EPSRC Industrial Doctorate (EngD) Centre

Efficient Power from Fossil Energy and Carbon Capture Technologies (EPFECCT)

now

Efficient Fossil Energy Technologies

Prof. Colin E. Snape, Director of the EngD Centre

- **The need for the Centre**
- Where the Centre will fit in the UK landscape within the EPSRC Doctoral Training Programme
- Where the Centre fits in the Midlands Energy Consortium (MEC) - Birmingham, Loughborough and Nottingham
- What the Centre will deliver

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The need for the Centre

- You are here today!
- You have contributed to a successful proposal.
- The weight of industrial backing was a crucial, if not the deciding element.
- The Centre represents the largest Research Council support for fossil energy power generation and conversion technologies (£6M)
- Did you notice for UK power generation statistics for January?

The need for Centre

UK power generation in January

- Wind: 0.3%
- Nuclear: 16%
- Gas: 34%
- Coal: 50%

Not certain how much coal–fired capacity will survive beyond 2015

Long-term future depends upon deployment of CCS but is needed as part of an affordable, secure and balanced portfolio.

To be on track to meet 80% CO_2 reduction targets by 2050, natural gas will need CCS.

EPSRC Industrial Doctorate (EngD) Centre
Efficient Fossil Energy Technologies

- The goal of the proposed EngD Centre is to produce research leaders to tackle the major challenges over the next 15 years in implementing new power plant to generate electricity more efficiently using fossil energy with near zero emissions
- Involves the successful demonstration of CO_2 capture, and also in reducing CO_2 emissions generally from coal utilisation, including iron making.
- 60 PhDs based in industry over the next 8 years.

We have research engineers not PG students!

- Demand is probably significantly higher, particularly due to proposed EU/UK demonstrations that are needed for deployment of clean coal CCS technologies by 2020.

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What's so special about an Engineering Doctorate and what will it produce?

- 4 year duration with a general training programme
- Higher stipend than for a traditional PhD (*ca*. £20k)
- Can recruit from companies – EPSRC covers feeds and stipends offset salary
- Extensive period of time of close to three years spent conducting basic research in industry.
- Still an emphasis on conducting original research, indeed, aiming for "Dutch style" PhD collating peer reviewed publications.

To produce leaders who will be:

- *Thoroughly versed in cutting edge fossil energy research*
- *Capable of operating in multi-disciplinary teams, covering a range of knowledge transfer, deployment and policy roles*
- *Skilled to analyse the overall economic context of their projects and to be aware of the social and ethical implications.*

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EPSRC Engineering and Physical Sciences Research Council

The rationale

- **EPSRC Centres for Doctoral Training** are a bold new approach to training PhD students, creating communities of researchers working on current and future challenges.
- 17 of the new centres will be industrial training centres that will equip their students with the business skills they need to turn pioneering ideas into products and services, boosting their impact on the UK's economy.
- The multidisciplinary centres bring together diverse areas of expertise to train engineers and scientists with the skills, knowledge and confidence to tackle today's evolving issues.
- They also create new working cultures, build relationships between teams in universities and forge lasting links with industry.

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EPSRC DTCs: The current position

EPSRC Engineering and Physical Sciences Research Council

44 (>£250 million) new Centres awarded in:

- Securing the Future" (12)
- Digital Economy (6)
- Energy (6)
- Nanoscience through Engineering to Application (3)
- Industrial Doctorates, including energy (17)

Securing the Future: objectives

- Attracting the most talented people to research;
- Pursuing the enrichment and enhancement of the quality of the training experience; and
- Enhancing the flow of people through their career pathway both in academic and industrial research careers

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Energy : the specific context, two long-term energy challenges

- tackling climate change by reducing carbon dioxide emissions both within the UK and abroad;
- ensuring secure, clean and affordable energy supply.

Energy : objectives

Centres for Doctoral Training (including Industrial Doctorate centres) were encouraged in the following themes:

- Carbon Capture and Storage
- Sustainable Power generation and supply, specifically Wind, Marine, Hydrogen and Fuel cells
- Demand Reduction

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EPSRC Energy Programme: Doctoral Training

EPSRC Engineering and Physical Sciences Research Council

-£50M Investment (including other programmes than Energy)

Doctoral Training Centres

- **University of Birmingham: Hydrogen, Fuel Cells and their Application.**
- University of Leeds: Technologies for a Low Carbon Future.
- University of Manchester: Nuclear Fission Research, Science and Technology Doctoral Training Centre.
- University of Sheffield: Sheffield Training in Interdisciplinary Energy Research: STIER.
- University of Strathclyde : Wind Energy Systems.
- University of Reading: Technologies for Sustainable Built Environments.

Industrial Doctorate Centres/Engineering Doctorate Centres:

- University of Manchester: Nuclear Engineering.
- **University of Nottingham: Efficient Power from Fossil Energies and Carbon Capture Technologies.**
- University of Surrey: Sustainability for Engineering and Energy Systems.
- University of Southampton: Transport and the Environment.
- University College London: Urban Sustainability and Resilience.

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The Midlands Energy Consortium
The Midlands Energy Graduate School (MEGS)

A Major Initiative for Post-graduate Training in Energy Technologies with £3M funding from HEFCE

- MEGS will accelerate the Doctoral and Masters level training of graduates across a broad range of energy technologies.
- This is a model for integrating the research and postgraduate training capabilities of three strong universities and a platform for knowledge transfer across the spectrum of our research portfolios.
- New Masters provision will be developed

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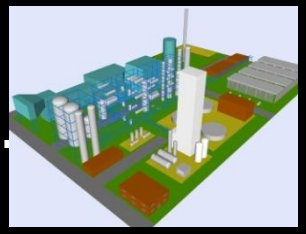
Univ. Of Nottingham Research in Clean Coal Technology And Carbon Abatement Technologies

- **CO_2 capture in combustion and gasification, novel adsorbents.**
- **Oxyfuel combustion**
- **Flue gas clean-up – Hg adsorbents, carbons for NOx reduction.**
- **CO_2 storage/sequestration, coal seams and mineralisation**
- **Long-term CO_2 utilisation, photocatalytic reduction.**
- **Social policy and public acceptability**



A multi-disciplinary internationally leading research programme

- **Editorship of Fuel – John Patrick.**
- **Nottingham hosted IEA sponsored 2007 International Conference on Coal Science & Technology.**
- **Colin Snape - 2006 Storch Award, the American Chemical Society.**
- **Mercedes Maroto-Valer - £1m EPSRC Challenging Engineering.**
- **Trecvor Drage – EPSRC Advanced Research Fellow**

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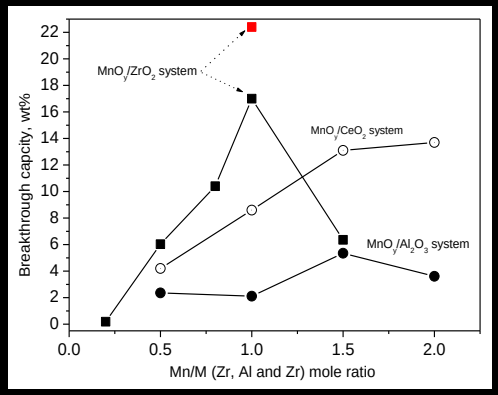
Clean coal technology and CO_2 capture: Innovative processes and materials

- New high capacity adsorbents for CO_2 capture for both combustion and gasification.

  Basic polymer system , polyethlyenimine adsorbed on mesoporous silica rate top performing adsorbent in independent US DoE study.

- Patented ultra high capacity adsorbents for Hg control in clean coal technology and natural gas processing, manganese oxide based and patented.
- Being trialled for natural gas purification in the Far East.



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Birmingham, Loughborough and the social science inputs

- Prof Richard Green at Birmingham won a Philip Leverhulme Prize for his work on electricity markets, is workstream leader for training in the Supergen Flexnet consortium and the Specialist Advisor to the House of Lords Economic Affairs Com. inquiry on renewable energy.
- Prof. Robert Dingwall is the founding Director of the Institute of Science & Society, has won over £5M in funding since 1998.
- Prof. Michèle Clarke at Nottingham holds a Chair in Environmental has a Chinese Scholarship Council project with Dalian University of Technology on Chinese public perceptions of carbon abatement technologies.
- Professor Rachel Thomson at Nottingham is Director of the Loughborough University, Materials Research School and leads Supergen consortium.
- Prof. Wu at Birmingham also brings expertise in high temperature materials.

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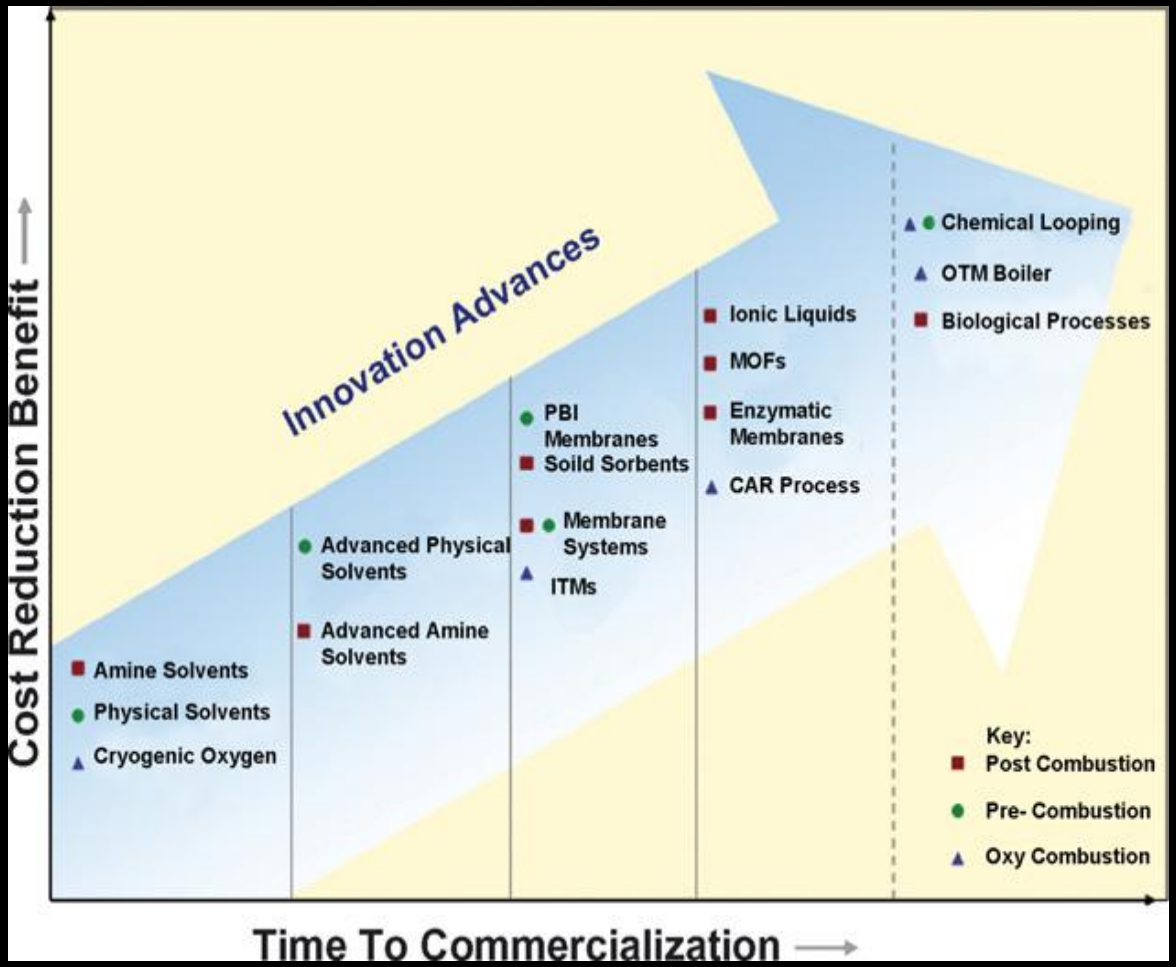
Some cross-cutting research challenges

- Improving the efficiency of carbon capture through better overall plant design and optimisation, and considering alternative capture routes to absorption in either chemical (post-combustion) or physical (pre-combustion) solvents.
- Improving the technologies for removing acid gases to low levels prior to carbon capture in combustion, gasification and oxyfuel firing, as well as controlling toxic metals, notably mercury (Hg).
- Maximising the utilisation and the range of biomass/waste feedstocks in coke making, smokeless fuel and gasification to partially displace coal from these applications.
- Slagging and ash composition needs to be thoroughly understood under the aggressive and new gaseous environments encountered in oxyfuel firing and in terms of the impact from biomass/waste.

Alternative capture technologies



- Technologies need to demonstrate clear competitive edge
- If plant is build as "capture ready" technologies can be integrated
- Technologies need to overcome challenges of other acids gases, SO_x and NO_x etc
- Rapid development required
- Risk that technologies will not scale up

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EPSRC Industrial Doctorate (EngD) Centre Efficient Fossil Energy Technologies

Led by the University of Nottingham involving collaboration with the University of Birmingham and Loughborough University

- The Centre will produce research leaders to tackle the major challenges over the next 15 years in implementing new power plant to generate electricity more efficiently using fossil energy with near zero emissions.
- Involves the successful demonstration of CO_2 capture and reducing CO_2 emissions from coal utilisation, including iron making and smokeless fuels.
- These leaders will be part of the new breed of engineers thoroughly versed in cutting edge research and capable of operating in multi-disciplinary teams, covering knowledge transfer, deployment and policy roles.
- They will have the skills to analyse the overall economic context of their projects and to be aware of the social and ethical implications.

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EPSRC Industrial Doctorate (EngD) Centre

Efficient Fossil Energy Technologies

Prof. Colin E. Snape, Director of the EngD Centre

How the Centre will Operate

- some specifics on the training programme and operation

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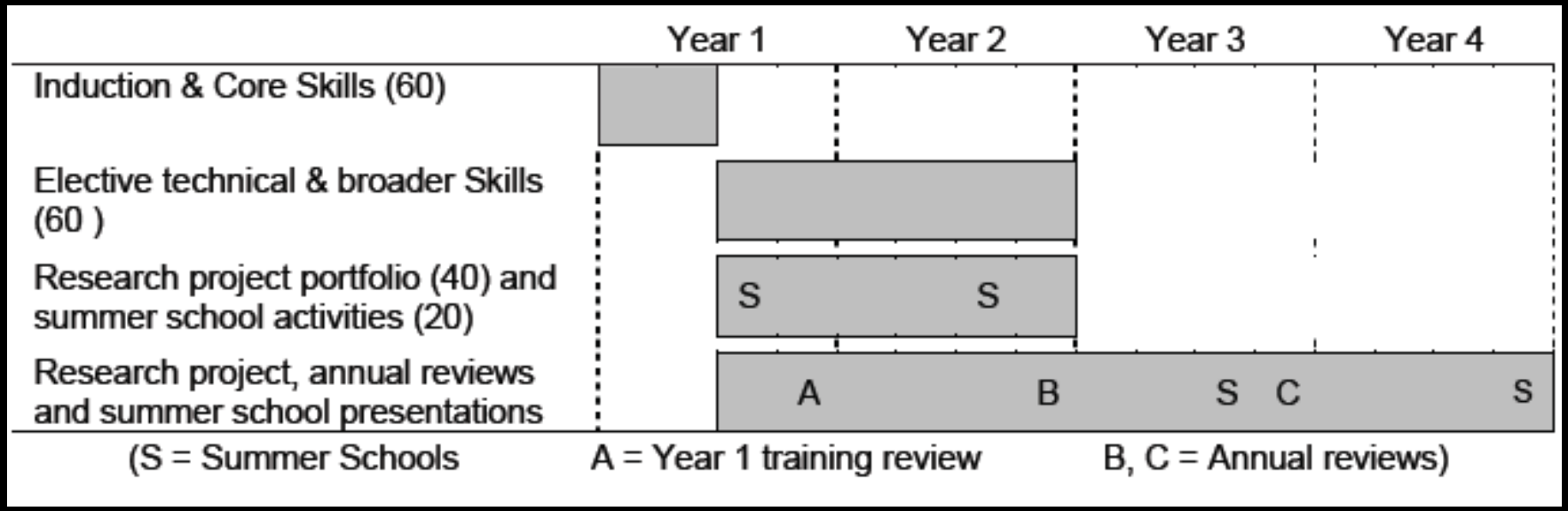
Schematic representation of the training programme



- Smooth transition into the project but training does continue
- Summer schools will play a key role
- ***Plenty of opportunities for industrial involvement in delivering the training programme***

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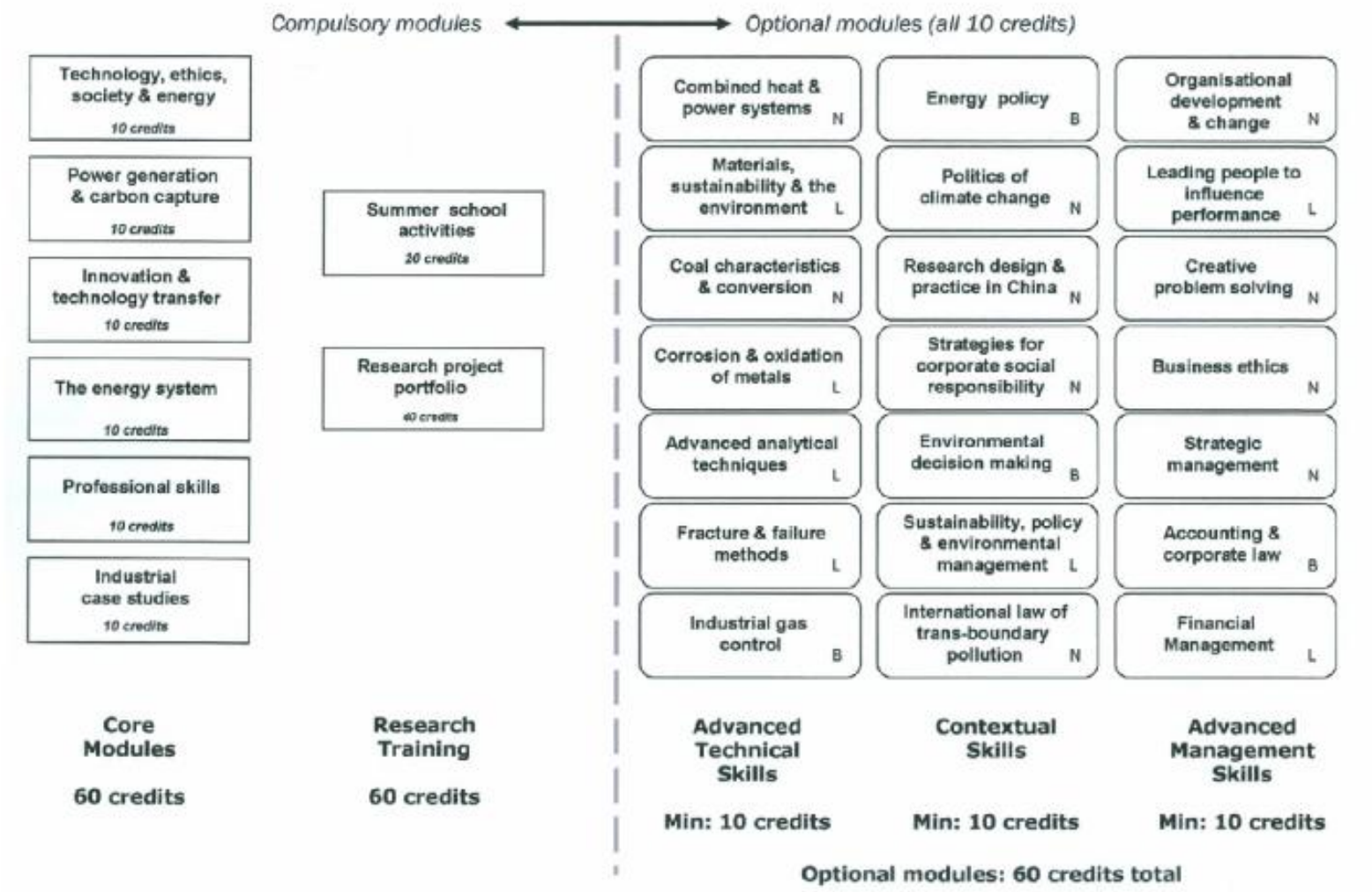
Eng.D training pathway showing the compulsory and elective modules



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Core Modules (60 credits) – first semester

Core Modules	Description
Technology, Ethics and Society (N) *NM*	This module will introduce students to ways of thinking about the wider societal, cultural, political and global contexts of technologies and innovation, and facilitate discussion of potential ethical questions that emerge at these interfaces.
Power generation and carbon capture (N) *NM*	The material will be developed from an existing fuel technology module to focus specifically on power generation, covering both combustion and gasification plant, and encompassing common issues associated with slagging and fouling, together with existing and emerging carbon capture technologies and technological issues surrounding CO_2 compression, transport and storage.
Innovation and Technology Transfer (UNIEI, N)	This 'hands on' practical-based module provides students with a clear understanding of the importance of innovation in the exploitation of new scientific and technological developments and the transfer process for this technology to enable commercialisation. The political and sociological debates about the significance of technology transfer from universities will be considered as well as the importance of IP and patenting as a key element of commercialisation.
The Energy System (B) *NM*	This new module will give students an overview of the energy system in the UK, from a technical and a socio-economic point of view. A team of lecturers will ensure that students were familiar with the main sources of energy and ways of generating electricity, with the demand for energy, its environmental impact, and with the economics of the energy industries.
Professional Skills (Graduate School, N)	This new module will consist of a carefully selected series of courses from the Graduate School research training programme to provide the student with training to complete their doctorate and prepare for their chosen career. Early courses will include *Nature of the Doctorate and Supervision*, *Research Policy and Management*, *Intellectual Property* and *Project Management*. Later courses will include *Getting Published*, *Preparing for the Viva* and *Media Awareness*.
Industrial Case Studies (L)	This module will comprise a series of presentations by colleagues from our industrial collaborators and other organisations, including IEA Coal Research, and will cover a broad range of technical and general issues related to power generation and clean coal technologies, CCS and reducing CO_2 emissions, highlighting particular topics of current interest and strategies for problem solving.

Research Training

Research training	
Research project portfolio (40 credits)	The portfolio will comprise the following activities during the first two years. (i) A reflective essay on the key issues, both technical and general, in relation to the topic area from the core modules (5 credits) (ii) A literature review of the topic area after this has been explored in conjunction with the company (15 credits). (iii) Detailed planning of the research project (10 credits). (Iv) A public engagement activity linked to the first UK summer school (5credits). (v) Presentations at the first two Summer Schools on the literature review/planning and the initial findings, respectively, together with preparing the first conference paper at the end of the second year (5credits).
Summer School activities (20 credits)	Two modules are based on the first two Summer Schools, the one in the UK involving the group exercise to fully explore the broader economic and societal aspects of their projects and the one in China exploring the status of relevant Chinese R&D activities also in relation to their projects.

The Summer Schools

- The annual Summer Schools are clearly a key feature in giving the EngD Centre identity, both nationally and internationally
- Will forge the dynamic interactions between the research engineers.
- Considerable value will also be added to these events from the participation of our international contacts so that these events will build up to becoming recognised distinctive events.
- The annual Summer Schools will alternate between China (held at the University of Nottingham Ningbo campus, Zhejiang Province) and the UK (to be rotated between Birmingham, Loughborough and Nottingham).

China Summer School Programme

Day	*Itinerary*	*Day*	*Itinerary*
1-2	International travel; Reception	9-10	Workshops of team-based multidisciplinary activities
3	Opening ceremony; Introductions; Facilities tours; Keynote Speakers	11	Student research project presentations
4-5	Lecture programme	12	Industry / academia visit
6	Visit to Power Stations	13	Summary, conclusions and close
7-8	Cultural activities / visits	14	International travel

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Allocation of Projects: Commitments will be honoured for the first two years and thereafter

Company/Organisation	Number of REs, first two cohorts except where stated	Status (as indicated in the letters of support)
Alstom	6 *(15 in total)*	Confirmed
Doosan Babcock	5 *(8 in total)*	Confirmed
E.ON	2	Confirmed
RWE	*2 (over 4 in total)*	Confirmed
Air Products	2	Confirmed
Rolls Royce	1	Confirmed
CPL	1	Confirmed
Welsh Power	1	Confirmed
Innospec	2	Confirmed
Corus	2 *(5 in total).*	Confirmed
The Energy Technologies Institute (ETI)	1 *(at least 2 in total)*	Confirmed, REs tied to particular projects
British Coal Utilisation Res. Ass. (BCURA)	*(5 in total anticipated)*	Envisaged after the first year
Drax Power	*(1 anticipated)*	Envisaged after the first year

Can front load, i.e. more than 10 per year in the first 2 or 3 years if there are the projects and we can recruit the research engineers.

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Supervisory Arrangements

- Each research engineer will be supervised by a multi-disciplinary team including:

  - the principal academic supervisor

  - the co-supervisor - often in a different institution to the main supervisor

  - an industrial supervisor and

  -a mentor with the responsibility of guiding the RE through the formal training programme, drawn from our team of social scientists and economists.

- The Centre will benefit from a wide range of supervisors.
- 16 scientific and engineering academic staff currently supervise over 80 doctoral students (46.0 FTE) and, in total, they have supervised over 100 PhDs to completion.

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PhD Supervisory Team

Supervisor	School/Res, Group	Main Research interests
Nottingham		
CE Snape EH Lester TD Drage MM Maroto-Valer JM Andresen JP Robinson	Chemical & Environ. Eng	Fundamentals of coal combustion, gasification and carbonisation, Catalytic effects of metals on combustion and gasification. Combustion burn-out models incorporating char morphology. Advanced characterisation of coals and chars by NMR and microscopy. Novel adsorbents for CO_2 capture, Hg and acid gas control. Mineralisation of CO_2. Impact of impurities on phase behaviour of CO_2. Membranes, microwave processing applications, plant design.
TH Hyde, AA Becker, P Shipway	Mech, Mat & Manu Eng.	Plant life monitoring and structural integrity of power plant components. Creep and Fatigue of materials and components.
H Power D Giddings	Mech, Mat & Manu Eng	Physical model development, flow visualisation & the application of CFD to complex fluid flows. Moving boundary & phase change problems, non-Newtonian fluids & flow instability.
MD Steven	Geography	Dispersion modeling, simulated CO_2 release into the atmosphere
Loughborough		
RC Thomson RL Higginson	Materials Dept.	Modelling and characterisation of microstructural evolution in complex power plant alloy systems in processing and service. Thermomechanical processing of metals.
Birmingham		
J Wood	Chem. Eng.	Adsorbents for CO_2 capture and catalysts to activate and convert CO_2 to fuels and methanol
X Wu I Jones	Metallurgy & Materials	Relationships between alloy, microstructure and failure, processing of materials and process development for manufacturing of components. Structural and chemical nano-assessment, using electron microscopy.

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Management of the Centre

- The Centre will be governed by a **Management Committee** that will meet quarterly to set overall research and training strategy, oversee quality assurance and ensure financial control of the Centre in accordance with Grant Terms and Conditions and University policy.
- MC will approve selection of EngD projects, changes to the training programme and action recommendations from the Advisory Board.
- It will also report to the Midlands Energy Graduate School which will provide the cohesion across the Consortium to deliver the broad energy training programme proposed.
- The **Advisory Board** will meet at least annually to ensure the Centre addresses policy and industrial drivers in the UK.
- It will be chaired by an industrial member (Mike Farley) with representation from the other industrial partners, the Knowledge Transfer Networks (KTNs), the ETI and professional bodies and other relevant organisations.

Recruitment

- Flyer to be used to target final year students in science & engineering, e-mail address for responses: efet@nottingham.ac.uk
- Web site ready to be launched: www.engineering.nottingham.ac.uk/efet
- Summer internships to attract future intakes.
- Procedures for handling recruitment and assigning project to be discussed and agreed by Advisory Board.
- ***Need to act quickly to recruit the first cohort, final year students generally make decisions before they embark on finals!***