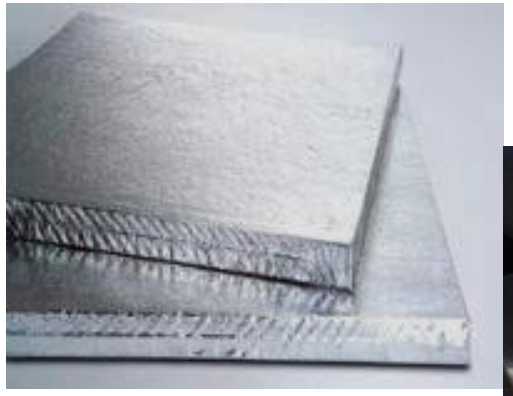
CHALMERS
UNIVERSITY OF TECHNOLOGY

EBC
Energy in Buildings and Communities Programme

Annex 65

Long-Term Performance of Super-Insulating Materials in Building Components & Systems



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Reading 2015 /April

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Challenges in the Building Sector

Renovation/Retrofitting

- Building stock : more than 80% of energy consumption.
- 75% to 90% of current buildings will still be standing in 2050

New Buildings

- NZEB (Net or Nearly Zero Energy Building)
- only 10 % to 20 % of additional energy consumption (2050)

Energy Efficiency

- Through Building Envelope & Thermal Insulation
  (IEA Roadmap)

Scope

Two main types of SIM :

- Vacuum Insulation Panel
- Advanced-Porous Materials, such as Aerogel

State of the Art

Learning from the past (ST1)

Three scientific & technical issues:

Performance & Durability - (ST2)

Design & Installation (ST3)

Sustainability (LCA, LCC, EE) – (ST4)

Table 1: Summary of the insulation materials

Insulation Material	Thermal conductivity (mW/K)	Density (kg/m^3)	Prices (US $)
Mineral wool	30-40 (at 10 °C)	30-200	0.5-4.2/Square meter
Expanded Polystyrene(EPS)	30-40 (at 10 °C)	40	3.5-5.2/Square meter
Extruded Polystyrene(XPS)	30-40 (at 10 °C)	100-150	1/Square meter
Cork	45 (at 25 °C)	120-200	0.2-2/Piece (H-26mm, D-13mm)
Polyurethane(PUR)	35 (at 10 °C)	40-60	2.2–2.5/Kilogram
Cellulose	35 (at 10 °C)	24-27.2	7.18–7.45/Kilogram
Vacuum Insulated Panel(VIP)	3-4 (at 10 °C)	—	5-28/Square Meter
Gas-filled Panels(GFP)	36.1 for Air	—	—
	49.2 for Argon	—	—
	86.7 for Krypton	—	—
Aerogel	13-16 at atmospheric pressure	3	75.24/Square Meter

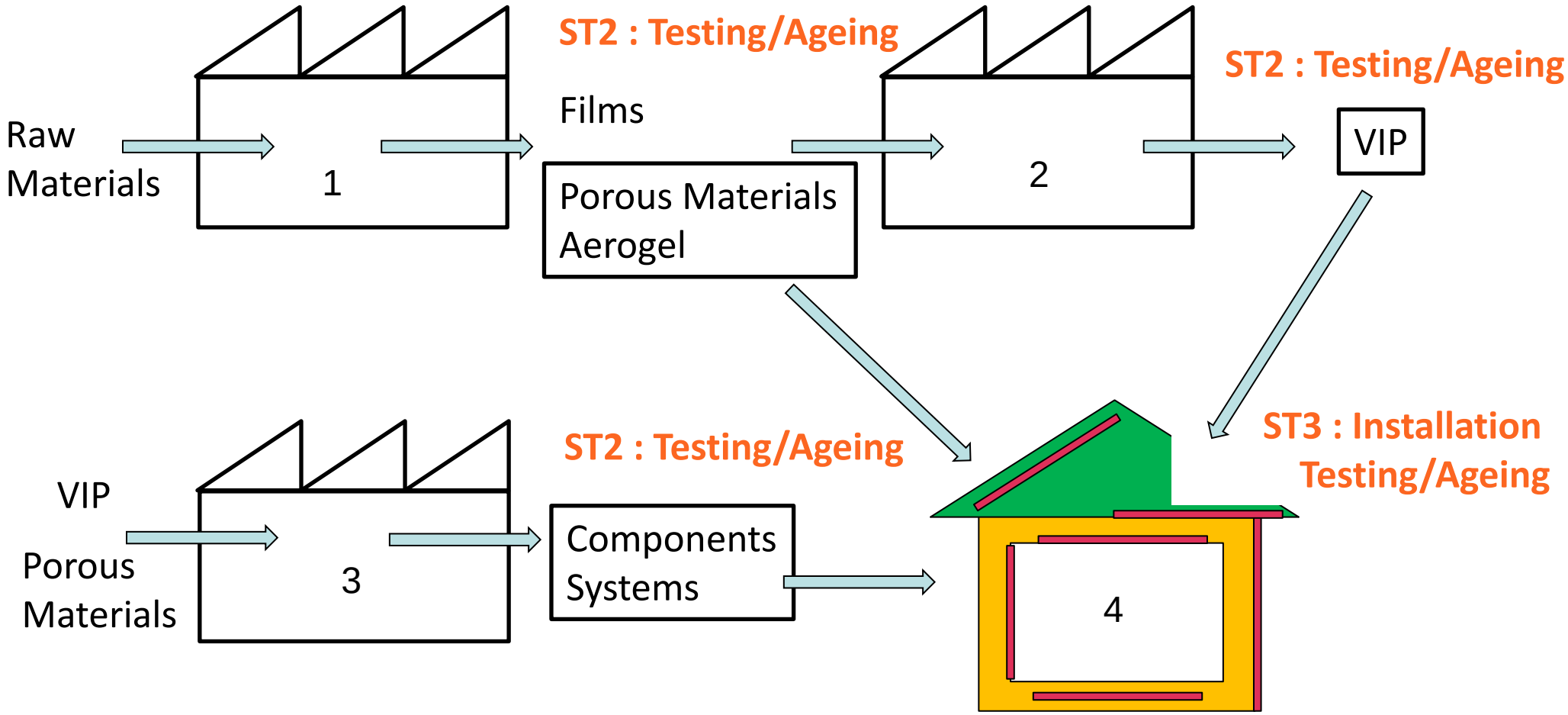
Source: (Alibaba, 2012); (Thermablok, 2010); (Foamsales, 2012)

VIP: about 40 US$

Aerogel blankets: about 40 US$

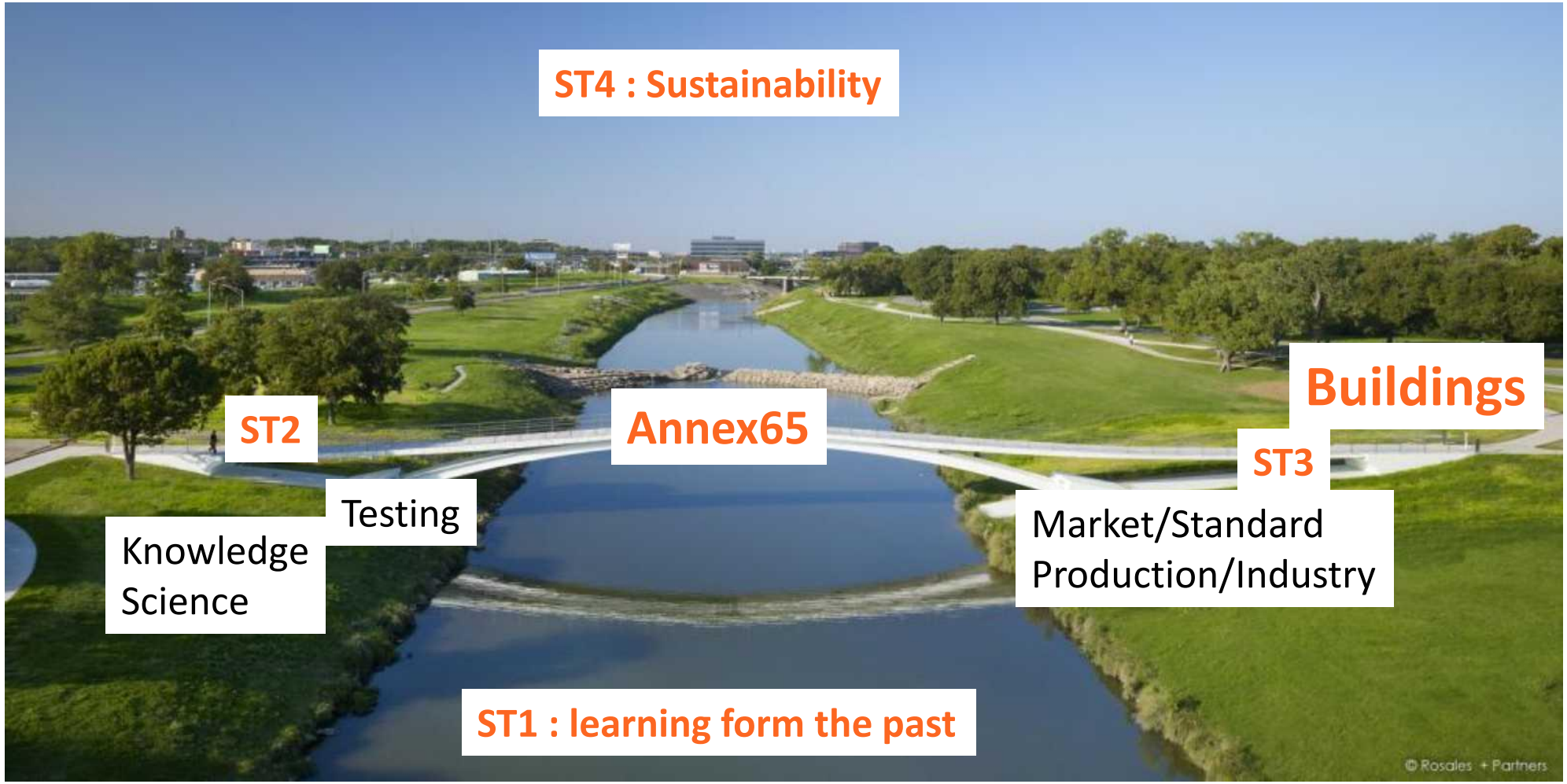
Annex65 & SIM value chain

ST1 : learning from the past



ST4 : Sustainability

Annex65 : a bridge between science & market



http://aasarchitecture.com/2013/03/phyllis-j-tilley-memorial-bridge-by-rosales-partners-architects.html

SubTask Description - SubTask Leaders

SUBTASK 1: State of the Art - Materials & Components - Case Studies

SubTask Leader: ZAE Bayern – Ulrich Heinemann

Action 1A : Materials, Components & Systems

Action 1B : Characterization Methods

Action 1C : Case Studies at the Building Scale

SUBTASK 2: Characterization of materials & components - Lab Scale

SubTask Leader: FIW Munich – Andreas Holm

Action 2A : Materials Assessment & Ageing Procedures (Experiments & Simulation)

Action 2B : Components & Systems Assessment (Experiments & Simulation)

SubTask Description - SubTask Leaders

SUBTASK 3: Practical Applications – Retrofitting

Subtask Leader: Chalmers Univ. Bijan Adl Zarrabi

Action 3A : Mapping of the Use Conditions (Components & Systems)

Action 3B : Performance at the Building Scale (Experiments & Simulation)
(possible links with Annex 58)

Action 3C : Practical Applications focused on Retrofitting

(possible links with Annex 61)

SUBBASK 4: Sustainability (LCC, LCA, EE)

Subtask Leader : Chalmers Univ. Holger Wallbaum

Action 4A: Life Cycle Assessment (LCA), including Embodied Energy (EE)
(links with Annex 57)

Action 4B: Life Cycle Cost Analysis (LCC)

36 Participants from Countries : 16

Belgium: Recticel, Dow Corning,
Canada : Ryerson University - Toronto
China: Nanjing University of Aeronautics and Astronautics (NAUU), Siltherm, Creek
France: EDF, Mines-Paristech, INSA Lyon, Univ. Lorraine, CNEES, Saint-Gobain ,Toray, ArcelorMittal, REXOR, PCAS, CSTB,
Germany: ZAE Bayern, Fraunhofer IVV, va-Q-tec, FIW Munich, Evonik, DLR , Metra-Group, Porextherm, Cabot, Aspen-Aerogel
Greece : National Technical University of Athens (NTUA)
Italy: Politecnico di Milano, Politecnica di Torino
Israel : Hanita Coatings (observer)
Japan : Annex65 Japanese Support Committee
Norway: SINTEF
Sweden : Chalmers University
Switzerland : EMPA
South Korea : Kongju National University, OCI
Spain: Tecnalia,
Turkey : Arcelik
United Kingdom: Kingspan,

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Long-Term Performance of Super-Insulating Materials

Task 3: Practical Applications – Retrofitting at the Building Scale – Field scale

Subtask Leader: Chalmers Univ. Bijan Adl Zarrabi

Action 3A : Mapping of the Use Conditions (Components & Systems)

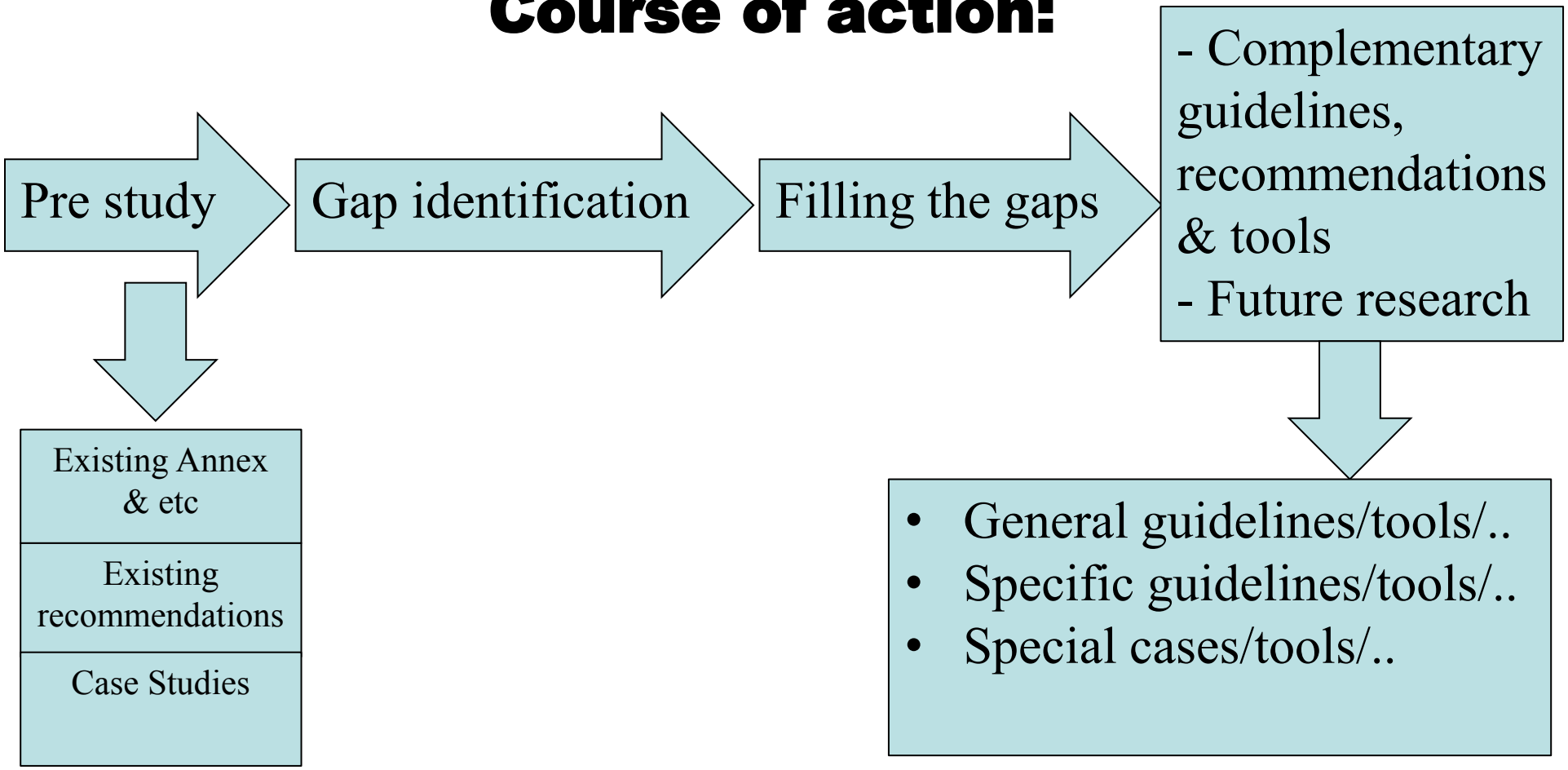
Action 3B : Performance at the Building Scale (Experiments & Simulation)

(possible links with Annex 58)

Action 3C : Practical Applications focused on Retrofitting

(possible links with Annex 61)

Course of action:



Parameters:

-Type of building
- Single family house
- Multi family house
- Office
- Special building

e.g. hospital, fitness centre, ..

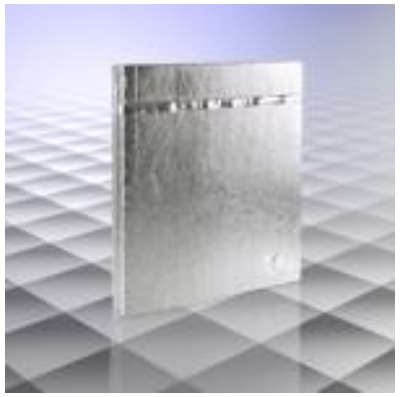
-Components
- Walls
- Roof
- Floor
- Windows
- Ground
- ……

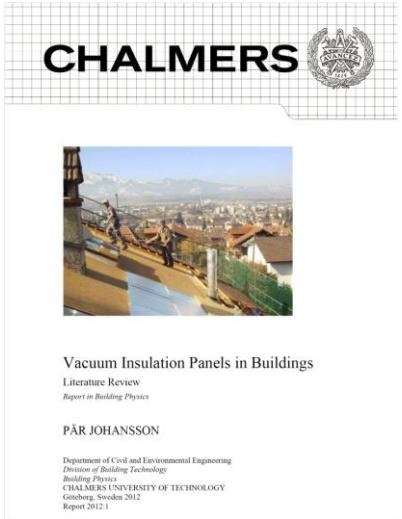
-Climate
- Cold/warm
- Dry/wet
- Windy
- …….

-age of building
- New
- Old
- Medium

SIM in buildings

- Retrofitting
  - Wall
  - Roof
- New buildings
  - Wall
  - Roof
  - Terraces





Johansson, P. (2012). *Vacuum Insulation Panels in Buildings: Literature Review* (No. 2012:1). Gothenburg, Sweden: Chalmers University of Technology, Department of Civil and Environmental Engineering. http://publications.lib.chalmers.se/publication/155961

Field study

Välten 1930

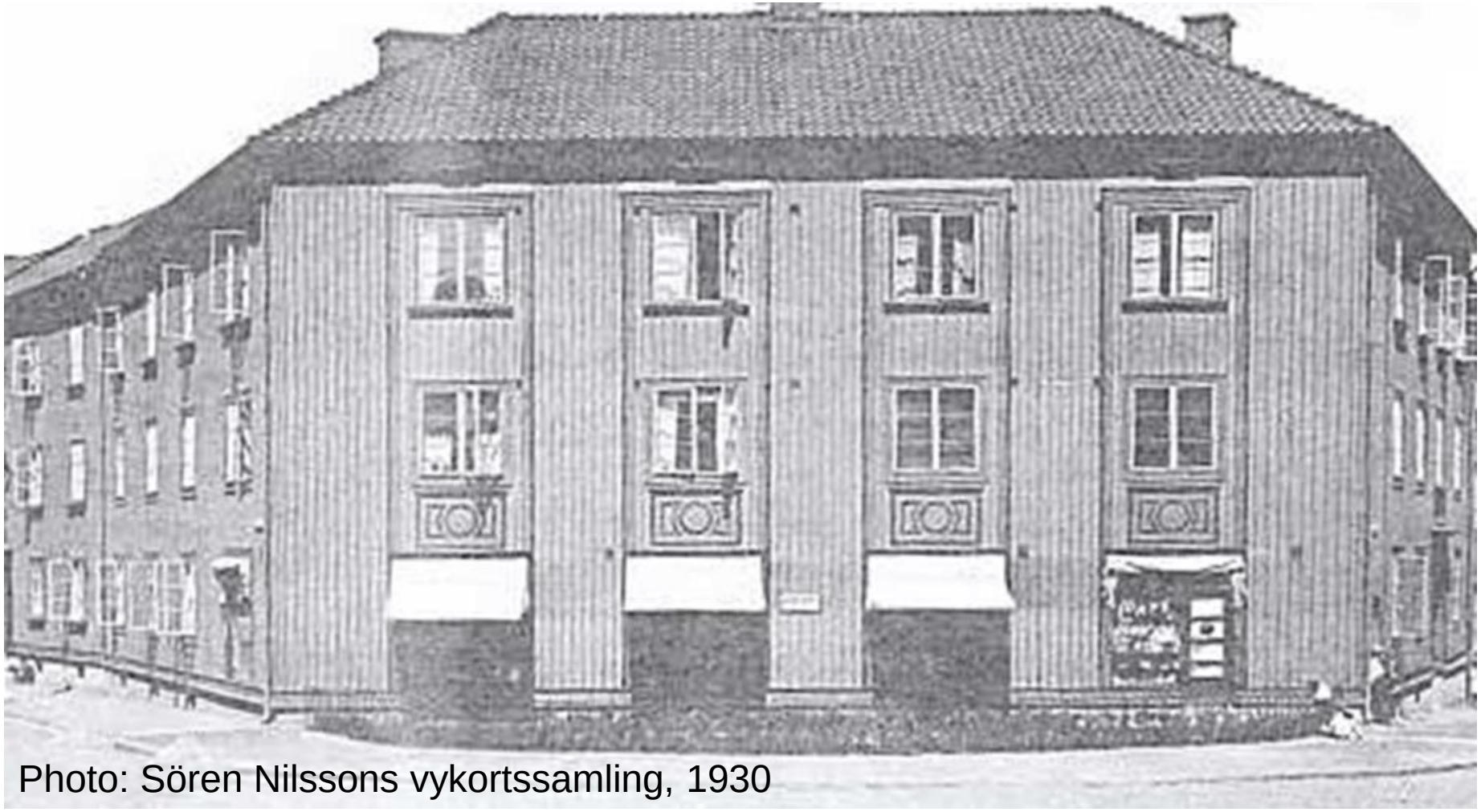
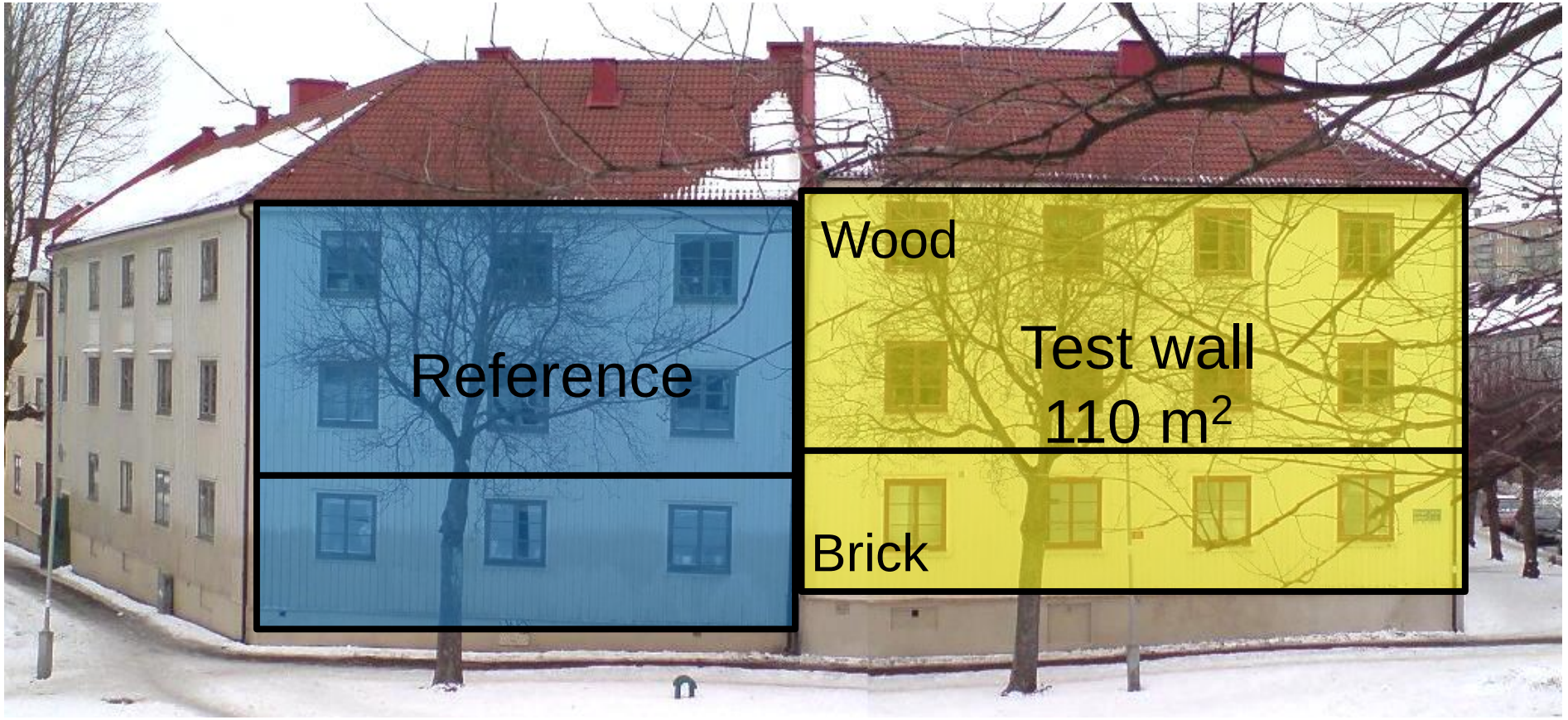


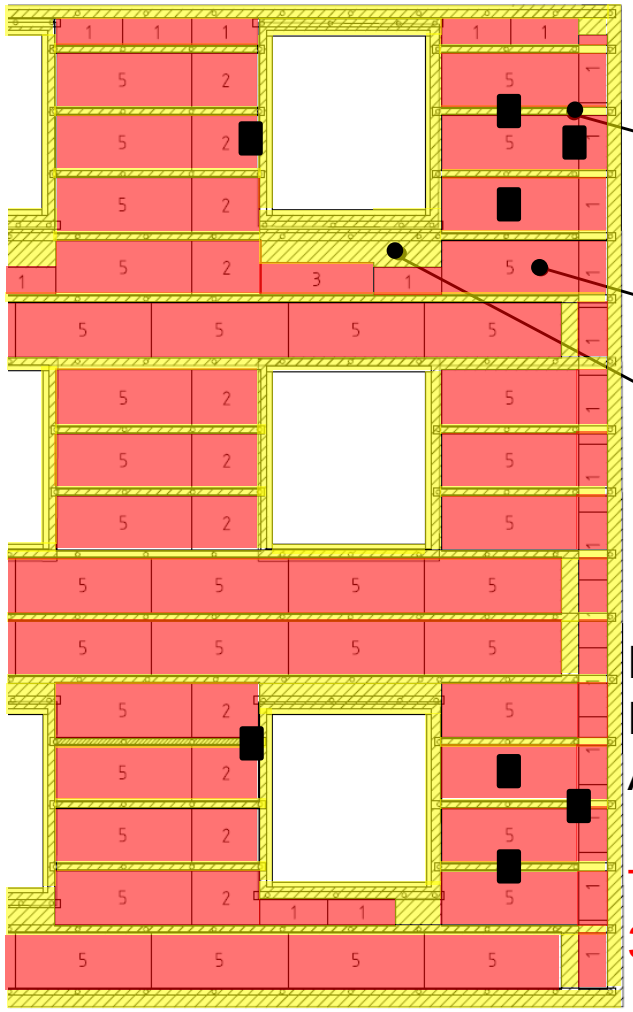
Photo: Sören Nilssons vykortssamling, 1930

Field study building

- Landshövdingehus from 1930, retrofitted in the late 1970s



Wall insulated on the exterior



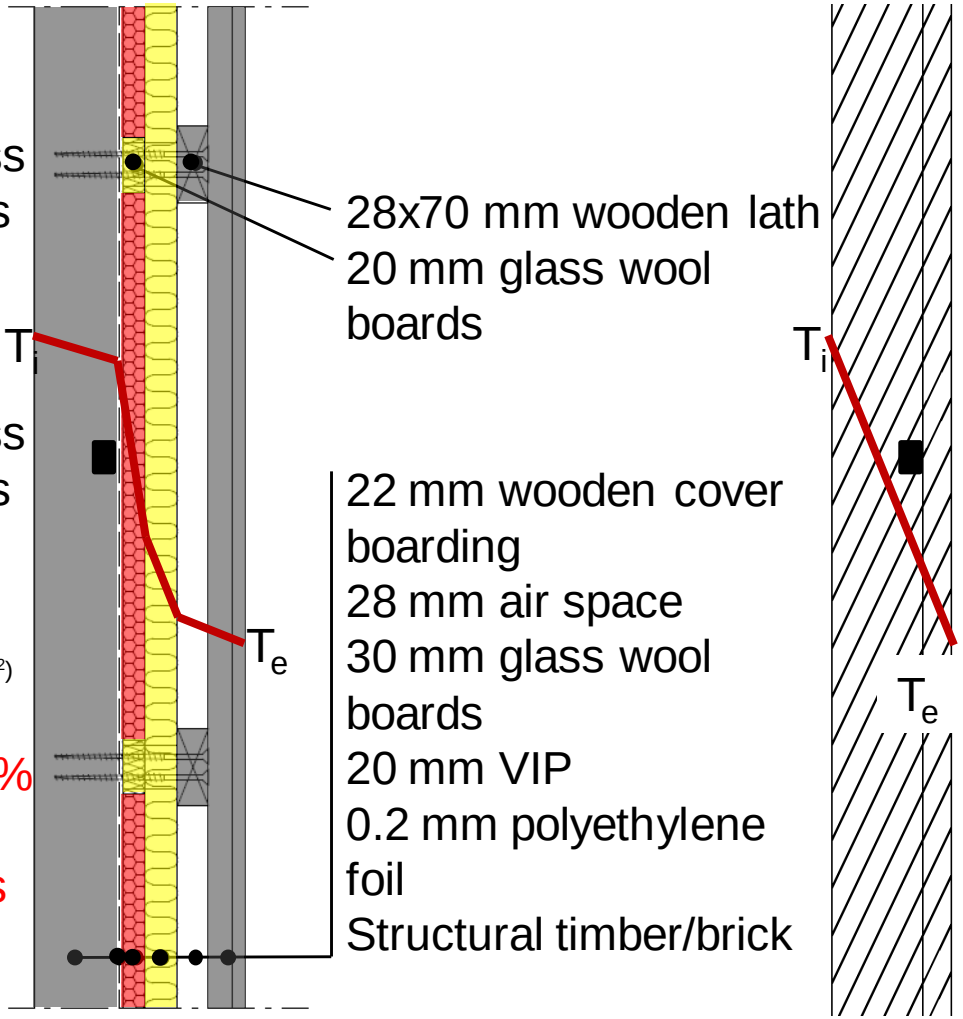
20 mm glass wool boards

20 mm VIP

20 mm glass wool boards

Energy use (kWh/m²)
Before: 158.7
After: 127.5 -20%

Thermal bridges
3-7% increase



28x70 mm wooden lath
20 mm glass wool boards

22 mm wooden cover boarding
28 mm air space
30 mm glass wool boards
20 mm VIP
0.2 mm polyethylene foil
Structural timber/brick

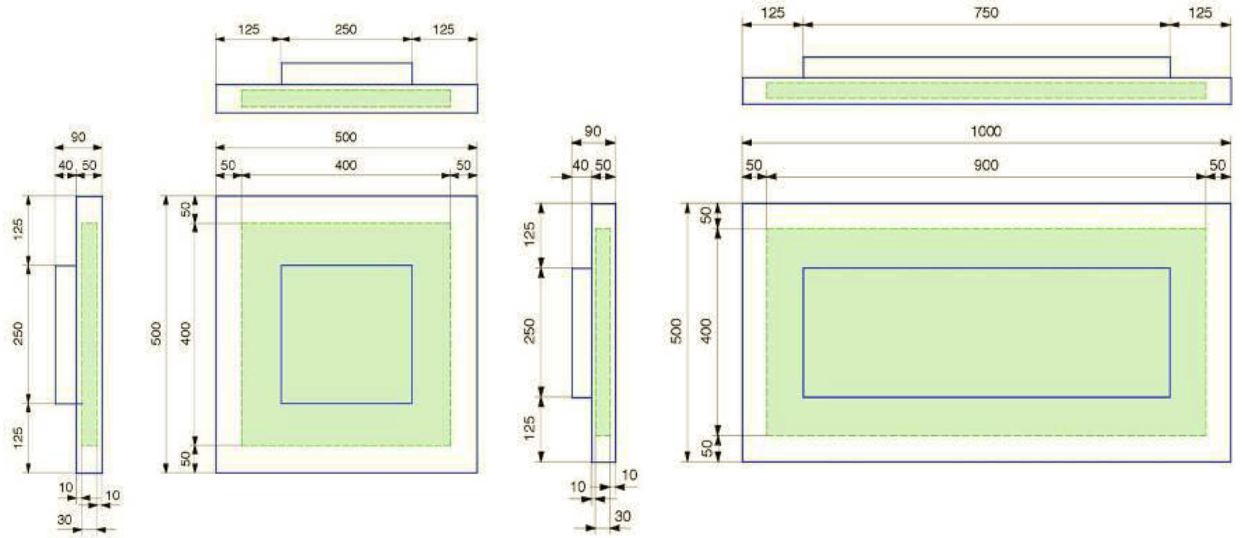
External and internal Insulation

Applications

Case Studies

Installation Tips

Retrofitting Munich



Kubina, L. (2011). LockPlate System ETICS with Integrated **VIP** - Experience from Building Practice. *Proceedings of the 10th International Vacuum Insulation Symposium, September 15-16, 2011, Ottawa, Canada.*

External Wall Insulation - Heritage

- Project Renovation
- Location Switzerland
- Bldg. Type Private Dwelling
- Application External Wall 20mm,10mm
- Benefit Heritage protected, breathable thermal bridge treatments

External Wall Insulation

- Project Renovation
- Location USA
- Bldg. Type Industrial Unit
- Application External Wall – 20mm under rolled metal profile
- Benefit Space saving, energy saving fast install, existing trades compatible

Internal Wall Insulation

- Project Renovation
- Location Italy
- Bldg. Type House
- Application Internal Wall
- Benefit Energy Saving, Space Saving

Interior insulation Copenhagen

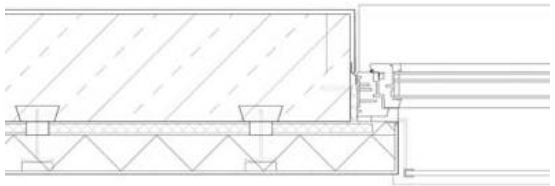
Martin Morelli, Leif Rønby, Svend Erik Mikkelsen, Maja G. Minzari, Troels Kildemoes, Henrik M. Tommerup. (2012). Energy retrofitting of a typical old Danish multi-family building to a “nearly-zero” energy building based on experiences from a test apartment. Energy and Buildings Volume 54 2012 395 – 406 http://dx.doi.org/10.1016/j.enbuild.2012.07.046

Facade and roof, Thun

neofas.

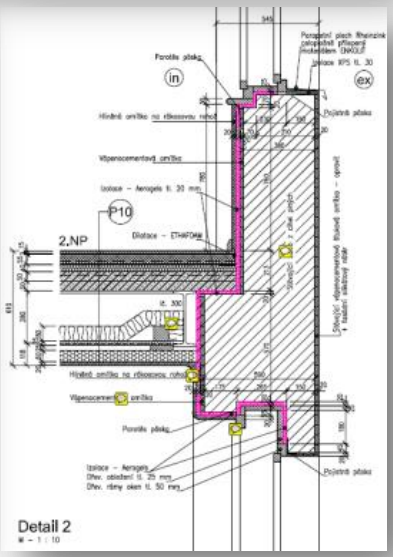
New office block Munich

- First commercial VIP project
- Concrete with VIPs, PUR between VIPs
- ”Ultra low energy standard” (20 kWh/m^2,a)

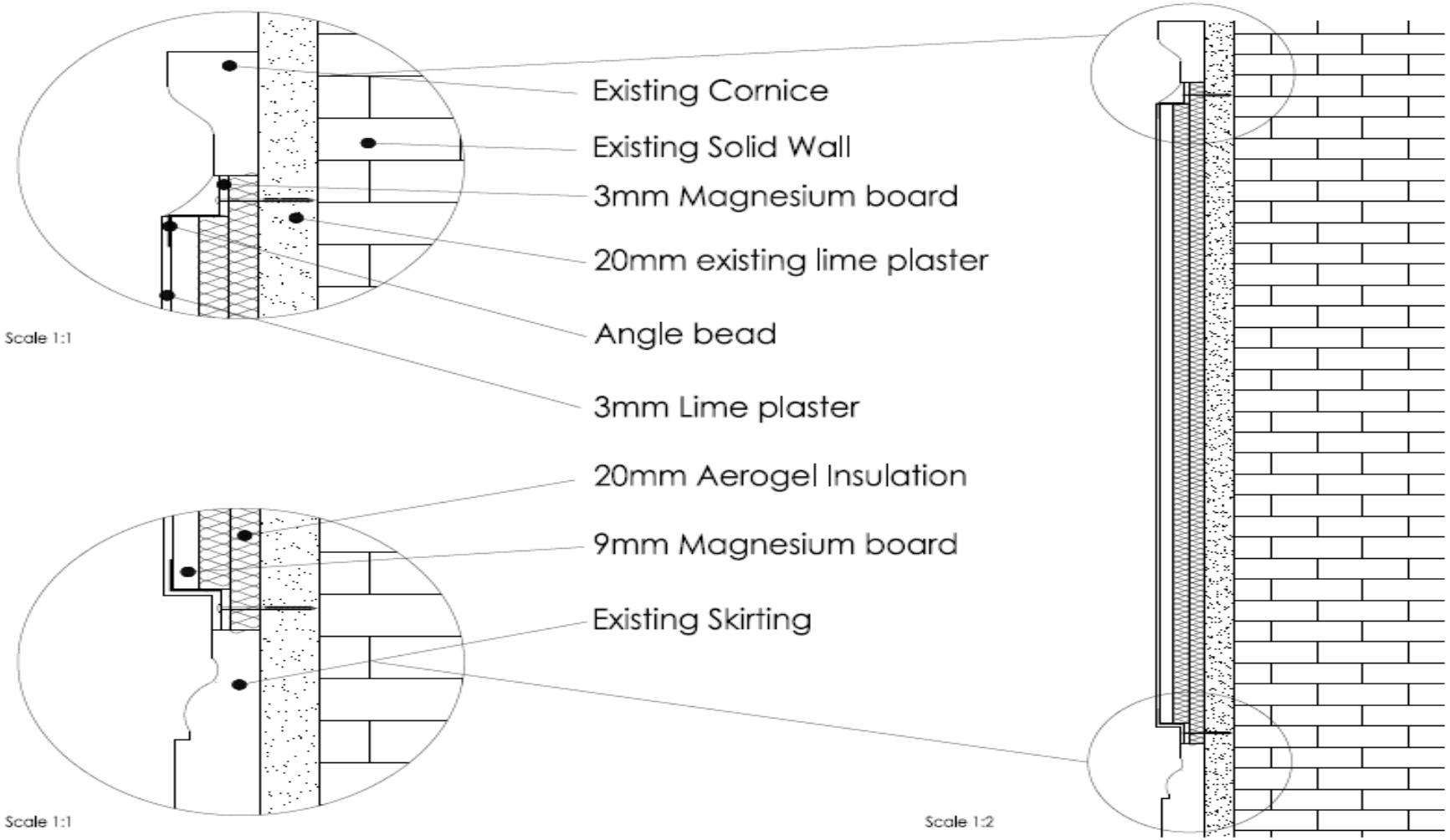


Internal Wall Insulation - Heritage

- Project Renovation
- Location Podebrady, Czech Rep.
- Bldg. Type Commercial, Dwelling
- Application Internal Wall – 20mm,10mm
- Benefit Heritage protected, breathable, thermal bridge treatments, challenging environment



Heritage Detail



Roof and floor Insulation

Flat roofs and terraces

(25 000 m²)

Source: Dr. Samuel Brunner, EMPA

Dormer Roof Insulation

- Project New Build
- Location Switzerland
- Bldg. Type Single Family
- Application Onsite fabricated dormer roof elements
- Benefit Energy saving, improved aesthetic appearance, reduced heat bridges, increased light gain

Facade and roof, Thun

Pitched Roof Insulation - Heritage

- Project Renovation
- Location Dublin, Ireland
- Bldg. Type Government, historic stone
- Application 20mm Pitched roof insulation
- Benefit Energy saving, space saving vapour open to allow roof elements to breathe

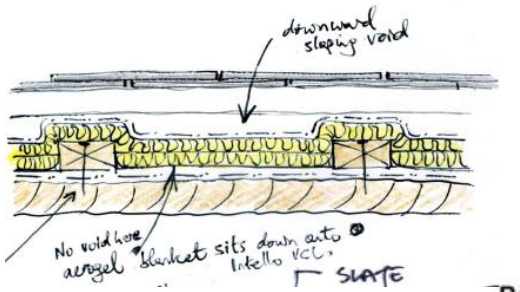


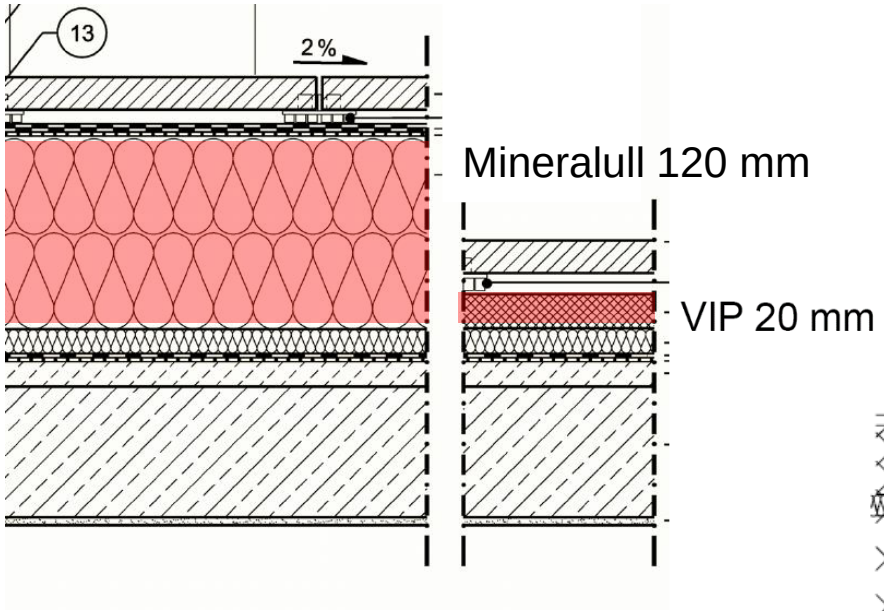
Figure 1 – inside view of existing roof

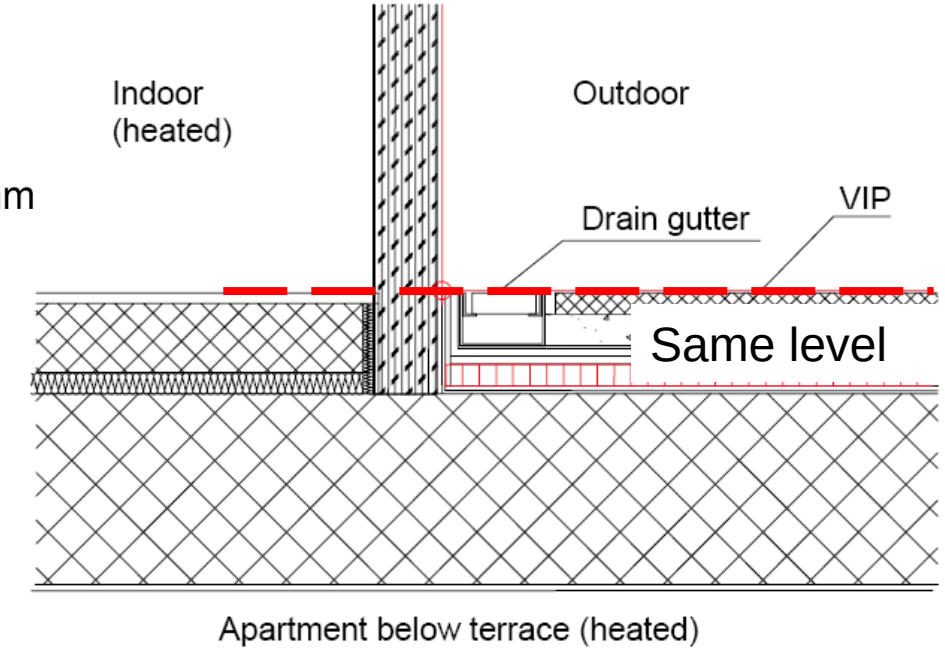
Request for analysis

Client wishes to assess performance of Aspen Aerogel as roof insulation in warm-roof buildup between a timber ceiling deck and battens of a vaulted Victorian courthouse building in the south suburbs of Dublin. Roof buildup to be absolutely minimised. Building to be intensely used by small number of people with a lot of electronics.

Flat roofs och terraces

(25 000 m^2)





Willems, W. and Schild, K. (2005). Vacuum Insulated Constructions in Detail. *Proceedings of the 7th Symposium on Building Physics in the Nordic Countries, June 13-15, 2005, Reykjavík, Iceland. pp. 928-936.*

Terrace Insulation

- Project Renovation
- Location Switzerland
- Bldg. Type Multi Family – concrete terrace
- Application Terrace Insulation
- Benefit Energy saving, height gain, no disruption to fixtures and fittings, no water ingress risk

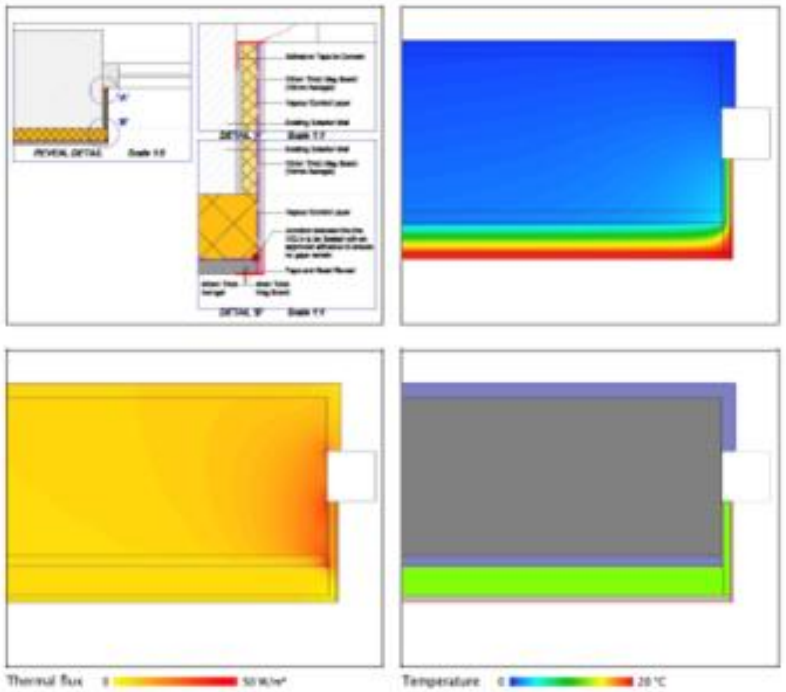
Thermal Bridge Treatments

Heat Bridge Insulation - Reveals

- Thin reveals do not interfere with window function
- Maintain temperature factors above condensation limits

Description

9mm thick magnesium silicate board on 40mm aerogel insulation on existing wall (retain lime or cement internal plaster but strip off any gypsum). 16mm thick board on reveal (10mm aerogel insulation between 3mm magnesium silicate boards).



Linear thermal transmittance

Ψ = 0.081 W/mK (reveal (DEAP))	Ψ = 0.086 W/mK (frame (PHPP))

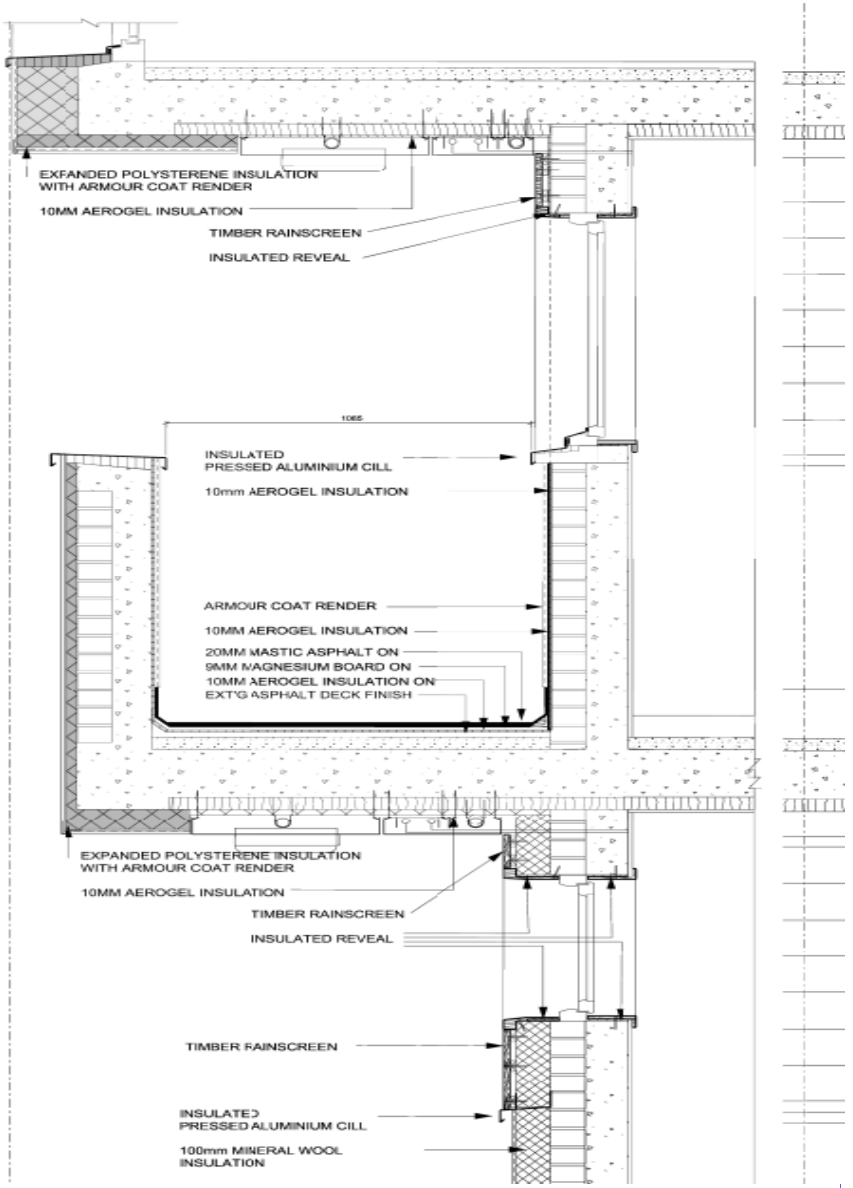
Temperature factor

f_{Rsi} = 0.875

This detail has been assessed in accordance with the procedure in BRE IP 1/06 "Assessing the effects of thermal bridging at junctions and around openings" and the guidance in BRE report BR 497 "Conventions for calculating linear thermal transmittance and temperature factors" in accordance with Appendix D of Technical Guidance Document L (2007) of the Irish Building Regulations. The calculations have been carried out analysing a 2D numerical model through conduction heat-transfer analysis based on the finite-element method performing to the standard indicated by IS EN ISO 10211.

Apartment Thermal Bridges

- Project — Renovation
- Location — Ireland
- Bldg. Type — Apartment Block
- Application — 10mm thermal bridge treatment
- Benefit — lower ψ values, space saving solution




Thank you for your attention