Coal-to-Liquids in Australia
Overview of Drivers and Status of Developments

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Australian Coal resources

• **Black Coal**: 44 Bt, ~7% of the world’s recoverable resources, fifth largest
• **Brown Coal**: 37 Bt, world’s largest recoverable brown coal resource (25%)

Source: Geoscience Australia
Australian Coal Industry Overview
Export markets and domestic power

World’s second largest exporter – about 27% of world export coal market

Coal production (2012)
- raw black coal: 454Mt
- saleable black coal: 345Mt

Exports (2012)
- 283Mt ($A44 billion)

Black and brown coal account for >70% of Australia’s electricity
Coal to Liquids Technologies
Direct Coal Liquefaction (DCL)

Hydrogen and/or Heat

Liquefaction

Syncrude

Hydrotreatment

Tendency towards highly cyclic naphthas

Residues to gasification

Recycle Solvent + Catalyst

Gases

LPG

Naphtha

Distillate

Bottoms
Indirect Coal Liquefaction (ICL)

Oxygen + Steam

Gasification

Syngas $\text{CO} + \text{H}_2$

Carbon Dioxide

Methanol -To- Gasoline

Mostly gasoline production

Fischer-Tropsch

Diesel fuels favoured

LPG

Naphtha

Distillate

Bottoms
Coal conversion pathways
Syngas platform enables many commercial options
Indirect or Direct CtL?

**Coal Properties** – Less of an issue with ICL, but for DCL the coal properties strongly influence process efficiency and product quality. Preferred coals eg:
- High hydrogen, vitrinite / liptinite, low inertinite
- High volatile sub-bituminous and bituminous coals. eg Surat basin of SE Queensland (Wandoan)
- Brown coals from Latrobe Valley in Victoria

**Emissions** – DCL is inherently more efficient and has lower GHG emissions, even after allowing for hydrogen production.

**Product** – Some fuel types are easier to produce in large quantities using specific process choices. DCL is more likely to struggle to meet tightening fuel standards.
CtL process performance (Surat Basin Coal)

Efficiency & CO₂ emissions

Note: “Captured Carbon Dioxide” refers to streams >90% CO₂
Early Australian CtL research
Historical CTL research in Australia

Extensive early work on Direct Coal Liquefaction

CTL research commenced in Australia in the 1930s with the State Electricity Commission of Victoria (SECV) sending brown coal to the UK for DCL testing.

However, despite a number of reviews of international developments, more extensive research did not commence until 1965 when ACIRL commenced a broad coal conversion program.

Then in the 1970s a series of programs were launched by CSIRO, BHP, Monash University, SECV and CSR specifically for CTL.
Early research explored many options
Driven by international and domestic oil issues

All major activities were DCL-related, usually hydrogen-donor solvent liquefaction or flash pyrolysis:

- **Coal Selection** – Many different Australian coals tested
- **Catalysts** – Focus on cheap iron from industrial wastes
- **Mineral Matter Content** – Coal preparation techniques
- **Vapour Stripping** – For conversion improvement
- **CO-Steam Liquefaction** – Reduction in hydrogen usage
- **Pre-heating of Coal Slurry** – For high moisture brown coal
- **Product upgrading** – Treatment to achieve fuel specifications
- **Flash Pyrolysis** – CSIRO 20kg/h test rig

**Major Industrial Outcome**: Brown Coal Liquefaction Victoria (BCLV)
Japanese consortium developed a 50t/d brown coal liquefaction plant
Brown Coal Liquefaction (BCL)

Joint Japan-Australia BCL 50t/day pilot plant at Morwell, Victoria (1987-1990)
What happened next?
Commercial CTL Proposals in Australia

- Sydney
- Melbourne
- Brisbane
- Adelaide
- Perth
- Darwin
- Townsville
- Hobart
- Sydney
- Canberra
- Port Hedland
- Esperance
- Alice Springs
- Townsville
- Brisbane
- Alice Springs
- Port Hedland

Legend:
- Coal mines
- Oil & Gas Processing
- CTL Prospect
Commercial CTL Proposals in Australia
Most projects failed commercial challenges
Linc Energy

Operated an Underground Coal Gasification (UCG) pilot plant at Chinchilla (Qld) from 1999 to 2013

Pilot scale GTL plant (~2bbl/day) using Fischer-Tropsch technology to convert UCG product gas operated from 2008

Reformulated products from the plant have been used to:

- Drive a diesel car across Australia
- Fly a corporate jet across Australia

According to Linc Energy analysis released in 2013, a combined UCG-GTL plant could produce ultra-clean fuel for AU$30/bbl.

Large scale plans for a 20,000bbl/d plant at Chinchilla and a 100,000bbl/day plant in South Australia have stalled and the company has shifted their focus to other countries.
Altona Energy

Company was preparing a bankability study for mined coal from South Australia for a combined FT and CTM plant.

Target plant size was 30,000bbl/d at US$3.5b cost.

In 2014 there was a shift in focus to UCG for Methanol production, with new financiers.

Source: Altona Energy website
Why are so many projects not progressing?

- Volatility in world petroleum prices
- Reduction in international coal prices
  - Coal companies reducing *all* costs
- Financing difficulties for large projects
- Changes in company ownership
  - Some projects developed by small players with a view to sell at early feasibility stage

- Major changes in Australia’s petroleum sector
  - Unconventional gas boom
  - Emerging export LNG industry
    – Possible price impacts on domestic gas
  - Closure of refineries
  - ………..
Transport Fuel Production & Capital Cost Estimates

Capex barriers for CtL

- LCOF ($/GJ)
- CapEx ($/(GJ/y))

Source: Australian Liquid Fuels Technology Assessment 2014, Australian Bureau of Resources and Energy Economics (bree.gov.au)

- 'mini' (200kt/y) LNG plant ($230M capex)
- Brown coal (5.3Mtpa) gasification/FT ($3B capex)
Australian Lignite Development Program (ALDP)

Adding value to Brown Coal

Victorian State Government funding support for demonstration scale projects

Coal Energy Australia (CEA) – $143M demonstration plant ($30M govt)
- Pyrolysis process (22Mtpa brown coal):
  - low volatile solid fuel or char – a substitute for Pulverised Coal Injection (PCI) coal in steel manufacture
  - pyrolysis oil, which can be distilled into various oils, including diesel oil for industrial heating
  - ammonium sulphate for use as a fertiliser or soil conditioner.

Ignite Energy Resources (IER) - $85M pre-commercial plant ($20M govt)
- Catalytic Hydrothermal Reactor to produce:
  - oily coal, which can be separated into high energy products: synthetic crude (Syncrude) and micronized upgraded coal
  - upgraded coal – for use in blast furnaces as PCI for steel manufacturing
  - synthetic crude oil.
Coal to Products in Australia
Will increasing gas prices drive innovation?

• Some early projects:
  • New Hope Coal (Qld)
    – Two technologies being evaluated - direct & indirect CtL
    – Pyrolysis of New Acland coal for diesel, jet fuel, power
    – 1 tonne/h pilot scale pyrolysers now commissioned
  • Latrobe Fertilisers Ltd (partner with Hubei Yihua, China)
    – Victorian brown coal (low cost $1-2/GJ) (2mtpa -5mtpa)
    – 520,000 tpa urea (stage 1), 1.3mtpa (stage 2)
    – Siemens gasifier
    – Planned commissioning Dec 2015
  • Perdaman Chemical Company (WA fertiliser plant, Collie coal)
  • KHI – Brown coal to Hydrogen (Vic)
    – CCS in association with CarbonNet project
    – Feasibility study in progress*

KHI “CO₂ free hydrogen chain”
Gasification of Australian brown coal with CCS

Brown Coal to Products via Gasification

Technology choice influences R&D needs

• **Oxygen-blown fluidised bed gasification**
  - There may be potential issues with ‘hot spots’ and formation of agglomerates
  - Still issues with carbon elutriation
  - Transport reactor design facilitates use of steam to manage temperature

• **Transport reactor**
  - Issues regarding mineral matter behaviour
  - Steam requirements for temperature management
  - Carbon conversion

• **Entrained flow gasification of lignites**
  - Is it worthwhile slagging a reactive lignite?
    - If so, how will the slag form, and behave? How will our models work? How do we manage $O_2$ requirements and hot alkali formation?
    - If not, then we need to figure out how to run an EFG at low temperatures with dry ash.

• All of these questions require good, transportable data for coal gasification behaviour.
MRC – the most efficient way of converting carbons into liquid fuels?

DICE fuel cycle

**Carbons**

Micronised refined carbon (MRC) has been produced from a range of sources:
- De-sanded and hydrothermally treated low rank coals
- De-ashed black coals (including tailings)
- Chars and algal matter (blended)

**Water-based slurry fuel (MRC)**

**Ultra efficient diesel engine generation (DICE)**

*direct injection carbon engine*
Coal fired diesel engine

Efficiency breakthrough with familiar technology

50-55% efficiency from coal water fuels

- Advanced coal preparation
  - Low cost demineralisation
- Adapt current 30–100MW engines
  - Medium speed (200-800rpm) direct injection
- CSIRO electronic fuel injection system
  - multi-shot injection of coal water fuel to 150MPa
- 20 MPa atomisation and combustion simulator

Successful operation on coal/water fuel from black and brown coals

- Partnering across the technology chain:
  - coal producers
  - coal prep plant technology suppliers
  - engine manufacturers
Summary

• Australia has a long history of CtL research
• Major projects conducted in the 1970s-1980s
• Extensive coal resources considered suitable for direct and indirect coal conversion processes

• Investment declined following reductions in international oil prices

• Renewed interest 2005-present
  • Major barriers are large capital requirements and market volatility
  • Many projects have failed at early commercial stages
  • Uncertainty regarding impacts of new LNG export market

• Current activities focus on value added products from low cost brown coal
• Challenges around large-scale, oxygen-blown gasification of high moisture, low rank coals
• Smaller, modular opportunities being explored (eg coal-water slurries, DICE)
Thank you

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