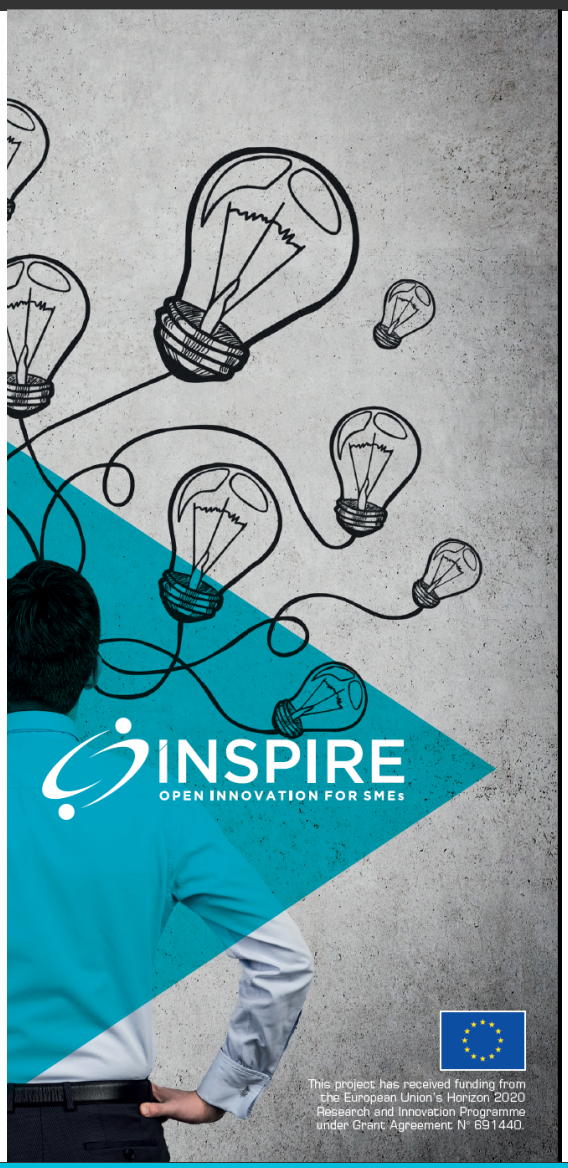

CTEC ENERGY

United Kingdom, www.ctecenergy.co.uk

After becoming involved in a number of open innovation collaborations with large companies, which helped develop its technology, an SME finally met the right OI partner to exploit a business opportunity

Executive Summary

CTEC Energy is a small company which has developed an exhaust heat energy system to convert it to steam and then to electric generation. After the successful development of the system in collaboration with a German multinational company (VIOTH), CTEC Energy tried a number of OI projects to implement their solution in various applications, starting with Renault and Volvo to integrate their system in trucks and trains, then with BABCOCK, a UK-based multinational enterprise working with nuclear power stations.

When commercialization failed to materialize, the SME then partnered with a pilot customer to use its technology for the development of small movable power stations that use residual waste, i.e. everything that cannot be recycled after the recycling process. This successful relationship led to increased financial performance for both companies.

CASE N°: UKI27

SECTOR: RECYCLING EQUIPMENT

TECH INTENSITY: LOW-MEDIUM TECH

LIFE CYCLE STAGE: ESTABLISHED

INNOVATION VECTORS: PRODUCT, PROCESS

OI PARTNERS: PSR, LARGE COPORATION, OTHER SME, INDIVIDUAL EXPERTS, LEAD USERS/ CUSTOMERS

KEYWORDS: Localized residual waste combustion system, open innovation with large corporations, open innovation with other SMEs, value proposition, technology and business vulnerabilities of open innovation partners

- BACKGROUND FRAMEWORK
- INNOVATION CHALLENGE & MARKET OPPORTUNITIES
- OI TRAJECTORY
- BUSINESS IMPACT
- LESSONS LEARNED

BACKGROUND

The founder of the company – who is today its CEO - was working for many years as an automotive engine designer at the Ricardo company. This experience helped him to realize that there was a big opportunity to increase the efficiency of internal combustion engines by exploiting the lost share of the produced energy. In particular, only one third of the produced energy in an internal combustion engine is used to drive the vehicle forward while one third of the total energy produced by the engine is lost as heat through the exhaust and one third is lost through the heat in the injection.

In 2005 the founder set up the company to explore ways to exploit the heat lost through the exhaust system. He started looking at the rotary motion and how it behaved to come to the conclusion that the best way to exploit the wasted energy through the heat was to use steam engines.

At that point, the company made a proposal to a German company named VOITH (a multinational company with £6.5 billion worth of turnover and employing 35 000 people) on the assumption that heat recovery engines would be a very big market in the future. The proposal was to collaborate to design and develop a small heat recovery engine: CTEC Energy would work on the heat exchanger and the control system and VOITH on the steam expander.

CTEC Energy managed to create a system that recovered heat waste from the exhaust system. They used old steam engines (from 1960) for heat recovery. Other companies played a role in this successful development, one of which an Irish company which developed a system to overcome one of the major problems, namely turning the steam expander outcome into AC load, then convert the AC load into DC load and then convert it back to AC load.

By 2010, CTEC Energy and VOITH installed the new system in trains and trucks. Their engines were put into the trucks of a food logistics company in the USA, which had refrigerator trucks taking food products from Florida to Canada. The new engine replaced the electrical motor of the trucks (which was there to operate the cooling system of the back part of the truck). Given that the average cost of fuel consumed by one of their trucks is $30 000, recovering a fraction of the generated energy from the exhaust could represent a considerable value.

CTEC Energy and VOITH also collaborated with Renault and Volvo producing good technical results. However, when both Renault and Volvo realized the cost of introducing the new system in their trucks and lorries, namely the cost of training the companies and their drivers, the cost of lobbying to various political bodies to develop regulations that made the new system compliant and the cost of truck vehicle approval after the installation of the new system, they both decided to pull out of the project.

They also put the new system in other CHP (Combined Heat and Power) engines such as Anaerobic Digestion plants (plants where organic materials are broken down by micro-organisms in the absence of oxygen, to produce renewable energy and nutrient-rich biofertilizers) and landfill plant (plants gathering, processing, and treating the methane gas emitted from decomposing garbage to produce electricity, heat, fuels, and various chemical compounds). The new system increased their efficiency by 10-12%, so an engine producing 1 MW of electricity was now producing an extra 100-120 KW of electrical energy.

CTEC Energy and VOITH managed to sell and install 25 systems in various places in Europe. Despite the clear efficiency gains of the new system, sales were very slow. The reason was that the developed system used a mechanical process for producing gas and turning it into electricity and this mechanical process was seen by customers as a drawback. For instance, setting up a gas plant in a landfill plant was considered risky, while using the system in anaerobic digestion plants started the rotting process very quickly since nowadays people put food waste in anaerobic digestion plants and food has high levels of chlorine.

In 2013, CTEC Energy decided to change its focus by switching to the development of a technology for heat recovery from residual waste – that is everything that cannot be recycled after the recycling process. Today CTEC is a company of 11 people producing and marketing small localized and movable power stations that generate heat and electricity from residual waste.

The main problem for CTEC Energy has been the high level of investment required to get to this point. To develop the technology for heat recovery, CTEC Energy has invested £20 million while VOITH has made a contribution of another £40 million.

CTEC Energy is looking to capture the value but the company has not performed well enough to move into mass production. Although 25 heat recovering units have been installed so far, the company is seeking a much higher number of orders in the future. The company is optimistic since currently there is a lot of interest from potential clients.

INNOVATION CHALLENGE & MARKET OPPORTUNITIES

The main challenge the company tried to resolve through the development of the heat recovery system from residual waste was the slow pace of sales achieved by its previous product, namely the engine installed in trains and trucks to recover heat waste from the exhaust system. In actual fact, the company wanted to leverage more value from the joint development project which they had carried out with VOITH some years previously.

The market opportunity stemmed from the fact that putting waste in landfills is very bad, not only because it takes away valuable land that cannot be used for several years but also because the decomposing waste is massively damaging to the ozone layer. It is for this reason that the British government declared that the country aims to close all its landfills in the foreseeable future. At the same time, heating homes and business units and industrial processes accounts for 49% of total energy demand in the UK while they generate 47% of the country's total carbon emissions. The UK aims to reduce its carbon emissions to 40% by 2030. An approach that treats residual waste as fuel, rather than matter that requires disposal, is therefore ideal for these circumstances.

In the company's opinion, the UK has to use thermal energy through heating networks in order to heat households and businesses and for industrial use. This process cannot be done through large waste incinerators (already in different locations around the country), because although they produce huge amounts of thermal energy (heat), this energy cannot be transported over a long distance. The incinerators must therefore be located inside cities and be small in size. Currently only 0.5 % of thermal energy used by households is being produced by renewable sources.

The comparison with the cost and the efficiency of a large incinerator is revealing. The Hastings incinerator cost £160 million to build and produces 60 MWh of electricity. However none of this energy is transformed into heating and no electricity is produced from it. Spending the same amount of capital on heat recovery from residual waste systems would enable the creation of 74 units which would be enough to heat a city of 350 000 inhabitants, such as Brighton and Hove.

After spotting the market opportunity in the UK, the company decided to explore potential market opportunities internationally. The company is trying to enter India, which faces huge problems with waste. According to the CTEC Energy founder, although India is very strong in recycling ("recycling almost everything"), it has purchased a number of large incinerators which do not really work for the country.

A typical example is Delhi where the "latest incinerator chucks out dioxins and smoke everywhere" without being able to carry out the full combustion because the waste has a high level of moisture. Nevertheless, the problem with India is that the national and local authorities have no money to spend on heat recovery systems like the one developed by CTEC Energy; the only way to overcome this would be to get large Indian corporations to commit some funding to such systems for the benefit of the community.

OPEN INNOVATION TRAJECTORY

Concept development

The main concept is the production and installation of small localized power generation stations generating heat and electricity from residual waste, i.e. everything that cannot be recycled after the recycling process, including medical waste, such as first degree infectious products, nappies, etc.

These stations are movable, coming in the form of two sink containers (12 meters and 6 meters linked together) and one combustion chamber (about 6 meters long). They can be used instead of large incinerators already in place. They follow a unique process involving three stages: gasification, partial gasification and full incineration. Through this process almost all the energy is taken out of the waste since the designed system captures around 82% of the calorific value of the waste, leaving only a small amount of energy 'lost' in the atmosphere.

At the beginning, the main focus was on the development of the fuel. If they could develop the fuel then they could create a product by mixing different kinds of plastic. Then the company realized that in order to burn the waste and to create energy, you have to mix various types of waste, namely biomass (75%) and plastic (25%). By applying this procedure to the waste, they realized that most of the waste contained a high level of both plastic and biomass.

After four years the company came up with an analytical model and a physical model of how they can calculate waste. Thanks to their experience

and the data, the company can identify how the waste is going to be burned, how much exhaust gas circulates, etc. One of the tricks that the company uses, is to import the exhaust gas back into the combustion chamber. By doing this, they increase the mass flow rate and at the same time as the oxygen is depleted, they get a better heat transparency in the heat exchanger. The CTEC Energy founder puts it succinctly, “we took a pretty standard type of technologies and we turn them into a unique system.”

The development process, IPR and competition strategy

The actual development process was divided into two different projects. First, the development of the steam expander was developed with VOITH. Second, the heat exchanger was initially developed with the collaboration of BABCOCK (later renamed DOOSAN BABCOCK), a UK-based multinational company of more than 5 000 employees specializing in nuclear power-stations.

The development of the heat exchanger was very challenging. They formed an agreement with BABCOCK, and they started to co-develop the concept. However, the collaboration faced serious challenges. Although the collaboration had the support of its senior management, it did not work in the end. BABCOCK, and especially its engineers, were very cautious about developing new technologies; they are used to taking into consideration regulations and various EU directives and tend to develop purpose-built products. However, the specifications of this development project were to design an innovative product, i.e. very small in size, operating in 600 degrees and long-lasting.

As a result CTEC Energy had to part company with BABCOCK, “not because they were a bad company but because they focused on what they know and what they do”. The company decided to move ahead and tackle its innovation challenges. One of the hardest problems for them was the emissions. The underlying problem was how to treat emissions and they decided that the exhaust gas recirculation was the way forward for them. This idea was a well-known solution which had not yet been implemented - at least to their knowledge: “if you look at the Internet, a lot of people talk about it but nobody actually does it,” said the CEO of CTEC Energy.

The solution adopted by other similar products in the market is to use back-end exhaust clean-up systems which use urea injection to clean the emissions. The problem is that the urea injection produces a lot of ammonia and then another ammonia cleaner is needed at the back end of the system. In addition, if a lot of urea goes into the heat that is mixed with moister, the result can be a high level of corrosion activity in the stainless steel part of the machine. Instead CTEC Energy decided to treat the exhaust gas recirculation as a physical system that uses the generated heat to reinforce the performance of the machine.

CTEC Energy puts a lot of emphasis on the technical development. Seven out of 11 employees are technical people. CTEC Energy is also a member of a special programme at the local university called Green Growth Platform, a networking programme providing links and introductions to other SMEs which have potentially complementary products or services, “linking problems with solutions”. This programme can also make introductions to academics who work in areas that are of interest to the company as well as potential investors.

On another level, the company needed a (pilot) customer. Once they had such a customer in place, they would not only be able to test and improve their product but they would also be able to show it to other potential customers and boost their sales.

The company has filed one patent to date. In fact a patent expert, who started doing some work for CTEC Energy on intellectual property rights, ended up becoming a company shareholder.

The company has clearly based its competitive advantage on the technical differentiation factor. Their system has developed a unique solution from the technical point of view. They used this differentiation to offer a value proposition that integrates several ‘strands’: exploiting the residual waste, maximizing the recycling gains, reducing the environmental pollution from waste and generating low-cost energy and electricity.

Commercialization and follow-up

The biggest challenge CTEC Energy faced was the high cost of manufacturing their product. To resolve the problem CTEC Energy found a medium-sized company (around 100 employees) called ZAK based in Germany which has been in business for 25 years. ZAK invented a system called maximum yield technology. This system takes biomass and municipal waste (about 200 000 tonnes per year), processes them and extracts high grade calorific value from the waste - predominantly from food.

ZAK machines process waste with a wash process which creates a watery substance which then goes to anaerobic digestion generating high-level calorific value. It then goes into a drying process

squeezing the waste out through two periods/four days of aerobic process that dries the waste, followed by a process to extract the last small pieces of metal, glass and ceramic from the waste. These leftovers have to be taken to a landfill or are taken away by specialized companies which charge €60-70 per tonne. Instead of paying €60-70 per tonne to remove this residue, ZAK saw an opportunity to use the CTEC Energy machines to turn the low calorific value waste into electricity and energy, removing a cost component from their process and creating additional value.

CTEC Energy's machines will be installed in the back end of ZAK machines, using the residue from ZAK's processing. This means that CTEC Energy's technology will benefit 2 400 homes. In more ways than one, CTEC Energy and ZAK complement each other through this relationship. The investment required for manufacturing the CTEC Energy machines is not an issue for ZAK since each of their machines would cost €50 million while CTEC Energy requires an investment of £3.3 million for manufacturing their system. ZAK is backed financially by the German government. The ash that comes out of their processing has high levels of phosphorus, which according to German government opinion, will be in short demand in the future; as a result ZAK is paid by the German government to landfill their ash which can be mined later on when the phosphorus is needed.

CTEC Energy is about to sign a contract with ZAK totalling £3.4 million which will enable them to move ahead with the production of their system. The agreement with ZAK involved a number of steps. First ZAK sent over a number of engineers and specialists to check out the quality of CTEC Energy products. Then they employed a third party to come and look at the analytical and physical models. Once they received satisfactory results from the third party, they requested a quotation from two other companies - a Swiss and a German one - with similar offerings to CTEC Energy. Both the Swiss and German companies were found to be more expensive. According to the CTEC Energy CEO the reason was down to the heat exchanger: CTEC Energy's heat exchanger is a compact and purpose-built design which is very robust and made with high-grade materials.

More than 50 people came to see CTEC Energy but "nobody wanted to be the first person to use the first system". In contrast, ZAK argued that although "we know we will have some issues, we all believe in it". CTEC Energy believes that the biggest enabler for a fruitful collaboration is that the partners "have a need for it, want to do it and want to make an advance!" Furthermore, the ZAK CEO, who is also the founder of the company, understands better the nature of the process since he has been an inventor of his system for more than 25 years. In the words of CTEC Energy CEO "He has taken a number of risks in his technology to make it work and he has spent his time engineering it himself. It has taken 25 years to develop this one plant!" As a result, George, the ZAK founder, is not risk-averse while he understands that the only way to make his company sustainable is to develop proactively new products where there is an opportunity or a problem. George, recognizing that there is an issue with the back-end of his machines, turned to CTEC Energy to include an offering that will address this.

It is worth emphasizing here that there is no formal agreement between the two companies for splitting the profit and there is no exclusivity. CTEC Energy plans also a roll out to India where the cost of production will be much lower than in Europe. CTEC Energy has targeted regions in India where big employers exist with the aim of convincing these big companies to invest in its technology for the benefit of the community.

For instance, CTEC Energy is currently talking to local hospitals in Puna and Puna Municipal cooperation with a view to installing their units in the city. The company is working with a local company – founded by an Indian engineer, Kashev - who used to work in the same company with the CTEC Energy founder in a TATA company project. Kashev's company contacted CTEC Energy asking to be its representative in India. An agreement was signed with this company. The collaboration works well for CTEC Energy because of the trust developed between the two CEOs as a result of their long working relationship. Kashev is very well-connected in India and CTEC Energy hopes to capitalize on these connections.

The company has not yet felt the need to restructure as a result of their OI project; this could happen once the manufacturing stage begins.

There is no marketing team in the company. The marketing strategy is defined by the founder of the company who is responsible for finding customers, advertising its product at conferences, etc. Moreover, the company's collaboration with ZAK industries has helped the company to identify potential customers by complementing its product to ZAK's offering. The collaboration with ZAK evolved into a more formal form; OPTIMA, a marketing company owned by ZAK industries, invested about £100 000 in CTEC Energy to acquire a small amount of its shares (around 1.5%).

As the same time, CTEC Energy continues its collaboration with VOITH (a large multinational corporation with 35 000 employees and a turnover of €6-8 billion). CTEC Energy made an agreement with VOITH that the patent regarding the steam expander will be theirs (agreed at the beginning of

the process). They also agreed that they will help each other, since there was a bilateral flow of knowledge in the design of the steam expander. The plan is for VOITH to become more involved in the promotion of the product. This will be very beneficial for CTEC Energy since VOITH has a presence in many countries around the world. The on-going discussions with VOITH assume a service-point-of view for them with CTEC Energy manufacturing the machines. For CTEC Energy, VOITH's presence will help with the distribution and the after-sales service of their machines around the world. The main problem collaborating with such large companies is that they need time in making decisions – for instance VOITH has 10 directors and it is expected to take them more than 6 months to agree a final distribution agreement.

The company also has an agreement with Vialog. Vialog is a small French co-operative (6 people), sponsored by the French government, whose purpose is to bring together companies in France. The biggest asset of Vialog is that its directors are CEOs in large corporations (like Toshiba, Euro truck company, etc.). CTEC Energy's expectation is that Vialog will facilitate investments in CTEC Energy as well as its sales and after-sales service in France and perhaps the rest of Europe. Although a special relationship has been developed with Vialog since 2007 (with a lot of pitches, etc.) no sales have been achieved so far, mainly because CTEC Energy has changed its product focus.

The future plan after the delivery of the first product is to create a subsidiary in India. This will happen for two reasons: the low level of costs and their presence in a large market. The main challenge in creating a subsidiary in India is to be able to control the quality of the manufactured products. This will be resolved through working with their established relations in the country.

BUSINESS IMPACT

A patent has been filed, but most importantly they have a new product that fits into a new value chain, delivering economic value to the company and securing its long-term future.

The company has picked up a number of lessons from their open innovation journeys. A first lesson is persistence and resilience: open innovation is a long journey that includes a number of 'lost battles'. CTEC Energy tried numerous open innovation projects with partners building trains, trucks, boats, etc. This long journey involved personal sacrifices in terms of (personal and family) money and a lot of emotional energy.

SMEs engaging in open innovation are faced with a double challenge. The SME should identify its main value proposition while at the same time trying to find a match or a convergence between its value proposition and the partner's value proposition. This is quite a challenging task. For a start it is much more difficult for small companies to identify their value proposition than their larger partners:

This can end up in a series of resource and time-draining open innovation projects where the SME is driven by the partner's value proposition rather its own, especially when the partner is a larger and more powerful company. The CTEC Energy CEO refers to the companies' sweet spot i.e. where companies are making their money and described the challenge of this strategic convergence:

"It took CTEC a long time, I think, to find a sweet spot – because we put a heat recovering system almost in everything. We put it into trains with VOITH because they build trains; we put it into trucks, we put it into anaerobic digestion, we put it into boats (that go up and down the Rhein), we put it pretty much into everything! And at the end of the day we came to the conclusion - wait just a minute - the world does not want that.

It is really in the realm of the engine manufacturer: what the engine manufacturer is doing is taking more heat out of engines in order to make them more efficient and give more boost to the engines, turbo charges, exhaust, etc. They are improving their products; that means that the sweet spot of where our system needs to be from the point of view of temperature is disappearing. If we hadn't made these changes four years ago, we would have been dead, we would not have been talking now."

In response to what can really help an SME manage successfully this challenging task, CTEC Energy argued that it is important to listen to your partners and be able to match your company's main competence with the "vulnerabilities" of the partner's value proposition:

"You have to listen to people and understand where their sweet spot is ... where your partner makes money. Look at external people and organizations, businesses and try to see where their sweet spot is. Understand their sweet spot and also try to understand the vulnerabilities of their technologies or their businesses. If you understand a company's sweet spot, where they make their money, you can go and help them to make more money. If you can do that this is a good recipe for success."

In other words, it is important to understand what

the partner's value proposition is and what gets in their way of delivering this value proposition. If you can help with this, then "this is a recipe for success". Of course once this match or convergence is identified the small company faces the challenge of "turning this sweet spot into cash", which is what CTEC Energy is about to do.

The main income of the company is from the sales of equities and from the investments of its shareholders.

LESSONS LEARNED

This case shows the value but also the difficulty of pursuing open innovation projects. The company has been involved in a number of open innovation projects mostly with large organizations. Although these projects helped them to build their know-how, they failed to deliver any significant economic value and hence make the company sustainable.

Persistence and resilience with open innovation have proved to be useful, but the critical leap was made possible when CTEC Energy met a medium-sized company which was prepared to play the role of pilot customer and open new markets for them. The crucial condition was that CTEC Energy systems and competence could address and improve one of the vulnerabilities in the partner's system and improve their financial performance.

Main lessons learned:

1. Persistence and resilience are important – open innovation requires dealing with 'lost battles' also.
2. Open innovation is a long run, more of a marathon, rather than a sprint.
3. Open innovation enables the company to test different value chains relatively swiftly.
4. An SME can be a very important pilot customer; probably its biggest strength is the knowledge of the innovation process from inside.
5. Successful open innovation requires the SME to have identified their "sweet spot", i.e. their main value proposition.
6. The most challenging task is to match the company's "sweet spot" with the open innovation partner's "sweet spot", a process that requires active listening and the identification of partners' vulnerabilities that match with the company's skills.
7. Strategic convergence at the top does not guarantee a smooth or working open innovation partnership; a convergence of purposes must be ensured also at the operational level, namely at the level of the people who will have to implement the open innovation agreement.
8. Turning a working open innovation partnership into cash is neither straightforward nor easy.