CO2CRC Capture & Storage update

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Cooperative Research Centre
for Greenhouse Gas Technologies (CO2CRC)

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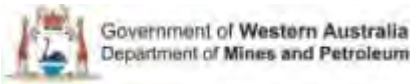
Bergen

CO2CRC : a leading CCS research organisation -Capture & storage

- **Integrates CCS R&D and economics along the value chain**
  - capture, storage and systems integration
- **Collaboration brings together:**
  - +150 leading researchers in CCS
  - industry sectors together (coal, gas, power, etc) to provide an exceptional stakeholder base
  - Australian Government, States and local government
  - major research institutions - CSIRO, Geoscience Australia, Universities, overseas institutions

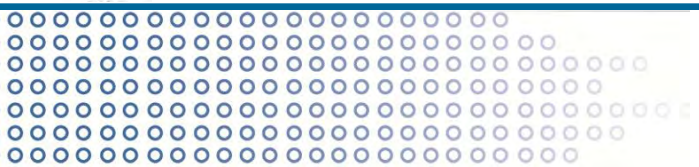
CO2CRC Participants



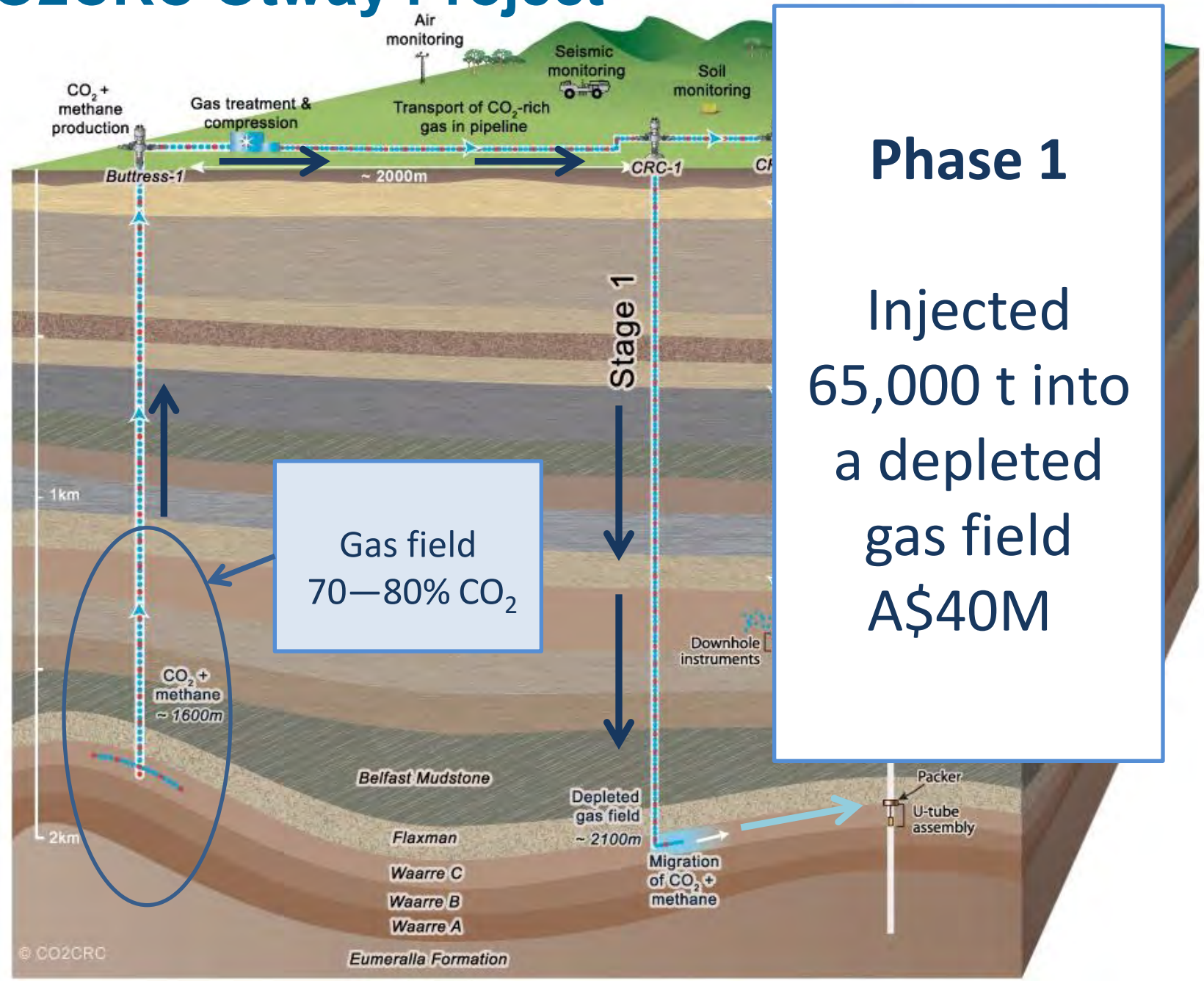
Supporting Partners: The Global CCS Institute | The University of Queensland | Process Group | Lawrence Berkeley National Laboratory

Government of South Australia | CANSYD Australia | Charles Darwin University | Simon Fraser University

Established & supported under the Australian Government's Cooperative Research Centres Program



The CO2CRC Otway Project



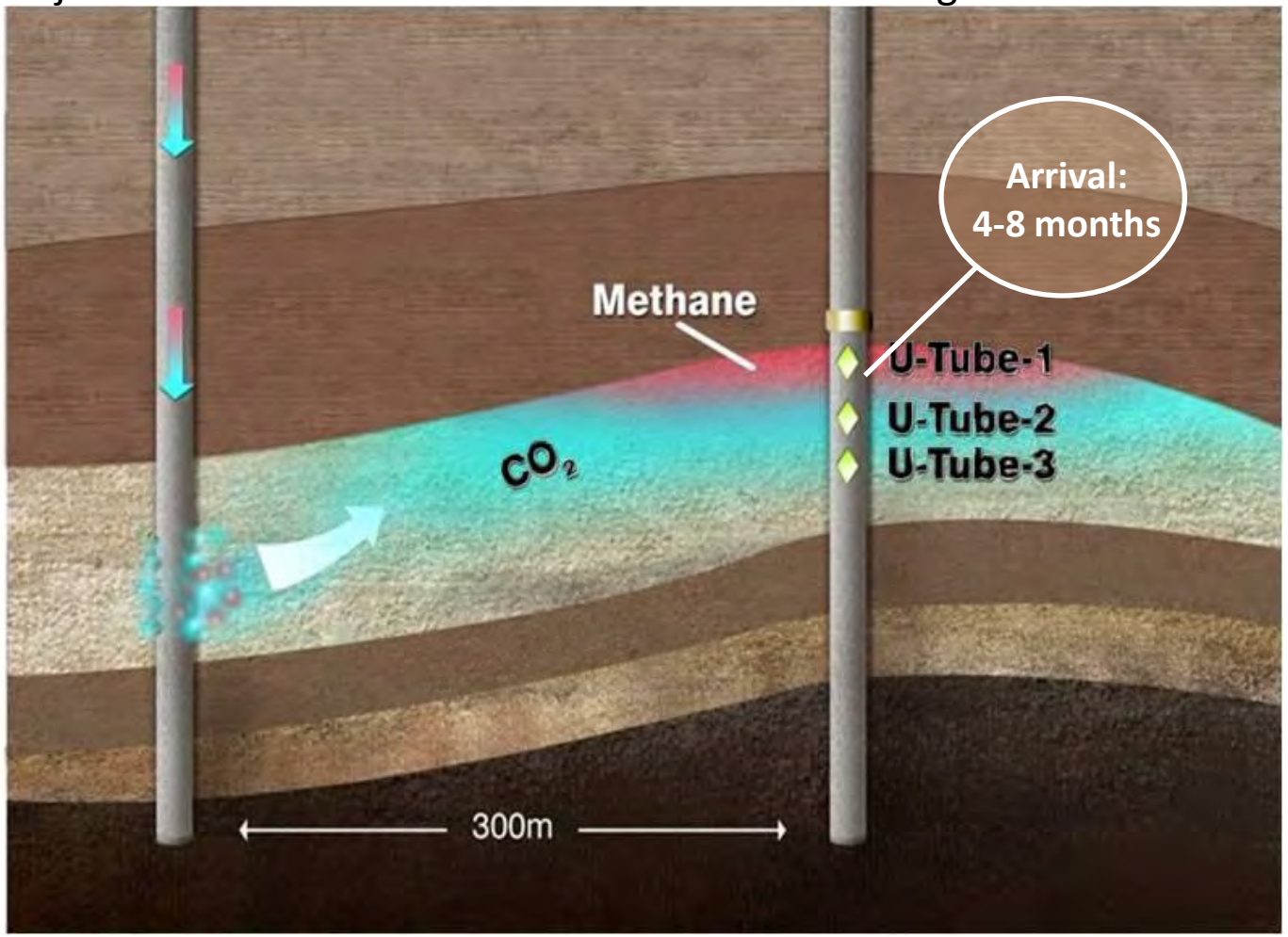
Phase 1

Injected 65,000 t into a depleted gas field A$40M

Otway Stage 1 65,000 – predictions matched results

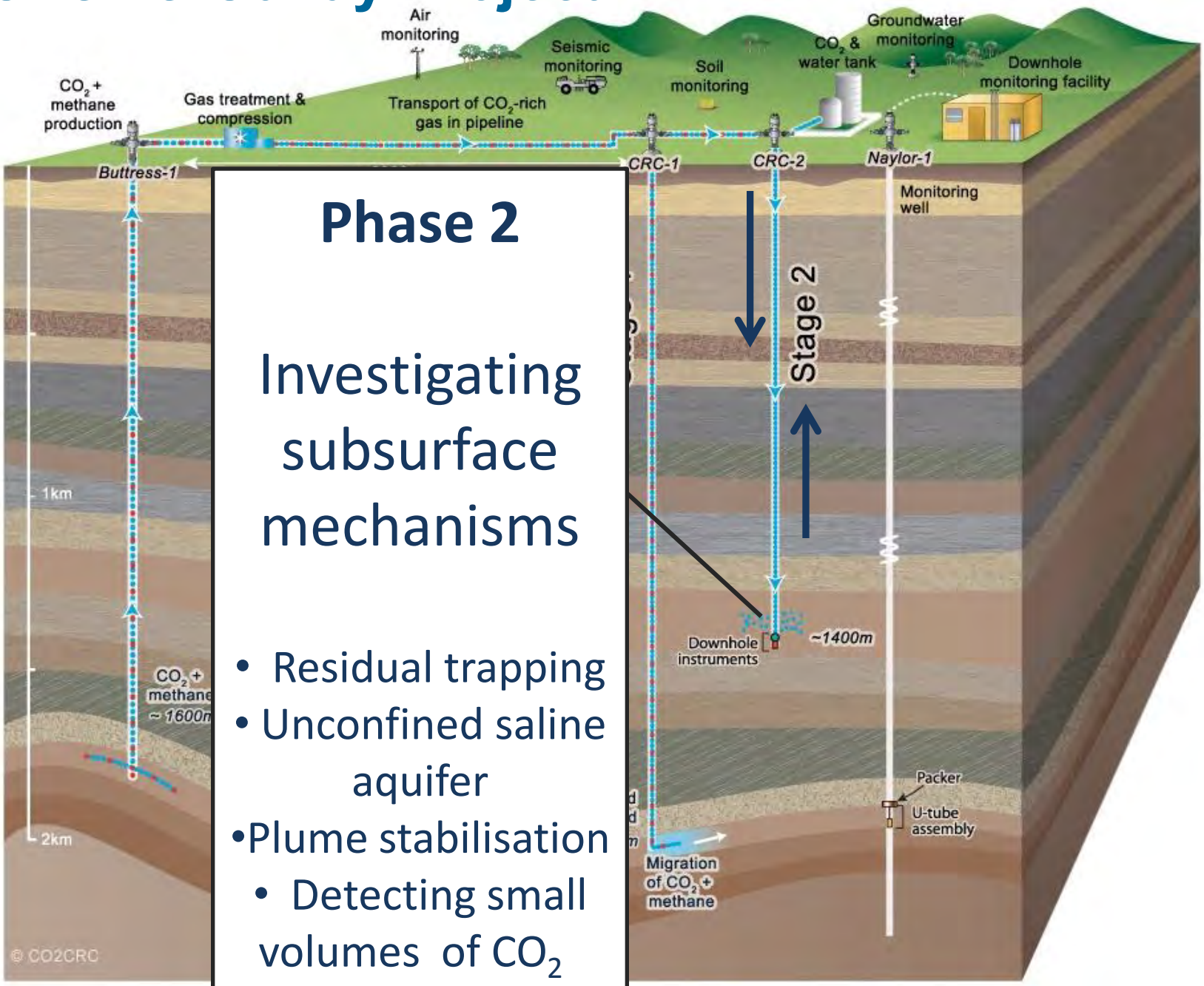
CRC-1
Injection well

Naylor-1
Monitoring well



Depth
~2000m

The CO2CRC Otway Project



Phase 2

Investigating subsurface mechanisms

- Residual trapping
- Unconfined saline aquifer
- Plume stabilisation
- Detecting small volumes of CO_2

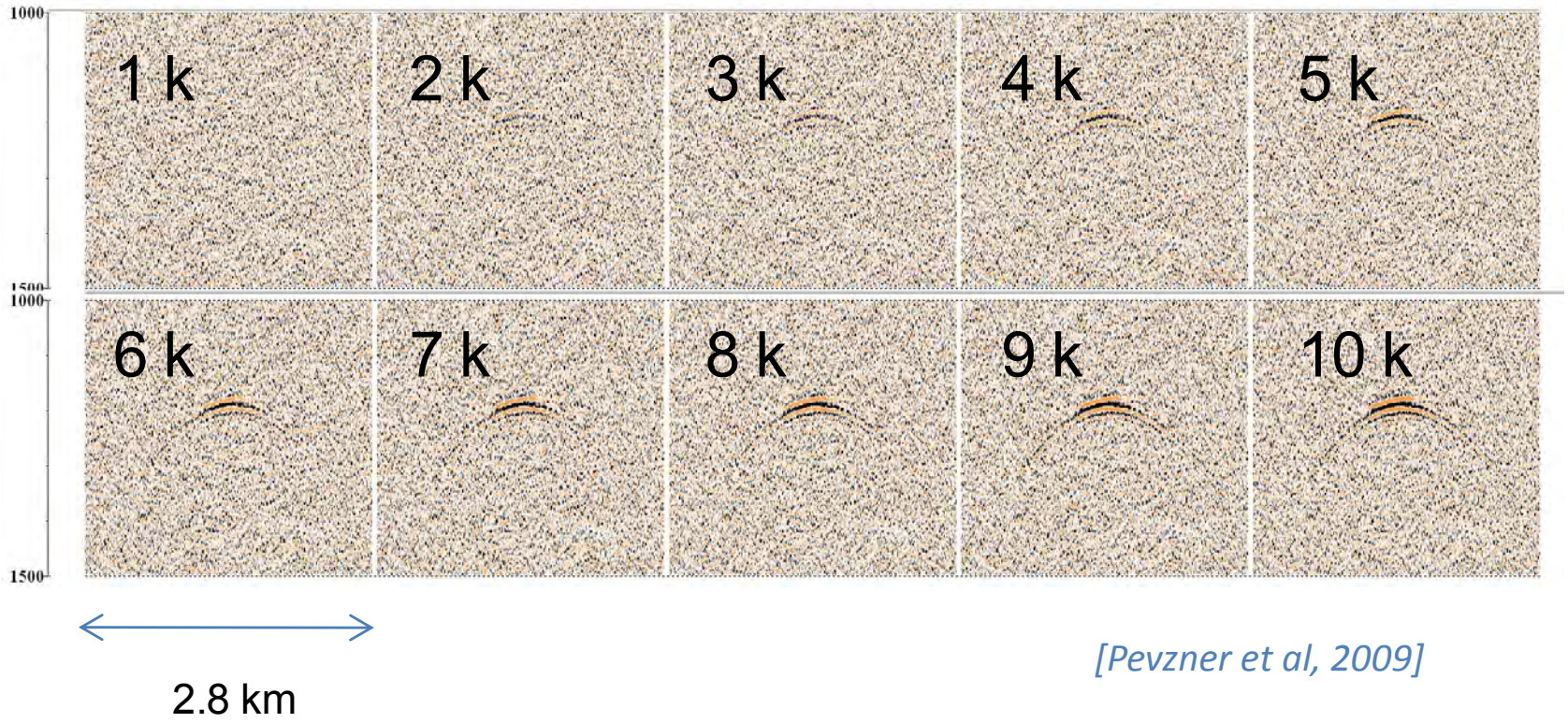
Otway Stage 2b
Determine the residual CO_2 saturation, Sgr

Five (5) independent approaches to determining residual trapping:

- Thermal test
- Tracer test
- History matching injection and production
- Saturation logging using wireline Saturation Tool
- Dissolution Test

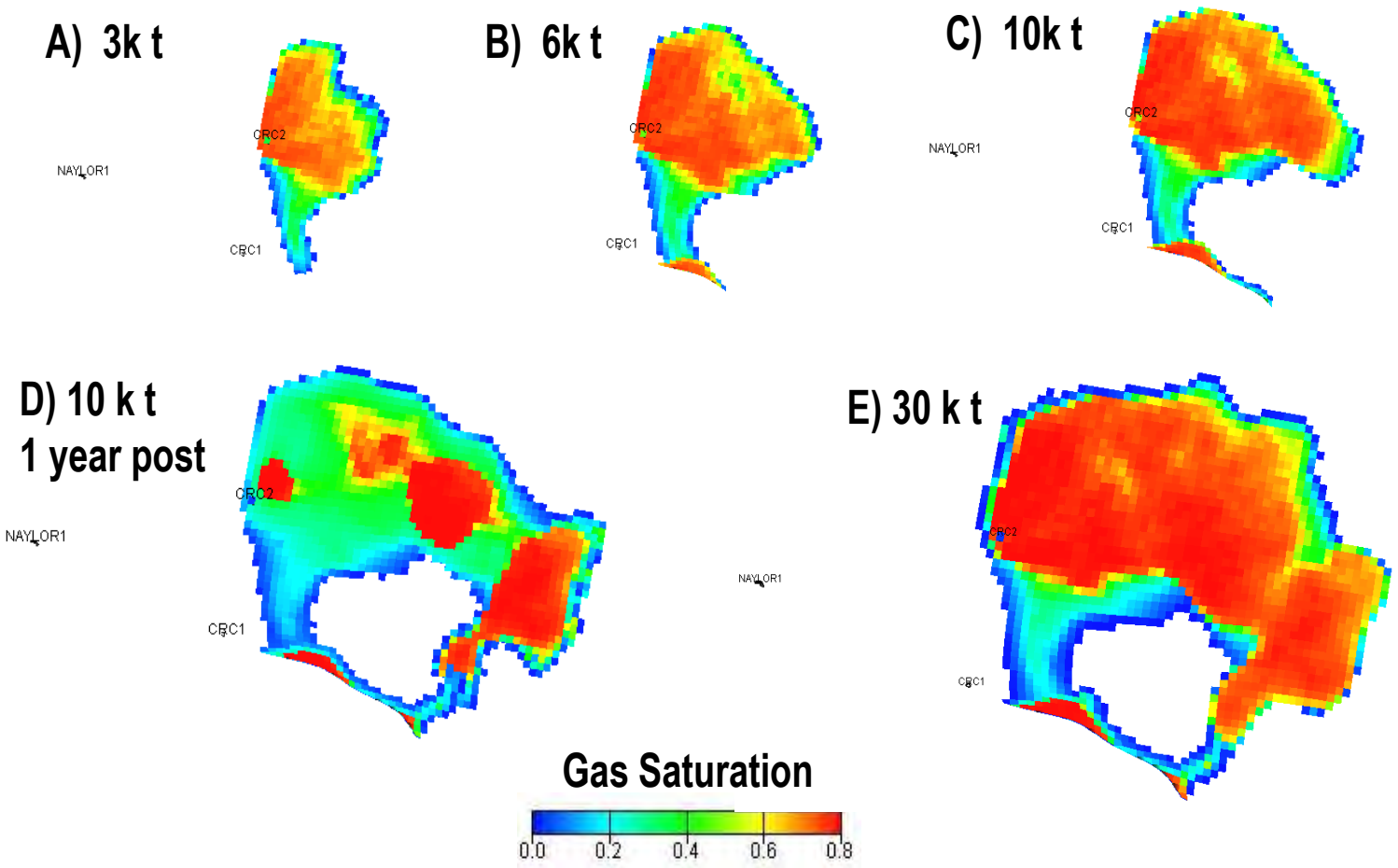
Otway Project Stage 2C – planning in progress

- **Injection of up to 10,000 tonnes of CO_2**
- **Testing ability to detect stored CO_2 in Paaratte Formation using seismic methods**

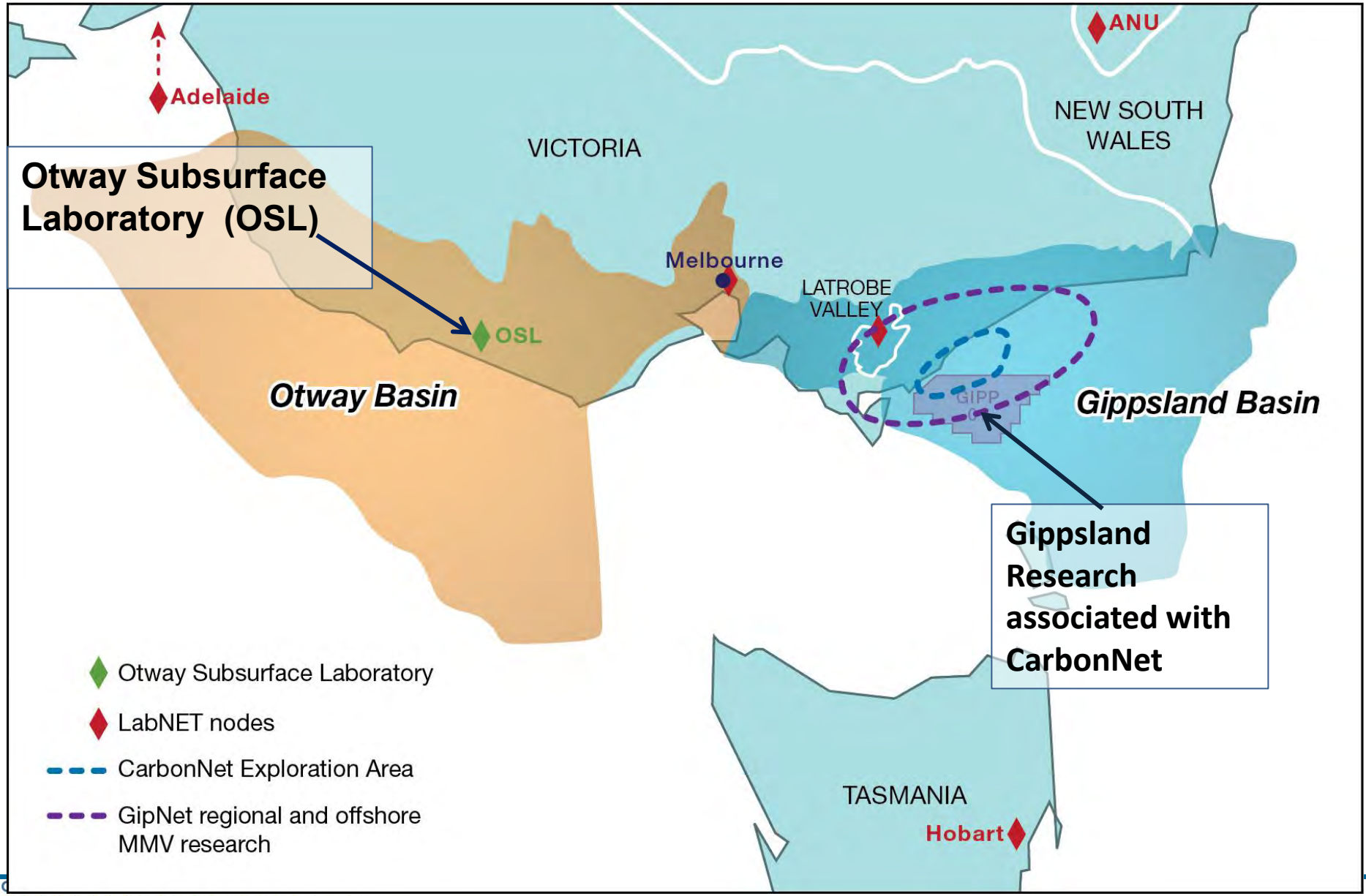


[Pevzner et al, 2009]

Plume evolution



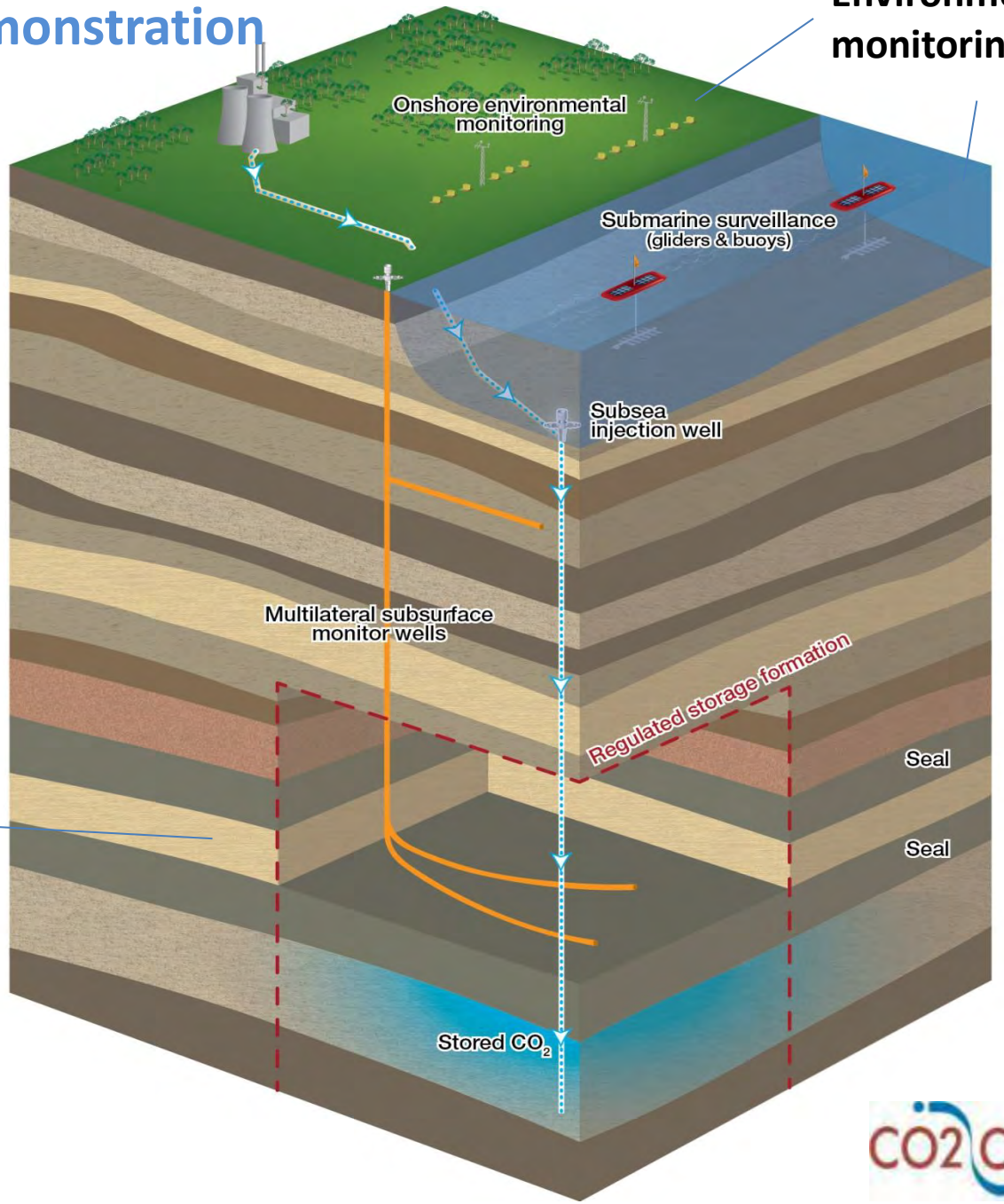
Research Associated with CarbonNet CCS Flagship Project



CarbonNet Flagship Demonstration 1-5 MTPA CCS – offshore storage

CO2CRC - providing research services

Low cost low impact subsurface monitoring



CO2CRC's Capture RD&D Portfolio

Laboratory and pilot scale activities:

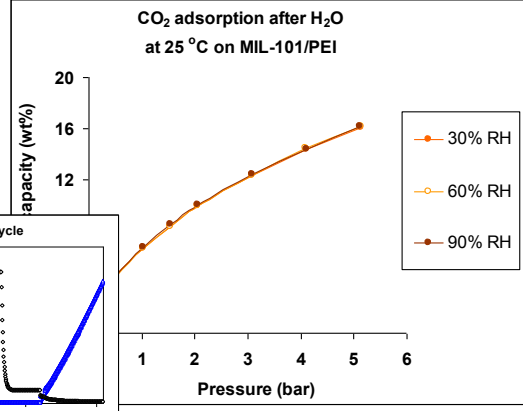
- **Solvent systems**
- **Adsorbents**
- **Cryogenics/hydrates**
- **Membrane systems**

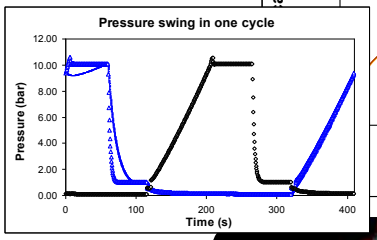
- **Engineering Development and integration**

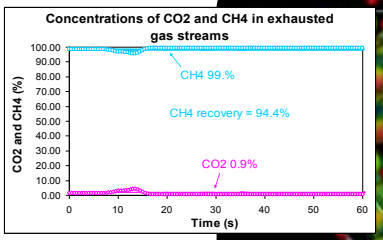
- **Techno – economic modelling**

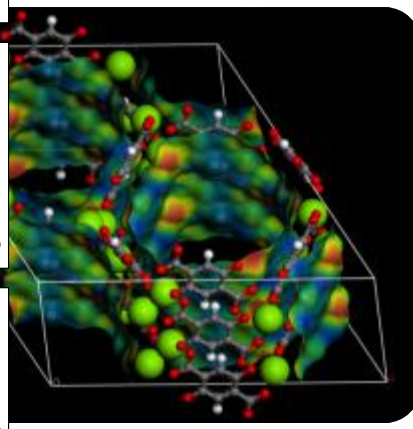
Adsorbent systems

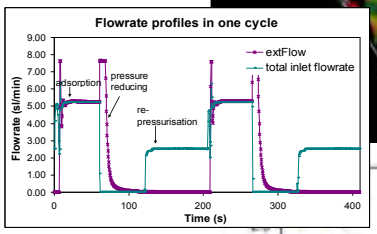
- **Post-combustion capture**
  - Materials: MOFs & tethered amines
  - Process development: zeolite 13X & PEI
- **Pre-combustion capture**
  - Materials: double salts & metal oxides
  - Process development: zeolite 13X, amine & metal oxides
- **Natural gas separation**
  - Materials: : hydrophobic PCPs & molecular sieves
  - Process development

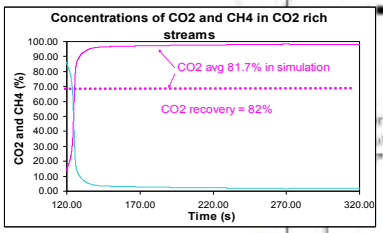


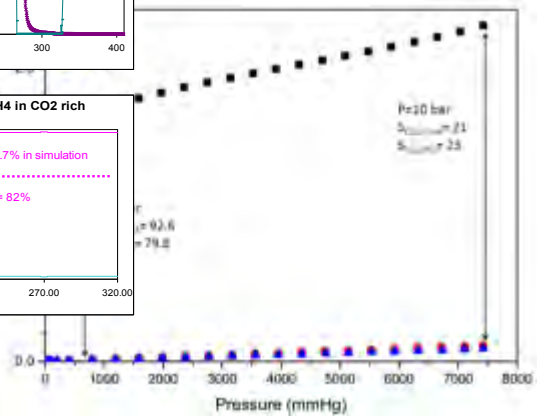






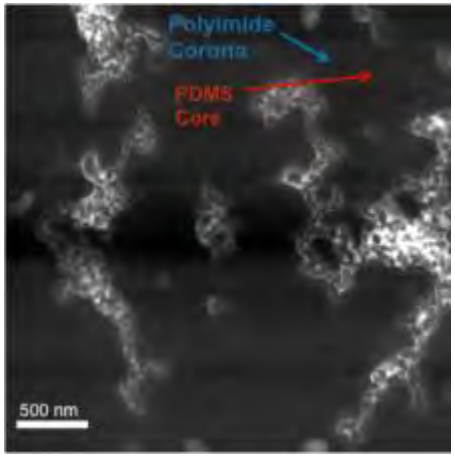


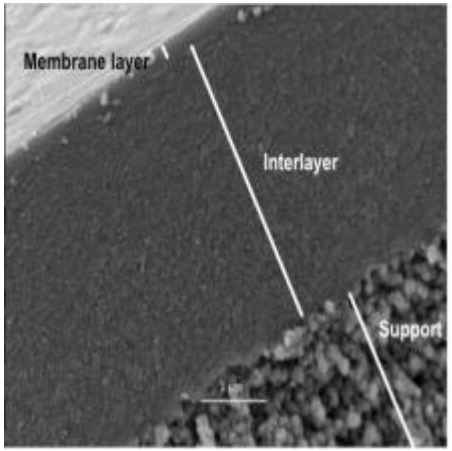




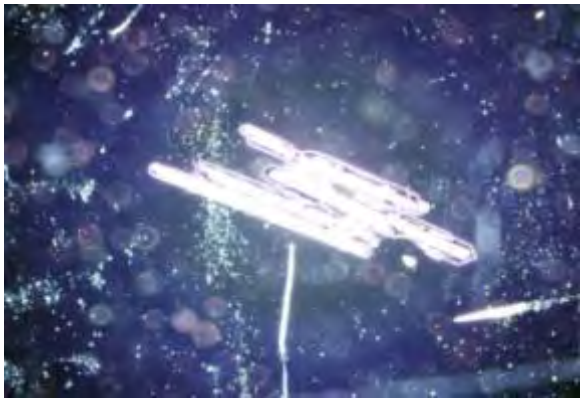
Membrane systems

- **New materials**
  - Macro-initiators and crosslinking
  - CAP polymerisation
- **Metal oxide silica membrane**
- **Hollow fibres**
  - High flux homopolymer
  - Stabilisation
- **Spiral wound modules**
  - Impact of ash and fluid mechanics
- **Natural gas separation**
  - Effect of impurities and water

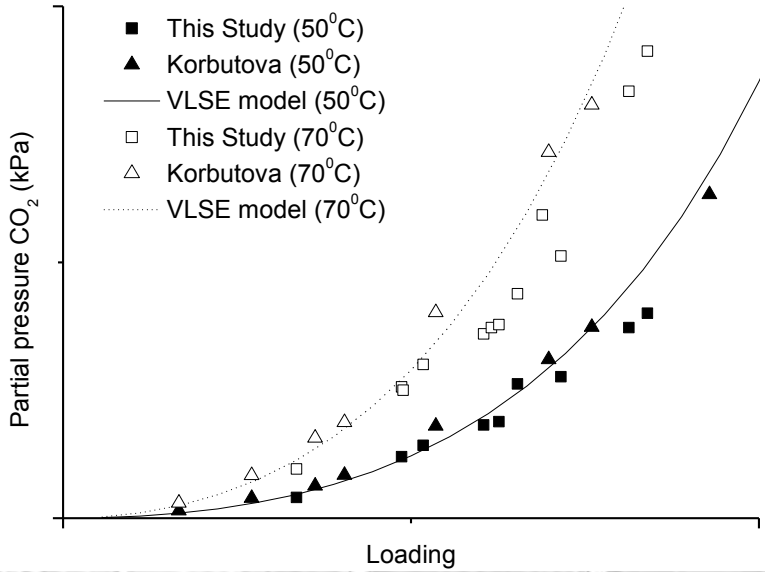


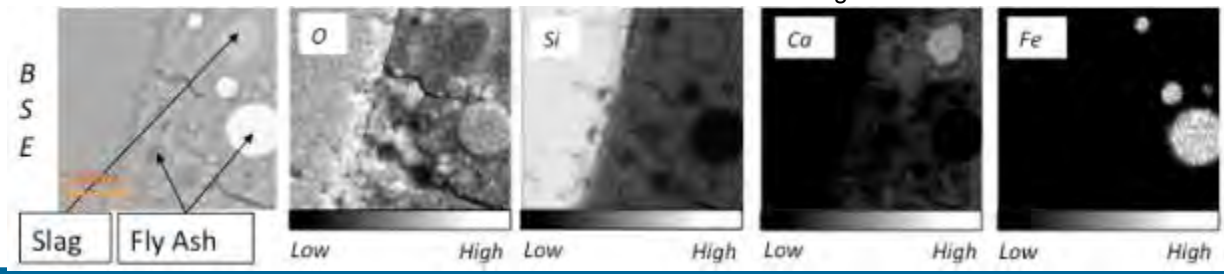


Solvent systems



- **Precipitating carbonate**
  - Thermodynamics
  - Kinetics
  - Promoters
  - Crystal formation ($KHCO_3$)
  - Impurities
- **Geopolymers**
  - High T effects
  - Interfacial effects

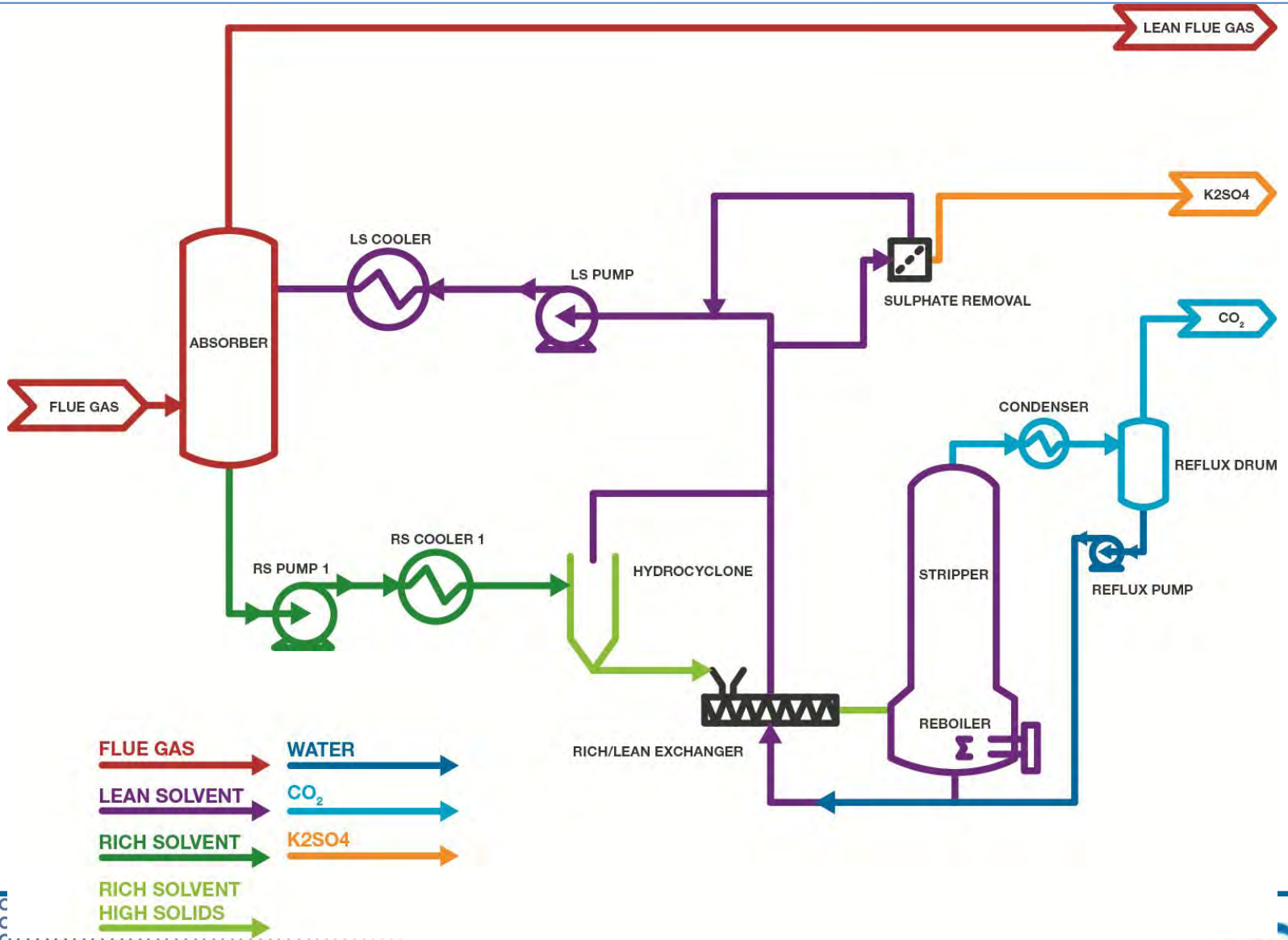




UNO Mk 3 Background

- **Potassium carbonate (K_2CO_3) solvent for post-combustion capture of CO_2 from flue gas**
  - Developed from research and multi-year trials on power plant
- **Precipitation of potassium bicarbonate product ($KHCO_3$)**
  - $K_2CO_{3(l)} + H_2O_{(l)} + CO_{2(g)} \leftrightarrow KHCO_{3(l)} \leftrightarrow KHCO_{3(s)}$
- **Separation of solid phase $KHCO_3$ for selective regeneration of a concentrated slurry stream**
- **Improved management of heat loads**
- **Separation of potassium sulphate and nitrate products resulting from reaction of SO_x and NO_x with K_2CO_3**

UNO Mk 3 Process Description



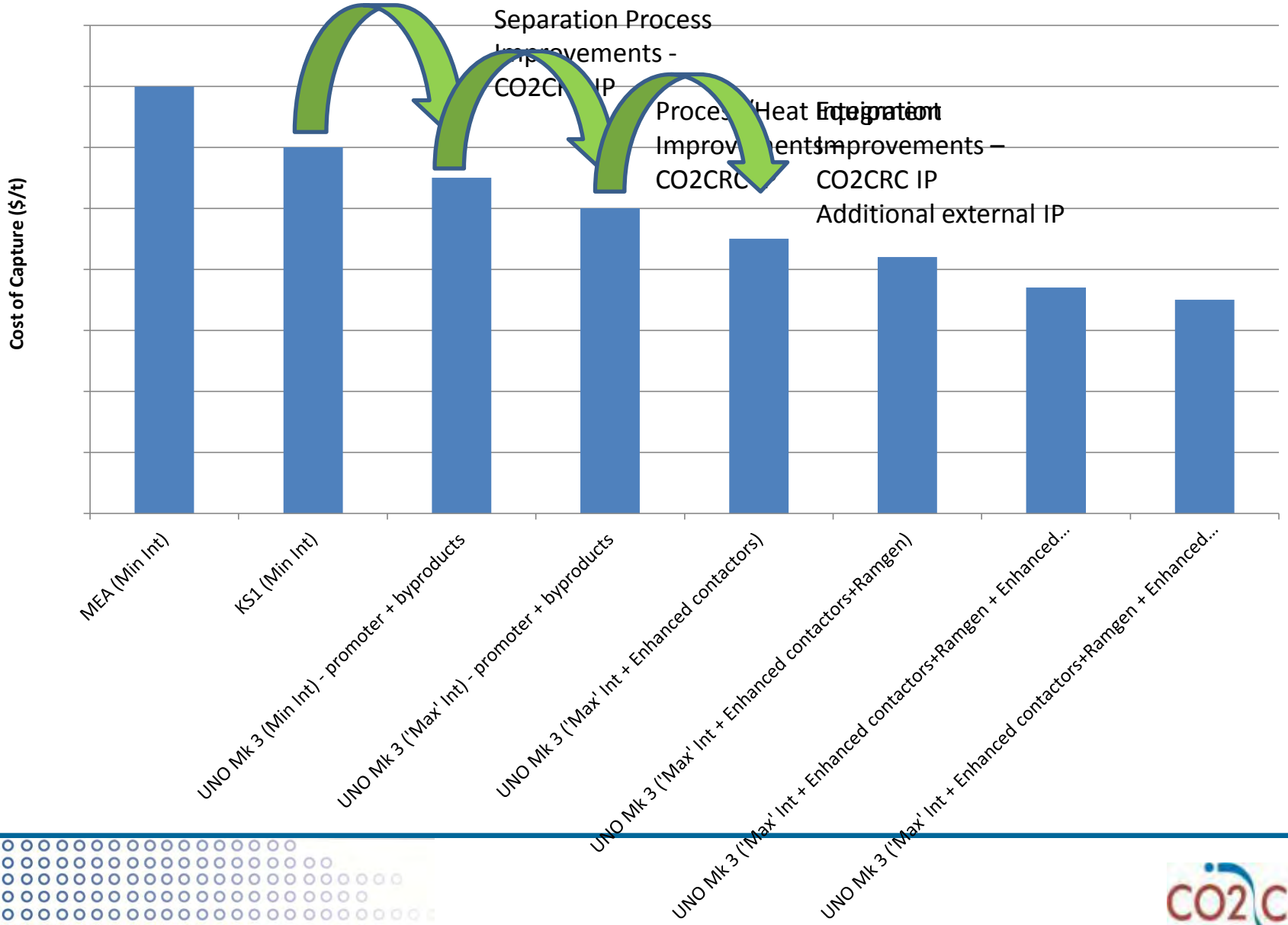
UNO Mk 3 Key Benefits

- ✓ Low energy of regeneration
- ✓ Low overall cost
- ✓ Low volatility and environmental impact
- ✓ Multi-impurity capture and production of valuable by-products
- ✓ Potassium usage fits within existing global market
- ✓ Applicable to post and pre-combustion capture including NGCC

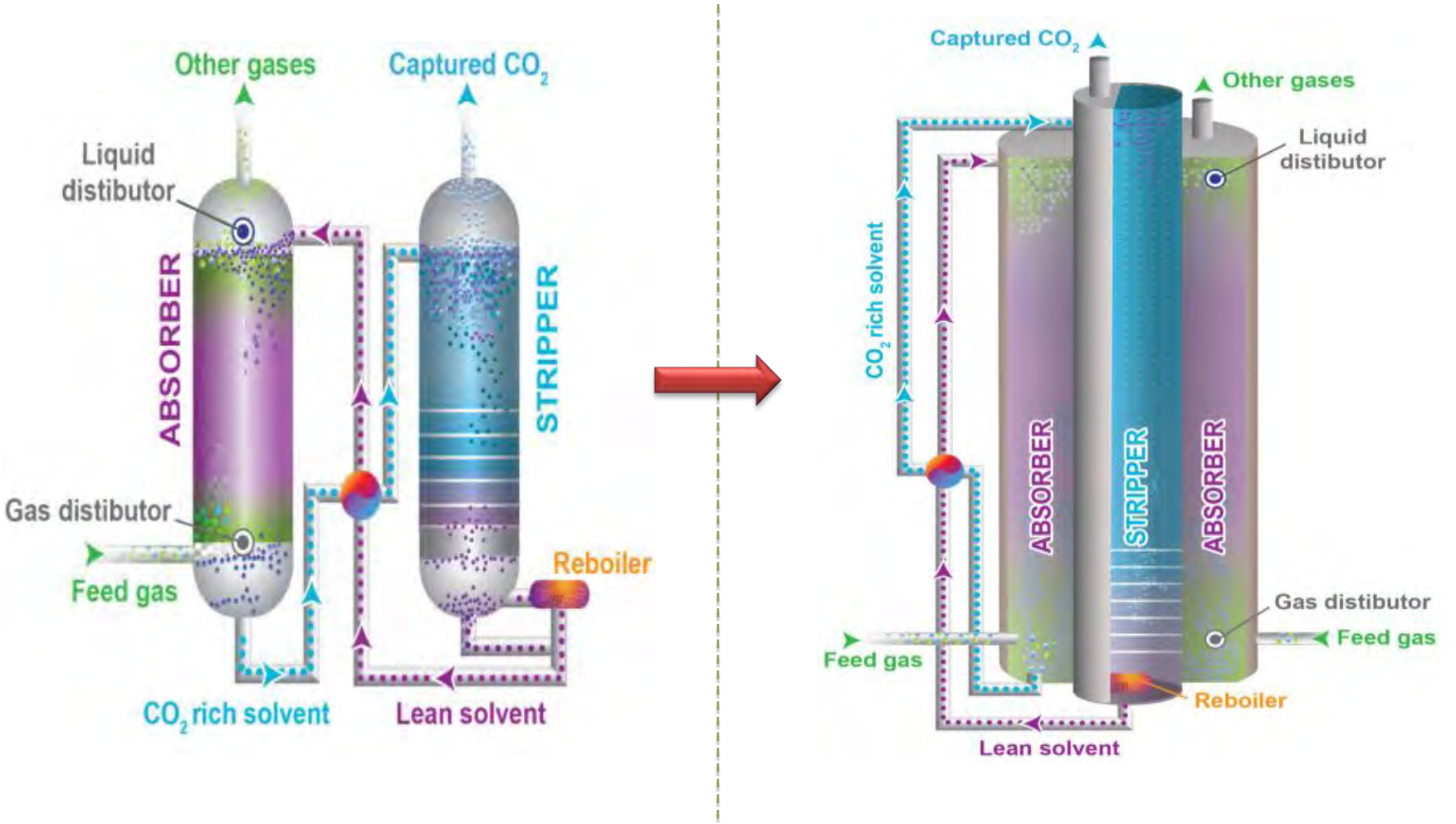
UNO Mk 3 Key Benefits - Cost

- ✓ **Low overall cost achieved through**
  - Heat integration
  - Enhanced rate promotion
  - Enhanced area contactor for a precipitating system
  - Smaller regeneration circuit and alternative reboiler designs
  - Lower solvent costs
  - Lower solvent replacement requirements
  - Elimination of de-SO_x and de-NO_x removal equipment
  - Production of valuable byproducts for fertilizer industry
  - Coproduction of alternative chemical products
  - Flexible capture with stockpiling of $KHCO_3$ salts

UNO Detailed Value Propositions – Preliminary

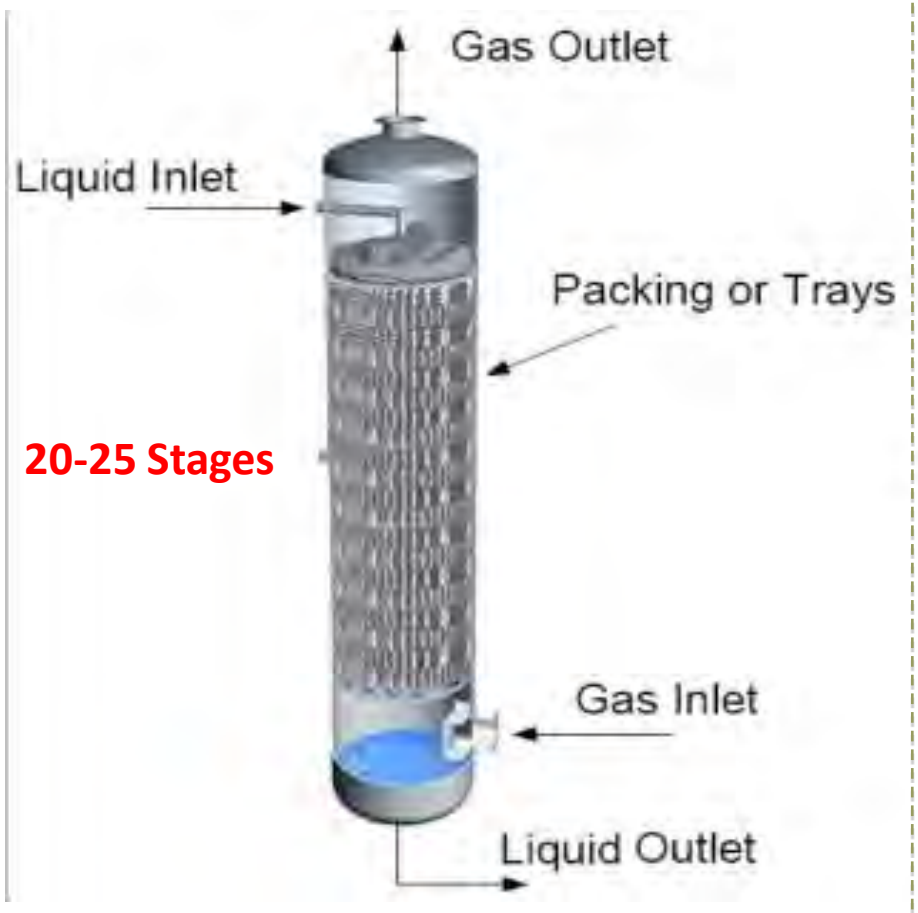


Large Scale Single Stream Designs



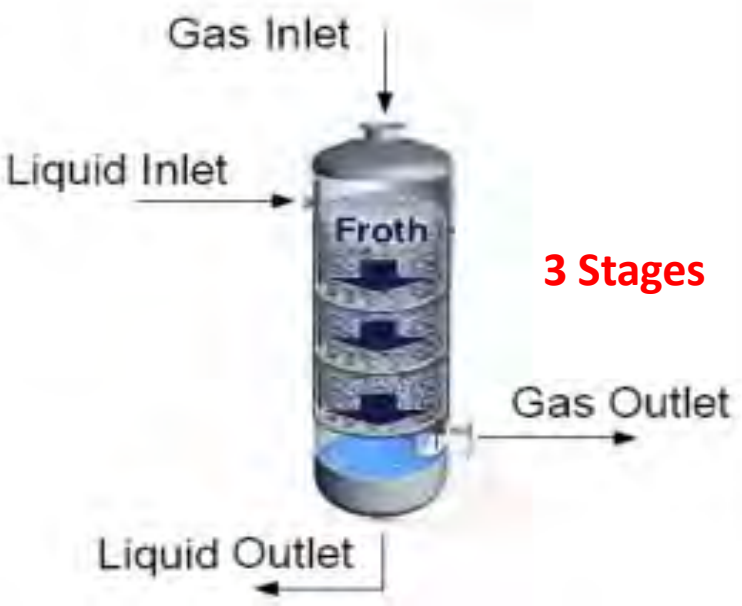
Absorption Column Comparison

Conventional Absorber

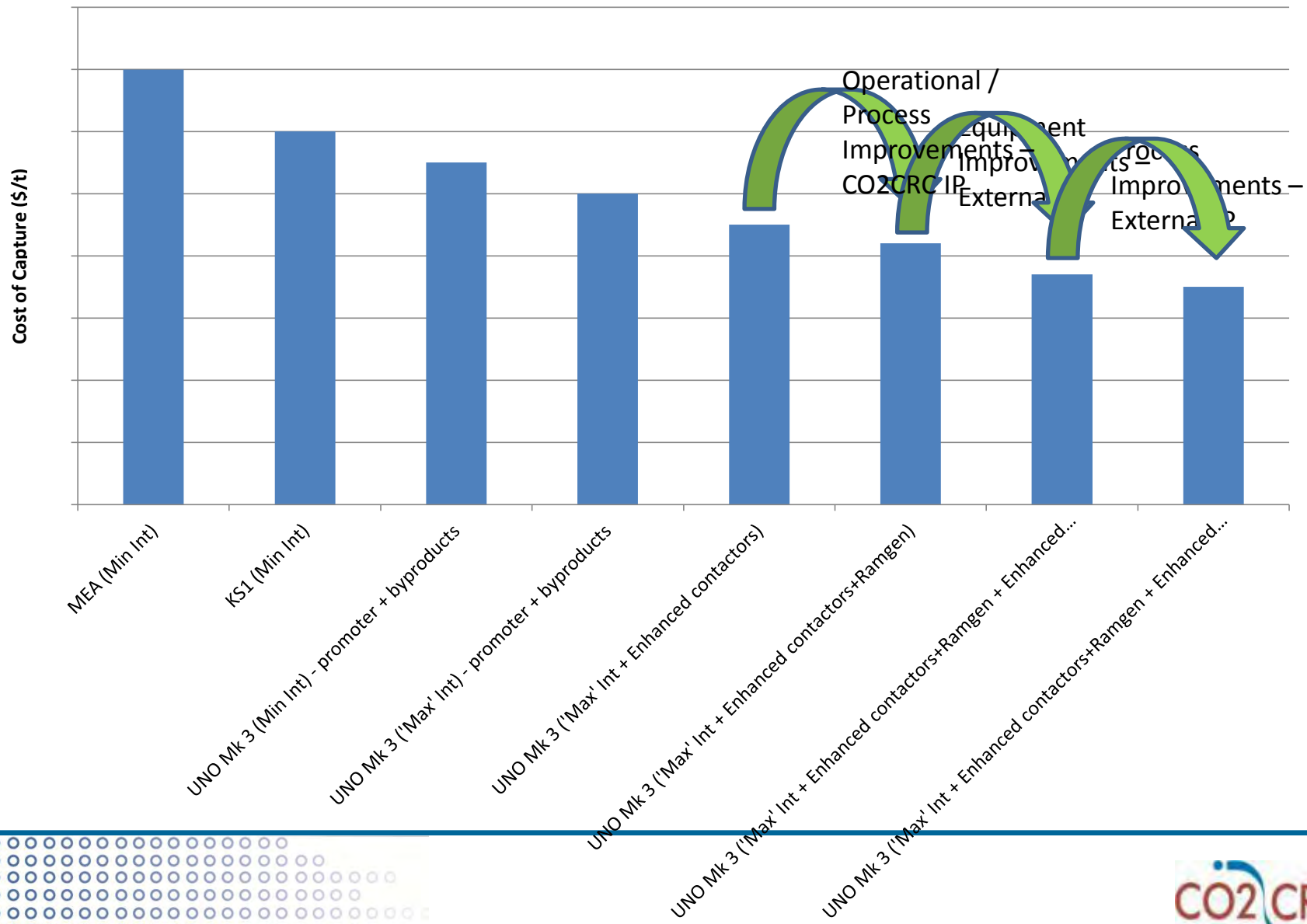


WES Absorber Froth Column

50% Reduction in Height



UNO Detailed Value Propositions – Preliminary



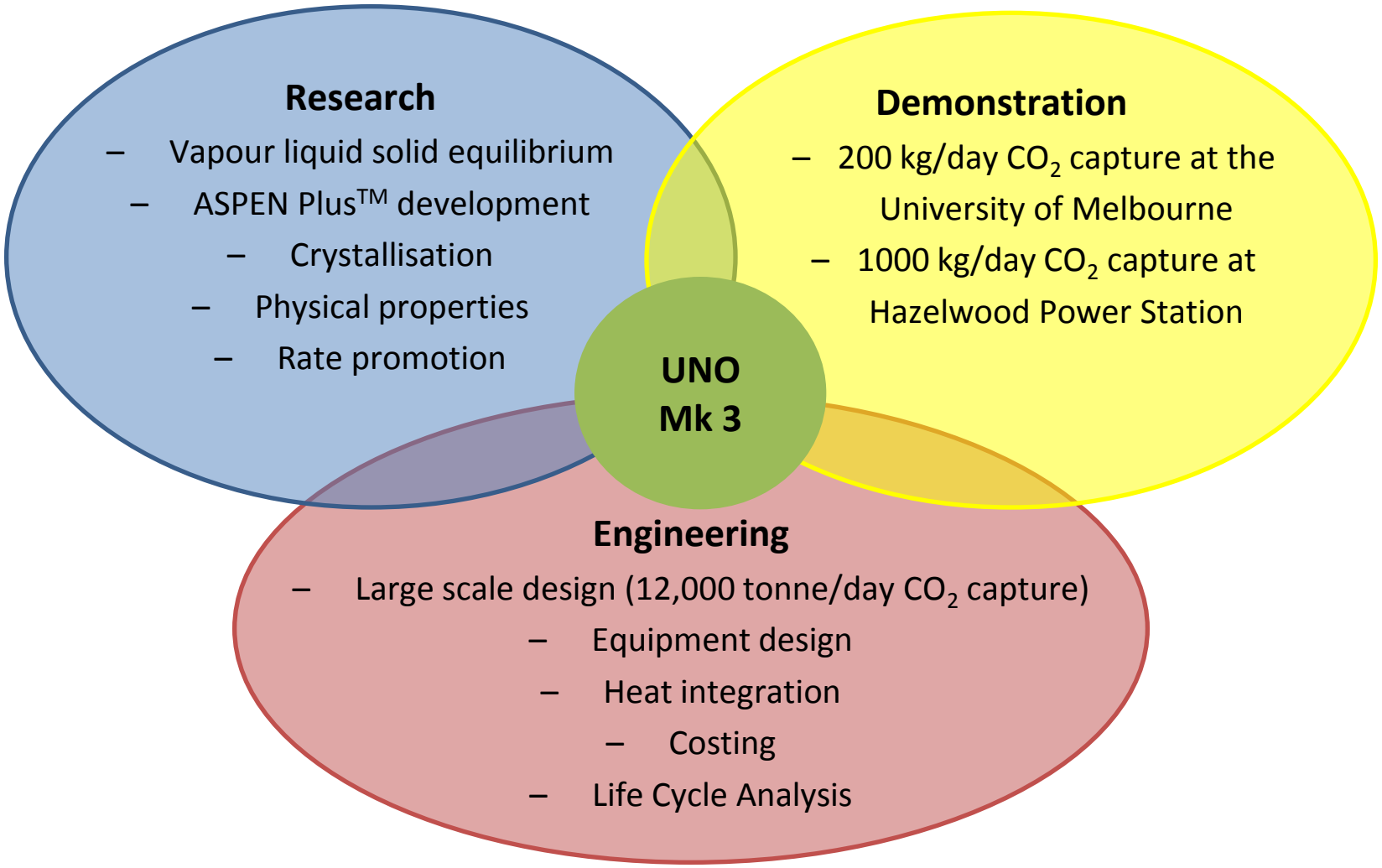
UNO Mk 3 Key Benefits - Environment

✓ Low volatility and environmental impact

- Low environmental emissions
- Low carbon footprint
- Easy handling and very low human toxicity potential
- Low acidification and eutrophication potential
- Low photochemical smog and low ozone layer depletion potential

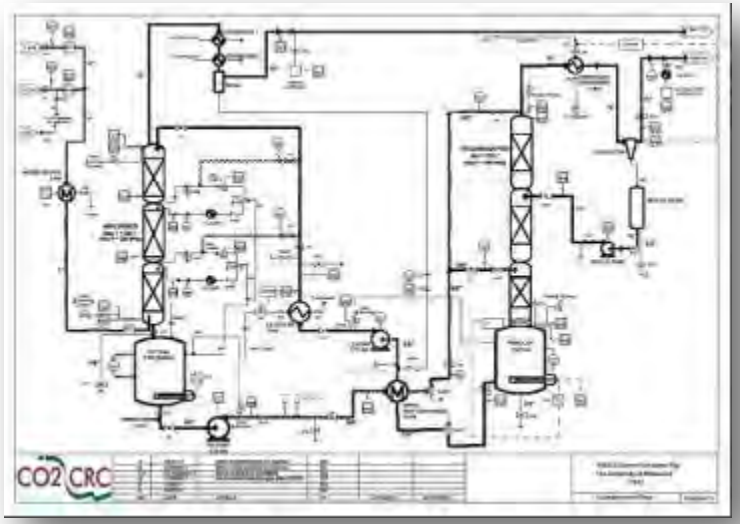
Environmental Impact	UNO MK 3	Amine (MEA)
Energy Use	<< 3 GJ/Tonne CO_2	> 3 GJ/Tonne CO_2
Carbon Footprint	Medium	High
Acidification Potential	Low	Medium
Eutrophication Potential	Low	Medium
Human Toxicity Potential	Low	High
Ozone Layer Depletion	Low	Low
Photochemical Smog	Low	Medium

UNO Mk 3 Work Program



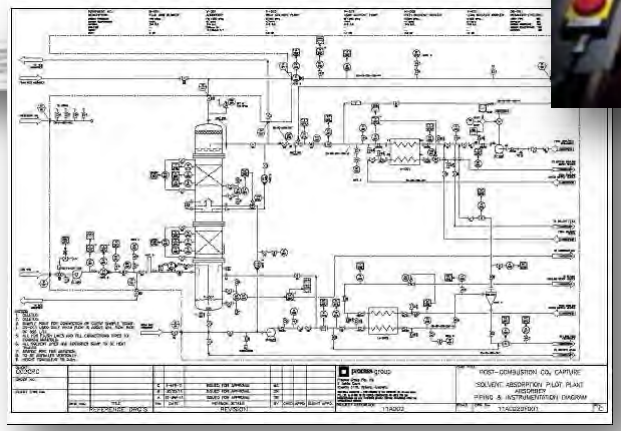
UNO Mk 3 Work Program – Demonstration #1

- 200 kg/day CO_2 capture at the University of Melbourne
- Currently in commissioned May 2012, operation until end 2013
- Partially funded by Australian National Low Emissions Coal Research and Development (ANLEC R&D)

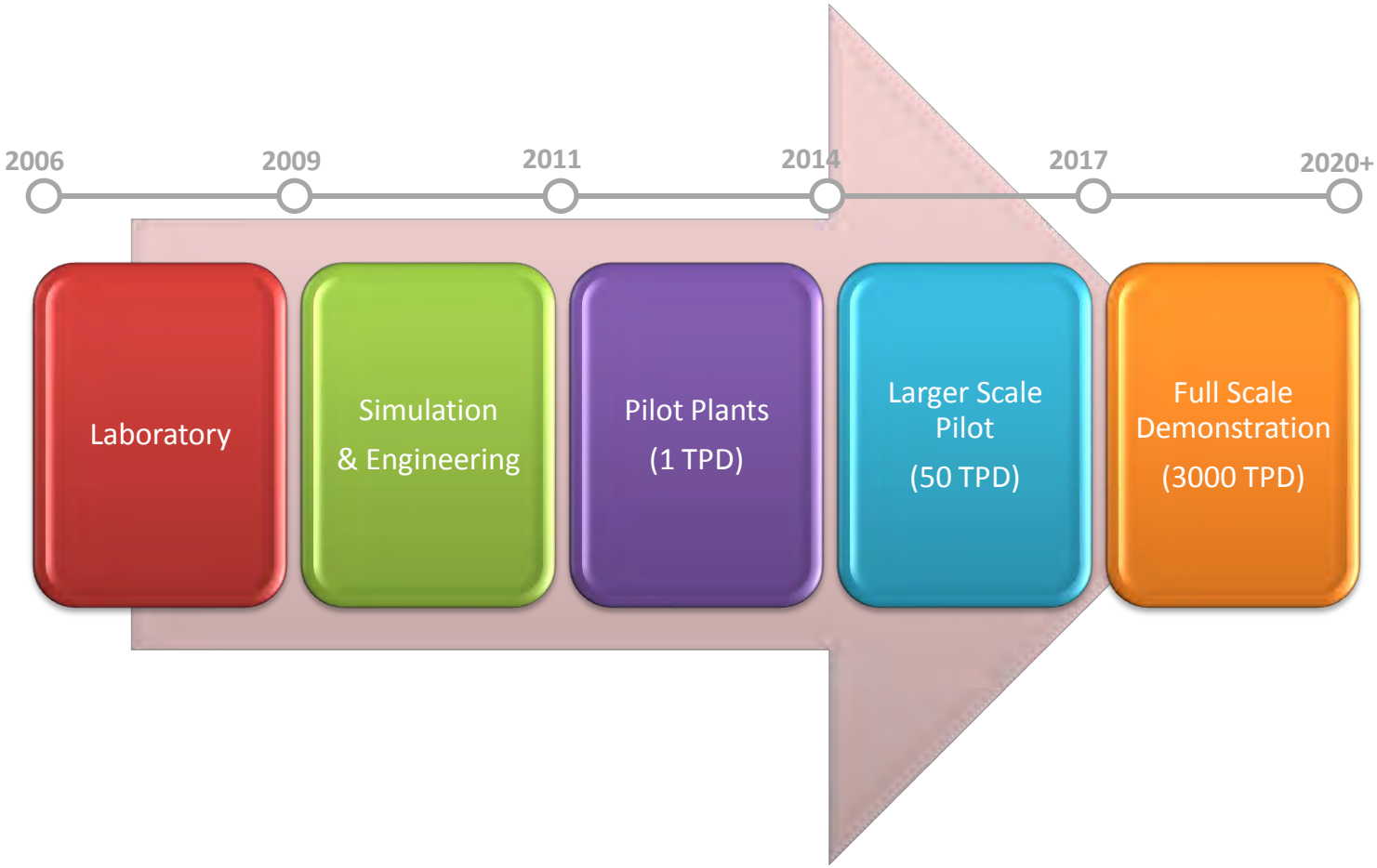


UNO Mk 3 Work Program – Demonstration #2

- **1000 kg/day CO_2 capture at Hazelwood Power Station, including demonstration of the WES™ Absorber**
- **Commissioning May 2012, operation until end 2014**
- **Partially funded by Brown Coal Innovation Australia (BCIA)**



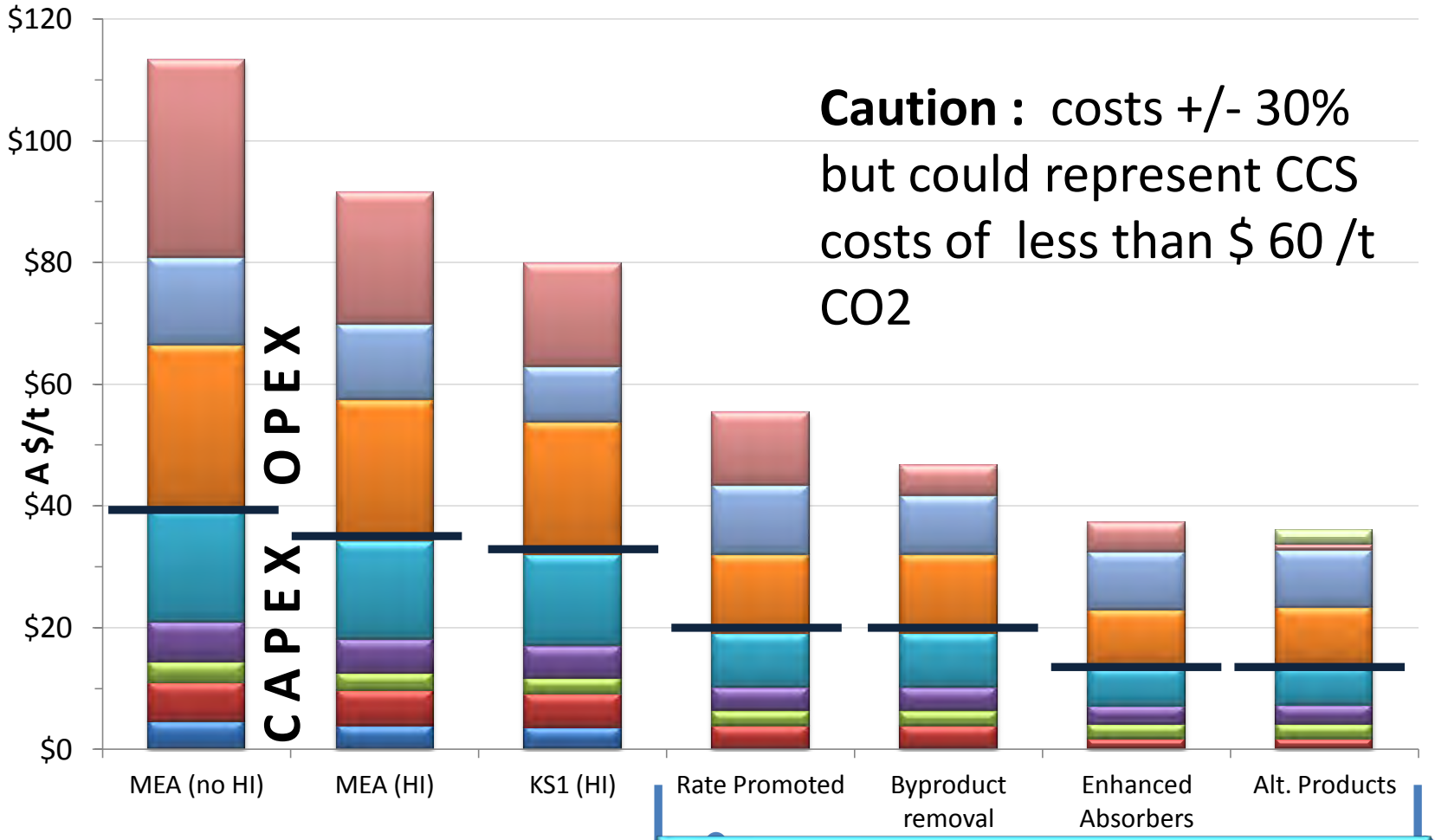
UNO Mk 3 Work Program – Timeline



UNO Mk 3 – A New Approach to Solvent Capture

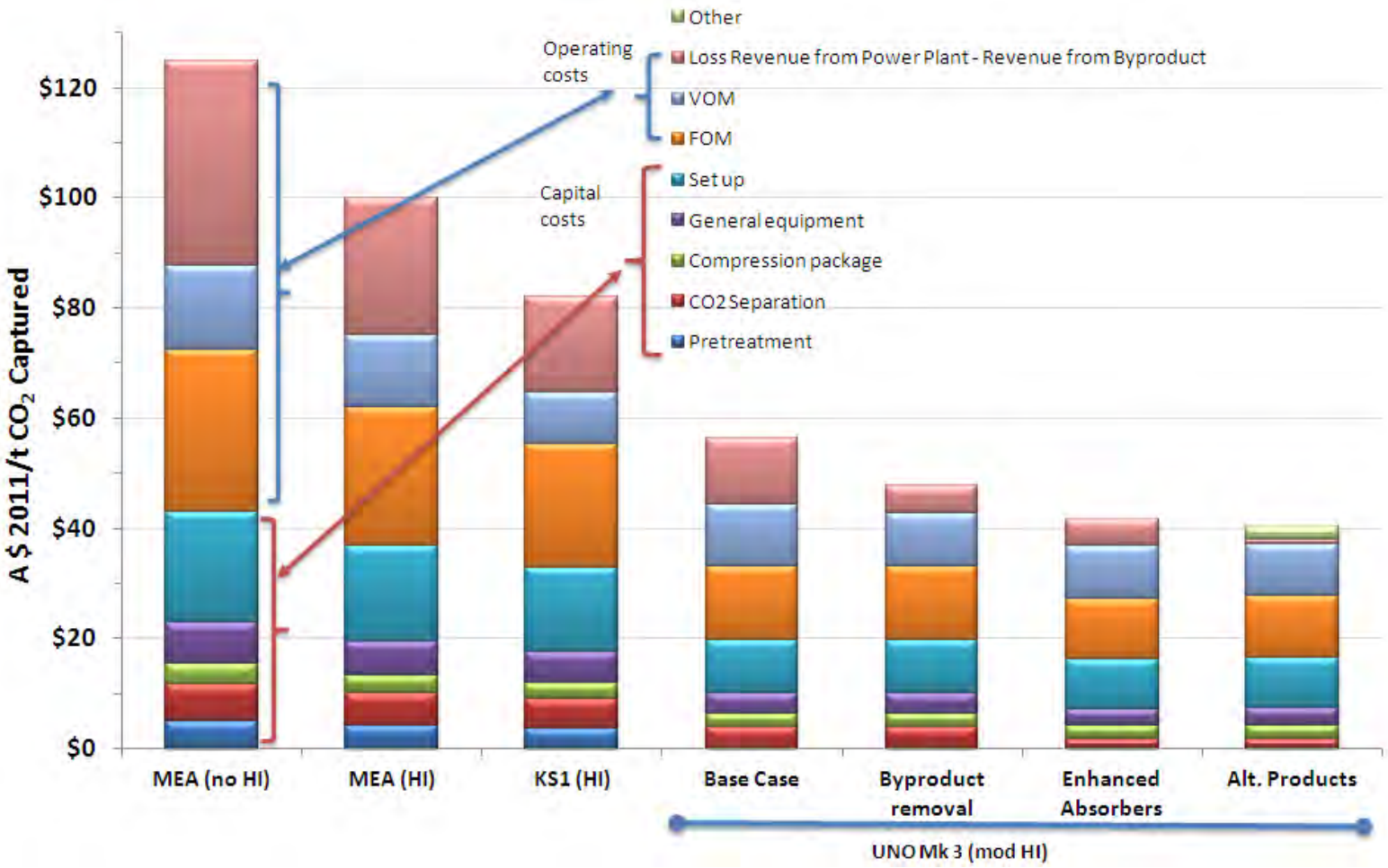
- ✓ **Low energy of regeneration** **2-2.5 GJ/t**
- ✓ **Low overall cost** **$15-20/t CO_2 better**
- ✓ **Low volatility and environmental impact**
  - ✓ Robust oxygen tolerant solvent with lower toxicity
- ✓ **Multi-impurity capture and production of valuable byproducts**
  - ✓ Holistic approach that delivers soft and hard benefits, new products and an improved business proposition
- ✓ **Potassium usage fits within existing global market**

70% reduction in capture cost looks possible



Large Scale Engineering Development of UNO Mk 3

Preliminary Cost Results



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