

Feedstocks for the emerging Biorefinery

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High Value Manufacturing



Europe (2013): €2.1 Tn
18.3 M jobs

UK (2012): Direct: £36.1 Bn; 600 K jobs
Indirect: £154 Bn; 4 M jobs



Bio-economy

Economic activities relating to the invention, development, production and use of biological products and processes (OECD)

Industrial Biotechnology

Use of enzymes and micro organisms to make biobased products using renewable raw materials
(EuropaBio)

2025: £8 Bn

Biotech Britain 2015

??????

Bio-refinery

Manufacturing site involved in the refining of biomass to yield purified materials and molecules: using biological and/or thermo chemical processing (NNFCC)

Challenge to sustain growth in a bio-economy



Waste less



Produce less



Consume less



Pollute less

UK: 80% reduction in GHG emissions by 2050

UK biofuels infrastructure - wheat ethanol, animal feed



Renewable Energy Directive

20:2020

10% share of renewable energy in the transport sector by 2020:

7% ceiling for conventional biofuels

0.5% share for advanced biofuels

Ensus, Wilton - 400,000 cubic metres pa

Vivergo, Hull - 420,000 cubic metres pa

The image shows an aerial view of two large industrial biofuel processing plants. A central blue text box contains the key regulatory information. The plants are surrounded by infrastructure like roads and rail lines.

Annex IX non-food feedstocks



Urban Organic Waste
Bio-fraction of MSW
Bio-fraction of C&I waste
Used cooking oil (UCO)
Sewage sludge

Wood and Forestry residues
Bark, branches & leaves
short rotation coppice
Saw dust & cutter shavings

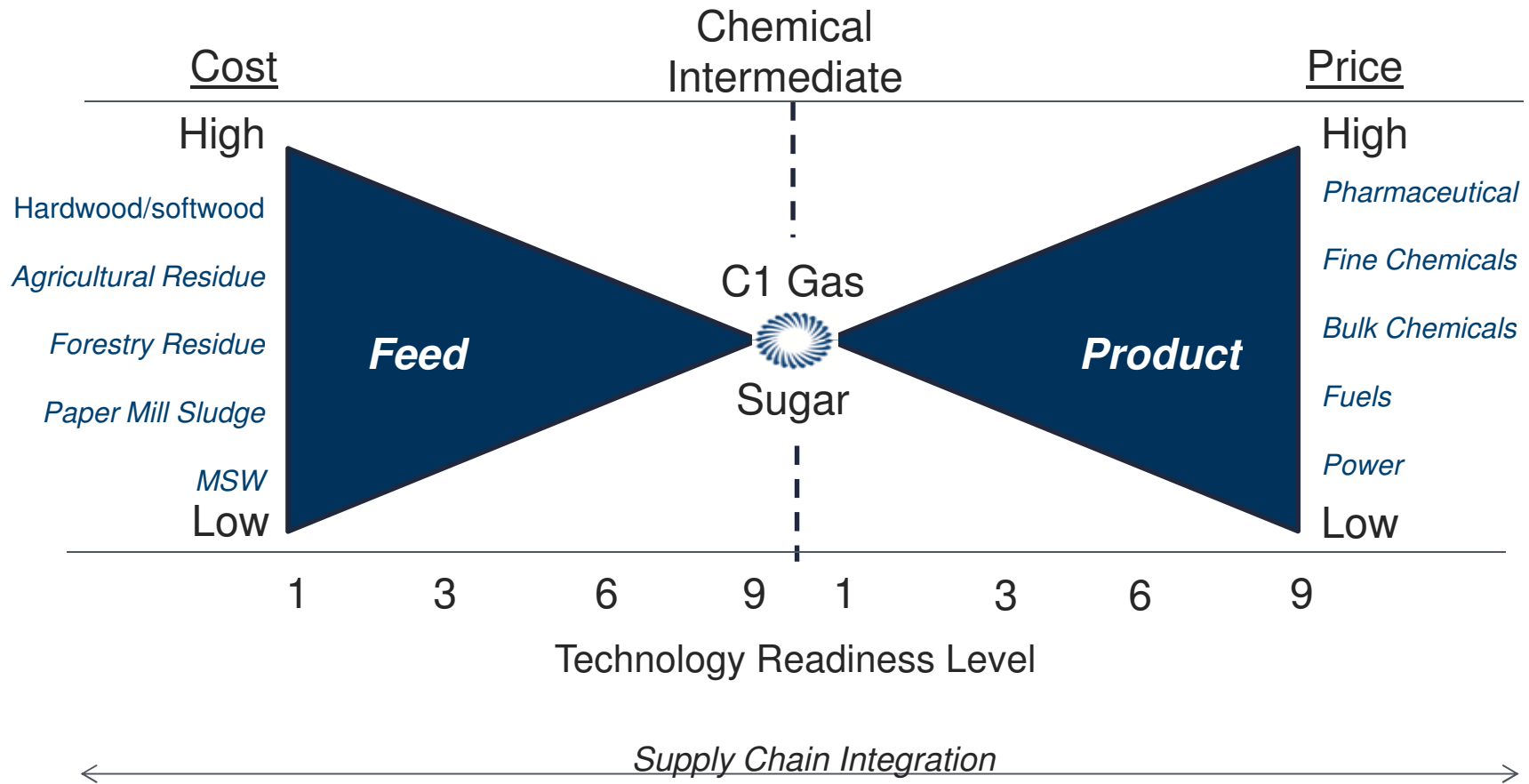
Agricultural residue
Animal manure
Palm oil mill effluent
Empty palm fruit bunches
Grape marcs
Wine lees
Straw
Cobs
Husks
Nut shells
Bagasse

Industrial side streams
Crude glycerine
Black & brown liquor
Tall oil pitch
Animal fats categories I & II

Biomass
Micro-algae
(Macro-algae)













Gases
Hydrogen
(renewable electrolysis)
Methane
(AD or catalysis)
Carbon dioxide
(combustion plant gases)
Carbon monoxide
(steel mill waste gases)

Biorefinery

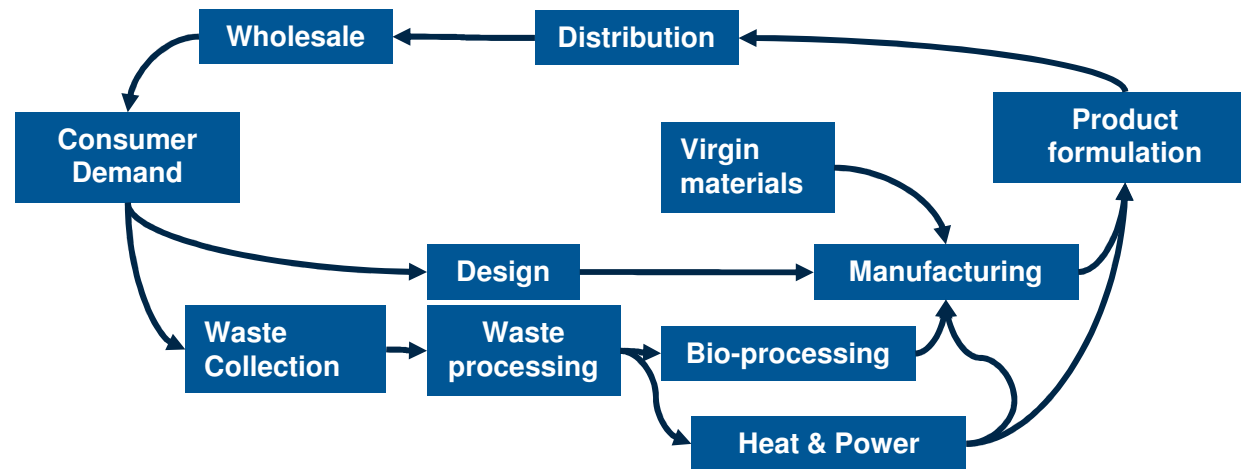


Applying IB to alternative feedstocks at CPI



  Waste Root Vegetables	  Waste Glycerol	  Municipal Solid Waste
Nanofibrillated Cellulose	Heterotrophic Algae Fermentation	Enzyme Hydrolysis
Viscosity Modifier	Advanced Biofuels Succinic acid	Surfactants
  Fish Waste Peptones	  Process Effluent	  Macro-Algae
Fermentation	Membrane Separation	Anaerobic Digestion
Industrial Enzymes	Protein Recovery	Methane

Building a Circular Bio-economy



What Manufacturing needs from the Bioeconomy



Lowest Cost



Security of Supply



Quality Assurance



Lowest Social and Environmental Impact

Help to address supply chain needs, such as raw materials and feedstocks.

Residues from cereal crops 2012



Cost Supply: Residues from Cereal Crops

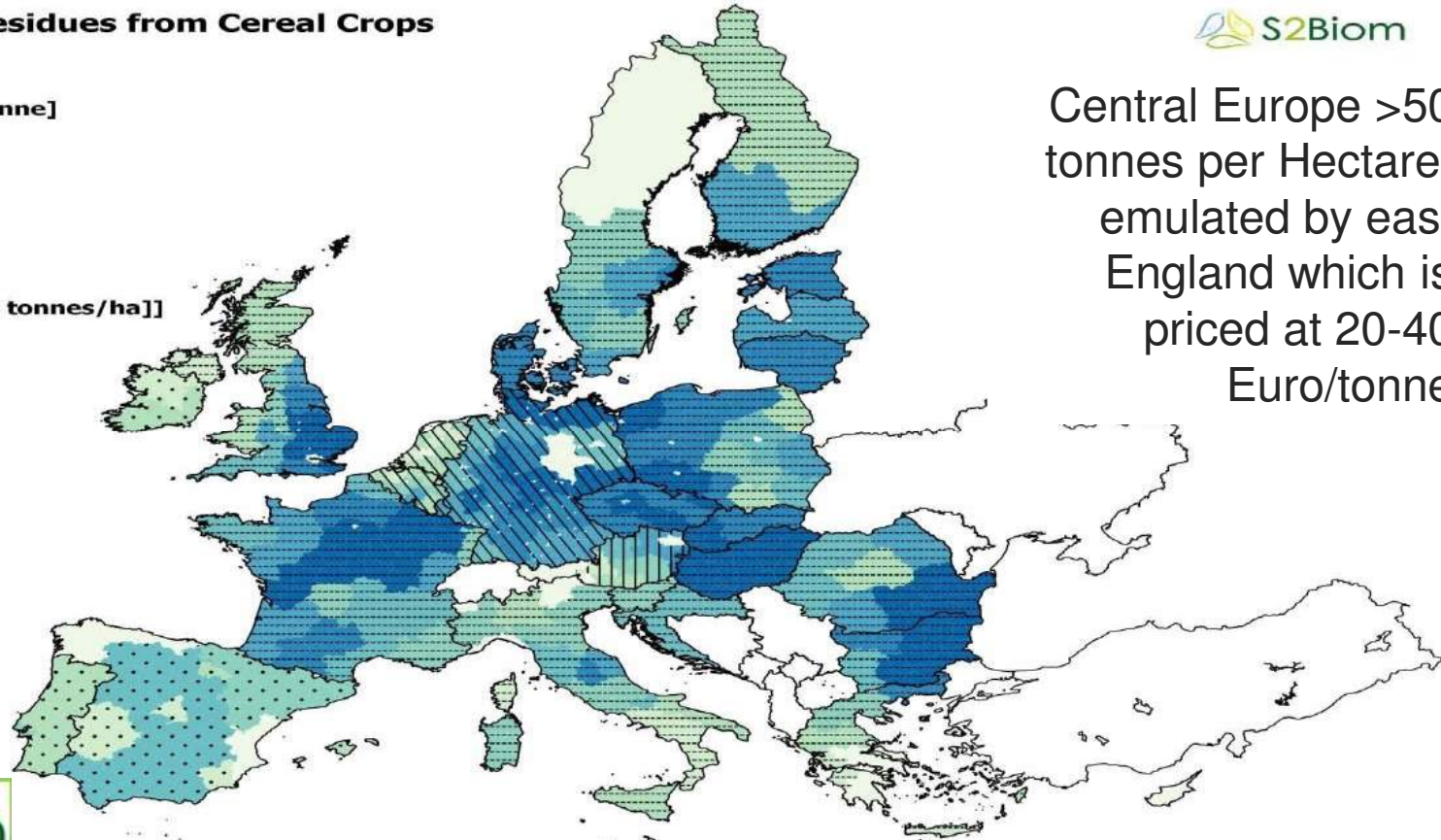
2012

Cost Levels [EUR/tonne]

- 10 - 20
- 20 - 40
- 40 - 60
- 60 - 80
- > 80

Supply Levels [1000 tonnes/ha]

- 0
- 0.00 - 0.0004
- 0.004 - 0.0015
- 0.0015 - 0.0075
- 0.0075 - 0.0150
- 0.0150 - 0.0250
- 0.0250 - 0.0500
- > 0.0500



Central Europe >50 tonnes per Hectare, emulated by east England which is priced at 20-40 Euro/tonne



Biomass from Early Thinnings 2020

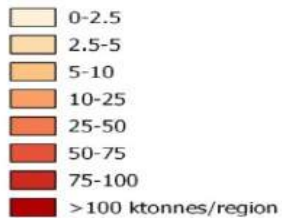


UK

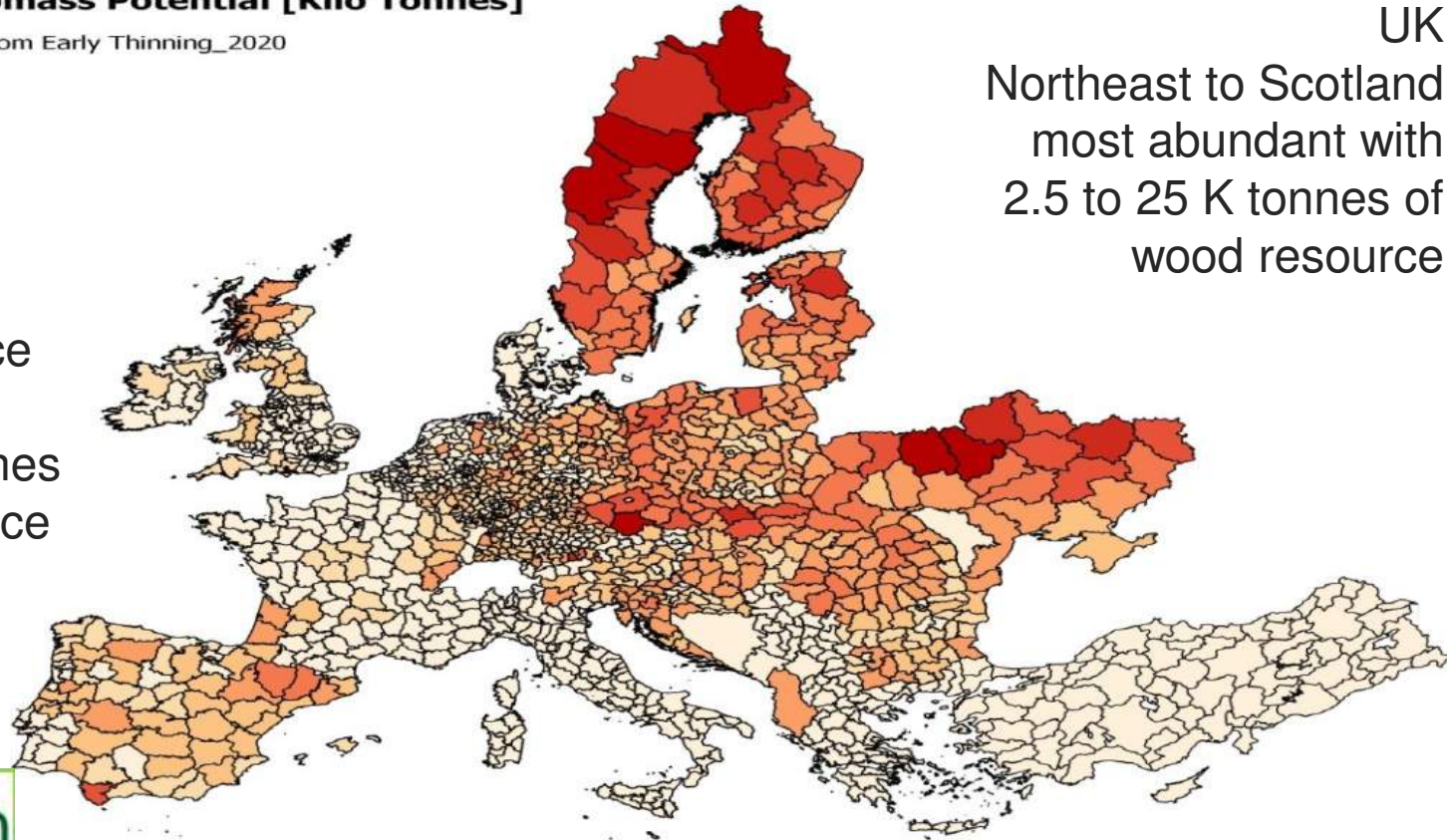
Northeast to Scotland
most abundant with
2.5 to 25 K tonnes of
wood resource

Lignocellulosic Biomass Potential [Kilo Tonnes]

Stem and Crown Biomass from Early Thinning_2020



Largest resource
is Scandinavia
25 – 100 K tonnes
Of wood resource



Urban Organic Wastes (Europe)



80% of the population is expected to live in European Cities by 2020 (Eurostat)



Food waste
89 M tonnes

Power, organic
fertiliser



Municipal Solid Waste
242 M tonnes

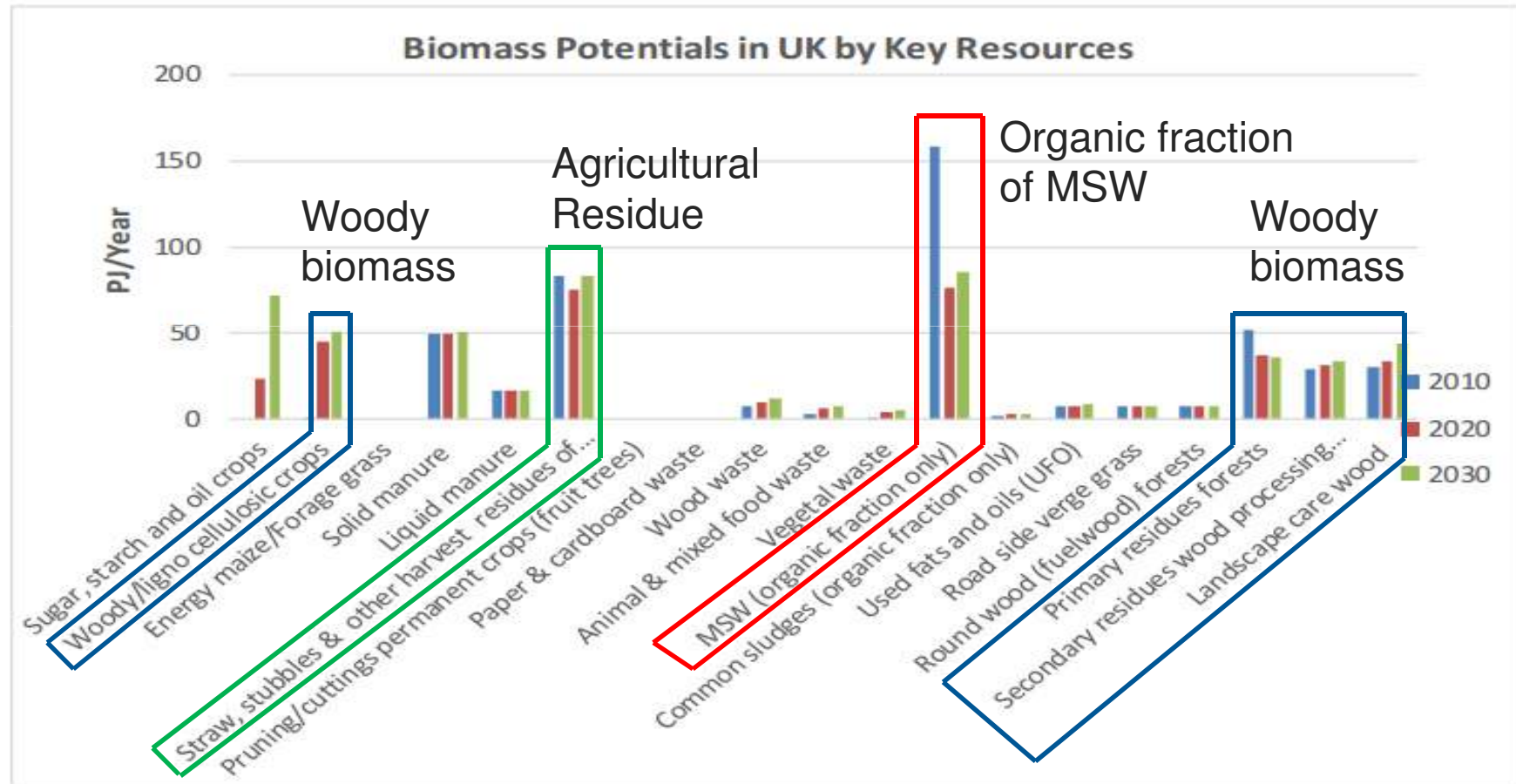
38% landfilled
27% incinerated



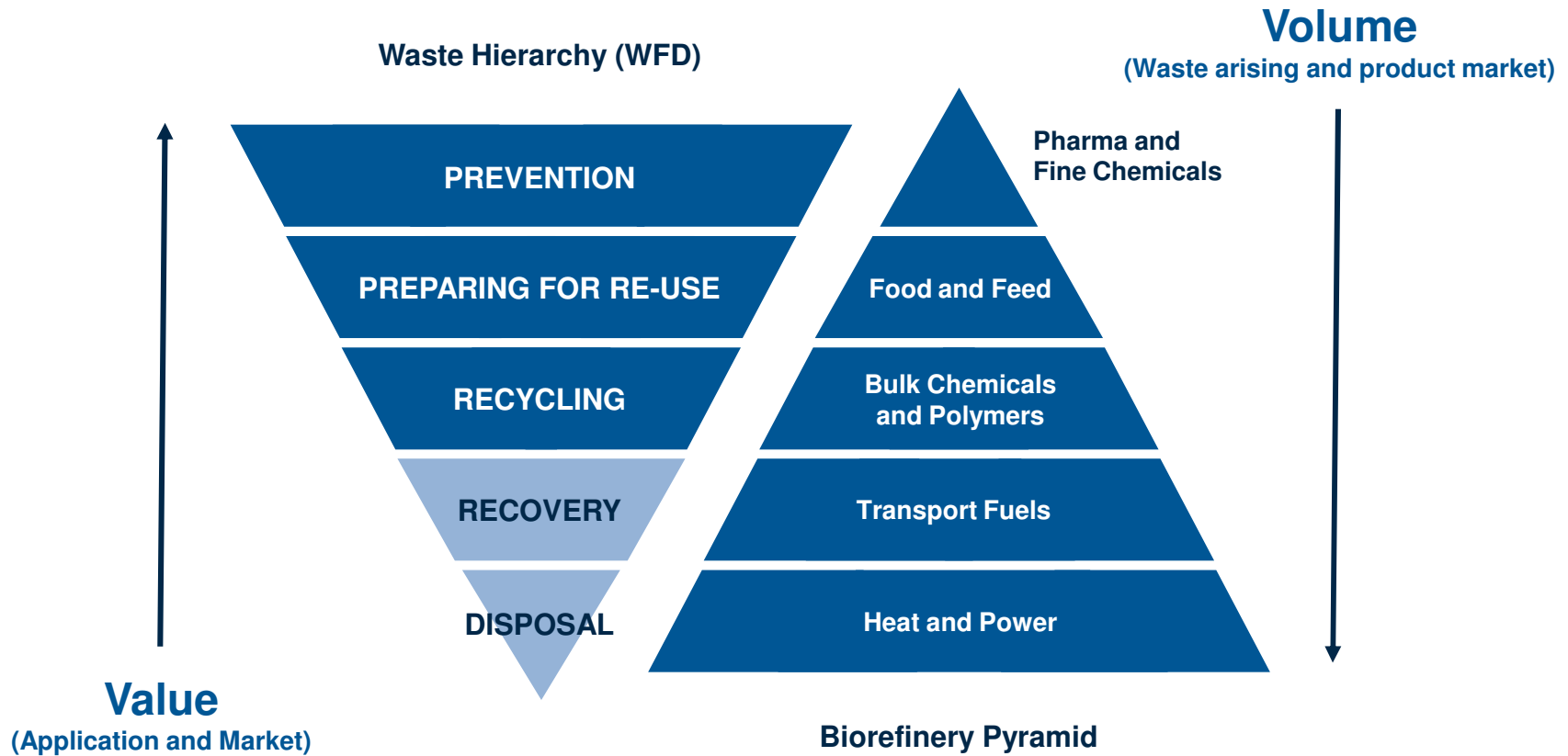
Treated Sewage Sludge
8 M tonnes

Power, organic
fertiliser

Biomass potential (PJ per year) 2010, 2020, 2030



Waste Hierarchy meets the Biorefinery Pyramid



Driving the value of waste



Incineration



Composting



Anaerobic Digestion



Fermentation

Power

Organic fertiliser

Methane
Organic fertiliser

Chemical

MSW to cellulosic sugars: Enzyme Hydrolysis at CPI



Feedstock



Product

£1 M IB Catalyst grant funded project

- Achieved 50% reduction in enzyme loading to unit mass of sugar produced
- Achieved a product sugar that is cost competitive/better than food grade sugars
- Overcame sterility issues in enzyme hydrolysis
- Developed novel inline real-time analytical techniques for enzyme hydrolysis process
- Demonstrated conversion of sugars to ethanol, levulinic acid and thermoset bioresin



Opportunity



Moving up the waste hierarchy by reducing the strain on fossil resources and virgin biomass through converting waste to fuels and chemicals (the circular economy)

Robust processes needed to deal with **heterogeneous feedstocks** producing drop-in intermediates for uptake by the chemical industry

Scale-up industrial biotechnologies as part of an integrated supply chain (the integrated biorefinery) to overcome barriers to commercialisation

Thank you...

For more information, please visit www.uk-cpi.com

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