Future markets for CST in minerals processing

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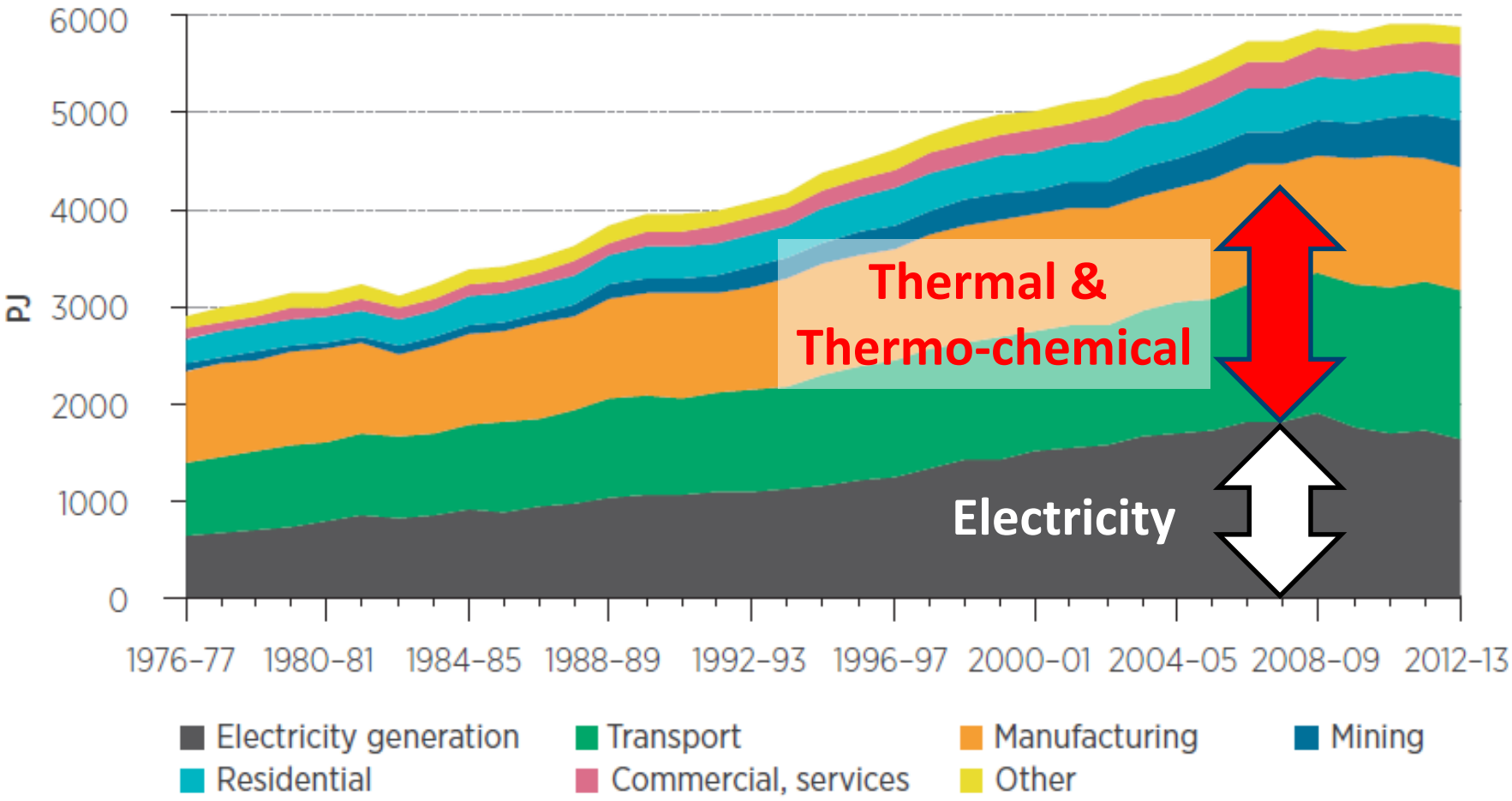
Australia's primary energy by sector



Source: Bureau of Resources & Energy Economics, Canberra, 2014

Potential markets for high temperature CST

ELECTRICITY

- Steam turbine
- gas turbine
- Future cycles

PROCESS HEAT

- Metals refining
- Cement production
- Plastics

Indirect use: ~ 65% loss
"Non" Exportable

Direct use ~ 15% loss
Exportable commodity

SOLAR TRANSPORT FUELS

- Solar gasification of biomass or coal
- Solar regeneration of CO_2 with H_2O

Image: CSIRO Tower, Newcastle

Market Drivers & Barriers

Market Drivers for CST in process heat:

- **Reduced fuel costs**
  - Natural gas rising toward world parity
  - Greater viability for stranded sites
- **Reduced vulnerability to potential carbon price**
  - Plant life typically exceeds 30 years
- **Potential to access new high value products**
  - Premium for low-carbon, solar commodities

Market Barriers to CST for process heat :

- **Anticipated high cost for continuous mineral processing with variable solar resource**
  - Continuous processing needed for high efficiency and low production costs
  - Hybridisation, with storage, proposed as lowest cost path
- **High temperature CST technology is pre-commercial**
  - Proposed to implement near-term and develop far-term technologies in parallel

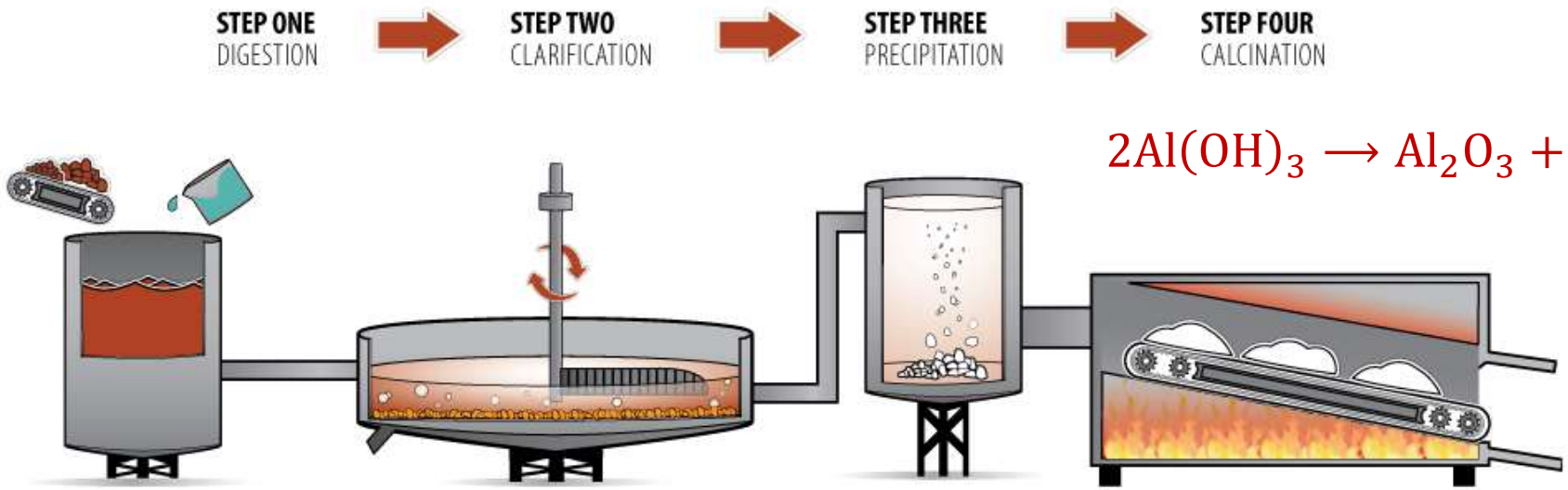
Key approaches of new ARENA project

Target 29-45% CST into a hybrid system:

- **Staged implementation of:**
  - Near-term low temperature process heat
  - Mid-term solar reforming of natural gas
  - Further-term high temperature process heat
- **Develop hybrid technologies**
  - Utilise solar when resource is strong
  - Can revert to present operation if needed
- **Address both Retro-fit and Greenfield**
  - **Retrofit:** low-cost barrier for demonstration & implementation
  - **Greenfield:** greater performance when technology is available

Bayer Alumina Refining Process

(Simplified diagram of the commercial alumina process)

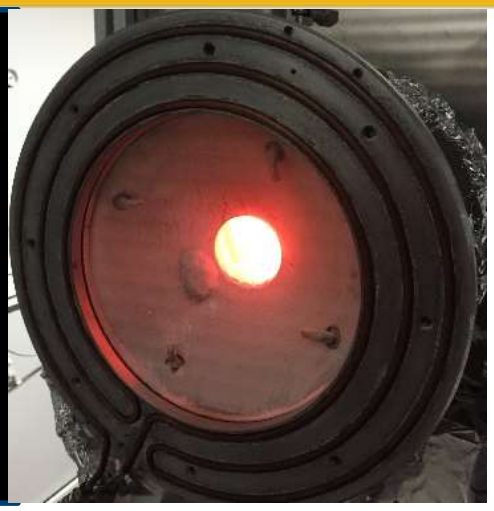


$$2Al(OH)_3 \longrightarrow Al_2O_3 + 3H_2O$$

- ~50–60% of energy at ~ 170–280 °C
- Suits commercial solar troughs
- R&D needed to address process integration

- ~40–50% of energy at ~1000°C
- Suits solar towers
- R&D needed for both reactor and storage

Parallel Technology Paths



Low temp CST

- Develop process models
- Techno-economic evaluation
- Recommend preferred options

CST reforming of natural gas

- Identify low-cost options for syngas storage
- Assess implications of fuel-change on process
- Identify preferred techno-economic options

CST Calcination

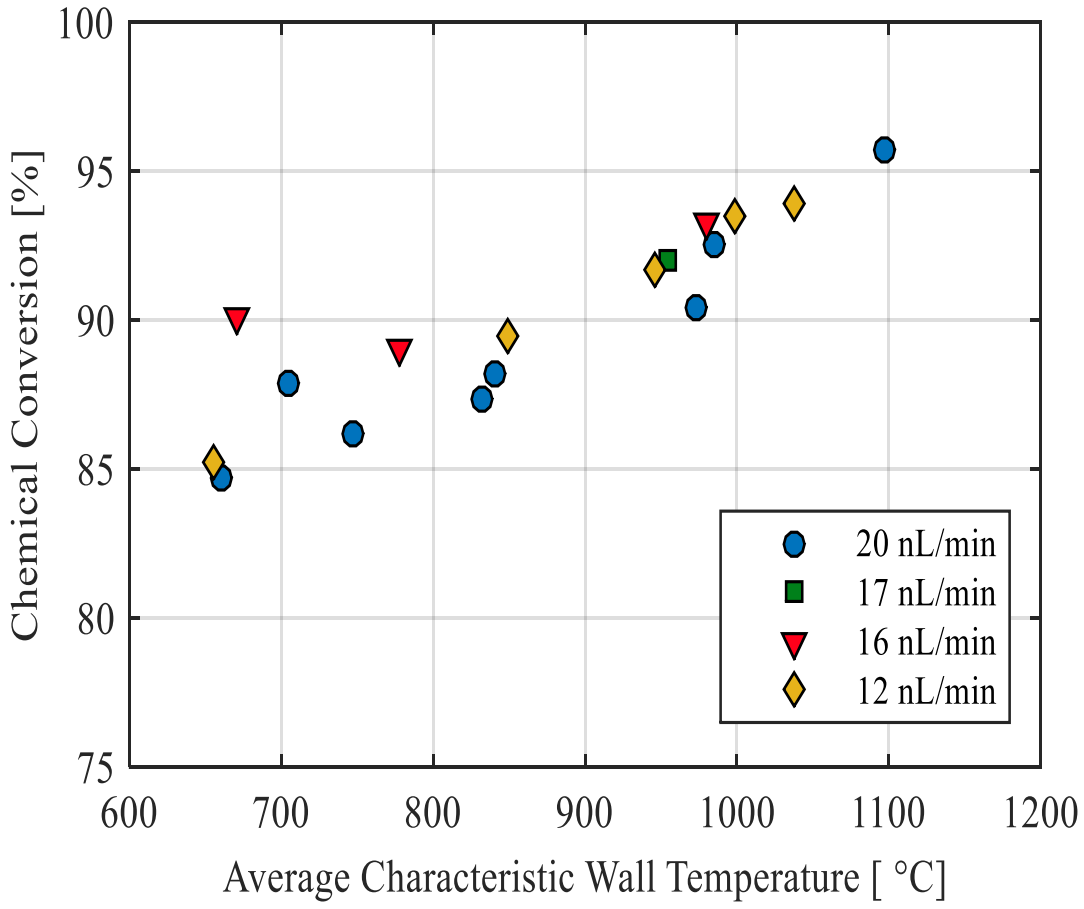
- Develop reliable models of reactor
- Develop reactor configuration
- Evaluate impact on process
- Techno-economics

Demonstration of solar calcination

Experimental conditions for maximum conversion	
Power	4.3kW
Avg. reactor Temperature	1278°C
Avg. wall temperature	1098°C
Air flow rate	19.85nL/min
Particle mass feed rate	2.53g/min
Chemical Conversion	**95.7%**

Conversion is defined as:

$$X = \frac{2n_{Al_2O_3}}{n_{Al(OH)_3} + 2n_{Al_2O_3}}$$



Source: Davis, Müller, Saw, Steinfeld, Nathan, High Temp Processing Symposium, Melbourne (2016)

Other potential applications in minerals processing

Other processes directly relevant to high temperature alumina calcination

- **Calcination:** lime, magnesium, zirconium

Other processes for which alternative CST reactors are under development:

- **Metals Refining:** copper, iron, etc
- **Low temperature:** Heap leaching

Requirements for solar fuels to be most viable:

- **Good solar resource:** many locations in central Australia
- **Carbonaceous feedstock:** biomass, wastes, natural gas, coal

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