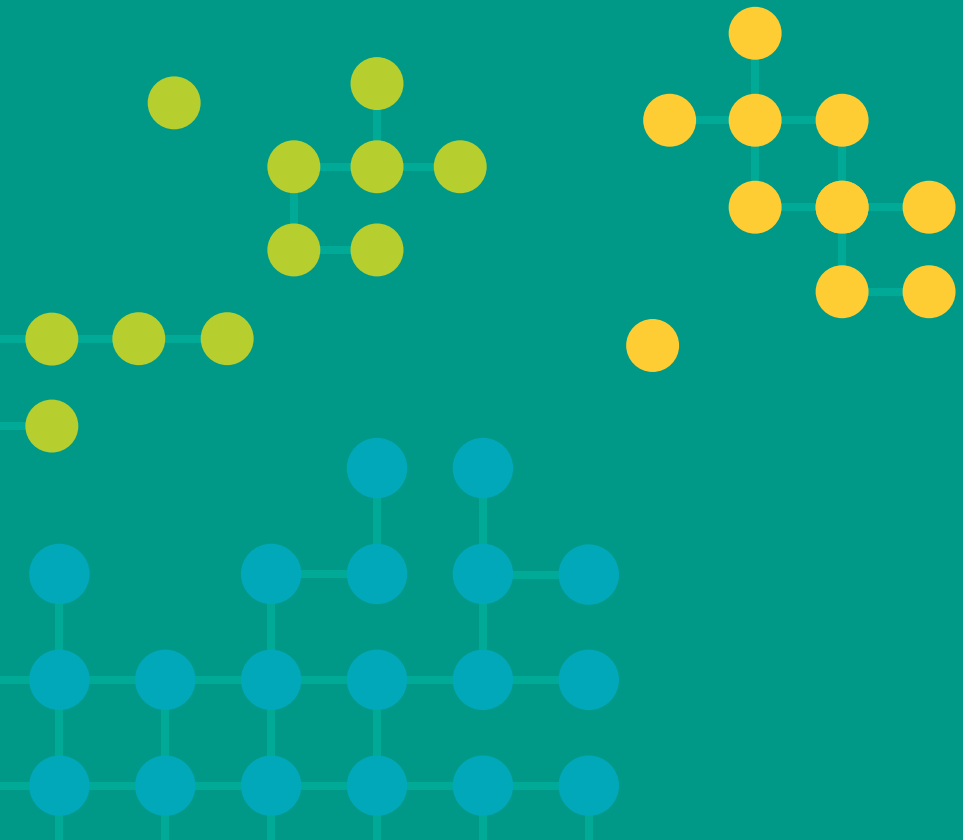
Technology Strategy Board
Driving Innovation

Collaboration nation

Carbon abatement feasibility studies



Acknowledgements

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Disclaimer

The entries in this directory were provided by the individual companies. The Technology Strategy Board cannot guarantee the accuracy or completeness of any of the information about the projects.

The Technology Strategy Board is a business-led executive non-departmental public body, established by the Government. Its role is to promote and support research into, and development and exploitation of, technology and innovation for the benefit of UK business, in order to increase economic growth and improve quality of life.

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Introduction

Nearly two-thirds of commercial innovation stems from small companies - a vital source of wealth-generating new products.

As part of its energy generation and supply investment programme, the Technology Strategy Board funded 19 collaborative projects covering a wide range of carbon abatement technologies including CO_2 capture and storage, alternative commercial uses of CO_2, instrumentation and sensors. We invested up to 75% funding in each project with the maximum project value being £150k. Each project was led by an SME, with at least one other partner and a maximum project duration of 12 months.

This directory provides a snapshot of the funded projects, their highlights and their proposed steps in taking the technology forward. This will enable potential collaborators, investors and organisations interested in carbon abatement technologies to get to know more about the companies involved and the technologies they are developing.

Index

Project 1

Consortium members
Avalon Sciences (ASL)

Applied Seismology Consultants (ASC)

Microseismic technologies in underground carbon storage

Established in 1997, and now part of Itasca International, ASC specialises in providing microseismic monitoring applied to rock and concrete structures through sensor array design and data analysis. The integration of geomechanical models and microseismic monitoring provides a unique insight into the evolution of geological reservoirs and their containment capability.

What problem have you tried to solve?

We have investigated the feasibility of using passive and active microseismic monitoring to assess the impact of injecting pressurised CO_2 into deep geological reservoirs. Microseismic monitoring has proved a unique tool for imaging fracture development and changes in fluid conductivity in oil reservoir treatment projects; applications with conditions similar to those involved in CO_2 storage. This project combines the expertise in monitoring equipment and software tools of two leaders in commercial microseismic monitoring, ASC and Avalon Sciences Ltd (ASL) a borehole seismic receiver/source manufacturer.

What approach have you taken and what have been the key findings?

- developed a suite of numerical models of reservoirs subject to CO_2 injection. Microseismicity was only observed in models with permeable pre-existing fracture under the highest injection pressure with activity increasing with temperature
- tested a prototype high pressure tubular housing for the monitoring tools and the electronics required to provide a high dynamic range, high bandwidth, low noise sensing
- software tools have been implemented to aid the processing of microseismic data recorded in a low signal:noise environment using the prototype
- feasibility of using a down-hole 'Sparker' based on a high voltage discharge device was tested.

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What are the potential benefits?

This project has demonstrated how existing microseismic technologies can be adapted and commercialised for monitoring under conditions typical of CCS. Both partners are world leaders in their fields: ASC in commercial microseismic processing services and software, and; ASL in borehole acquisition equipment. This project has the long-term commercial benefits of both advancing the state-of-art within the UK and accelerating the two participants into the global market.

Who are the likely customers for this technology?

- oil services providers
- energy producers
- environmental agencies.

What are the next steps towards commercialisation and what are the barriers?

Beyond this project we anticipate that both participants will require a development phase leading to commercialisation and demonstration over 1-3 years, in which both participants are experienced in other market sectors. The demonstration and testing phase will require partnerships with companies and institutions involved in this sector.

Sparker test

Project 2

Consortium members
University of Cambridge,
Department of Materials

Cambridge Carbon Capture

Sequestration of CO_2 within a direct oxidation hydrocarbon fuel cell

Cambridge Carbon Capture (CCC) is an early-stage venture developing unique electrochemical mineral carbonation technology that enables profitable and scalable capture and storage of CO_2 as high-value mineral products. We offer technology and business expertise in mineral carbonation technologies to the waste, mining, energy and materials process industries.

What problem have you tried to solve?

As a hugely expensive process, carbon capture and geological storage (CCS) will be challenging for businesses and nations to implement at scale. CCC set out to address this problem by creating a fundamentally profitable technical approach to CCS that will be easy for industry to adopt. With our team's extensive expertise in fuel cell technology and materials chemistry we realised that a scaleable solution may lie in converting fuels and CO_2 directly to clean electricity, solid carbonate minerals and high-value by-products.

What approach have you taken and what have been the key findings?

In partnership with the University of Cambridge, we have tested the science and modelled the business case underlying our novel ideas. We successfully demonstrated the feasibility of electrochemical mineral carbonation, with key achievements being:

- a direct-alcohol fuel cell was built and used to generate electrical power with simultaneous, integral capture of product CO_2, both from the fuel and from the air, with no release of CO_2 to the environment from the fuel cell exhaust
- permanent sequestration of the captured CO_2 as a solid mineral by regeneration of the carbonated capture solution through reaction with a range of mineral feedstocks
- identification of suitable widely-available low-cost feedstock minerals and practicable low-energy, low-cost feedstock digestion and mineral carbonation processes compatible with our electrochemical carbon capture process
- modelling work at Judge Business School showed that our CCS process can be highly profitable.

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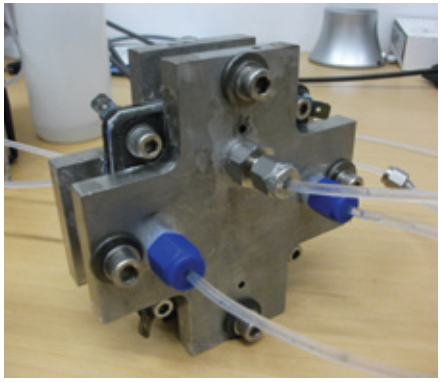
What are the potential benefits?

Successful commercialisation and demonstration of profitability could ultimately lead to:

- creation of a new CCS and materials process and recycling industry based on electrochemical mineral carbonation
- uniquely addressing the whole global fossil power generation CCS and construction aggregates markets, potentially saving 7bn tonnes CO_2/year and worth around US$400 bn/year.

Who are the likely customers for this technology?

- waste treatment companies (eg: hazardous alkaline industrial wastes, metal refining slags, combustion ashes, mineral tailings)
- CCS technology providers
- metals, minerals and mining companies
- aggregates and construction materials companies
- industrial emitters of CO_2 and fossil power station operators
- producers of precipitated carbonates and silica
- coal, oil and gas producers



Direct oxidation alkaline fuel cell

What are the next steps towards commercialisation and what are the barriers?

- process development, life cycle analysis and demonstration at pilot scale in partnership with industrial customers and research and technology organisations
- building a technical and management team and investment fund raising
- implementation of a commercial road-map that initially exploits high-value niche market industrial opportunities in the waste and mining sectors, and ultimately scales up to service global CCS power generation markets.

Project 3

Consortium members
Alcan Aluminium (UK) Ltd

Carbon Sequestration Ltd

CO_2 mineralisation using fly ash and seawater

Carbon Sequestration Ltd is an R&D science-based SME established in 2007. We are successfully developing and patenting new technologies ranging from recovery of high value chemicals from industrial waste streams to the esterification of palm oils for fuel processes. Our major area of expertise is in the field of carbon abatement, specifically the alternative use of CO_2 to create industrially useful products.

What problem have you tried to solve?

As an alternative to existing carbon capture and storage (CCS) methodologies, our study seeks to offer an innovative, cost effective and efficient means of converting impure CO_2 into carbonate materials. By using the by-products of our industrial partner and addressing issues of impurity (SOx and NOx removal), this feasibility study has successfully validated the feasibility of this carbon abatement methodology. Innovative mass transfer techniques have also demonstrated improved transfer rates which will assist in the project's future development.

What approach have you taken and what have been the key findings?

All of our projects are commercially driven and this study provoked the interest of our multinational industrial partner. Initially literature searching was undertaken to identify any potential barriers in our area of work. Laboratory analysis of our partner's feedstocks was then critical in establishing the likely CO_2 conversion ratios. A notable feature was the potential of mineralising impure CO_2 without affecting the chemistry. The ability to selectively remove additional species such as NOx and SOx was developed to address this. Mass transfer could be a further obstacle if we are to apply such a route on an industrial scale. Inclusion of a novel micro-bubble assistance has increased transfer rates by 100%.

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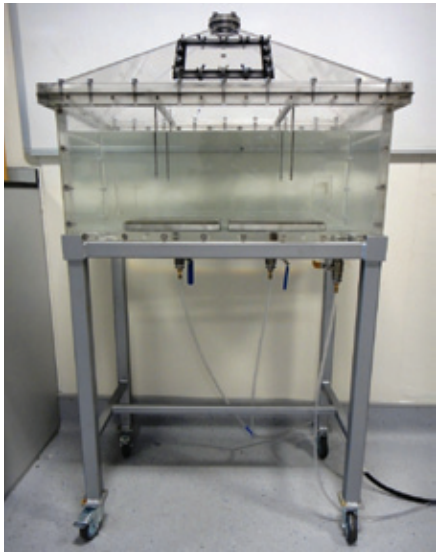
What are the potential benefits?

- reduction of CO_2 emission by 90,000 tonne per annum (limited only by feedstock availability)
  - benefit: environmental (reduced emissions), cost (reduced taxes)
- creation of value product
  - benefit: calcium carbonate sales price £50 to £100 per tonne
- reduction of SOx and NOx
  - benefit: environmental (reduced emissions), cost (reduced penalties)
- creation of value product
  - benefit: worldwide shortage of SOx and NOx based fertilisers.

Who are the likely customers for this technology?

Our carbon abatement methodology targets all CO_2 emitting industries including processing and power plants of all sizes. The natural abundance of the feedstock used within this project means that no industry is prevented from using this technology process.



Reaction vessel(70 litre scale)

What are the next steps towards commercialisation and what are the barriers?

Further development work is required for scale-up and optimisation of the process. We would welcome discussions with partners interested in moving this project forward and sharing the registered IP and networks established to date.

Fly ash for hydroxide feedstock

Project 4

Consortium members
British Sugar plc

Carbon Sequestration Ltd

The feasibility of converting CO_2 to organic products (carboxylic acids and lactones)

Carbon Sequestration Ltd is an R&D science based SME established in 2007. We are successful in developing and patenting new technologies ranging from recovery of high value chemicals from industrial waste stream to the esterification of palm oils for fuel processes. Our major area of expertise is in the field of carbon abatement, specifically the alternative use of CO_2 to create industrially useful products.

What problem have you tried to solve?

This feasibility study sought to research, trial and outline a continuous catalytic process to convert CO_2 into high-value, demand-led organic products - carboxylic acids. This is considered an alternative and value added process to that of existing carbon capture and storage (CCS) methodologies. Through novel chemical processing, a suitable organometallic catalyst was identified and our partner's by-products effectively utilised as the feedstocks to ensure a viable route was achieved. Innovative micro-bubble technology was also incorporated to improve dwell times.

What approach have you taken and what have been the key findings?

A combination of literature searching and experimental laboratory work have been undertaken to successfully prove the feasibility of this carbon abatement process. Through experimentation, a bio-catalytic system was refined and reaction kinetics enhanced along with other key experimental parameters. Initial analyses of our partner's by-products also identified a readily available feedstock through a substance known as molasses. This was utilised alongside available CO_2 and the bio-catalyst to produce a series of carboxylic acids in varying amounts, including succinic acid, lactic acid and formic acid. By judicious control of reaction conditions the selectivity of reaction products may be controlled, thus allowing the technology user to tailor the chemistry as desired. This simple, robust procedure was carried out at room pressure and at 37°C on a multi-litre scale.

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What are the potential benefits?

The potential benefits may be summarised as:

- reduction of CO_2 emission (limited only by feedstock availability)
  - benefit: Environmental (reduced emissions), cost (reduced taxes)
- creation of value product
  - benefit: Succinic acid sales price £15 per kilo, bolt-on technology.

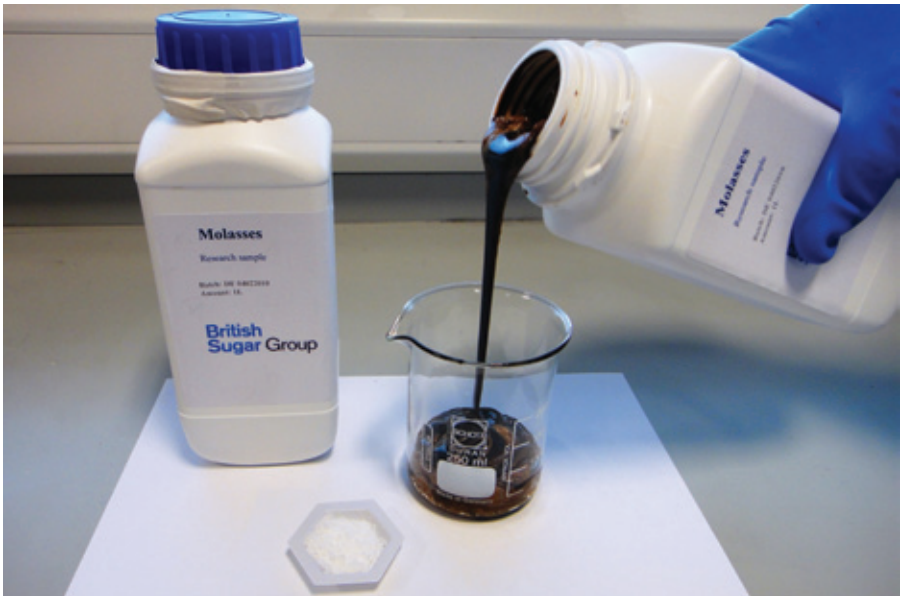
Who are the likely customers for this technology?

Specific markets at which the project is targeted include all large CO_2 emitting sectors namely industrial processors and power stations. However, its effective, energy efficient, reliable and durable nature means it may also be applicable and attainable by smaller contributors, such as brewers.

What are the next steps towards commercialisation and what are the barriers?

Further development work is required for scale-up and optimisation of the process. We would welcome discussions with partners interested in moving this project forward and sharing the registered IP and networks established to date.

Sample feedstock (molasses) and product (succinic acid)



Project 5

Consortium members
University College London
Building Research Establishment

Carbon8 Systems Ltd

Carb-ATTACT: Carbon Abatement Through Accelerated Carbonation Technology

Carbon8 Systems is a waste management company developing novel technologies for the treatment of a variety of difficult wastes using waste carbon dioxide. The company has four full time employees and was established in February 2006. It has won environmental prizes including the IChemE green chemistry award, the Kent Innovation Challenge and the Shell Springboard award.

What problem have you tried to solve?

Utilising CO_2 gas from industrial processes as a feedstock for a process that converts what are currently regarded as waste materials into products that may be used in engineering applications (eg aggregate) by the conversion of the CO_2 gas to solid carbonates. The process represents both capture and permanent storage of CO_2 in a single step, under benign conditions (ie, no toxic solvents are required).

What approach have you taken and what have been the key findings?

The project reviewed the feasibility of using impure carbon dioxide from industrial sources and demonstrated the feasibility on a pilot plant. The kinetics of the reaction were modelled in the laboratory using in an artificial gas stream composed of nitrogen and up to 20% carbon dioxide. These results were compared with the use of a real gas stream derived from the combustion of landfill gas in an industrial boiler so that the influence of other factors such as impurities could be established.

A landfill pilot plant trial showed that it was possible to strip CO_2 from a gas stream with a concentration of CO_2 as low as 10%.

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What are the potential benefits?

The project gave the company confidence to move towards the formation of a new company to treat air pollution control residues from waste to energy plants and manufacture aggregate specifically for cement blocks.

Who are the likely customers for this technology?

Waste management companies, waste to energy plant operators, local councils, block manufacturers.

What are the next steps towards commercialisation and what are the barriers?

The technology is being commercialised through the formation of a new company licensed to treat a specific waste stream. Further research and development work needs to be carried out to use the technology on the gas emissions from a waste to energy plant.

Pilot scale flue gas capture plant at North Farm landfill site, Tunbridge Wells, Kent

Aggregate product

Project 6

Consortium members
Steetley Dolomite Ltd (SDL)

Centre for Process Innovation Ltd (CPI)

Co-firing with algal biomass and the design of a supporting closed loop system

CPI is a technology based SME, established in 2005 to drive innovation within the process sector. The organisation has established an international reputation, undertaking both collaborative projects and commercial activities.

What problem have you tried to solve?

The project addressed industrial carbon abatement through evaluating the technical and economic feasibility of using algal biomass as a partial replacement for fossil fuels in a rotary kiln, used for the production of dolomitic lime.

An energy profile of the site was undertaken, opportunities for energy recovery identified and a combined economic model developed; taking into account current and future UK financial incentives.

What approach have you taken and what have been the key findings?

This systematic study showed the viability of using algal biomass as a partial replacement for coal (pulverised fuel). In terms of energy displacement, this can be achieved without significantly changing the flame structure that exists within the kiln. Technical limitations with respect to percentage substitution are primarily governed by the trace elements found within the algal biomass.

Development of an energy recovery system (specifically targeting low grade heat) represents a significant opportunity for the plant.

A comprehensive financial model was developed and used to assess and compare the technical options identified. It also illustrates that carbon abatement solutions are essential to ensure the long term viability of dololime, lime, cement and brick manufacture in the EU.

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What are the potential benefits?

The project has demonstrated that the partial replacement of fossil fuel through co-firing with algal biomass is theoretically feasible but has highlighted the R&D aspects that need to be addressed prior to commercial implementation.

Assuming future commercialisation, the potential benefits to the market include the reduction of CO_2 footprint, positive environmental and financial impact, future business competitiveness, securing UK and EU manufacturing and job creation.

Who are the likely customers for this technology?

The lime, cement, power generation and brick manufacturing across the EU represent a market opportunity for any technology designed to maximise energy efficient and reduce fossil fuel consumption.

Fermentation vessel used to grow algae samples

Algal Biomass (Chlorella Protothecoides): evaluated as a partial replacement for fossil fuels

What are the next steps towards commercialisation and what are the barriers?

This study revealed the sensitivity of kiln operation to fuel source. Modelling showed combustion properties of algal biomass are significantly different from conventional fuels. Laboratory and pilot plant trials are essential to: establish operational parameters; undertake process optimisation; and ensure products within specification, prior to full scale kiln trials.

Similarly an off-the-shelf energy recovery system is not available. Financial support is required to take this project to completion.

Project 7

Consortium members
Sheffield University
Cascade Technologies

Compound Semiconductor Technologies Global Ltd (CSTG)

Optical sources for distributed CO_2 monitoring

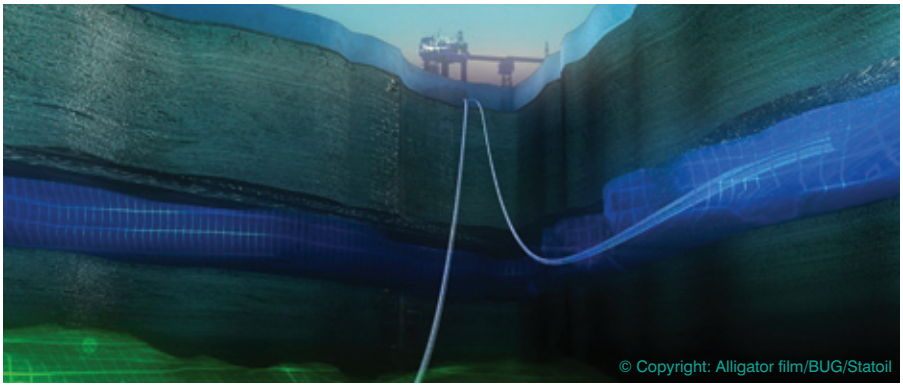
CSTG is a semiconductor foundry specialising in the manufacture of compound semiconductor opto-electronic devices, providing specialist manufacturing services to a number of high-tech industries since 1999 including the manufacture of a wide range of optical components such as laser diodes, LEDs and detectors. Specific current interest is in mid infrared (IR) optical sources for a range of optical sensing applications.

What problem have you tried to solve?

The ultimate success of carbon sequestration technology will depend on the effective monitoring of CO_2 levels. Concentration determination over large area will be essential for verifying storage efficiency, penetration levels and fugitive loss. Many different sensing technologies will be deployed, depending on the cost versus sensitivity requirements. Our project seeks to develop novel optical sources for high sensitivity CO_2 detection as a precursor for full optical sensor development.

What approach have you taken and what have been the key findings?

We have demonstrated miniaturised, high brightness diode laser sources which are suitable for integration in distributed optical gas sensing platforms. We have demonstrated the technology at an absorption wavelength tuned for maximum sensitivity for CO_2 detection at 4.2μm wavelength. We believe the laser to be the highest power diode source at this wavelength and suitable for a demonstrator in a range of closed cell and open path optical sensing architectures.



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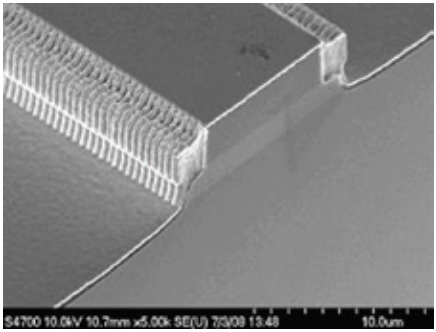
What are the potential benefits?

Diode laser technology is a key enabling technology for mass market optical applications- eg, CD, DVD and fibre optical telecommunications. Mid IR optical sensing technology is an established technology for high-end sensing solutions, using expensive high specification laser sources. The integration of diode laser technology has the potential to realise cost effective multi-point distributed sensing for large scale monitoring of carbon capture projects.

Who are the likely customers for this technology?

Consumers of this product would include gas sensing equipment product manufacturers who manufacture both trace and mid concentration level CO_2 sensing products.



Scanning electron microscope image of laser diode chip

What are the next steps towards commercialisation and what are the barriers?

Currently we have samples of devices under scrutiny with several optical gas sensor manufacturers with very different sensing architectures. The next steps will involve finessing the specifications required for different application and system implementations and scoping the optimum production route to realising usable, commercially viable solutions based on the core laser technology.

CO_2 pipeline

Project 8

ITI Energy Ltd

Consortium members
Newcastle University, Prof. G. Akay,
Process Intensification and Miniaturisation Centre

OxyGasification with oxygen separation, hydrogen generation and carbon capture

Established in 2006, ITI Energy manufactures intensified, small scale biomass fired gasifier systems for power generation using internal combustion engines. Having built two such systems, ITI Energy is currently building more advanced systems, extending to syngas-process water cleanup, syngas conversion to liquid fuels/ammonia and hydrogen through collaborative research.

What problem have you tried to solve?

In order to generate high calorific value clean syngas and capture CO_2 after power generation through fuel cells or internal combustion engines, or syngas-to-liquid fuel conversion, ITI Energy/Newcastle University are developing OxyGasification. This uses advances made in nano-technology/materials science, computer modelling and process control at power outputs of 2MWe using a biomass or biomass-coal mixture. These distributed production systems are commercially viable, but also act as demonstration for large scale generators.

What approach have you taken and what have been the key findings?

Our programme covers both fundamental and applied research and addresses:

- gasifier manufacture for OxyGasification
- materials and intensified process development for OxyGasification, syngas and process water cleaning and gas separation
- intensified catalyst and catalytic reactor development for syngas-to-liquid fuel conversion and ammonia synthesis
- modelling and computer control of gasifiers.

Our recent findings/results (which are IPR protected) include:

- OxyGasier system
- high temperature gas separation membranes
- novel catalyst systems for tar cracking, syngas-to-liquid fuel conversion
- intensified catalytic reactors for syngas-to-liquid fuel and ammonia conversion
- intensified processes for syngas and process water cleaning.

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What are the potential benefits?

- retrofitting of existing ITI Energy gasifiers could enhance calorific value by 50%
- availability of intensified, energy efficient syngas and process water cleanup systems instead of expensive commercial systems
- new commercial activities in catalyst preparation, intensified reactor/process design-manufacture for syngas-to-liquid fuel/ammonia conversion.

Longer term we aim to integrate our findings into developing distributed/centralised OxyGasifiers for full CO_2 capture and high quality syngas generation using biomass/coal.

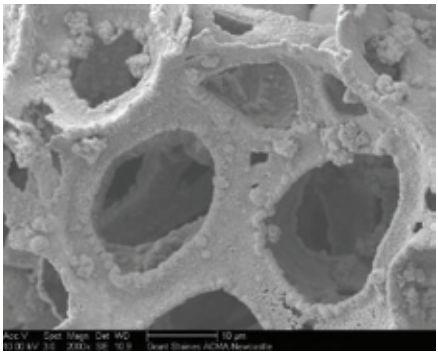
Who are the likely customers for this technology?

- power generators (both biomass or coal fired)
- waste biomass owners
- energy companies
- gas suppliers
- gas to liquid industry.

What are the next steps towards commercialisation and what are the barriers?

Technology Strategy Board-CAT funding enabled us to initiate the OxyGasification project, the scope of which is now widened with full funding through 2 large European FP7 projects (which are called COPIRIDE and POLYCAT) totalling ca. EUR2 million. A third FP7 project is short listed. Three new patent applications have been made and together with the existing IPR held by ITI Energy and Newcastle University, we are in a position to develop new intensified processes as outlined above. We believe this is best achieved through industry partnerships and technology finance.

New metal foam structure



Oxy-gasifier rig

Project 9

Consortium members
Arla Foods UK
University of Nottingham

Lindhurst Engineering Ltd

Bio-gas from microbial fuel cell to tackle carbon emissions in the dairy industry

Lindhurst was established in 1985. We currently employ 40 people and have a turnover of £3.0m. We provide design and build services in the fields of fabrication, mechanical and electrical engineering to a wide range of industries, in particular water utilities anaerobic digestion plants.

What problem have you tried to solve?

The organic content, or chemical oxygen demand (COD), in industrial effluents is currently costly. An industry producing 200m^3 effluent with 1,000 mg/L COD will pay £35-70,000 annually for COD treatment only, while wasting 200,000 kWh of energy contained in the COD. This project has demonstrated a technology called microbial fuel cell (MFC) where the COD is converted into a bio-gas and electricity to convert the liability of COD into a renewable energy asset.

What approach have you taken and what have been the key findings?

Microbial fuel cells (MFC) use an anode and a cathode where the anode harbour a microbial culture that reduces COD by up to 70% per day without aeration. Thus the size is considerably reduced compared to other treatment alternatives and the main by-product is biogas. The main barriers have been: to move the technology from the laboratory to a demonstrator; and to reduce cost of the anode and cathode. This project constructed a 1m^3 demonstrator and developed IP to reduce anode and cathode costs by 90-95%. The project confirmed that the laboratory generated COD reductions are transferable to the demonstrator.

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What are the potential benefits?

The new MFC technology developed can help companies:

- reduce effluent costs by significantly reducing their COD levels
- generate biogas on-site to offset energy costs
- lower carbon footprint by introducing a sustainable technology
- promote the generation of grey water that can meet environmental regulations especially for agricultural based industry.

Who are the likely customers for this technology?

The following industries could greatly benefit from this technology:

- food and drink
- agriculture, especially dairy
- other industries with high COD effluents, such as tanning, pulp and paper, and textile.

What are the next steps towards commercialisation and what are the barriers?

The next step toward commercialisation is using the existing 1m^3 demonstrator towards a full commercial system. The current project has established the transfer of the science to a demonstrator level, and the next step will be to show case how the demonstrator can be transferred to a full commercial scale utilising the IP advantage. Designs need to be optimised and integrated towards automation.

1m^3 demonstrator

Project 10

Mycologix Ltd

Consortium members
Imperial College London

Biorefining scale up and process modelling

Mycologix is a recently-formed company operating in the advanced biofuels area. We have a unique technology for biological pre-treatment of biomass for processing into low-carbon biofuels. We currently have about five full-time equivalent staff, and are in the process of growing and recruiting more. Our main activities are in technology development and partnering for demonstration.

What problem have you tried to solve?

We have been working on the development of a biological pre-treatment process for biomass. This replaces harsher chemical or mechanical processes which must take place early in the biofuels production process. Our process reduces the capital cost, energy requirements and carbon footprint of biofuels production. We have used the Technology Strategy Board funding to optimise process scale-up via experimentation and modelling.

What approach have you taken and what have been the key findings?

The approach uses a combination of targeted experimentation and process modelling. The experimental programme scaled up the lab process from tens of grams of material to kilogrammes and also identified a new potential in-vessel process. The modelling programme was used to optimise the integration of the pre-treatment process into the overall biofuels production process. The important findings were that the expected process yields would be similar to the best yields reported for advanced biofuels but with energy reductions of up to 30%.

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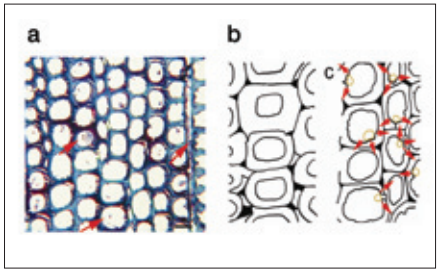
What are the potential benefits?

Biomass pre-treatment is one of the main impediments to the adoption of large-scale advanced (cellulosic) biofuels production processes. We believe that our approach will help to unlock this technology and therefore support the UK and global aspirations of fossil fuel replacement and greenhouse gas reductions. The biological process itself will require an inoculation manufacturing facility or set of facilities, and thereby support job creation in advanced manufacturing.

Who are the likely customers for this technology?

Companies wishing to develop advanced biofuels from agricultural and forestry wastes, energy crops, forestry etc would be ideal partners and customers for this technology.

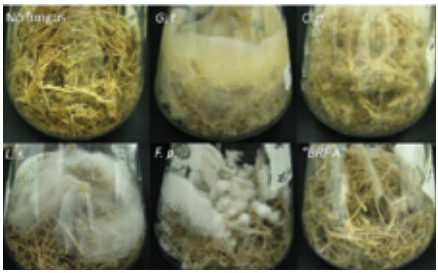
Biological pretreatment: decay mechanism



What are the next steps towards commercialisation and what are the barriers?

Our current strategy is to scale up our technology to the next level (tonnes per day). This will be done in conjunction with a demonstration partner who already has a pilot cellulosic biorefinery and who is interested in exploring the retrofit of our technology. This will overcome the barrier of credibility and support the collection of business case data which will be invaluable in further exploitation. To support this we have been in discussion with potential partners and funders.

Bagasse pre-treatment



Project 11

Consortium members
Noviatec
Scottish and Southern Energy
DoosanBabcock

Newcastle University

Synthesis of cyclic carbonates from power station exhaust gas

A group led by Professor North in the School of Chemistry, Newcastle University, has been working in the carbon abatement field for five years and has developed a uniquely active catalyst to convert the carbon dioxide in flue gas directly into useful chemicals. This has led to the establishment of a spin-out company (Dymeryx Ltd) to commercialise this chemistry.

What problem have you tried to solve?

Our work aimed to convert the CO_2 in power station flue gas directly into valuable chemicals without the need to first capture, purify and pressurise the CO_2. Thus, our approach avoids all of the financial and technical difficulties associated with carbon capture and storage, and provides an additional income stream to power generators from the sale of the chemicals. This is the innovative aspect of the project.

What approach have you taken and what have been the key findings?

Previous work has shown that the Newcastle catalysts have excellent activity with pure carbon dioxide. This project focused on investigating the lifetime and activity of the catalysts when used with real and simulated flue gas. Initially, chemical synthesis was carried out using simulated flue gas in which the carbon dioxide was present at a concentration similar to that in real flue gas and various NOx and SOx impurities were also present. This study showed that catalyst activity and lifetime was retained under these conditions. Subsequently, the catalysts were exposed to real flue gas, resulting in only a small loss in catalyst activity.

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What are the potential benefits?

Carbon capture and storage is a highly energy intensive (and hence costly) process, requiring around a third of the energy generated by a power station. In contrast, using the carbon dioxide in flue gas directly for the synthesis of chemicals for which there is a major commercial demand can avoid all of the expense associated with carbon capture and storage, whilst delivering a financial benefit to the power station operators.

Who are the likely customers for this technology?

Principally the operators of large scale, coal or gas fuelled power stations. There are also numerous other, smaller fossil-fuel power plants often serving a particular industrial complex.

What are the next steps towards commercialisation and what are the barriers?

A spin-out company (Dymeryx Ltd) has recently been established to commercialise this technology. Dymeryx is now seeking further investment/grants to finalise the catalyst and support structure prior to the construction of a pilot plant. A full business case analysis of all of the many income streams associated with reducing carbon dioxide emissions and/or sale of chemicals is also being undertaken.

The Dymeryx technology for producing cyclic carbonates from waste CO_2

Project 12

Consortium members
United Utilities plc

Newton Industrial Group Ltd

Highly energy efficient oxygen transfer device for wastewater treatment

Newton Industrial is a small development and engineering company formed in 1969 to develop and manufacture instruments and later solar thermal systems. In 2008 United Utilities approached Newton to help it develop and trial an innovative aeration system. Successful implementation of this technology would reduce UK CO_2 emissions by 800,000 tonnes CO_2 - a significant contribution to EU targets.

What problem have you tried to solve?

The main aim was to develop an energy efficient pump and air injection system that would pump an air/water mixture into a deep shaft Gravitox aeration process. This required the air/water mixture to flow vertically down a 100m deep shaft; a process that has not been attempted to date.

What approach have you taken and what have been the key findings?

Two separate designs were created and three prototypes developed. An initial prototype was developed that fed a 100m deep shaft at low flow rates. Two much larger designs, including the innovative Saxfal aerator/pump were also developed, each pumping in excess of 100 l/sec.

The initial prototype that fed Gravitox failed to operate satisfactorily but the two larger prototypes were very successful air/water pumps. Saxfal showed enormous potential as an air/water pump but is judged unsuitable as a feed for Gravitox.

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What are the potential benefits?

The size of the global aeration market is estimated to be £500m per year and growing as developing countries improve their aeration systems for wastewater treatment and for remediation of lakes, canals and rivers.

The system could reduce UK electricity consumption by around 0.8% and CO_2 emissions by almost 1 million tonnes.

Who are the likely customers for this technology?

The initial market would be UK water utilities, but these would be closely followed by food and drink processors. The market would then expand worldwide and include bodies responsible for cleaning up polluted waters.

CCD aerator being tested

Saxfal aerator being tested

What are the next steps towards commercialisation and what are the barriers?

The next two steps involve development of an aeration process to replace Gravitox and its testing in a test tank, and then in a full scale aeration lane. The aeration process has been designed and its development for a test tank will commence shortly.

Full scale testing will require further funding. United Utilities are committed, but partners are required to exploit the technology into overseas markets.

Project 13

Consortium members
Such Salinger Peters Ltd

Ocean Resource Ltd

Offshore CCS using innovative sea commander autonomous buoy technology (Sea Sequestor)

Ocean Resource is an innovative SME operating in the oil and gas global markets, developing and supplying low cost solutions using its offshore buoy and platform technologies. Its patented buoy technology was first used over 20 years ago and has been applied to a range of offshore activities. We are now adapting these technologies for CO_2 injection and storage offshore.

What problem have you tried to solve?

Our control and injection buoys have been used in marginal oil and gas fields where cost of extraction is a major issue. In the CO_2 market we also see an issue with costs since the economic models for carbon sequestration are limited by the market price of CO_2 and carbon taxes and credits. The cost of transport and storage must be minimised, and the re-use of current offshore infrastructure may not be economic.

What approach have you taken and what have been the key findings?

We started by exploring the carbon capture and storage (CCS) market to understand the current position and what the leading voices in the CCS market were saying. At the same time our technical team worked on how buoys can be applied to this market, and what additional technology would be needed so they can be used to control and power a carbon sequestration field offshore. It became clear that the economics of our solution were attractive, especially when working with transport vessels as proposed by Maersk and Anthony Veder.

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What are the potential benefits?

The key benefit from using buoys in the emerging CCS market is the low cost basis of this technology plus the ease of moving the buoy and buffer storage to new storage fields as CO_2 storage fields are developed. The risk of laying an expensive pipeline and infrastructure is avoided and the shortage of space on existing platforms is overcome when the buoy provides power and control for sequestration.

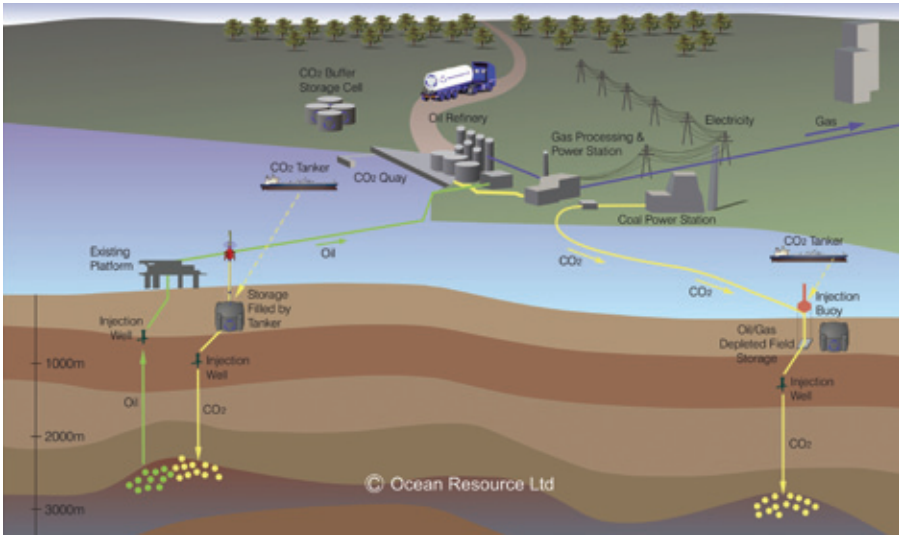
Model of Sea Sequestor and Sea Store CO_2 storage system

Who are the likely customers for this technology?

Oil and gas companies who want to use CO_2 for enhanced oil recovery (EOR). CO_2 storage companies who will offer to take CO_2 from producers and store it.

What are the next steps towards commercialisation and what are the barriers?

We are focusing on developing a full scale demonstration project for offshore CCS. The timeline for this is very sensitive to the route that the CCS market takes. Our next step however, is to work on a front end engineering design and costing (FEED) project with suitable partners, both commercial and funding. We are currently actively seeking grants to support the FEED project.



Project 14

Scionix Ltd

Consortium members
TWI Limited
Independent Power Company

Novel method for capturing CO_2 from fossil-fuelled power stations

Scionix specialises in the commercialisation of ionic liquids technology, it has been in business for around nine years. It is a small company with an excellent track record of commercialising the use of ionic liquids in electropolishing stainless steel, metal plating, precious metal recovery and biodiesel purification. CO_2 capture is a new field for Scionix.

What problem have you tried to solve?

This project focused on the issue of tackling CO_2 emissions by developing a cost effective process of capturing post-combustion CO_2 gas produced by fossil fuel power stations. We use a novel non-volitile, non-flammable, high acid gas soluble, energy efficient ionic liquids (ILs). The benign nature of the ILs would also allow transport of the captured CO_2 and long-term storage to be more easily and cheaply achieved.

What approach have you taken and what have been the key findings?

The approach was based upon an integrated project management system of interdependent work packages (WPs), with an industrial-based focus on scalable processing routes to meet the technical, commercial and environmental requirements, and basic research to investigate the ionic liquid development and the rates of reaction.

- we found that solvents based on choline chloride showed no ability to absorb the significant quantities of CO_2 from power station flue gases
- the costs of carbon capture technology depends factors such as the type of fuel, the design of power plant and the technology employed for capturing. The largest share of the costs originates from the extra energy needed to capture CO_2.

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What are the potential benefits?

- we estimated that using ILs to remove CO_2 from power station emissions would cost as little as £12/tonne, making them 65% cheaper than the current industry best
- ILs are benign, hence they offer key environmental advantages over current techniques
- ILs enable the process to be carried out using much smaller equipment, because of the higher reaction rate and more gas being captured per volume of solution. This also helps to reduce the cost of the process
- ILs have very low vapour pressures, so reducing the risk of atmospheric pollution and energy wasted.

Who are the likely customers for this technology?

Fossil-fuelled power generating companies and CO_2 emitting companies.

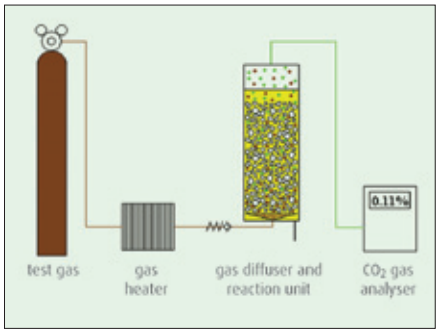
Test rig set up

What are the next steps towards commercialisation and what are the barriers?

More applied R&D to develop suitable ILs or other solvents for CO_2 capture processes is required.

Industrial partners (power generators and plant manufactures) are needed to join the partnership to take technology forward.

Schematic of test rig



Project 15

Consortium members
Leeds University

Stopford Projects Ltd

Novel combustion of synthetic gas in highly efficient gas turbines

An engineering consultancy established in 1982, Stopford has developed significant experience in the delivery of green technology development and waste to energy projects worldwide. A comprehensive knowledge of feedstocks, technologies (gasification, pyrolysis and anaerobic digestion) financing and regulation coupled with engineering excellence has positioned Stopford as a leader in this field.

What problem have you tried to solve?

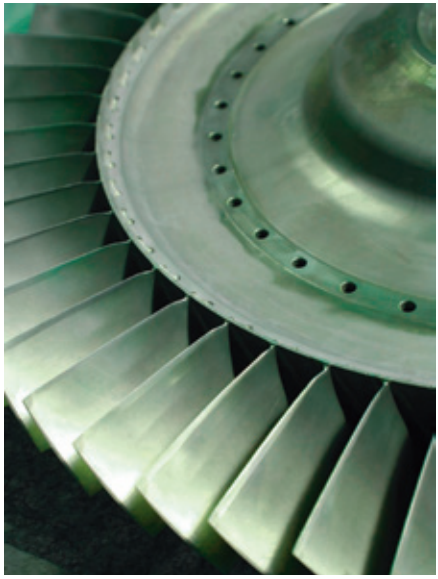
The aim of this project was to investigate the feasibility of using a novel regime to achieve the successful combustion of waste derived synthesis gas (syn-gas) in gas turbines. Gas turbines potentially provide greater electrical conversion efficiencies compared to that of steam cycle and gas engine systems. However, due to the inherent flame instabilities of syn-gas, the operational efficiencies of gas tubines for this application are compromised.

What approach have you taken and what have been the key findings?

The project was conducted in four discrete work packages:

- determination of waste derived syn-gas composition
- flame characteristic experimentation using determined syn-gas compositions
- assessment of combustion constraints and existing combustion technologies
- development of a conceptual combustion scheme.

The key deliverable of this project was the identification of areas in which gas turbines could be modified to enhance their operational performance for the combustion of waste derived syn-gas. The development of this technology will provide an opportunity for small to medium scale waste to energy plants, either planned or operational, to significantly increase their energy generation capacity.



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What are the potential benefits?

We believe the process has the potential to facilitate the development of a specific gas turbine for the combustion of waste derived syn-gas. If successful this development could revolutionise the advanced thermal waste technology market, elevating electrical conversion efficiencies and reducing relative CO_2 emissions for power generation. The technology would also assist the UK to meet EU targets for waste disposal and renewable energy generation.

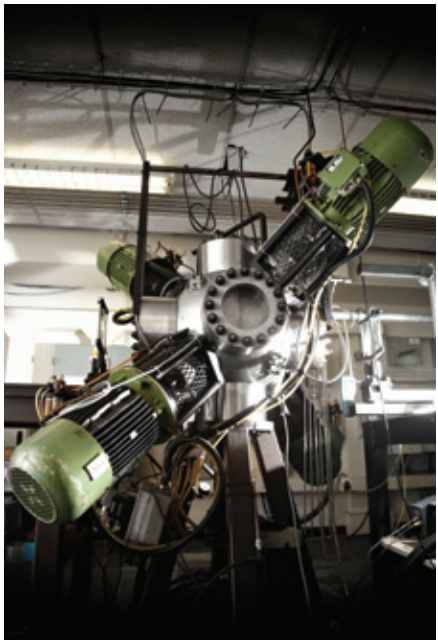
Who are the likely customers for this technology?

This research is likely to be of interest to operators and developers in the waste to energy sector and gas turbine manufactures.

What are the next steps towards commercialisation and what are the barriers?

In order to successfully commercialise the described technology, major development work is required to test and validate the proposed combustion regimes. Further funding is therefore required to progress the project so that design modifications to the combustion chambers of gas turbines can be achieved and combustion tests conducted accordingly. As such, a turbine manufacturer or turbine developer would be a desirable addition to the project team.

Fan-stirred closed volume combustion vessel Mk II



Project 16

Consortium members
Liverpool John Moores University

Stopford Projects Ltd

Highly efficient microwave induced plasma in advanced gasification

An engineering consultancy, established in 1982, Stopford has developed significant experience in the delivery of green technology development and waste to energy projects worldwide. A comprehensive knowledge of feedstocks, technologies (gasification, pyrolysis and anaerobic digestion) financing and regulation coupled with engineering excellence has positioned Stopford as a leader in this field.

What problem have you tried to solve?

The aim of the project was to design and construct a lab scale plasma gasification reactor, using highly efficient microwave induced plasma as an alternative to direct current (DC) plasma torches. This novel application of microwave plasma will enable the development of a commercial scale gasification system that will have a significantly lower parasitic load, a longer operational lifespan and reduced capex costs compared to that of conventional technologies.

What approach have you taken and what have been key findings?

- characterisation of waste and biomass samples
- theoretical simulation and design of microwave plasma torch
- development, build and optimisation of microwave plasma torch
- design and build of pilot scale gasification reactor and integration of microwave plasma torch
- technology trials, parameter monitoring and process optimisation
- analysis of synthesis gas composition
- process scale-up and technology exploitation.

Key findings:

- acquisition of waste stream composition data and trial samples
- development of an operational microwave plasma torch, achieving torch auto-ignition
- development of an operational batch microwave plasma gasification reactor
- development of a method for measuring synthesis gas composition throughout plant operation.

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What are the potential benefits?

Microwave plasma gasification technology presents the UK with a real opportunity to reduce CO_2 emissions under obligations set by the Kyoto Protocol. Furthermore, the technology will assist the UK to meet EU targets for waste disposal and renewable energy generation. Successful commercialisation of the microwave plasma gasification reactor will result in job creation and enhanced earnings through the provision of technical and consultancy services to the waste to energy sector.

Who are the likely customers for this technology?

The niche market for the microwave plasma gasification reactor is for the thermal treatment of waste streams for subsequent energy generation. Customers will include waste management companies, energy producers and developers.

What are the next steps towards commercialisation and what are the barriers?

In order to successfully commercialise the described technology, the consortium will require further funding to develop a commercial scale, continuous feed, microwave plasma gasification demonstration plant. This will require scale-up of the existing facility, the development of a multi-microwave plasma plume array that is capable of generating the operational temperatures required for gasification, and the conversion of the reactor from a batch process to a continuous process.

Microwave induced plasma gasification system

Project 17

Consortium members
TataSteel
University of Sheffield

Suprafilt Group Ltd

Steel plant CO_2 sequestration using high efficiency micro-algal bioreactor

Suprafilt is an SME dedicated to aeration technology and supplies a full range of related products. Our focus is to improve energy efficiencies and we work in partnership with the supply chain, including the UK's major water companies and leading industrial organisations. Our focus on CATs is improving gas exchanges for greater algal biomass production rates and smaller footprint systems with higher efficiency.

What problem have you tried to solve?

Assessing the feasibility of growing algae directly from high concentrations of CO_2 in steel plant stack gas by a step change in the gas transfer dynamics in the bioreactor design. Conventional wisdom is that bioreactors achieve low density of algae and are inhibited in their growth, and would thus be poisoned by high concentrations of CO_2 and other trace components. Preliminary lab studies led us to believe that better gas transfer of CO_2 in, and crucially O_2 extraction, would overcome these perceived barriers to greater efficiency of production.

What approach have you taken and what have been the key findings?

Two field trials of batch algal biomass growth, mediated by micro-bubble transfer processes in an airlift loop bioreactor, were carried out. These showed steady growth of biomass with 100% survival rate. Analysis of the gas passing into and out of the 2200 litre bioreactor showed a specific CO_2 uptake rate of 0.1g / litre / hr for an exhaust gas containing 23% CO_2. This is an average CO_2 reduction rate of 14%. This uptake level resulted in steady production of chlorophyll and total lipid (oil) content of the algae in the bioreactor, and an accelerating exponential growth rate of biomass.

The gas analysis also showed anti-correlation of CO_2 uptake and O_2 production, along with the apparent stripping of the O_2 to the equilibrium level by the micro-bubbles, strongly suggests that algae growth in this air lift bioreactor is not mass transfer limited, nor O_2 inhibited. Removing O_2 inhibition results in high growth rates and high density of biomass. The ability to utilise steel plant CO_2 emissions presents a significant opportunity and could help secure the future of steel making within the UK by contributing to reductions in CO_2 emissions from manufacturing processes.

A landfill pilot plant trial showed that it was possible to strip CO_2 from a gas stream with a concentration of CO_2 as low as 10%.

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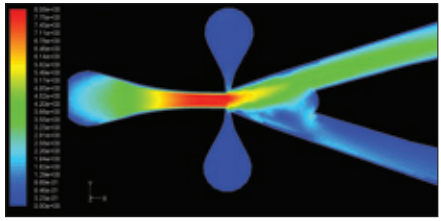
What are the potential benefits?

The results suggest that an order of magnitude jump change in algal densities and production rates is possible, particularly due to the greater O_2 extraction accelerating the algal metabolism and biomass growth rate. This then draws more CO_2 uptake, as well as to the better mixing leading to more uniform exposure of the algae to sunlight, hence the zero fatality rate and unfouled surfaces. This is a large step towards the potential profitability of algal biofuels and the CO_2 sequestration by plant integration. In terms of nearest to market activities, it should be a 'slot in' technology for nutraceuticals production in algal bioreactors, which is under discussion with several European companies and TataSteel.

Bioreactor



Velo contour

Who are the likely customers for this technology?

Major CO_2 producers, biofuels companies, algal bioreactors companies, particularly nutraceuticals producers.

What are the next steps towards commercialisation and what are the barriers?

To get to market an integrated pilot plant with the industrial steel plant must demonstrate at a larger scale for a longer time the economic production all the way through to biodiesel generation. The technologies are in development to remove the next major barriers to economic operation, but they must be tested and demonstrated in a pilot scale operation to assess the economics. Nutraceuticals are at present a small market, such as omega-3 oils that sell at US$25-US$75 per litre. However, if these were the sole target markets, rather than biofuels with large demand, the price would collapse by oversupply. It may provide intermediate profitability as production ramps up to deal with the sequestration issue, but long term sustainability relies on developing other co-products such as bioplastics and pharmaceuticals precursors, fish food and other foodstuffs, to complement biofuels. The consortium is already planning the next stage of pilot scale investigations on advanced technologies for the unit operations and assembling a larger consortium for demonstration plant.

Project 18

Consortium members
Lancaster University
Cheshire Innovation

West & Company

Latent power turbine

Established in 1983, West & Co is a management consultancy delivering business development projects for clients in the UK, USA, Middle East and in SE Asia. Current focus is on early-stage technology projects where the partners are directly involved, including electronics, mechanical engineering, manufacturing, commercial development and product sales.

What problem have you tried to solve?

Steam turbines generating electric power operate on the Rankine cycle, extracting heat energy from superheated steam. This power generation process is typically 45% efficient: much of the remaining 55% coal/oil/gas/nuclear energy being released as latent heat into the environment through cooling towers. We propose to slightly modify operating temperature and pressure conditions at the exit from existing turbo-generators, creating a flow of saturated exhaust steam at 100ºC and, by using a chain of novel turbo-generators, extract latent heat from this exhaust steam flow and form an additional, secondary power generation capability.

What approach have you taken and what have been the key findings?

Our latent power turbine theory makes two predictions:

- When saturated steam passes through a nozzle, the pressure and temperature drops are minimal compared with the flow of a unsaturated vapour or gas.

  Experiment: This was the key demonstration: as saturated steam passes through a constriction in a duct, a proportion of the steam condenses as the static pressure reduces. Latent heat is released from the condensing liquid and the heat release is absorbed by the on-going gasflow. Our results are consistent with this prediction, in spite of the large duct losses imposed by the small scale bench-top rig.

- When saturated steam passes through a turbine unit the pressure and temperature drops across the turbine are minimal compared with the flow of an unsaturated vapour or gas.

  Experiment: a simple turbine stage was installed in the duct, and a similar procedure was followed to the previous experiment. Again, our experimental results are consistent with this second prediction.

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What are the potential benefits?

If a secondary power generation process can increase the output of a power generation plant by (say) 10% - from 45% to 55% of the available energy - the value of additional electricity generated could be in the region of hundreds of millions of pounds.. The potential for increased output may be even greater, for all heat energy sources. At least 50% of the total energy used in electric power generation for 100 years has been exhausted to the environment: the latent power turbine concept can reduce this waste, while creating jobs and an entirely new British technology with significant export potential.

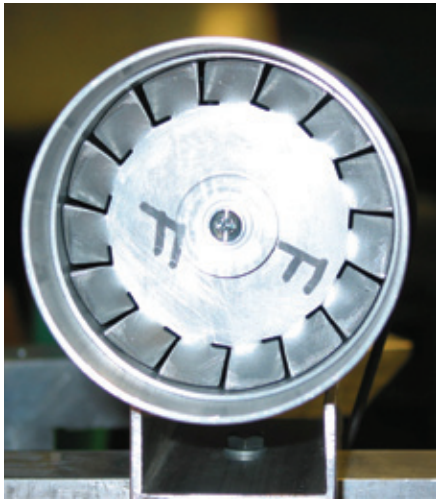
Who are the likely customers for this technology?

Governments; electric power generation utilities; power generation equipment suppliers.

What are the next steps towards commercialisation and what are the barriers?

A UK patent is granted on the basic concept, with two additional patent applications pending. All relevant IP has been transferred into our UK Limited company. We want to license the technology to a company or industry co-operative able to fund and build a pilot plant, and then further develop the technology to production-scale installations. Suitable partners and/or licensees are electricity generation equipment suppliers.

Latent power turbine: axial view on the upstream face of an experimental turbine



Project 19

WRK Design & Services Ltd

Entrapment of carbon dioxide for reuse

WRK, established in 2002, undertakes contract research, feasibility studies and process development in fields of chemical, environmental and alternative energy. WRK's proprietary technology, the downflow gas contactor (DGC) reactor, a mass-transfer device, has been successfully used for various industrial applications like effluent treatment, gas absorption and selective carbon capture.

What problem have you tried to solve?

The project was aimed at selective capture and sequestration of carbon dioxide from air and mixed gases, specifically biogas, using a DGC reactor. This has not been used anywhere before and has excellent gas absorption and gas-liquid mass transfer properties, thereby effecting:

- reduction of environmental pollution and effects of global warming of CO_2
- enhancement of methane concentration in biogas - improving the calorific value and reduction of energy production costs.

What approach have you taken and what have been the key findings?

- a DGC reactor unit was designed and installed for the CO_2 absorption trials
- operating conditions and absorbent liquid were varied to study effects
- 100% absorption efficiency achieved, at high CO_2 absorption rates, to reduce CO_2 levels in air, from an average of 360 ppm to nearly 10 ppm – and even 0 ppm in some cases
- the DGC unit was able to absorb all the CO_2 and H_2S content in (simulated) biogas (60% methane, 38% CO_2 and 2% H_2S). Methane concentration could be increased to greater than 95 -100 %
- absorbed CO_2 can be recovered
- preliminary design parameters for scale-up were obtained.

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What are the potential benefits?

The project processes would allow shorter operating times, lower energy requirements, reduced capital and lower operating costs, can be easily retrofitted and located at CO_2 emission point, achieving highest degree of CO_2 absorption, effecting a major reduction in global warming effects.

Commercialisation:

- would allow stabilisation of WRK's financial position
- facilitate growth and expansion of WRK
- would create recruitment of further technical personnel.

Who are the likely customers for this technology?

- power generation – large scale and small scale plants
- anaerobic digestion plants
- waste and wastewater management companies – operating landfill gas recovery, thermal and biological treatment processes.

What are the next steps towards commercialisation and what are the barriers?

- IP application submission
- construct and test a larger scaled-up unit
- trials at actual plant sites, varying operating conditions – detailed analysis and confirmation of design data
- contacting various industries including power generation, renewable energy, oil and gas and waste management, all having requirements for carbon capture
- demonstration at exhibitions – showcasing potential clients/companies/anaerobic digestion plants/funders/ venture capitalists
- papers for submission to conferences.

Absorption of CO_2 from air in a DGC reactor - water with sea salt

The Technology Strategy Board would like to acknowledge the role of our Carbon abatement technologies Collaboration Nation delivery partners:

Energy Generation and Supply Knowledge Transfer Network

Supported by the Technology Strategy Board, the Energy Generation & Supply KTN is an integrated and dynamic network of business, technology, academic and policy stakeholders that has been set up to deliver strategic and effective knowledge exchange to advance the UK energy generation and supply sector. Its main areas of activity are:

- Supporting accelerated innovation
- Promoting and supporting funding opportunities
- Establishing networking and partnerships
- International engagement
- Influencing policy and regulation
- Promoting beneficial cross-sector links
- Supporting faster technology deployment
- Contributing to the debate and decisions on future energy mix.

The KTN covers the EG&S priority areas of offshore renewable energy, carbon abatement technologies, nuclear, fuel cells and hydrogen, oil and gas and emerging technologies and is delivered by a dedicated team.

Membership of the EG&S KTN is free and open to anyone with an interest in the sector. To join visit www.innovateuk.org/energyktn.

Advanced Power Generation Technology Forum (APGTF)

The APGTF is an industry-led stakeholder group active in the area of carbon abatement technologies (CATs). It is an independent body providing a representation for the CATs sector. In particular, it provides a consistent, long-term, proactive technology focus for the power generation sector in the UK on the research, development and demonstration activities for fossil fuels, with the main focus on CATs including carbon capture and storage (CCS). However, it also provides a focus for associated technologies including: large-scale fossil generation greater than 1MW; heat, including waste heat utilisation; combined heat and power; biomass; hydrogen production from fossil fuels; and environmental control technology. The objectives of the APGTF are to provide the strategic focus in the UK on near-to-zero and zero emission technologies from fossil fuel, biomass and associated technologies.

The APGTF is the delivery partner of the EG&S KTN responsible for carbon abatement technologies. For more information visit www.apgtf-uk.com.

The Technology Strategy Board acknowledges the support of the following organisations for their sponsorship of the Collaboration Nation event and for the Northern Way's co-funding of the original 'Carbon abatement technologies' feasibility competition.

N8 Research Partnership

N8 is a group of the eight most research-intensive universities in the North of England: Durham, Lancaster, Leeds, Liverpool, Manchester, Newcastle, Sheffield and York.

The N8 universities have expertise across the full range of CCS technologies and can provide a fully integrated, whole systems approach to support the industrial delivery of CCS. N8 combines technical capability with expertise in risk, social policy and economics to support the full CCS supply chain. Current and previous clients include Scottish and Southern Energy, Progressive Energy and Doosan Power Systems.

By working together as a consortium the universities combine complementary strengths and create 'best with best' teams to work with industry. N8 offers a wide range of technology capabilities and facilities across all major areas of CCS including CO_2 capture, transmission, storage and alternative uses of CO_2. N8 also has significant experience in the key areas of policy and economics and offers expertise in areas of CCS policy, socio-economics, risk management and liability/insurance.

By combining strengths, the N8 partnership is able to provide unique, innovative, and practical solutions towards the commercial deployment of CCS.

For more details, visit www.n8research.org.uk.

The Northern Way

The Northern Way is a unique initiative, bringing together the cities and regions of the North of England to work together to improve the sustainable economic development of the North towards the level of more prosperous regions.

Northern Way aims to influence policy and delivery across the North, to join up thinking and encourage collaboration. Northern Way works with regional development agencies and local enterprise partnerships, local and central government, business and universities.The group focuses on issues such as transport, new energy, business investment and innovation where the North needs to work across boundaries. Northern Way adds value through economic research and policy development, influencing national policy, and by facilitating collaboration and joint investment across the North.

The initiative was formed as a partnership between the three northern regional development agencies: Yorkshire Forward, Northwest Regional Development Agency and One NorthEast. The Northern Way was one of the co-funders of the Technology Strategy Board's 2009 CAT feasibility competition.

For more details visit www.thenorthernway.co.uk.

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