NORTHERN RESEARCH PARTNERSHIP

JRI for energy and clean technologies

The Northern Research Partnership: overview: The University of Aberdeen, the University of Dundee and the Robert Gordon University have joined together to establish a research partnership in engineering and related disciplines, known as the Northern Research Partnership.

The purpose of this partnership is to pool research strength in areas common to partner universities, and to exploit areas of complementarity. It is the first time that the institutions have agreed to go beyond collaboration on an ad-hoc basis towards a convergence of research priorities in the area of engineering research. This will enhance research performance of the participating groups in all partner universities by creating critical mass, and increase significantly the competitiveness of research groups in the region. The proposal mirrors the establishment of similar regional partnerships in Edinburgh and Glasgow.

Research activity is taken forward through four JRIs and one overarching joint research group:

JRI for Civil Engineering (also to form part of the national Telford Institute)[1]
JRI for Computational Systems
JRI for Energy & Clean Technologies
JRI for Medical Technologies
Non-linear and Complex Systems Group

The partner universities have also set up a common Graduate School to support and enhance research student activities.

The partner universities have selected members for the JRIs with a view to international excellence, applying stringent criteria relating to research grants and contracts income and RAE submissible publications. The partnership represents a cluster of research groups in the engineering area, comprising 135 researchers, 160 research assistants and 286 PhD students.

JRI for energy and clean technologies: Summary

This JRI is structured around three key themes that address the issue of finding solutions for future energy supply.

The aim of the first research theme will be to develop new and renewable sources of energy, particularly through marine, wind, biomass, solar and fuel cell technologies including hydrogen storage, electricity storage and distribution networks. It will also provide infrastructural remote monitoring and control systems and strategies to maximise use of resource and efficiency of operation. Production and development of liquid biofuels from biomass will also be pursued.

[1] This JRI will also involve a researcher from the University of Abertay, Dundee.

The aim of the second research theme is to develop innovative solutions and technologies to; enhance recovery of oil & gas reserves from existing fields, advance reservoir imaging and characterisation, enable the recovery of stranded reserves of significant value, effect improvements to drilling efficiency, provide better sand control systems and produced water treatments. There are also significant opportunities to introduce new and improved methods for gas stream clean-up and separation through catalytic and membrane technologies.

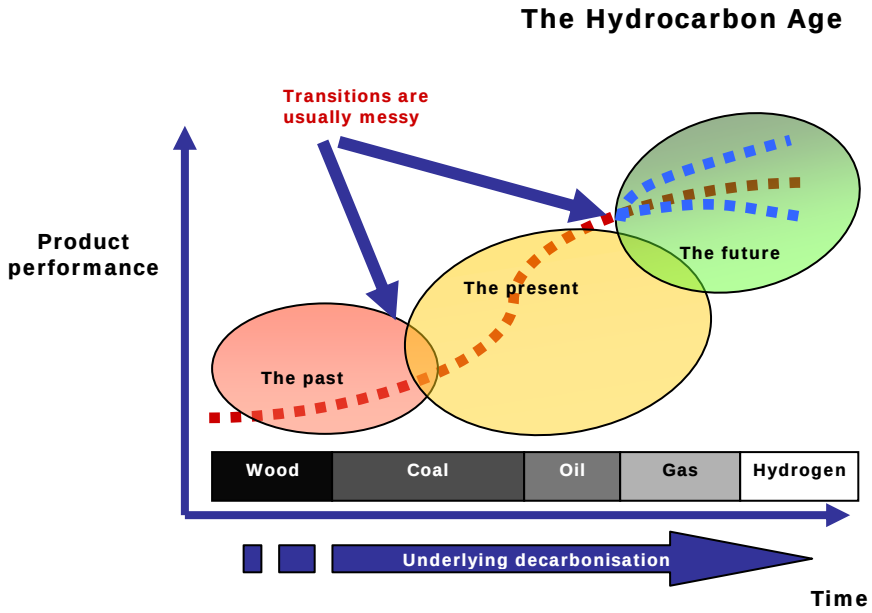
The aim of the third research theme is to develop innovative and clean technological solutions for CO_2 stripping, the production of high purity hydrogen, sub-surface sequestration, water purification through catalysis, and bio-remediation of energy related activities.

Aims of the JRI

The principal aim of this JRI is to build on the complementary strengths of the three partner institutions to create a critical mass to address some of the key issues concerning the development of future sustainable energy supplies. It is anticipated that there will be synergies and potential collaboration between the collaborative work undertaken in this JRI and the Subsurface Science and Engineering (ECOSSE) and Energy Systems JRIs in the Edinburgh Research Partnership (ERP) and the Electronic Communications and Power Systems (ECPS) JRI in the Glasgow Research Partnership (GRP).

Rationale

At the beginning of the new millennium the great challenges facing mankind are becoming ever more stark and obvious. Pre-eminent amongst them are questions such as how we become sustainable in our use and production of energy, and how we provide everyone with the necessities of clean drinking water and a safe environment in which to live. These challenges are magnified by the fact that we are at a transition point in our development in our reliance on different energy carriers as illustrated below.



Energy Carriers with Respect to Stage of Development

The future, by definition is always uncertain, and never more so than in times of transition, which makes the challenges we are facing more extreme, and the finding of appropriate solutions even more compelling.

Future supplies of energy are a matter of great concern for society, with a significant series of ongoing enquiries (e.g. Royal Society of Edinburgh) and consultations (e.g. DTI consultation on – "Our Energy Challenge, securing clean, affordable energy for the long term"). There have also been several reports on future energy demand and supply relations, and strategies for future energy production and supply. These are informing UK government, EU and International energy and sustainability policies, particularly with respect to meeting Kyoto targets.

This high level of activity relates to concerns about: security of energy supply; declining reserves of oil and gas in the world, and from the UK perspective the UKCS; the aging, and soon to be decommissioned, fleet of coal and nuclear electricity generating stations; demands to find safe and acceptable means to store nuclear waste; climate change; and overarching public concerns and perceptions of energy and environmental sustainability.

The imperatives arising from these concerns are to:

- Extend the life of oil and gas as energy sources through exploration, reservoir characterisation and enhanced production from existing and yet to be discovered reservoirs of hydrocarbons;
- Develop the means to utilise oil and gas reserves efficiently, effectively and in an environmentally sensitive fashion (particularly in transport), and hence prolong their availability;
- Develop clean coal technologies and including CO_2 stripping and carbon capture and storage (CCS, also referred to as sequestration);
- Carbon storage can be in underground saline aquifers, by adhesion to coal seams, and in depleted oil and gas reservoirs. In the latter case, CO_2 floods can be used to enhance recovery;
- Develop renewable means to generate electricity at an acceptable cost to business and society;
- Develop fuel cell technologies and hydrogen storage solutions to enable the proposed hydrogen economy to become a reality;
- Develop intelligent grid electricity distribution systems which will be able to cope with future supplies from distributed generation systems;
- Develop technologies to produce liquid biofuel transportation fuels from a range of biomass feedstocks which are carbon neutral to replace existing transportation fuels which produce a significant proportion of greenhouse gases emitted through society's activities.

The future sustainability of society will require solutions to these issues, some of which will be addressed through the collaborative effort of the JRI, viz:

- Increased recovery of known, and potential recovery from oil and gas reserves through better resolution of sub-surface seismic sections, and improved characterisation of reservoirs;
- Increased production capacity through the development of new drilling and well completion technologies and innovative subsea engineering solutions;
- More efficient recovery systems for oil and gas, so that known reserves, including heavy oils, can be maximised – i.e. enhanced oil recovery from mature assets;
- Development and deployment of CO_2 capture and sequestration strategies (geological and biological), to ensure that fossil fuels have a much lower carbon "footprint" than currently thus reducing emissions of greenhouse gases;

- Development of clean technologies and methodologies for future energy production, so that all energy sources can be used in an environmentally responsible way – e.g. "clean coal";
- Development of innovative, sustainable electricity production and distribution systems to cope with the new demands imposed by smaller, more widely distributed generation plants;
- Development of suitable strategies for the integration of the different means of electricity generation, including fossil fuels, bioenergy, marine and wind power, solar power and nuclear energy into the electricity distribution system;
- Development of the means to replace fossil transportation fuels with biofuels and hydrogen and thereby reduce the transport carbon footprint;
- Development of decommissioning strategies and technologies for energy installations and infrastructure, including nuclear waste disposal strategies;
- Development of effective water resource management technologies, involving; clean-up and remediation, purification and treatment technologies, together with appropriate environmental sensing methodologies to reduce the environmental footprint to the energy industries.

These key areas have been identified through several of the ITI Energy Foresighting exercises (Conventional Power Generations, Future Power Networks, Low Cost Renewable Energy, Materials for Hydrogen Storage, Improved Reservoir Imaging, Mature Oil & Gas Assets) and the current DTI consultation on "Our Energy Challenge, securing clean, affordable energy for the long term".

The JRI will assist in the provision of solutions to these important issues relating to the essential transition from fossil fuels to a more sustainable future that recognises the current attachments we in the developed world have to our life style, whilst also being critically aware of the need to assist and allow developing parts of the globe to achieve their ambitions for their citizens. It is intended that it will have a major role in ensuring that Scotland has a pre-eminent position of research leadership in the above areas.

The Joint Research Institute between the Universities of Aberdeen and Dundee, and the Robert Gordon University will bring together a critical mass that will more readily be able to:

- Conduct world-class research into the development and deployment of future energy systems and clean technologies for an economical and environmentally sustainable society;
- Leverage research funding from research councils, industry, government and international agencies;
- Engage fully with industry, commerce and the Intermediary Technology Institutes in these sectors to develop and grow an internationally recognised indigenous capacity;
- Make a major contribution to the economy of this country, and to the well-being of its citizens;
- Provide postgraduate education and training in energy futures and sustainability to meet the needs of these existing, and emerging, sectors.

JRI Research Partners

The Joint Research Institute comprises relevant research activities in the University of Aberdeen, University of Dundee and the Robert Gordon University (outlined below). It should be noted that the University of Aberdeen and the Robert Gordon University are already collaborating in the creation of an Energy Futures Chair and Research Team with funding from Aberdeen City Council. Discussions between the three institutions are well advanced concerning the potential joint delivery of a PGT programme in renewable energies.

Activities in the University of Aberdeen

Collaborators in this JRI from the University of Aberdeen will be drawn from the College of Physical Sciences, specifically Chemistry, Engineering, Geology & Petroleum Geology, and the Institute for Future Energy Systems.

Energy-relevant research ranges from the characterisation of oil and gas reservoirs to engineering solutions to high pressure, high temperature fields to innovative drilling technologies to pioneering the development of renewable energy technologies. All energy-related research is conducted within the recently established Institute for Future Energy Systems.

Characterisation of oil and gas reservoirs

Research and development in this important area is focused in Geology & Petroleum Geology and particularly in the Centre for Research Excellence in Sedimentology and Stratigraphy (CRESS) and the Seismic Applications: Limitations and Developments (SALAD) facility. Research has centred around the following topics: petroleum geology, focused largely on reservoir characterisation and sedimentology.

Research in CRESS focuses on determining the sedimentary architecture of clastic depositional systems to reduce uncertainty in input parameters for reservoir models. This structured research programme will improve knowledge of permeability architecture, facies transitions, net to gross, connectivity, diagenetic effects, geobody definition and lateral relationships. It brings together the different skill sets to help better define the likely locations of new sources of oil & gas whilst increasing understanding of the geological features of existing assets which will aid recovery.

Research in the SALAD seismic imaging and data analysis laboratories investigates seismic forward modelling of outcrops; seismic stratigraphic interpretation of seismic data sets; siliciclastic and carbonate systems worldwide; and basin to outcrop scale analysis. This group brings together the seismic data interpretative skills of colleagues with a wealth of both academic and industrial research experience to better characterise oil & gas reservoirs. This group is already working with members of the Non-linear & Complex Systems Group to bring data mining algorithms to enhance interpretation of complex and noisy seismic data and thereby better characterises oil & gas reservoirs.

Other research groups investigate: organic and petroleum geochemistry; deep-water clastic reservoirs; prediction of reservoir sand quality; geomorphology and sedimentology of dry land river deposits; all of which add to a fully integrated approach to characterising oil & gas reservoirs.

Engineering solutions for oil and gas recovery

There is significant research effort research in engineering which is energy-related focusing on engineering facilities for development of High Pressure-High Temperature (HP-HT) gas fields, innovative drilling solutions, and sub-sea technologies including safety engineering. The Scottish Offshore Materials Centre (SOMC) has at its heart a state of the art HP-HT test facility which allows the testing of materials, components, equipment and geological materials under typical HP-HT down-hole service conditions. This facility will also service the needs of the Civil Engineering JRI with which it is anticipated that there will be collaboration on the development and testing of materials suitable for deployment in adverse down-hole HP/HT operating conditions.

An innovative drilling solution is under development which will significantly reduce drilling and subsequent operational costs. There is substantial research effort in collaboration with industry directed towards the use of steel tubulars and safe engineering solutions to down-hole and subsea engineering problems – both topics highlighted by the oil & gas sector as

major problem areas. This group is working with the geologists and the complex systems group to better define geological structures, controlling systems for drilling to deliver meaningful solutions to the industry.

Renewable energy research

Research in renewable energy technologies is focused on the development of bioenergy (particularly for heat, electricity and liquid fuels); innovative wave energy electricity generating systems; and the development of novel solutions for wind energy generation capacity linking into the grid infrastructure.

Work in our laboratories has significantly aided the development of bioenergy production and supply strategies in the UK. This a developing industry and there are a series of significant research challenges where technical and logistical breakthroughs will enable more cost effective production of electricity, heat and transport fuels. These breakthroughs will only be realised through multi-disciplinary research to develop innovative supply and conversion technologies to integrate with the emerging energy supply mix. It is envisaged that there will be developing multidisciplinary work involving colleagues from the Non-linear & Complex Systems and Materials Group in the Civil Engineering JRI.

Fuel cell research, whilst directed primarily towards water purification, also generates electricity, and work is ongoing to optimise the system for application in the offshore industry and potential deployment in developing countries. Our work on catalysis is providing innovative solutions to the difficult problem of hydrogen storage. Breakthroughs in this area are required to make the hydrogen economy a reality.

Carbon sequestration strategies are being investigated on two fronts: biological capture and sequestration of carbon through growing energy crops; and sequestering carbon dioxide into geological formations following extraction of oil and gas reserves. Our important work on land use modelling with respect to carbon cycling coupled with work with bioenergy is producing interesting results which could drive future scenarios for carbon sequestration coupled with energy production. Our geologists are developing deeper understanding of the processes involved in carbon storage and migration in geological structures, particularly modelling the long-term fate of sequestered CO^2.

An innovative device for generating electricity from waves is under active development and power stabilisation systems for offshore electricity generating facilities (wave, wind and tidal) are being developed.

The University of Aberdeen and the Robert Gordon University are both founder members and directors of the Aberdeen Renewable Energy Group (AREG) – a private public partnership to aid the development of renewable energy technologies. The 80+ industry membership provide significant potential for the deployment of research ideas into commercial practice.

The new Joint Chair (with RGU) in Energy Futures, funded by the Aberdeen City Council, will bring together activities in renewable energy technologies focused on bioenergy for electricity, heat and potentially transport fuels, marine and wind energy, fuel cell technologies and sustainable transport systems, and grid infrastructure related to dispersed generating systems.

Activities at the University of Dundee

The University of Dundee carries out a number of activities of direct relevance to the energy sector and to renewable energy. These include; solar cell research involving the development

of new and better materials for such devices, environmental monitoring via satellite systems, and finding solutions to the fluid dynamics problems associated with marine energy devices.

Solar Cell Research

The University of Dundee has a long history in the development of photovoltaic devices. The Amorphous Materials Research Group pioneered the field of large area electronics. The development of thin film silicon led to the first thin photovoltaics that is now a global industry and forms a key element of the mid term generation policies world wide. Devices made from PECVD silicon are still being researched at Dundee, where new methods are being sought to improve efficiency of solar cells and to lower the cost of materials and processes. This is the subject of a Supergen programme. The University houses clean rooms and laboratories for the production of thin film amorphous silicon. The work is underpinned by electronic and optical measurement and by modelling of devices and materials systems.

Environmental Monitoring

The University of Dundee has the internationally recognised NERC-funded Dundee Satellite Receiving Station, in the Centre for Remote Sensing and Environmental Modelling (CRSEM). CRSEM provides a service to the environmental research community and supports research in areas such as oceanography, marine biology, atmospheric sciences, volcanology, hydrology, snow, ice and forest fire monitoring. There are new opportunities emerging in the renewable energy sector using land based data from these satellites in conjunction with automated condition based monitoring systems. In particular, the;

- understanding, and modeling of the physical processes involved in the acquisition of remote sensing data
- design and development of remote sensing instrumentation
- interpretation and reliable extraction of key environmental variables from remotely sensed data

Environmental and Physical Fluid Dynamics

Analytical, numerical and laboratory models (together with field observations) are being used to investigate a wide range of fluid mechanics problems many of which have direct applicability to the deployment of wave and tidal energy devices. For example, research at a fundamental level is being pursued into the fluid dynamical phenomena associated with oceanic, coastal, estuarine and meteorological flows. There are specific interests in the near shore and coastal zone, where anthropogenic influences are particularly prominent.

Activities at the Robert Gordon University

Research appropriate to the JRI takes place in the Schools of Engineering, and the Built Environment. It may be categorised as follows;

Renewable technologies:

- Marine energy systems, with particular emphasis on tether-free support structures for sub-sea turbines;
- Novel designs for turbines, and micro scaling for run-of-river applications;
- Marine environmental modelling and energy extraction analysis;
- Control and integration of wind farms into power systems;
- Design of buildings for high energy efficiency;
- Renewable hydrogen production from tidal stream energy, for utilisation in fuel cells;

- Dye sensitised, liquid junction photo-voltaic cells;
- Solar energy storage through the photolytic reduction of CO_2.

***Other clean technologies*:**

- Hydrogen stripping from gas streams to produce high purity hydrogen
- CO_2 stripping from natural gas and flue gas streams
- Recovery of volatile organic compounds during oil and gas transfer operations
- Remediation of ground water systems and the assurance of water quality through waste water management
- Purification techniques for the first use and re-use of drinking water
- Photo-catalytic processes for the removal of hydro-carbons from produced water during oil and gas production
- Taggant technologies for tracking and security purposes
- Intelligent condition monitoring systems for the energy industries

Other oil and gas technologies:

- Virtual well simulations for enhanced well production
- Gas to liquids technology for the exploitation of "stranded" gas fields
- Sand control systems for enhanced oil and gas production

This research is carried out, principally, in the University's Centre for Research in Energy and the Environment (CRE+E), and the Centre for Process Integration and Membrane Technology (CPIMT). Both centres have international standing and are recognised as leading players in their fields. This is exemplified by membership of the EPSRC College, and through members acting as advisors to; the Scottish Executive, the Northern Ireland Parliament, and the UK Government.

A particular feature of these Centres is their closeness to the needs of industry. This is evinced by their outstanding record of success in acquiring PoC and KTP awards, and translating their output into Spin-Out opportunities. They have secured 8 KTP awards in the past 4 years, and received 7 PoC awards in the same period. In the past 2 years 5 Spin Out companies have been born as a result of their research. This is supported by more than 12 registered patents.

Existing collaborations

The University of Aberdeen and the Robert Gordon University together with the Aberdeen City Council are in the process of appointing a Chair and establishing a major research centre in Energy Futures. This is providing a significant opportunity through investment by the Universities and the city, and is a clear statement of commitment to the work of the JRI.

Key research challenges to be jointly addressed

The work of the JRI will be addressed through 3 main themes:

- New and renewable energy technologies
- Oil and gas technologies
- Clean technologies

New and renewable energy technologies

The future lays down a significant challenge for energy production and distribution. Climate change mitigation strategies and the decline in availability of fossil fuels will necessarily reduce, in the long term, electricity generation through conventional means requiring the development of efficient and effective means of generating and distributing energy from renewable sources such as marine, biomass, solar and wind energy generators. These coupled with electricity distribution networks are areas of expertise and strength in the three participating HEIs. The North East of Scotland is in prime position through AREG to move into the production and deployment of renewable energies and it is the stated aim of the two local authorities to actively enhance the research capacity in future energy technologies.

The aim of the research theme will be to develop new and renewable sources of energy, particularly through marine, wind, biomass, solar and fuel cell technologies including electricity storage and distribution networks. It will also provide infrastructural remote monitoring and control systems and strategies to maximise use of resource and efficiency of operation. Production and development of liquid biofuels from biomass will also be pursued.

Oil and gas technologies

Oil and gas reserves are becoming increasingly difficult to find and to extract efficiently and economically. To do so requires higher-resolution reservoir imaging data to more precisely locate reserves, and more efficient and accurate drilling technologies and down-hole and subsea technologies, particularly for use in extreme conditions such as high pressure, high temperature fields, and at the great water depths beyond the continental shelves necessitating innovative subsea engineering solutions.

The aim of this research theme is to develop innovative solutions and technologies to; enhance recovery of oil & gas reserves from existing fields, advance reservoir imaging and characterisation, enable the recovery of stranded reserves of significant value, effect improvements to drilling efficiency, provide better sand control systems and produced water treatments. There are also significant opportunities to introduce new and improved methods for gas stream clean-up and separation through catalytic and membrane technologies.

Clean technologies

Mitigation of climate change, availability of clean water and remediation of environmental pollution each has a strong link to future energy technologies.

The aim of this research theme is to develop innovative and clean technological solutions for CO_2 stripping, the production of high purity hydrogen, sub-surface sequestration, water purification through catalysis, and bio-remediation of energy related activities.

Exemplars of research opportunities that can be realised through the research partnership

The three research themes bring together the complementary research strengths in the three partner institutions which will allow the significant emergent issues in future energy systems to be addressed. This capability is significantly enhanced by interaction with the Non-linear & Complex Systems Group. This opens up whole areas for new research which could not have been realised by any one of the institutions operating alone.

For the new and renewable energy technologies theme the synergy will allow heightened research effort to address the problems of developing fuel cells and the raft of issues relating

to hydrogen storage and the development of hydrogen carriers. This coupled with emerging research in liquid biofuels will allow collaboration between engineers and chemists on addressing the bottlenecks concerned with the development of alternative transport fuels.

The JRI will allow a wider consideration of the issues relating to carbon sequestration as we can bring together groups at RGU looking at carbon stripping with geologists working on the sequestration of carbon dioxide in geological formations with engineers and land-use modellers looking at biological sequestration of carbon to develop wide ranging carbon sequestration strategies. The complementary strengths at the three institutions can be brought to bear on the development of fuel cells, not just for electricity generation but also water purification. Each of the partner institutions have capabilities in the area of marine energy whether it be in the field of hydrology, tidal stream or wave energy or grid management systems, or remote monitoring and control, or environmental monitoring. Bringing those groups together will lead to a step change in our capacity to address the research

Using seismic data to characterise oil & gas reservoirs is a major concern of the petroleum industry when trying to enhance recovery from mature assets but also for discovering new reserves. This is an area where interaction with the Non-linear & Complex Systems Group can realise real benefits as the data-mining algorithms developed in this area can be applied to interpretation of seismic data. This will allow higher resolution of the geological structures and hence reservoir characterisation. At this point the engineers at the institutions who are actively involved in developing innovative drilling solutions and down-hole techniques can be brought to bear in ensuring that the identified reserves can be accessed and extracted efficiently and effectively.
High resolution geospatial and geological information is critically important in the exploration for oil and gas reserves on the new frontiers. The combined strengths of the Centre for Remote Sensing & Environment Modelling (Dundee) and the CRESS group (Aberdeen) will allow the JRI to develop research on automatic characterisation of geobodies and in the development of new techniques to aid exploration. The experiences of modelling the UKCS of the partners will enable extension into the wider global arena, capitalising on the North Sea know-how.

Clean technologies have their application in carbon sequestration but in particular in clean-up of hydrocarbon contaminated water arising from the oil and gas industry. There is already collaboration between groups at RGU and UoA but the JRI will enable the level of that activity to be heightened.

Exemplar Projects

Offshore Electricity Generating Platforms (Davies[D], Grebogi[A], Jovcic[A], Owen[R], Rose[D,] Teo[R] and Wiercigroch[A]) [2]

With increasing pressure from environmentalists generating of electricity by wind turbines is moving offshore. Currently operating schemes are relatively close to shore but the Beatrice Project will demonstrate the potential of deploying large 5MWe turbines on offshore structures operated by the oil & gas production companies. Tidal stream and wave devices are developing in a variety of directions but all will rely on passing the power generated back to substations onshore. This presents particular logistic and technical problems. Solutions may

[2] Where A signifies a University of Aberdeen staff member, D a University of Dundee staff member, and R a Robert Gordon University staff member.

lie in the development of integrated offshore floating structures which could combine wave, wind and potentially tidal stream devices (depending on positioning).

Development of such a scheme will require a multi-disciplinary team to research the component parts and the design criteria necessary for integration onto a floating platform. It will require the hydrodynamic expertise from Dundee (Davies) coupled with the design expertise in tidal systems at RGU (Owen), the design of wave energy systems at Aberdeen (Wiercigroch), the wind energy and grid integration expertise at Aberdeen (Jovcic) and RGU (Teo). Potentially solar energy collectors could be integrated and bring in the expertise from Dundee. As this will be a floating structure it will need to be positioned relative to the sea floor and this presents significant technical problems. However, we believe that they can be overcome through Aberdeen's expertise (Grebogi) in controlling chaotic systems.

Solar Photocatalysis for Volatile Organic Carbon Destruction (Howe[A] & Robertson[R])

In 1998 the UK and US petroleum industries generated over 186,000 and 496,000 tonnes of volatile organic compounds (VOCs) respectively. Recent legislation mandates that gaseous effluents generated by the oil and gas industry, particularly volatile organic compounds, must undergo treatment prior to release in the environment. Semiconductor photocatalysis could potentially address these requirements. When TiO_2 photocatalysts are illuminated with light powerful oxidising agents are generated capable of destroying simple and complex chemical compounds. The advantage of this effective *cold combustion* process is that it results in the total destruction of the contaminants. Although this has been applied to destruction of contaminants in water to date, however, no group has applied photocatalysis to destruction of VOCs generated by the oil and gas industry. A worldwide patent search has been performed and no patents relating to the use of the technology for the proposed applications have been found. It is proposed to investigate the application of TiO_2 photocatalysis to detoxify plumes containing a multitude of VOCs under various atmospheric conditions, a situation that is more representative of actual field conditions and one that facilitates technology transfer from the basic arena to the applied arena. The project will involve the development of both new photocatalysts and a novel photoreactor.

The Robert Gordon University and the University of Aberdeen have already collaborated in an initial study, involving a joint PhD studentship, of the viability of this technology for destruction of typical VOCS generated by the Oil and Gas sector. This project resulted in the development of a lab scale fluidised bed unit which utilised commercially available TiO_2 photocatalysts. This process proved very effective for complete removal of VOC within 30 minutes treatment time. It is proposed that the two Universities will take this exciting technology forward to utilise solar radiation. This will involve the development of visible light absorbing photocatalysts by Aberdeen University which will be deployed in a solar fluidised bed reactor which will be developed by the Robert Gordon University.

Currently there is no method for the total removal of VOCs generated by the oil and gas industry because many of the emissions are dilute and efficient collection cannot ensue. The development of this reactor thus represents a very significant step forward in this area of environmental technology. The new unit will also provide a significant economic benefit to the oil and gas industry in both the UK and USA and has excellent scope for future commercialisation. The solar photocatalytic process developed through the collaborative effort of both Universities will provide a sustainable and effective complete solution for removal of VOC enabling an innovative technology to comply with future zero emission legislation.

CO_2 stripping and Carbon Sequestration (Gobina[R] & Macdonald[A])

Carbon dioxide emissions from fossil fuelled power stations are responsible for a significant contribution to global greenhouse gas emissions and hence impact on climate change.

Reducing levels of CO_2 emissions and sequestering the carbon in geological structures is a technology which is attracting a lot of interest from industry and internationally. An advantage from the UKCS perspective is the possibility to pump the CO_2 into nearly depleted oil & gas reservoirs to enhance oil recovery. The Peterhead Power Station/Miller field project is an interesting demonstration project in this regard.

There will be several different technical solutions emerging as this methodology develops. From the perspective of the JRI we can bring RGU's technology of using membranes to extract the CO_2 from flue gas streams, compress the gas and then pump it back into the geological formation. Once in the formation the fate of the gas is largely unknown and here the understanding of geological structures, mechanisms that operate in oil & gas reservoirs and 3 and 4 D seismic imaging expertise at the University of Aberdeen can be brought to bear on the project. Together the combined research effort may well yield innovative carbon sequestration strategies. It is envisaged that there will be a degree of synergy with the work conducted under ECOSSE and collaborative projects across the research partnerships may well emerge.

Technology Transfer

Each of the three partner institutions have good track records for working with industry through the KTP and POC funding mechanisms as well as attracting industrial funding. Each has also spun out a number of sector relevant companies recently. The research undertaken within this JRI is hugely important to the energy industries and it is anticipated that a significant proportion of the activity will be devoted to technology transfer activities.