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Version final 30 March 2012

Presenting the (economic) value of patents nominated for the European Inventor Award 2012

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1. The invention

1.1 Historic account

Using a material such as ETFE (Ethylene tetrafluoroethylene) for foil roofs is probably not something that was in the immediate mind of the original material inventors when the cousin of the famous TEFLON was first developed in the early 1970s. However, German inventor Dr. Stefan Lehnert and his firm Vector Foiltec succeeded in developing ETFE-based technologies, which have led to roof and cladding solutions that enjoy fundamental advantages in terms of energy efficiency or the ability to withstand hurricanes and bomb blasts. The technology has also pushed the boundaries of architecture and allowed the creation of projects such as the Eden Botanic Garden in England or the Beijing National Aqauatic Centre in China.

Vector Foiltec was founded in 1982 in Bremen in Germany. Starting from an interest to develop new sails with ETFE, the firm quickly became involved with the development of systems of plastic roofs based on the ETFE material. The path of success was nonetheless one of many barriers that had to be overcome, both of technical and non-technical nature.

The first two projects in the early 1980s were for clients in the Netherlands. One customer was a recreational park, which needed a transparent roof for their swimming baths. The other client was a zoo. The zoo looked into the possibility to implement a new concept whereby visitors would pass through the zoos in small confined pathways while the animals would be, according to Stefan Lehnert, almost living in broad areas *"...almost in freedom."* The zoo, the Burger´s Zoo in Arnheim, hence also looked for transparent roofs, which were to cover a large area and at the same time would allow the passage of UV rays. The Burger´s zoo project eventually became the very first project of the firm in 1982.

The technological problems, which needed to be solved for this and later for other projects were manifold. For example, the firm had to design and build production machines, which would be able to process the ETFE foils in the first place. Furthermore, development work was needed to develop the frame systems for holding and mounting the foils in place. There was a lot of theory development, testing and experimenting necessary to achieve applicability of the technology under real life conditions. Many problems occurred 'on-the job' while developing projects and had to be solved on the occasion of the project. Other problems had to be tackled through constant R&D. In fact, Vector Foiltec became in this context also a specialist firm for handling and processing ETFE foils outside the roofing/architecture area. There were a number of research projects conducted in collaboration with universities, and contract development was performed for the aerospace industries or for insulation in low temperature environments. All these projects added know-how, provided process support and created opportunities to analyse possible application areas. The firm spent around 5% to 10% of its turnover on such R&D, and frequently made use of R&D grants and support programmes. This type of R&D is seen as essential for the development of the technology and is still continued today.

Another set of problems was fulfilment of regulations, for example safety regulations or fire protection regulations. The various local building and construction regulations had no provisions in place for the use of ETFE materials in roofs or for cladding – a gap that needed to be closed. Eventually, there was the sense of feeling with potential customers that *"...such a solution with foils instead of glass could not work."* (interview Stefan Lehnert). There was hence a pronounced need for innovative pilot customers and reference projects, to which the firm could refer when they were in contact with potential new clients.

Stefan Lehnert recounts:

> *"For a time of around 15 years, development and growth was rather slow. It was a step-by-step process for the development of various technological solutions, and the patent(s) were only one small part of the equation. It was also a time were the market had to be developed. In fact, as there was no technology, there was also no market. In order to develop the market we needed the innovative customers, we needed to involve potential clients in discussions and negotiations and demonstrate them what is possible, to organise trainings or to cater for editorial contributions on our technology in industry news services and papers."* (Stefan Lehnert)

The big turning point came in the late 1990s with the Eden project. Completed in 2001, the Eden project, a recreational park in the UK, sparked considerable media interest as well as interest by architects such that the firm started to enter a steep growth path which it is still pursuing. By 2012, Vector Foiltec has executed more than 650 projects. Among the most renown of these are the aforementioned Eden Project; the Art Center College of Design, California, completed 2004, the Southern Cross Station, Australia, completed 2006 and the Beijing National Aquatics Centre, China, completed 2007. The latter project is of particular relevance as it sparked again media interest and that of architects throughout the world, in particular in the U.S. The U.S. market was then underdeveloped compared to the Euroepan market. An article in the business week asserted *"...ETFE may be about to get its moment in the architectural spotlight"*. [1] The project can be considered a marketing door opener for the U.S. market for Vector Foiltec.

1.2 Technological features

Ethylene Tetraflouroethylene (ETFE) is a fluorine-based plastic. A UV-stable copolymer, it was developed in conjunction with NASA as a thermo-plastic sister product of Teflon for use in electrical insulation in space travel. The usage of ETFE in foils for cladding, roofing and covering buildings involves, as explained above, the mastering a number of technological problems. One such area is the way the foil is attached to the building via a frame. The nominated patent covers a specific in this context, namely the transition of the foil to the frame material on which the foil is mounted. This transition area is potentially prone to thermal/air leakage - eventually, one could anticipate that the air/gas creating the typically cushion like appearance in buildings such as the Allianz arena would dissipate with time.

The patent addresses this issue and optimises energy efficiency in the transition area. The solution is that two or more sheets (foils) of ETFE are held in place by aluminium extrusions. This forms a gas-tight envelope into which air is introduced, producing a thermal cavity within a cushion. The extrusions, which are formed by aluminium strips, hold the foils in place and can be attached to a buildings´ support structures. The cushions are inflated with air at low pressure. The cushions are attached to a support apparatus. With a wide array of possible formats, the cushions can be welded together, much like a tessellation, to cover large structures.

The advantages of the patented technology in particular (and the ETFE foil technology in general) are:[2]

- The membrane structure with the pressurised air cushions in between the layers has very good insulating properties, and the patented technology makes sure that

[1] Woyke, E. (2007): Material for an Architectural Revolution, http://www.businessweek.com/print/innovate/content/apr2007/id20070424_903199.htm

[2] see also the Website of Vector Foiltec, http://www.vector-foiltec.com/en/technical/durability.html

there are no leakages in the transitions from the foil to the frame material. This provides the opportunity to create very energy-efficient buildings

- The ETFE foils are long-lived, as they are not susceptible to air pollution or degradation due to sunlight.
- The surface of the ETFE foils is very smooth. They do not need to be cleaned from the outside, as rainwater will carry dirt away (and in areas with low precipitation, the specific surface tension will avoid accumulation of dirt). Cleaning from the inside is only needed at much larger time intervals
- Foils can be made transparent across 90% to 95% of the solar spectrum. Foils can be transparent, e.g. with respect to UV light, they can be translucent, opaque, and can support graphic patterns created by flouropolymer ink. The technology enables the control of solar glare. Cushions can be engineered to selectively transmit or reflect different wavelengths of light, making it highly adaptable to local requirements.
- The multi-layering of foils allows for the creation of visual depth and transparency. Laminating LEDs and light tapes to each foil layer allows a building to change colour. Surfaces can be engineered to capture projected light, allowing the display of video and images.
- ETFE foils weigh much less than glass and can be designed to be bomb blast and hurricane proof (i.e., they can be designed in such a way that once destroyed by said forces, they behave in predetermined manner which minimises risks of injuries to persons).
- ETFE foils are recyclable, and only a fraction of the energy is needed for their production, compared to other technologies. This creates a very low carbon footprint.
- ETFE foils can be combined with photovoltaic cells to produce energy. In fact, Vector Foiltec has already such solutions on offer.

2. The market

The company states to be the world-market and technology leader for foil roofing and cladding systems, not the least due to constant and heavy investment into R&D. The technology for the specific application of foils and ETFE for roofing and cladding is predominantly developed in Germany, where also most of the global competition of Vector Foiltec is located. There are some five main competitors to Vector Foiltec. According to the Vector Foiltec, the firm has a market share of around 50% in Germany and around 85% in international markets. The overall (global) market volume is currently estimated at around €130 million p.a.

There are three main market segments:

- Zoo architecture
- Replacement of glass solutions in architecture and
- Iconic architecture

All three market segments are of roughly equal importance/size.

The company Vector Foiltec sells ETFE foil solutions under the brand 'Texlon'.[3] The firm offers clients a complete design and construction service, from initial concept

[3] Website of Vector Folitec GmbH, http://www.vector-foiltec.com/de/profile/vector-foiltec.html

through scheme design, production, installation and facility management. The Texlon group, founded in 1982 and headquartered in Bremen/GER, has seen, as discussed above, an interesting growth path. In the 15 years time frame before the Eden project, the firm was *"…roughly larger than a garage start-up"* (quote Stefan Lehnert) with about 8 to 10 employees and a yearly turnover between € 1.5 million to € 2.5 million. With the publicity gained for the Eden project, firm sales took off. While in 1999 turnover amounted to €3 million, it is today in the range of € 70 million. The company employs some 250 staff worldwide and has production facilities in Europe and, since 2005, also in China. There are 16 subsidiaries outside of Germany, according to Stefan Lehnert.

Growth is between 10% and 30% p.a. and managing growth is a prime success factor:

> *"Because of the performance characteristics of our technologies, new projects consistently add to our reputation and generate follow-up projects. By experience, one implemented project leads to about 3 follow-up projects in between five to ten years. Under such circumstances, it is important to anticipate, manage and control growth accordingly and to cater for recruitment and changes in organisational processes."* (Stefan Lehnert)

In terms of geographical spread of the markets, the U.S. can be still perceived as a difficult market, as the *"…U.S. customers are usually conservative and risk-averse."* This behaviour is due to insurance issues and a rather high risk for being sued for damages should something go wrong. However, there are also dynamic market segments in the U.S. when it comes to replacing glass architecture. Against this background, foil solutions prove to be a superior and rather inexpensive solution for public buildings, which call now for bomb- and blast resistant architecture. The middle and far-East are also very interesting markets, because these markets exhibit in general a high demand for construction services. And while it is true that growth in the construction industry is closely related to the general business cycle, *"…somewhere in the world there is always an economy growing"* (Stefan Lehnert). The share of exports of Vector Foiltec is currently around 80% of turnover.

Factors limiting (even) higher usage of ETFE have been, traditionally, rather 'conservative' architecture mindsets (i.e., architects which prefer to use traditional materials) – see also above - but also drawbacks of the material itself:[4] *"In order to become more widely spread, the [ETFE] plastic films will have to be low-cost, easy to process and free of health hazards to have a chance in international construction business."* There is still plenty of room for innovation, and the nominated patent is one element of the game. Other innovations concern the integration of photovoltaics, the creation of LED facades, of ETFE membranes which are able to create heat barriers. Fraunhofer researchers of the Institute for Building Physics believe that with time *"…ETFE will emerge as a strong market of its own"*.

3. The role of patents and Intellectual Property Rights (IPR)

3.1 Motives and benefits of patenting and employed IPR strategy

Patents are an important factor for Vector Foiltec in order to protect technological leadership and recuperate R&D costs incurred. In fact, *"…patenting might be considered as specific accompanying measure or aftereffect of R&D…"*, as Stefan Lehnert puts it. "*Once patented, many of the technologies are rather easy to copy, and as competitor you also get to know whether the solution has worked in a particular project. It would be rather cheap to freeride."*

[4] Aid, R. (2010): ETFE material research made plastic facades more practicable and affordable

Against this background, enforcement of IP rights becomes an important issue. Vector Foiltech is ready to defend its patent rights, but has to strike a balance:

> *"It is not only about competitors, but also about potential customers. We find out rather easily, due to our market position, whether a new project is trying to infringe our patents, and we will by no means be satisfied with a licensing contract. If they go through with the project, we will sue and we will demand that the project be built back. We are, however, of course aware that some parties which we could sue could be potential customers. This is why we will address the problem as early as possible, in advance of project realisation. What definitely helps, is to be the market leader. Being technology leader without market power would be considerably more difficult"* (Stefan Lehnert)

International patent protection is an integral part of the IP strategy. The firm tries to selectively patent in countries where there are, on the one hand, potential competitors and infringers as well as, on the other hand, where there are framework conditions which favour the application of the firm´s technologies: *"As the patent in question is, for example, about insulation, energy efficiency and saving the costs for heating, the technology is likely to be applied in countries such as Germany or in parts of the U.S., but probably not in Italy. Our patenting strategy reflects that. We therefore follow with our patents the markets..."* explains Stefan Lehnert.

3.2 Patent statistics and patenting trends

Vector Foiltec has applied for a total of eight patent families[5] since 2001. Patent protection has been sought for in Germany, Denmark, Austria, the U.S., China, Russia; on one occasion, the application was performed via the European route, and on another via the World-PCT route. The nominated patent has been so far granted in the said European countries and in the U.S. A second patent has been so far granted in the U.S. All other patent applications are still pending.

A search for patents that describe the usage of ETFE in architecture reveals hat there are less than 100 patent families worldwide in this field. The Japanese firm TORAY INDUSTRIES INC. filed a very early application of ETFE in this context in 1973. Japan has been the leading applicant in the 1980s and 1990s with applicants such as ASAHI, NIPPON and the aforementioned TORAY INDUSTRIES. Since 2000, one can see an increase of applications by U.S. firms (GENTEX, 3M, GORE) and China (SHENYANG YUADA ALUMIN. Interestingly, there are relatively few European applicants. A small number of applications describe ways of how photovoltaic elements can be in integrated in ETFE roof structures. Early applications in this context are from Japan, the U.S. (after 2000) and Italy and China (after 2008, respectively).

If the search in the patent databases is extended to also include the general use of foil membranes in architecture, one can see that the number of patent families increases only slightly to 196. The geographic distribution of the countries of the applicants now moves towards Germany, and Vector Foiltec leads the ranking list with its six applications in this field, followed by Swiss firm PROSPECTIVE CONCEPTS with five applications and Fraunhofer with 3 applications. With respect to cushions made of foil there are very few applications, and those of Vector Foiltec belong to them.

The resulting picture is one that demonstrates a high degree of exclusivity of the ETFE (and foil) technology in architecture. It also shows that there may be, in line with the assessment of Vector Foiltec, quite a variety of rather independent and individual technical problems that are addressed by the various patents. That being said, it stands to reason to believe that the firm´s patents protect a specific technological

[5] Patents filed in different countries, but on the same invention, denote a so-called patent family.

solution for markets and products addressed by the German firm and secure in this area the technological leadership position.

4. Conclusions

The collected evidence tells the story of a very successful and fast growing SME specialised in a specific technology, where it became world-market leader. Patents are an important component of the firm strategy to maintain the technological edge over the competition.