



# Performance of CSIRO Absorbent Liquid 007 (CAL007): A comparison to MEA

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# CSIRO's chemical absorbent research program

## Near-term

- **Absorbent formulations based on readily available compounds**
  - typically aqueous amines and low cost additives
- Advanced aqueous ammonia

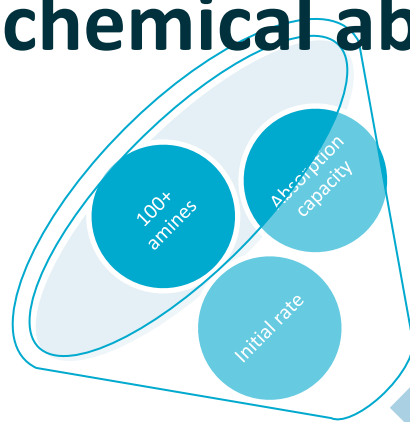
## Mid-term

- **New compounds** designed specifically for CO<sub>2</sub> capture – new amine compounds

## Long-term

- **New absorbent systems and associated process concepts:**
  - Light-driven absorbents
  - Absorption and conversion to methanol
  - Energy harvesting from CO<sub>2</sub> capture

# CSIRO's chemical absorbent research program



**Concept**

Kinetics,  
equilibria &  
thermo

Mass  
transfer &  
physical  
properties

VLE

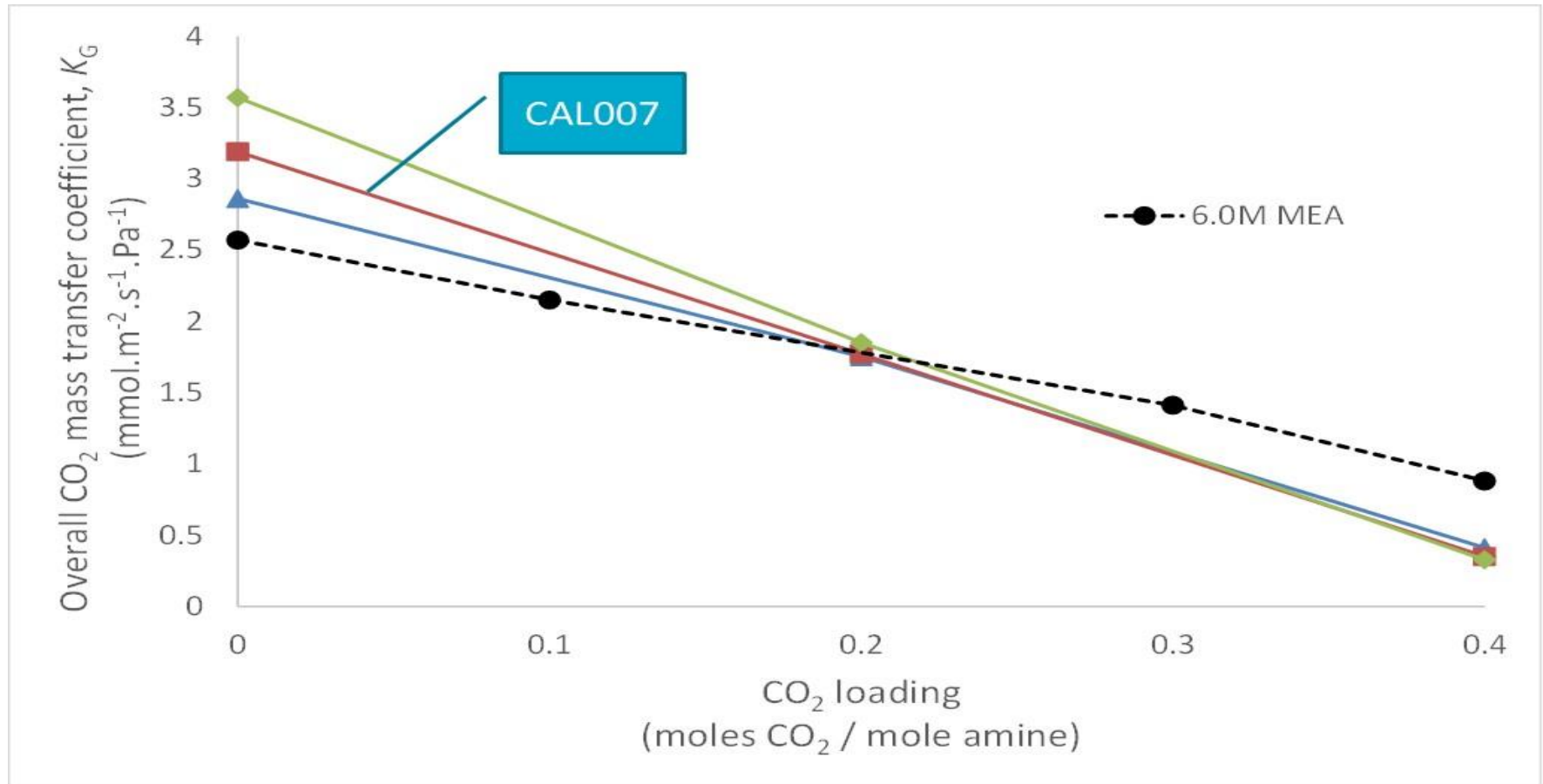
Predicted  
process  
performance

Operability and  
scale-up

# What is CAL007 and why choose it?

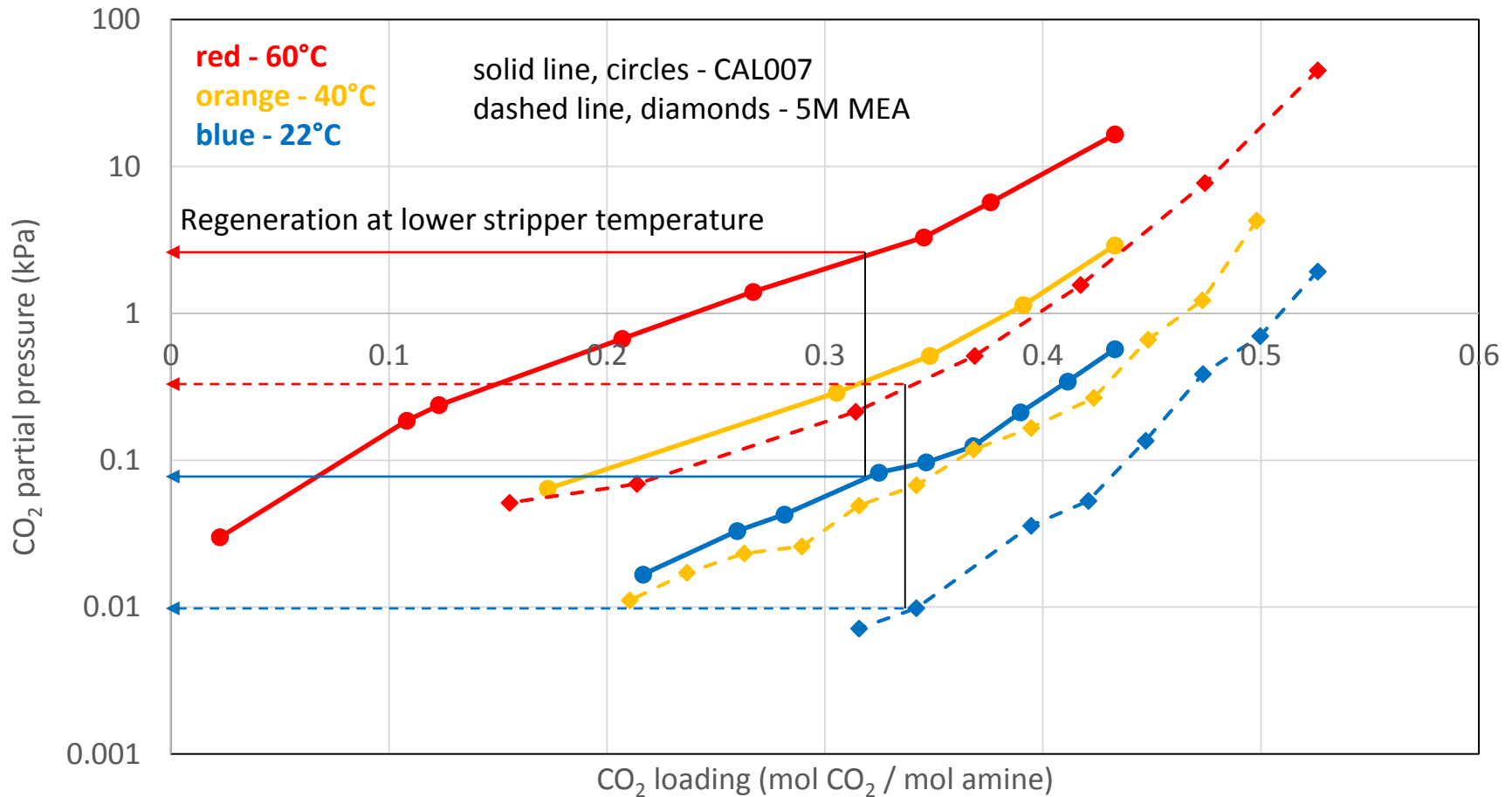
- CSIRO Absorption Liquid 007
- 6M di-amine in solution
- Higher cyclic capacity than MEA with 25% larger protonation enthalpy.
- 29% lower heat capacity reduces sensible heat duty
- Similar mass transfer rates to MEA with lower regeneration energy.
- Viscosity is higher than MEA but within an acceptable range
- No sign of foaming in lab trials
- Similar but slightly lower thermal degradation than 5M MEA
- No signs of oxidative degradation, no nitrosamine formation
- High boiling point with similar vapour pressure to 5M MEA
- 2-3 times lower corrosion rates than 5M MEA
- Low toxicity, biodegradability

# Mass transfer

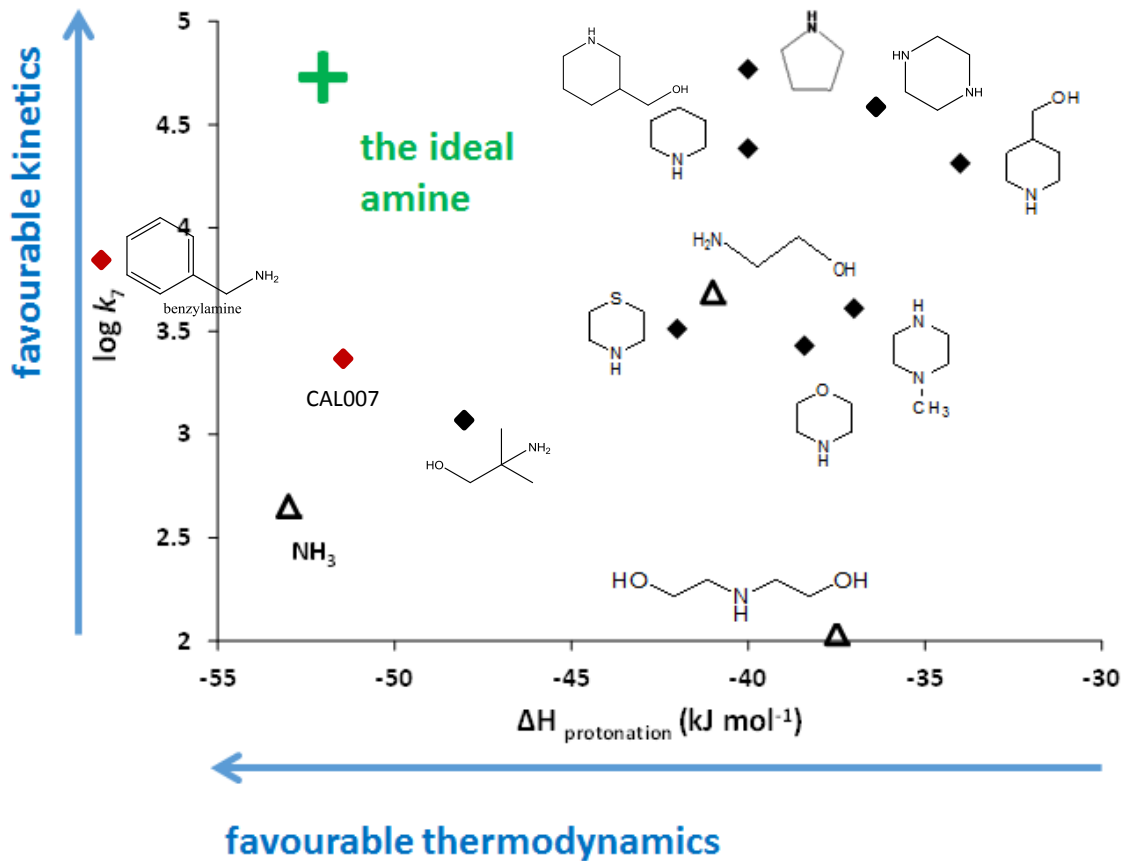


- Typical operation 0.08-0.4 CO<sub>2</sub> loading vs 0.2-0.45 for MEA
- Greater cyclic capacity with lower stripper temperature

# VLE – CAL007 vs MEA

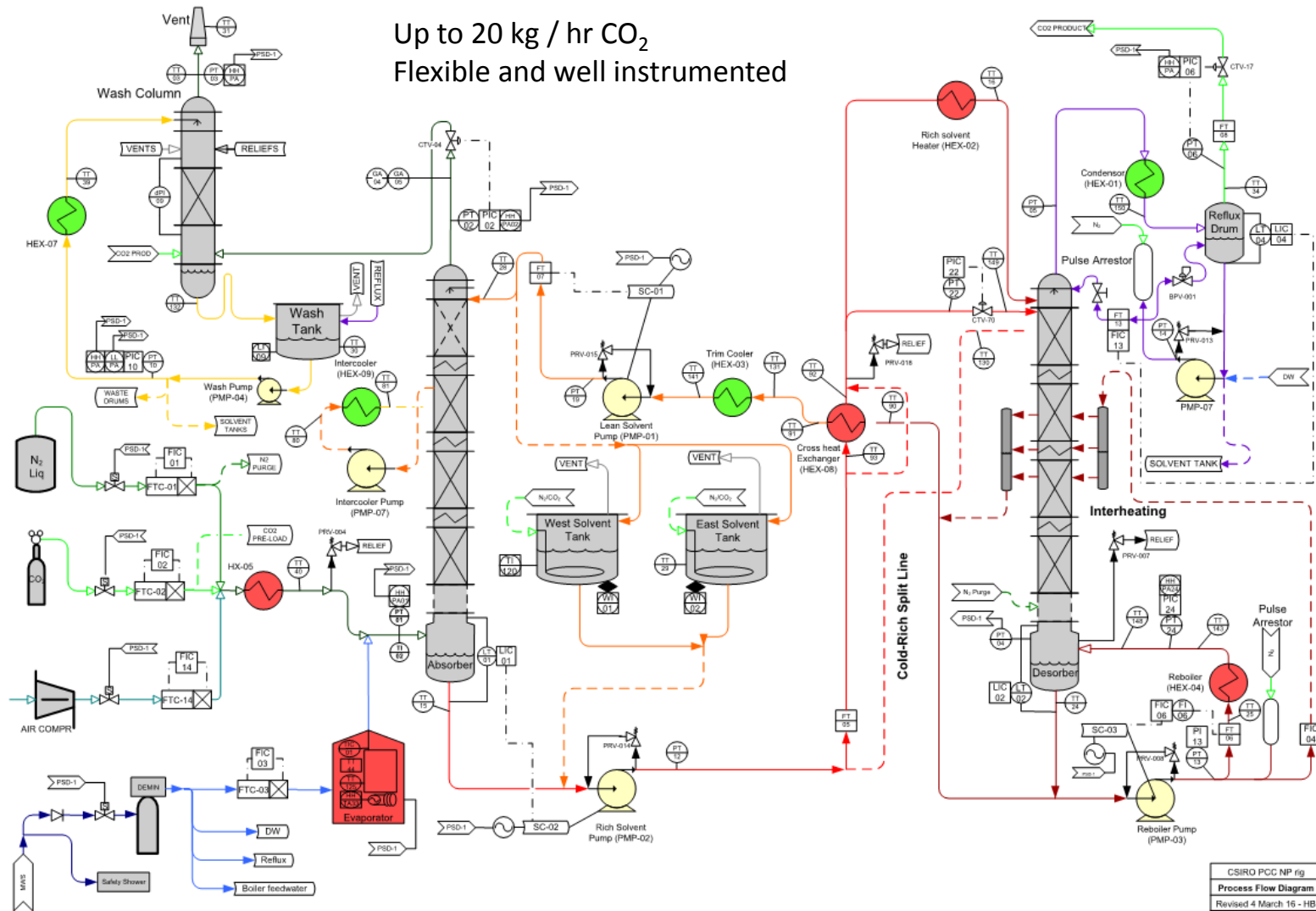


# Relationship between enthalpy and kinetics



# Process performance – Process Development Facility

Up to 20 kg / hr CO<sub>2</sub>  
Flexible and well instrumented

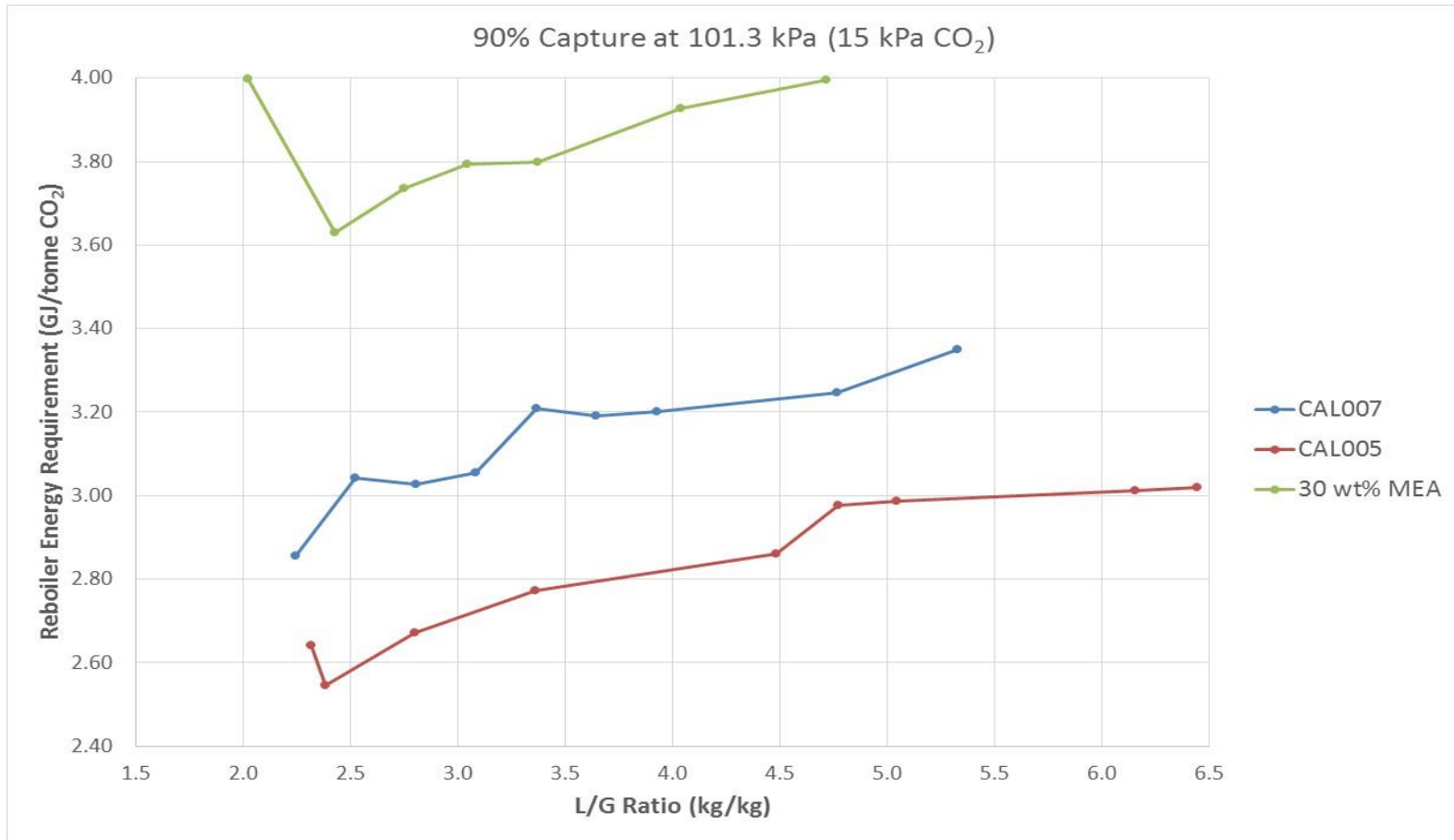




# PDF –CAL007 trials – synthetic flue gas

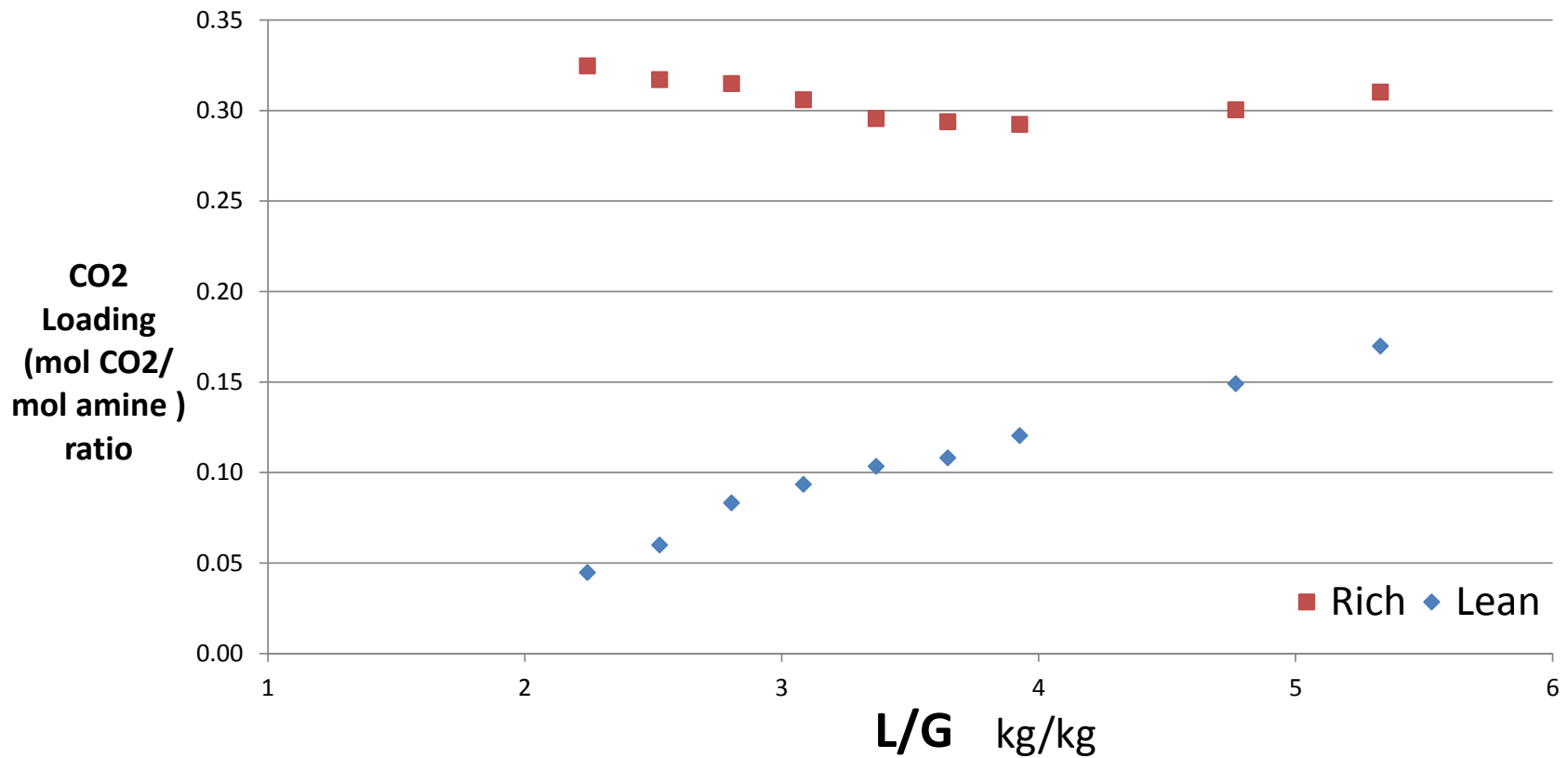
- 12 extended duration run days.
- 150 hours solvent operation.
- Parametric operation with fixed flue gas (14.5% CO<sub>2</sub>) rate, fixed capture rates (90%) and varied:
  - L/G
  - Stripper pressure
  - Lean solvent temperature
  - Alternate stripper configuration + Cold Rich Split.
- 100 plant samples
  - CO<sub>2</sub> loading
  - CAL007 concentration

# Process performance



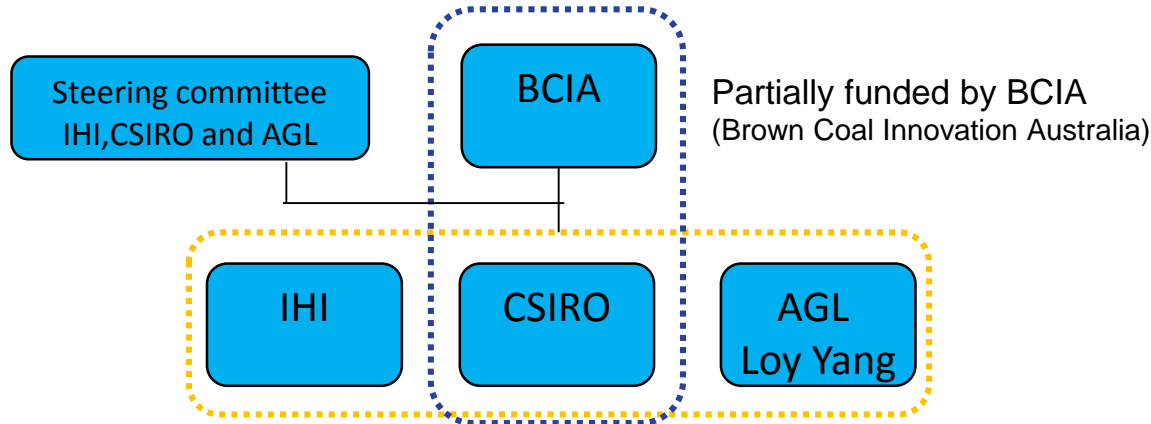
- Conventional process configuration – note L/G is on mass basis
- Does not include heat losses.

# CO<sub>2</sub> loading measurements



# PICA project

PICA (Post-combustion carbon capture, IHI, CSIRO, AGL)



Realize your dreams

Australia



Loy Yang A Power Station & Loy Yang coal mine

## IHI Corporation

- Design, construction, operation and evaluation of the PCC pilot plant (IHI system)

## AGL Loy Yang Pty Ltd

- Operator of Loy Yang A Power Station using brown coal
- Host of PCC pilot plant in this power plant.

## CSIRO (the Commonwealth Scientific and Industrial Research Organisation)

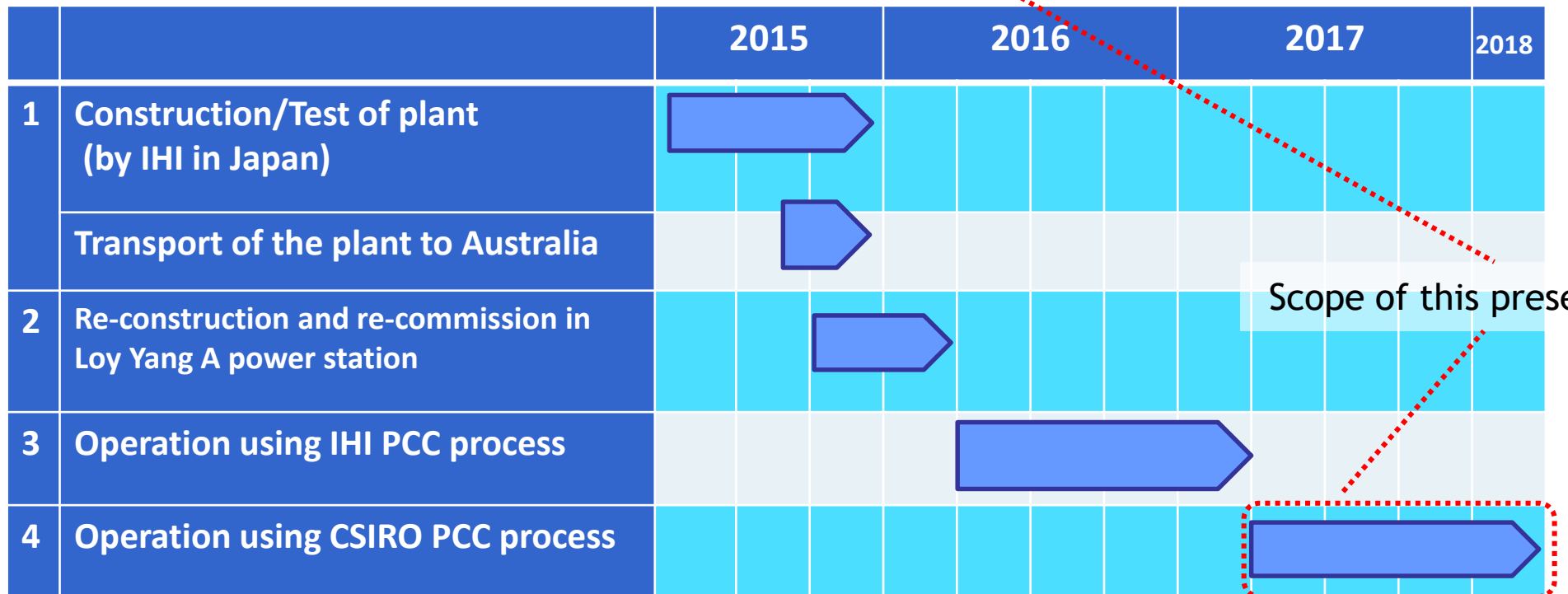
- Supporting design, site preparation, operation and evaluation of the pilot plant.



# Tasks and schedule



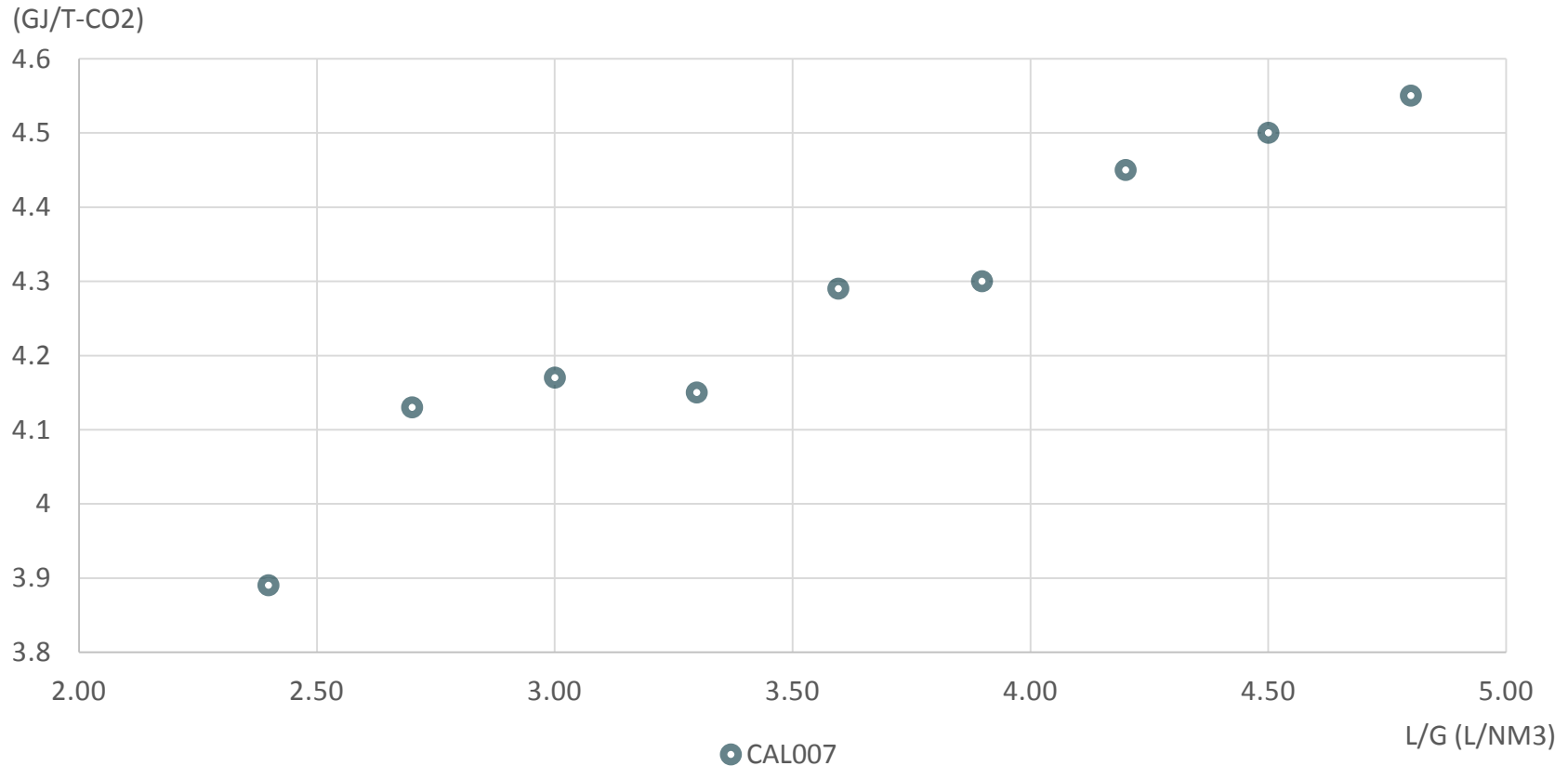
- Design, construction and commission of PICA pilot plant
- Operation using IHI's advanced system
- Operation using CSIRO's advanced system



# PICA pilot plant trials – CAL007

- Based at Loy Yang power station - brown coal
- Real flue gas
- No FGD/SCR prior to caustic wash/direct contact cooler
- $\text{SO}_2 < 5\text{ppm}$ ,  $\text{NO}_2 < 1\text{ppm}$ ,  $\text{NO} > 100\text{ppm}$ ,  $\text{O}_2$  6-8%
- Gasmet FTIR – multi-component gas analysis online
- Horiba IR gas phase –  $\text{CO}_2$ ,  $\text{SO}_2$ ,  $\text{NO}_2$
- **Liquid IR – Water%, Amine%,  $\text{CO}_2$  loading%, degradation%**
- 0.4 t $\text{CO}_2$ /day at 90% capture
- Parametric studies
- 5,000 hour duration campaign
- Heat losses determined by air/water operation ~ 6kW

# Regeneration vs L/G in PICA plant



- Conventional process configuration
- Direct regeneration energy (includes heat losses) ~ 1.3 GJ/t CO<sub>2</sub>

# Effect of IHI process configuration

Solvent	MEA	CAL007	CAL007
L/G (L/m <sup>3</sup> N)	3.6	3.6	3.6
Process configuration	CON	IHI	CON
Regeneration energy (GJ/t-CO <sub>2</sub> )	4.61	3.99	4.29

- Non-optimised L/G
- Direct regeneration energy (includes heat losses) ~ 1.3 GJ/t CO<sub>2</sub>



# Summary and Conclusions

- CAL007 has been developed by CSIRO as a stable absorbent for reducing energy requirements in CO<sub>2</sub> capture.
- Demonstrated benefits in lab
  - ✓ Offers high CO<sub>2</sub> cyclic capacity at relatively low stripper conditions
  - ✓ Low corrosion rates
  - ✓ Similar behaviour to MEA in other respects
- Validated energy performance in PDF facility on synthetic flue gas
  - Potential for lower energy with increased absorber packing height
- Validated energy performance in PICA pilot plant
  - Demonstrated benefit of IHI process optimisation in PICA operation
  - Potential for lower energy for absorber design to suit lower L/G
- New amine has been identified from learnings of pilot work

# Where to from here

- Continue trials for parametric and duration trials of CAL007.
- Conduct emissions studies for CAL007 through PICA+ project.
- Investigate absorption degradation products through detailed absorption liquid analysis at Federation University.
- Beyond the PICA project, IHI, CSIRO and AGL will continue to collaborate in absorbent and technology trials at the Loy Yang power station in Victoria
- CSIRO aims to facilitate the development of a demonstration scale facility.

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# Thank You

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