Impact Objectives

- Develop the potential for cost-effective liquefied natural gas (LNG) at all scales and in deep water and remote locations
- Increase growth, productivity and capabilities in Australia's key LNG industry
- Establish a micro-scale LNG plant and facilities for training, demonstration and research purposes that is unique in the world in terms of its scale, scope and accessibility

Securing the future flow of oil and gas

*Professors **Eric May** and **Mike Johns** from the **Australian Centre for Liquefied Natural Gas Futures (ACLNGF)** discuss their work developing efficient oil and gas production and processing technologies, which is done in close partnership with industry*

Eric May

Mike Johns

What is the structure of the Fluid Science and Resources Laboratory (FSR) and how big a component is the ACLNGF?

EM: FSR is part of the Chemical Engineering faculty at the University of Western Australia (UWA). The group was established over 10 years ago and now comprises around 50 researchers, including six academics, 14 research fellows and more than 30 PhD students. Establishment of the ACLNGF was the culmination of many years of applied research by FSR with industry. The Centre enables us to build on previous research and to significantly expand it with existing and new industry partners. It is therefore a key component of the research group.

What are FSR's main research areas and objectives?

MJ: Our research has a strong industry focus and concentrates mainly on oil and gas production, with a particular emphasis on LNG. However we also have ongoing research collaborations with mining, water treatment and other heavy industry sectors. We have four complementary research themes and undertake research into all elements of the production chain, from reservoir to final product. Each area of research is tied to specific industry challenges. At the reservoir level we apply nuclear magnetic resonance (NMR) and core flooding techniques to better characterise and model reservoir production, while simultaneously sequestering CO_2. Our flow assurance research helps oil and gas fluids to be transported from subsea wellheads to the production plant. We apply novel processes to separate a range of impurities such as nitrogen and helium relevant to onshore (or floating) production and processing plants. Finally, further downstream we study LNG boil-off processes to ensure its safe and efficient transportation.

EM: We recently collaborated with Woodside Energy on the development of their Greater Enfield asset which had for many years been unviable due to the risk of hydrate formation in production pipelines. Our research showed that hydrate particles would not agglomerate and form blockages, due to the inherent properties of the oil in this field.

How have you created and maintained collaborative relationships with industry?

EM: In 2014 I spent six months seconded to a major oil and gas company. This experience has been extremely effective in developing ongoing relationships with that organisation. We also undertake many industry engagement activities including running regular short courses and free industry workshops to showcase our research. For the last four years we have hosted flow assurance industry workshops. These are attended by employees from more than 20 engineering companies based in and around Perth.

MJ: We have also developed ties with industry through our PhD student internships and mentoring programmes. We have key industry champions in many of partner companies, including a recently appointed adjunct professor who spends one day a week with our group. Alumni and our international academic networks are also an important link to industry both within Australia and throughout the globe. As with all relationships, communication is the key to success.

Playing a key role in Australia's LNG future

*The **Fluid Science and Resources Laboratory** at the **University of Western Australia** specialises in supporting cost-effective LNG production at all scales and locations while simultaneously minimising the environmental impact of production and refining facilities*

As an Australian Research Council Industrial Transformation Training Centre, the Australian Centre for Liquefied Natural Gas Futures (ACLNGF) within the Fluid Science and Resources Group (FSR) at the University of Western Australia (UWA) is dedicated to building closer partnerships between academia and the oil and gas industry. Centre Director Professor Eric May says that global demand for energy continues to rise and although renewables are beginning to take off in Australia and around the world, oil and gas will remain important mainstays for years to come. He believes natural gas is a vital transitional energy source while moving from a fossil fuel-based economy to one of that makes strong use of renewables: 'It is much cleaner burning and more efficiently converted to energy than oil and coal, meaning it has a smaller greenhouse footprint and no particulate emissions.'

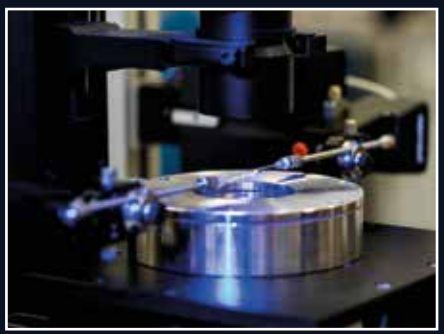
Australia is a significant producer of natural gas, with most reserves located off the coast of Western Australia, often in deep water and challenging environments. As a result, Perth has become a centre of expertise for RTD in all aspects of natural gas production and refinement. FSR is a leading exponent of advanced experimental technologies aimed at helping oil and gas companies recover gas efficiently from offshore assets while minimising greenhouse gas emissions from production facilities and refineries. The group works closely with industry partners and also with other research centres, including the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and Curtin University.

WORLD-FIRST MICRO-SCALE LNG PLANT

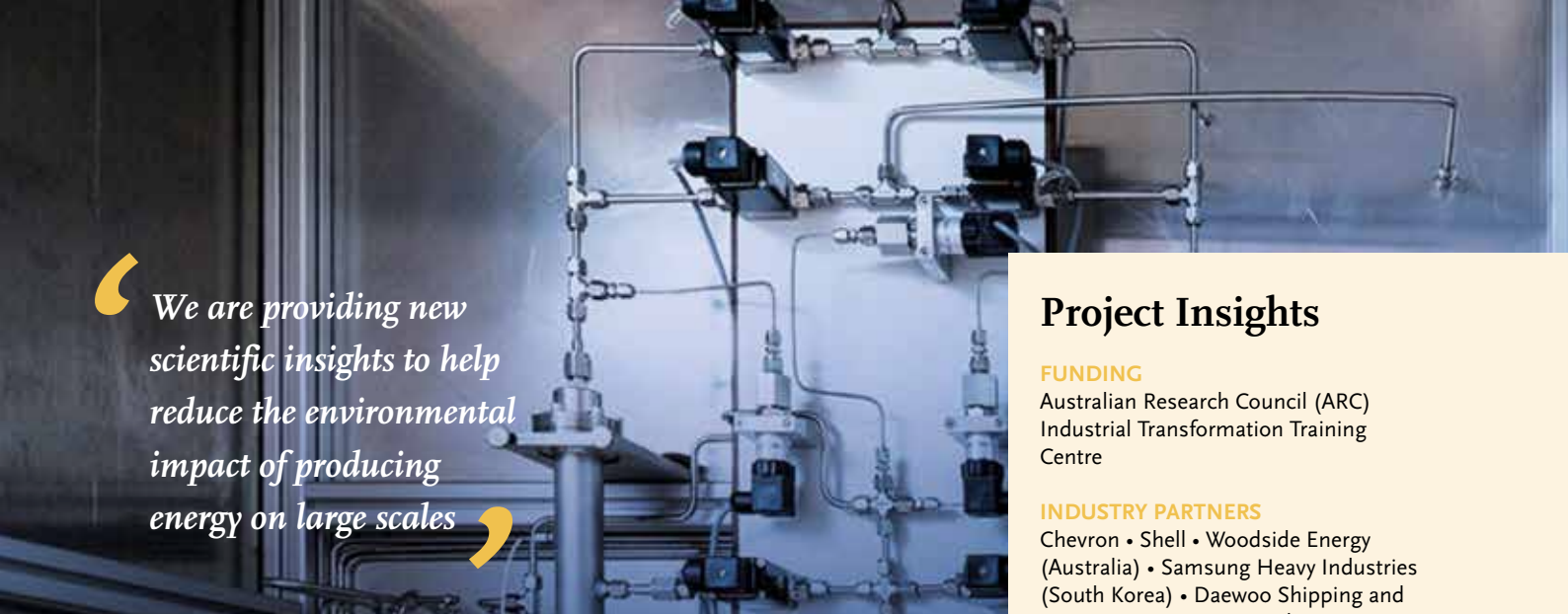
FSR is a large group of over 50 highly experienced researchers and undertakes a wide range of R&D projects. The ACLNGF is a major component of FSR and its overarching objective is to enable cost-effective LNG production, at all scales, in remote or deepwater locations. The flagship project of the ACLNGF is establishing a micro-scale LNG plant which would be capable of producing 10 tonnes of LNG and generating up to 2.3MW of electricity per day.

The plant, which has been scoped and designed in collaboration with GE Oil and Gas and engineering company Clough, will be a world-first research, training and technology demonstration facility. 'As well as providing full visibility of all stages of LNG production, research will be enabled on real fluids in order to optimise each process. It is estimated that there will be a major shortfall in trained operatives over coming years; the micro-scale LNG plant will help meet this demand,' explains Professor Mike Johns, a Chief Investigator at ACLNGF. Live feeds from each stage of the plant will be fed to the research facility running in parallel to the industrial plant. Multiple stakeholders are involved in the project, with UWA being the lead institution. Funding is currently being sought for the plant, which will be located in Perth and will take 18 months to bring to fruition.

When gaseous fluids are brought onshore, it is challenging to separate nitrogen and methane owing to their similar physical and chemical properties. Traditionally the combined methane and nitrogen feed is cooled to allow the required separation in cryogenic distillation columns. The methane is liquefied and becomes the



Flow assurance research: Micromechanical force apparatus allows measurement of forces between hydrate particles



> *We are providing new scientific insights to help reduce the environmental impact of producing energy on large scales*

produced LNG stream whereas the nitrogen is warmed via heat exchange and then vented to atmosphere. This separation is not perfect, and the vented nitrogen can contain around 2 per cent of recoverable methane. FSR has developed two means to recover the methane from the nitrogen vent stream, says May. A highly selective adsorbent has been designed and produced and an advanced pressure swing adsorption (PSA) process has been developed in which some of the product streams are recycled back through the adsorbent beds, resulting in highly enriched separate gas streams. This process has been demonstrated at pilot scale and the group is now working on its commercialisation.

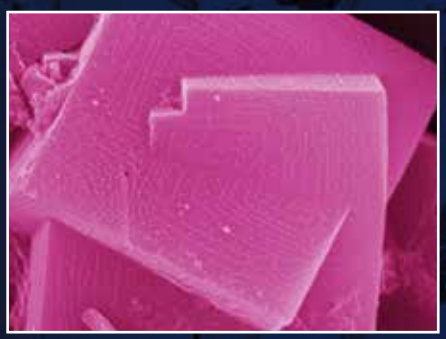
IMPROVING PRODUCTION AT REDUCED COST

One of the major research themes within FSR is flow assurance. Deepwater developments, which feature higher pressures and a cooler environment, plus longer pipelines to reach shore, lead to a greater risk of pipeline blockages through hydrate formation and agglomeration. Hydrate blockages can be hard to shift and have to be broken down using injected methanol, heat or by depressurising the pipeline. Each of these interventions is costly and time-consuming, leading to significant production losses; they can also represent appreciable hazards to safety if not done carefully with expert oversight.

FSR has a comprehensive programme of flow assurance research and has produced and continues to develop software to enable engineers to model their particular well fluids and production environment. The group's expertise is in gas-dominant systems such as those found in Australia. Software is a key way for the group to engage industry and distribute their research results. In addition, UWA hosts twice-yearly flow assurance workshops which are widely attended and help focus and direct research towards real-world problems, as well as promoting the group's research capabilities.

May is pleased that FSR's research is already making a big difference to recovery rates, downtimes and processing efficiency in the oil and gas sector in Western Australia: 'We are providing new scientific insights to help reduce the environmental impact of producing energy on large scales, which will be increasingly necessary in the coming decades.' Cutting-edge technology such as acoustic levitation and use of Raman spectroscopy will provide new ideas that can help production companies ensure the flow of oil and gas, while also reducing emissions of greenhouse gases. May says that the main objectives of the group for the immediate future include the realisation of the micro-scale LNG facility as a research and training plant and training more PhD level researchers.

Flow assurance research: Contacting hydrate particles using the micromechanical force apparatus



Gas Separation Research: SEM image of a typical zeolite 3A molecular sieve (standard natural gas dehydration adsorbent) synthesized from coal fly ash in our laboratory.

Project Insights

FUNDING

Australian Research Council (ARC) Industrial Transformation Training Centre

INDUSTRY PARTNERS

Chevron • Shell • Woodside Energy (Australia) • Samsung Heavy Industries (South Korea) • Daewoo Shipping and Marine Engineering (South Korea) • China Guodian Corporation (China) • GE Oil and Gas • Clough • Virtual Materials Group

ACADEMIC PARTNERS

University of Western Australia (Australia) • Curtin University (Australia) • University of Melbourne (Australia) • University of Adelaide (Australia) • University of Queensland (Australia) • Northeastern University (China) • Seoul National University (South Korea) • University of Auckland (NZ) • Commonwealth Scientific and Industrial Research Organisation (Australia) • Colorado School of Mines (USA)

CONTACT

Eric May
Centre Director

E: lngfutures-ecm@uwa.edu.au
W: http://lngfutures.edu.au/

CENTRE DIRECTOR BIO

Professor Eric May is the Chevron Chair in Gas Process Engineering at UWA which, in 2011, was endowed in perpetuity. He is now also the Director of the ACLNGF, funded by the Australian Research Council through the Industrial Transformation Hub programme. May has been an academic at UWA since 2005, where his research group works closely with industry, conducting projects in LNG production, flow assurance, CO_2 sequestration and fluid property prediction. He was awarded the Malcolm McIntosh Prize for Physical Scientist of the Year as part of the 2012 Australian Prime Minister's Prizes for Science.

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FLUID SCIENCE & RESOURCES