CCS in Australia

HiPerCap Workshop, Melbourne, Victoria, Australia

Paul Feron

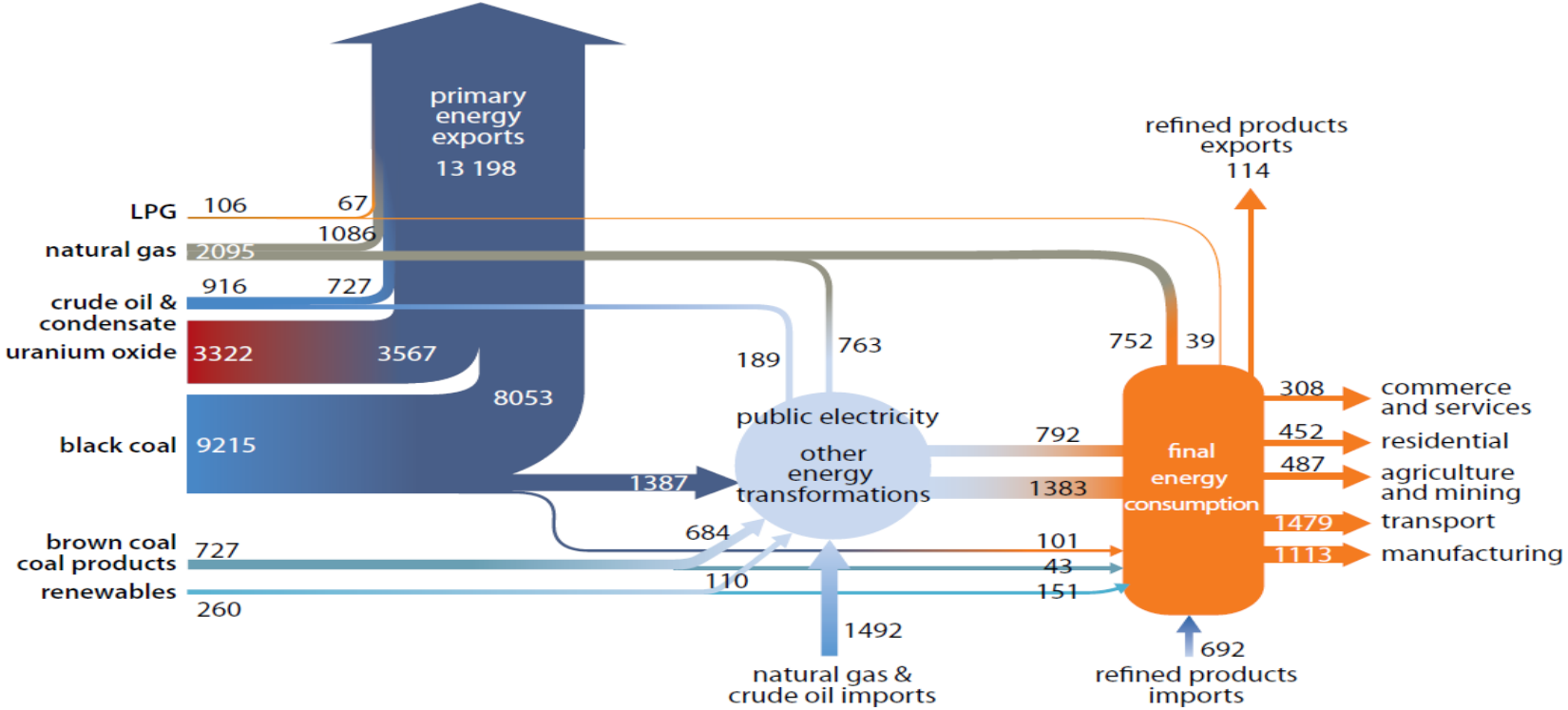
25-26 March 2015

Overview

- Drivers for CCS in Australia
- CO_2 capture and storage in Australia
- Towards safe CO_2 storage demonstration
- CO_2 Capture Demonstration
- CCS R&D funding support
- Activities CO2CRC
- Post-combustion CO_2 Capture at CSIRO

Drivers for CCS in Australia

Australia's energy flows: 2010-11 (petajoules)



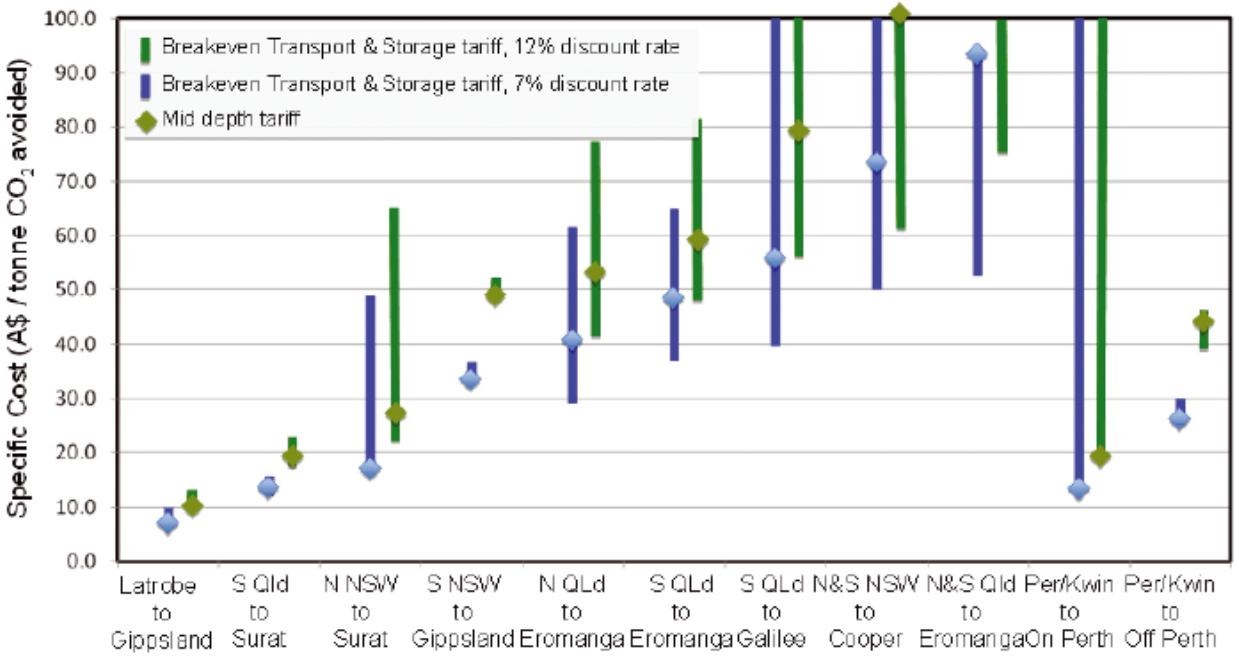
Source: BREE 2012, Australian Energy Statistics

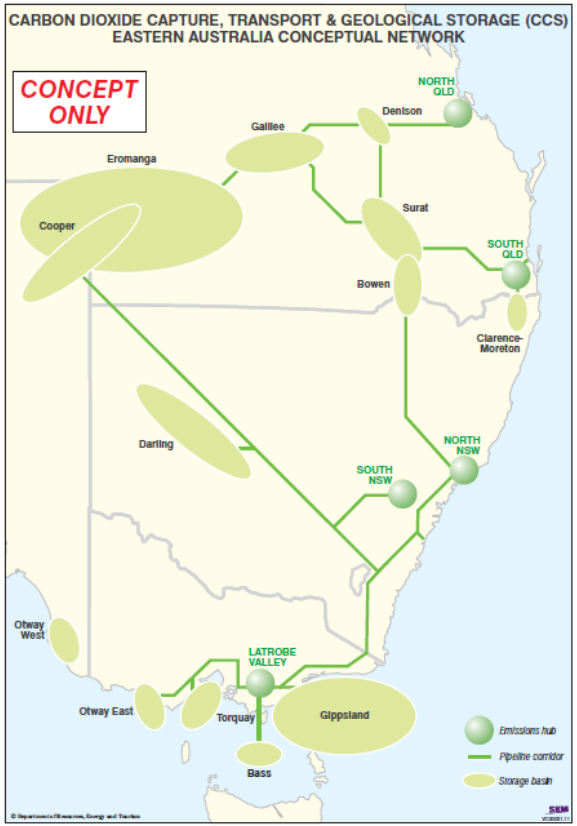
Coal is important for Australia

- Australia is the world's 2nd largest coal exporter
- Coal is Australia's 2nd largest export earner ($ 45B in 2010-11)
- Most of Australia's electricity is produced from pulverised coal fired boilers (52% black coal, 23% brown coal in 2009-10)
  - Generation capacity ~ 28 GW
  - Electricity production ~ 170 TWh/a
  - CO_2-emissions ~ 170 Mtonne CO_2/a from ~ 60 flue gas streams

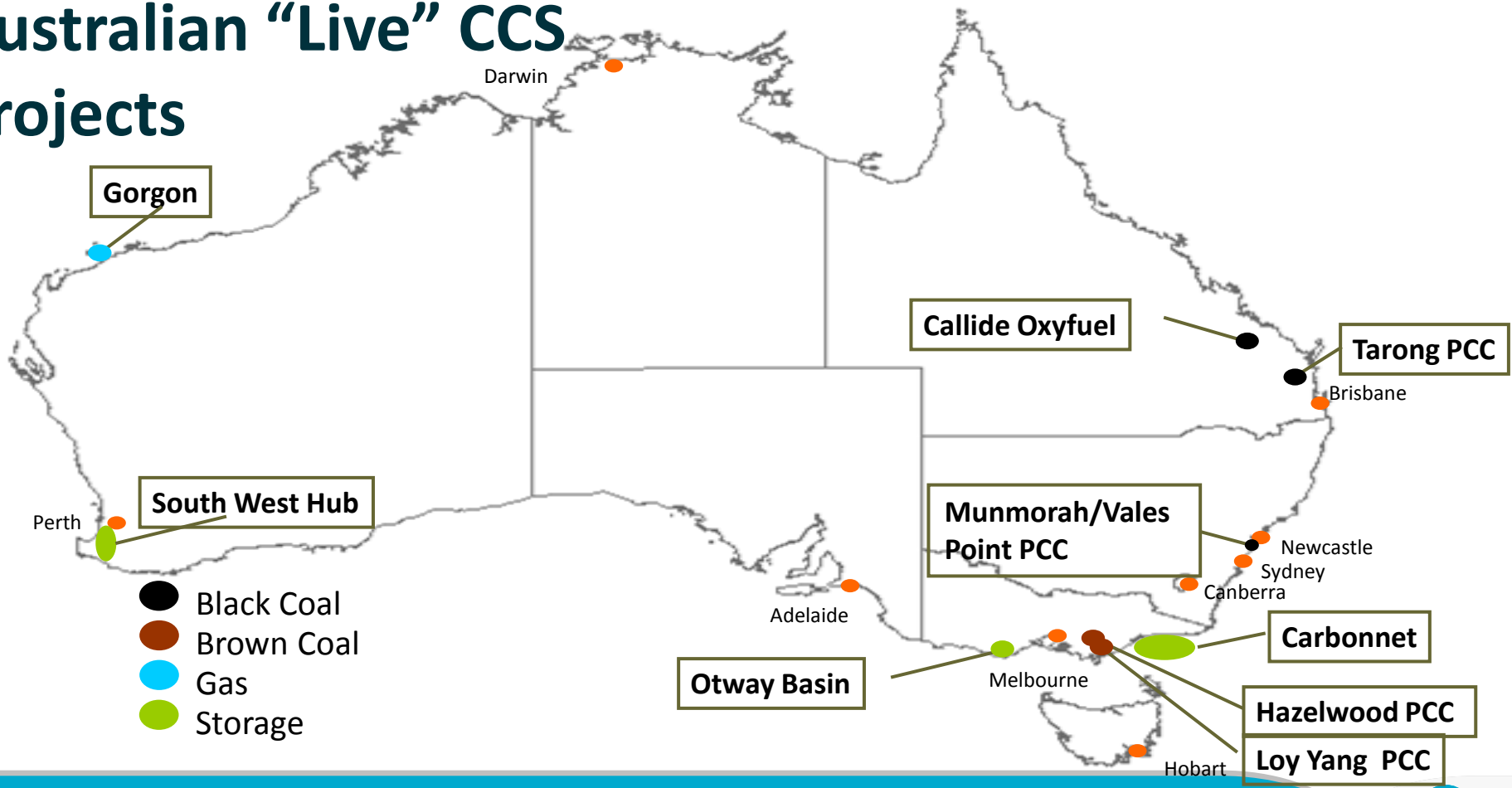
CO_2 Capture and Storage (CCS) in Australia

National Carbon Mapping and Infrastructure plan - 2009





Australian “Live” CCS projects



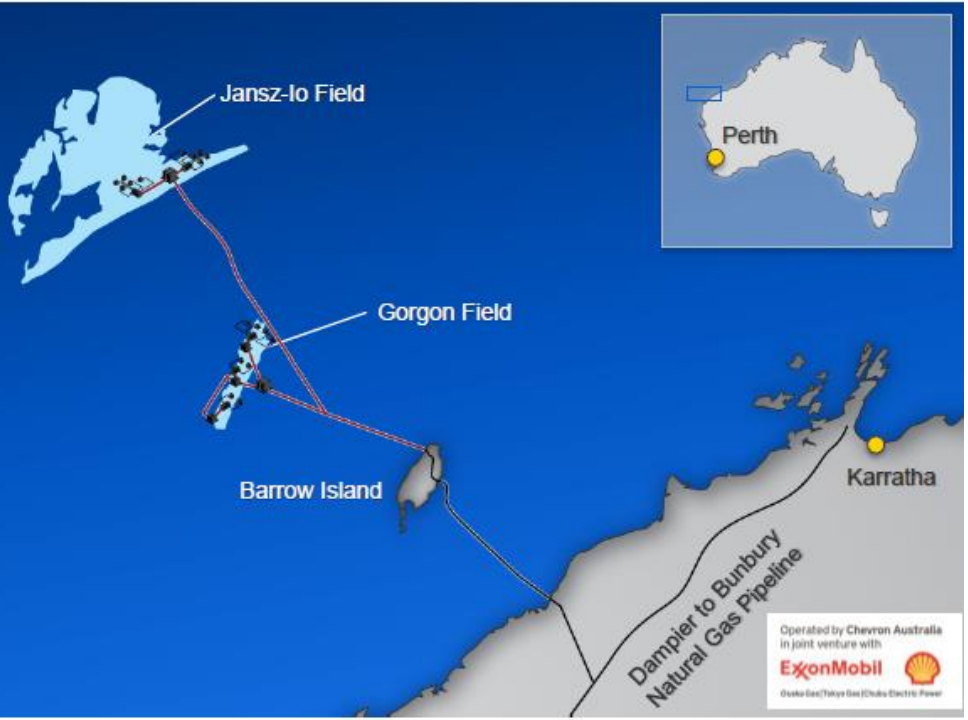
Towards safe CO_2 storage demonstration

Gorgon Project Overview

- AUD $55 billion investment
- 3 x 5.2 MTPA LNG trains
- A domestic gas plant with capacity of 300 terajoules per day
- Carbon Dioxide Injection Project

Joint Venture Participants

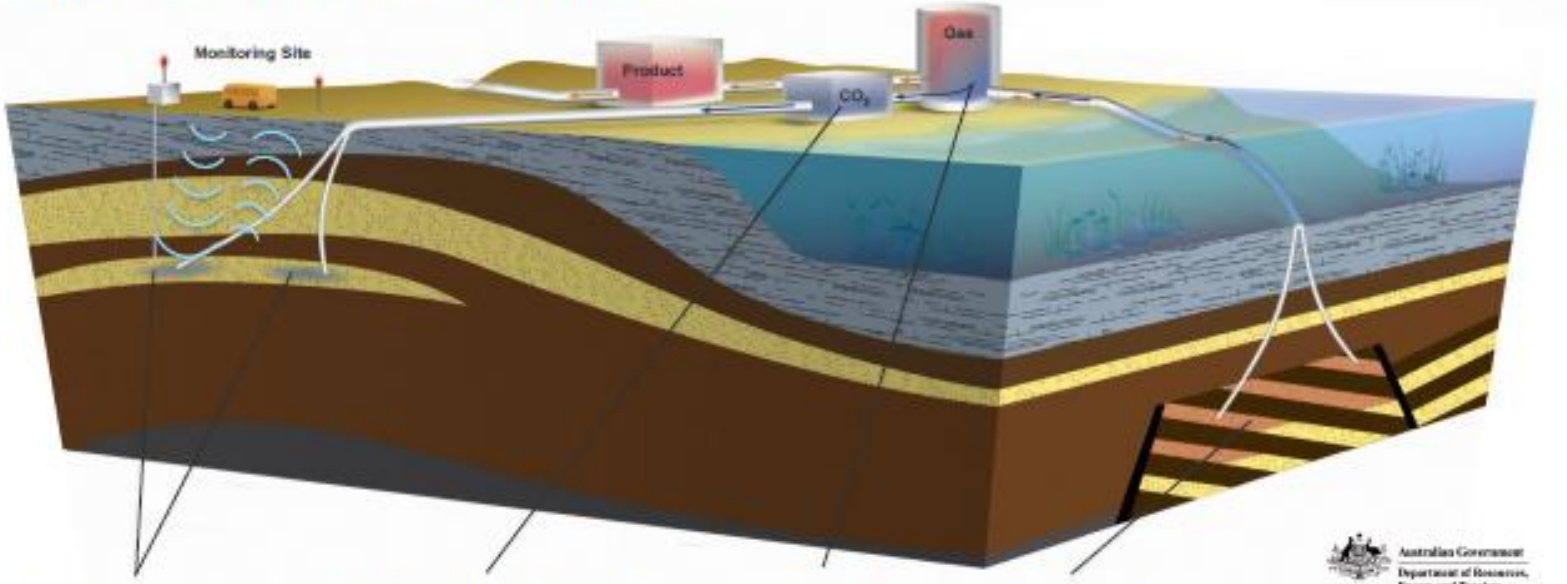
- Chevron (47.3%)
- ExxonMobil (25%)
- Shell (25%)
- Osaka Gas (1.25%)
- Tokyo Gas (1%)
- Chubu Electric Power (0.417%)



John Torkington, Feb 2015, Perth

Chevron-operated Gorgon Project

Carbon Dioxide (CO_2) Injection Project

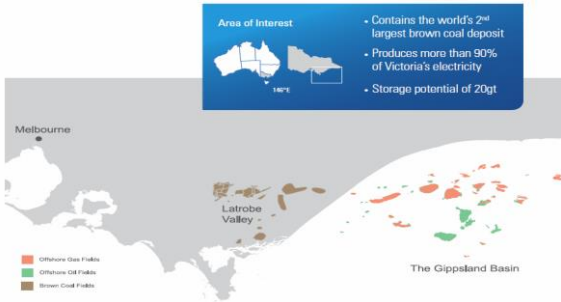


John Torkington, Feb 2015, Perth

Australian CCS Flagships

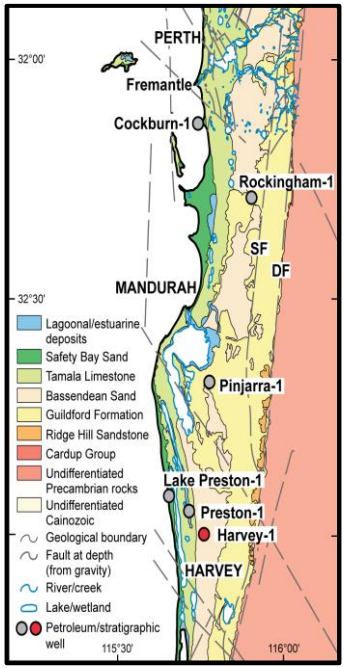
1. South West Hub project, Western Australia (from June 2011)
2. CarbonNet project, Victoria (from February 2012)

- The initial focus on proving up geological storage at each of these locations
- $ 820 M investment in CCS deployment
- $100 M from Education Investment Fund



Supporting Commercial Scale Storage

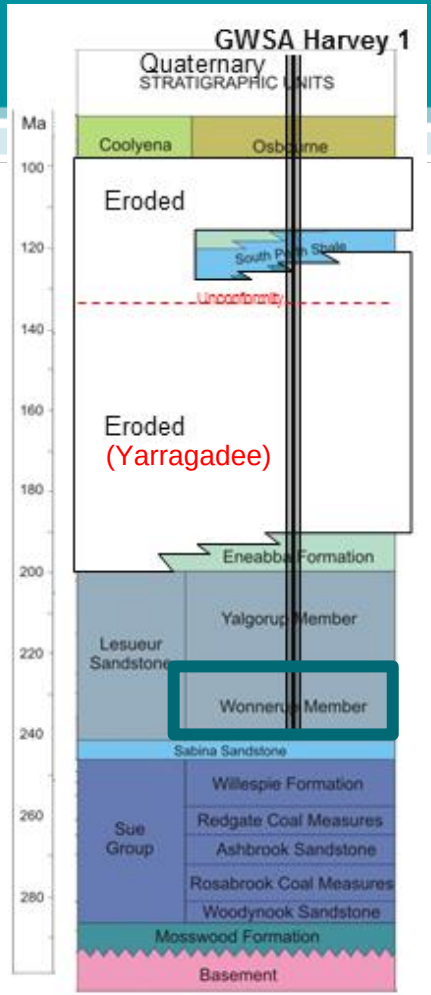
- South West Hub CCS
  - Location: 110km south of Perth, WA
  - WA DMP pre-competitive data acquisition
  - Stage gated approach
  - Greenfield site with little pre-existing data
- NGL
  - Supporting data acquisition, synthesis and interpretation for Site Characterisation
  - Deployment of dedicated equipment



Slides from Linda Stalker – Science Director NGL

SWH Site Characterisation

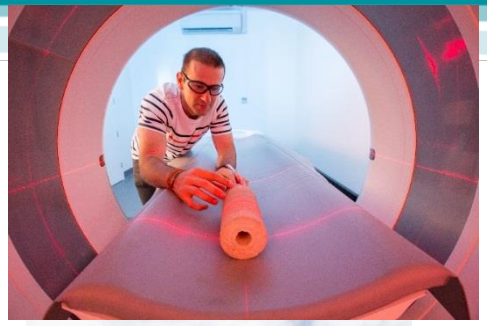
- Harvey-1 (2012)
  - Drilled to 2945m, 217 m cored intervals, logs etc
  - R&D Project outcomes on ANLEC R&D website
- Harvey-2, -3 & -4 drilling now (2015)
  - Shallow wells, 2 are mineral rigs, with continuous core through confining layers
- Harvey-5 (late 2015/early 2016)
  - Deeper well to characterise target injection interval in different fault block
- Seismic Activities
  - 2D survey on roads (2011); 2D shallow survey (2013); 3D survey over 115km^2 (2014); nested high resolution survey (2015)
- Future activities
  - Data integration across the area and updated models
  - Testing, testing…..!



Slides from Linda Stalker – Science Director NGL

NGL Facilities

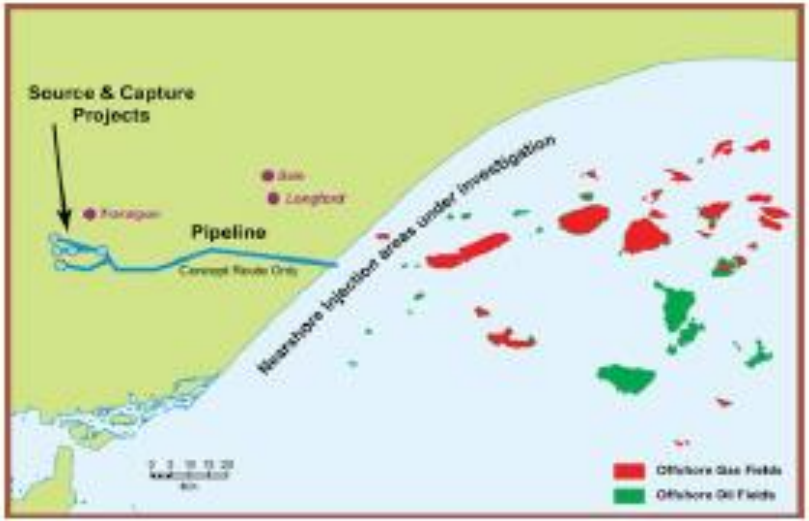
- Organic and inorganic geochemistry laboratories
- Sensors laboratory
- Rock mechanics, including petrophysics, core flooding and computer tomography
- CO_2 processing and sequestration laboratory (UWA)
- Mobile (containerised) geophysical and geochemical laboratories
- 3D immersive visualisation
- Surface and down-hole seismic sources
- Seismic recording and geophysical data acquisition
- Environmental (shallow groundwater, soil and atmospheric) monitoring
- Calibration and training facilities, including a 900m borehole (Curtin)
- “In situ” laboratory (SWH)



Slides from Linda Stalker – Science Director NGL

The CarbonNet Project

- Investigating the potential for a commercial-scale, multi-user CCS network in Gippsland, Victoria, Australia
- Funded by the Australian Government & the State of Victoria
- Capturing CO_2 emissions from industrial sources and injecting it for storage in rock formations deep below the sea bed
- Working collaboratively with industry



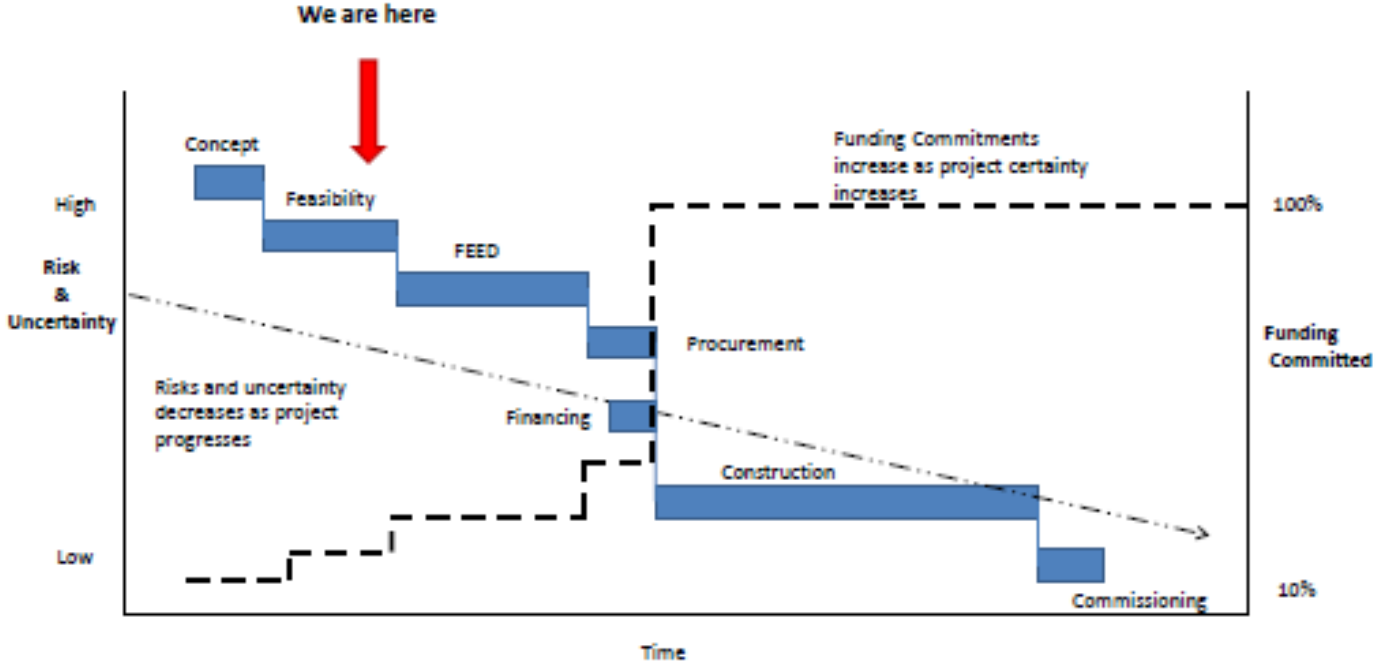
Ian Filby, Perth, Feb 2015

The CarbonNet Project

- Provide scalable infrastructure to underpin growth and development of a commercial scale CCS network
  - Foundation project: 1 to 5 mt of CO_2 pa for 25 years
  - Expansion phase: up to 20 mt of CO_2 pa
- Common user pipeline and storage infrastructure
  - Hub based concept
- Minimise conflicts with petroleum activities
  - Foundation storage sites focused on near shore zone
  - Over the longer term there is potential to use depleted oil and gas fields as production ceases

Ian Filby, Perth, Feb 2015

A gated approach



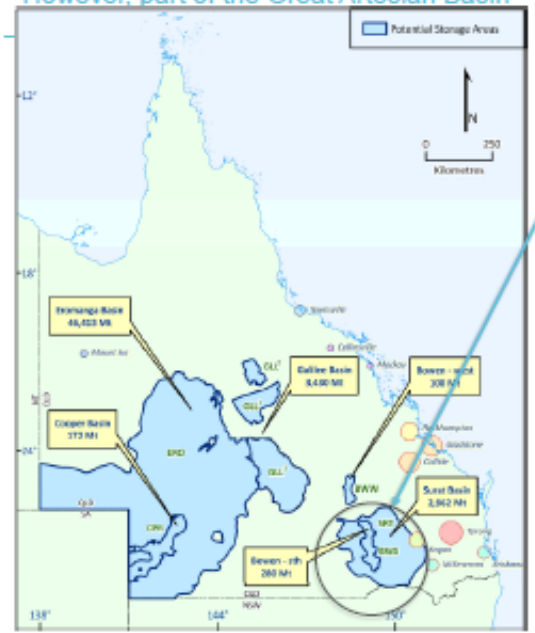
Ian Filby, Perth, Feb 2015

CTSCo's Surat Basin integrated CCS project

Surat Basin has significant potential

However, part of the Great Artesian Basin

CTSCo
Carbon Transport and Storage Company



Source: Queensland Government GHG Storage Atlas 2009

- Almost 3 billion tonnes of CO2 theoretical storage potential
- Precipice Sandstone accounts for 1.3 billion tonnes of theoretical storage potential
- Identified as a key geostorage area under the 2009 National Carbon Storage Taskforce report and the Qld Govt GHG Storage Atlas
- Coal fired power stations closer to Surat Basin

1. Known geology for trial injection of CO_2 at 60 ktpa for three years to permit the option of 120ktpa injection for many years after that
2. Deploys currently available, 'industrially scalable' modular PCC technology to minimise technology risk – several choices available
3. Industry funded (ACALET) Glencore hosted project
4. Test injection on Glencore land with no overlapping CSG rights delivers lower social licence risk
5. Sensitive Social Licence environment
6. Supportive Greenhouse Gas legislation in Queensland

GLENCORE

Alan Dumee, Perth, Feb 2015

CSIRO

CO_2 Capture Demonstration

Callide Oxyfuel Project

- 30 MW_e Oxyfuel boiler,
- 2 x 330 TPD ASU's
- 75 TPD CO2 Capture
- CAPEX $180M; OPEX $65M

1. > 10,000 hours overall boiler operation
2. > 7,500 hours of actual oxy-firing operation
3. > 3,700 hours of CO_2 capture plant operation
4. Demonstrated sustained operation under oxy-firing conditions
5. Demonstrated boiler turn-down to 50% Load Factor
6. Demonstrated CO_2 capture rates > 85%
7. Demonstrated high purity of CO_2 product

Oxy-firing flame

Chris Spero – National CCS Conference 2014

CCS R&D funding support

R&D Funding organisations

- ANLEC R&D - $150 M

  - Accelerate the technology development cycle by making accessible the knowledge and skills that reduce the risk and/or cost of developing and deploying Low Emissions Coal Technology (LECT) in Australia.
  - 50/50 Commonwealth – Coal Industry
  - Targeted research - Alternatives/Fundamentals ($ 35 M)

- Brown Coal Innovation - $16 M R&D funding

  - Developing research, technologies and people to reduce the environmental impact - and deliver social and economic benefits - from sustainable use of brown coal
  - Membership based organisation including international members

Activities CO_2CRC

CO2CRC: one of the world's leading CCS research organisations

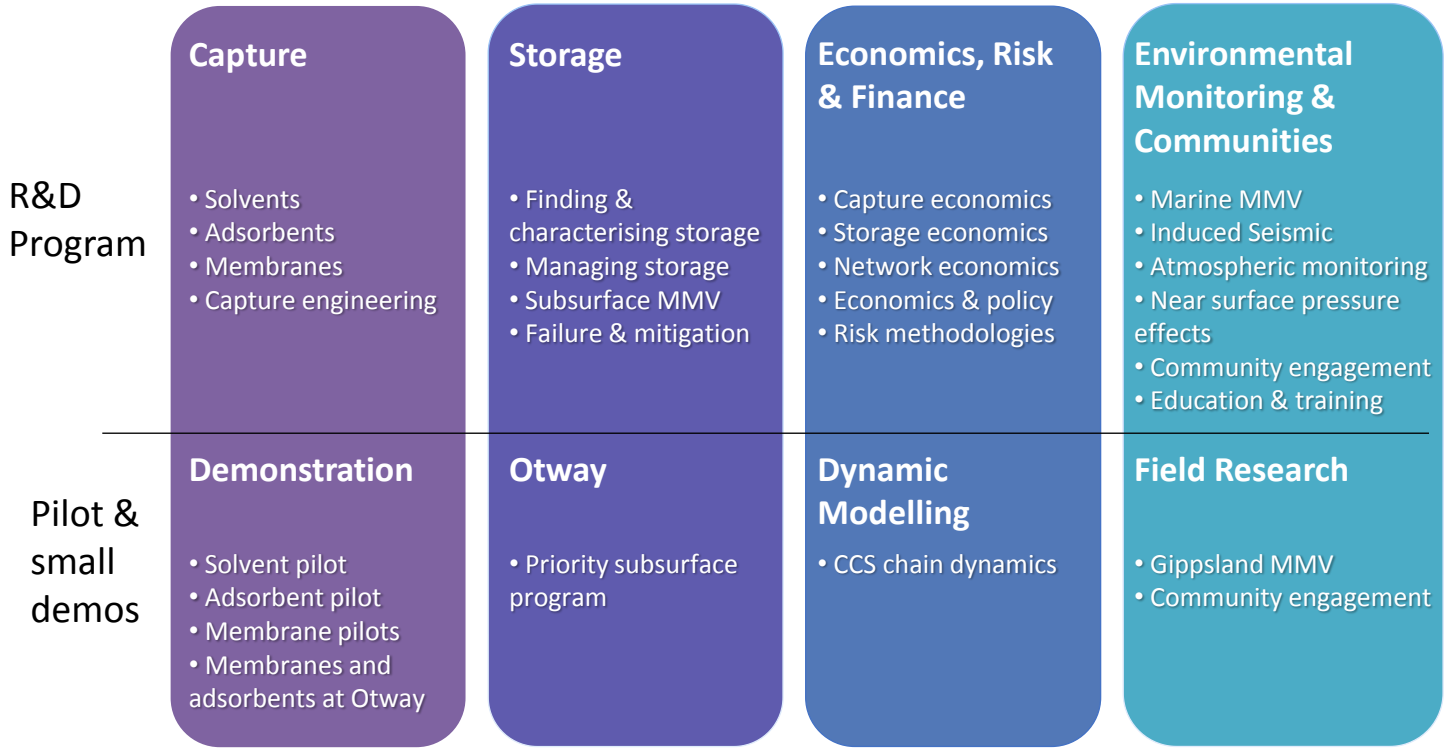
- R&D across the CCS value chain
- Brings industry sectors together (coal, gas, power, etc) to provide an exceptional stakeholder base
- Brings together Commonwealth, States, local government and the community in the Otway Project
- Includes major research institutions - CSIRO, Geoscience Australia, Universities, major overseas institutions eg. LBNL(USA) , KIGAM(Korea)
- Over 150 leading researchers in CCS
- Broad international perspective and experience
- Successful track record in running major CCS facilities

Slides from Dianne Wiley/Matthias Raab

Participants

Supporting Partners

CO2CRC research portfolio



Slides from Dianne Wiley/Matthias Raab

CO2CRC Otway Project

The CO2CRC Otway Project is Australia's first demonstration of the deep geological storage or geosequestration of carbon dioxide (CO_2), the most common greenhouse gas.

- Stored over 65,000 t CO_2
- World first residual trapping study

Slides from Dianne Wiley/Matthias Raab

CO2CRC Storage Research Highlights

Exceptional Datasets

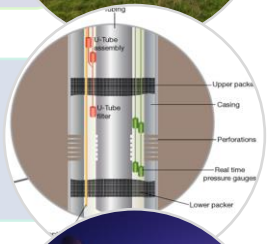
- Atmospheric (continuous monitoring)
- Soil Gas
- Seismic
- Reservoir fluids

Field Validation

- Validation of models in actual field tests
- Fully permitted and operational site
- Availability of CO_2
- Globally unique advantage

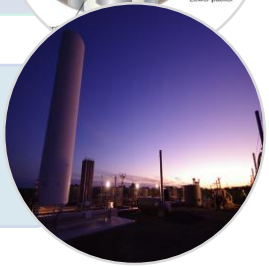
Developing Novel & Innovative Concepts & Technology

- Single Well Test for reservoir characterisation
- Several generations of U-Tube systems deployed
- Innovative well instrumentation



First of its kind experiments

- First CO_2 storage demonstration project in Australia
- Reducing risk and uncertainty
- Advising regulators and project proponents in Australia and world wide
- A go-to project



Slides from Dianne Wiley/Matthias Raab

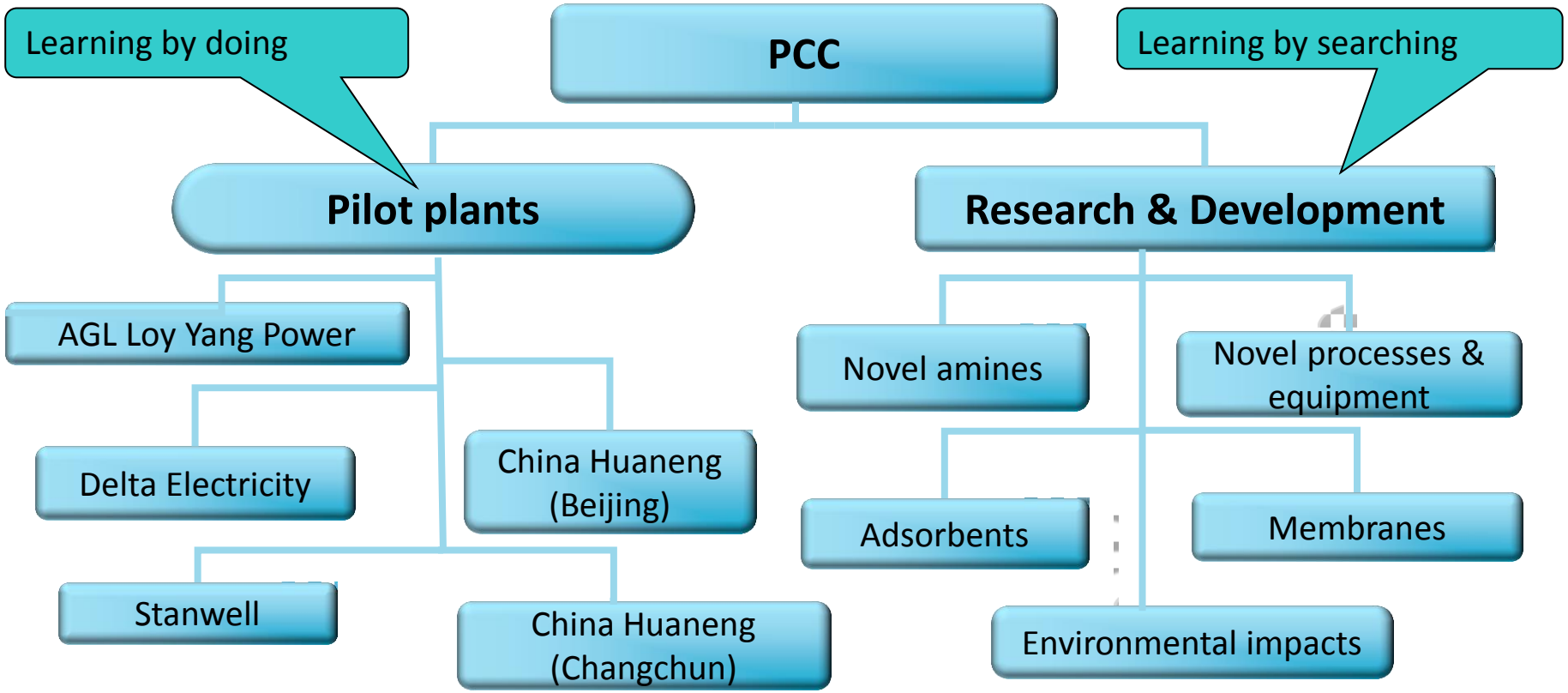
CO2CRC Capture Research Achievements

- Post-combustion field facilities for solvents, adsorbents and membranes.
- Patented potassium carbonate solvent.
- Testing of nanofiltration and electrodialysis for heat stable salt removal.
- Patented pelletization technique for PEI adsorbents.
- Identified trapdoor mechanisms of chabazite adsorbent for CH_4/CO_2 separation.
- Rapid screening and process cycle tools for adsorbents.
- Patented flat sheet CAP gas membrane fabrication process.
- Fabrication and testing of high performance hollow fibres for post-combustion capture.
- Fabrication of inorganic metal oxide silica membrane for CO_2/H_2 separation.

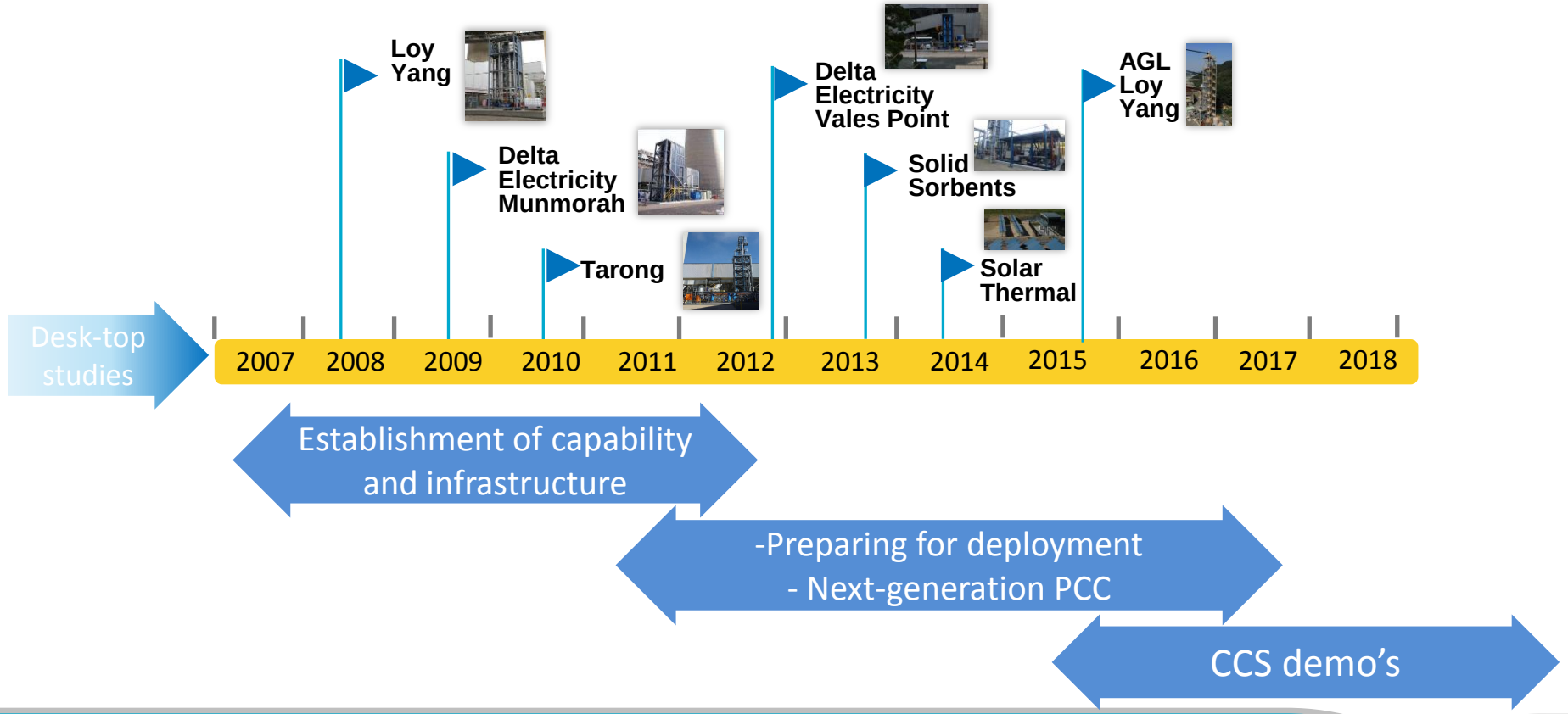
Slides from Dianne Wiley/Matthias Raab

Post-combustion CO_2 Capture at CSIRO

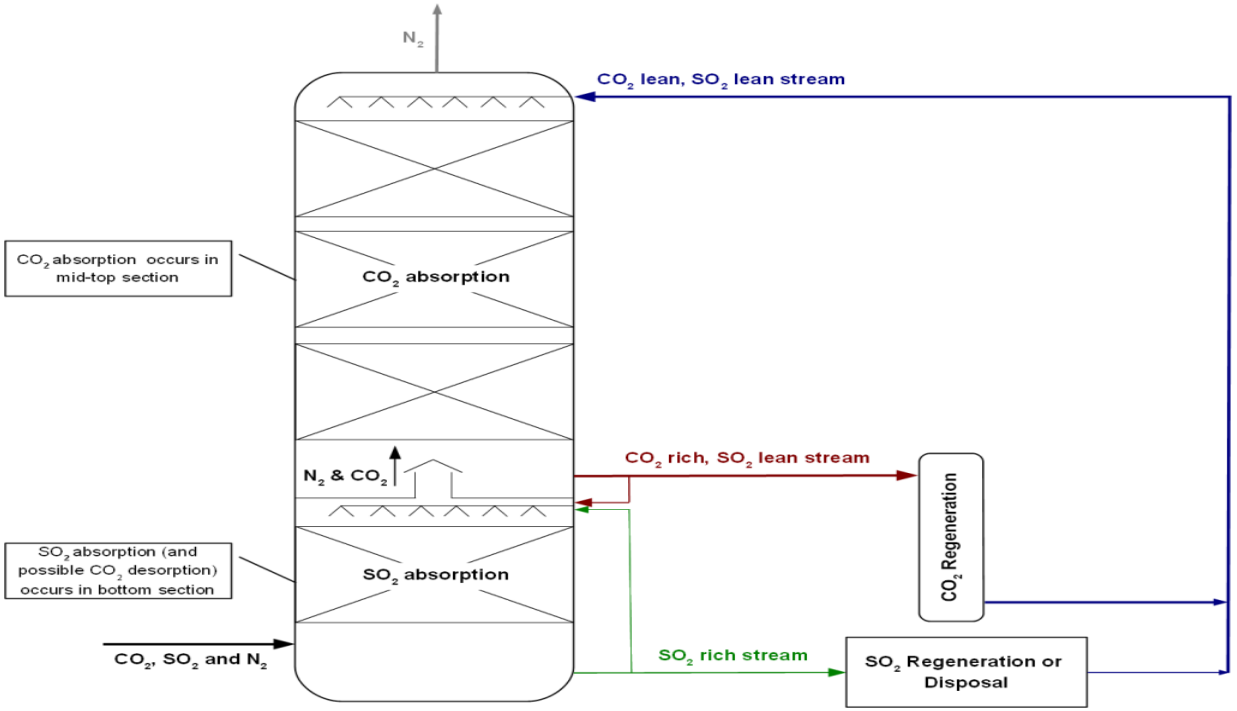
CSIRO's PCC program 2014

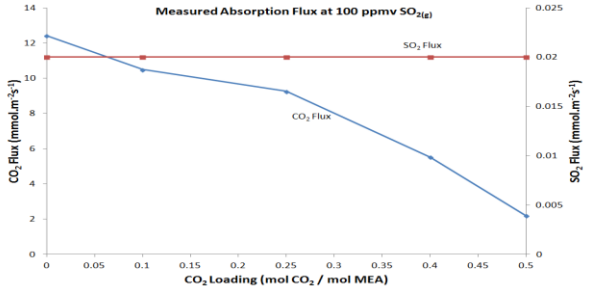


Piloting PCC Technologies in Australia



Integrated Single Stream SO_2 and CO_2 Capture (Dr. Erik Meuleman)





Puxty *et al.*, 2012, WO2012_097406

Rotating Liquid Sheet contactor (Dr. Leigh Wardhaugh)

Basic principles

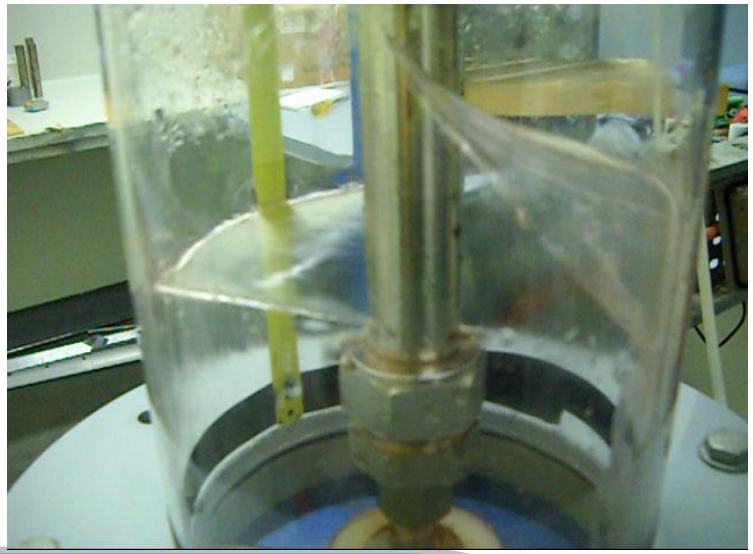
- Surface area of stabilized liquid sheet greater than that resulting droplets.
- Rotating liquid surface proven experimentally to pump gas .
- Centrifugal + liquid pumping force creates interfacial area.

Advantages

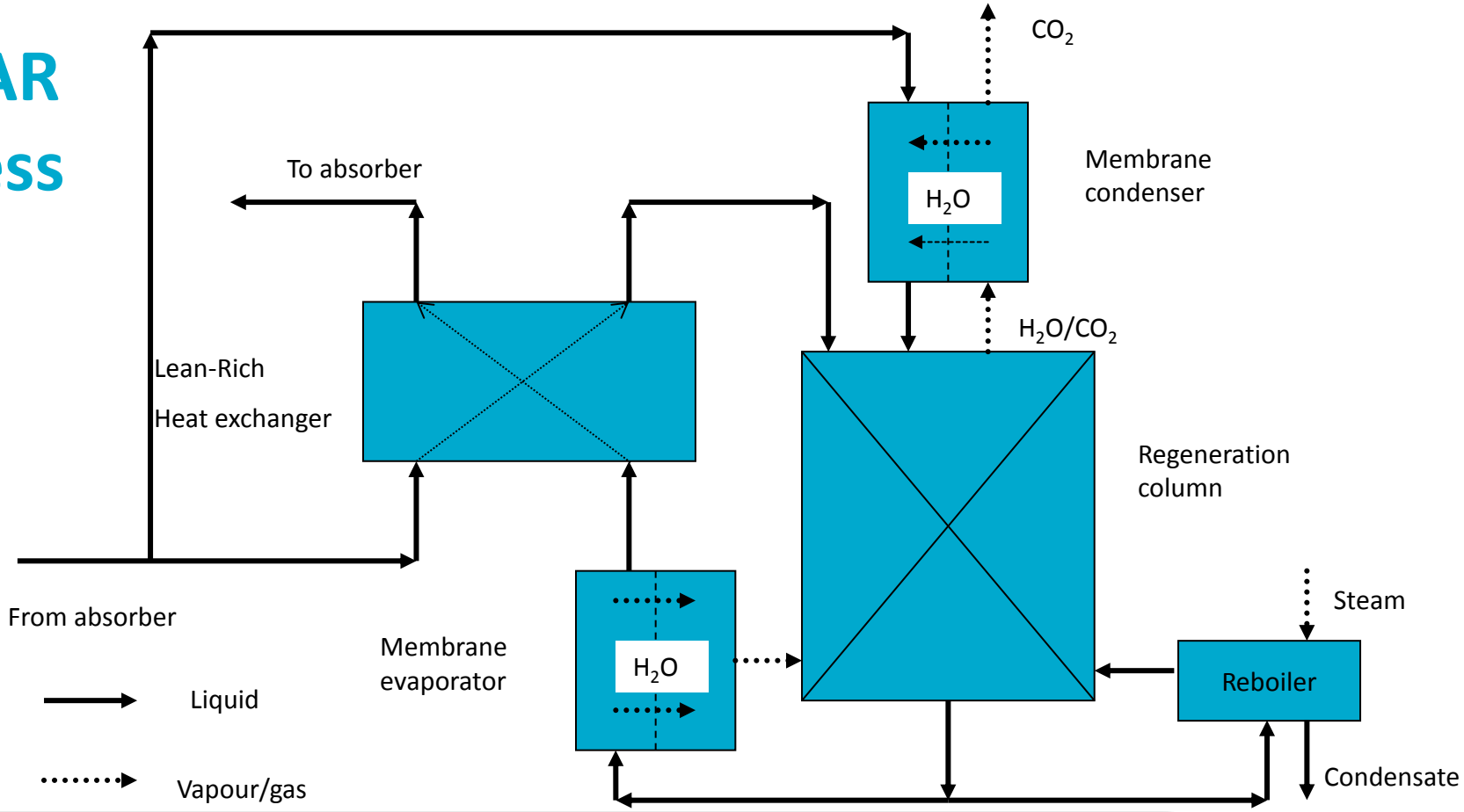
- Higher gas velocities possible.
- Liquid entrainment significantly reduced
- Suitable for viscous solvents

Challenges

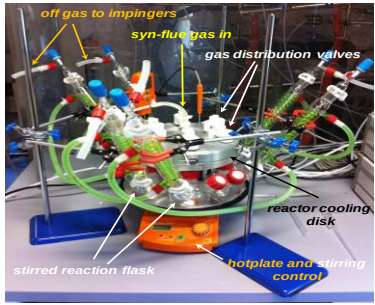
- Scale-up to commercial scale
- Liquid residence time low



MALAR Process



Emission issues addressed via integrated approach (Dr. Merched Azzi)



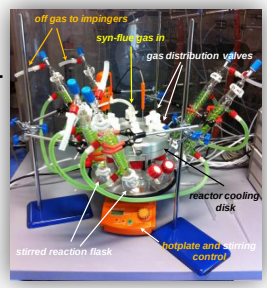
1. **Formation of potentially harmful components**
   - Absorbent degradation in absorber
   - Absorbent degradation in desorber

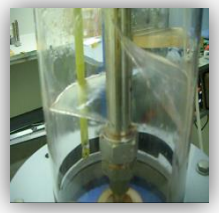
2. **Emission analysis**
   - Estimation of concentrations using process models
   - Actual measurements in pilot plants

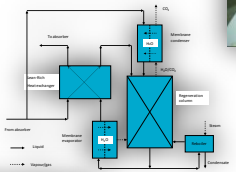
3. **Dispersion**
   - Smog chamber to investigate atmospheric degradation
   - Updating dispersion models with atmospheric chemistry

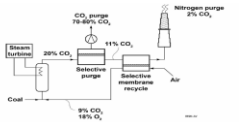
Perspective on PCC cost reductions in Australia

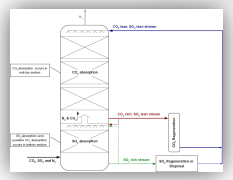
Cost reduction	0%	10%	25%	50%
Designer amines	Higher reactivity; low regeneration energy			
Packing-less contactor	Capital & operating cost reduction			
Process Intensification	Energy efficiency			
Co-capture of $CO_2/SO_2/NO_x$	No FGD			











Key research and engagement partners in PCC

Thank you

Energy Flagship

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w http://www.csiro.au/science/Post-combustion-capture.html

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