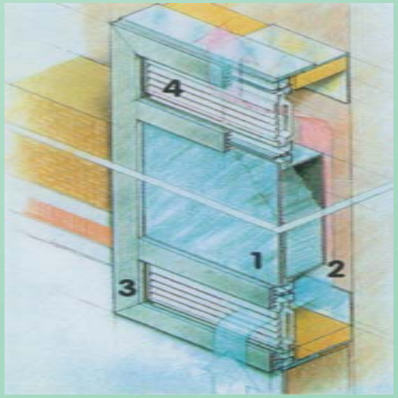


Transparent BTIS

1. absorber coating
2. TI-capillary panel
3. armouring
4. translucid glass-mortar



incidence angle in summer



TI-Facademodule

1. glass cover
2. absorbing layer
3. closable air inlet
4. and outlet (summer)

Transparent Insulation (TI): Application Area and Benefits

- walls of density ≥ 1200 kg/m³
- walls without any existing insulation
- surface share of TI ≤ 5 … 10 %
- energy benefits ./. opaque thermal insulation: 80 … 130 kWh/m²a
  (south surface; U_{opaque} = 0.15 W/m²K)
- higher share of TI:
  → decreasing specific energy benefit
  → risk of overheating in summer
- costs 5 times higher than opaque BTIS
- TI do not replace high efficient thermal insulation, only considered as complement

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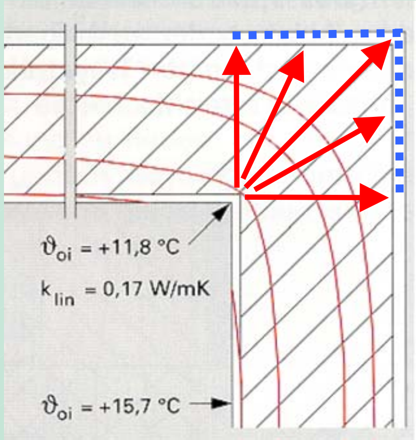
Thermal Bridges: Characterisation

- thermal bridges = areas with higher heat drain than in standard component
- → cooling-down of inner surface
- below critical value: interior air humidity condenses in place
- humid, cool surface → mildew
- consequences:
  - needless higher energy-losses
  - risk of component-damages caused by condensate
  - risk of health-damages caused by mildew
  - receivables of tenants; vacancy
- remedy: thermal protection raises inner surface temperature

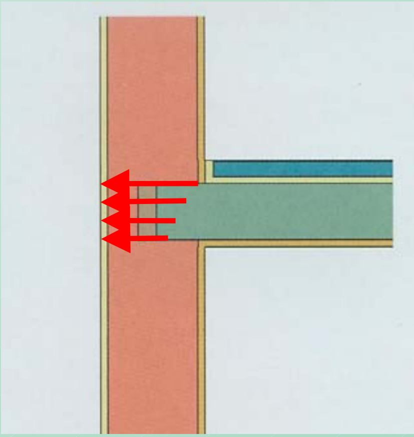
Thermal Bridges: Examples

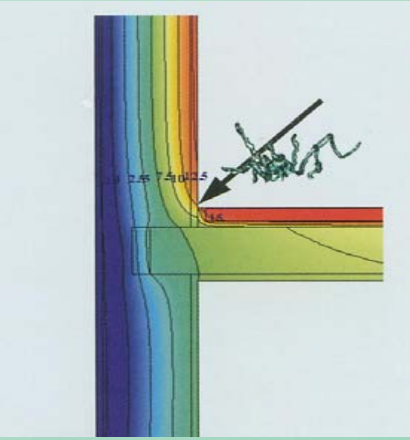
External Corner ('Geometrical Thermal Bridge')



- outer surface > inner surface
- → higher heat-flux than in centre of wall area (standard surface)

Concrete Ceiling ('Material Thermal Bridge')





- component with high(er) thermal conductivity pierces standard surface or insulation
- e. g. thermal conductivity concrete ceiling > brickwork
- → higher heat-flux than in centre of wall area (standard surface)

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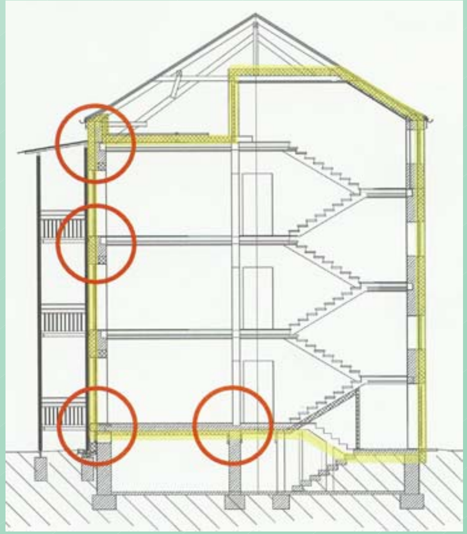
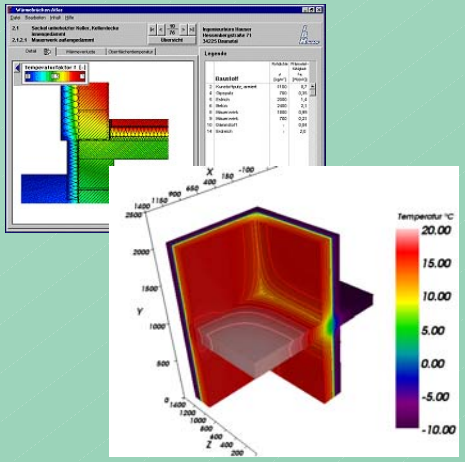
Thermal Bridges: Planning

Thermal-Bridge free Building begins in Planning Office



- insulating mantle has to wrap up the heated room without interruption
- refurbishment: some thermal bridges only reduced
  (e. g. basement ceiling at cellar walls)
- comparison of different solutions:
  estimation of efficiency aided by software
  - catalogues of thermal bridges
  - calculation tools
- important: detail drawings of critical areas
- no craftsman can compensate a lacking concept !



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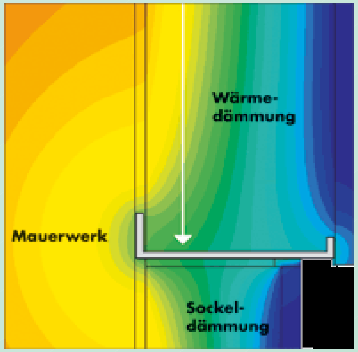
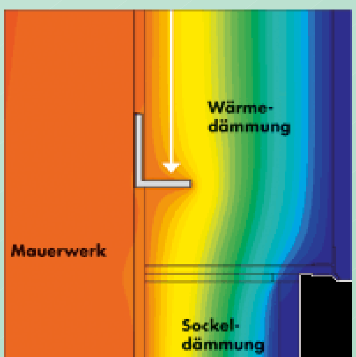
Avoiding new Thermal Bridges: Plinth



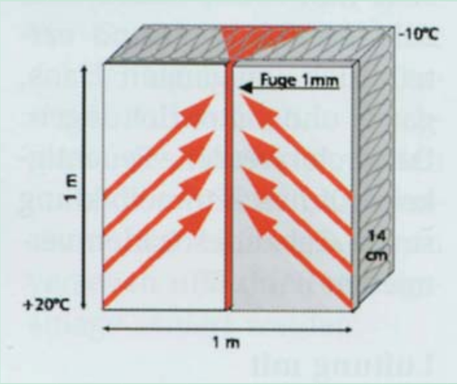


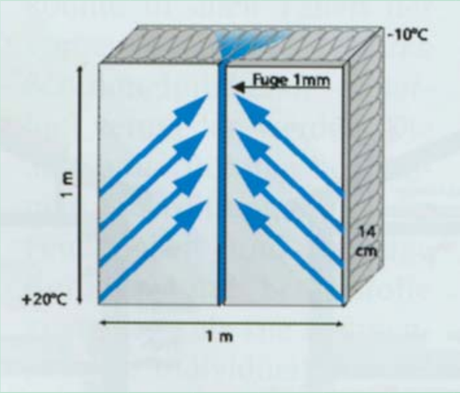
- standard closing-off profile made of aluminium
  (thermal conductivity 4000 times higher than insulation material)
- → thermal bridge
- higher heat losses equivalent to 1…2 m² insulated outwall area per meter profile

  thermotechnical interpretation:
  'ground floor 1…2 m higher due to aluminium profile'

- thermical uncoupled closing-off system avoids higher heat losses and low temperatures on inner surface

Airtightness: Reasons for Airtight Buildings





- gap, 1mm width x 1m length (related to 1m²); airstream pervades construction
- U-value declined by factor 5 ! (0.3 → 1.44 W/m²K)
- airstream carries interior air humidity into construction; amount of condensate due to convection more than 100 times higher than by vapour-diffusion !
- consequences:
  - insulation largely ineffective
  - risk of grave construction damages
  - dissatisfaction of dwellers because of infiltration
  - abatement of rent, vacancy
- ventilation system with heat recovery requires airtight building-envelope

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Airtightness: Respiration-Air via Leakages?

- yield of airflow through leakages insufficient
- air quantity fluctuates with weather (insufficiency ... infiltration, cold draughts), do not meet the needs
- respiration air via leakages = unhygienic
- superior: - planned outer-air apertures
  - ventilation system

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Planning Airtightness: Concept of Airtightness

Determine Airtight Envelope

- course: - flat towards outer air
  - in-between flats (e. g. at installation ducts)
  - airtight separation from cellar (housed staircase)
- layer: determine position of airtight layer for every component part
  - sealing of plain (e. g. inside plaster at brickwork)
  - connection in line between different partial areas
  - punctiform connections at pervasions for construction and building services
  - components with splices for mounting and closing (windows, doors,..)
- prevent pervasions and connections (e. g. building services → installation layer)
- prevent change of airtight-layer (inside↔outside; e. g. insulation upside rafters)
- planning details (connection details)

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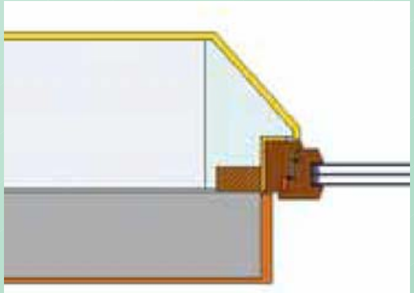
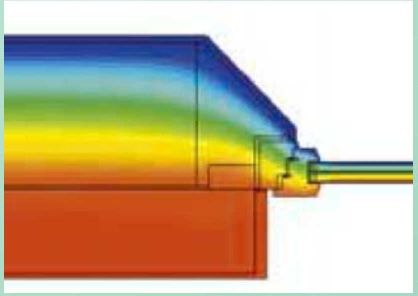
Exemplary Solutions: Window-Mounting



- mount window from outside the exterior wall (fixing e. g. by elbow-mounting)
- airtight connection of window frame to airtight-layer of exterior wall
  - fleece cladded tape on prepared subsurface
  - later inserted with BTIS-glue


- insulation of blind frame as far as possible
- cant insulation for wider angle of view and improved incident light

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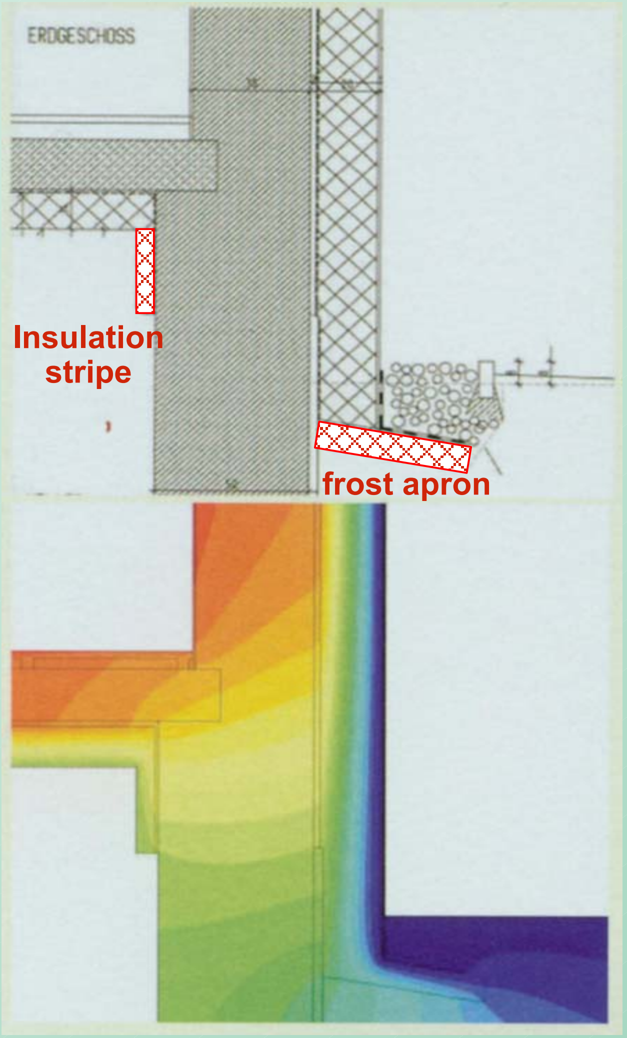
Exemplary Solutions: Plinth and Basement



- insulation of basement due to cost reasons only 25 cm below terrain
- Supplemented with frost apron
- Remaining Effect of Thermal Bridge:
  + 0.86 m² outwall area per plinth meter
- Improvement: basement insulation down to ≥ 50 cm below terrain;
  + frost apron at 25 cm below terrain
- additional insulation stripe at basement walls towards basement ceiling (at inner walls too)

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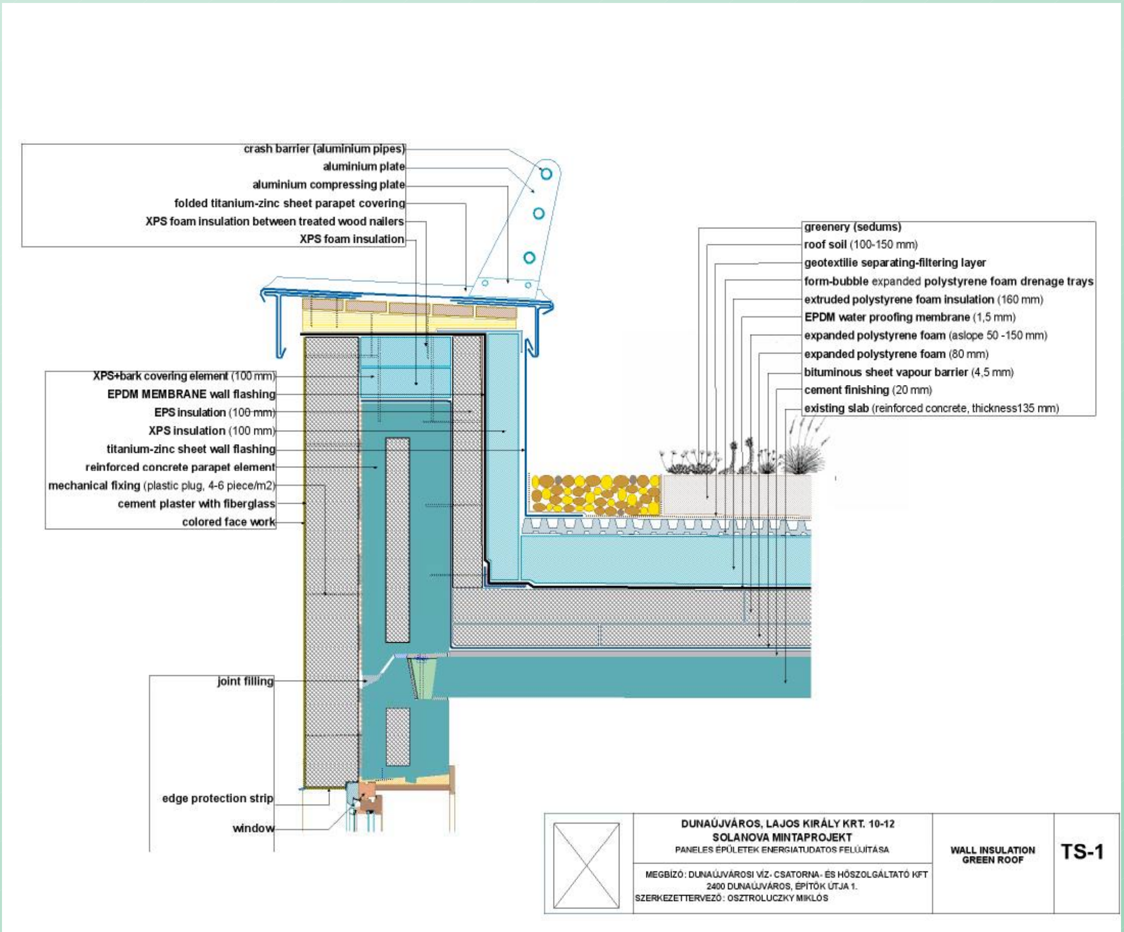
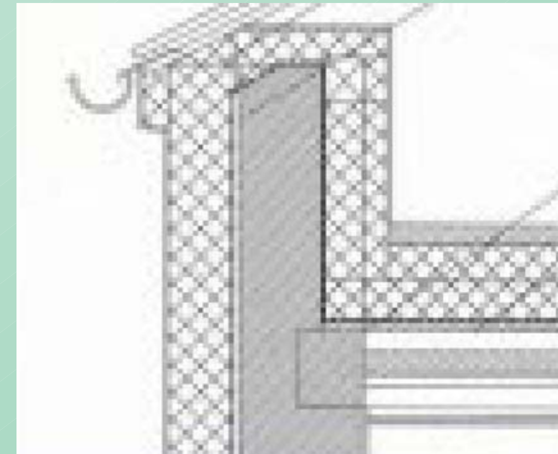
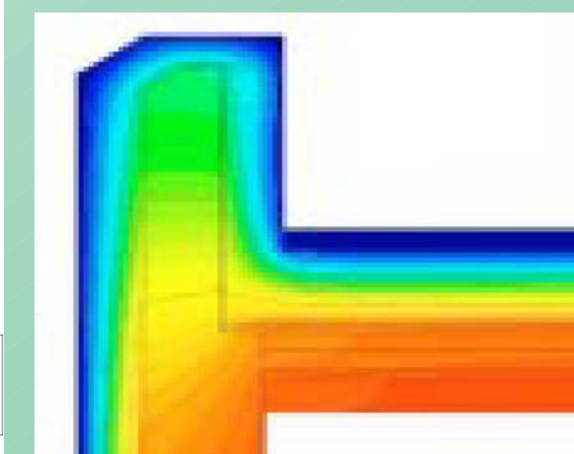
Exemplary Solutions: Attics or Sills







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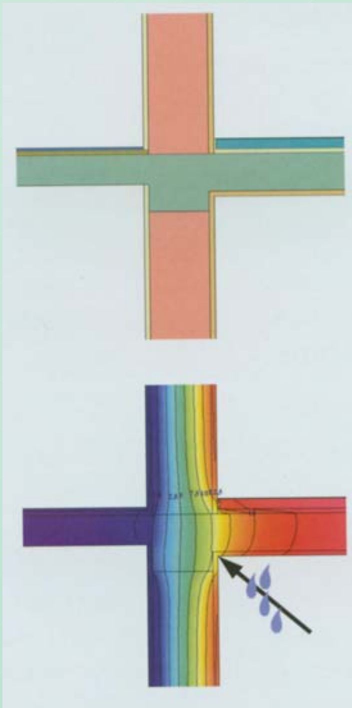
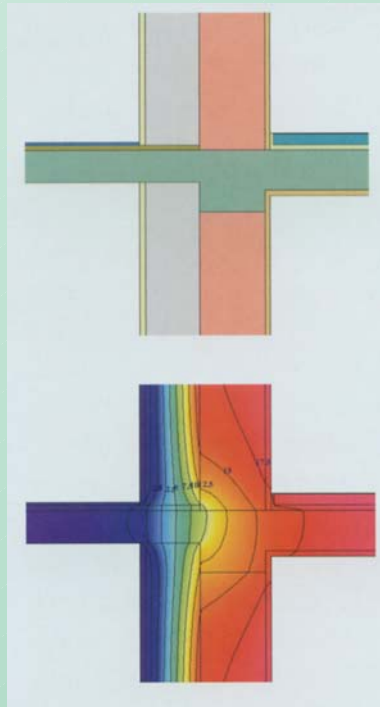
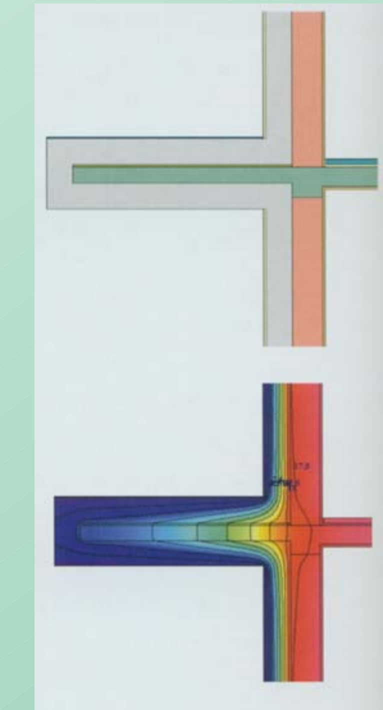
Exemplary Solutions: Projecting Ferroconcrete Balcony Slab

Uninsulated	High Efficient Ins.	+ Wrapped Slab	uncoupled
			
+ 3.5 m² mildew !	+ 0.50 m²	+ 0.15 m²	+ 0.02 m²

Thermal Bridge Losses = Additive Outwall Area / m Balcony Connection

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Quality Assurance

Aim: Reaching the Targeted Energy-Standard

- draft-planning time: concepts of insulation and airtightness
- execution-planning: graphics of connection details
  (minding the practicability at the construction site)
- tender and allocation/contracting: pointing to particularities in execution
- defining interfaces to other crafts and performances
- specify the particular quality criteria of the construction parts
- introducing craftsmen early while executing + monitoring the construction
- coordinate the responsabilities and competences of the crafts
- adjust immediately mounting faults or wrong decisions at material choice
- result checking by means of Blower-Door + Thermography
- use check lists