



Future of Lignocellulose processing



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A specialist bio-based economy consultancy based in York, UK.

Company Vision

We view bio-based technologies as key components of the low carbon economy delivering economic, social and environmental benefits.

We believe the bioeconomy will create sustainable business opportunities for feedstock suppliers, technology and project developers, manufacturers and investors.

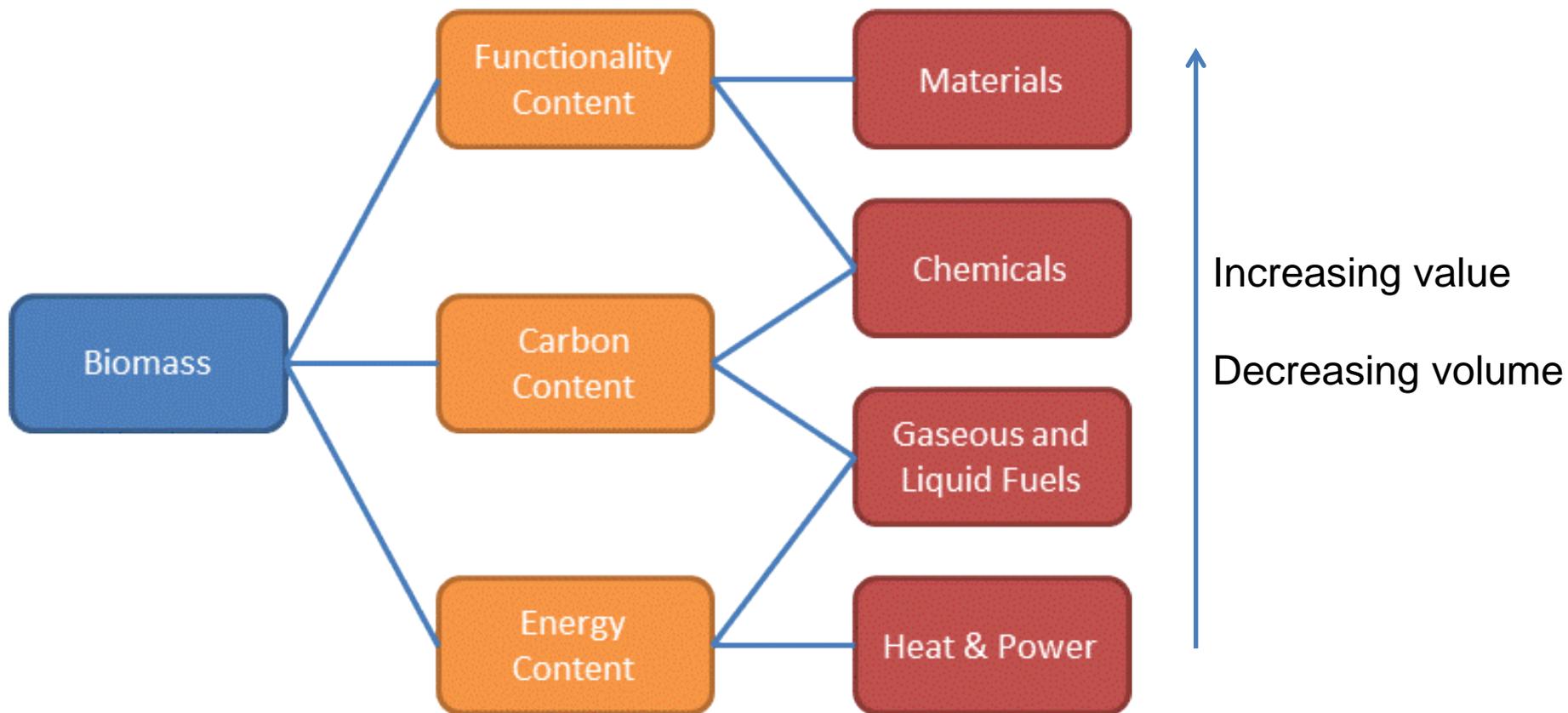


Company Mission

To provide clients with a holistic view of feedstock, technology, policy and market development across the bioeconomy, enabling them to make informed business decisions and develop sustainable business strategies.

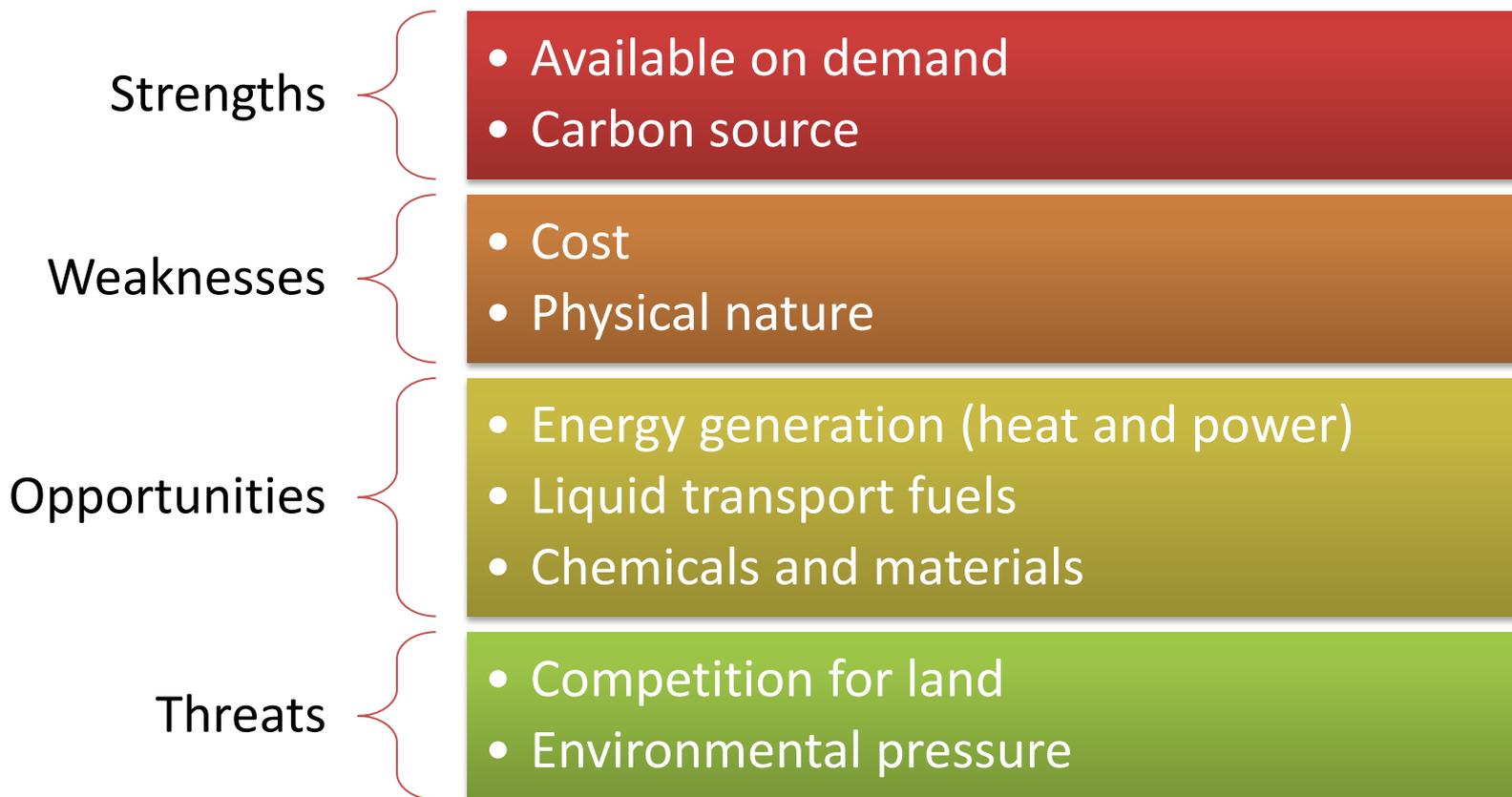


The value of lignocellulose



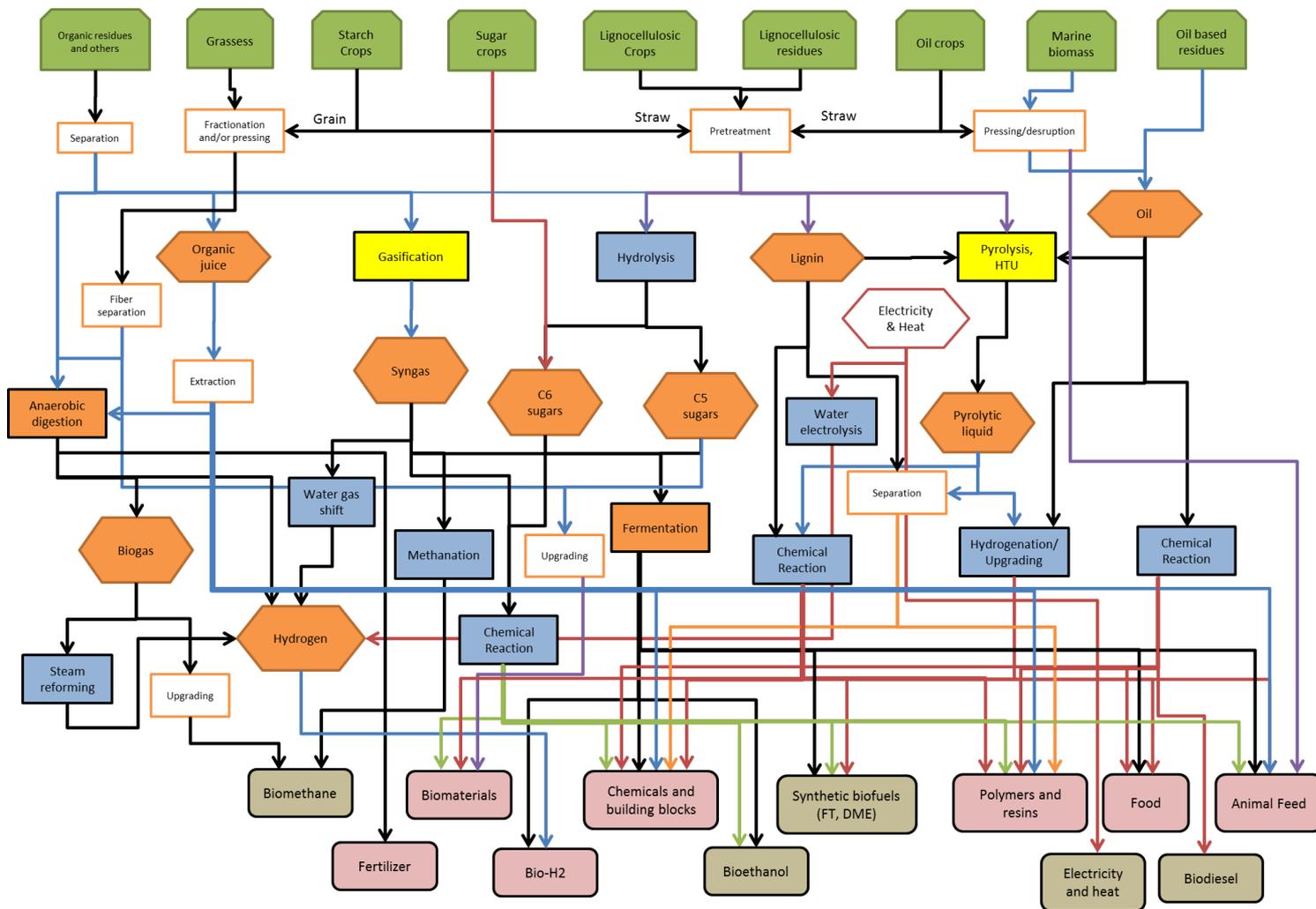


Biomass – A love hate relationship!





Development options

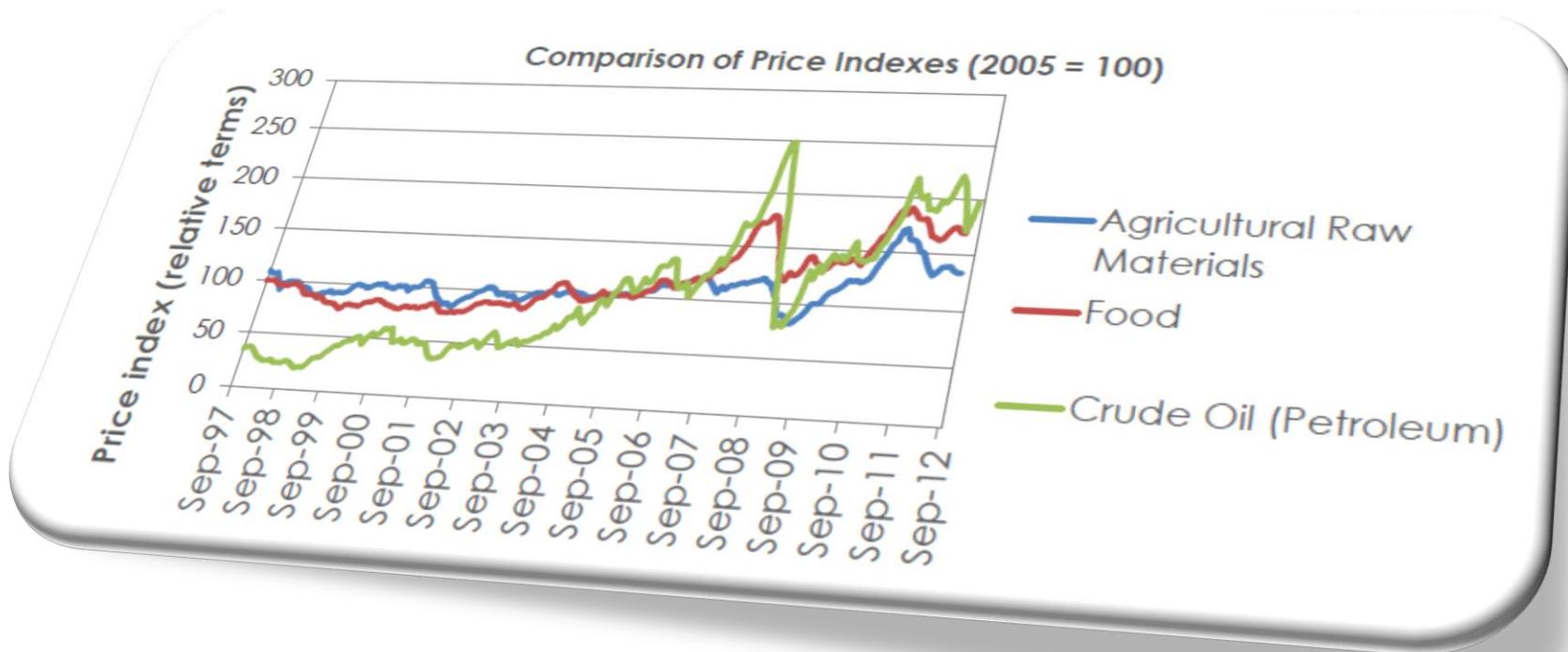




Drivers of market development

The relative costs of crude oil, food basics and agricultural materials have moved significantly over the last 15 years.

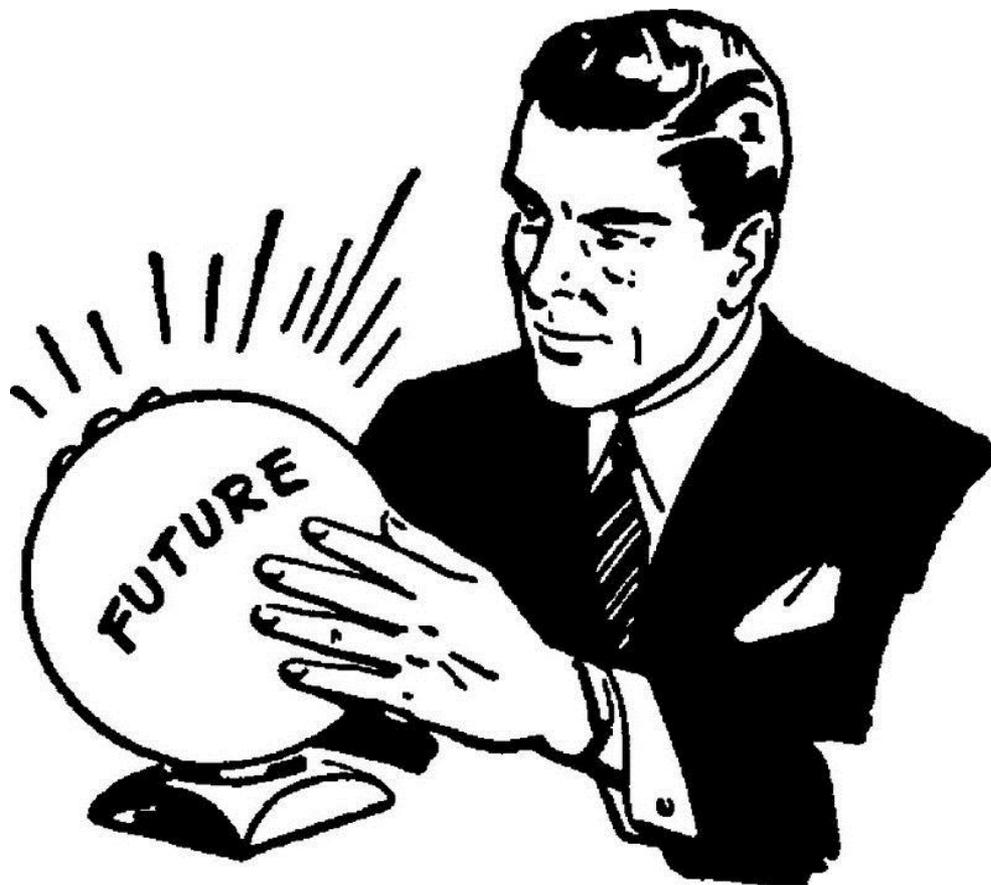
All raw material prices increasingly linked to energy





Prediction is very difficult, especially about the future.

Niels Bohr





Perspective

Amera's Law

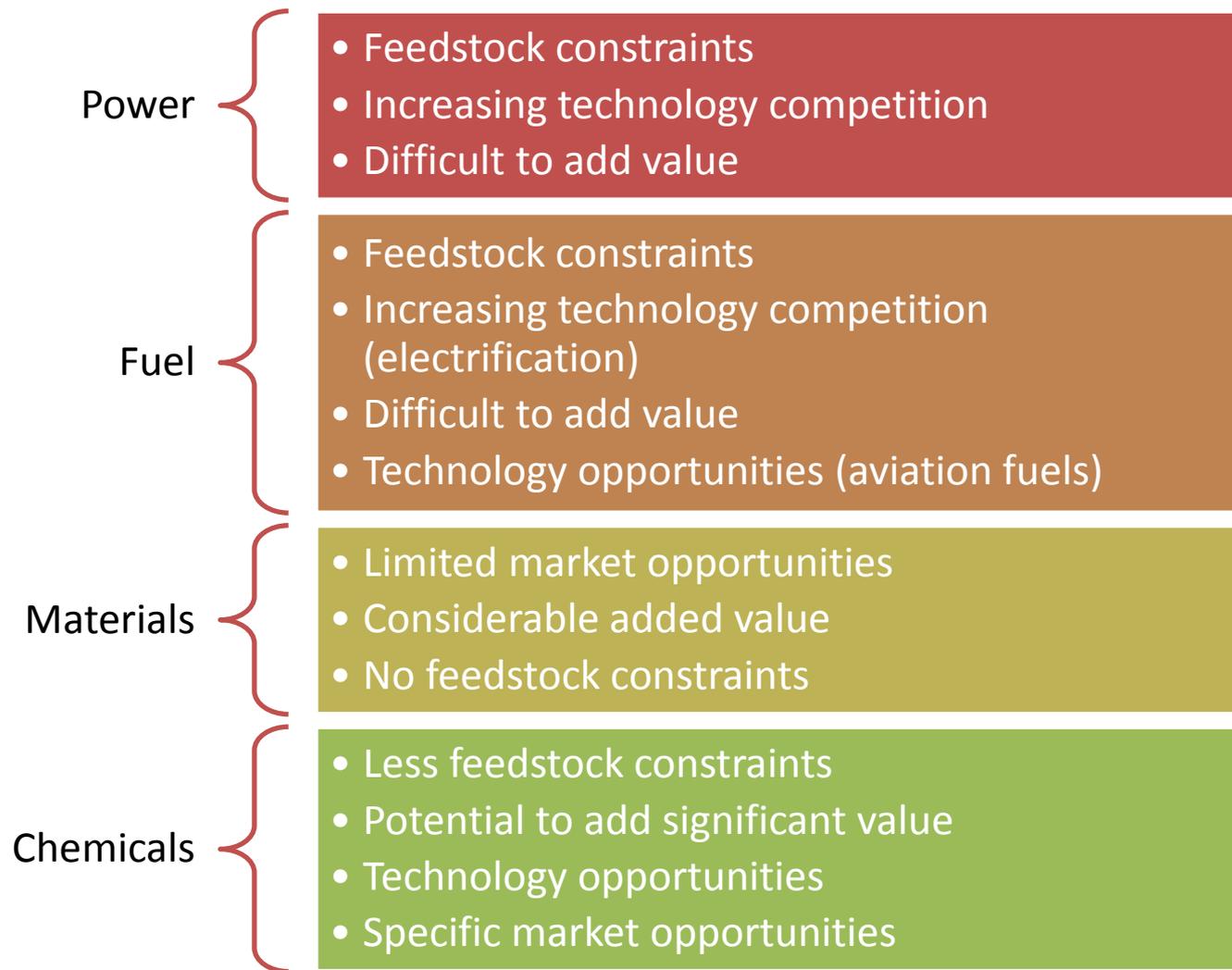
"We tend to overestimate the effect of a technology in the short run and underestimate the effect in the long run."

Thoughts on 2020

- Timeframes for commercial deployment generally under estimated
 - Financing, construction, commissioning and achieving capacity take time
- Expansion of current technologies
- Technologies currently in demonstration move to commercial



Longer term perspectives





A high value market for lignocellulose?

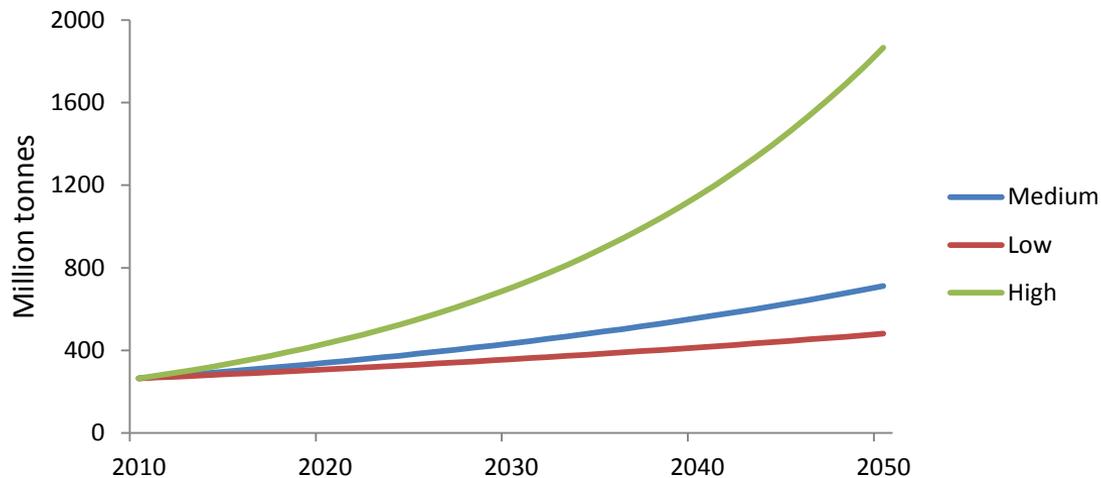
1967 – There’s a great future in plastics

2012 - There’s a great future in bio-based plastics



The Graduate (1967),

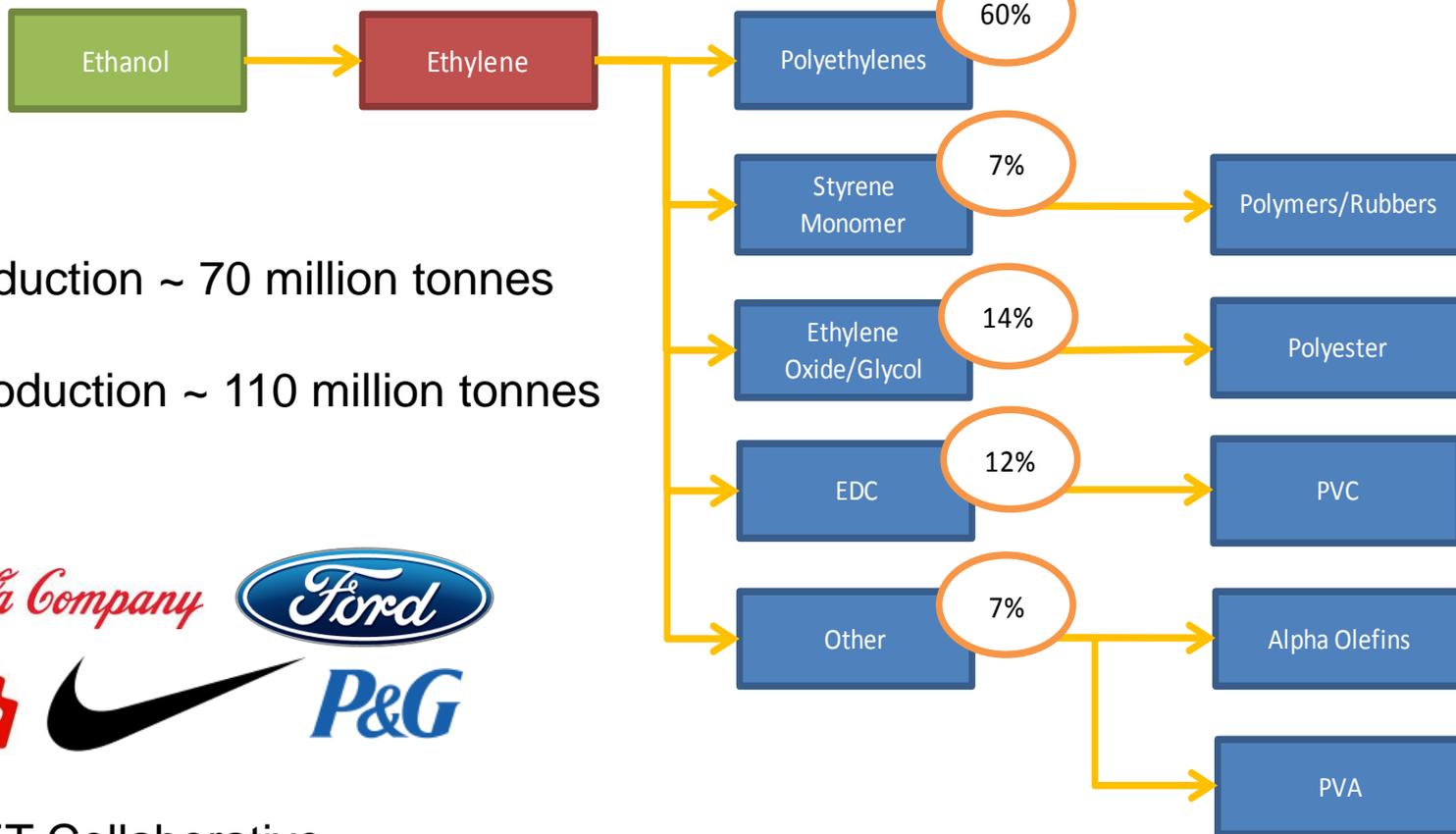
Plastics production: projected growth



Plastic production: medium growth	
2020	339 million tonnes
2030	434 million tonnes
2050	712 million tonnes



Ethylene value chain



Ethanol production ~ 70 million tonnes

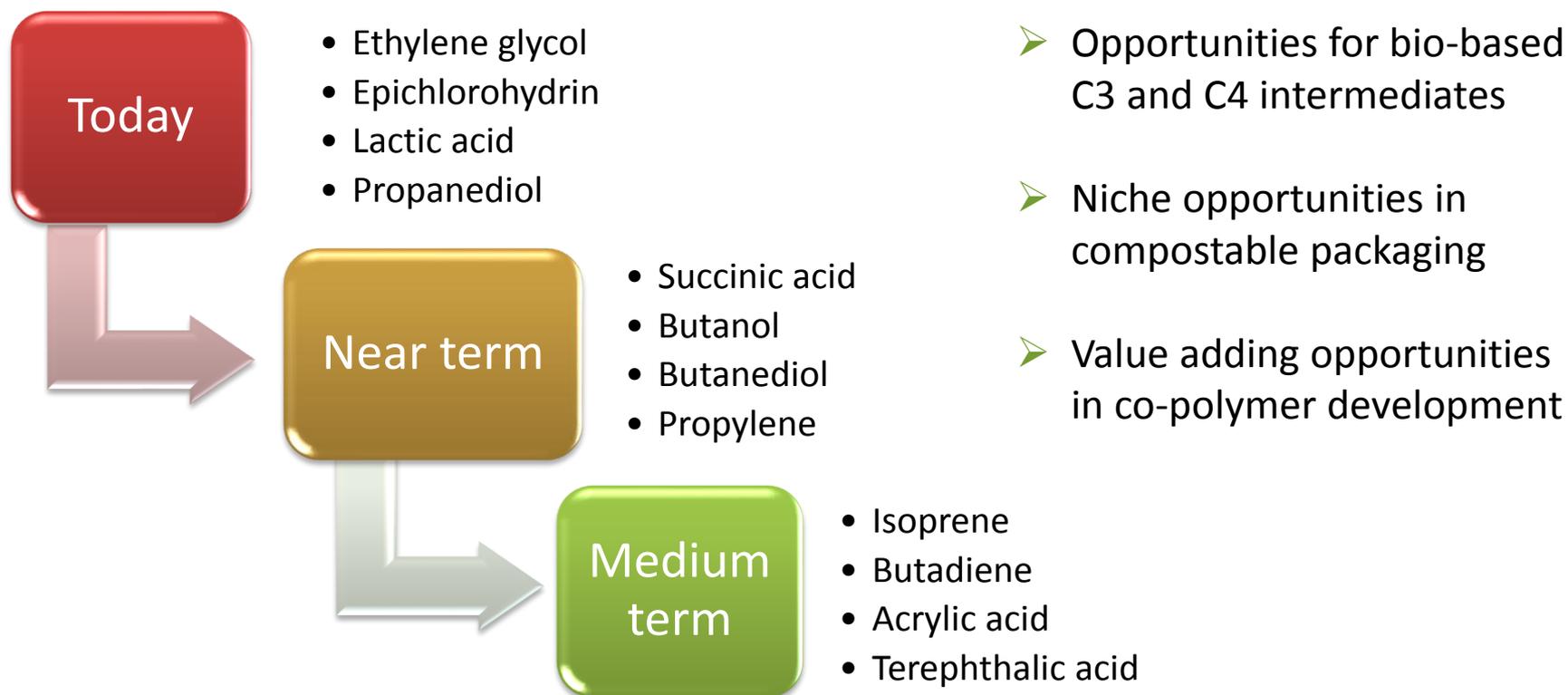
Ethylene production ~ 110 million tonnes



PET Collaborative



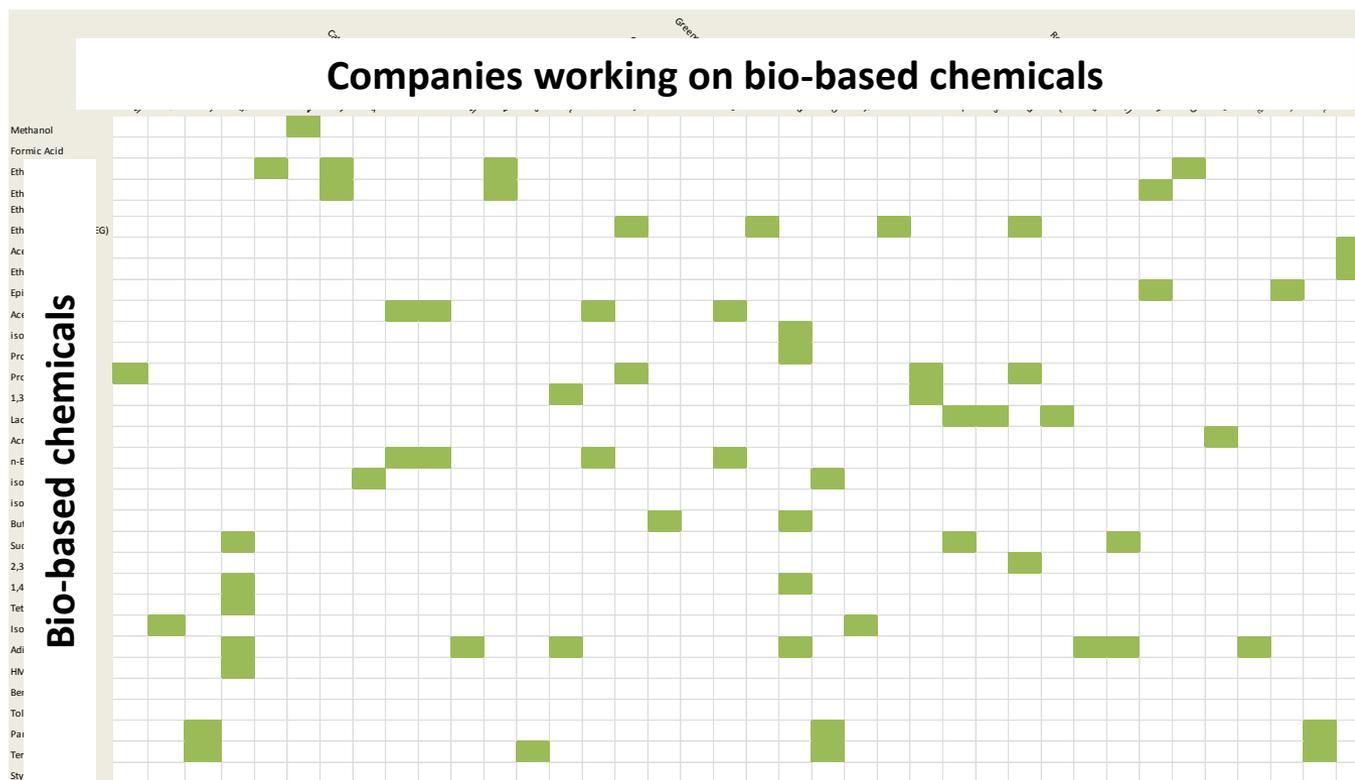
The developing bio-based chemical industry





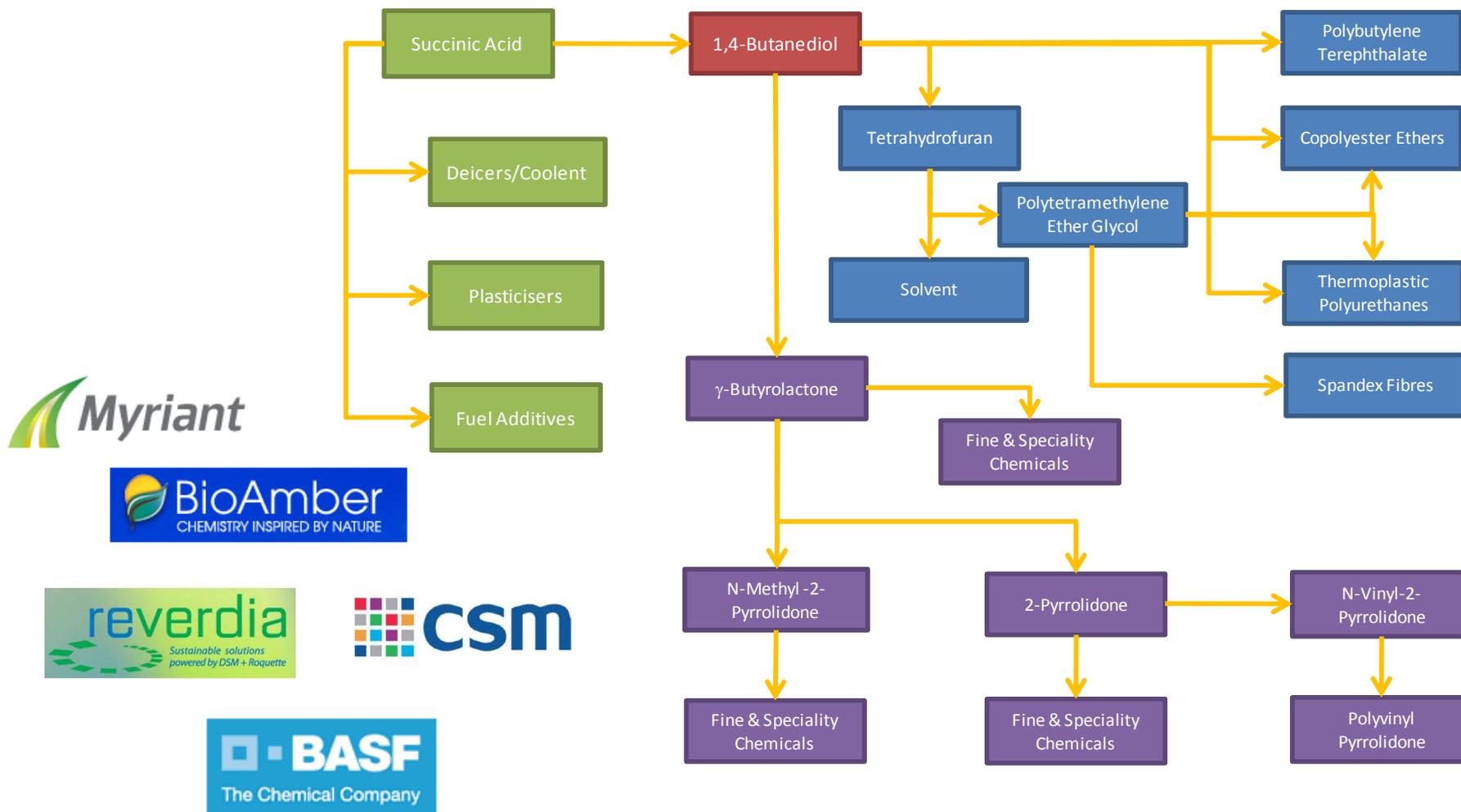
Market expansion and development activity

Currently over 50 companies actively developing and commercialising over 50 bulk chemicals





Succinic acid value chain





Bio-based polymer industry

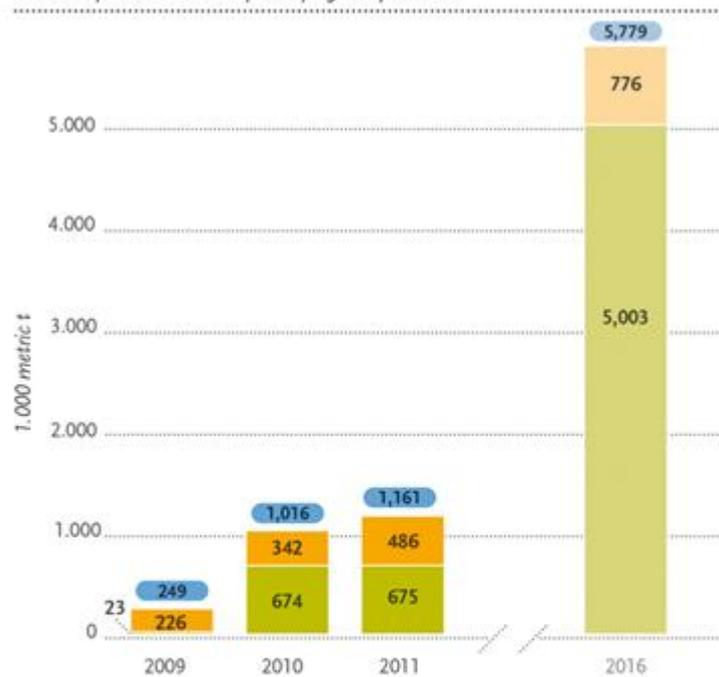
Industry demonstrating double digit growth.

Near term growth dominated by expansion of the bio-based ethylene value chain

Growth in novel bio-based plastics as polymer blend applications expand

New monomers entering the market

Global production capacity of bioplastics



● Biodegradable ● Biobased/non-biodegradable ● Total capacity
● Forecast

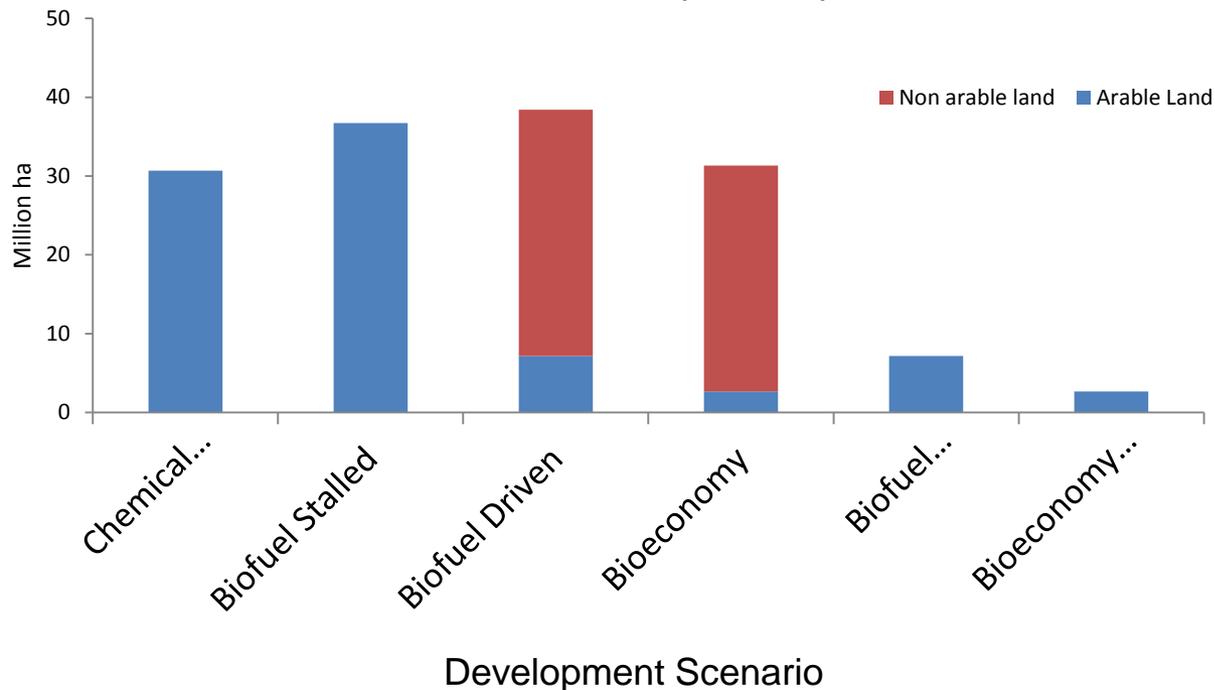
Source: European Bioplastics / Institute for Bioplastics and Biocomposites (October 2012)





Implications on land requirements

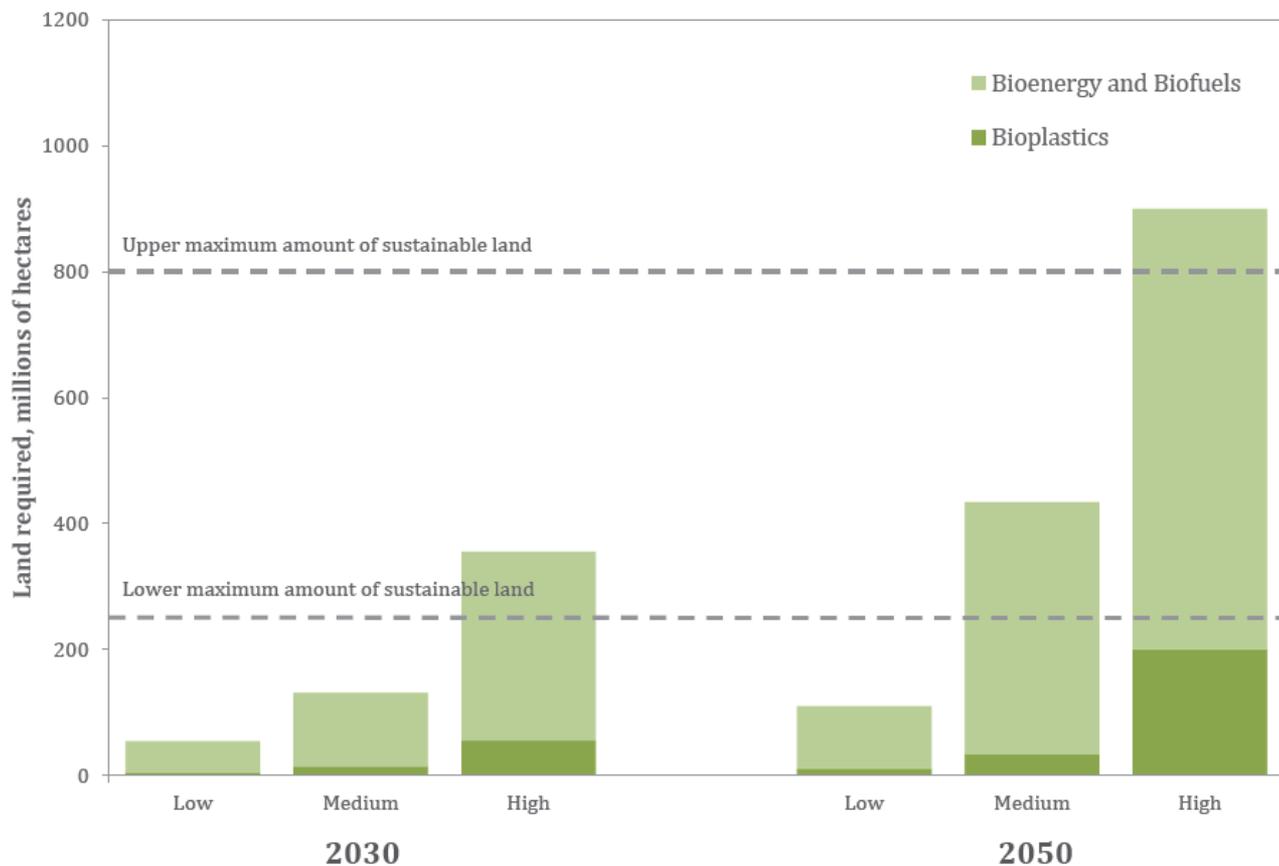
2050 Land demand for bioplastics production



Under a high growth scenario, market penetration of 40% and 5% YoY growth, the land demand for bioplastics may approach sustainable limits, without the use of residues.



Land requirements – the bigger picture



Predicted biomass demand scenarios versus land availability in 2030 and 2050.



The challenges

Technology

- Biomass crop yields
- Biomass composition
- Logistics
- Enzyme development
- Fermentation yields
- Novel products

Strategic

- Integration into existing value chains
- Financing
- Policy robustness
- Standards & labels
- Public procurement

Sustainability

- Direct land use change
- Indirect land use change
- Biodiversity
- Emission (land, air, water)
- Social impacts



Challenges for industrial biotechnology

- Chemical production
 - How to process lignin
 - Understand and control lignin biochemistry
 - Integration of chemistry and biotechnology
 - Metabolic engineering and synthetic biology

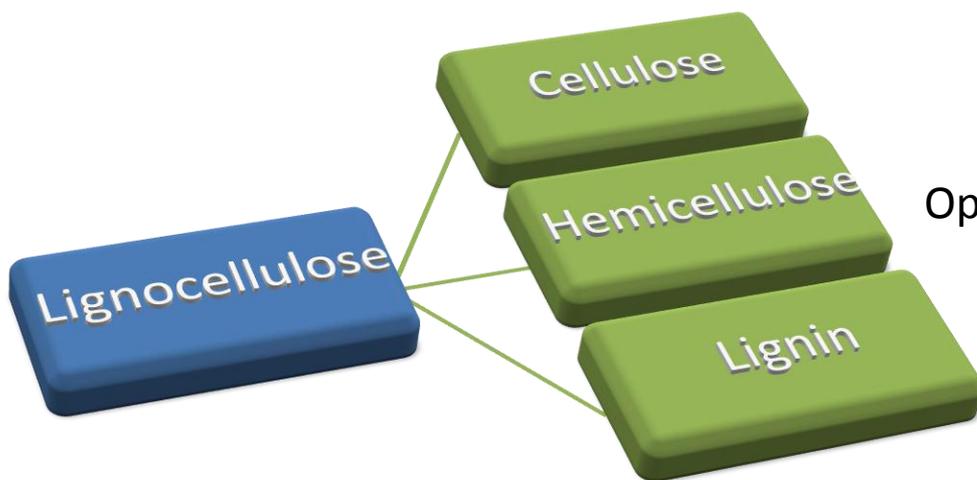
- Increase cellular productivity - how to handle toxic products
 - Continuous extraction
 - Cellular compartmentalisation

- Working in dilute aqueous environments
 - Product isolation and purification – in situ processing
 - Process intensification



Pre-treat or fractionate?

The lowest cost process versus the highest value product slate



Option A – Clean fractionation of three streams - requires value adding outlets for 2 or more streams

Option B – Pre-treat to allow carbohydrate processing – requires high conversion yields if fuel is target product

Option C – Convert to homogeneous intermediate

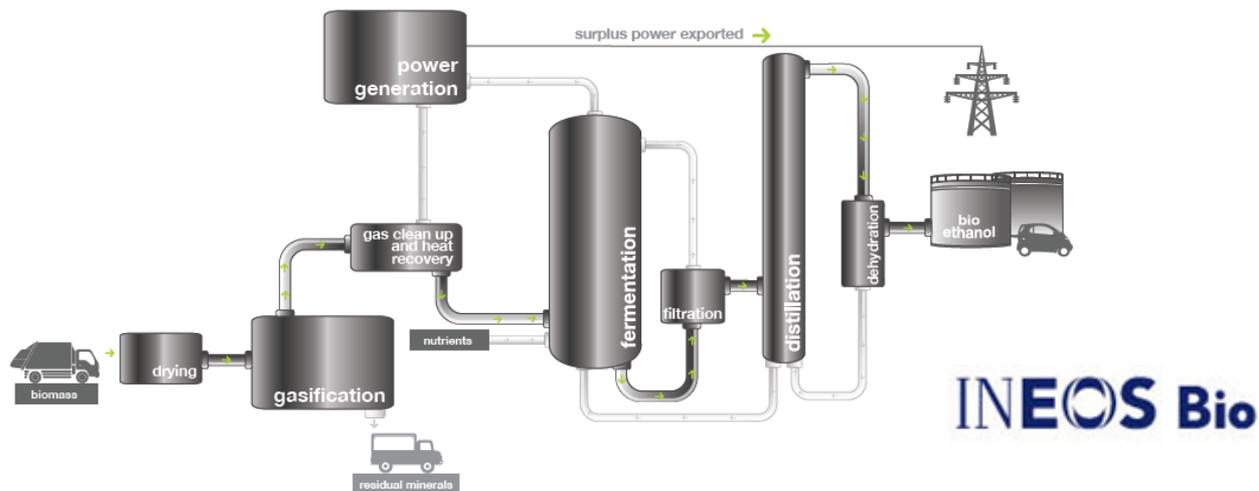


Lignocellulose gasification

- Gasification technology at demonstration / early commercial
- Potential for cost savings through innovation.
- Higher process efficiencies than combustion, therefore increasing the relative GHG emission savings.
- Carbon efficient power production facilitates the migration of the car and taxi fleet towards electric vehicles.
- Gasification is a unifying technology for the efficient production of power, heat and transport fuels (cars, light/heavy road vehicles and aviation).



Synthesis gas based fermentation



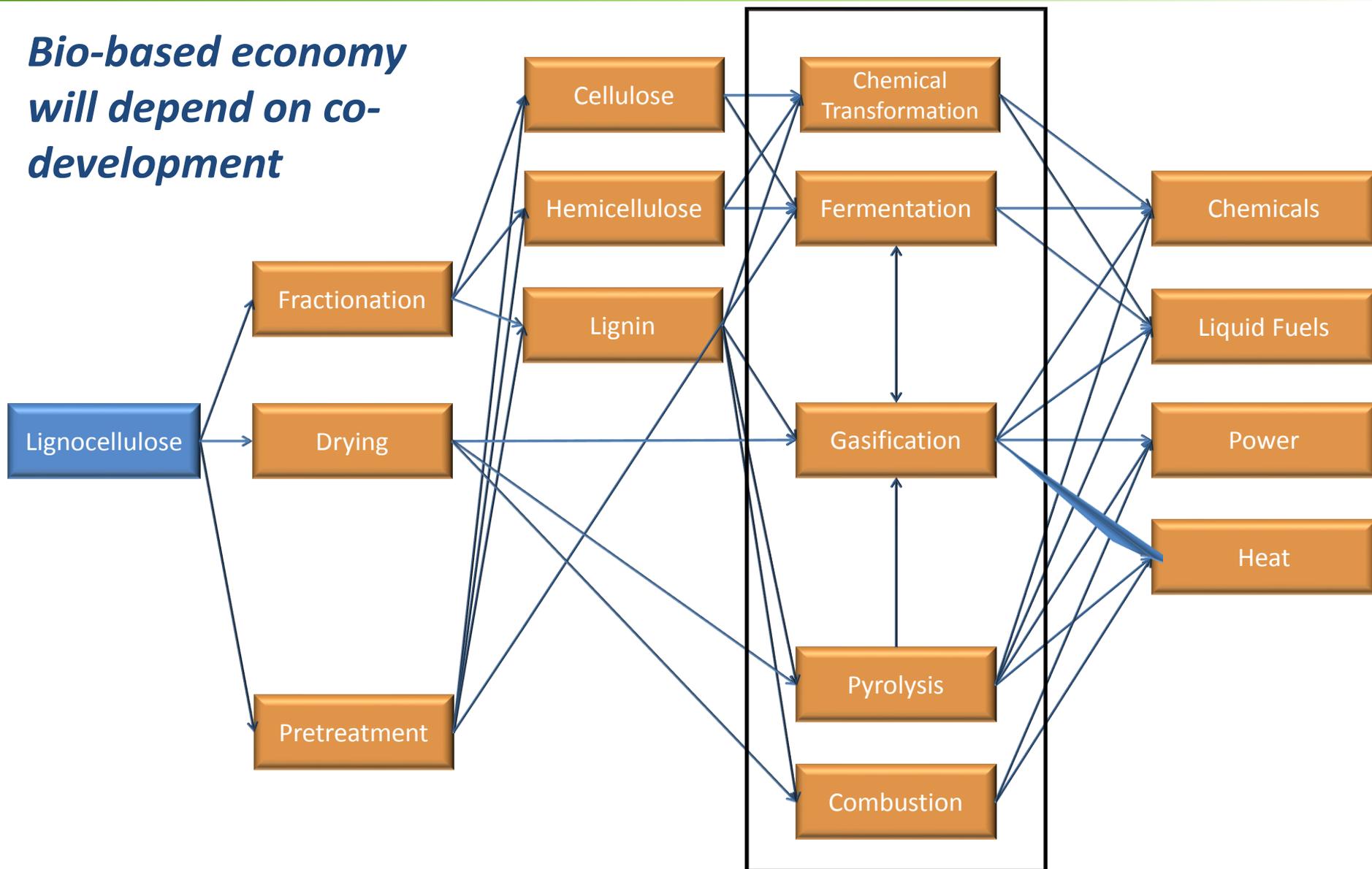
News Release



Aug. 13, 2012 - Joint Development Agreement for Bio-Based Butadiene



Bio-based economy will depend on co-development





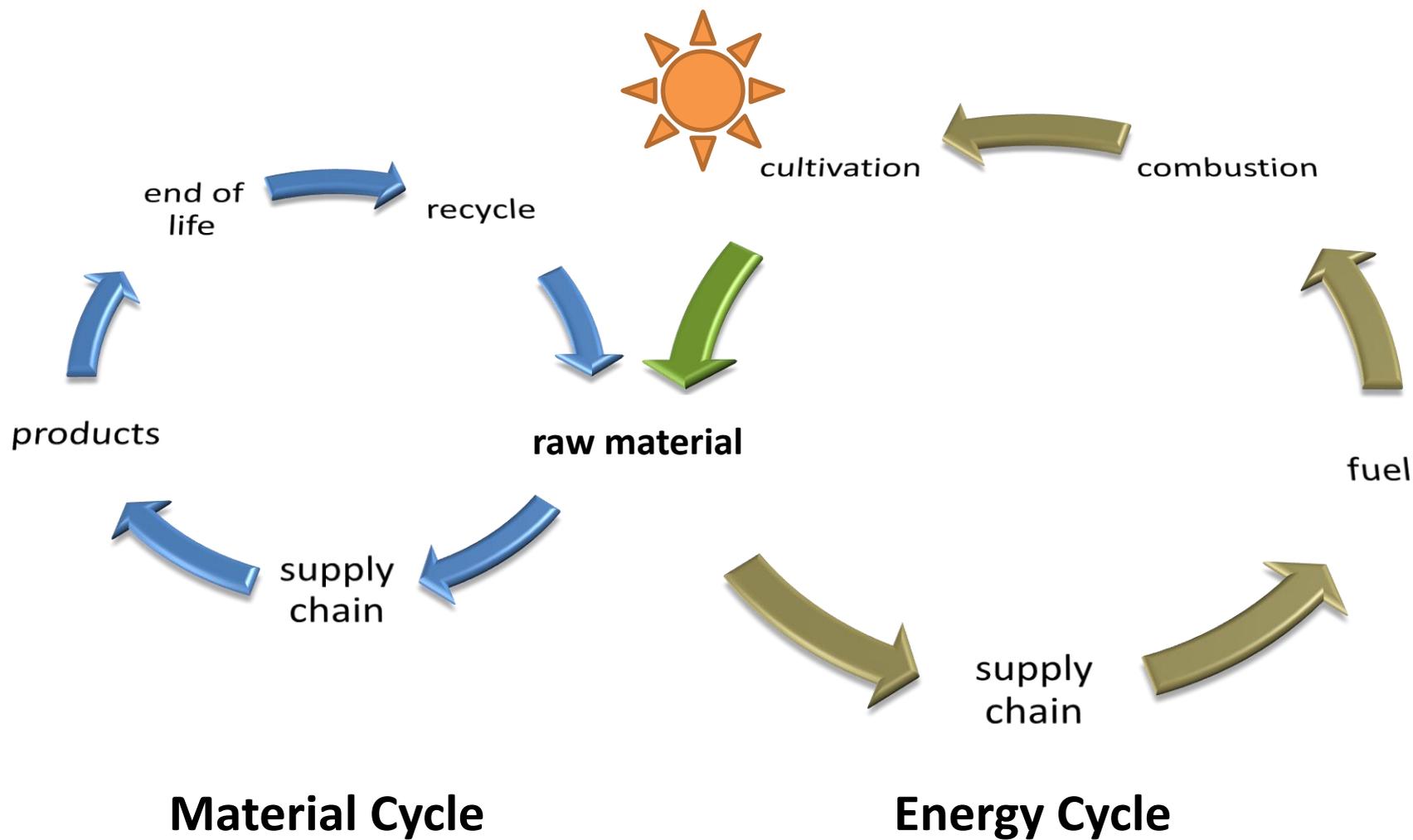
Requirements

- ✓ Development with environmental caution
- ✓ Public investment to support and mitigate financial risks
- ✓ More consideration of development pathways
- ✓ Push policies towards sectors with limited alternatives

Feed
Bio-based chemicals
Food
Road transport biofuels
Wood products
Electricity
Domestic heat
Ecosystem Services
Bioplastics
Industrial heat
Aviation fuels



Development should maximising resource use





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- **Future Market Analysis**
- **Feedstock Logistics Planning**
- **Sustainability Strategy
Development**

- **Technology evaluation & associated
due diligence**
- **Project feasibility assessment**
- **Policy and regulatory support**