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Industrial Partnerships: Turning research ideas into new technology

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Content

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- Explain why I am qualified to talk about this subject
- Where I presently work
- Why industry and academia should collaborate
- Show two examples of how industry and academia can collaborate successfully

My Own Timeline of Development

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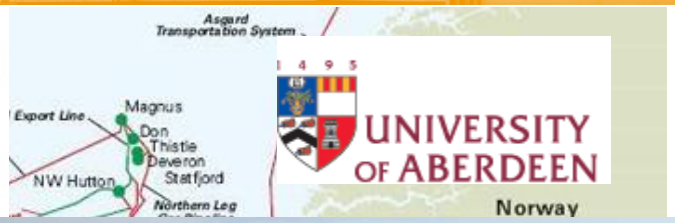

What is the Sustainable Gas Institute?

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- A research centre founded by **BG Group** and **Imperial College London**
- BG Group does not have a history of investing large sums of money in research. The Brazilian research levy, created the opportunity to invest millions in Brazilian research.
- Imperial had a research and contract income of **£330 million** in 2013 and is regularly ranked inside **the world's top 10** research institutes
- Imperial is geographically close to BG Group's headquarters in Reading, England and is therefore well placed to assist BG in investing their money wisely.
- What research areas should the money be invested in and why?
- New applications? Can we resolve problems like low density, tendency to leak, **climate change**?
- How can the gas industry **improve efficiency** and **reduce emissions**? What role will it play in a future powered by **renewable energy**?

The Pathway to Commercialisation

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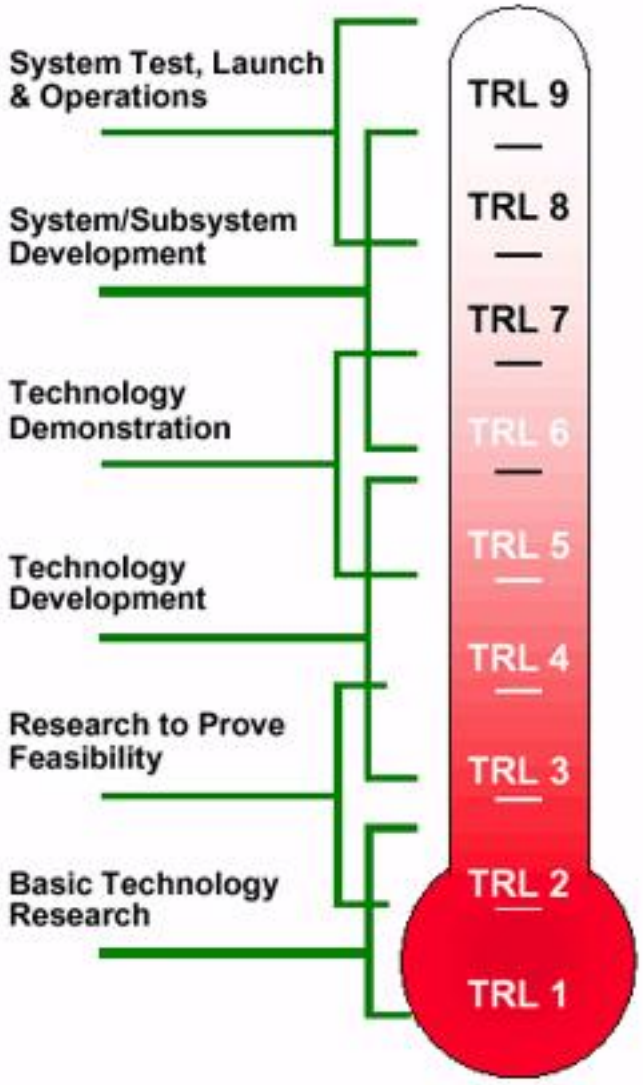
- The pathway to commercialisation involves answering a series of questions (and repeatedly!):
  - What do we hope to achieve and by when?
  - Who will use the technology and do they want it?
  - Where does it fit in to the business?
  - How much money can it make?
  - How much does it cost?
  - Is there a demand for the technology?
  - Is it realistically and technically feasible?



Why Should Industry and Academia Collaborate?

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Academia	Industry
Enhancement of teaching	Sourcing latest technological advances
Funding/financial resources	Laboratory usage
Source of knowledge and empirical data	Personnel resources/cost savings
Political pressure	Risk sharing for basic research
Enhancement of reputation	Stabilising long term research projects
Job offers for graduates	Recruiting channel

Intellectual Property Rights - Who should own them?

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- Very few universities are successful at commercialising inventions that they've patented. In Europe, only 10% of universities account for 85% of the total income generated by inventions.
- Industry engagement can be encouraged by granting intellectual property (IP) rights in return for research grants. Universities restricting IP when they have no capability or desire to commercialise is pointless.
- The university policy for IP rights should be clear so that companies know what will happen (to avoid bitterness and arguments).
- Some universities now allow faculty members to suspend their careers so that they may pursue commercialisation activities.
- Some universities also allow students to own the inventions they created while they were enrolled.

Imperial Innovations

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Since becoming a public company in 2006, Innovations has raised more than £446.0 million of equity from investors.

Around one third of the companies in their portfolio have come from Imperial College, with the rest coming from other research organisations in Cambridge, Oxford and London.

What Imperial Innovations does:

- Writes and reviews patents
- Forms companies based upon new research
- Licences technology to industry partners in exchange for royalties
- Supports researchers in attracting translational grant funding
- Sells new research materials through its own online licensing platform

yoyo wallet™

An app based payment system

nexeon

New lithium battery technology

CORTEXICA
VISUALLY EMPOWERING RETAIL

Image recognition software

econic technologies
Polymers from CO_2

Catalysts for CO_2 activation

An Example of a Successful Collaboration between Industry and Academia

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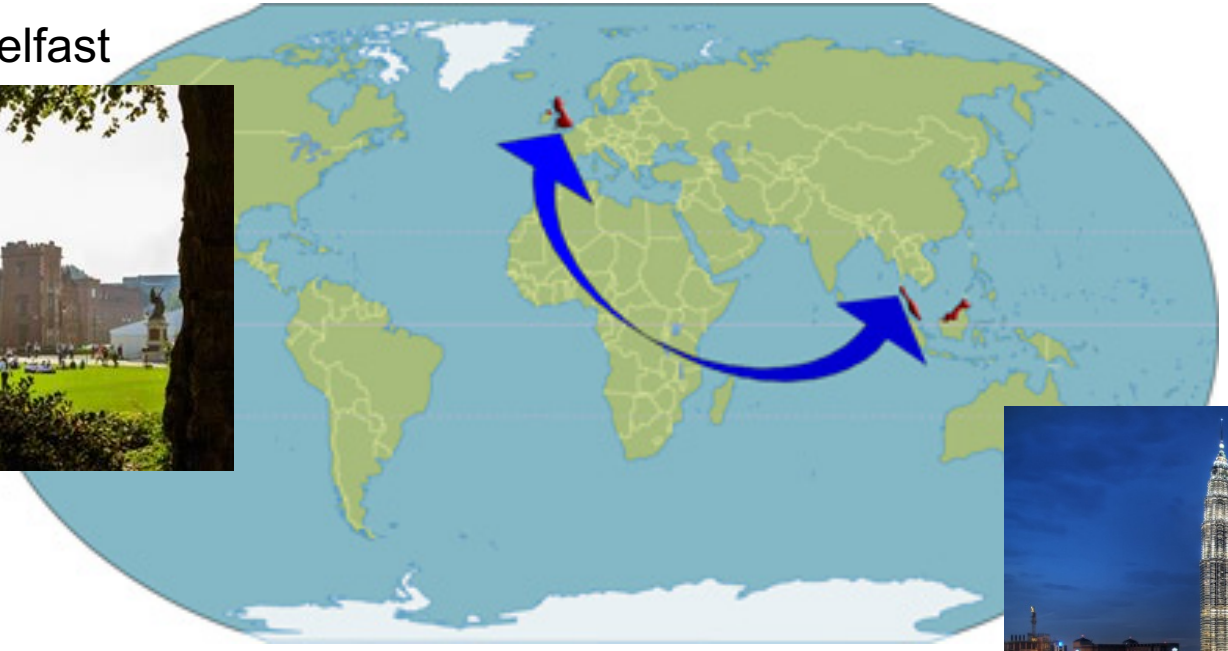
Queen's University Belfast



PETRONAS

Mercury is present in many oil and gas reservoirs around the world

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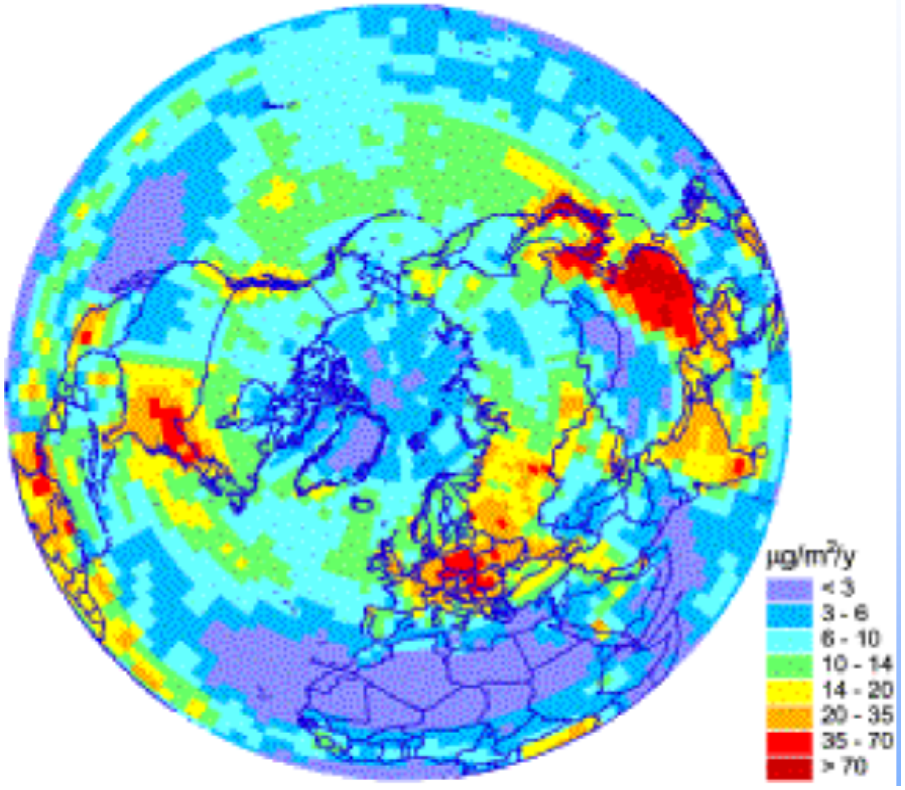
Location	Mercury Concentration	
	Gas ($\mu g\ m^{-3}$)	Liquids ($\mu g\ kg^{-1}$)
Europe	100 - 150	-
South America	50 - 120	50 - 100
Gulf of Thailand	100 - 400	400 - 1200
Africa	80 - 100	500 - 1000
Gulf of Mexico USA)	0.02 - 0.4	-
Overthrust Belt (USA)	5 - 15	1 – 5
North Africa	50 - 80	20 – 50
Malaysia	1- 200	10- 100
Indonesia	200 - 300	10 - 500

Estimated levels of Mercury in natural gas and condensate from around the globe.



Mercury can cause many serious problems…..

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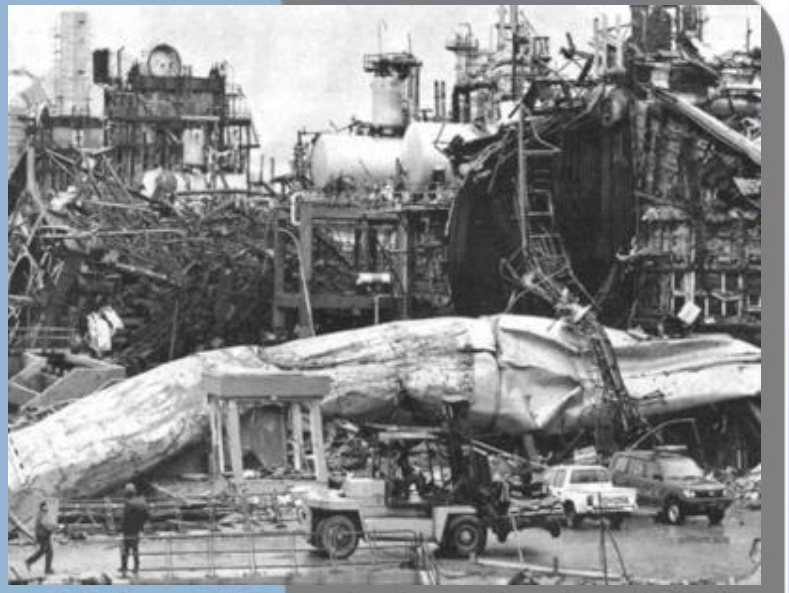
- Geological contamination could adversely affect the safety and integrity of a process plants.
- Accumulation in the process units can cause HSE issues for workers.
- Potential threats:
  - Metal embrittlement and corrosion especially in the aluminum cold box
  - Deactivation of catalysts in downstream units
  - Products contamination



Skikda LNG plant, Algeria (2004)
LME induced explosion in cold box
27 killed, 72 injured, cost US$30,000,000

The Project Developed a New Type of Mercury Adsorbent

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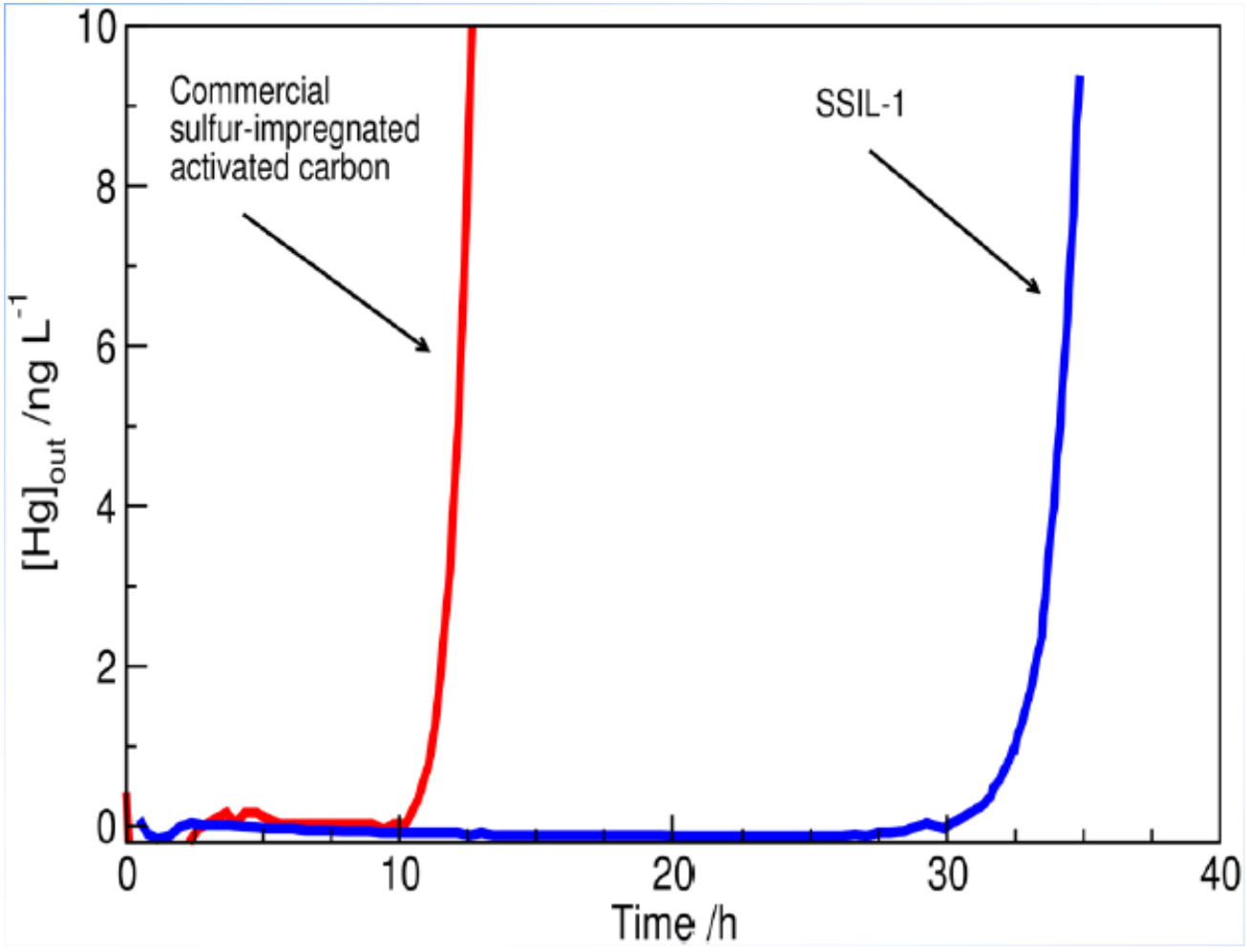

- Laboratory results indicated better performance in terms of mercury uptake as compared to commercial adsorbents.
- Lab worked focused on the selection of the optimal adsorbent composition and support structure.
- The technology was developed specifically for operation in the next stage pilot demonstration.

Slip Stream Pilot Plant

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- The heart of the slip stream pilot plant is multiple reactors fed direct from the main plant gas feed.
- The unit is set-up for “doping extra Hg” to allow adsorption capacity to be estimated (life of the adsorbent).
- The unit sees all plant operational variances and feed gas changes in the main plant.
- Multiple beds allows comparison of different adsorbents.
- Additional capability and understanding generated on site.
- Early opportunity for training on new technology.

Commercial Trial Loading at Gas Processing Plant

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Development Pathway and Timeline

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Lab Scale (Nov 07 – Oct 10)

- Ionic Liquids was identified as having potential for mercury removal.
- Successfully impregnated on several supports (SSILs).

Pilot Scale (Apr 10 – Nov 11)

- Pilot testing of SSIL at gas processing plant with real feed gas.
- Performance is 2 to 3 times better than a typical market product.

Commercial Scale (Nov 11 onwards)

15 tons SSILs loaded into Mercury Removal vessels at PETRONAS Gas Processing Plant.

Final Product is called ‘Hycapure’

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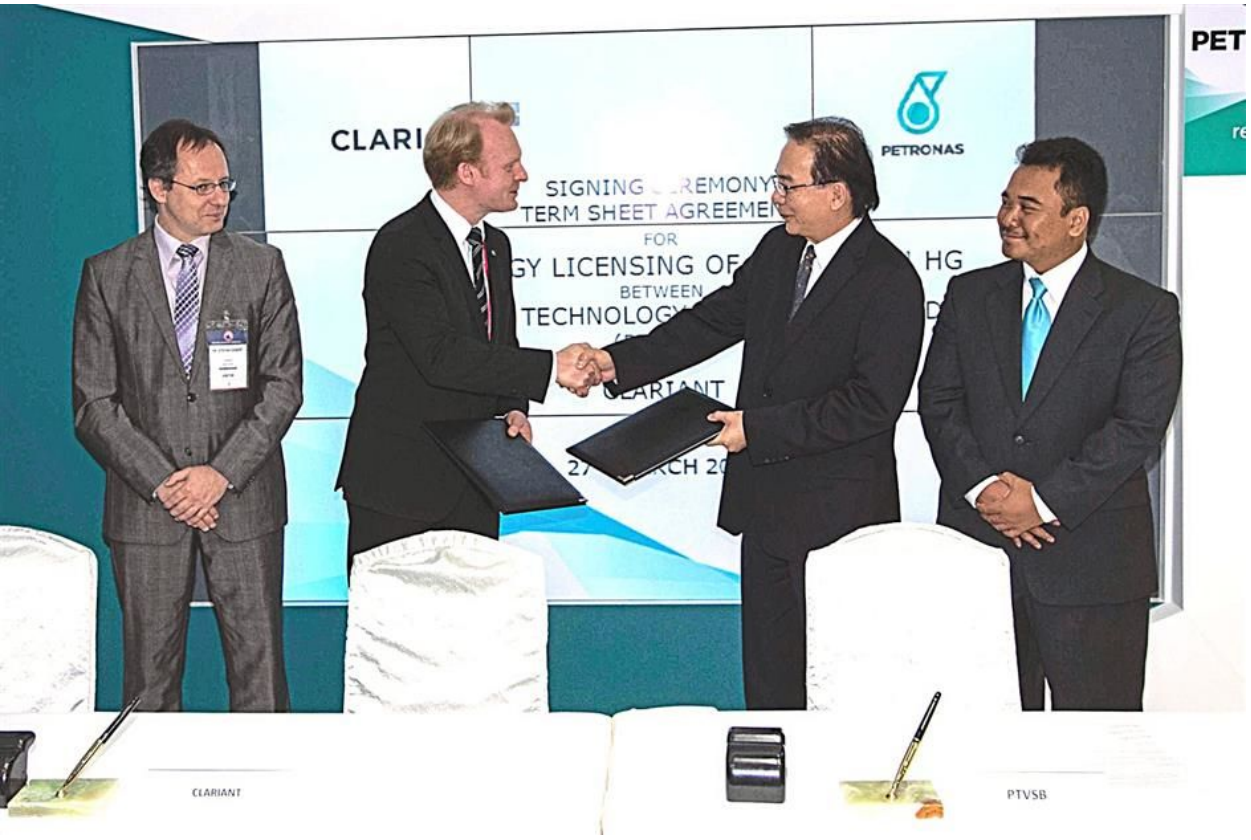

- ‘Hycapure’ is licensed to the speciality chemicals manufacturer Clariant for sale internationally.
- Clariant expects to reach a global market share of between 25% and 30% within the next five years.

The Keys to Success

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It is possible to fast track R&D commercialization. It needs:

1. **The "right project" – realistic and well thought out.**
2. **The right partners: catalyst manufacturer; support supplier, fundamental support, in-house expertise (e.g. Petronas Hg analysis).**
3. **Commitment from industrial partner, especially site management and personnel.**

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CO_2 Separation – Hollow Fibre Membrane Contactor

Membrane Contactor Technology

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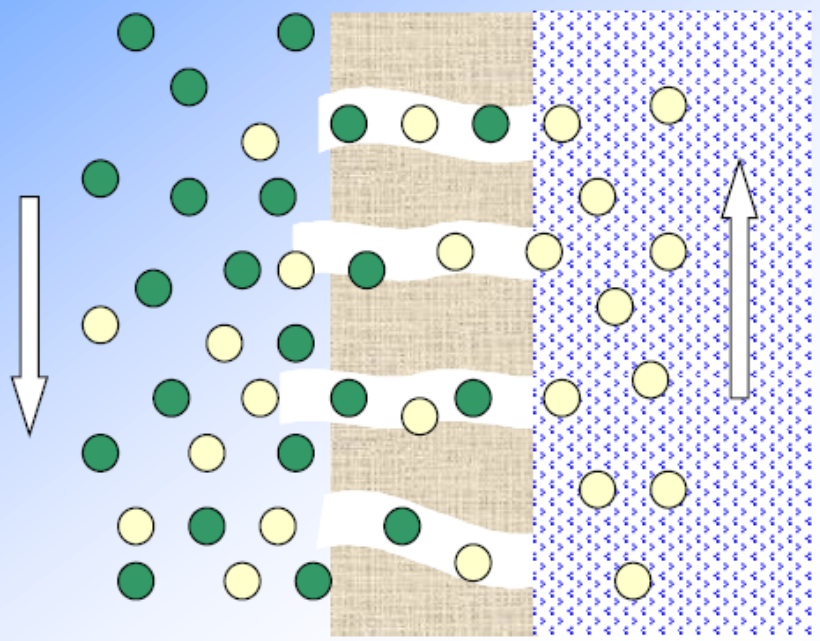
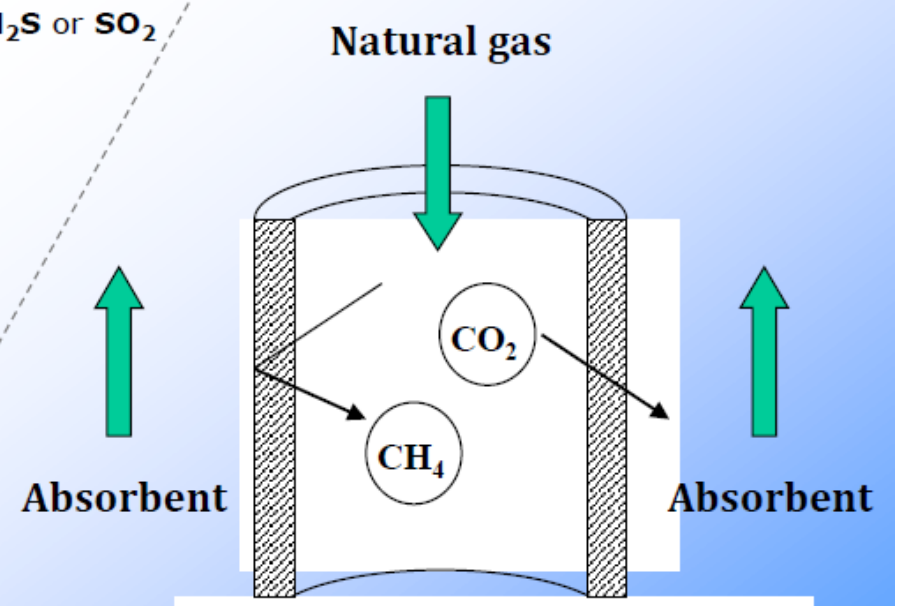


N_2 or CH_4

CO_2 or H_2S or SO_2

Membrane contactor combines conventional absorption process with membrane technology



Natural gas purification by membrane contractor process

Development of PTFE Hollow Fibre Membrane Module

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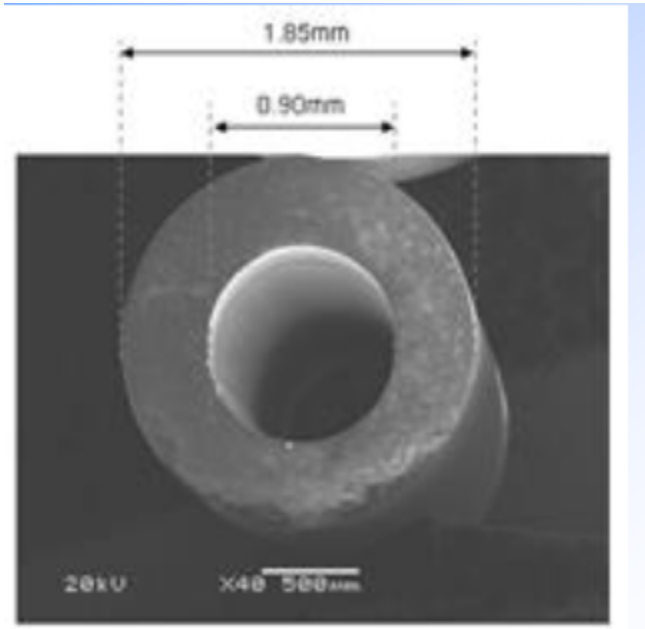

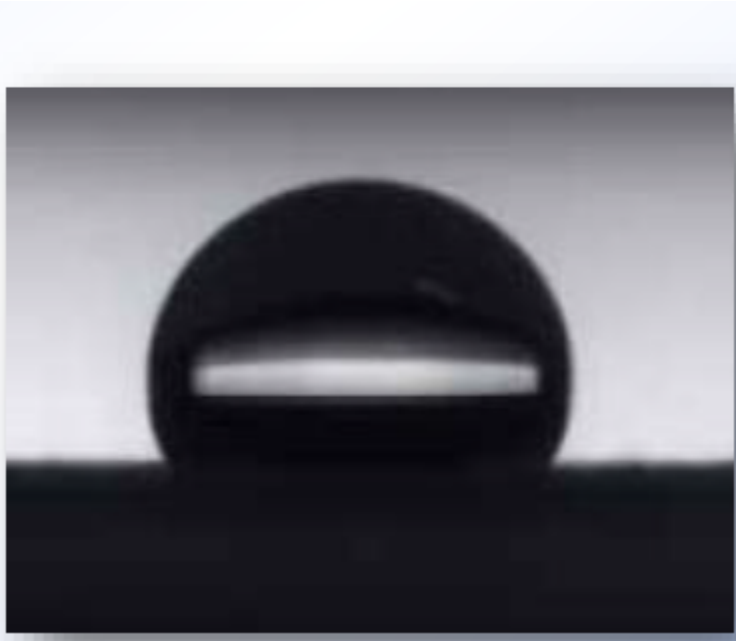

Development of Membrane Contactor Pilot Plant

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The membrane contactor system integrates the advantages of membrane separation technology and traditional adsorption process and has been demonstrated to have:

- **low energy consumption**
- **high separation efficiency**
- **compact size**
- **low maintenance.**

Can be used for natural gas purification, biogas purification and CO_2 capture from flue gases.

Target Application was FLNG

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Petronas' first floating liquefied natural gas facility, known as PFLNG SATU, is developed for the Kanowit gas field off the coast of Sarawak in Malaysia. It will be the world's first FLNG facility to start operations, upon its completion in March 2016.

The facility will be towed to its location, 180km offshore of Bintulu, in the second quarter of 2016. It will be moored at the location and is estimated to produce 1.2 million tonnes of LNG a year.

Conclusions

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- Industrial partners need to be committed for several years.
- USP are very fortunate to have long term commitment from BG Group, this is a great opportunity.
- Quick wins are possible, but the level of ambition must be realistic.
- Commercialisation without serious commitment of time and money is impossible.
- Commercialisation can be great for academia and can bring in more funding (public and private).