**CAMBOND**

**PAPER, ASH AND RESIN**

**Project summary**

UK industry produces huge volumes of by products or waste:

Energy generation, metals and ceramics - 10MT ash

Bioethanol, distilling and sugar production -- 1.75MT DGS and pulp

Paper Mill Waste-- 1MT sludge

A substantial portion of above materials is used in low value products, animal feeds, soil improvers or additives in cement manufacture or goes to landfill.

But better use of these wastes could supplant the use of expensive virgin resources in the manufacture of many products with a higher commercial value.

One of the biggest barriers to more effective use of these resources is cost. The cost of transforming or processing waste streams into useful materials is often too high when compared to the cost of existing methods of use or disposal. This leads to a failure of innovative change and the maintenance of existing environmentally damaging and high carbon manufacturing processes.

Sappi, Cambond and the Biocomposites Centre have independently developed expertise in cost effective processing of waste streams (Sappi), transformation of by-products into high value biomaterials (Cambond) and evaluation of sustainability and environmentally advantageous manufacturing (Biocomposites Centre).

This project focusses the combined expertise in a robust plan to drive the commercial development of a new low carbon materials technology which recognises the potential in waste streams, develops new materials technologies and and provides a valuable development in materials manufacturing in the UK.

Paper wastes, fly ash and resins can be combined to provide a range of materials for the construction and ceramics sectors in the UK. These materials offer commercially attractive opportunities to develop and manufacture *improved*, low carbon, sutstainable, products such as:

* Fire resistant boards for construction
* Decorative panels and tiles with ceramic-type finishes
* Ceramic type materials which can be moulded into many types of product

Technical innovations developed by Sappi and Cambond can be combined to valorise large waste streams. We could turn environmental problems into valuable commercial opportunities producing large reductions in the carbon footprint of UK manufacturing and establishing a materials technology which embodies circular economy principles

This project uses the waste from several foundation industries to produce an innovative manufacturing platform which would enhance UK productivity and competitiveness. Innovation in the use of multiple waste streams will be commercially competitive and help meet one of the Grand Challenges -- Clean Growth.

**1. Need or challenge**

**What is the business need, technological challenge or market opportunity behind your innovation?**

The UK will fail to meet its fifth carbon budgets because of a failure to adopt innovative carbon savings measures in industry1. Many UK initiatives are limited in scale and associated with expensive engineering processes.

Transforming the handling of foundation industry waste streams using circular economy principles could provide significant carbon savings. This will require low cost technologies to transform waste streams into commercially attractive materials2.

Ash (fly ash) is produced in huge quantities \> 8MT a year by the combustion industry (coal/ biomass power and ceramics and metal)3. Large amounts are used in cement manufacture. Although ash waste from power generation is falling, there is still a large annual volume and a significant legacy resource (up to 100MT present in old power stations and landfill sites)3,4.

The UK produces almost 1MT of waste from paper mills. Some of this is used as a low value soil improver but much is burned or landfilled5.

Paper and ash wastes from foundation industries are of significant commercial and competitive value to UK plc if they could be exploited cost effectively.

Saapi is a global leader in sulfite pulping with mills in several European countries. Its UK operations expanded in 2017 with acquisitions of Plaxica and Rockwell Paper Solutions. Saapi pioneered the valorisation of paper waste streams and it is also one of the world's largest manufacturers of magnesium lignosulfonates (MLS). Sappi has developed a market for lignosulfonates with sales into the cement additives market of c. 50ktpa. However, *the majority of this product is currently incinerated*. It is symptomatic of the global paper and pulp industries in that the most widely available natural biopolymer is used as a fuel rather than for high value biomaterials.

Cambond has worked with Saapi to see if MLS could be used in higher value construction products. Manufacturing construction products from paper mill waste, ash and resin enables them to be embedded into buildings for up-to 100years. This dramatically reduces the embodied energy and carbon footprint of paper mill and combustion industries.

This project will facilitate the development of a circular bio-economy in the EU in which all of the value created is underpinned by UK research and development .

1 EADIE website report 07/01 2020

2 Bioplastics News 07/01 2020, WRAP 2018

3 Business and Environment Report: Environmental Outlook for the combustion industries --Environment Agency 2019

4 [www.ukqaa.org.uk](http://www.ukqaa.org.uk/)

5 Confederation of Paper Industries 2018

**2. Approach and innovation**

**What approach will you take and where will the focus of the innovation be?**

Sappi Biotech UK Ltd is a wholly owned subsidiary of the global Saapi group, a worldwide supplier of sustainable woodfibre products. The UK team is the R&D arm of the global entity and has developed bio- and chemical technologies to valorise waste streams. e.g. sugar-rich waste streams into xylose and xylitol.

Saapi is the world's largest producer of magnesium lignosulfonates (MLS) with has unrivalled technical know-how in its production. However, the majority of this material is burnt for bioenergy generation with some 50KT sold as an additive to the cement industry. Saapi are working on new applications for lignosulfonates produced at several mills in Europe and South Africa.

Cambond has a suite of patents covering the manufacture of sustainable resins from agricultural by-products, chemistry of the biopolymer process, uses of biomass based adhesives for products and 3D printing/molding .

Cambond has explored1 the uses of paper mill waste. Board production was possible and properties could be modified by the mineral content1,2. Cambond developed the technology for bioceramic type materials.

Sappi and Cambond have undertaken self-funded studies to demonstrate the utility of using MLS, ash and bioresins to produce biocomposites and bioceramic composites2.

Use of Saapi MLS to make biocomposites could provide significant commercial advantages because it is a **very low cost feedstock**. Sappi's sulfite pulping mills are operated on decades of in-house know-how resulting in their mills operating in the lowest quartile of production costs. A recent Freedom To Operate search indicates no patent or commercial barriers to rapid exploitation. Cambond's core patent has granted in the US and will grant in Europe in 2020. These these factors underline the commercial imperative for further development and early market entry.

Main project outputs will be materials formulations for:

Fire resistant boards for construction

Construction materials with ceramic-type finishes

Ceramic type materials which can be moulded into many types of product

A key deliverable will be a business case for a demonstrator plant to manufacture 10,000T MLS-composites a year and identified customers.

The project will reinforce Saapi Biotech UK Ltd as the global R&D hub for Saapi and its new role as the lead for UK and global IP management and licensing. Cambond's materials platform technology will be strengthened and accelerated by expansion into new commercial markets.

1 Adu 2019. Designing a circular business model from industrial by products: case study on paper mills. Cranfield Report

2 Saapi/Cambond data see Appendix 2.

**4. Market awareness**

**What does the market you are targeting look like?**

The project addresses a double-sided market with underused waste streams (paper waste and ash on the feedstock side) and various industries on the product side (construction products,and bioceramic materials).

**Ash Market1**

There are almost 12MT ash produced a year. Fly ash from coal power stations (4.7MT and reducing) is generally used as an additive to reduce the amount of cement in concrete. Ground Granulated Blast-Furnace Slag is also used in this way. The value of both types of ash is shown by the import of quantities of both from the EU for concrete manufacture2.

**Paper Sludge and Lignosulfates UK3**

1MT

Uses -- as fuel, in some construction products.

Lignosulfonates

No UK production although could be produced from paper sludge.

Sales limited to low value applications e.g. in the construction industry: lignosulfonates are excellent dispersants for cement and allowing transportation over greater distances and improved workability. However, this sector is growing at <1% pa3 and under threat from cheap imports into the EU. Use in concrete admixtures has stagnated recently due to competition better polycarboxylate alternatives3.

**Product markets:**

Construction boards (replacement for wood based products)

Woopanel market (£310Bn globally). Fireproof boards £3.6Bn, CAGR 5%4

Fireproof boards UK (BS476 20-24) £120M4

Ceramic finish boards (no exact product match, concrete finish composite?) about £45M

Ceramic 'finish' consumer products (multi-M UK market but product specific numbers).

**Value chains and business models:**

Construction Products

The panel markets are dominated by large global players. High capital cost and complexity of manufacturing are barriers to entry. Feedstock and energy are key costs.

* Low cost feedstocks and efficient manufacturing (low energy, low toxicity) give opportunities to disrupt existing markets.
* MLS composite technology could be licenced by large existing players and premium panel manufacturers (focussed on interior design or fire safety).
* Building a pilot manufacturing plant for MSL composites is critical for introducing customers to the technology.

Ceramic Products

\*Large number of manufacturers of varying size. Feedstocks and energy costs are key. Value of products enables smaller enterprises to be successful and profitable.

\*MLS ceramic composites positioned as a low energy (no high temperature firing) low carbon alternative to existing materials.

\*MLS ceramic composites suitable for moulding and pressing processes. Cost competitive.

1 Business and Environment Report : Environmental Outlook for the combustion industries --Environment Agency 2019

2 [www.ukqaa.org.uk](http://www.ukqaa.org.uk/)

3 Confederation of Paper Industries 2018, Saapi internal reports

4 Passive Fire Rsistance Market Share 2019-2025 GrandviewResearch.Com

**5. Outcomes and route to market**

**How are you going to grow your business and improve productivity and competitiveness of the companies and supply chains into the long term as a result of the project?**

The project aims to establish the commercial viability of products produced from waste stream materials.

A successful project will enhance the value of Sappi know how and IP concerning the exploitation of MSL materials in new applications. A direct consequence will be the adoption of this commercial approach within Sappi production facilities and outlicencing the process to UK paper mills with immediate impacts on their carbon footprint and commercial operations.

Cambonds position as a leading biomaterials company will be advanced and it's resin sales will gain valuable new applications and markets. The extension of its technology applications into ash and paper waste streams opens up significant commercial opportunities in new materials sectors.

Target customers are the foundation industries who produce the waste and the waste handlers/recyclers who deal with waste on the feedstock side. They could not only reduce disposal costs from unused waste in their supply chains but increase their commercial opportunities from re-aligning supply chains to service the new demands for their waste in 'up-cycled' products.

On the product side, our first target is the construction products and bio-composites industry who benefit from sustainable high-quality, low-cost, low carbon input materials.

Cambond is already engaged with specialist interior design companies and niche manufacturers. This work has led to it being shortlisted for the Futurebuild Innovation Award 2020 and being given showcase space to demonstrate products.The route to market consists of developing the concepts, design and economic case for a pilot plant (ca. 1ktpa) to produce MLS biomaterials.

Preparatory work will be carried out to map the basis and business case for an industrial demonstration plant (ca. 10ktpa), This will allow Sappi/Cambond to generate revenue from the sale of biocomposite products. Cambond will gain an additional market for its bioresins and Sappi will generate extra revenue from lignosulfonate sales.

IP and Exploitation:

* IP concerning materials formulation and processing generated in this project will be protected.

A demonstrator plant will allow process design packages and licences can be sold to achieve faster growth. The demonstrator plant will further be used to test other feedstocks, allowing for the technology to be exported.

Dissemination:

* Academic/industrial results will be presented at relevant conferences, such as the Futurebuild or RWM 2021
* Cambond will produce a series of short videos and social media outputs for communications use.
* Biocomposite Centre will coordinate academic outreach activities and present at conferences share technology and help develop the cleantech economy.

**6. Wider impacts**

**What impact might this project have outside the project team?**

There is considerable commercial potential in efficient use of waste or by product streams to use as feedstocks in the manufacture of materials that compete with virgin materials at a competitive price in a more sustainable, environmentally friendly way.

Cambond and Saapi will work with the existing manufacturers to ensure the product development work synergizes with existing market and social developments.

Economic Impacts:

* New market for MSL to replace stagnating cement admixture market
* Increased market for MSL to drive increased production and divert MSL away from bioenergy production
* MSL technology could be rolled out to other paper mills in UK to provide new side stream products and divert paper sludge from landfill.
* MSL would represent a lower cost feedstock than virgin timber for the panel industry
* Use of ash in MSL composites and ceramics develops ash market and provides route for valorisation of bioenergy ash.
* Increased demand for DDGS could drive more efficient use of existing production facilities in North East England.
* Ash and PMS recyclers: Offering higher recycling rates to customers makes them more competitive.
* UK access to cheaper materials than those available in US or EU, generating increased manufacturing and exports.

Environmental impacts:

* Alternative feedstock to virgin wood or crude oil reducing carbon footprint of products. Construction boards at 0 to -5 CO2e per board, saving 4-6Kg CO2 per board. Cost effective carbon reduction technology.
* Removing ash could improve environmental quality and ease of remediation of landfill sites.
* Diverting MLS waste from landfill or incineration results in less CO2 and methane from incineration/ degradation. Could divert 10MT over 10 years.
* Use of MLS in boards and construction products will lead to a decrease in the use of wood and wood imports, reducing deforestation.

Government priorities/other benefits:

* Reduction of embedded carbon in foundation industries
* Development of commercially viable circular economy ecosystem.
* Enhanced R&D activity in development areas in North Wales, North East England and East Anglia.
* Increased and sustainable production of biocomposites to revitalise industry.
* New markets for existing waste supply chains
* Helps to meet waste reduction targets.
* Reduces the carbon footprint in all industries using pallets in the supply chain.
* Development of Circular Economy manufacturing.

Socioeconomic Benefits:

* Less air pollution from incinerators, improving air quality.
* Creation of jobs in the Cleantech sector working Cambond and other plants.
* Increased markets for hard pressed industrial and recycling sectors.
* Planned out-reach educates the public about sustainable production of materials and chemicals.

**8. Risks**

**What are the main risks for this project?**

The risks in this project will be managed following PRINCE2 Risk Theme; experienced and certified personnel will be allocated to this. The full risk register is shown in AppendixQ8-50840. The main risk areas relate to the technical, commercial, managerial and environmental aspects.

The main technical risks for this project are around the process experiments and the virtual design of the pilot plant.

T.R.1 Process does not produce high-quality cost-competitive outputs (P: M / I: H) is mitigated by evaluation of experimental outcomes and process optimisation with continuous monitoring of outputs.

T.R.2 Readily available MLS not suitable for board or panel manufacture (P:L / I:H) mitigated by leveraging ESCN access to a variety of MLS

T.R.4 ineffective data management (P:H / I:H) mitigated by developing testing/formulation matrices to ensure thorough technical evaluation.storage.

T.R. 4 compromise of data collection/storage/dissemination )P:M/ I:H) mitigated by enhanced cyber security procedures, additional external data storage and back ups using cloud based systems

The key commercial risk C.R.3: Limited market interest in outputs applications (P: L / I: M) is significantly reduced by feedback from Cambond customer and partner interactions and seeking expertise from the ESCN.

Environmental risk

E.R.1: Unexpected waste effluents contamination causing environmental issues (P: L / I:M) is mitigated by testing effluents in the lab to assess its contamination potential.

E.R.2: Unexpected health or safety issues in materials handling or use in manufacturing processes (PL / I:H) is mitigated by consultation with SaapiSaapiSaapiSaapiSaapi and ESCN and appropriate PSE measures

Key managerial risks are M.R.2: Cambond lack of technical resources (P:H / I: H) is mitigated by planning the hire of key personnel to run lab experiments and coordinate project, and M.R.4-5: Loss of key personnel and Cambond being unexperienced employer (P:H / I: H) reduced by identifying key personnel with support provided at all times and Cambond to attend workshop in people management.

It is important to manage project creep and delay of deliverables as M.R.5 (P:L / I: H). Therefore, the project consortium has defined a fixed scope of activities and timescales prior to the project. The project manager will ensure keep to time and budget.

Risk around Intellectual Property Rights (IPR) will be addressed through early establishment of a Background IPR log, confidentiality agreements and the continuous development of foreground IPR as the project progresses.

The project will aim to role models in entrepreneurship and in STEM.