SOME CHALLENGES OF BIOMASS

- Energy density, moisture
- Handling characteristics
- “Shelf-life” and hazards
- Composition (inorganics)
- Digestibility and enzyme conversion rates/efficiencies
- Economics of process options

Equivalent volumes for the same net heat content

Wood pellets
Torrefied pellets, pyrolysis oil
Coal
Purposes:
- Remove pathogens
- Improve energy density
- Improve handling characteristics
- Extend “shelf-life”
- Improve ash content/composition
- Improve performance in conversion
- Improve digestibility and enzyme conversion rates/efficiencies – modify/solubilise cell-wall components
- Extract useful co-products
Physical Methods:
- Pelletising, briquetting etc

Washing methods:
- Water washing
- Chemical washing (many varieties)
- Wet oxidation
- Hydrothermal processing

Thermal methods:
- Torrefaction
- Steam explosion, ammonia fibre expansion
- Hydrothermal processing
- Pyrolysis
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EXAMPLES – water washing waste wood

Performance impacts – slagging, fouling, corrosion, emissions all reduced
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EXAMPLES: Ionic liquids

* Remove hemicellulose

* Modify (and solubilise) lignin

Potential to be
- More efficient
- More flexible
- More profitable

From: Jason Hallet, Imperial College
## STATUS OF TECHNOLOGIES

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EXAMPLES: Hydrothermal Carbonisation (HTC)

Biomass + water $\xrightarrow{180-250^\circ C}$, 14-40 bar Bio–coal + water solubles

- **Gas**
  - Mainly CO$_2$

- **Water and TOC**
  - Sugars, organic acids, NH$_4^+$, PO$_4^{3-}$ and inorganic salts

- **HTC Coal**
  - Carbon dense lignite like material (retains 80% energy)

**HTC** = potential pre-treatment for biomass
- Combustion and gasification
- Biomass based synthetic chemicals

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**From:** Andy Ross, Leeds University
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<td>Anaerobic, &lt; 300 °C.</td>
<td>Dehydration, decarboxylation. Preferential decomposition of hemicellulose</td>
<td>Solid</td>
<td>High yield; improved solid properties; energy densification</td>
<td>Demonstration. Mix of TRLs on specific remaining challenges</td>
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<td>Steam Explosion</td>
<td>Explosive decompression in steam (180-240 °C, 1-3.5 MPa)</td>
<td>Softens lignin; Breaks down fibres, cell-wall and particle size. Partial hydrolysis; some dehydration; breaks crystallinity of cellulose</td>
<td></td>
<td>Depends on severity. Hydrophobic Solid; and/or solubilised sugars</td>
<td>Versatile – Pellets, energy densification; preprocessing for bio-liquids and biogas. Biorefinery. Commercial to mix of TRLs depending on application</td>
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<td>Ammonia Fibre Expansion</td>
<td>liquid ammonia 100 to 400 psi, 70 to 200°C, rapid release of the pressure</td>
<td>partially solubilises lignin and some hemicellulose De-crystallises cellulose</td>
<td>Slurry for enzyme conversion</td>
<td>Improved conversion efficiency in enzyme processes</td>
<td>Planned commercial plant (Dupont)</td>
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<td>Pyrolysis</td>
<td>400-700 °C, 2 sec - days</td>
<td>Thermal decomposition of the cell wall</td>
<td>Versatile. Bio-oil for fast pyrolysis; biochar, charcoal for slow pyrolysis</td>
<td>Versatile energy densification. solids; liquids; biorefinery</td>
<td>Commercial and demonstration. Mix of TRLs on specific remaining challenges</td>
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EXAMPLE: Torrefaction

- Torrefied biomass becomes friable and less fibrous.
- The heating value increases (~22 MJ/kg).
- Torrefied biomass is hydrophobic (repels water).
- Torrefied biomass is easier to homogenise.
- Improved transport, handling and storage.
- Improved milling behaviour.
- With pelletisation, bulk density increases
- Bulk energy density increases
CONCLUSIONS

- Pretreatment is an important step in bioenergy and can represent a huge fraction of the cost of the process
- Many different options at different TRL
- Exciting opportunities to remove high value products for use in more than one conversion technology
- Or to improve economics, efficiencies, rates and conversion in existing processes