BPIE | BUILDINGS PERFORMANCE INSTITUTE EUROPE

i2-4C INDUSTRIAL INNOVATION FOR COMPETITIVENESS

ADVANCED INSULATION MATERIALS FOR BUILDING ENVELOPES

Deep-dive #2

SUMMARY

Heating and cooling loads represent the largest building sector energy-end-use. Insulation of the building envelope can be significantly improved to reduce the energy needed to heat and cool buildings. Current and future energy performance standards for renovations demand high insulation levels. However, traditional insulation materials cannot always do the job, and space- or weight[1]-saving insulation solutions are necessary.

New super insulating materials (SIMs), such as vacuum insulation panels (VIP), gas filled panels (GFP) and aerogel based products (ABP), provide promising solutions. Today they are mostly used in fridges and other appliances, aerospace applications, Formula 1 and industrial applications, but are slowly finding their way into the construction market. According to Microtherm, a SIMs manufacturer, the products are mature but the market is not.

SIMs have a high material cost and were originally developed for industry applications. To be implemented on a higher scale in the built environment, SIMs should be adapted to the needs and concerns of the construction sector. Manufacturers need to evolve from a single material or product to a system solution that includes fixings, finishing and more. They need to develop innovative solutions customised to the current and future reality of the construction market.

Approximately 75% of the current European building stock will still be standing in 2050, with most energy consumption in these buildings attributed to space heating. Refurbishing existing buildings, both in depth as in rate, especially by applying thermal insulation, is one of the most cost-effective methods to reduce energy consumption. Studies show that thermal insulation has the best cost-abatement profile to reduce greenhouse gas emissions. With the adequate system solutions and a correct market price, SIMs can play a role in every deep energy refurbishment, although their cost is still considerably higher than that of traditional insulation materials.

The total market for thermal insulation products in Europe reached 234.6 million m3 in 2014, and until 2019 the thermal insulation market is poised to grow at a rate of 2.8% per year. SIMs have a small share in this and will not achieve the same market value as conventional insulation materials, but they have a high market potential in niche areas of the renovation market, such as refurbishments with weight or space limitations or to avoid thermal bridges.

Most of the building services and on-site workforce have few or no direct contact or experience with SIMs. However, it is much more likely that these actors will be trained to handle SIMs rather than having completely new players enter the market. Within the on-site workforce,

[1] Existing buildings are constructed with a certain weight taken into account for the structural calculations. Adding a significant extra load might endanger the stability of a building.

it is most likely that existing (sub-)contractors, specialised in insulation, will be the first to install SIMs. Therefore, these actors, together with architects, must be the primary target interlocutor of SIMs manufacturers.

While manufacturers of conventional insulation materials are investing in some R&D regarding advanced insulation materials, their focus remains on conventional insulation material. Indeed, there is still a large market value to be captured within their core business. The current market of traditional insulation materials is still growing, mainly due to increasing legislation on energy efficiency of buildings. There is still room for growth of traditional products both for new buildings and renovations.

ENABLING MEASURES TO UNLOCK THE TRANSITION ARE:

- **Establishing targets, stricter legislation and incentives for deep energy renovations.**
- **Better communication and integration in policy of the co-benefits of low energy buildings.**
- **Trainings, guidelines and quality schemes to increase competence levels.**
- **Case studies and demonstrations of added-value high-performance insulation.**
- **Accurate test protocols, ratings and performance declarations for the energy performance of materials.**

This focus paper on 'ADVANCED INSULATION MATERIALS FOR BUILDING ENVELOPES' is part of a larger report looking into innovation within the construction value chain. The report and three other papers are available on BPIE and i24c's websites. www.bpie.eu and www.i2-4c.eu

ONGOING TRANSITION

Heating and cooling loads represent the largest building-sector energy end-use. The insulation of the building envelope – the boundary between the conditioned interior of the building and the outdoor environment – can be significantly improved to reduce the energy needed to heat and cool buildings.

Current and future energy performance standards for renovations demand high insulation levels. However, traditional insulation materials cannot always do the job (for example to avoid thermal bridges) and space- or weight[2]-saving insulation solutions are necessary.

New super insulating materials (SIMs), such as vacuum insulation panels (VIP), gas filled panels (GFP) and aerogel based products (ABP) provide promising solutions. They can allow a reduction of insulation thickness by as much as a factor of five.

The conventional insulation market is highly mature and, from a technological perspective, the deployment of traditional insulation has been successful, reaching full maturity in most regions worldwide. However, much more work is needed globally to level up SIMs from the initial market stage to a market uptake.

Today they are mostly used in fridges and other appliances, aerospace applications, Formula 1 and industrial applications, but are slowly finding their way into the construction market.

Most of these advanced insulation materials were not designed with the construction sector in mind and can therefore not simply be transferred without adaptation. For example, on a traditional construction site, it is difficult to apply SIMs since they do not come with tools or means to install and attach them. They are also to be handled with great care or might lose some of their key features.

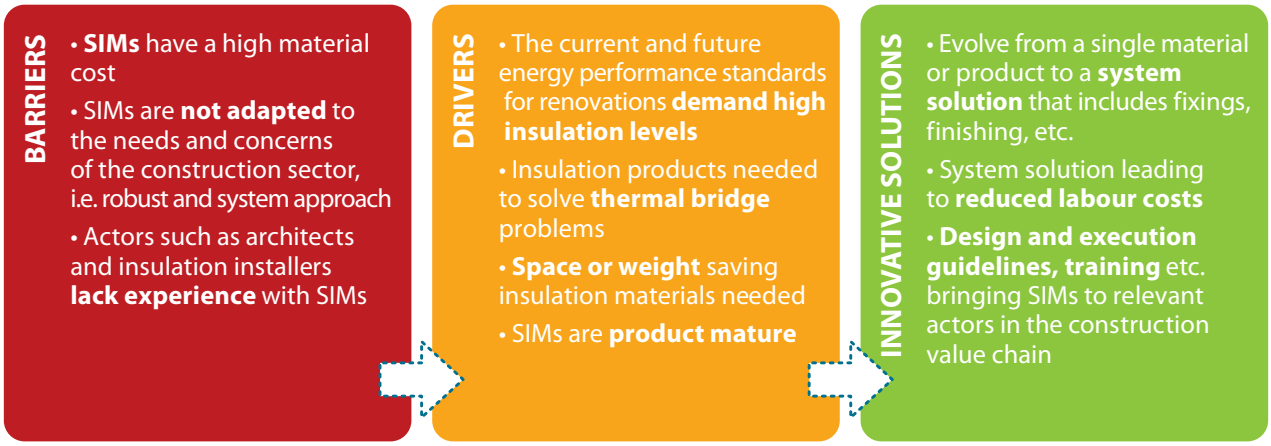
"The products are mature but the market isn't yet." Promat

Belgian production facility of Promat – other facilities in Italy, UK, USA and Japan (Source: Promat)

[2] Existing buildings are constructed with a certain weight taken into account for the structural calculations. Adding a significant extra load might endanger the stability of a building.

INNOVATION POTENTIAL

Figure 1: Outlining the innovation of 'Advanced insulation materials for building envelopes' (Source: BPIE)



SIMs have a high material cost and were originally developed for industry applications. To be implemented at a higher scale in the built environment, SIMs should be adapted to the needs and concerns of the construction sector.

Manufacturers need to evolve from a single material or product to a system solution that includes fixings, finishing, etc. They need to develop system innovation customised to the current and future reality of the construction market:

- SIMs should be easy and efficient to install, with all fixings, the attachment structure and the necessary tools to handle them included.
- Price setting: a system solution can lead to SIMs reducing labour costs, especially regarding building renovations (e.g. interior wall insulation in historic buildings). Cost-effectiveness comprises both labour and material cost. With labour costs having the largest impact on the total price, an easy-to-install system could have a significant positive impact on the overall price setting.
- The viability and robustness of the system has to be tested in real-life construction environments and iterations with relevant actors such as architects, contractors and installers are necessary before launching a new product.
- Detailed design and execution guidelines have to be available and customised for the different actors such as architects, contractors and installers EU-wide. During trainings and events, manufacturers can show the benefits and added value of high-performance insulation materials, thus bringing these high-tech materials to the relevant players of the construction value chain.

VALUE TO CAPTURE

Approximately 75% of the current European building stock will still be standing in 2050 and the largest part of energy consumption in these buildings is attributed to space heating. Refurbishing existing buildings, both in depth and rate, especially by applying thermal insulation, is one of the most cost-effective methods to reduce energy consumption. Studies show that thermal insulation has the best cost-abatement profile to reduce greenhouse gas emissions. With the adequate systems and a correct market price, SIMs can play a role in every deep energy refurbishment.

Table 1: An assessment of market saturation for high-priority building envelope components (Source: IEA)

MARKET MATURITY / SATURATION	ASEAN	Brazil	China	European Union	India	Japan / Korea	Mexico	Middle East	Australia / New Zealand	Russia	South Africa	United States / Canada
Typical insulation	★	●	★	★	●	★	●	★	★	★	●	★
Exterior insulation	●	▲	●	★	●	●	▲	●		▲	▲	★
Advanced insulation (e.g. aerogel, VIPs)				▲		▲				▲	▲	▲

★ MATURE MARKET ● ESTABLISHED MARKET ▲ INITIAL MARKET

Notes: ASEAN = Association of Southeast Asian Nations. Blank cells indicate that there is currently not any market presence or it is so low that it is not known to domestic experts. Some technologies may not be recommended for all climates, such as cool roofs in Russia or highly insulated windows in hot climates. Typical insulation refers to widely available products such as fibreglass and various foams with thermal conductivities higher than 0,02 watts per meter Kelvin (W/mK). VIP = vacuum-insulated panel. See Annex A and Glossary for more detailed descriptions.

The cost of SIMs today is still considerably higher than that of traditional insulation materials. The average cost difference for walls with the same thermal resistance is a factor 10 today[3]. Compared to EPS insulation, payback periods of most investments range from 7 to 15 years (Alam et al, 2011).

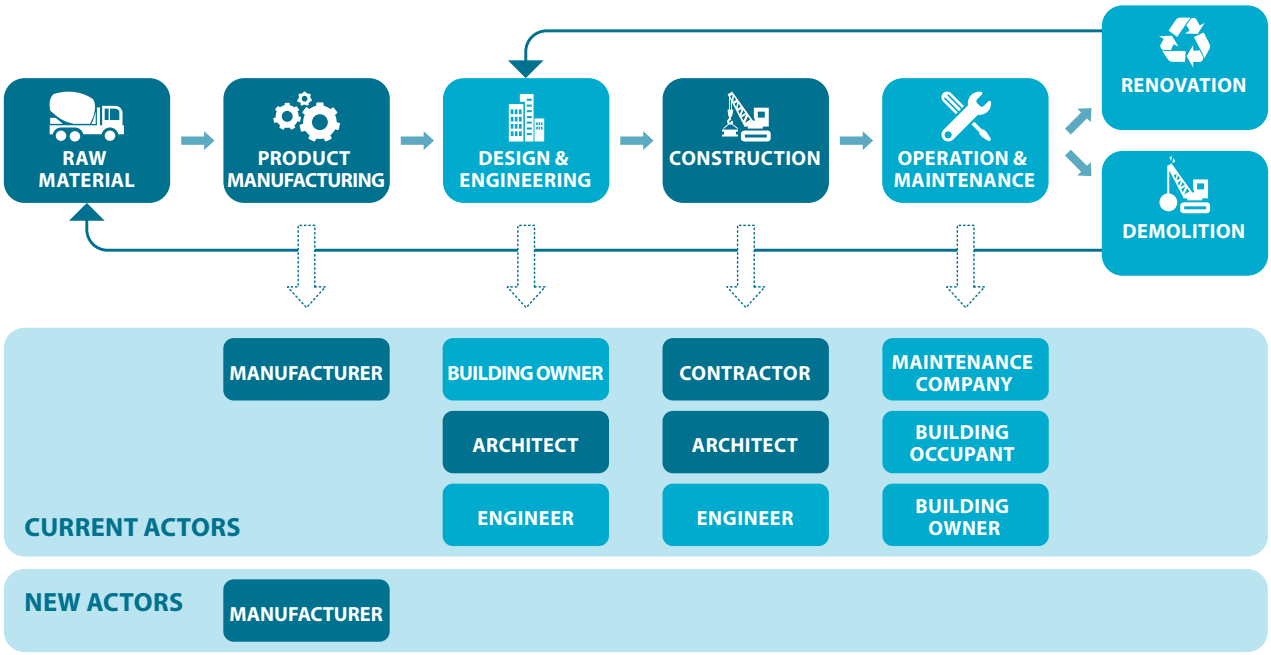
The total market for thermal insulation products in Europe reached 234.6 million m^3 in 2014. This equates to an approximate market value of €11.5 billion, of which glass and stone wool insulation together represent 58%. Until 2019, the thermal insulation market is poised to grow at a rate of 2.8% per year. The growth in Central and Eastern Europe combined is expected to exceed that of Western Europe, where the thermal insulation market is more mature. Interesting current growth has been reported in countries such as Germany, Italy, the United Kingdom and Turkey.

SIMs have a small share in this and will not achieve the same market value as conventional insulation materials. But they have a high market potential in niche areas of the renovation market, such as refurbishments with weight or space limitations or to avoid thermal bridges. Switzerland and Germany seem to be the front-runners in SIMs implementation.

[3] S. Alotaibi and S. Riffat, "Vacuum insulated panels for sustainable buildings: a review of research and applications", Institute of Sustainable Energy Technology, University of Nottingham, 2013.

IMPACT ON EXISTING AND NEW ACTORS ENTERING THE VALUE CHAIN

Figure 2: Innovation in the construction value chain – involved actors in advanced insulation materials for building envelopes (Source: BPIE)



Most of the building services (e.g. architects, energy experts and building management) and on-site workforce (e.g. installers and contractors) have few or no direct contact or experience with SIMs. However, it is much more likely that these actors will be trained to handle SIMs, rather than having completely new players enter the market. Within the on-site workforce, it is most likely that existing (sub-)contractors specialised in insulation will be the first to install SIMs. Therefore, these actors, together with architects, must be the primary target interlocutor of SIM manufacturers.

While manufacturers of conventional insulation materials are investing in some R&D regarding advanced insulation materials, their focus remains on conventional insulation materials. After all, there is still a large market value to be captured within their core business. The current market of traditional insulation materials is still growing, mainly due to increasing legislation on energy efficiency of buildings. Both for new buildings and for the renovation market, there is still room for growth of traditional products.

Manufacturers of industrial and highly technological insulation materials for aerospace, machinery, train and container insulation etc. (e.g. Panasonic, BASF and Promat) are interested in entering the construction market, attempting to expand their market by selling SIMs. So far, however, they have had little success since their products have not (yet) been adapted to the more artisanal nature of today's construction market. Compared to conventional players, they have the disadvantage of not having a wide network in place both with building services and with the on-site workforce.

Product, service and marketing innovations on the SIMs market, leading to more viable solutions for deep energy renovations, could slowly disrupt the conventional insulation market. This might force them to adapt their products and services by lowering prices, increasing marketing efforts, delivering more systematic approaches or focusing on SIMs, too.

IMPORTANT ENABLING MEASURES TO UNLOCK THE TRANSITION

Establishing targets, stricter legislation and support measures for deep energy renovations. Progress should be tracked, reported and integrated with national energy-policy plans.

Main actors to engage with on this topic:

- European policy makers responsible for buildings and energy;
- National (or regional) policy makers responsible for buildings and energy;
- Sector federations representing the construction sector different stakeholders.

The co-benefits of low-energy buildings, such as comfort and health, need to be communicated in a better way to the public and to financial communities, and integrated in policy measures.

Main actors to engage with on this topic:

- European research institutes;
- European executive agencies responsible for EU support programmes;
- European policy makers responsible for buildings and energy;
- National (or regional) policy makers responsible for buildings and energy.

Integrated and consistent sets of policies[4] overcoming barriers and promoting advanced materials and technologies that contribute significantly to energy-efficient building envelopes.

Main actors to engage with on this topic:

- National (or regional) policy makers responsible for relevant cross-thematic environments (e.g. housing, innovation, energy);
- National (or regional) sector federations representing the construction sector stakeholders.

Trainings, guidelines and quality schemes to increase the competence level of the on-site workforce and building services. Quality frameworks enforce market trust, leading to an increasing demand and decreasing prices. Consumers should be able to rely on the skills of building professionals and get value for money, which means that a building's equipment should achieve the expected energy performance, comfort level and operational lifetime. Negative experiences might though have an impact on the whole market uptake.

Main actors to engage with on this topic:

- Sector federations representing the construction sector stakeholders;
- European executive agencies responsible for EU support programmes[5];
- National (or regional) policy makers responsible for buildings, energy and education;
- European and national certification and standards bodies;
- Formation centres;
- Research institutes.

Conduct case studies and demonstrations of added-value high-performance insulation to show overall greater system energy efficiency and monetary effectiveness.

Main actors to engage with on this topic:

- Sector federations representing the stakeholders in the construction sector;
- European and national research institutes;
- European and national executive agencies responsible for EU support programmes.

To allow one type of insulation to be compared with another, it is vital to have accurate test protocols, ratings and performance declarations for the energy performance of different materials. The performance of insulation types may vary according to types of applications, climate and the ageing process of materials. Therefore, it is best for independent bodies or government agencies to provide unbiased information about product energy performance and appropriate applications and to ensure that appropriate product material certifications are available.

Main actors to engage with on this topic:

- European and national certification and standards bodies;
- European and national research institutes;
- National (or regional) sector federations representing the construction sector;
- European and national policy makers responsible for building standards.

[4] Integrated policies take into consideration the relevant cross-thematic policy environments such as innovation, energy, housing, economy, spatial planning, employment, etc.

[5] The European strategic initiative BUILD UP Skills aims to increase the number of qualified workers across Europe addressing skills in relation to energy efficiency and renewables in all types of buildings.

BEST PRACTICES AND PILOT PROJECTS

INNOVATION PROJECT ALMSHOUSE 'DE SCHIPJES'

- **What?** The housing zone called 'De Schipjes' was built in 1908 and consists of twelve almshouses inhabited by persons with a disability and seniors. A methodological approach is being developed to upgrade housing zones' energy in historic centres. To maintain maximum space in limited living areas, super insulating materials (SlimVac) and aerogel plasters are used.
- **Where?** Bruges, Belgium
- **Stakeholders?** Public Centre of Social Welfare De Schakelaar (client), Architecture office Murk Hanssens, University of Leuven, University of Ghent, Engineering Office Boydens, Promat and Viessmann Belgium. Project supported by the Flemish Agency for Innovation by Science and Technology (IWT).
- **Target Group?** Example project for other historic buildings in Flanders and in Europe.
- **Type of works?** Whole-house energy renovation with respect for historical heritage and monitoring user behaviour.
- **Timing?** 2014-2018
- **More information?**
  - www.kennisplatform-renovatie.be/wp-content/uploads/2015/06/5-VanKenhove.pdf
  - www.kennisplatform-renovatie.be

Source: UGent

OFFICE BUILDING OF FRYMAKORUMA

- **What?** An energy retrofit of a 50-year-old office building with the aim of improving heating and energy efficiency. Reduction of the heating energy consumption from 333.000 kWh/a to calculated 200.000 kWh/a by the façade and window refurbishment.
- **Where?** Switzerland.
- **Stakeholders?** Evonik and Porextherm.
- **Type of works?** In order to achieve the requested objective of a U value of < 0.18 $W/m^2.K$ in standard building envelope construction procedures, an extreme renovation of the entire façade structure would have been necessary – meaning that the façade structure would have had to be replaced and all front buildings, the roof, the carpark in front of the building, would also have had to be adapted. Vacuum Insulation Panels were presented as a good alternative to this massive intervention. The intervention was minimally invasive while at the same time allowing for preservation of the existing façade structure. The construction process did not influence the workflow of the office, making this an attractive method.
- **More info?** www.vipa-international.com/case-studies

Buildings Performance Institute Europe

Rue de la science 23
1040 Brussels
Belgium
www.bpie.eu

Industrial Innovation for Competitiveness

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1040 Brussels
Belgium
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The full report is available at http://bpie.eu/publication/construction-value-chain/