

Gas Futures – a European perspective

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Imperial College London



Imperial at a glance

Objectives

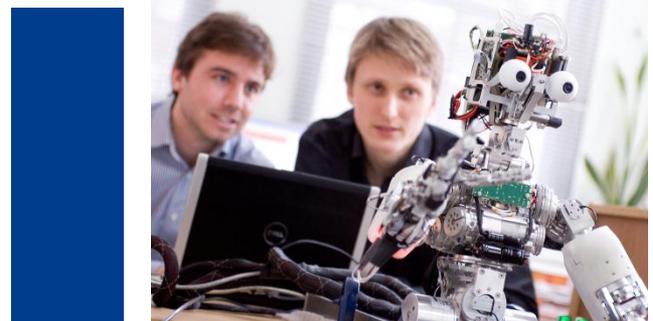
- World-class scholarship, education & research in science, technology, engineering, medicine & business
- Interdisciplinary collaboration
- Communicate & share knowledge

Faculties

- Business School
- Engineering
- Medicine
- Natural Sciences

£700M Turnover

- Student fees £120M
- Research income £300M



An international institution

49% students non-UK nationals
from **126** countries

35% staff non-UK nationals

14,000 students

- **8,600** UGs
- **2,500** taught PGs
- **2,400** research PGs



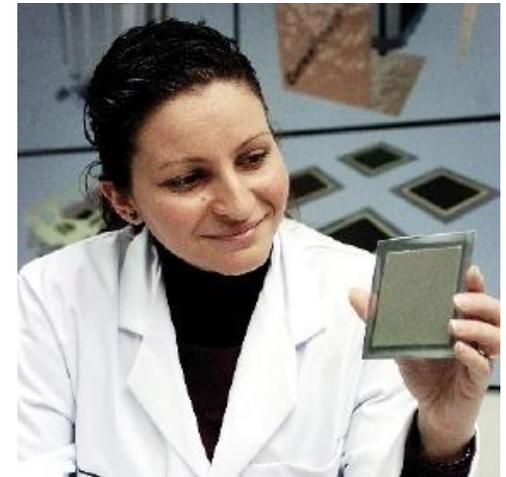
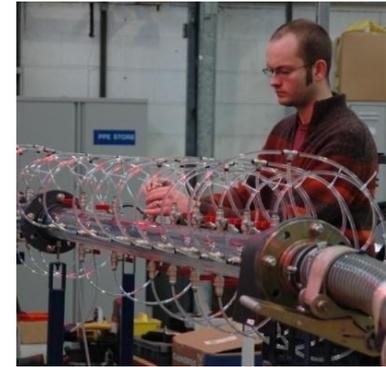
Enterprise & translation

Imperial Innovations

- 79 equity holdings in spin-out companies
- 163 commercial agreements under management
- 150+ licence agreements
- £14M invested in 20 companies
- £75M raised from portfolio of businesses
- 3 businesses sold & 3 new businesses funded
- 344 inventions disclosed
- 48 patents filed
- 24.6% increase in asset net value

Imperial Consultants (ICON)

- Leading UK academic consultancy provider
- 500+ Imperial staff involved

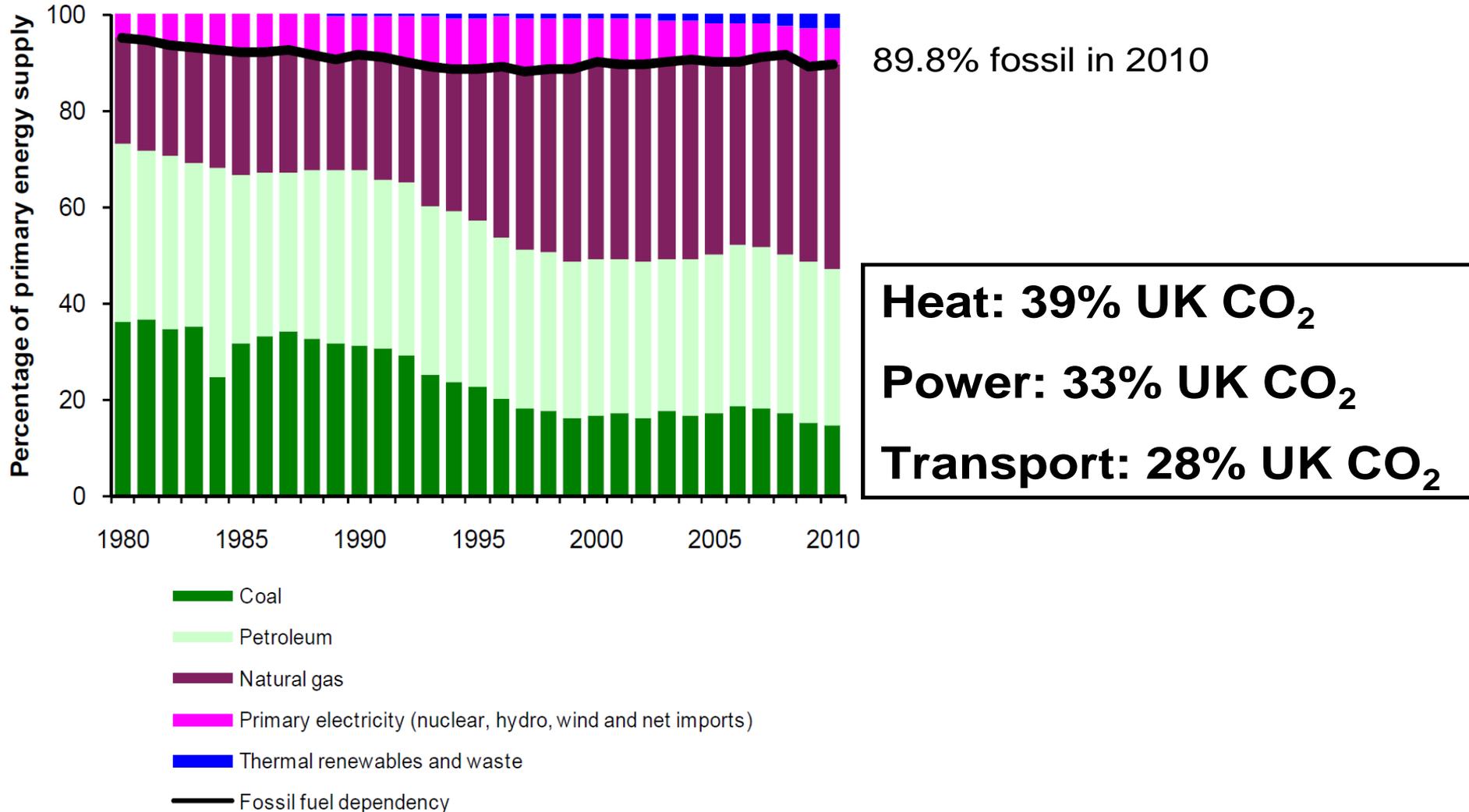


Energy Futures Lab: an institute of Imperial College London

- Established in 2005 to promote and stimulate multi-disciplinary research, education and translation in energy at Imperial College London.
- Imperial has around 600 researchers undertaking energy research, plus dedicated energy Masters programmes.
- A flagship 'Global Challenge' institute of Imperial College London with the remit to:
 - Build strategic energy research programmes with partners - £90M of industry funding has been invested in energy research through EFL to date, £60M from industry.
 - Support and widen participation in energy research across the College.
 - Develop energy professionals of the future.
 - Engage with business and policy makers.
 - Offer an award-winning Outreach programme with the Outreach Lab.



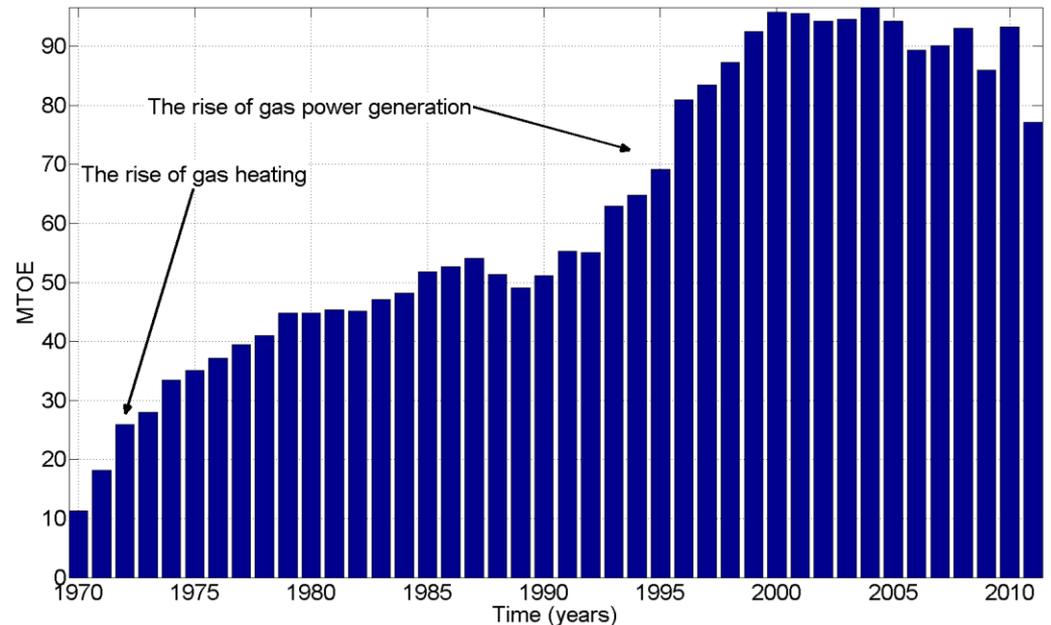
UK: Share of fuels contributing to primary energy supply



The rise of gas in the United Kingdom

- Over the last 40 years, gas has become a key player in the UK energy system
- Seeded by the discovery of gas in UKCS
- Sustained by a coal -> gas switch in heating, and introduction of central heating
- Consolidated by the "dash for gas" in the 1990s for power generation
- Despite **marked** contextual differences, could Brazil follow a similar path?

The Rise of Gas in the UK Energy System
(Gas Primary Energy Consumption 1970-2011)



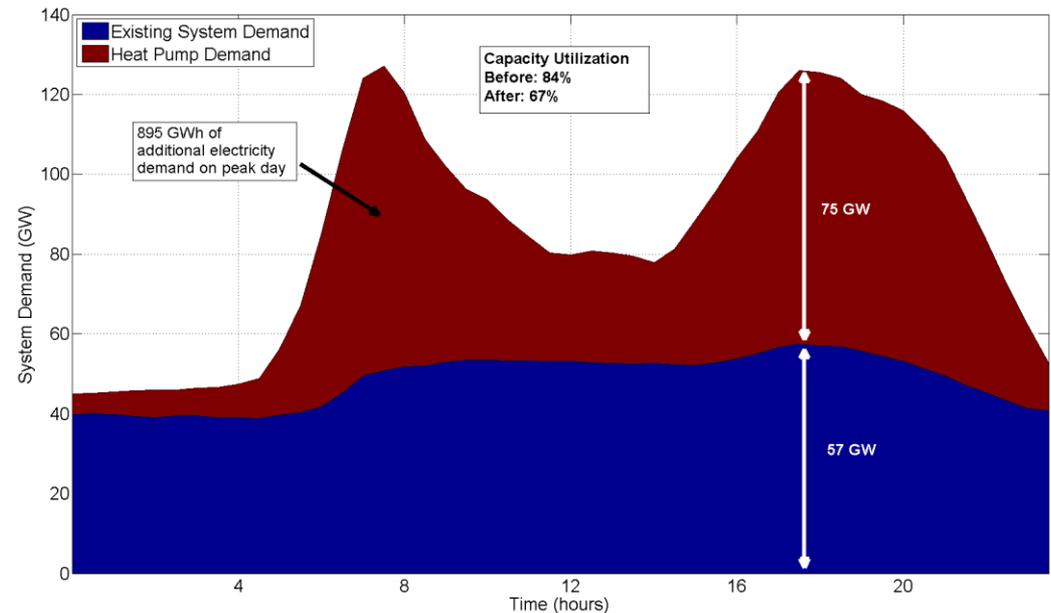
Source: Digest of UK Energy Statistics, 2012

Why gas?

- Increasingly large proven and probable reserves worldwide, including “unconventional” shale gas and coalbed methane
- Relatively low carbon fuel => Hedge against uncertainty in climate change mitigation targets
- Low pollutant emissions => local applications
- Key balancing partner for intermittent renewables
- Gas generation assets often have low capital cost, short lead times, fast capital streams, and are often price-setters in electricity markets => reduced risk
- Reducing geo-political concerns, and increasing diversity of supply options
- LNG trade creating a global market

Does electrification make sense?

- Europe has signed up to challenging targets of ~80% CO₂ reduction by 2050. Many studies to date have focussed on low carbon electricity as the key enabler for this transition, supporting the increased electrification of transport and heat.
- But there is increasing recognition of the extremely high system costs arising from delivering this vision.
- e.g. analysis of UK electricity demand if electrical heat pumps are used to displace gas in the heating sector showing the large increases in peak load



(Adapted from: Hawkes AD, Brett DJL, Brandon NP, (2011) Role of fuel cell based micro-cogeneration in low carbon heating, PROC IMECHE PART A- JOURNAL OF POWER AND ENERGY 225 pp198-207).

How can gas best contribute to a future low carbon energy system?

- Analysis published by the European Gas Forum [*Making the Green Journey Work*, 2011] has shown that Europe can reach its 2050 greenhouse gas reduction target at lower cost (450-550B Euro), with less risk, and with less challenging implementation than has been suggested by other recent studies such as that of the European Climate Foundation's Roadmap 2050 which emphasised electricity as the primary low carbon energy vector.
- The pathways developed make greater use of low-cost generation technologies in the near term, complemented by a significant proportion of renewable energy sources (RES) in order for emissions goals to be met, with the RES share of the power mix growing steadily to 30-34% by 2050.

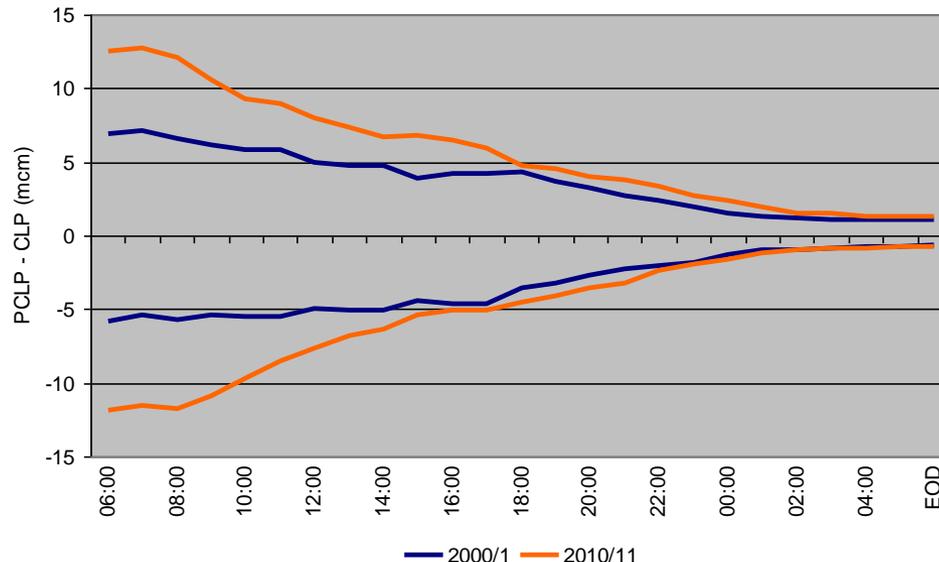
How can gas best contribute to a future low carbon energy system?

- There is increasing capability in the academic community to analyse the integration in gas and electricity networks on both a spatial and temporal basis to explore optimum system design and support the analysis of policy measures [e.g. *Multi-time period combined gas and electricity network optimisation*, Chaudry, Jenkins and Strbac, *Electric Power Systems Research* 78 (2008) 1265–1279].
- We have recently used these approaches to explore the economic benefits of energy storage, showing a value of the UK energy system of as much as £10B per annum by 2050 for some scenarios.

www.carbontrust.com/resources/reports/technology/energy-storage-systems-strategic-assessment-role-and-value

The need for a Smart Gas Infrastructure

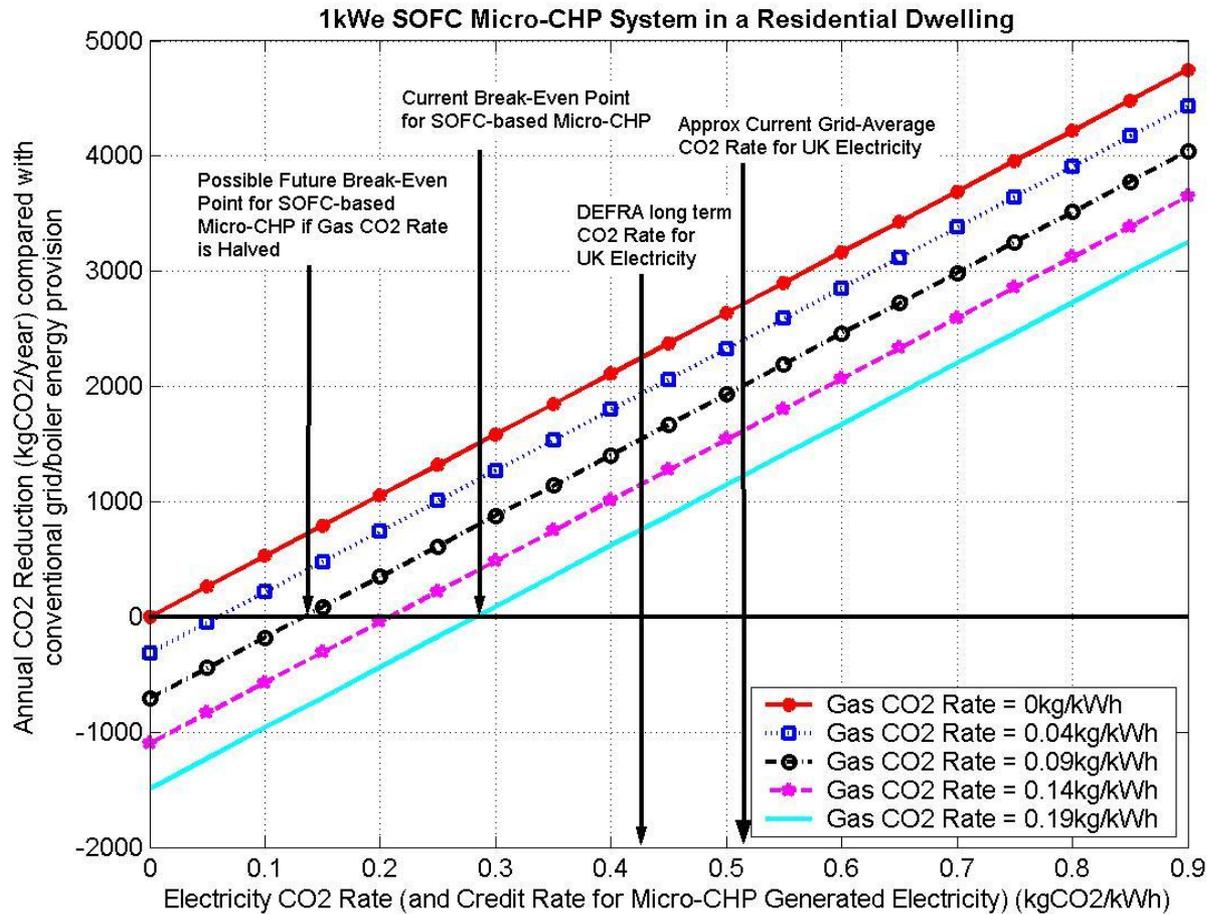
- Predicting flows in the UK national gas grid is becoming more challenging.
- Changes are being driven in part by gas power generation balancing unpredictable wind power generation.
- Increased role and value for high deliverability energy storage, and for the potential for gas to contribute as a transport fuel.
- Increased potential for load shedding/shifting across energy vectors - e.g. shifting heat or cooling load to accommodate balancing activity.
- Gas will therefore be a key partner in future **smart energy** networks.



Performance of PCLP – CLP (PCLP: Predicted Closing Linepack, CLP: Closing Linepack)

Source: National Grid **Gas Ten Year Statement 2011**

Environmental benefits of gas fuelled mCHP in the UK showing how the carbon benefits depend on the reference case



What are the key research questions?

- We need to develop technologies to reduce the carbon impact of gas to secure its future and benefits beyond a transition fuel – such as increased use of carbon capture and storage, carbon capture and conversion, bio-gas, and hydrogen.
- We need to develop new technologies for the high efficiency utilisation of gas, e.g. in transport, for cooling, for power generation, etc.
- We need to continue to develop and apply tools to explore the economic and environmental benefits derived from integrating gas into future energy systems in Sao Paulo, in Brazil, and elsewhere, against a range of future scenarios.

Experience of collaboration - Research networks

18 research networks to enable internal cross-departmental communication and provide external focal point



An example – the Smart Energy Network



Control and
power
electronics



Integrated
heat strategy

Bloomberg

Business
strategy



Appliances

Manufacturing
And services
efficiency



Smart
grids

Smart
Energy
Networks

Gas
Utilisation &
networks



Communications



Transport
Systems &
policy



Transport for London

Vehicles



Consumer
behaviour



Grand Challenge Research programmes

The Energy Futures Lab develops strategic, multi-disciplinary research programmes with industry, and has a track record of working internationally.

Urban Energy Systems

- Funded by BP to explore the ways in which flow can be optimised within cities to reduce energy usage.
- Case study cities include London, New York and Shanghai plus eco-towns in China and Middle East.
- Software tool developed and applied to a range of eco-town projects.

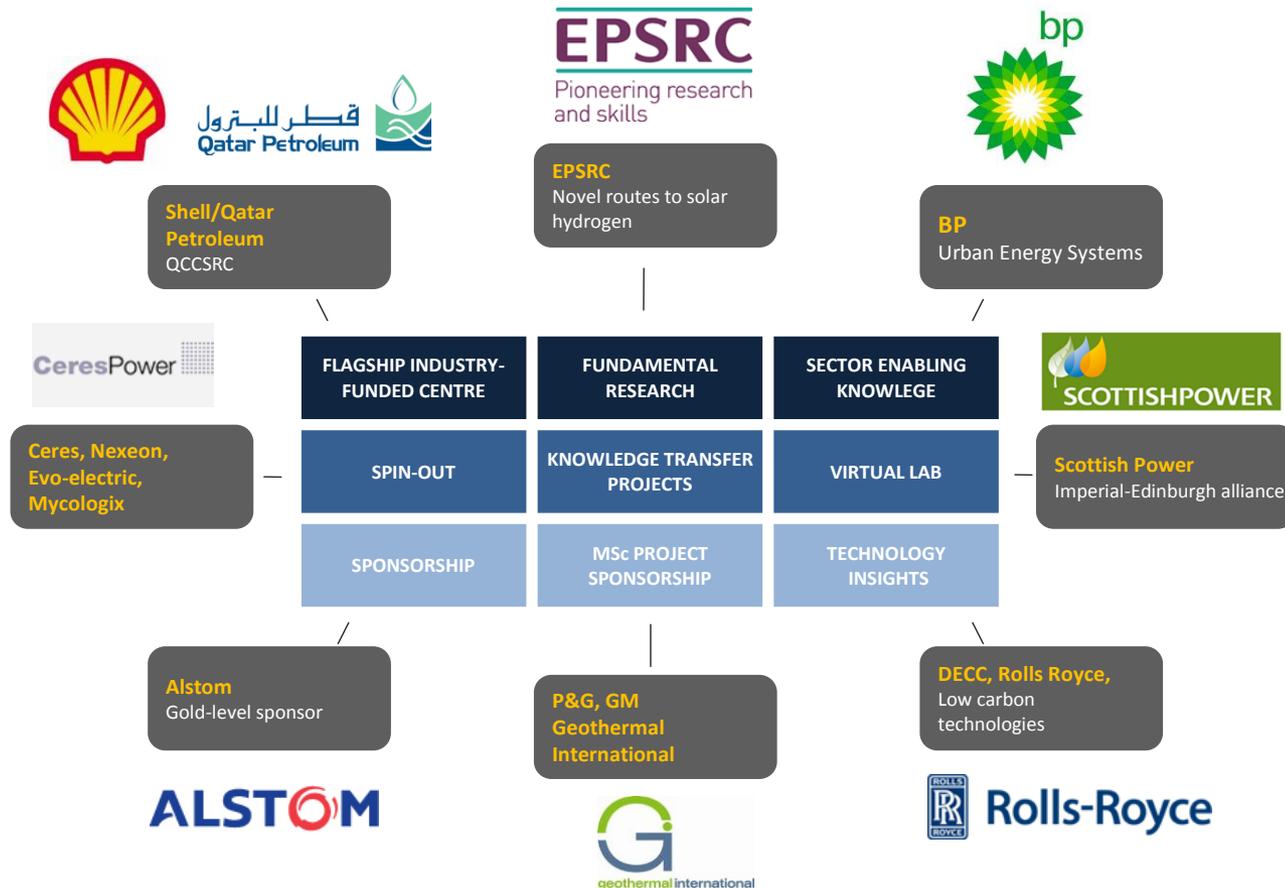


Advanced Petroleum Engineering

- 3 funded programmes with Shell as industry sponsor
 - Shell-Imperial Grand Challenge on Clean Fossil Fuels .
 - Qatar Carbonates and Carbon Storage Centre – with Qatar Petroleum including education and capacity building in Qatar, and supporting the establishment of a new research and technology centre in Qatar.
 - CO₂ capture, transport and storage technologies – with Masdar in Abu Dhabi.



Experience of Partnership: working with Industry, both within the UK and internationally



Educating the next generation of energy professionals

MSc in Sustainable Energy Futures

Uniquely structured one year masters course for students from varying backgrounds taught across 3 Faculties (science, engineering, business).



Centre for Doctoral Training in Energy Futures

Provides Imperials energy PhD students with the opportunity to put their research into the wider context of the energy system.



Racing Green Endurance

Student led project which in 2010 designed and built an electric supercar and drove the 26,000 km length of the pan-American highway.



Beetle hires
sustainable
energy
expert

Mr Veys recently took time out from his money management career to do an MSc in sustainable energy futures at Imperial College London.

Translating energy research

Imperial translates its research at a variety of levels and timescales.



Public engagement in energy issues

Knowledge transfer with industry and government



Media coverage on energy issues

Evidence based policy advice

Commercialising energy research via Imperial Innovations



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