WORKSHOP QUALICHECK
Performance of thermal insulation in low energy buildings and advanced building renovation projects
BRUSSELS – 15 December 2016

Super Insulation materials: an overview of international activities and new products on the market

IEA-EBC Annex 65:
Long-Term Performance of Super-Insulating Materials in Building Components & Systems

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Introduction

Why SIM?

What are SIM?

SIM around the world

Technical Assessment – Certification - Normalization
“Heatleaks”, the first energy user?

... through building envelope, water tank, pipes ...

Source: IEA - Millennium

60 to 80%
For example, in France ...

Stock Renewal Rate
~ 1% per year

Buildings of yesterday are the problems of today & tomorrow
2050 : Challenges in the building sector

New Buildings
- NZEB : a well insulated building first
- only 10 % to 20 % of additional energy consumption (2050)

Renovation/Retrofitting
- Building stock : more than 80% of energy consumption.
- About 75% of current buildings will still be standing in 2050
Insulation among the most efficient way to reduce GHG emissions.

Global cost curve for greenhouse gas abatement measures beyond “business as usual”.

Why new insulating materials?

Already a large number of insulating materials ...

... but still some weak points at the wall & building scales

Source FIW
Insulation requires Continuity
No Thermal Bridges, No “Air Tunnels”

1: still, too much thermal bridges, even for ETICS

The better the insulation, the more we should care about thermal bridges

Window reveal
Balconies
Terrace...

Thermal bridges = “cold spots”
Risk of condensate
Risk of mould growth
Risk of corrosion

Source: POUGET consultant
2: Space savings

*Maison de l’Alsace*

The choice of SIM comes from the Indoor Designer
3 - Fire risks for ETICS

China: From early 2009 to early 2011

Three major fires of high rise building with loss of lives and destruction of property (millions of USD)

In 2/3 scenarios, traditional insulation materials - release of huge tonnage of toxic hydrocarbons

(for illustration only, not link with fires from China)
Comfort & Health

4 – Low room temperature & diseases

Winter Average T & H in Bedroom in Japan

Prof. A. IWAMAE – Kindai University
What are Super Insulating Materials?

What are Super Insulating Materials?

<table>
<thead>
<tr>
<th>Advanced Porous Materials (APM)</th>
<th>Vacuum Insulation Panel (VIP)</th>
</tr>
</thead>
</table>

Thermal conductivity of embedded gas:

\[ \lambda_g = \frac{\lambda_{g0}}{1 + C \cdot \frac{T}{\delta P}} \]

25 mW/mK for still AIR
Heat Transfer Reduction

Heat flow $\phi$ (W) through a wall:

$$\phi = U \cdot S \cdot \Delta T \, (W) \quad \text{with} \quad U = \frac{\lambda}{t} \, W/m^2.K$$

- 1: **reduce the surface S**: architects and designers, compactness
- 2: **reduce the temperature gradient $\Delta T$**: climatic conditions and occupant behavior ...
- 3: **reduce the U-value** (W/m².K):
  - increasing the thickness (t)
  - reducing the thermal conductivity $\lambda$

How to keep living space without increasing building footprint? Thin Walls?
U-value

$\phi = U \cdot S \cdot \Delta T \ (W) \ \text{with} \ U = \frac{\lambda}{t}$

$U \text{ value } W/m^2.K$

- TIM
- VIP
- Aerogel Fiber Mat
- Aerogel Based Rendering

$0 \quad 2 \quad 4 \quad 6 \quad 8 \quad 10 \quad 12 \quad 14 \quad 16$

$0 \quad 0.5 \quad 1 \quad 1.5 \quad 2 \quad 2.5 \quad 3 \quad 3.5$
M. Alam †, H. Singh, M.C. Limbachiya Sustainable Technology Research Centre (STRC), Kingston University, Roehampton Vale, Friars Avenue, London SW15 3DW, UK

Payback period of VIP and EPS different scenarios of insulation for buildings

Average rent of commercial buildings situated in London assumed as £40 ft²
### Profit as function of living area market

![Graph showing VIP Profit](image)

<table>
<thead>
<tr>
<th>Living area 10m × 10m</th>
<th>Market value living area (EUR/m² living area)</th>
<th>Increased living area gain by application of VIPs and reduced wall thickness of 20 cm (EUR/m² living area)</th>
<th>VIP costs 6 cm thickness (EUR/m² VIP)</th>
<th>Traditional thermal insulation costs 35 cm thickness (EUR/m² insulation)</th>
<th>Profit due to VIP application (EUR/m² living area)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000</td>
<td>80</td>
<td>200</td>
<td>20</td>
<td>-100</td>
<td>-100</td>
</tr>
<tr>
<td>2000</td>
<td>160</td>
<td>200</td>
<td>20</td>
<td>-20</td>
<td>-20</td>
</tr>
<tr>
<td>3000</td>
<td>240</td>
<td>200</td>
<td>20</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>4000</td>
<td>310</td>
<td>200</td>
<td>20</td>
<td>130</td>
<td>130</td>
</tr>
<tr>
<td>5000</td>
<td>390</td>
<td>200</td>
<td>20</td>
<td>210</td>
<td>210</td>
</tr>
</tbody>
</table>

Profit in EUR/(m² living area) by application of VIPs as function of living area market value where the wall thickness reduction is 20 cm for an example building of 10m × 10 m. An interior floor to ceiling height of 2.5m is assumed.

SIM around the world

VIP : Vacuum Insulation Panels

APM : Advanced Porous Materials
(aerogel, porous silica)
SIM: mature products but ...
... still an important innovation potential

**BARRIERS**
- SIMs have a high material cost
- SIMs are not adapted to the needs and concerns of the construction sector, i.e. robust and system approach
- Actors such as architects and insulation installers lack experience with SIMs

**DRIVERS**
- The current and future energy performance standards for renovations demand high insulation levels
- Insulation products needed to solve thermal bridge problems
- Space or weight saving insulation materials needed
- SIMs are product mature

**INNOVATIVE SOLUTIONS**
- Evolve from a single material or product to a system solution that includes fixings, finishing, etc.
- System solution leading to reduced labour costs
- Design and execution guidelines, training etc. bringing SIMs to relevant actors in the construction value chain

IEA-EBC Annex 65:
Long-Term Performance of Super-Insulating Materials in Building Components & Systems
### The SIM market according to IEA

<table>
<thead>
<tr>
<th>MARKET MATURITY / SATURATION</th>
<th>ASEAN</th>
<th>Brazil</th>
<th>China</th>
<th>European Union</th>
<th>India</th>
<th>Japan / Korea</th>
<th>Mexico</th>
<th>Middle East</th>
<th>Australia / New Zealand</th>
<th>Russia</th>
<th>South Africa</th>
<th>United States / Canada</th>
</tr>
</thead>
<tbody>
<tr>
<td>Typical insulation</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
</tr>
<tr>
<td>Exterior insulation</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
</tr>
<tr>
<td>Advanced insulation (e.g. aerogel, VIPs)</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
</tr>
</tbody>
</table>

- ★: MATURE MARKET
- ○: ESTABLISHED MARKET
- ▲: INITIAL MARKET

**??**
Certified Products

Description of ISOVIP product

- Panel core: Fumed silica under vacuum
- Envelope: Trimetallized film
- Surface: Mechanical protection for the 2 facings by glueing XPS (3 mm)

Panel thicknesses between 25 and 50 mm
+ 2 x 3 mm XPS protection XPS

Two panel sizes
- 600 mm x 300 mm
- 600 mm x 1000 mm

\[ \lambda = 5.2 \text{ mW/(m.K)} \]

Certifié ACERMI
OPTIMAVIP(1/7) – Step by step implementation

- Accept and prepare the construction site
  - Wall dimension measurements, configurator use, order products, prepare the wall surface

- Fixation of Clip’Optima upper and lower horizontal rails
  - Use a ISOVIP to adjust the rail at the correct distance from the wall. The panel must smoothly slide behind the rail without forcing in order to avoid piercing.
Protected VIP

Handling & Transportation
Installation / fixing

Sources: va-Q-tec – Roland CAPS
01. Existing wall
02. Optional protection layer (PE foam, PET foam)
03. Stud (wood batten 27x35 mm²)
04. Plug + screw
05. VIP Slimvac 1200 x 600 mm² or 1300 x 600 mm²
06. VIP Slimvac other dimension
07. Tape 100 mm
08. Finishing insulation material for gaps (PSE, PU)
09. Vapor control layer
10. Siniat Plasterboard BA13
11. Siniat screw Prégy TF 212x35
12. Strip + Finishing
Insulation Panel Living System

**Background**
- Energy consumption in housing

**Insulation Panel Living System**
- Insulation retrofit

**Feature of Insulation Panel Living System**
1. Save the cooling and heating cost
2. Easy and Quick install: without scaffolding.

Heat load in F. R. is 70%* of the whole house in Japan

Just add the insulation panel on the existing wall from indoor side
System Solutions in Japan

Floor Panel

- Installation:
  1. Take off wallpaper
  2. Install ceiling panel
  3. Install inner window
  4. Install wall panel
  5. Install floor panel
  6. Paste wallpaper and finishing floor

- Features:
  - Only 3 days work
  - Keep living during installation

Wall Panel

- Materials:
  - VIP (Core Material: Glass Fiber)
  - MDF
  - Aluminum foil
  - Rigid Foam (Polyurethane)
  - Zinc Plated Steel Board
  - Aluminum Hydroxide Paper

- Features:
  - Preventing the puncture by the penetration of nail
  - Fire preventive performance: Quasi-Noncombustible (ISO5660)
### VIP in KOREA

<table>
<thead>
<tr>
<th>Building type (city)</th>
<th>Insulation system</th>
<th>Insulation layers and thicknesses</th>
<th>Outer wall $U$-value (W/m²·K)</th>
</tr>
</thead>
<tbody>
<tr>
<td>H bank (Jeju)</td>
<td>External insulation</td>
<td>VIP, 30 mm</td>
<td>0.15</td>
</tr>
<tr>
<td>I office (Iksan)</td>
<td>External insulation</td>
<td>VIP, 15 mm + EPS, 45 mm</td>
<td>0.26</td>
</tr>
<tr>
<td>N office (Iksan)</td>
<td>Internal insulation</td>
<td>VIP, 20 mm</td>
<td>0.23</td>
</tr>
</tbody>
</table>

Fastening

① Reinforced concrete
② Adhesive
③ Steel fastener
④ Covered-type three-layer insulation unit (EPS + VIP + EPS)
⑤ Reinforcing mesh and coat, finish plaster
VIP Insulation System in China

Concrete wall

Mortar VIP Mortar

Patented composite film
VIP in China

I - Existing wall
II - Interface adhesive powder
III - Bonding mortar (with gutters)
IV - Vacuum insulation panel
V - Hole for support
VI - Plastic spacer
VII - Plaster mortar
VIII - Fiberglass mesh
IX - Surface mortar plaster
X - Surface decorations
VIP in China

Thermal Bridges

Plastic spacer
Suzhou city renovated commercial building
VIP in China

Harbin city renovated residential building.
New York State Energy Research and Development Authority (NYSERDA)

1770 (left) and 1780 (right) Davidson Avenue – New York
Aerogel in USA: storage & design

Proposed Wall Design Detail For Spaceloft Aerogel Insulation
Interior Installation on Exposed Masonry or Concrete

- Gypsum Wall Board, taped joints
- 2 coats latex paint on interior surface to moderate water vapor movement
- Fastener, Masonry Compatible (Tapcon Screw or Ramset Pin), length, at least 1.5”
- Approximately 16” o.c. horizontally and vertically
- Pre-drilled for ease of installation, and minimized GWB surface damage
- Spaceloft 10, or layers thereof, installed directly to masonry with adhesive (3M 77 or 78/PL Adhesive/Liquid Nails), gaps minimized between wall and new insulation
- Existing Masonry Wall, cleared of major debris

Aerogel Insulation Storage
Aerogel in USA : installation
A Study on the Architectural Application of Aerogel

Young Cheol Kwon
School of Architecture, Halla University, Gangwon 220-712, Korea
Dec. 2013, Volume 7, No. 12 (Serial No. 73), pp. 1494-1500 - Journal of Civil Engineering and Architecture, ISSN 1934-7359, USA

Other aerogel Applications

Aerogel blanket used in mobile homes

Aerogel blanket used in roofing applications

Aerogel blanket used under heating pipe
Aerogel Blanket for Thermal Bridges Treatment

Aerogel Building Insulation Blanket was placed to cover the neck of the curtain-wall to the below-grade insulation.

Without Building Insulation Blanket

Perimeter heat loss for curtain-wall at-grade by varying U-values

<table>
<thead>
<tr>
<th>Depth of Insulation</th>
<th>Below Grade Insulation (hr·ft²·°F/ BTU)</th>
<th>Slab Perimeter heat Loss (BTU/hr·ft·°F)</th>
<th>% Reduction in Heat Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Without Building Insulation Blanket</td>
<td>10mm Building Insulation Blanket</td>
</tr>
<tr>
<td>24”</td>
<td>R-10</td>
<td>0.495</td>
<td>0.370</td>
</tr>
</tbody>
</table>
Aerogel Blanket for Thermal Bridges Treatment
Window Reveals

Source: Enviroform
Aerogel for prefabricated buildings

Sea Containers Refurbished
For Residential Use

Aerogel Insulating Plaster

- $\lambda = 0.028 \text{ W/mK}$
- Commercially sold since 2013
- Water repellent & diffusion open
- Swiss environmental award at Swissbau 2014
- Innovation award „Praxis Altbau“ at BAU 2015
Technical Assessment & Standardisation
La conductivité thermique certifiée du produit sans protection est de 0,0052 W/(m.K).

La formule donnée est : $\lambda_{\text{eff}} = \lambda_c + \psi \cdot e \cdot 2 \left( \frac{1}{l} + \frac{1}{w} \right)$.
France : Technical Assessment : VIP/PIV & Aerogel
EOTA – ETA VIP & AEROGEL
Thermal insulation products for buildings — Factory made Vacuum Insulation Panels (VIP) — Specification

Produits isolants thermiques pour le bâtiment — Produits manufacturés en laine vacuum isolation panel (VIP) — Spécification
Some preliminary conclusions from Annex 65

About Products & Systems
- SIM can be considered as mature products
- Need to move from single product to system solutions

About Performances
- Reproducible values for “fresh” products around the world
- Still some deviations for aged panels?

About Applications
- Avoid severe conditions without preliminary design & SIM protections
- Interior Insulation is fine
Two Associations to promote VIP & APM

VACUUM INSULATION PANEL

GLOBAL ASSOCIATION

Advapor
Advanced Porous Materials Association

Advanced Porous Materials
IVIS2017 : International Vacuum Insulation Symposium

PARIS : 20-21 September 2017

http://ivisparis2017.org
Annex65 : a bridge between science & market

Thank you for your attention

http://aasarchitecture.com/2013/03/phyllis-j-tilley-memorial-bridge-by-rosales-partners-architects.html
QUESTIONS ?
SUBTASK 1: State of the Art on Materials & Components, Case Studies
SubTask Leader: ZAE Bayern (EMPA - NTNU)

SUBTASK 2: Characterization of materials & components
Laboratory Scale : SubTask Leader: FIW Munich

SUBTASK 3: Practical Applications – Retrofitting at the Building Scale
Subtask Leader: Chalmers University

SUBBASK 4: Sustainability (LCC, LCA, EE – Risks & Benefits)
Subtask Leader : Chalmers University.
Strategic Relevance

1: To provide reliable data
   - properties & measurement procedures
   - durability & ageing methods

2: Secure Installation:
   - design: fixing/fastening – thermal bridges ...
   - handling / transportation
   - installation

3: Sustainability of SIM (LCA, LCC, Embodied Energy ... )
Annex 65

Objectives

Establish a SoA of a decade of pioneer development of SIM by the industry and of applications in the building sector.

Development of experimental & numerical tools to provide reliable data

Guidelines for secure implementation of SIM

Support for standardization and assessment procedures

Improvement of knowledge and confidence of end-users regarding SIM, thanks to sustainability analysis

To foster a wider public acceptance of SIM in the future by communication/dissemination initiative
Participants ~40 - Countries : 14+2

**Belgium**: Recticel, Dow Corning,

**China**: Nanjing University of Aeronautics and Astronautics (NUAA), Siltherm, CREEK

**France**: EDF, Saint-Gobain, Mines-Paristech, INSA Lyon, Univ. Lorraine, Toray, ArcelorMittal, CSTB, REXOR, ENERSENS

**Germany**: ZAE Bayern, va-Q-tec, FIW Munich, Fraunhofer IVV, Evonik, DLR, Metra-Group, Porextherm-Morgan, CABOT, ASPEN

**Italy**: Politecnico di Milano, Politecnica di Torino

**Norway**: NTNU, SINTEF

**Spain**: Tecnalia,

**Switzerland**: EMPA

**United Kingdom**: Kingspan,

**South Korea**: OCI, Kongju National University, KAIST

**Sweden**: Chalmers University

**Israel**: Hanita Coatings (observer)

**Greece**: National Technical University of Athens (NTUA) (observer)

**Japan**: around 10 participants
## Deliverables/Target Audience

<table>
<thead>
<tr>
<th>Ref.</th>
<th>Deliverables</th>
<th>Related subtask</th>
<th>Target Audience</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1</td>
<td>State of the Art and Case Studies (first draft)</td>
<td>ST1</td>
<td>Supply Chain</td>
</tr>
<tr>
<td>D2</td>
<td>Scientific Information for Standardization Bodies (Hygro-Thermo-Mechanical Properties &amp; Ageing) (first draft : end of 2016)</td>
<td>ST2</td>
<td>CEN, ISO, EOTA, UEATc, Testing laboratories Materials Manufacturers</td>
</tr>
<tr>
<td>D3</td>
<td>Guidelines for Design, Installation &amp; Inspection Special focus on Retrofitting (first draft : mid 2017)</td>
<td>ST3</td>
<td>Designers, Engineers, Contractors, Builders</td>
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<tr>
<td>D4</td>
<td>Report on Sustainability Aspect (LCC, LCA, EE ) (first draft : end of 2016)</td>
<td>ST4</td>
<td>Supply Chain</td>
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