

### EPSRC Industrial Doctorate (EngD) Centre

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

or

## Efficient Fossil Energy Technologies (EFET)

Led by the University of Nottingham involving collaboration with the University of Birmingham and Loughborough University, our partners in the Midlands Energy Consortium

### Prof. Colin E. Snape, Centre Director

- The need for the Centre and where it fits in the UK landscape within the EPSRC Doctoral Training Programme and the Midlands Energy Consortium (MEC)
- What the Centre will deliver and how it will operate



### EPSRC Industrial Doctorate (EngD) Centre Efficient Fossil Energy Technologies

- The goal of the 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
- 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.
- 60 PhDs based in industry over the next 8 years (50 funded by EPSRC).

#### **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.



## 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 fees 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.



## Drivers for change - skills

- Leitch Review (Dec 2006) and *World Class Skills: implementing the Leitch Review of Skills in England*
- Working Futures report (Jan 2006)
- Energy White Paper (May 2007)
- Meeting the Energy Challenge: A White Paper on Nuclear Energy (Jan 2008)
- Skills Needs in the Energy Industry – EI (2007)
- Investigation into high-level skills shortages in the energy sector – UKERC (2008)
- Energy Skills – Opportunity and Challenge – A report to government by the Sector Skills Organisations responsible for energy (Oct 2008)
- Low Carbon Industrial Strategy (July 2009)
- Low Carbon Transition Plan (July 2009)
- Skills for a Low Carbon Resource Efficient Economy (2009)



## High level skills - UKERC

- Skills shortages already causing problems
- Technical skills in greatest need
- Innovation and infrastructure replacement will exacerbate the problem (or be limited by it)
- Shrinking pool of technical graduates
- Increasing recruitment required from overseas
- Sector has a poor image
- Skilled labour tends to stay in the industry, retention rates good even post-training
- Generally good levels of pay and sector seen as "engaging and exciting"



## EPSRC DTCs: The current position



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

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





**EPSRC Energy Programme:  
Doctoral Training**

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

**EPSRC** Engineering and Physical Sciences Research Council

**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.



**The Midlands Energy Consortium hosting the ETI  
The Midlands Energy Graduate School (MEGS)**

*A Major Initiative for Post-graduate Training in Energy Technologies with £3 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
- Work with themed doctoral training centres, 150 new PhDs
  - Efficient Fossil Energy Technologies
  - Hydrogen, Fuel Cells and Applications
  - Energy Demand Reduction and the Built Environment

**Outcomes of the Midlands Energy Graduate School**

- Significantly increased number of post-graduates in low carbon technologies to match the market demand.
- Pioneering level of collaboration within the Midlands Energy Consortium and Regional Partners improving the quality of the training programme, particularly awareness of *knowledge transfer, deployment, policy, society and ethics*.
- New partnerships with industry, UK & abroad, for doctoral and masters training.

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Director of MEGS**



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

- CO<sub>2</sub> capture in combustion and gasification, novel adsorbents.
- Oxyfuel combustion
- Flue gas clean-up – Hg adsorbents, carbons for NO<sub>x</sub> reduction
- CO<sub>2</sub> storage/sequestration, coal seams and mineralisation
- Long-term CO<sub>2</sub> 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.
- Trevor Drage – EPSRC Advanced Research Fellow, MEGS\Assoc. Prof.









**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.

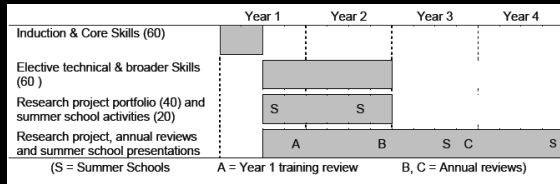


**Some cross-cutting research challenges**

- 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.

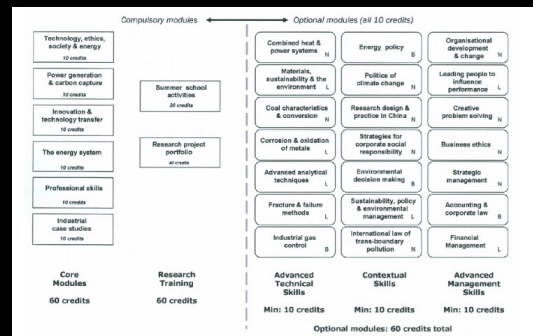
## Schematic representation of the training programme



- 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**



## Eng.D training pathway showing the compulsory and elective modules



## 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 <sub>2</sub> compression, transport and storage.
Innovation and Technology Transfer (UNIEL, 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 <i>Nature of the Doctorate and Supervision</i> , <i>Research Policy and Management</i> , <i>Intellectual Property and Project Management</i> . Later courses will include <i>Getting Published</i> , <i>Preparing for the Viva and Media Awareness</i> .
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 <sub>2</sub> emissions, highlighting particular topics of current interest and strategies for problem solving.



## 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 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



## 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.

Virtually a full order book before the Government announcement of up to 4 CCS demonstrations.



## Supervisory Arrangements and Industrial Support

- Each research engineer will be supervised by a multi-disciplinary team including:
  - the principal academic supervisor
  - the co-supervisor - often in a different MEC 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.
- In addition to £6M EPSRC funding and the inherent costs for hosting the research engineers, each industrial partner will provide an additional £40k for each project (£2.4M).



## The First Cohort of 11



- Projects RWE (3), Doosan Babcock (3) and Alstom (5)
- Topics
  - oxyfuel (2)
  - high T materials (3)
  - high T diagnostics (2)
  - biomass co-firing (1)
  - capture plant optimisation (1)
  - amines (1)
  - CO<sub>2</sub> phase behaviour

### Second year – new industrial partners

E.ON, BP, Corus, Air Products, SSE, Roll Royce, Johnson Matthey, UCG

