



Business Innovation Observatory



Advanced Materials

Aerogels, getting their second wind

Case study 56

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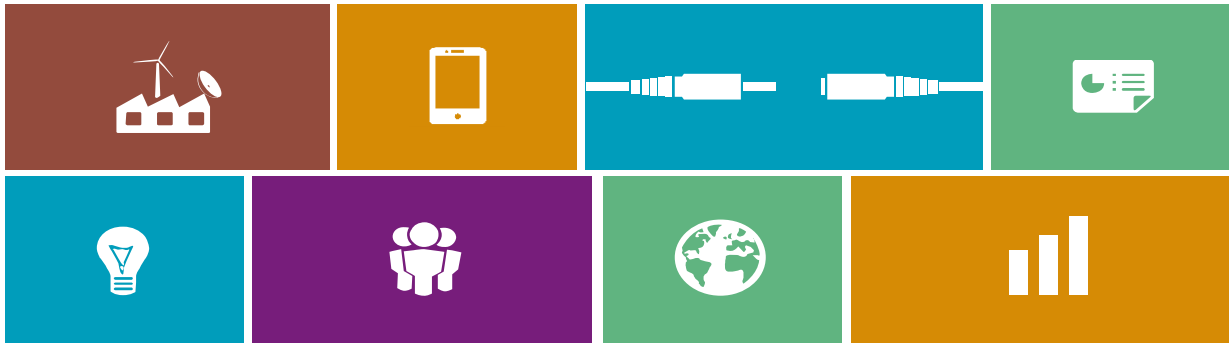
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1. Executive summary

Aerogels are light and highly porous solid that are created by rapidly evaporating the liquid in a solgel mixture and replacing the liquid with air. These materials are notable for their low density and their low thermal conductivity. Because of their unique properties, aerogels are used in chemical adsorption, as lightweight composite materials, in chemical catalysis and in insulating materials. They can also be seen in products such as capacitors, in paints and cosmetics (as thickening agents), and chemical absorbers for cleaning chemical spills.

Aerogels were first isolated several decades ago, but never truly took off given their high cost. Today however, this advanced material is experiencing a renaissance following technological developments driving costs down and market factors driving up demand.

To date the global aerogel market accounts for some EUR 250 million with approximately 10,680 metric tons of aerogel purchased in 2014, and the oil and gas sector accounting for the large majority of the market. The market is predicted to grow, particularly given its rising use for the insulation purposes. The growth of the aerogels market could result in the creation of jobs and their use insulation can help contribute towards improving energy efficiency and move towards the EU's climate policy.

The companies showcased in this paper found an innovative way of addressing the biggest challenge of the market: cost

effectiveness. Their approaches vary, but they ultimately offer an aerogel product superior to competing products, being more affordable and attractive to consumers.

Today the market is driven by the ever increasing demand for energy-efficiency in terms of prices as well as reduction of greenhouse gas emissions. The cost of producing aerogels, an important blocking point in the past, is set to decrease following recent technological developments and will be further decreased as the market develops and finds new opportunities, e.g. novel construction and architecture techniques. Even if the risk-aversion of the construction sector and the lack of enthusiasm from the venture capital industry to invest in cleantech are major obstacles in this regard.

There are several policy options which can support the development of this market. The first is to ensure as quickly as possible that energy-efficiency targets continue beyond 2020 in order to reassure the market about the continuous demand for insulating solutions like aerogels. In addition, insulation and re-insulation of buildings could be subsidised by Member States through national initiatives, which could help promote the use of aerogels. Investment into applied research should continue to develop also new or improved applications for aerogels. Finally, the visibility of aerogels as an advanced materials being more efficient than before, could be supported in order to raise awareness of both investors and consumers.



2. Aerogels, innovating an old technology

2.1. Trend presentation

Technological advancements in the production and quality of basic materials are a serious driver of disruptive innovation and growth. New advanced materials arising from developments in the material sciences offer new growth prospects through the support of new existing industrial and commercial products and processes. These possibilities come from the support of new existing industrial and commercial products and processes.

Within the context of the trend, this case study will present the latest technological developments and new innovative applications of the materials known as “aerogels”.

Aerogels, one of the lightest solid materials known today, are created through the combination of a polymer with a solvent forming a gel. The liquid, formed at the point where polymers join, is then extracted and replaced with air, resulting in a light solid with a **high porosity**, a **low density** (a type of aerogel is recognised as the worlds lightest solid¹) and a **very low thermal conductivity**. They can be made using a variety of different substances, are eco-friendly and recyclable.

Figure 1: Crayons supported on an aerogel over a flame



Source: NASA Jet Propulsion Lab²

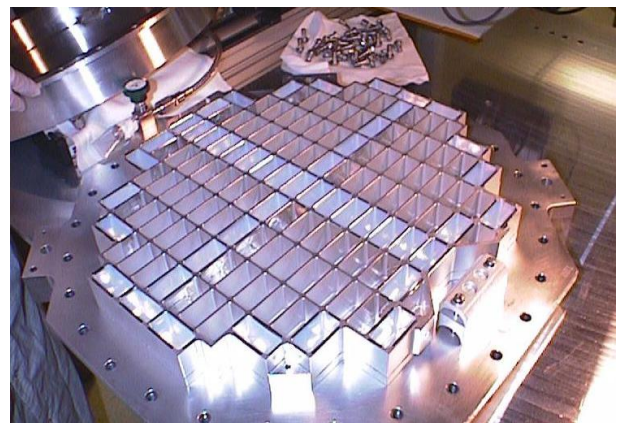
The most common aerogels found on the market are composed of silica, derived from silica gel. They can also be made from metal oxides and can be exploited for their conductivity, as catalysts for chemical reactions, matrices for explosives, or as precursors for other materials like carbon nanotube catalysts. Carbon can also be used as a material to produce aerogels. Aerogels made from aluminium are often found in catalysis when combined with a metal. There are

also semiconducting metal chalcogenide aerogels proposing a unique combination of porosity, optical translucency, and photoluminescence, and have potential applications in photovoltaics and as chemical sensors. Finally, metal aerogels which can be exploited for their high conductivity and surface area³.

The unique properties of aerogels offer a wide variety of market applications, and today aerogels can be found in⁴:

- High-performance insulation, such as the piping to transport oil and gas, in ovens, in vacuum cleaners, or in building walls;
- Optical devices;
- Chemical catalysis, both as catalysts and catalyst supports;
- Acoustics including sound absorption (anechoic chambers) or efficient ultrasonic devices;
- The space industry, again as an insulant, but also in cosmic or cometary dust collection (NASA's Stardust Project in Figure 2 being an example of this);
- Dielectrics for microwave electronics and high voltage insulator;
- Electronics given that carbon aerogels are electrically conductive: electrodes for batteries and capacitors. Some metal oxide aerogels are highly conductive as well;
- Filters and absorbing media for desiccation and waste containment.

Figure 2: A space dust collector made of aerogel



Source: NASA Jet Propulsion Lab²



Despite this variety of different potential market applications, the use of aerogels is still limited. This is mainly because of the cost and time of production, making them generally uneconomical for businesses.

The trend that has seen aerogels garner interest does not originate from any radical new developments in the technology itself, which exists for several decades now. Their rising popularity has been generated through innovations in their production as lighter, strong and more environmentally-friendly materials. This is especially the case in the use of aerogels as a high performance insulating material.

Aerogels are also seeing greater importance in sectors such as the space industry, where the minimisation of weight is critical. Today, market forces are driving demand for new insulating solutions also for houses and buildings.

Europe stands to gain from the growth generated by companies that can offer aerogel products to the market that are cost effective vis-à-vis competing technologies. In addition, new innovative companies are starting to provide new means to produce competitively priced aerogel materials, or new aerogel products to tackle old problems in a new innovative way.

2.2. Overview of the innovative companies capitalising on this trend

Table 1: Overview of the company cases referred to in this case study

Company	Location	Business innovation	Signals of success
Green Earth Aerogel Technologies	Spain	GEAT is a start-up company that directly produces aerogels using agricultural waste materials from rice as raw materials.	<ul style="list-style-type: none"> - Finalist in 3 major international business plan competitions. -
Svenska Aerogels	Sweden	Svenska Aerogel is a Swedish company that has developed a new production process which is estimated to reduce the cost of producing aerogels by 90% ⁵ .	<ul style="list-style-type: none"> - Multiple mentions in the press - Collaborations with several large multinational companies - Classified as a "Climate Solver" by the WWF for its potential to influence the overall insulation market and contribute to global energy savings and reduction of CO2 emissions.
Aerogels Poland Nanotechnology	Poland	Aerogels Poland Nanotechnology was created in 2008 and has exclusive rights to sell aerogel products from Aspen Aerogels to the Polish, Czech, Hungarian and Russian markets.	<ul style="list-style-type: none"> - Exclusive rights to sell aerogel products on behalf of Aspen Aerogels. - Organises one of the biggest conventions for the insulation industry in Poland - Numerous mentions in the press
Separex	France	Separex is a French company originally spun out of academia employing thirty expert employees with unique experience in research and implementation of industrial supercritical fluid applications.	<ul style="list-style-type: none"> - Member of the AERSUS project geared towards developing aerogel applications for the space industry - Clients include important market players such as Nike - Numerous mentions in the mainstream media -

Problem 1 – Aerogels are a better performing insulator than most other technologies. However they have been made using expensive and toxic components which makes them unattractive.

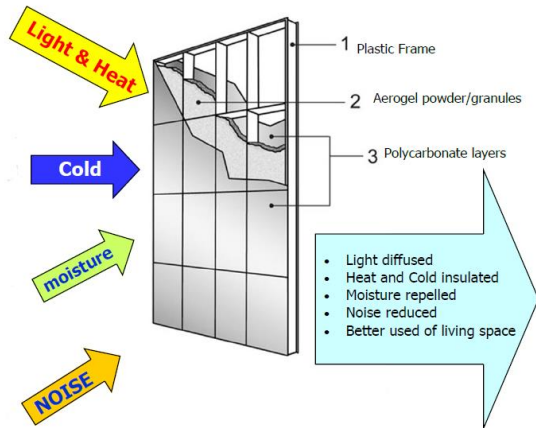
Innovative solution 1 – Green Earth Aerogel Technologies is a Spanish start-up that offers aerogels made from agricultural waste which are cheaper, more environmentally friendly and quicker to produce than other conventional aerogels. The company offers two types of aerogels. Silica

aerogel made from rice husk ash that makes it an excellent insulation material which allows light to pass through; and carbon aerogel, made from broken rice waste that can block infrared. Both of these aerogels are also fireproof.

Translucent fireproof wall insulation made from Green Earth Aerogel Technologies' cost effective insulation which offers



dual energy savings in heating and illumination.



Source: Green Earth Aerogel Technologies⁶

Problem 2 – The properties of aerogels make them an ideal insulator, a good component of paints, and it allows them to be used in chemical adsorption and filtration. However the production process is far too costly for them to be a cost-effective solution for businesses.

Innovative solution 2 – Svenska Aerogel has patented a novel production method that has helped reduce the production cost of aerogel by roughly 90 per cent. This new competitive advantage has allowed Svenska Aerogel AB to set up multiple partnerships with leading insulation companies across Europe and the rest of the world and develop products with superior insulation properties at a competitive price. In addition, as opposed to conventional aerogel production processes, their product is produced in an environmentally-friendly way.

Svenska Aerogel AB's patented Quartzene® is a fine and porous silica-based powder but can be made in gel and in pellets (as shown in the picture below) to meets the needs of its customers.



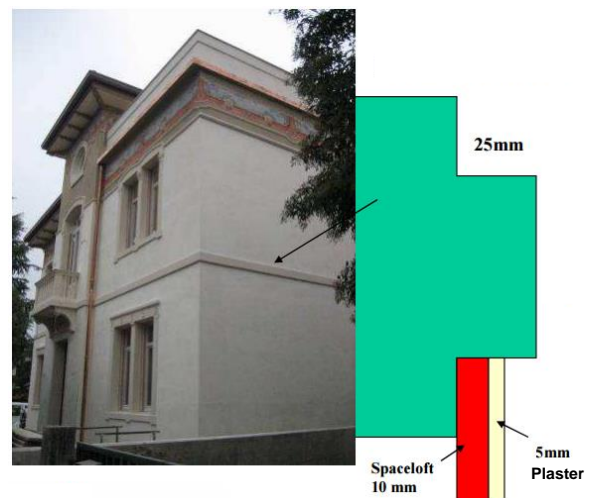
Source: Svenska Aerogel⁷

Problem 3 – Many buildings are going to have to install insulation (or expand upon existing insulation) in order to meet the ever increasing demands set by energy-efficiency regulation. To meet these new energy efficiency standards with conventional insulating materials would require building new layers on the exterior of buildings, which may not be aesthetically pleasing. This is particularly problematic for heritage buildings, where alterations to the exterior are forbidden.

Innovative solution 3 – Aerogels Poland Nanotechnology is a distributor of aerogels products based in Mragowo, Poland. The company caters to the Polish, Czech, Hungarian and Russian markets through the sales of insulating materials to the construction sector.

The aerogel insulators provided by the company are not only better insulators than conventional materials, but resolve the issue faced by the market by providing an insulating material that is both thinner than competing technologies but also, crucially for heritage buildings, can be installed from the inside of a building without requiring resurfacing the exterior with insulation.

Aerogels Poland Nanotechnology's aerogel products offer consumers the means of insulating buildings using thinner insulating layers than conventional materials, resulting in a more aesthetically-pleasing end result.



Source: Aerogels Poland Nanotechnology promotional material⁸



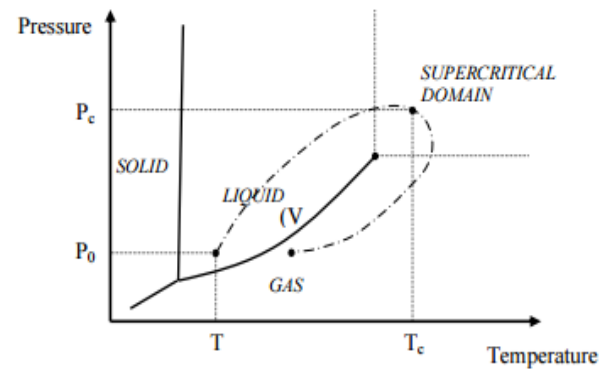
Problem 4 – The solgel polymerization process to create aerogels has important restraints. It is difficult to control the size of the sols or the way they come together. As such the structure and density of the final aerogels are influenced by the conditions during polymerisation (e.g. temperature, pH, type of catalyst). Therefore using most production methods, the structure of aerogels cannot be controlled at the molecular level⁹. This makes the market uptake of aerogels more difficult because of the lack of a truly standardised product.

Innovative solution 4 – Separex has developed their own proprietary method for “supercritically” drying aerogels using supercritical CO₂ (where CO₂ is at a temperature and pressure above its critical point and is no longer strictly speaking either a gas or liquid).

This method for producing aerogels helps reducing the distortion of the aerogels in the internal structure. This results in a better quality in terms of its insulating properties.

In addition the company offers a service for other aerogels companies looking to improve the quality of their aerogels by applying their patented supercritical drying method.

Separex's supercritical drying procedure consists in eliminating the solvent by pressurising the solgel mixture and heating to a supercritical state and then depressurising and cooling to room conditions, producing a superior aerogel.



Source: Separex promotional material¹⁰



3. Impact of the trend

3.1. The market potential of the trend

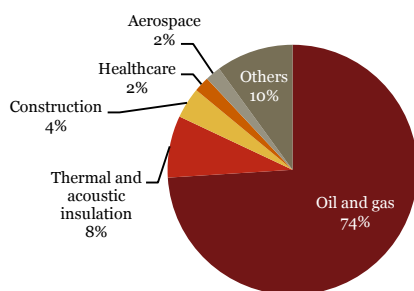
According to market research by Technavio, the global aerogel market accounted for some EUR 250 million in 2014 and approximately 10,680 metric tons of aerogel was purchased in 2014¹¹. Aerogels cater to the following markets:

- Oil and Gas Sector;
- Thermal and Acoustic Insulation Industry;
- Construction Sector;
- Healthcare Industry;
- Aerospace industry.

The oil and gas industry is the most dominant of the market applications for aerogels where these act as insulators to maintain the temperature for transported or stored oil or gas. This sector accounted for 74 per cent of the entire aerogels market in 2014 (Figure 3).

The US is the major producer of aerogels, driven by the steady growth of aerogel production and government support for research in the field. Europe comes second in terms of aerogel production and accounts for 36 per cent of the market (2014). To date the major players in this EUR 250 million market are: American Aerogel, Aspen Aerogel, BASF and Cabot.

Figure 3: The segmentation of the global aerogel market by application in 2014



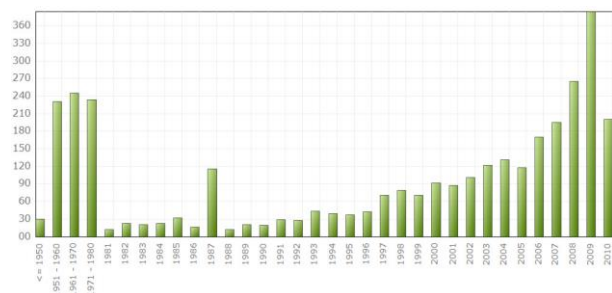
Source: Technavio Insights ¹¹

The global aerogel market is expected to grow significantly at a CAGR of 35.86 per cent during the forecast period. North America was the leading producer worldwide and accounted for 51 per cent of the market in 2014.

Aerogels will also see increasing importance in the construction and insulation markets. This is driven by the growing commercialisation of thermal and acoustic

applications across different industries and because of the growing need to reduce energy costs. Especially the insulation market is very large and offers a lucrative potential for aerogel companies. The global insulation market is estimated at around EUR 34 billion and predicted to grow to EUR 50 billion¹².

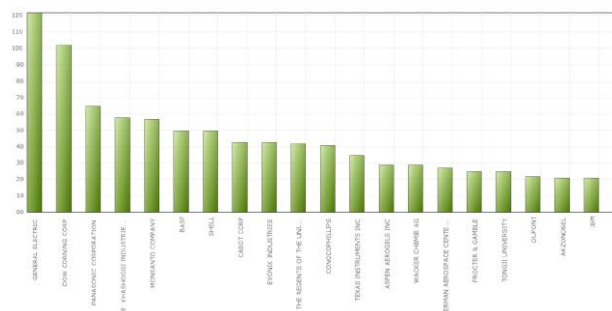
Figure 4: The number of IP publications in the area of aerogels filed over the years



Source: Patent iNSIGHT Pro

The aerogels market has recently seen a surge in the number of patents filed on aerogels (Figure 4). Published patents started to rise rapidly from about 80 published in 2000 to over 400 in 2009. This demonstrates the incredible increase in nanomaterials research in recent years. As shown in Figure 5, the major patent portfolios for this nanomaterial are owned by major market players including GE, Dow Corning, Panasonic, and Monsanto.

Figure 5: Top assignees of patents for aerogels



Source: Patent iNSIGHT Pro

The increase in patents together increases in the R&D investment (through initiatives like the EUR 4.3 million invested through FP7 into the aerogel insulation research and commercialisation project run by a consortium of research centres and two companies¹³) can only suggest that the market believes aerogels will become increasingly important. And that results in increased protection of intellectual property.



3.2. The socioeconomic impact of the trend

The development of the aerogels market will help generate growth and create jobs. The Europe currently accounts for 36 per cent of the aerogel market and can benefit from its development, e.g. in increased demand for skilled labour to support this growth. Given the knowledge intensity of the nanomaterials sector, the majority of the jobs created will require skilled labour and will thus be ideal for the European jobs market vis-à-vis other competing geographies given the emphasis placed in many European Member States to promote skilled labour^{14,15}.

According to market statistics, Europe, the Middle-East and Africa account for 30 per cent of global insulation. The consortium of European insulation firms recently called for

an enforced target of 30 per cent energy efficiency to be set for their sector by 2030, which according to their estimations could save consumers EUR 300 billion in energy bills¹⁶. Another example of this future demand can be drawn from the UK's plan to achieve its 2050 energy efficiency commitments. In order to do this, the UK government estimated that some 3.5 million solid walls will need to be insulated by 2030 in the residential sector¹⁷. This demand could be met by aerogels.

Greater use of aerogels in the European construction sector could also have a big impact on job creation. It has been estimated that approximately 1 million jobs could be created if a 30 per cent energy efficiency target was enforced for 2030 for European insulation and construction companies¹⁶.

4. Drivers and obstacles

As mentioned before, the aerogels market benefits from an increasing demand for greater energy efficiency. The cost of aerogels has so far been an obstacle in the growth of the market, but the latest developments are seeing their cost reduce, which will help drive the market. New construction and architectural techniques are helping to make aerogels more popular. However, the construction sector is notoriously risk-averse and SMEs offering aerogel products face an obstacle in getting their clients in this sector to move away from conventional insulating products towards aerogels. Finally, access to finance for SMEs offering aerogels products is made more difficult by the reluctance of venture capital to invest into.

of recent policies implemented at both the EU and national level.

The EU had set itself the target of achieving a 20 per cent reduction in energy efficiency as part of the Europe 2020 strategy¹⁸ along with the 2012 Energy Efficiency Directive (EED)¹⁹. The latter is complemented by sector-specific instruments such as the Energy Performance of Buildings Directive which sets the standards on insulation in new buildings. It is also complemented by the Ecodesign Directive²⁰ which establishes performance standards, energy-using products and the Energy Taxation Directive²¹, which sets minimum rates for energy products.

While the demand for energy efficiency has originally been policy driven, the market is beginning to demand greater energy efficiency independently of these regulations, with consumers helping to create market pull.²² This is because of greater consumer awareness of climate change and the need for energy efficiency (also to reduce the energy bills).

Consumers start to increasingly demand more environmentally-friendly products. While conventional aerogels are produced from less-desirable materials (in terms of waste management and toxicity), technological advances have allowed companies such as Green Earth Aerogel Technologies to synthesise carbon aerogels using agricultural waste.²³ These new types of aerogels stand to benefit from existing regulations (environmental or chemical standards like the REACH legislation) and contribute towards the transition to a circular economy.

"Aerogels are particularly of benefit to old historic buildings, where you cannot change the façade. They are also flexible, inflammable, hydrophobic and can be installed regardless of the weather" – Aerogels Poland Nanotechnology

"Our product is really eco-friendly and despite strict regulations under REACH we were able to achieve our goal of producing effective insulation materials using low cost material and safe processes with green raw materials." – Green Earth Aerogel Technologies

4.1. Increasing demand for greater energy efficiency and environmental-friendliness

One of the primary drivers of the aerogels market is the same as for the insulation market: energy efficiency regulations. Given their

greater insulating potential than conventional technologies, aerogels can clearly benefit from this demand, being result



4.2. The cost of producing aerogels stand to drop as the market develops

Aerogels have been around for several decades now, and despite their high performance, their uptake by the market has been limited by the high cost of producing aerogel (cost of the substrates as well as the synthesis process), resulting in a high cost of the product. This meant that the threat of substitution by other products has been high, even if these competing products did not perform as well as aerogels. In addition, it limited the bargaining power of the sellers of aerogels as customers are more inclined to opt for materials that provide a more cost-effective product, and only some industries can afford the aerogels (the oil & gas industry for example). Additionally, aerogel manufacturers have been highly dependent on their suppliers because of the difficulty in sourcing the necessary raw materials and their high costs¹¹.

As the market develops however, the cost drops. Aerogels Poland Nanotechnology argues that the aerogels market will benefit from increased investment by the Chinese market into the technology, and as production levels increase, the cost of aerogels will have to decrease. In addition, technological advances in production methods such as the one developed by Svenska Aerogel mean that aerogels became more cost-effective for consumers than ever before.

4.3. Increased use of novel construction and architectural techniques

Another important driver of this market, which is tied in with demand for greater energy efficiency through insulation, is the increasing use of novel construction and architectural techniques in the construction sector¹².

For example, the construction sector increasingly makes use of techniques such as daylighting to reduce energy consumption. To improve energy efficiency of this solution fibreglass and glass windows can be substituted with transparent aerogels.

Insulation layers in walls are often bulky, and when an existing building needs to be re-insulated, these layers are often simply built around the existing wall. Along with having an aesthetic impact, it can also lead to complications when the building cannot be further expanded because of planning permissions. Aerogels present the advantage that they can also be applied from within a building to insulate walls. In addition, aerogels require less volume than conventional

insulating materials, so the aesthetic impact is less noticeable.

Due to all those characteristics aerogels are becoming an attractive solution in the refurbishment or insulation of old or historical buildings. Amending the exterior of these buildings is often restricted by legislation on national heritage, making insulation with conventional means impossible. Aerogels Poland Nanotechnology have capitalised on this and a good proportion of their aerogel sales are for this purpose.

Despite the obvious benefits of the advanced material, breaking into the construction sector is difficult²⁴. The construction industry is widely regarded as being conservative and slow to innovate and adopt new technologies. This conservatism and risk-aversion stems out of the overriding need for durable and long-lasting products, that are often expensive to build, but also very costly if they fail to perform as required. The industry is also highly fragmented and for the most part populated with SMEs with a low level of industrialisation²⁵.

4.4. VC market less inclined to invest into cleantech

Finally, several of the interviewed companies stated that they found it difficult to access finance through venture capital because of lack of appetite from venture capital firms towards cleantech and nanomaterials.

“Venture capitalists used to be very enthusiastic about cleantech, but today they are more interested in the next IT or website company than an environmentally and cost-effective aerogel” – Svenska Aerogels

Few years ago new environmental regulations and energy efficiency subsidies were helping push market demand for cleantech. Because of this stimulus, venture capital outfits were eager to invest in cleantech like photovoltaics, wind farms, but also those of relevance to aerogels (energy efficiency initiatives such as insulation). When the subsidies ceased along with a relaxing of environmental regulations following the economic crisis, the appetite to invest in cleantech died down.



5. Policy recommendations

The following policy recommendations could be considered in order to support the development of the aerogels market, and address the obstacles that hinder its growth. First, higher energy efficiency targets should be set beyond 2020 in order to continue to drive the market. Second, public schemes supporting insulation or re-insulation of buildings could be encouraged. Third, investments into applied research on aerogels could be continued in order to help commercialisation of new and better aerogel products. Finally, the visibility of aerogels could be raised through awareness-raising campaigns at the Member State level.

5.1. Continue pushing for greater energy efficiency targets

As previously mentioned the aerogels market is primarily driven by the market push generated by regulations pertaining to energy efficiency and the Europe 2020 targets²⁶.

"It is important that Europe continues to enforce its environmental regulation and not relax them. Equally the consumer should be properly informed". - Separex

While some Member States set their own targets, many have no energy efficiency targets to hit as part of a general climate change policy beyond 2020. The sooner a post-2020 proposal is approved, the sooner the market can begin to

increase investing in energy efficiency solutions, including aerogels as an insulator.

5.2. Promote insulation initiatives

As energy-efficiency standards continue to increase, both as a result of policy and because of consumer requirements to drive down energy costs, the greater performance of aerogels can make up for their higher costs. In addition, these costs tend to come down as the market develops and technological advances in production continue.

Existing policies to help subsidise the (re-)insulation of buildings could be strengthened or further supported. This will however require aerogels to continue to become more competitive in terms of costs with other insulators.

5.3. Maintain investment in applied research for aerogels

There are several important European research projects that aim to further develop both the understanding of aerogels and their applications. Projects like the AerSUS (which is run by a consortium of companies and research institutions aims to develop aerogel applications and products, and supply them for the space industry) or the aerogel insulation research and commercialization efforts are major research projects which are bound to produce knock-on beneficial impacts to the wider market.

Given that aerogels are a relatively mature technology, the focus on investment should be geared more towards applied research and into its commercialisation by identifying new ways to incorporate aerogel into products and capitalise on their unique properties.

5.4. Increase the visibility of aerogels as a cleantech

A special awareness campaign through collaboration between the EC, Member State governments, private companies or research groups could also help encourage investors. This could be done through the support of networking and visibility initiatives run by incubators, accelerators or demonstrators at the national level and encourage the participation of venture capital, particularly when geared towards the construction industry.



6. Appendix

6.1. Interviews

Company	Interviewee	Position
Green Earth Aerogel Technologies	Fortunato Cardenas	CTO and founder
Svenska Aerogels	Anders Lundström	CEO
Aerogels Poland Nanotechnology	Dariusz Krakowski	Sales representative
Separex	Audrey Ngomsik-Fanselow	Managing Director

6.2. Websites

Company	Web address
Green Earth Aerogel Technologies	www.green-earth-aerogel.es
Svenska Aerogels	www.aerogel.se
Aerogels Poland Nanotechnology	www.aerogels.pl
Separex	www.separex.fr

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