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The Opportunity for Biomass Fractionation in the North East

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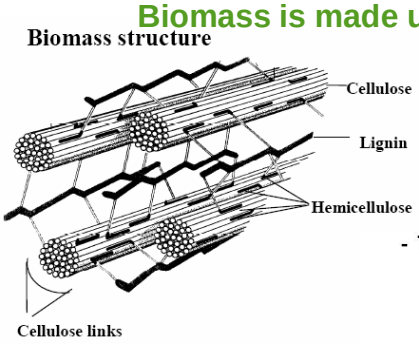
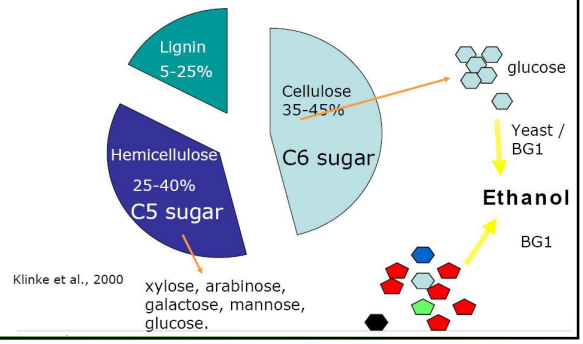
Biomass is made up of 3 complex polymers



- Three major components



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Pre-treatment or fractionation

- The distinction between the different technologies is subtle yet can have a significant influence on the end use markets of the biomass
- The aim of biomass fractionation is to split the biomass into one or more fractions of the three major components of lignin, hemicelluloses and cellulose, allowing further conversion to products.
- Biomass pre-treatment on the other hand aims to disrupt the lignin, cellulose and hemicelluloses components allowing efficient hydrolysis of cellulose and hemicelluloses to fermentable sugars.
  - Pre-treatment can lead to a separation of components; however, this is a consequence of processing rather than intent.

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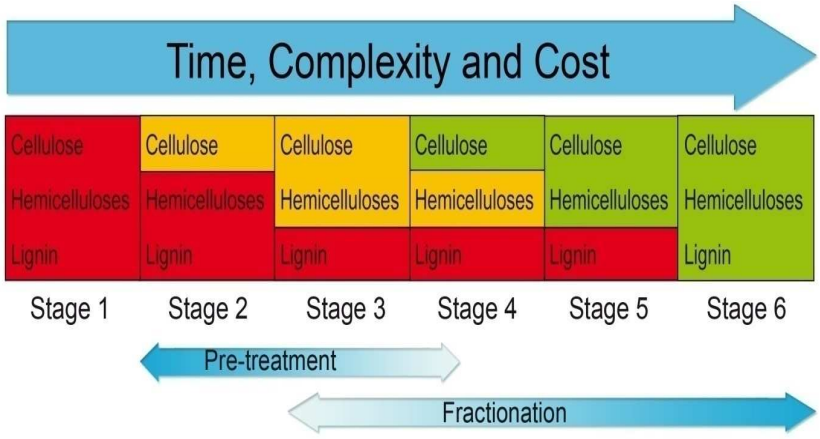
Opportunity Range



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Market Opportunity – Key Assumptions

- Quantities of each fraction typical of the NREL Clean Fractionation process.
- All biomass fractionation processes have the same feedstock preference as the NREL process, i.e. hardwoods, agricultural residues and herbaceous biomass.
- The feasibility of different scenarios is primarily based on the regional and UK potential for supply, with the scope for limited imports to supplement domestic production.
- We have used the economic modelling of the NREL process as a basis for our assumptions.
- In the absence of a publically available price for dissolving pulp, we have used Northern Bleached Softwood Kraft (NBSK) pulp price as a proxy.
- We have assumed that biomass fractionation products will be produced for captive markets.

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Feedstock

Hardwoods, agricultural residues and herbaceous biomass

- Energy Crops
  - Miscanthus, Short rotation coppice
  - Energy crops are currently a small resource with an estimated production of 90,300 odt of crops in the UK, and around 17,428 odt in the North East
- Hard wood forestry
  - Hardwood resources are difficult to estimate
  - North East forestry is dominated by soft wood production
  - Predicted availability around 90,000 tonnes
- Straw
  - Range of sources (wheat, rape, barley etc)
  - Existing uses
  - Prediced availability 467, 000 tonnes/year

building sustainable supply chains

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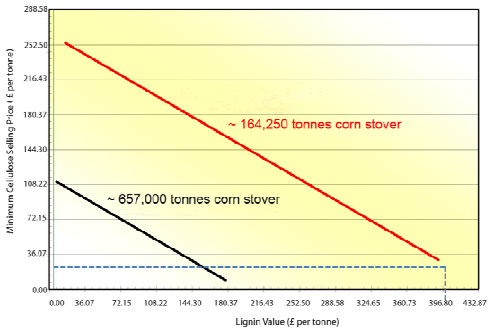
Comparison of cellulose markets



The price of sugars over the past 10 years, but has usually been between £ 70 and £ 150 per tonne

Over the past 10 years, pulp prices have typically varied between £ 300 - £ 450 per tonne

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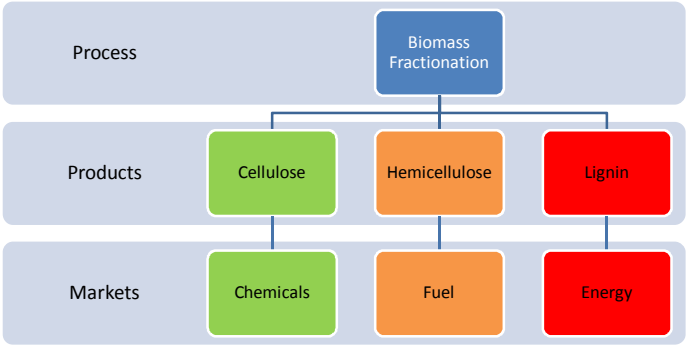
Chemicals, Fuel and Energy



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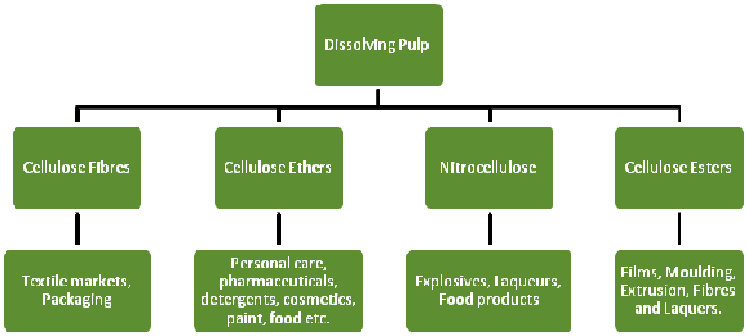
Speciality Pulp Markets



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UK cellulose strength

- The UK has significant strength in the commercial production of cellulose derivatives and the development of new cellulose applications.
- The UK has three companies producing between 10-100,000 tonnes of cellulose derivates each per annum. We estimate that;
  - Innovia use around 20,000 tonnes for the production of Natureflex and Cellophane,
  - Lenzing around 50,000 tonnes for the production of regenerated cellulose fibres,
  - Clarifoil between 30-40,000 tonnes for the production of cellulose acetate
- The UK has a number of innovative SME developing technology applicable to C5 sugar fermentation

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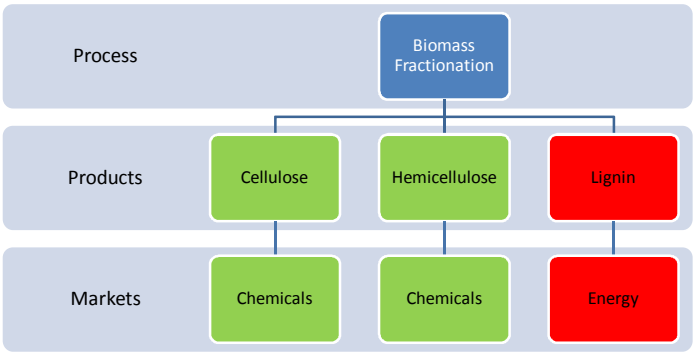
Chemicals & Energy



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Hemicellulose Outlets

- Furfurals may be a possibility. Although furfural is predominantly produced in China, South Africa and the Dominican Republic; the world's largest furfuryl alcohol production unit is operated by TransFurans Chemicals (TFC) in Geel, Belgium.
- The purity of the hemicelluloses arising from clean fractionation would be an advantage in the production of Xylitol, because it is known that Xylitol production is especially sensitive to contaminants.
- High value applications such as; pentose components in surfactants, barrier coatings, adhesives etc
- HOWEVER
- These applications require development or lack a UK development opportunity

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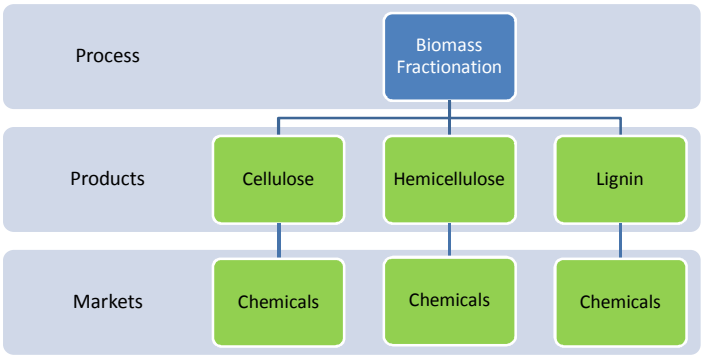
Chemicals



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Lignin

- Long term opportunities for conversion to aromatic bulk chemicals and functional speciality chemicals
  - Phenolic aromatics
  - Functional anti-oxidants
  - Carbon fibers
- Near term opportunities lie in lignin's calorific content
  - High quality pellets for domestic use
  - Supply to large scale renewable energy producers

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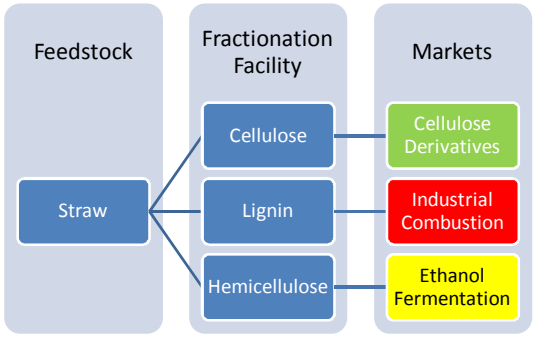
Opportunity Potential



Alternative feedstock – hardwood coppice initially based on inports

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Summary

- Biomass fractionation based on an organosolv process
- Scale of plant – typical of current sulfite pulp plant
- Raw material – straw supplied from region and neighbouring regions
- Dissolving pulp grade cellulose designed for UK production of cellulose film and/or fibre
- Fermentation quality hemicellulose sugars
  - Either ethanol 'bolt on' to the fractionation facility
  - Sugar supply to ethanol facility with C5 fermentation (i.e. DDGS fermentation)
- Lignin converted to domestic fuel pellets or supplied to biomass power plant


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