Hydrothermal Upgrading of Lignite and Biomass

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New Products from Catalytic Hydrothermal Process

Lignite (Brown Coal)
~ 17 MJ/kg as mined
65% water

Syncrude
~ 6% Oxygen
~ 0.2% Sulphur
40 MJ/kg

Upgraded Coal
~ 31 MJ/kg

Biomass
Waste wood
~ 17 MJ/kg dry
Components:
Lignin
Hemicellulose
Cellulose

Bio-crude
~ 11% Oxygen
~ 0.02% Sulphur
36 MJ/kg
Feedstock Properties

- Victorian Lignite (Brown Coal)
  - Victoria has up to 20% of the World's lignite reserves
  - Among the highest quality coals in the World
  - Low in sulphur, ash and metals
  - Little overburden – low cost mining
  - High moisture content (~65%) means inefficient combustion unless dried
  - Difficult to transport due to self-combustion tendency
  - Low bulk density and energy density
  - Complex biopolymer plus oils and waxes

- Woody Biomass
  - Significant quantities of wood residues e.g. pine sawdust, sawmill residue can be aggregated
  - Low in sulphur, ash and metals
  - Relatively low cost
  - High moisture content (10-60%)
  - Low bulk density and energy density
  - Complex biopolymers plus fatty acids and resins
  - Also bagasse, stover, energy grasses, macroalgae, microalgae...
Why Develop These New Products?

Greenhouse Gas Reduction
Use cleanest energy resources available with greatest thermal efficiencies & lowest greenhouse emission factors possible

Renewable Liquid Fuels
• Renewables industry generally lacks high energy-density liquid fuels from non-edible feedstock

Aromatic Chemicals
• Opportunity to develop new industry based around renewable and non-renewable aromatic chemicals used e.g. renewable phenol for plastics

Steelmaking
• Ongoing need for high quality carbon products for metallurgical and other uses
Pilot Plant to Demonstration Plant

• IER has been running Cat-HTR pilot plants at Somersby, NSW since 2009
• Pilot has been scaled-up three times
• Pilots have been using biomass and lignite and mixtures of each
• Next scale-up will be demonstration plant - one module of commercial-sized plant
• IER awarded $20M grant by Victorian and Commonwealth Govts. to build demonstration plant in Latrobe Valley of Victoria

<table>
<thead>
<tr>
<th>Reactor Progression</th>
<th>Plant</th>
<th>Construction</th>
<th>Reactor diameter scale up</th>
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<tr>
<td>1st Generation</td>
<td>Small Pilot</td>
<td>2009</td>
<td>-</td>
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<tr>
<td>2nd Generation</td>
<td>Large Pilot</td>
<td>2011</td>
<td>x 2</td>
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<td>4th Generation</td>
<td>Commercial</td>
<td>2016</td>
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IER Awarded ALDP Grant, Signs MOU with PT Bukit Asam
ALDP Plant Represents Next Scale-up for Licella

• IER awarded A$20m through the Advanced Lignite Demonstration (ALDP) program, can access further ~A$28m through government incentives
• Grant is for the design, construction and operation of lignite-upgrading plant in Victoria’s Latrobe Valley
• ~ $84 M AUD project to build commercial-scale Cat-HTR reactor module in end-to-end pre-commercial plant with capacity ~ 143 ktpa lignite (65% water)
• Three phases over four years to 2018, including engineering and procurement, constructed by mid 2017
• Also plan to operate on biomass feed – Licella’s next scale-up
• MOU signed with PT Bukit Asam (Persero) Tbk regarding development of Cat-HTR in Australia and Indonesia
Upgrading the Synthetic Crudes

100% Straight Run Gas Oil

100% Bio-crude

Blends in ratio: 95:5 90:10 70:30

Hydrogen Hydrotreating Catalyst

Diesel
Scale-up Strategy - Integration

• Work with partners with brown-field infrastructure and complementary processes

• Synergies
  • Feedstock aggregation
  • Wastes with high lignocellulose content
  • Feedstock preparation
  • Water treatment

• Pulp and paper industry
• Lignite mines and power stations