



EPO SME CASE STUDIES | SKELETON

Graphene draws on capacity for energy storage

Skeleton offers one of the first commercialised technologies to use graphene, a ground-breaking and Nobel prize-winning material. This Estonian company develops, manufactures and sells ultracapacitor energy storage cells, modules and systems based on patented advanced materials and designs. Its IP portfolio has been created to protect the company's technology along the whole value chain, including development, production and sales. The IP and business strategies evolved simultaneously, starting with a platform built on protection for the core graphene-centric technology and a focus on protecting inventions with the best business potential first. Employees at Skeleton are cross-trained so that everyone is aware of and has competencies in the company's IP strategy and is familiar with how it relates to the R&D strategy.



SkelCap ultracapacitor cell series uses patented graphene-based materials for mass market applications in the motorsport, automotive and aerospace sectors in particular.

Founded in 2009, Skeleton is a young and ambitious company. To date it has raised more than EUR 40 million in investments and has spent considerable time and resources developing its technology into a product suitable for commercial-scale production and use. With roots in a private research institute conducting contract work for Toyota Motors, the two young Estonian non-tech founders Oliver Ahlberg and Taavi Madiberk from the University of Tartu, in collaboration with scientists Jaan Leis and Anti Perkson, started Skeleton with a technology and IP base focused on advanced materials. Madiberk's father was a scientist in the field during his career, which provides a link between the technology and its commercialisation that supports Taavi's entrepreneurial spirit. All four founders still work for the start-up as employees and shareholders.

Once Skeleton had been set up, the management was able to swiftly translate the technology into a commercial product. In 2011, the European Space Agency signed a contract with Skeleton, which gained the company a lot of publicity and recognition. Investors were attracted, and in the period 2013–2014, a pilot manufacturing plant was built in Tallinn with money invested by UP Invest (an Estonian venture capital and private equity firm). By 2015, a full manufacturing plant was up and running. The last milestone in the commercial production scaling was reached in 2017 with the finalisation of another plant in Saxony, Germany, to meet growing customer demand.



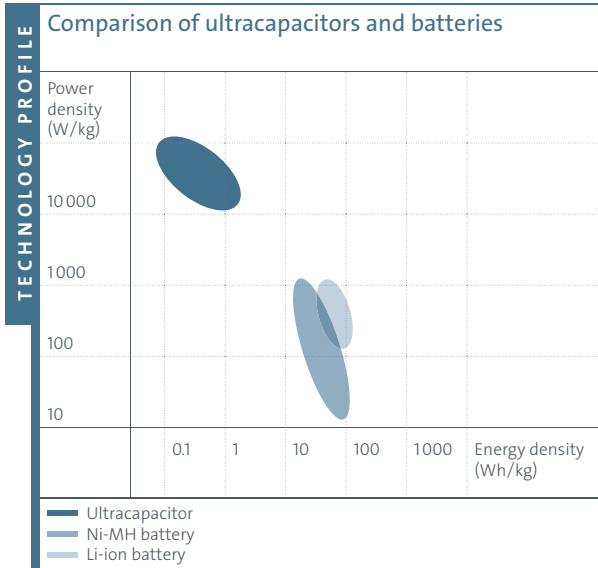
Skeleton's SkelStart is a powerful engine start module based on ultracapacitor technology developed for the demanding needs of the mining and heavy machinery industries.

A new and better way to store energy

Skeleton's innovation is based on a breakthrough graphene material. The company produces high-power-density energy storage solutions using ultracapacitors, made possible by advancements in nanomaterials. Skeleton's products address the increasing need for efficient energy storage to accommodate the fast-growing remote use of electricity, stronger reliance on intermittent sources of energy from wind and sun, and volatile energy prices. Ultracapacitor technologies deliver stability and economic benefits across numerous fields, including heavy transportation (maritime and land), and the automotive, aerospace and (renewable) energy markets, as they can be used as quick-charge buffers and provide the most efficient way to recuperate braking energy and re-use it for acceleration.

The combination of greater power density, instant recharging, longer lifetime and lower resistance has fuelled commercial growth for ultracapacitor energy storage of around 30% yearly since the mid-2000s. According to a 2015 report by IDTechEx, sales of ultracapacitors are expected to grow from around EUR 243 million in 2015 to EUR 1509 million in 2021, giving them a significant share of the energy storage market. Despite their lower energy density and increased cost, ultracapacitors have numerous technical advantages over competing batteries. Shorter charging time, longer lifetime, low resistance (no significant resistance $> 0.12 \text{ m}\Omega$), improved efficiency and environmental friendliness have all contributed to making ultracapacitors a real alternative. They work well paired with high-energy-density storage technologies such as lithium-ion batteries, which can be connected in parallel to create combined power supply units.





The superior performance of Skeleton’s ultracapacitors is due to a patented curved graphene nanotechnology which has major advantages over the activated carbon used by other manufacturers. Curved graphene is superior to the organic precursors, usually coconut shells, used for carbon synthesis by competitors. The patented process allows for optimum pore size distribution and for the fine-tuning of pore size for a perfect matching with the electrolyte ions, resulting in maximised capacitance as well as superior electrochemical stability and low resistivity of the material. Moreover, this process yields a highly pure graphene material compared with activated carbons, making ultracapacitors more reliable and longer-lasting. Skeleton’s SkelCap-branded ultracapacitors are not only more advanced and have double the energy density of competing products, but they also have the lowest equivalent series resistance (ESR), which translates into energy-efficient cells, since the amount of energy converted into heat is low. This reduced energy consumption creates the additional possibility of downsizing or removing cooling systems in many applications.

Aim high, conquer all

Skeleton’s business model is based on the development, production and sale of ultracapacitors to a variety of industries. The company has addressed the task of controlling its technology throughout the whole business-to-business value chain. Its patent portfolio aims to protect competitive advantages throughout, with a few strong patents (the number is restricted by budgetary constraints).

Skeleton has taken on the challenge of creating a commodity for established markets (automotive, transport, maritime, electric grid, aerospace) where it needs to convince the big incumbent companies to switch from their current technology and actively choose Skeleton. Its unique selling point is, of course, the performance of the curved graphene material. While the production and application of this material is technically sophisticated, it could still be reverse-engineered by target customers and other big companies with the capacity to either outsource development or develop parts and materials themselves. Thus, protection of the technology and material is immensely important and paves the way for win-win oriented collaborations. Patents, in combination with know-how, were essential to protect the company’s investments in R&D as well as production set-up and consequently to raise capital in the company’s early days. The branding power of Skeleton’s patents is also used as a marketing tool to convince customers of the uniqueness and superiority of the technology.

Growth through co-development and standards

For Skeleton to continue growing as a company, it must not only ensure freedom-to-operate (FTO) status for its protected technology, but also actively contribute to expanding the ultracapacitor market together with other actors in the business, so it actively collaborates on the co-development of technologies.

Skeleton is a developer and manufacturer of components that need to be adapted for integration into its customers’ products. To ensure interoperability, it designs its ultracapacitor cells, systems and modules in co-operation with its customers. Such collaborations allow the company to build internal competence by incorporating technology and know-how from its partners. Conversely, Skeleton may also share sensitive know-how with external partners. Patents are then a necessary condition for safely disclosing information while keeping the company’s technology adequately protected.

Skeleton's collaborations may also be instrumental in creating a competitive advantage through standardisation. Since the market for ultracapacitors is still nascent, there are opportunities to influence future regulatory standards for the interoperability and safety of ultracapacitor systems. This requires active participation in standard-setting bodies, backed by industry co-operations and strong IP positions. Skeleton has at this point relied on a few strategic patents and trade secrets. However, in order to grow and shape the market as it develops, the company needs to strategically expand its patent portfolio to gain more authority in standard-setting bodies, and in order to actively contribute to the creation of standards.

Evolving IP strategy

"Our IP strategy evolved together with the company," says Taavi Madiberk. The first phase began with a focus on advanced material technologies and an early strategic decision to concentrate on the ultracapacitor application for energy storage. According to Madiberk, "That was the most marketable product from a business case point of view." An IP strategy was then created primarily to build up the patent portfolio, particularly with regard to the process for synthesising the new material with the hexagonal graphene structure. The goal was to use the portfolio as a platform for further applications for advanced materials.

TAKEAWAY

TIMELY IP STRATEGY

Having put into effect an IP strategy as soon as the company was formed, Skeleton ensured that the patenting of inventions in the initial stages of R&D has been streamlined with early product development. This led to three benefits: **1** better IP capture; **2** a better idea of the value of the invention, which is of huge importance at the beginning, where investment is crucial, and **3** the ability to assess whether the company will be able to use the invention without being dependent on others (FTO investigation).

The focus in the second phase was to build cell modules and storage systems, and align the company's IP strategy to support this new phase. At this stage the company analysed the technological and patent landscape to re-evaluate and design the ultracapacitor applications that the R&D team worked on. The goal was to identify the applications which not only had the best IP protection but also a technological advantage and business potential.

The third phase was to establish a proper process for IP creation and IP management. This culminated in the realisation that cross-trained employees (employees trained, in addition to their core discipline, in IP, business and/or science) are necessary for a functional IP management process. "All R&D personnel need a basic understanding of IP, and some need specific and extended IP knowledge," says Madiberk.

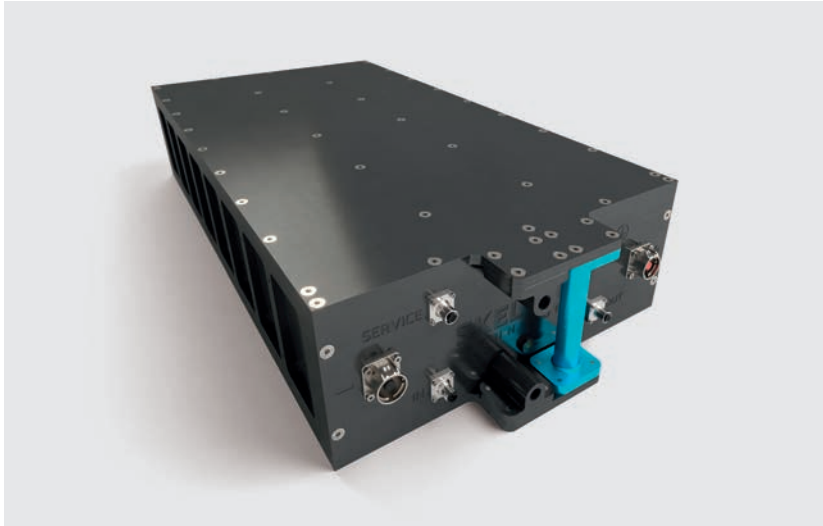
TAKEAWAY

IP TRAINING

The whole innovation team needs to think in terms of IP rights, as well as to be competent in the use of patent search tools. This will enable them to realise the full potential of their R&D (more efficient and effective R&D processes), translate R&D into innovations (through FTO analysis) and understand how to protect innovations through IP rights.

The fourth phase was to implement a detailed R&D scheme in alignment with the IP strategy, directed at recording and evaluating as much of the knowledge created as possible, and linking short-term research aims with long-term IP opportunities. The R&D scheme is modular: scientific goals are broken down into separate objectives and divided between cross-trained scientists, each of whom has a specific responsibility for one part of the overall technical challenge to be solved.

Skeleton's production lines have recently been established and are delivering the company's first products to market. So far, only a limited budget could be allocated for patent protection, so those technical inventions with a clear competitive advantage are patented and the remaining technology is kept as trade secrets. The actors in the market are currently not suing each other, and Skeleton has not been sued nor has it petitioned for infringement of any of its patents. However, Madiberk still recognises the importance of a strong IP portfolio: "Larger markets lead to more IP litigation as a general rule. Skeleton's emerging and growing business will attract a lot of competition and IP litigation will come in the future, so it is very important to be prepared now – and we are."



SkelMod ultracapacitor modules for applications in heavy transportation, rail applications, pulse power supply, regenerative power and peak assistance in power grids and industrial applications.

Cross-training for IP competence

IP management at Skeleton is the responsibility of the R&D manager, who is assisted by three people in the R&D department with special IP responsibilities. These cross-trained specialists are employees with in-depth knowledge in their field who receive specific training in IP, to ensure that IP competence is present at the source of innovation. This enables the team to assist in evaluating ideas and communicating with external IP experts. The four-person IP team is supported by the CEO, to maintain alignment between corporate and IP strategy. The IP team provides monthly reports to senior management. This is integral to the R&D process because of Skeleton's strong focus on identifying what can be protected with IP rights. Patent attorneys are mostly used at an operational level, primarily for the drafting of patent applications, but they are also relied on for their input on IP strategy issues. IP experts are chosen based on previous experience and relevant competencies, and are usually identified through recommendations.

TAKEAWAY

INTERNAL IP EXPERTISE

In-house IP specialists can be used to complement external patent attorneys when drafting corporate and IP strategies. They can assist in the development of internal organisational processes, helping the company to consider the relevant IP questions and integrating IP as part of both its strategy and its in-house training.

“IP is key to our competitive advantage, and it is important for management to understand more than just the basics.”



Taavi Madiberk
Founder and CEO, Skeleton

Budgetary aspects

The Skeleton patent portfolio consists of 15 patent families covering different elements, including material, modules and cells, providing comprehensive protection along the value chain. The geographical scope is geared towards the big markets in Europe (Germany, France, the UK and Estonia), as well as the US. The rationale behind the portfolio is to create as much patent protection as possible in the main markets (Europe and the US), while taking into account the limited funds available to the company as a start-up.

Madiberk recognises that the priority for IP management is to obtain more IP. However, it is expensive to apply for multiple new patents, as well as maintaining a large and growing portfolio. For him, therefore, the Unitary Patent will aid the company's IP management in Europe. Its benefits will not affect Skeleton's fundamental IP strategy, but will allow the company to consider more protection and better enforcement at lower cost and with less bureaucracy. “The wider patent coverage offered by the Unitary

Patent would not change much now for the company, but in the future, it will be very beneficial,” Madiberk says. One of the long-term IP management goals at Skeleton is to police and enforce its IP rights. Madiberk sees advantages in the Unitary Patent in combination with the Unified Patent Court. “For a small company, it is better to put all your eggs in one basket than to become involved in litigation in multiple jurisdictions!” he says. “What it boils down to is that if you have a strong patent portfolio, the risk is low.”

TAKEAWAY**UP-TO-DATE INFORMATION**

You can save a lot of time and money by keeping up to date with changes and developments in the patent system.

Creation, selection and protection

At Skeleton, the R&D manager is responsible for IP management, in particular prior art and FTO searches, which, together with monitoring competitors’ patent applications, provides intelligence for both R&D and IP purposes, a process also known as patent landscaping. “The first question to answer is whether you can patent something, and whether the R&D is up to date. You can then use patent landscaping to ensure that you are not developing something that has already been invented or for which there is no FTO. It is also a good way for researchers to find inspiration and ideas,” says Madiberk.

The IP team decides in two phases which inventions they will select for protection. The first phase involves evaluating the invention in-house together with the inventors. The second phase is done in collaboration with external patent attorneys, who perform a more detailed and complex assessment of the invention, e.g. a prior art search, and then decide on the best way to draft the patent claims.

Since Skeleton introduced IP training for its team, patent quality and alignment with corporate strategy have improved. “It [the creation of patents] is best done together with patent attorneys. Without this internal-external collaboration, the result would be a patent that doesn’t fit the overall strategy. At the end of the day, it all comes down to the disclosure of sufficient and appropriate content in the drafting of the patent specification in order to ensure that the claims provide strategic protection in relation to the business case. Patent lawyers can be competent and good, but for them to fully understand the company strategy is difficult, so we have gained IP capabilities and use internal specialists as well,” says Madiberk.

Patents or trade secrets?

Skeleton has implemented a structure for protecting technical know-how that cannot be patented or which it has been decided should be kept as a trade secret. A system with various levels of access has been set up to manage secrecy on a compartmentalised and need-to-know basis. The system is used to transfer knowledge between different positions within the company. At its heart is an internal database of knowledge. Madiberk explains: “It is important to know what others are working on, so researchers don’t work on the same thing, or tackle a question where the answer is already known. It is an internal arrangement for knowledge transfer.”

COMPANY PROFILE**SKELETON TECHNOLOGIES OÜ**

- > Headquarters: Tallinn, Estonia
- > Year of establishment: 2009
- > Staff: 90
- > www.skeletontech.com

PRODUCTS/SERVICES

Ultracapacitors, ultracapacitor modules and full energy storage systems. The use of curved graphene, a nano-material, allows the ultracapacitors to achieve high power and energy density.

MARKET AND TECHNICAL AREA

Energy storage

CUSTOMERS

Automotive, electric buses, trucks, aerospace, renewable energy and the electric grid

SELECTED AWARDS

- 2016 RSM European Entrepreneur of the Year
- 2017 RSM European Entrepreneur of the Year
- 2017 Bloomberg New Energy Pioneer

PATENT PORTFOLIO

15 patent families, including EP2633532, EP2614512

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