University challenge

BP has created a series of innovative, long-term relationships with leading universities around the world to research the fundamental science that will change the way the world sources and uses energy. In the second feature to appear in The BP Magazine, BRUCE MCMICHAEL reports on two of the cutting edge programmes underway in Europe and America.

PHOTOGRAPHY DAVID HIGGS AND BPIMAGESHOP

Alchemy: Scientists in California are looking at how to transform gas into easily transportable fuels and chemicals.

Natural gas flares burn openly across vast areas from Africa to Russia wasting billions of cubic feet of gas every day, a by-product of oil production. About two-thirds of the world's gas reserves are too far from markets and moving this so-called remote gas from source to refinery and market is difficult and expensive.

In California, researchers from the University of California at Berkeley and the California Institute of Technology (Caltech) have been awarded a $20m grant by BP to advance the frontiers of gas conversion research aimed at transforming gas into easily transportable high value fuels and chemicals. "Their only boundary to research is that feedstock must be methane, the main ingredient of natural gas," says Theo Fleisch, Exploration and Production distinguished advisor and BP's enthusiastic US programme director.

Meanwhile, scientists from the BP Institute on Multi-phase Flow at Cambridge University, England (BPI) are already forming knowledge-led networks with a wide range of BP scientists, engineers and technologists publishing academic papers and filing patents.

These are two of BP's sponsored research programmes which are seeking step-changes in how the planet's precious energy resources are used.

This freedom to research is highly valued by the academic community. Professor Andrew Woods, leader of the BP-supported BPI research team at Cambridge, says: "The choice of which research projects we undertake is informed by industry's needs as well as the excitement of doing scientific research."

Woods believes BP's relationship with academia needs careful nurturing and this opinion is endorsed in California by Berkeley's professor of chemical engineering Alex Bell, who likens BP rapport with the universities as "riding an Arabian steed on a light rein.

"We do fundamental research. If it is too applied we have less interest. We are working on projects in which a breakthrough would make a material difference to BP."

However, technical successes do not necessarily mean that it will be commercialised: "That's BP's call," he says.

The academic institutions chosen to join the BP-sponsored research followed a rigorous selection process involving many leading universities. The proposals submitted by Caltech and Berkeley were of such high calibre and relevance to BP's business and environmental ambitions that each college was awarded a $10m research grant spread over a decade. The grant will help support up to ten faculty members and some 25 graduate students and postdoctoral fellows.

Although separated by just 300 miles of sun-drenched southern Californian landscape there has been little contact between their respective chemistry and chemical engineering departments, until now.

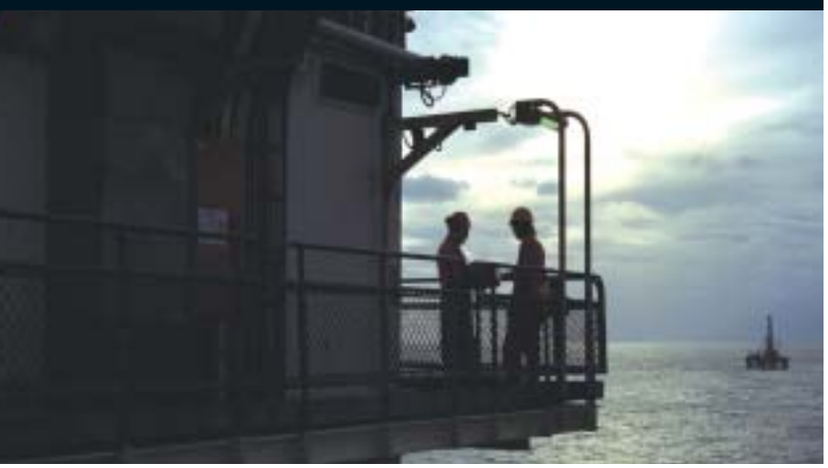
The two universities are collaborating through the Methane Conversion Co-operative (MC^2) programme, focussing on the role of catalysts in methane activation chemistry. An overall aim is a major reduction in the energy required for conversion, potentially leading to substantially lower emissions of greenhouse gases.

Converting natural gas into products is an exercise in modern day alchemy. One way to do this is to blend methane (natural gas' main ingredient) with oxygen and/or water under heat and pressure in a reformer to produce synthesis gas or syngas, a mixture of carbon monoxide and hydrogen.

Via the Fischer-Tropsch process, syngas is transformed into waxy hydrocarbons, which in turn are cracked into a range of products including clean diesel and jet fuel. Other syngas conversion processes yield methanol, ammonia and hydrogen.

Testing times: In this experiment at Cambridge, multiphase flow through joining pipes is explored. Gas is injected at the base of a pipe filled with liquid and the resulting bubbles rise through the pipe, lifting liquid up and out of the apparatus.

Talking heads: Meetings to discuss the Methane Conversion Cooperative programme are held at BP locations, including the company's gas-to-liquids facility at Nikiski, Alaska.



As the search for cheaper feedstocks gathers pace, MC^2's work on developing more effective catalysts becomes imperative. BP's Fleisch says: "methanol is a promising fuel and the centrepiece in a gas refinery".

A measure of MC^2's success will also be judged on how the technology can improve the economics and viability of BP's upstream operations.

Fleisch identifies recent bold moves by some of our competitors in Qatar as the beginning of the "gas to products", or "GTP", age. Large volumes of stranded gas are converted into liquid fuels and chemicals feeding into ready, high value markets.

While the two universities work in co-ordination with BP, they are taking different routes in their approaches to methane conversion.

The Berkeley group focuses on heterogeneous catalytic approaches for producing liquid fuels and chemicals. Building on its strength in understanding catalyst structure-performance relationships, professor Bell's team seeks major breakthroughs in catalyst and process design for both direct and indirect conversion of methane. By contrast, the Caltech team, led by Jay Labinger and John Bercaw, are developing novel, homogeneous catalytic approaches.

"We have independence that allows us to look at problems and manage them in a different way than would be the case if the work were being done in commercial laboratory," Berkeley's Bell says.

For the MC^2 programme, biannual meetings are held alternately in California and at BP-specific locations, including the petrochemicals research-facility in Hull, England and at the company's gas-to-liquids test facility at Nikiski, Alaska, where dialogue and ideas are refreshed and vital contacts nurtured.

Present at many of the meetings is Enrique Iglesia, professor of chemical engineering at Berkeley and a key member of the MC^2 programme. This year he received the prestigious 2004 Award for Excellence in Natural Gas Conversion, signalling, says Theo Fleisch that: "MC^2 begins to be a dominating force in the natural gas conversion research sector."

This type of international, peer group recognition leads to graduate research places being keenly sought after. Now, four years after the programme started students are progressing in their careers, moving to different universities or into a commercial environment, and some of them seek employment with BP. Attracting some of the brightest young researchers to BP is another key objective of MC^2.

Programme leaders in California and Cambridge agree, in the words of Bell, that BP's financial support: "gives us great flexibility in choosing the research projects and stability to allow researchers to concentrate on their work without having one eye on financial constraints."

In Cambridge, the relationship between BP and the BP Institute is based on a $40m endowment, guaranteeing BPI financial support 'in perpetuity'. The Multi-phase Flow research team will grow to around 40, attracting research students and five endowed faculty positions.

Understanding how fluids move underpins everything that BP does, says BPI's Andrew Woods. "It is core to what the company does." BP moves molecules around hydrocarbon reservoirs thousands of feet under the ocean floor, through pipelines, around refineries and petrochemical plants and on to customers.

BPI is housed in a purpose built facility, its architecture designed as a smoothly edged flow with outside walls, corridors and staircases bending and twisting like the colourful liquids the scientists study in tube and pipe filled laboratories.

Like California, the research environment in Cambridge is open and free and designed to foster strong links between the university and industry.

The institute researches primary problems in multi-phase flow and is highly interdisciplinary, spanning five university departments including applied mathematics and theoretical physics, chemistry, chemical engineering and earth sciences.

"The relationship is throwing up more research ideas than is possible to pursue. We take on research that fits with our academic interests and capabilities …this has provided us with a number of breakthroughs, and applications that were not foreseen at the start of the process," says Woods.

An early success for BPI was adding to the understanding of oil flows in Magnus, a BP-operated oilfield in the North Sea. Faced with a water flooding problem squeezing out oil from the field earlier than predicted, BP drilling engineers

"Their only boundary to research is that feedstock must be methane, the main ingredient of natural gas."

Theo Fleisch

Flow of information: Enhanced understanding of the oil flows in Magnus oilfield in the North Sea was an early success for the Multi-phase Flow team at the BP Institute at Cambridge.

Seeing blue: A turbulent gravity current experiment where swirls of blue dye colour a concentrated salt solution prior to the release of the mixture into an observational tank of fresh water which helps scientists better understand how deposits may later become oil and gas reservoirs.

approached professor Woods and his team seeking a scientific explanation to the problem. Through theoretical modelling and experiment the BPI team gained sufficient understanding of the subterranean forces acting thousands of feet under the seabed to solve the water inflow problem.

A new production well was drilled down-dip of the existing reservoir restoring production and significantly adding to BP's knowledge of reservoir management. Experimental work at the BPI helped the Magnus team analyse the subtle interplay between gravity and pressure, factors that are difficult to assess in conventional reservoir simulations.

Another such query led the BPI team to study options of using time-lapse seismic studies to track water/hydrocarbon fronts to better understand flow patterns. This 4D seismic work requires an advanced understanding of physics, a discipline BPI can offer through the multi-disciplinary approach of the Institute. Chemists have also been drafted in to work on scale and wax problems in deep water wells for BP offshore Gulf of Mexico.

And in Algeria, the Institute is monitoring an aquifer to study whether any drilling mud might leak into the water bearing structure from nearby production.

As the relationship approaches its fifth year, increasing numbers of BP staff are engaging with Professor Woods and his team. "Through visits to BP's offices at Sunbury, courses and workshops I meet up to 100 BP staff each year. I am keen to make as many connections with BP people as possible," he says.

He welcomes anyone who has a fluid dynamics problem to contact him at the Institute.

"We have an independence which allows us to look at problems and manage them in a different way than commercial laboratories," says Woods.

BPI staff have already published more than 100 academic papers, a key measure of how successful an academic/business relationship can contribute to the global body of scientific knowledge.

Through the university programmes BP gains access to science at a very high and influential level, says BP's chief scientist Steve Koonin. "The work being undertaken is not only fundamental to the company's future; it is significantly adding to the global body of scientific knowledge.

"It's also good for business, building brand awareness within and outside the scientific community and networks of scientists who progress through the wider academic world and beyond," he adds.

Speaking in California at the start of the MC^2 programme, BP chief executive Lord Browne said: "From BP's perspective, partnering with leading educational and research institutions enables us to demonstrate responsible leadership while remaining on the cutting edge of scientific development, through funding projects that will not only benefit the company, but society as well. That is very much the way we expect to pursue aspects of fundamental scientific research."

For BP and the universities, this meeting of academia and business has fired the imagination of all involved.

"There is plenty more to be done," says Koonin. "We are looking at other universities to partner and new technologies such as photo-voltaics and bio-mass to explore. Our scientists at BP have been energised by these programmes. We have only just begun." BPM

● *Bruce McMichael is a journalist specialising in business, energy and the environment.*