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# Post-combustion CO<sub>2</sub> capture R&D and pilot plant operation in Australia

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31 March 2009

National Research  
**FLAGSHIPS**

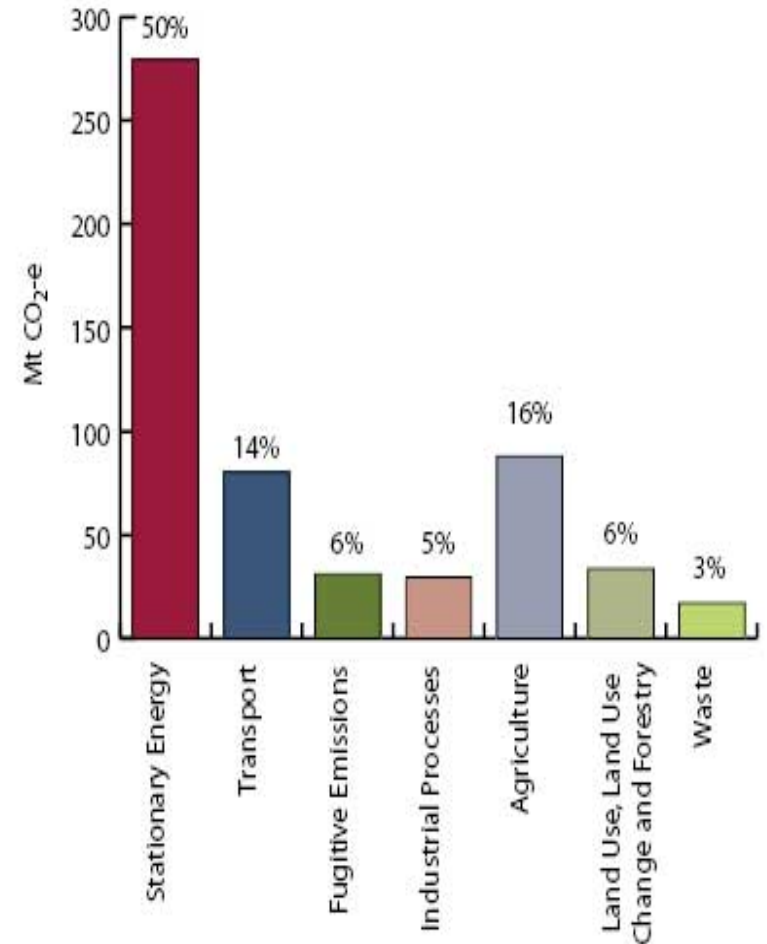


# Overview

- PCC in Australia
- PCC programme at CSIRO
- What next?

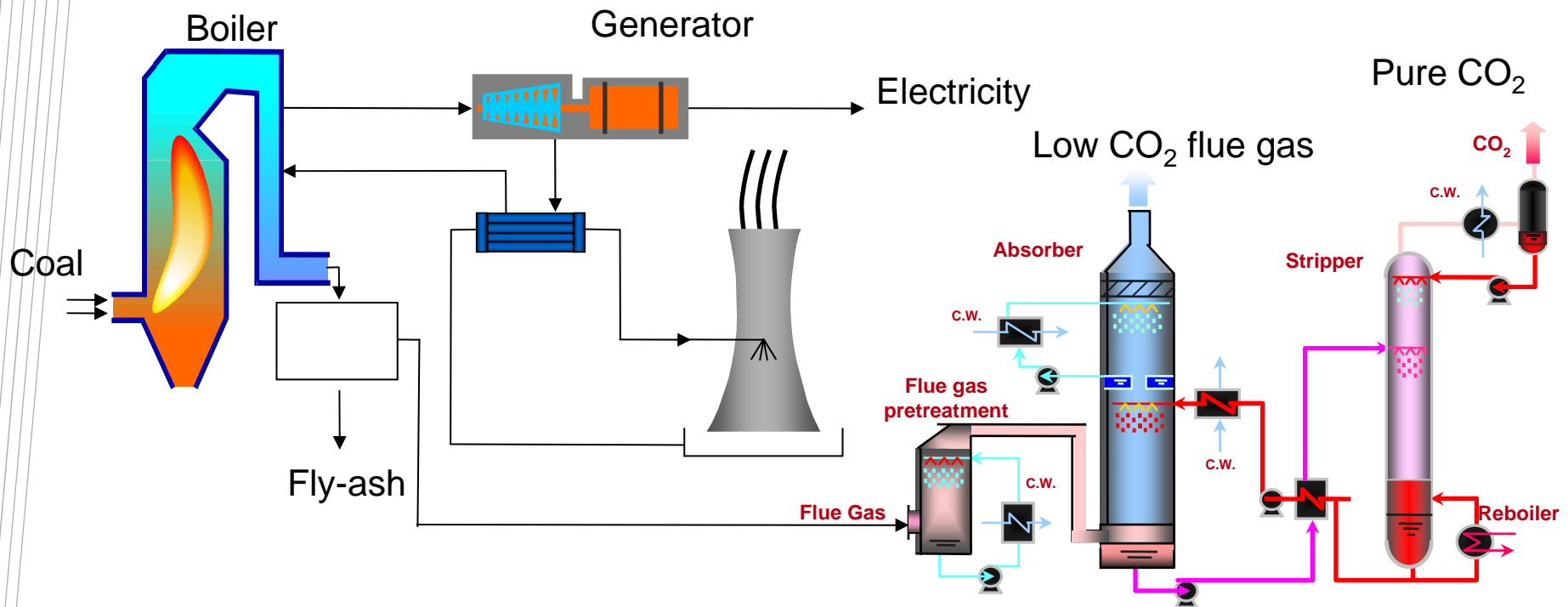
# Australian coal fired power stations

- **Generation capacity ~ 28 GW**
- **Electricity production 170 TWh/a**
- **Average generation efficiency**
  - Black coal: 35.6% - 0.9 tonne CO<sub>2</sub>/MWh
  - Brown coal: 25.7% - 1.3 tonne CO<sub>2</sub>/MWh
- **CO<sub>2</sub>-emissions ~ 170 Mtonne CO<sub>2</sub>/a from ~ 60 flue gas streams**
- **SO<sub>2</sub> levels:**
  - Black coal: 200 - 600 ppm
  - Brown coal: 100 - 300 ppm
- **NO<sub>x</sub> levels:**
  - Black coal: 300-700 ppm
  - Brown coal: 100-200 ppm
- **Flue gas temperature**
  - Black coal: 120 °C
  - Brown coal: 180 °C
- **Cooling water: 1.5-3.0 m<sup>3</sup>/MWh**



Data used from CCSD – technology assessment report 62

# PF Power Plant with Post Combustion Capture



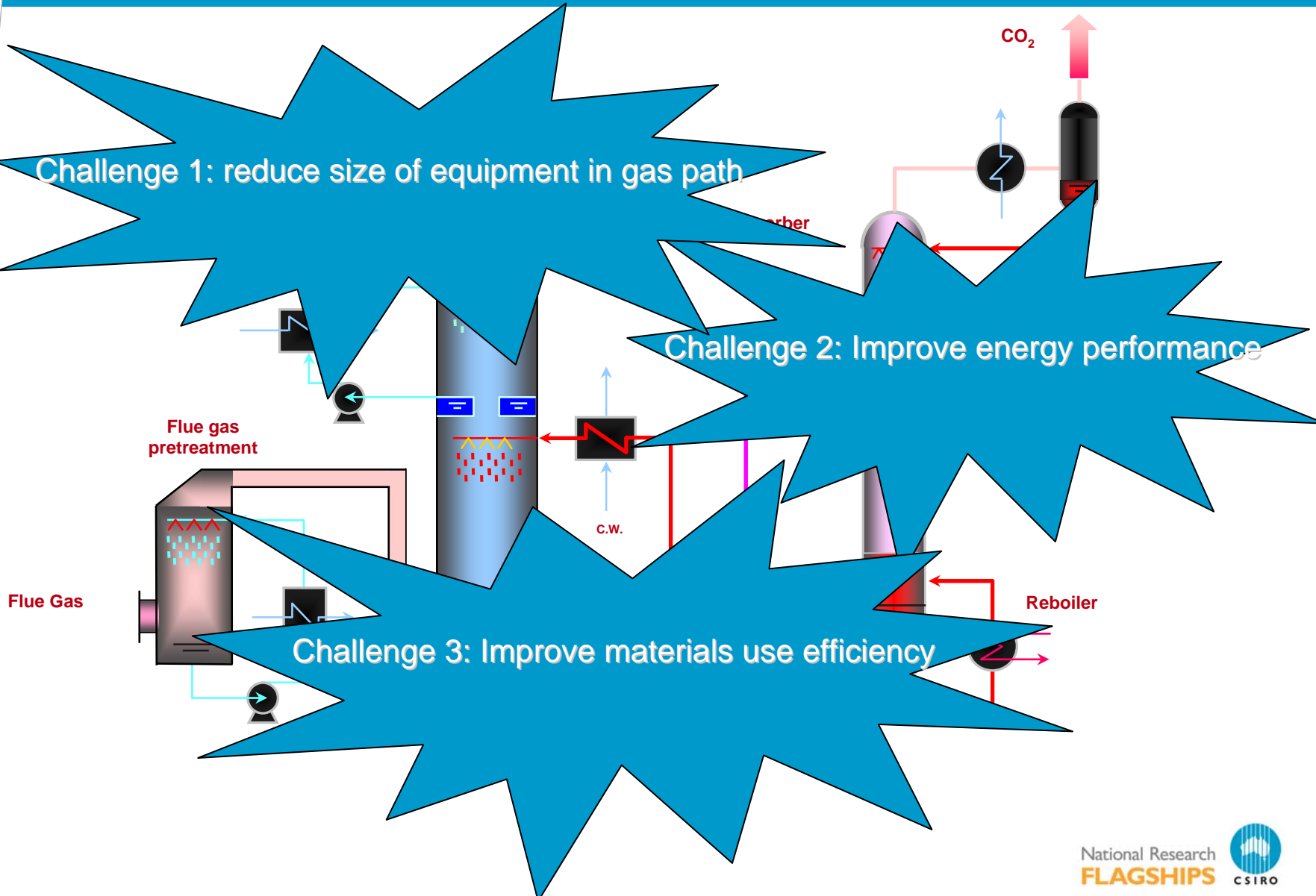
# Why PCC?

- Low technology risk
- Flexible operation, in tune with market requirements
- Ability to adopt technology improvements, providing pathway toward zero-emissions
- For new and retrofit applications, preventing stranded assets

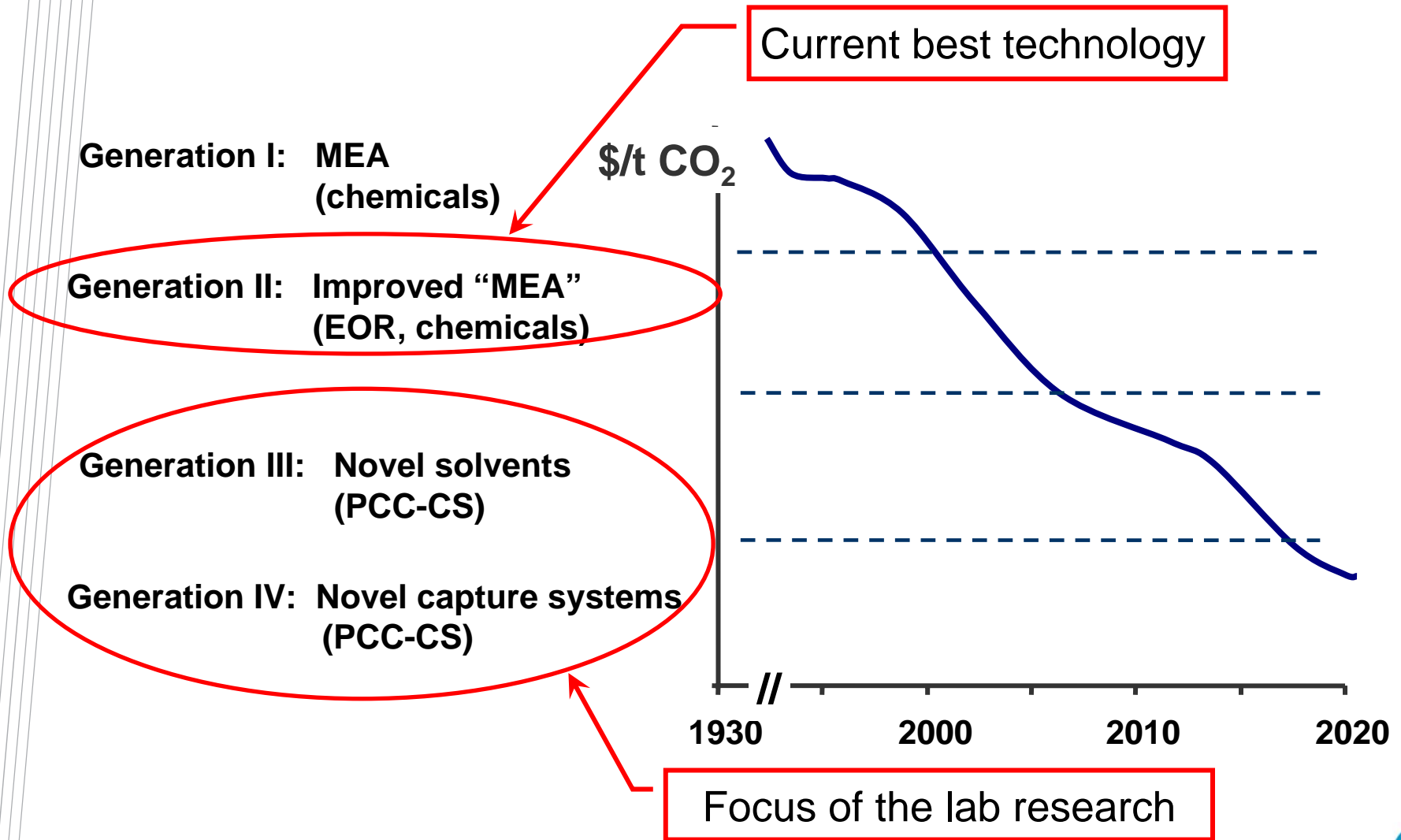
# What are known issues with PCC?

- High capture cost
- Electricity cost increase
- Loss of generation efficiency
- Not demonstrated in integrated power plants at scale
- Sensitive to O<sub>2</sub>, SO<sub>x</sub> and other flue gas constituents
- Large increase in cooling water requirement

# Three main S&T challenges for PCC

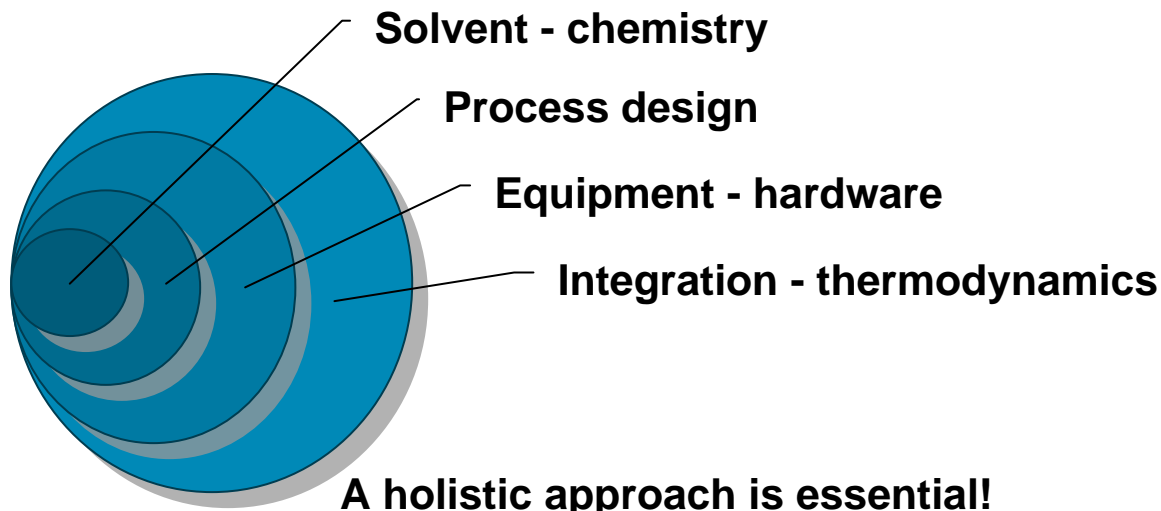


# Development Pathway for PCC

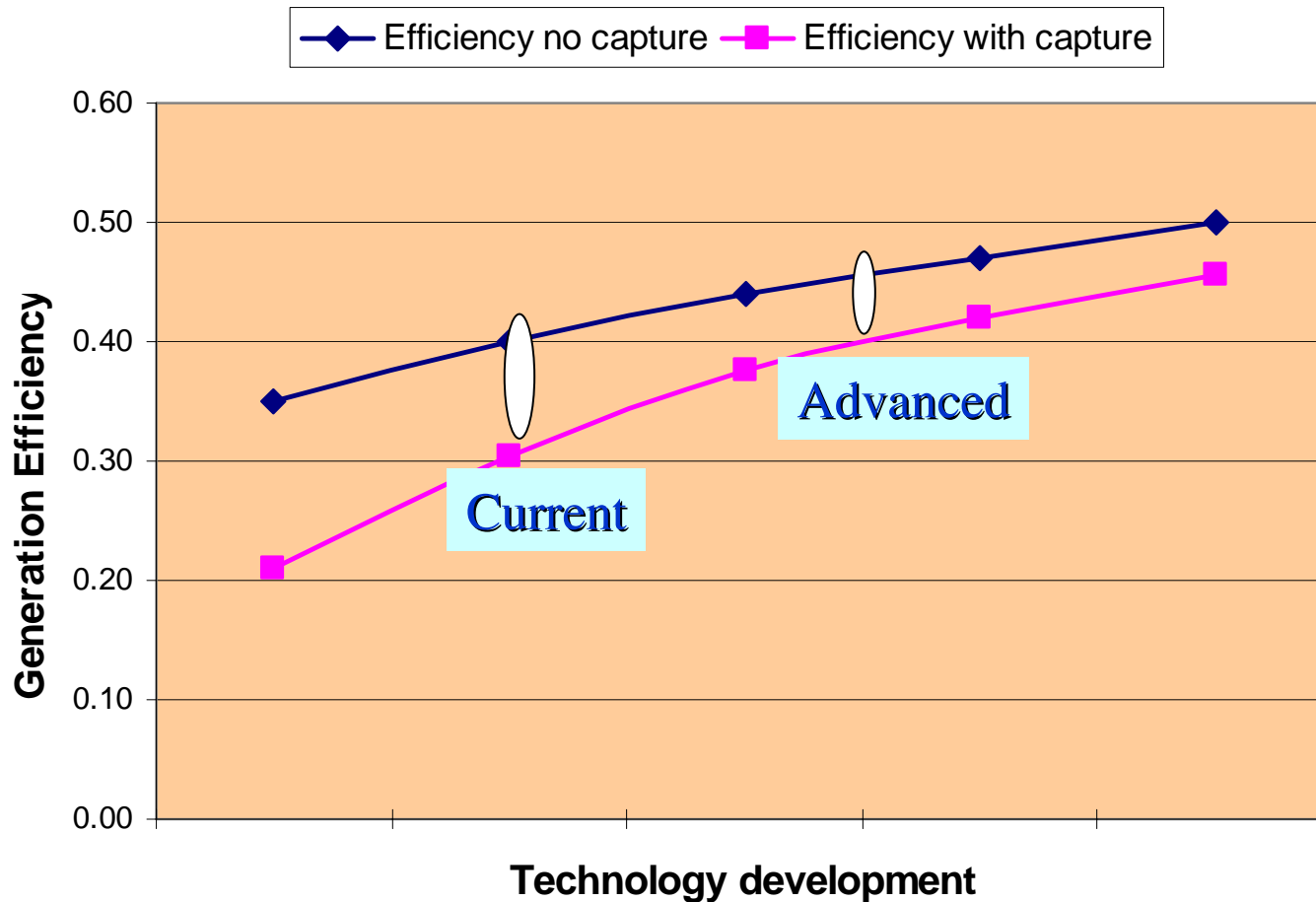


# Improve the energy performance

- Efficiency decrease is major contributor to generation cost increase
  - Leads by itself to 1/3 increase in cost of generation
- Environmental impacts
  - Environmental impacts dominated by increase in coal consumption
  - for every three coal mines a fourth one is required to capture CO<sub>2</sub>
- Implications for transport & storage



# Impacts on Power Generation Efficiency



# CSIRO PCC R&D Programme

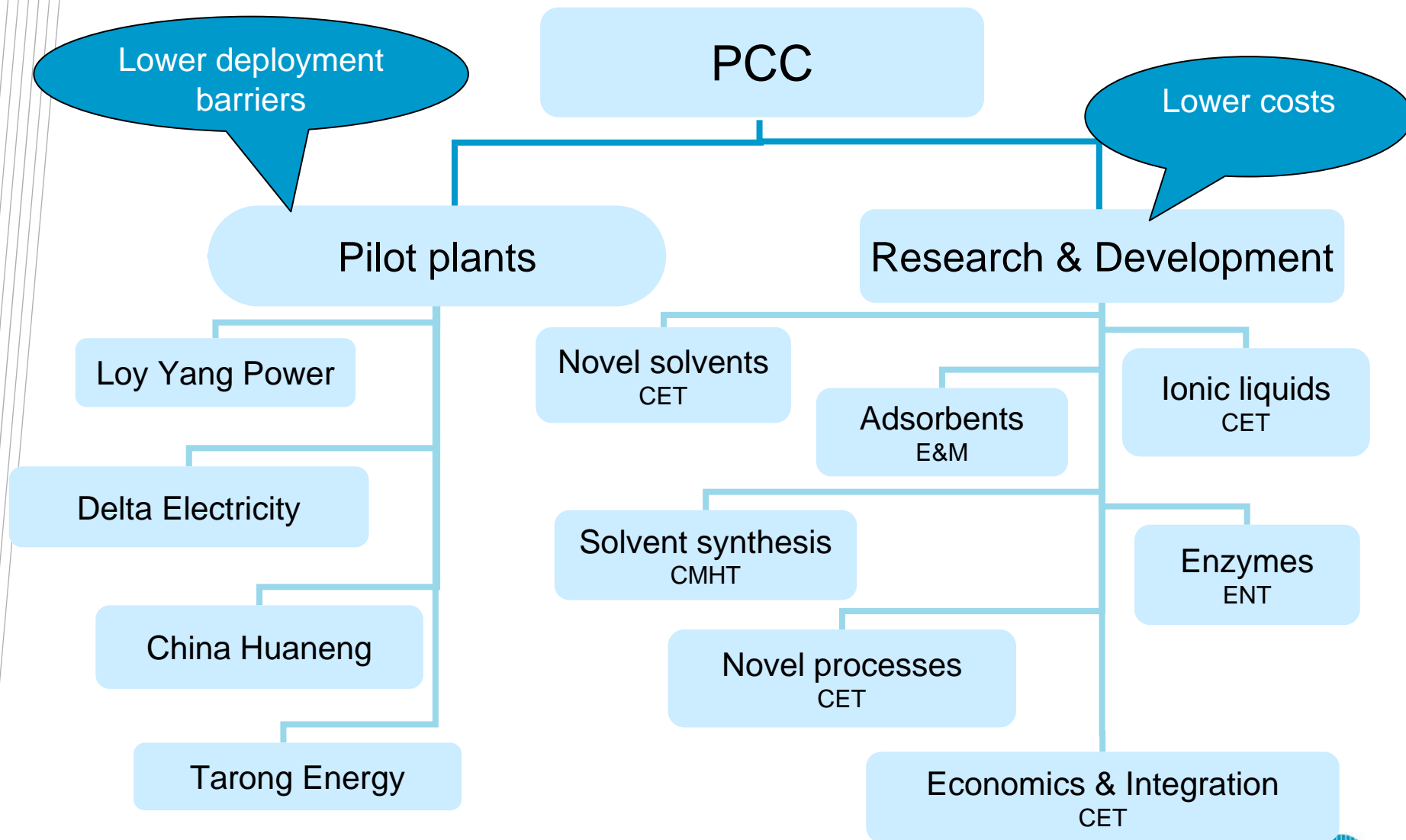
## Pilot plant programme (Learning by doing)

- Hands-on experience for future operators
- Identification of operational issues and requirements
- Evaluation of existing and new technologies under real conditions

## Lab research programme (Learning by searching)

- Support to pilot plant operation and interpretation of results
- Develop novel solvents and solvent systems which result in lower costs for capture
- Addressing Australian specifics (flue gases, water)

# PCC Programme Overview



# Established Pilot Plants



**Latrobe Valley Post Combustion Project**

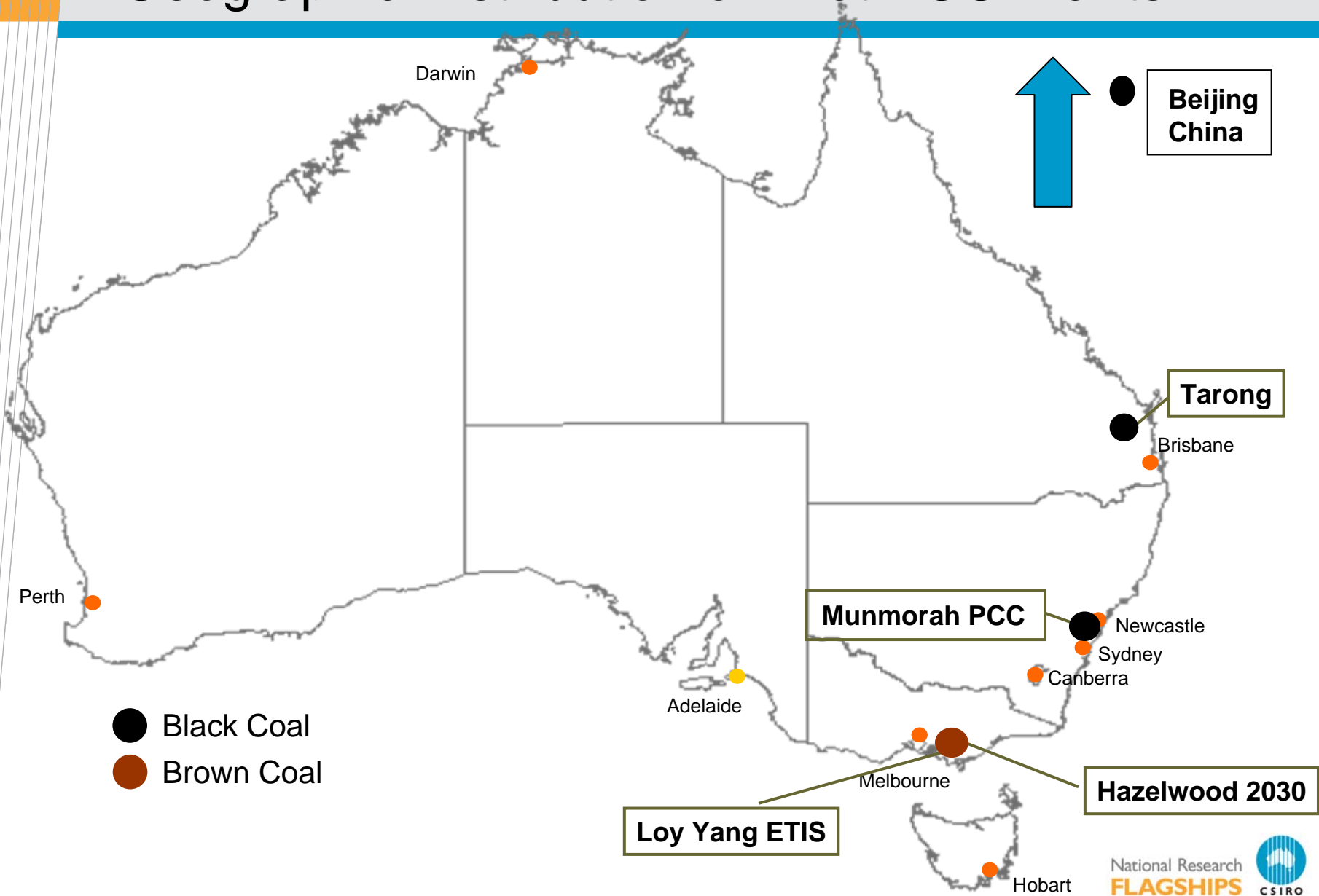
- ETIS support
- Loy Yang Power Station
- Lignite
- Amine based
- No FGD/DeNox



- APP project
- Gaobeidian Power Station
- Black coal
- Amine based
- FGD/DeNox installed

- APP project
- Munmorah Power Station
- Black coal
- Ammonia based
- No FGD/DeNox

# Geographic Distribution of Pilot PCC Plants



# General scope of pilot plant experiments

- Technical and economical scale-up information about CO<sub>2</sub> capture plant based on operation on flue gas from brown coal combustion
- This includes determining the following interrelationships:
  - CO<sub>2</sub> capture energy consumption
  - CO<sub>2</sub> capture efficiency
  - Solvent CO<sub>2</sub> loading
  - Solvent and flue gas flow rates
  - Regeneration temperature and pressure
  - Absorption temperature
  - Solvent consumption and degradation rates
  - Fouling and corrosion
  - Effectiveness of the conditioning stage
  - Reagent loss rate both to acid gas and to release with flue gas
  - System water consumption

**Caustic Wash  
Column**

**Solvent Feed Tank**

**Condenser**

**Stripper**

**Absorbers**

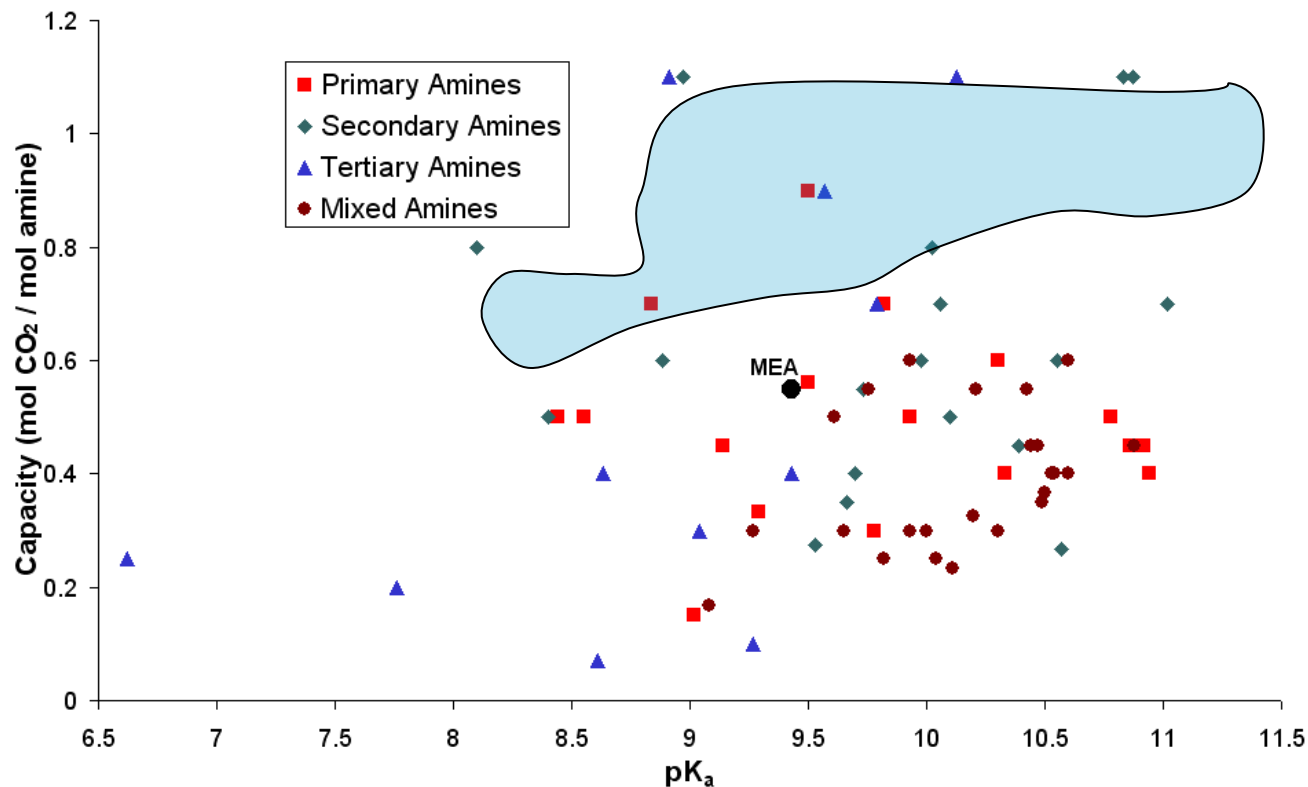
- Pilot plant scale : ~100 kg/h
- Design CO<sub>2</sub> capture : 85%
- Solvent base : MEA
- First capture : April 2008

# CSIRO PCC Research programme overview

1. Solvent development focuses on new chemicals or chemical formulations for reversible binding of CO<sub>2</sub>
2. Solvent process development involves the development of alternative processes and inclusion of other separation processes such as membrane technology to improve the solvent process performance
3. Equipment development is particularly aimed at reducing the equipment sizes and the physical footprint of capture technology and hence reducing investment costs
4. Optimal power plant integration is required to have minimal impact of the capture process on the power plant, including the usual of solar energy

# Screening study

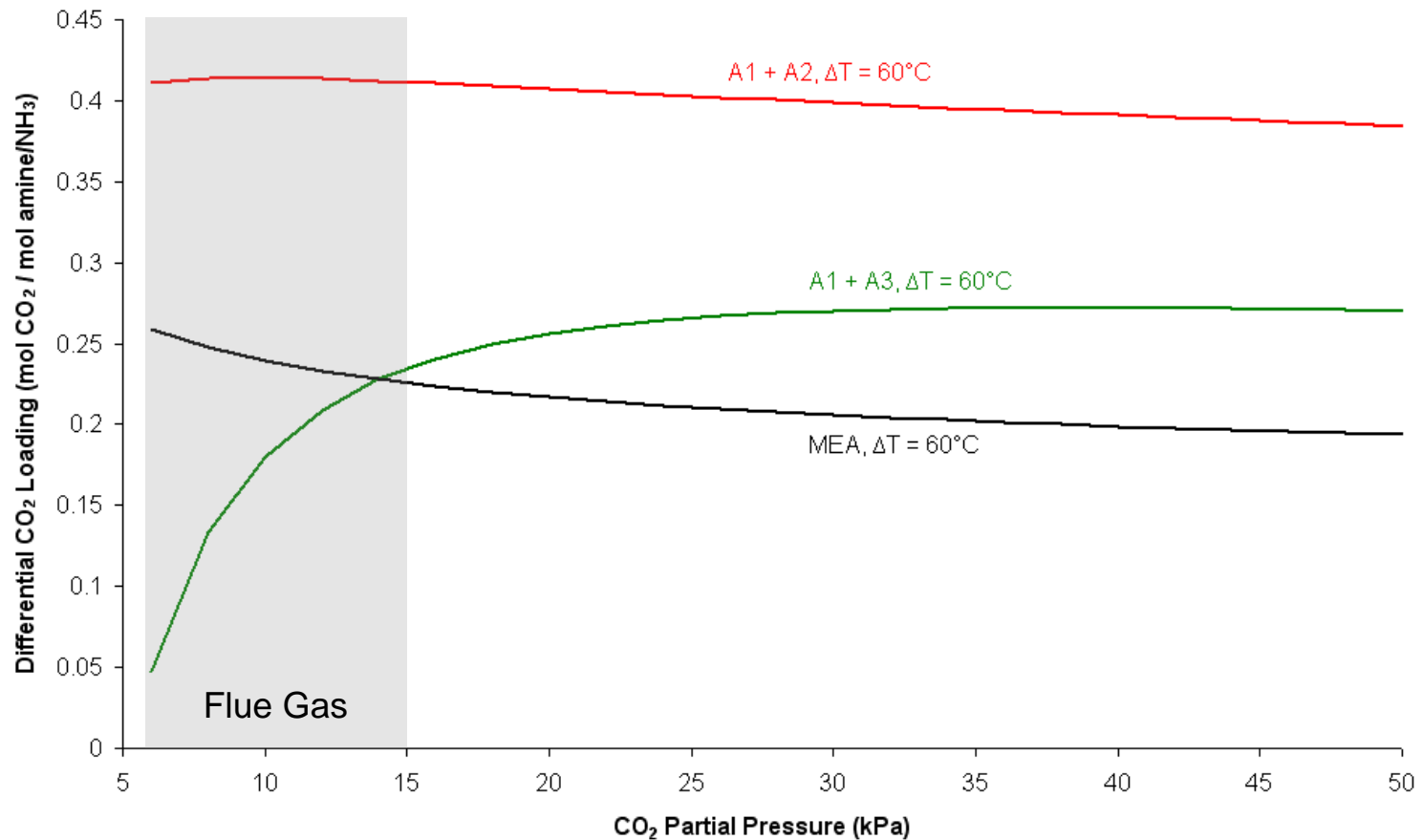
- Over 100 amines screened for CO<sub>2</sub> absorption capacity and absorption rate via rapid throughput methods
- 8 amines identified as having outstanding capacity and acceptable rate



# Characterisation of candidates

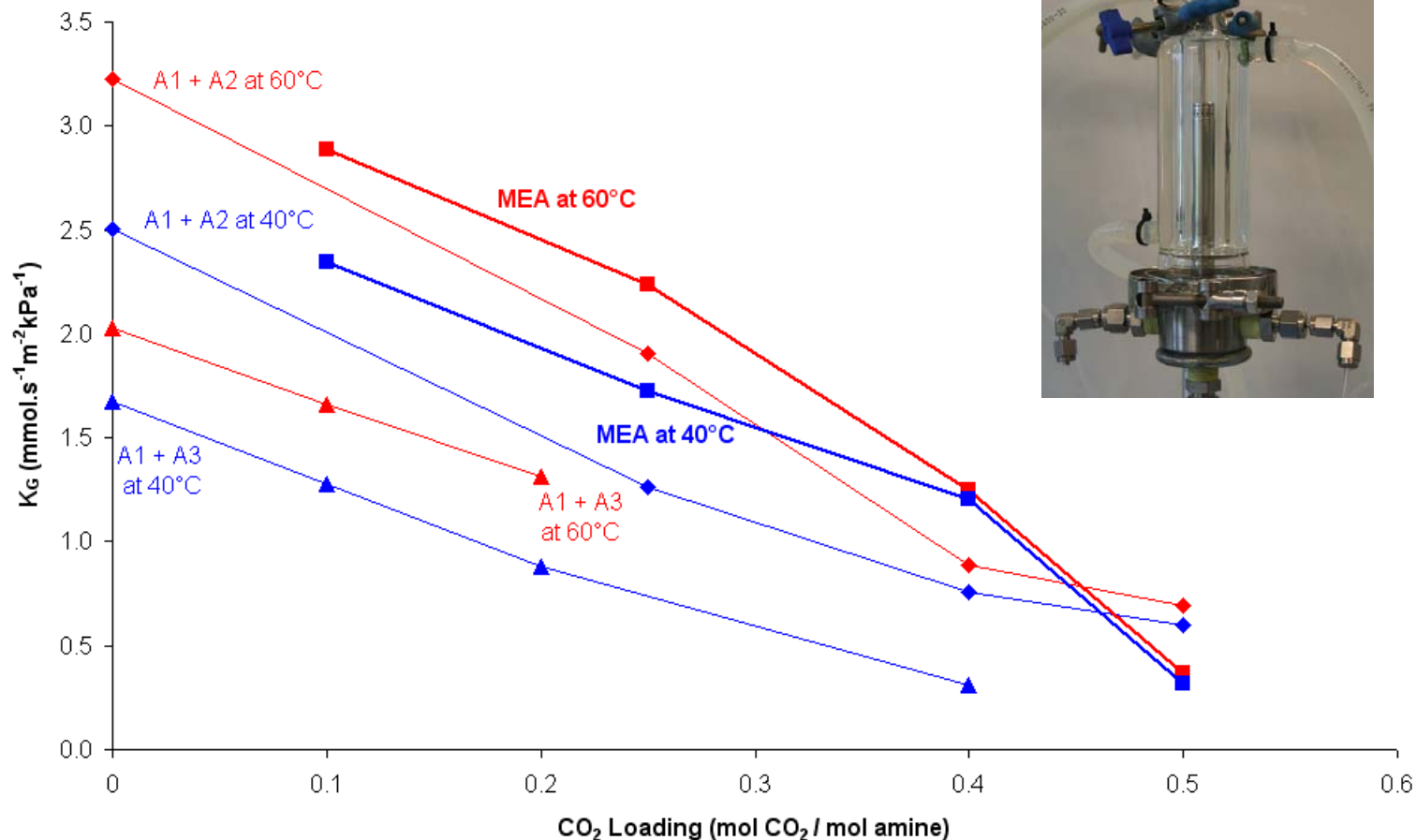


## CO<sub>2</sub> absorption capacity – VLE apparatus



# Formulated amines show high absorption rates

## CO<sub>2</sub> absorption rate – wetted wall

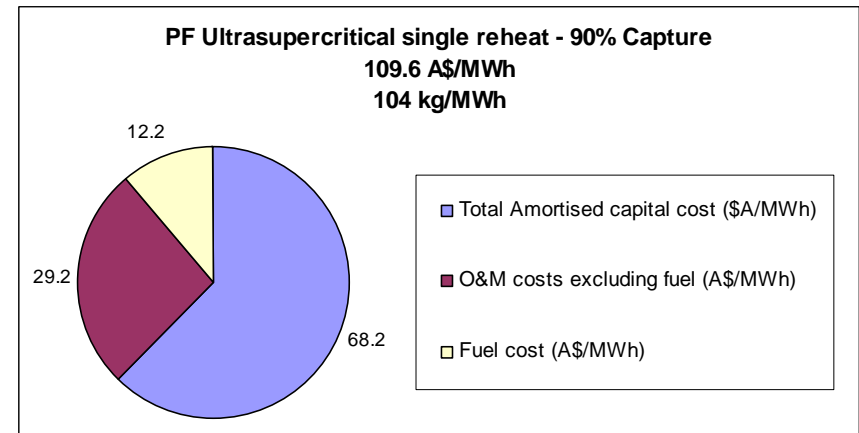
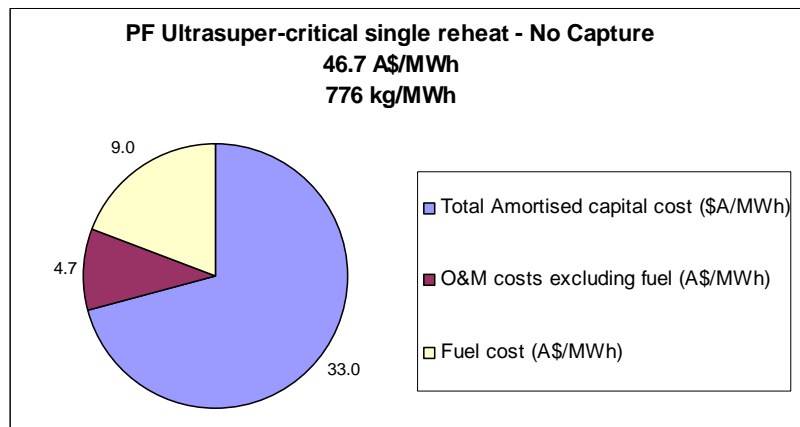


# Other activities

- Use of enzymes to capture CO<sub>2</sub>
- Use of ionic liquids
- Economic analysis of capture technologies

# Example results from economic modelling

- Supercritical and ultra-supercritical with single reheat provided lowest Cost of Energy (CoE) for power plants
- Example for USC-single reheat and mechanical draft cooling tower



- Efficiency reduced from 40% to 30%
- CoE is more than doubled with 90% CO<sub>2</sub>-capture
- Specific capital costs are doubled with 90% CO<sub>2</sub>-capture
- Cost per tonne avoided 94 A\$/tonne CO<sub>2</sub> represents a worst case, but is 50% higher than costs in 1999 study

# What's next?

- Demonstration projects are needed to show the CCS-technology works
- Development of novel solvent processes to reduce capital costs and loss in efficiency
- Assessment of overall environmental impact using data derived from pilot plants
- Continued need for increasing process efficiency beyond the state-of-the-art, i.e. near-zero emissions and near-zero efficiency loss!

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# Thank you

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