Assessment of Potential Biorefineries

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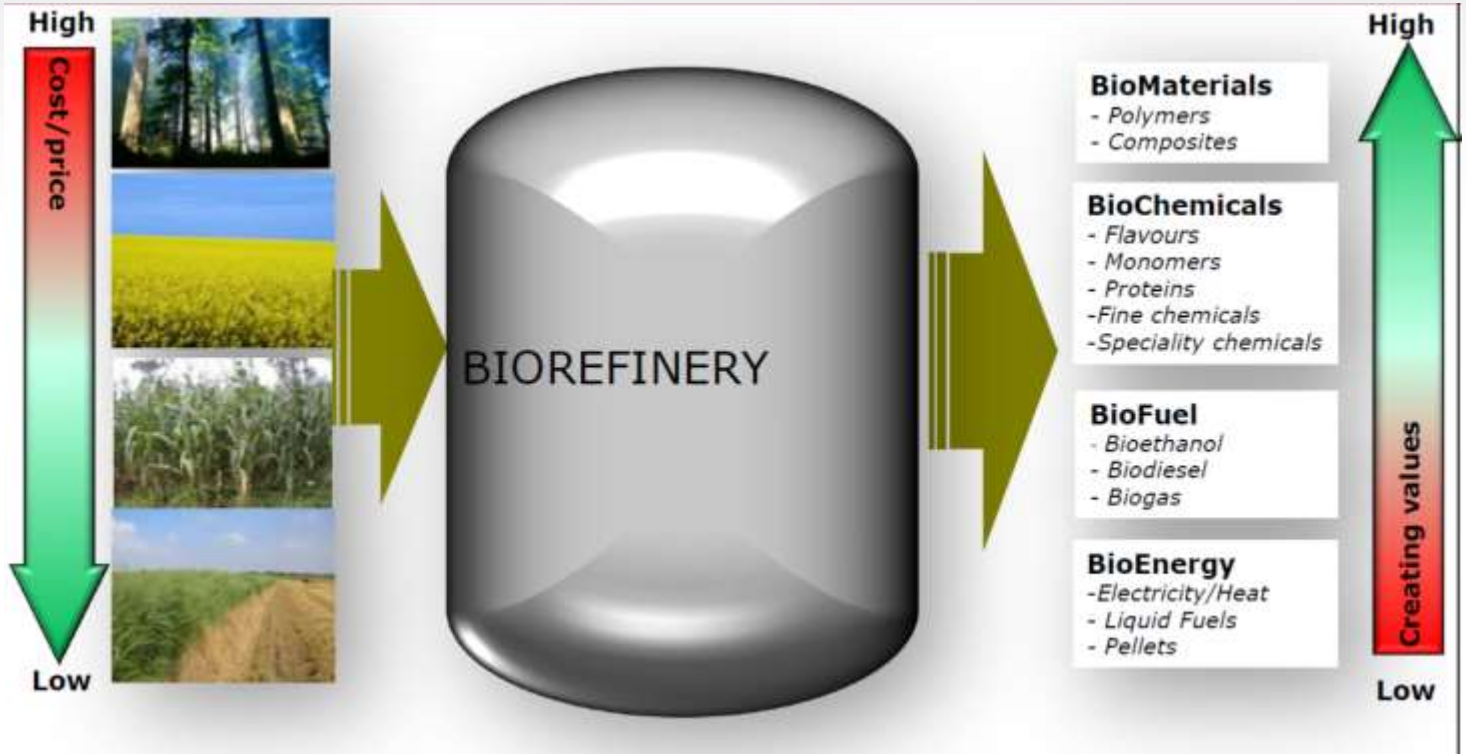
Overview

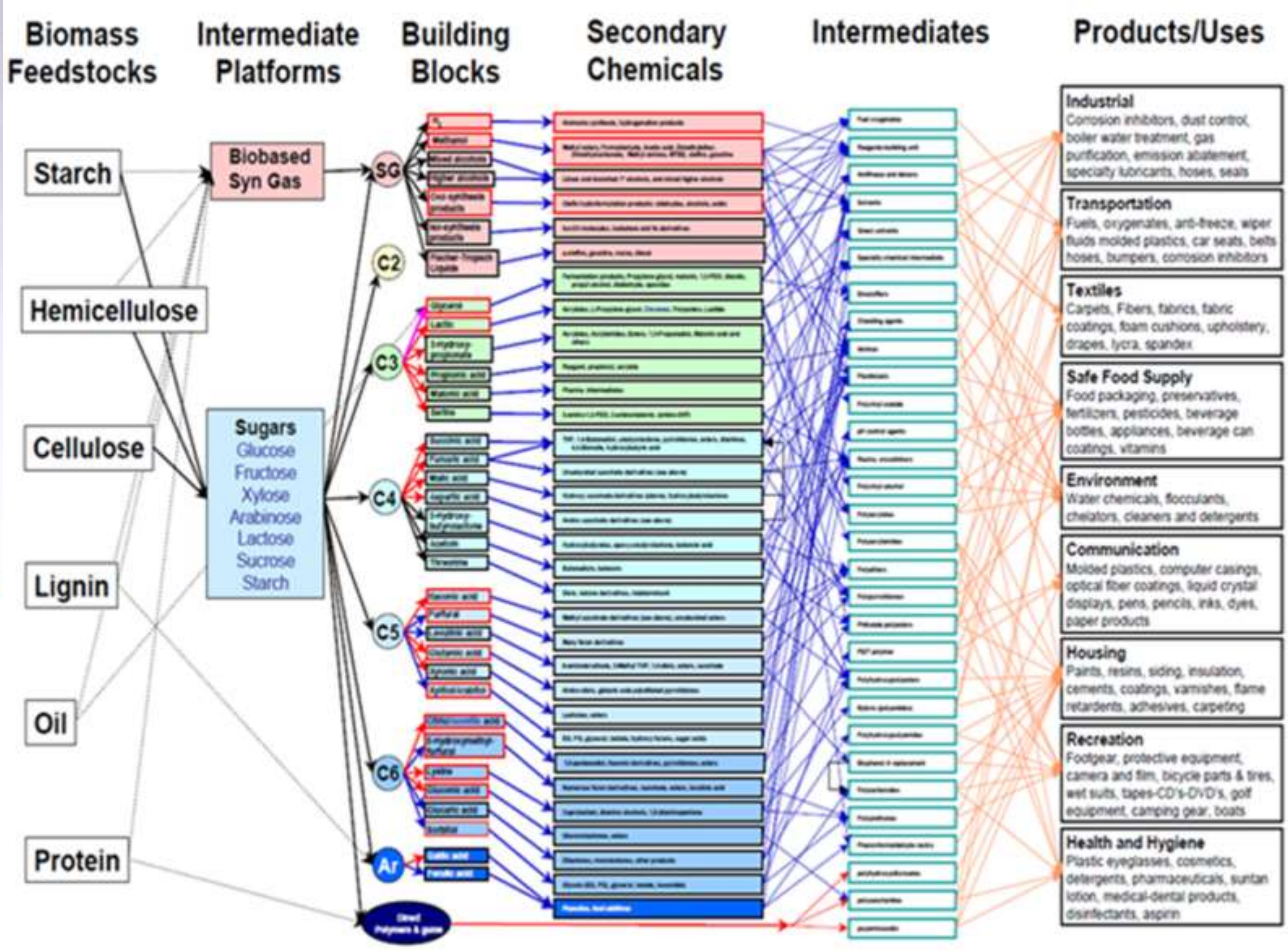
- Why investigate biorefinery scenarios?
- Technologies, techniques and processes currently under investigation
- Techniques for assessing biorefinery scenarios
- Where to next?

Sugar Industry Residues

- Leaves and tops are burnt prior to harvesting
- Some leaves drop and could be harvested
- Sugarcane bagasse → surplus after mill upgrades
- What about higher value options?

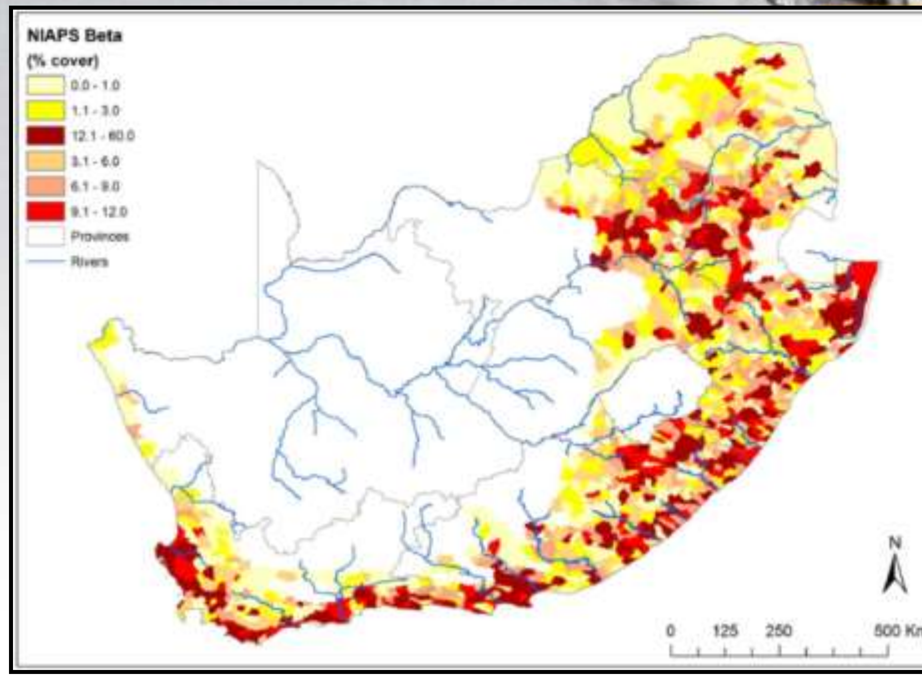


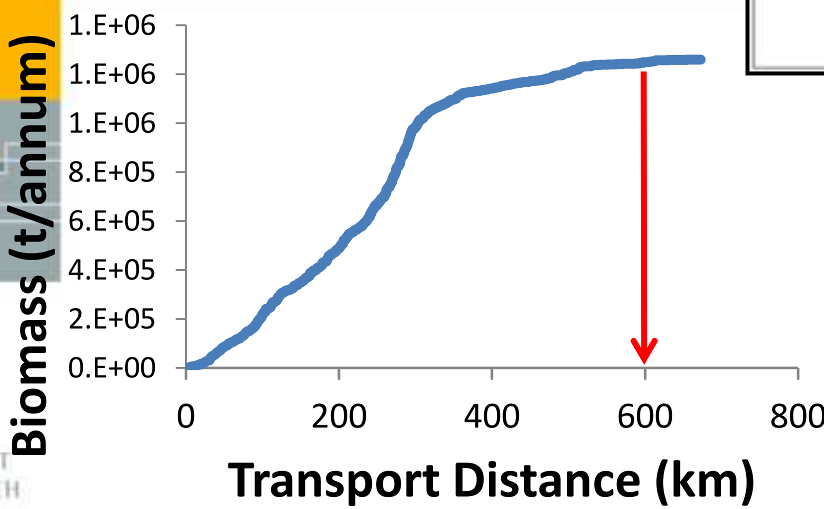
Biorefinery Options



Example: Gasification of Invasive Plants

- 120 - 180 million tons
- Clearance estimated as 15-20 years





PetroSA could process 2.2 million tons per year

Pyrolysis Projects

- Pyrolysis is the thermal decomposition of organic material in the absence of oxygen
  - Charcoal, bio-oil and gaseous products
- Previous and ongoing research:
  - *Eucalyptus grandis* wastes
  - Agricultural wastes: Sugarcane bagasse and tops & trash
  - Invasive plant species: Kraalbos, Schotzbos and Asbos
  - Catalytic pyrolysis of lignin

An Example of Research

- Carried out in conjunction with the Pulp and Paper industry

Valorisation of low (8.5 wt%) and high ash (46.7 wt%) paper waste sludge (PWS) and via pyrolysis (Angelo Ridout).

1. Maximisation of bio-oil yield from fast, slow and vacuum pyrolysis by optimizing temperature and pellet size.
2. Comparison of the product yields and quality, as well as the energy efficiency

→ Determine most suitable technique for PWS valorisation.

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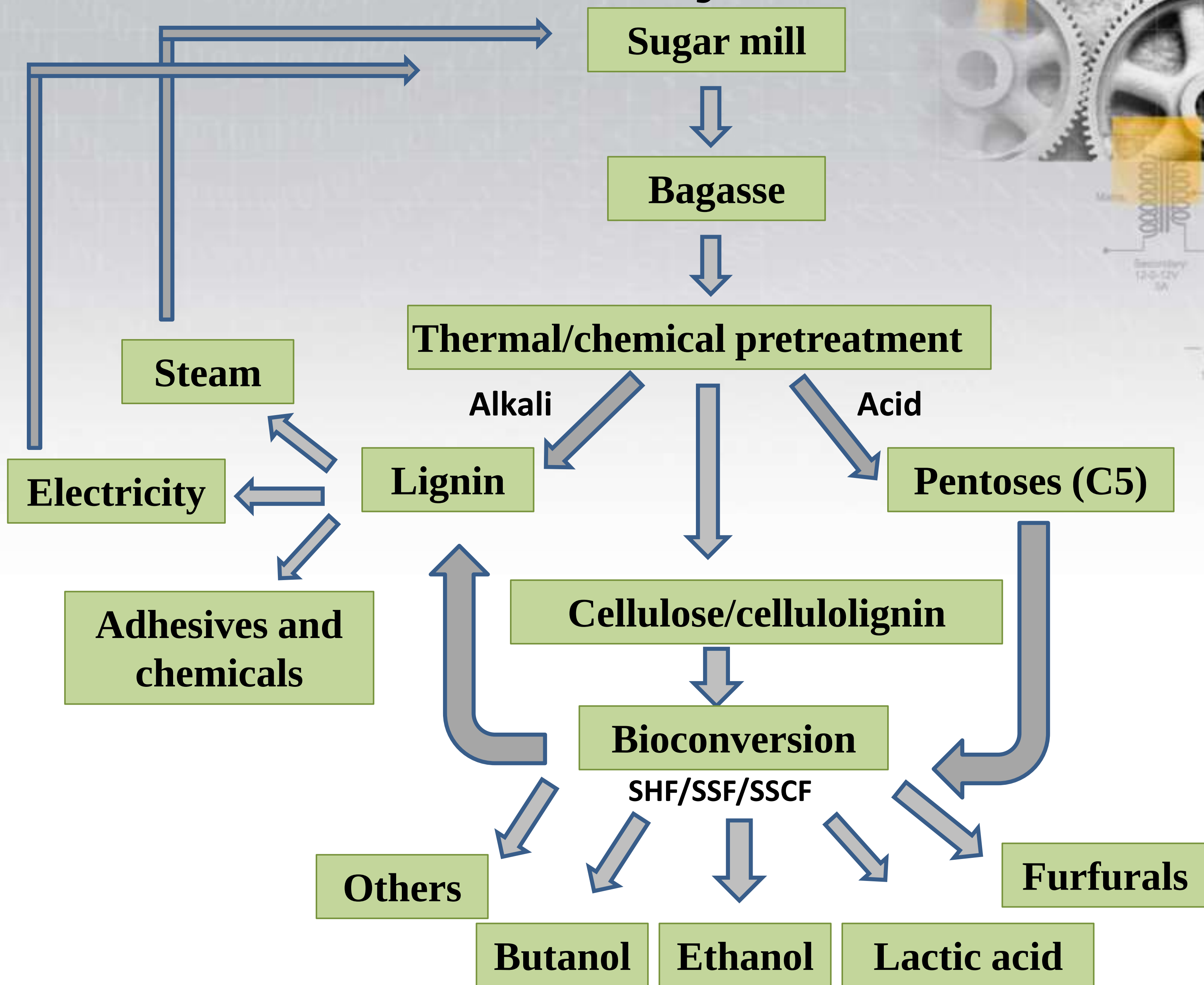
Pyrolysis Equipment

- Available equipment:
  - TGA-MS and TGA-TD-GCMS: Kinetics and volatiles production during pyrolysis
  - Pilot scale fast pyrolysis → 1 kg/hr
  - A fixed bed for slow and vacuum pyrolysis (50g/batch)
- Currently designing slow/vacuum pyrolysis at pilot scale → 20 kg/h

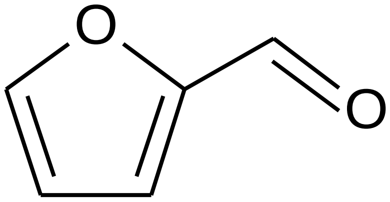
Biomass pyrolysis is commercially ready → we can test feedstock and advise on conditions

Potential Biorefinery



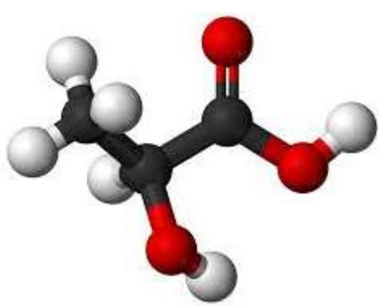
Experimental: Furfural

- Often formed during pretreatment and inhibits ethanol fermentation
- A chemical process typically using acid catalyst
- Two process approaches will be considered
  - Direct furfural production → digestible solids?
  - Indirect furfural production from solubilised hemis
- Process to be considered include
  - Using a high boiling point solvent → atmospheric pressure
  - Steam stripping

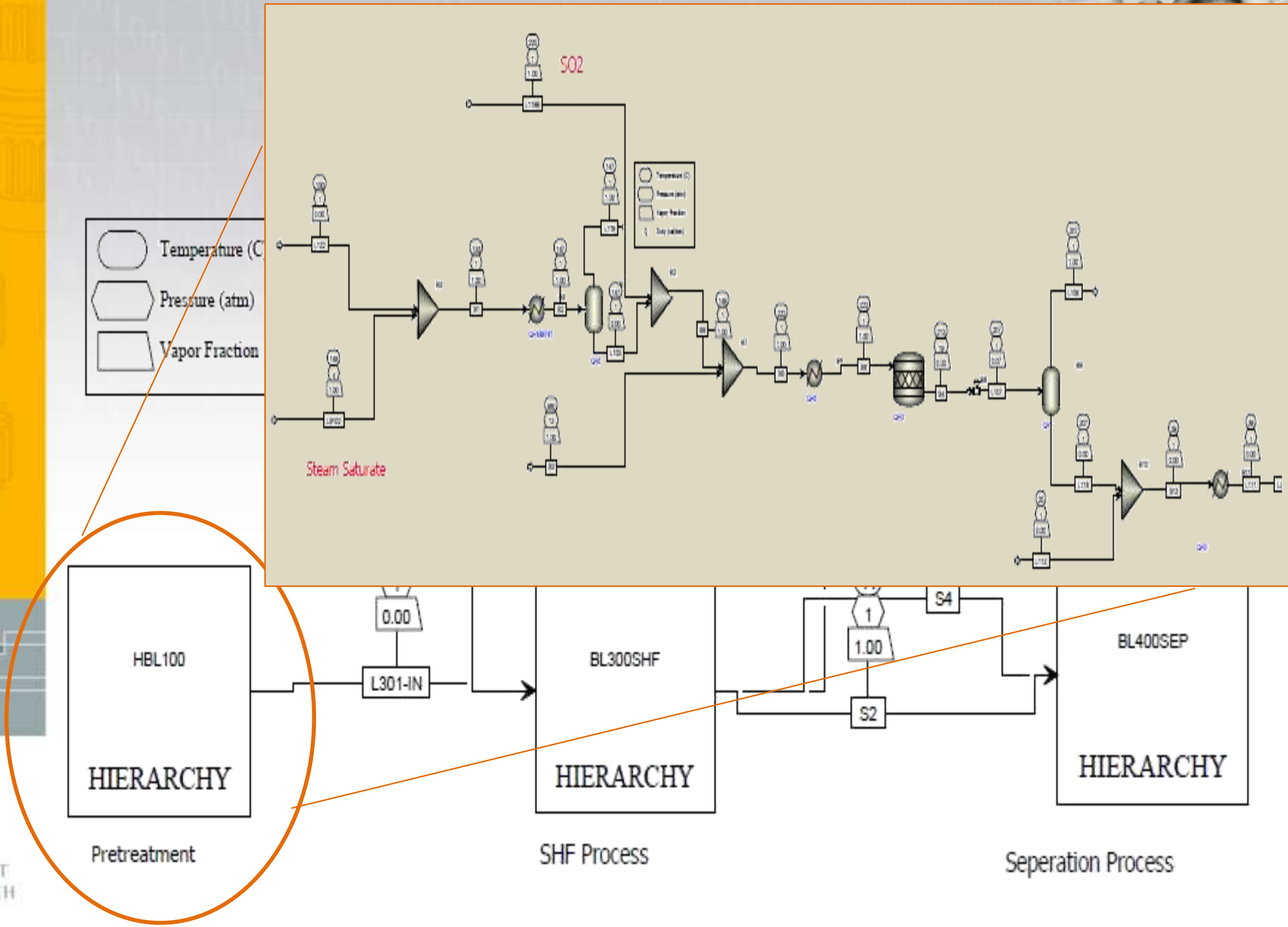


Experimental: Lactic Acid

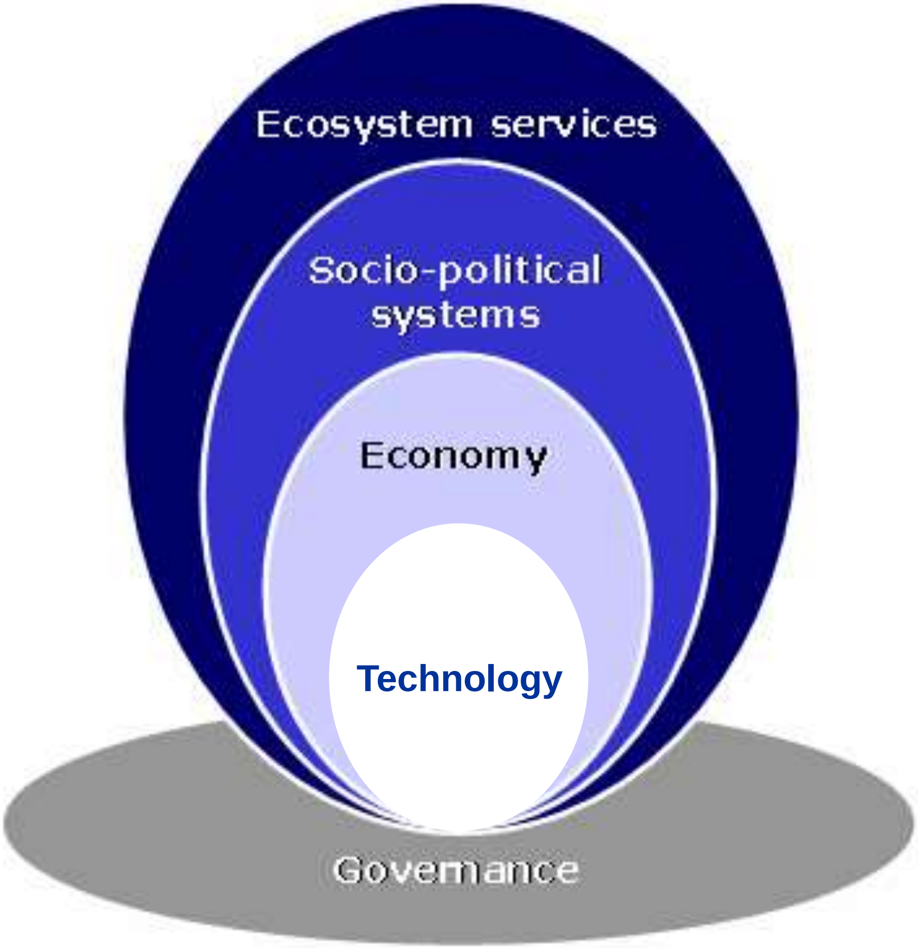
- Lactic acid bacteria requirements
  - Tolerant of inhibitors in hydrolysate (the substrate)
  - Able to ferment glucose (C6 sugar) and xylose (C5 sugar)
- Procedure for assessing selected bacteria
  - Test fermentation of xylose using shake flasks
  - Test tolerance of hydrolysate using test tubes
  - The best two bacteria will be tested using 1 L fermenters and a fed batch process



Process modelling of biorefinery scenarios



Assessment of Sustainability



Technological Readiness

Process	Maturity	Readiness Level
Lactic Acid	Commercial scale plants, Examples using a variety of feedstocks	9
Furfural	Commercial scale plants in South Africa, DalinYebo has developed a more efficient process	9
Cellulosic Ethanol	A small number of commercial scale plants have been built but there are still challenges	8-9
Biorefineries	A wide variety of configurations being investigated globally. A few examples at commercial scale	Typically: 2-3 Specific configurations: 7-9

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Biorefinery Challenges

- Product and configuration selection
  - 20-30 person years to investigate all of the potential products => no shortcuts or pet projects!
- Limited data to develop an overall process simulation
  - Downstream processing often not considered
  - Industrially relevant conditions and scale
- We need to develop the capacity to test technologies at industrially relevant scale
  - Select preferred technologies for demonstration, based on IP space, markets and local resources => globally competitive technology offering!
- We need to develop the skills to build and operate these new technologies

Waste Tyre Research

- Large amount of valuable material is disposed
- (Catalytic) tyre pyrolysis (with refining) to produce:
  - Monomers for rubber manufacturing,
  - Valuable chemicals (e.g. DL-limonene)
  - Activated carbon, carbon black, fuels
- Devulcanisation to reclaim rubber polymers, incl. biological desulphurisation
- Gasification of waste tyres to produce syngas
- Pilot scale technologies expected → 2yrs


Acknowledgments

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greenfund

Thank you for Listening

Pyrolysis technology

400 – 800 ˚C

Inert atmosphere

Solid – Char
(Biochar,
Activated carbon or
Coal replacement)

Volatiles

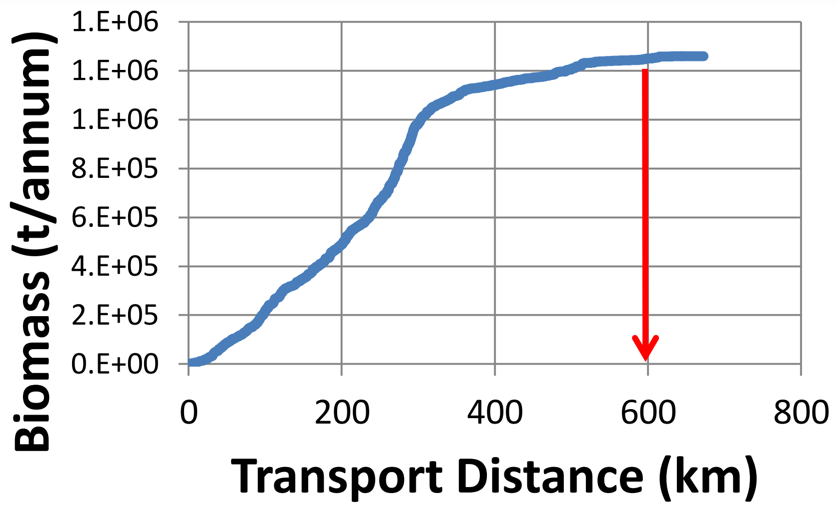
Gas fraction
(Chemicals or fuel)

Liquid fraction
Pyrolysis oil
Organic compounds
H_2O
(Chemicals or fuel)

Yields depend on feedstock composition and operating conditions (heating rate, temperature, particle size, pressure, etc.)

Biomass Processing at PetroSA

- Currently running at half capacity – supply problems → What about biomass?
- Co-processing biomass and natural gas could increase yield and reduce costs
- Feedstock Costs in terms of energy content
  - Invasive plants → ~R35/GJ
  - Coal → ~R41/GJ
- Alternatives
  - Plantation residue
  - Wheat residue



Courtesy of Wim Hugo, BioEnergy Atlas Project and Rethabile Melamu, GreenCape

Fuel properties

Proximate analysis (wt %)

	Moisture	Volatile	Fixed Carbon	Ash	HHV (MJ/kg)
Clean plastic	< 0.5	> 90	0.5-2	< 5	> 35
Waste tyre	< 2	60-70	22-30	3-10	33-40
Wood	5-10	75-82	15-20	< 2	17-20
Agricultural residues	5-10	65-80	10-20	0.5-15	15-25

Feedstock composition

Elemental analysis (wt %)

	C	O	H	N	S
Clean plastic	82	3-8	13	0.6	< 0.1
Waste tyre	75-85	1-5	7-8	0.2-1	1.5-2
Wood	45-50	40-45	5-7	< 1	< 0.3
Agricultural residues	40-45	30-40	5-9	0.5-3	< 0.3

Sugar calculations

	ton/(day. mill)	ton /(year.mill)	ton / year
bagasse (12%)	864	233280	3265920
trash	501	135270	1893780
9 mons operation	270	day/year	