



NORDREGIO

Nordic Centre for Spatial Development

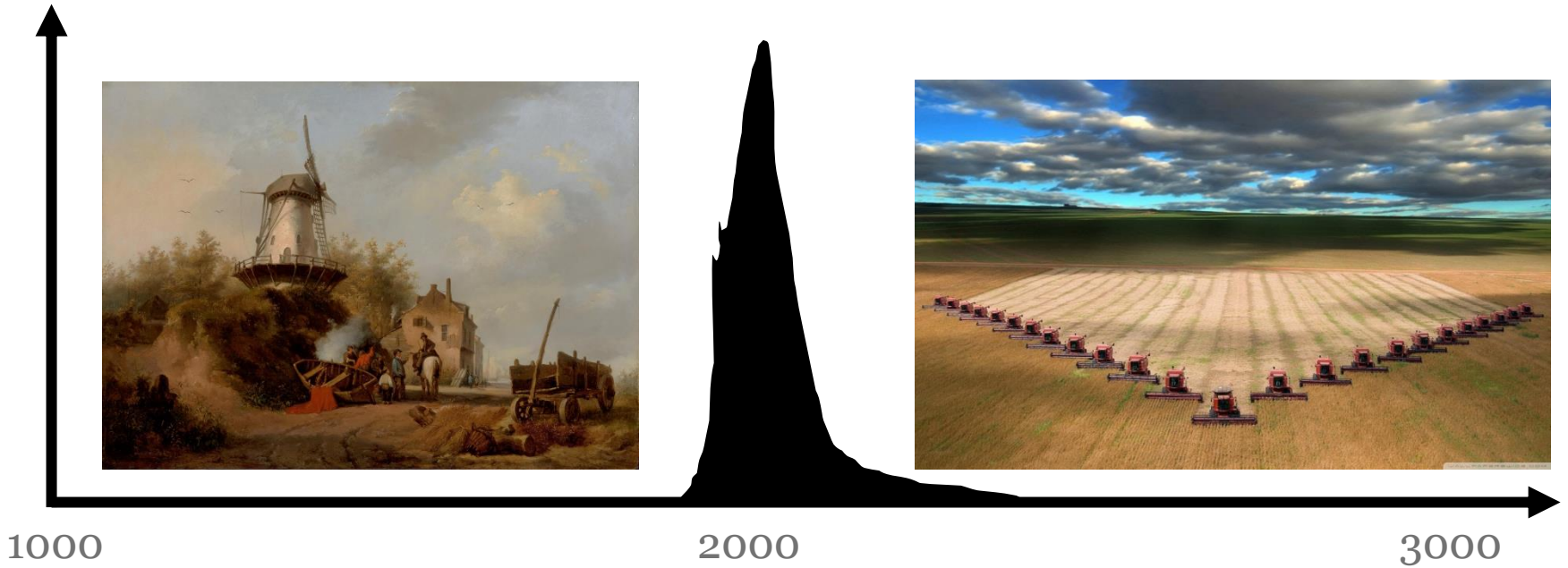
GREEN GROWTH AND BIOECONOMY FROM AN INTERNATIONAL PERSPECTIVE

Dr Jim Philp, Policy Analyst, OECD Paris



From bioeconomy to bioeconomy

Oil
consumption



Living off the land

*A brief
moment
in history*

Living off the land



OECD definition

- “A bioeconomy can be thought of as a world where biotechnology contributes to a significant share of economic output. The emerging bioeconomy is likely to involve three elements:
 - the use of **advanced knowledge of genes** and complex cell processes to develop new processes and products;
 - the use of **renewable biomass** and efficient bioprocesses to support sustainable production, and;
 - the integration of biotechnology knowledge and applications **across sectors**”.

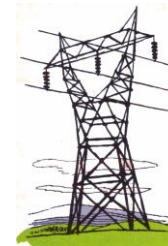
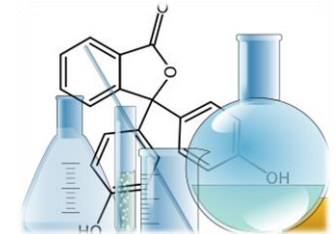
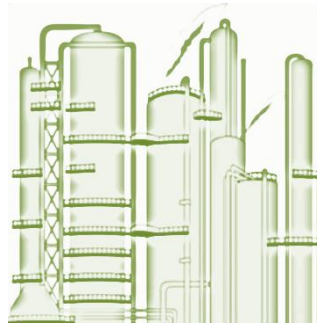


What is a bioeconomy ?

- **Decouple economic growth from environmental degradation**
 - Doubling of wealth has historically been linked to an 80% increase in emissions
- In particular the need to **drastically cut GHG emissions**
- Biotechnology will be used in the development of all pharmaceuticals and most new varieties of large market crops



Sustainable
biomass





Industrial Biotechnology and the bioeconomy

A Bioeconomy for Europe¹

“Significant growth is expected to arise from sustainable primary production, food processing and industrial biotechnology and biorefineries, which lead to new bio-based industries, transform existing ones, and open new markets for bio-based products. New high skilled jobs and training options need to be developed to meet labour demands in these industries...”

US National Bioeconomy Blueprint²

This envisaged *“a previously unimaginable future”* in which two of the categories of new materials are:

- (i) *“ready to burn liquid fuels produced directly from CO₂ and;*
- (ii) *biodegradable plastics made not from oil but from renewable biomass.”*

¹ EC (2012). Innovating for Sustainable Growth: A Bioeconomy for Europe. COM(2012) 60, final. Brussels, 13.2.2012.

² The White House (2012). National Bioeconomy Blueprint. April 2012. 43 pp.

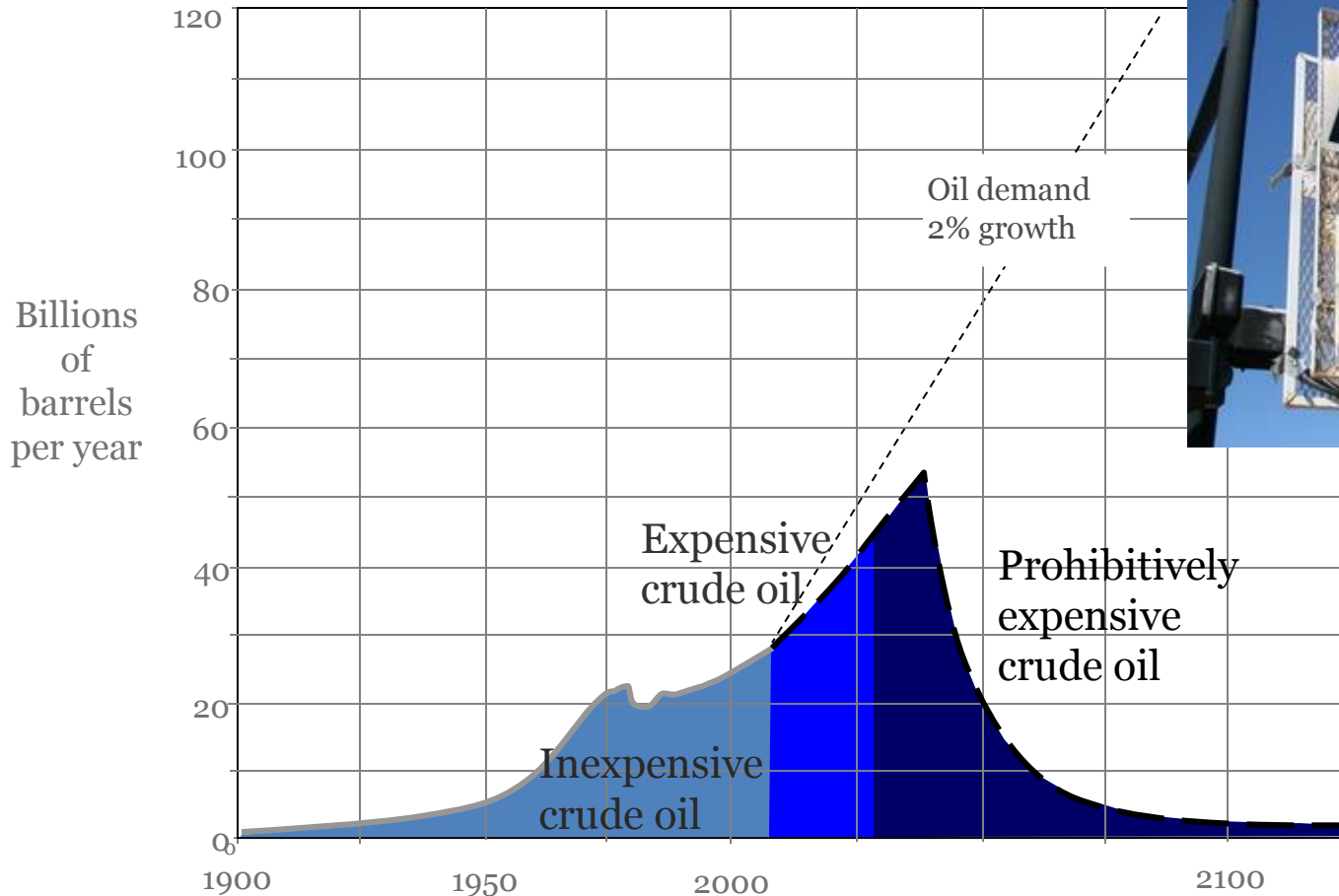


Current R&D expenditures *versus* future markets for biotechnology by application

	Share of total OECD business expenditures on biotech R&D, 2003	Est. potential share of total biotech GVA in the OECD area, 2030
Health	87%	25%
Primary production	4%	36%
Industry	2%	39%
Other	7%	-
	100%	100%



Energy security



“Out of the turmoil of the energy markets of the last 12 months and our evaluation of future influences on the sector has emerged a new underlying price assumption for the World Energy Outlook — an oil price through to 2030 which nudges twice the level in WEO-2007. *The era of cheap oil is over.*”



The hydrocarbon trap

- 10 out the 11 previous major recessions in the US have been preceded by an oil price spike¹
- A 10% rise in oil prices removes 0.2-0.3% from global GDP growth²
- As other technologies are rolled out e.g. solar, biomass, this may threaten oil prices
 - Bio-based plastics prices have recently come closer to petro-based plastics
- Can oil production be maintained ?
 - By 2030, there may be 1.3 billion vehicles on the roads and by 2050 this could double again
- *Deepwater Horizon* costs may exceed a staggering \$42 billion³
- For an average platform, each 30 metres of added depth increases the probability of a company-reported incident by 8.5%⁴

1 Hamilton JD (2011). *Macroeconomic Dynamics*, Cambridge University Press, volume 15(S3), pp. 364-378.

2 The Economist (2011). Print edition Special Report, September 24.

3 <http://www.thetimes.co.uk/tto/business/industries/naturalresources/article3801365.ece>

4 Muehlenbachs et al. (2013). *Energy Policy* 55, 699–705.



Bioeconomy jobs through Industrial Biotechnology

- Bio-based chemicals and plastics support more jobs and value-added than biofuels and bioenergy^{1,2}
- Agricultural efficiencies have drastically reduced rural jobs
- Shifting **20% of current plastics production into bioplastics** could create a **net 104,000 jobs in the US economy**³
- Triple policy goals: rural regeneration, high quality jobs, competitive chemicals industry

Sub-sector ⁴	Number of jobs in Europe (2011)	Turnover (2011)
Biofuels	~150,000	EUR 6 billion
Bio-based chemicals	~150,000	EUR 50 billion

¹ Carus et al. (2011). Nova- Institute Publication 2011-04-18

² Sormann (2012). Departement Economie, Wetenschap en Innovatie (EWI), October 2012

³ Heintz & Pollin (2011). Political Economy Research Institute, Amherst, MA

⁴ BRIDGE 2020 (2012). BRIDGE presentation



Importance of chemicals in Europe

- The EU chemical industry is the world leader
- Major contributor to the EU economy (24% of the world turnover of EUR 2.4 trillion in 2010)

BUT

- Competitiveness is at risk due to
 - high cost of production
 - low market growth
- Petrochemicals sector is growing in the Middle East and China
- More European refinery closures to come



\$5 billion capital expenditure project *expansion* of the Petro Rabigh petrochemicals complex.



“Scientists call for action to tackle CO₂ levels” BBC News, May 11/2013

Scientists are calling on world leaders to take action on climate change after carbon dioxide levels in the atmosphere broke through a symbolic threshold. Daily CO₂ readings at a US government agency lab on Hawaii have topped 400 parts per million for the first time. Sir Brian Hoskins, the head of climate change at the UK-based Royal Society, said the figure should “*jolt governments into action*”¹.

- To date 167 countries have signed up to the Copenhagen Accord in trying to limit the temperature rise, compared to pre-industrial levels, to 2°C.
- **Most of the remaining fossil fuel are unburnable**² (Carbon Tracker, 2013)
- Achieving a 2°C scenario means only a small amount of fossil fuels can be burned unabated after 2050
- **Update: global energy-related CO₂ emissions increased by 1.4% to reach 31.6 Gt in 2012, a historic high**⁴

1 <http://www.bbc.co.uk/news/science-environment-22491491>

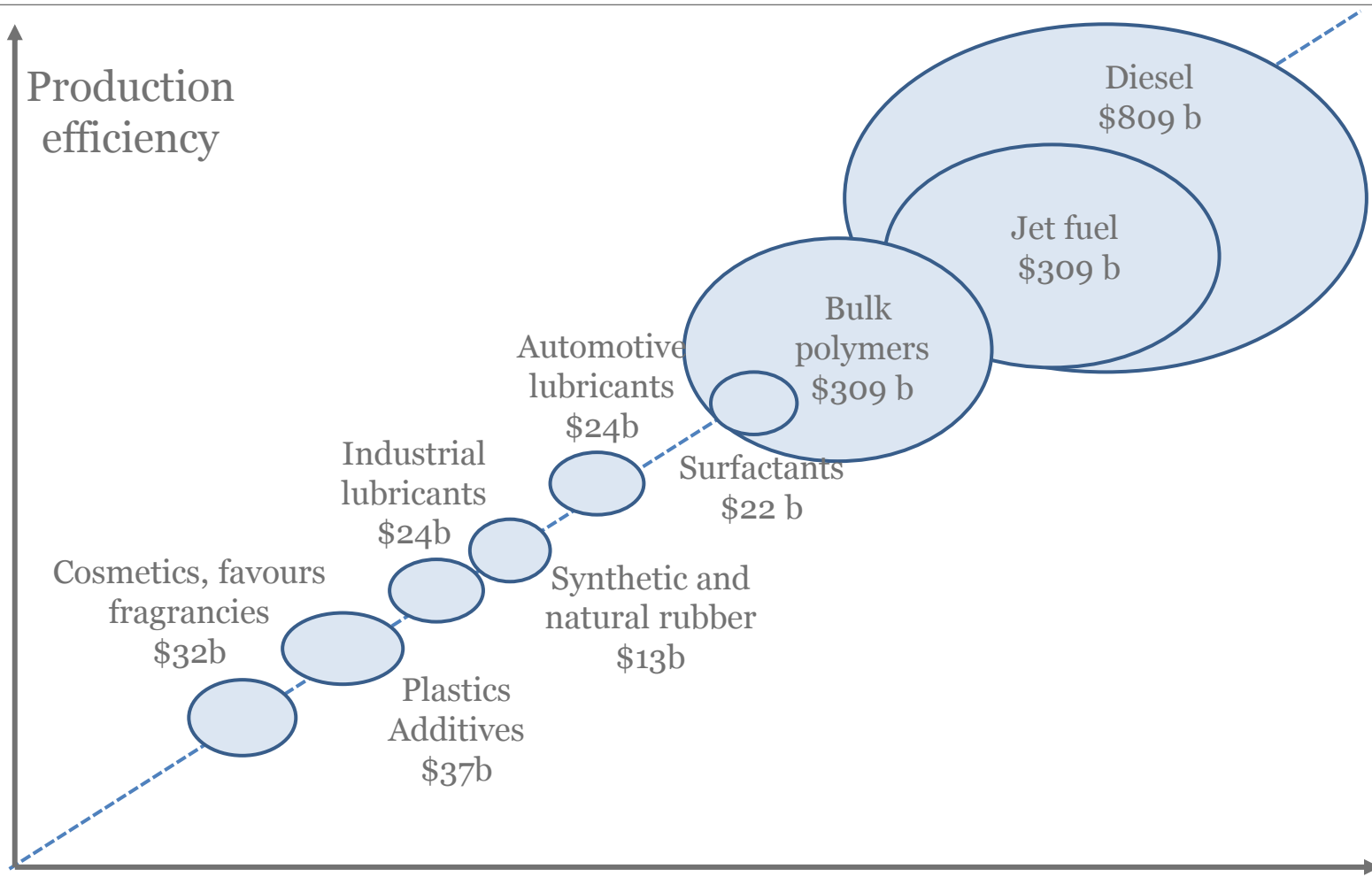
2 Carbon Tracker (2013). Unburnable Carbon 2013: Wasted capital and stranded assets. www.carbontracker.org

3 Meinshausen et al. (2009). *Nature* 458, 1158-1163

4 IEA (2013). Redrawing the energy-climate map. World Energy Outlook special report.



Addressable markets for bio-based products





How much of the oil barrel can be replaced ?

Dicarboxylic acids

- Adipic
- Acetic
- Lactic
- Succinic
- 3-Hydroxypropanoic

Thermoplastics

- Polyethylene
- Polypropylene
- PET
- PVC

Short-chain alkenes

- Ethylene
- Propylene
- *n*-Butenes
- Isobutene
- Isoprene
- Butadiene

Aromatics ?



Lower alcohols

- Ethanol
- Butanol

Diols

- 1,3-PDO
- 1,4-BDO

Petrol

- Short-chain alkanes

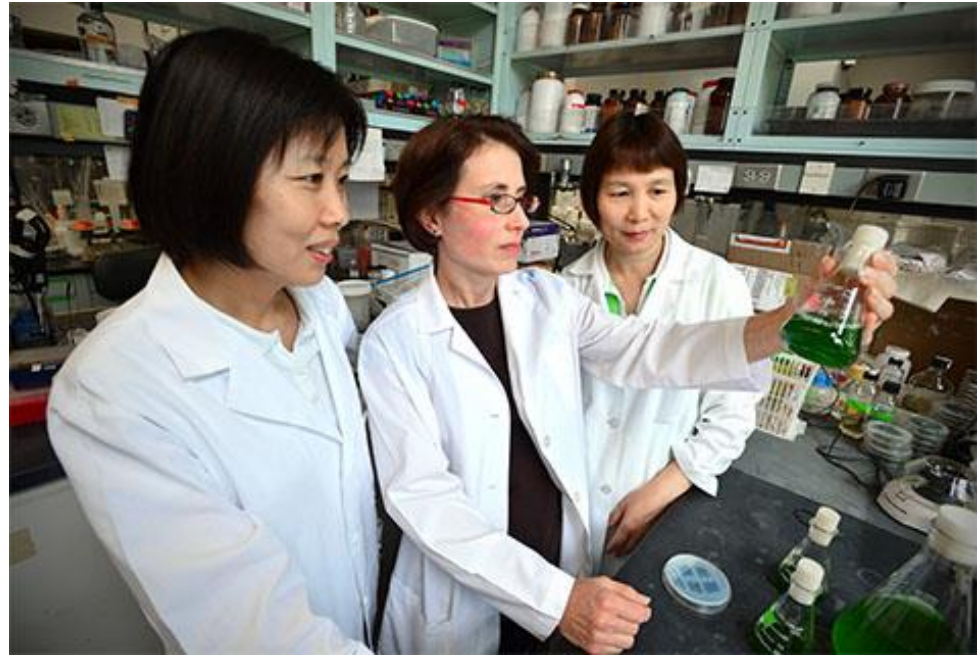
Diesel

- Mid-chain alkanes
- Fatty acids



Agricultural applications

- Water use efficiency – producing crops that use less water
- Nitrogen use efficiency – using less fertiliser
- Crops that are more resistant to disease
- More ‘efficient’ plants – increasing yield, and producing less CO₂

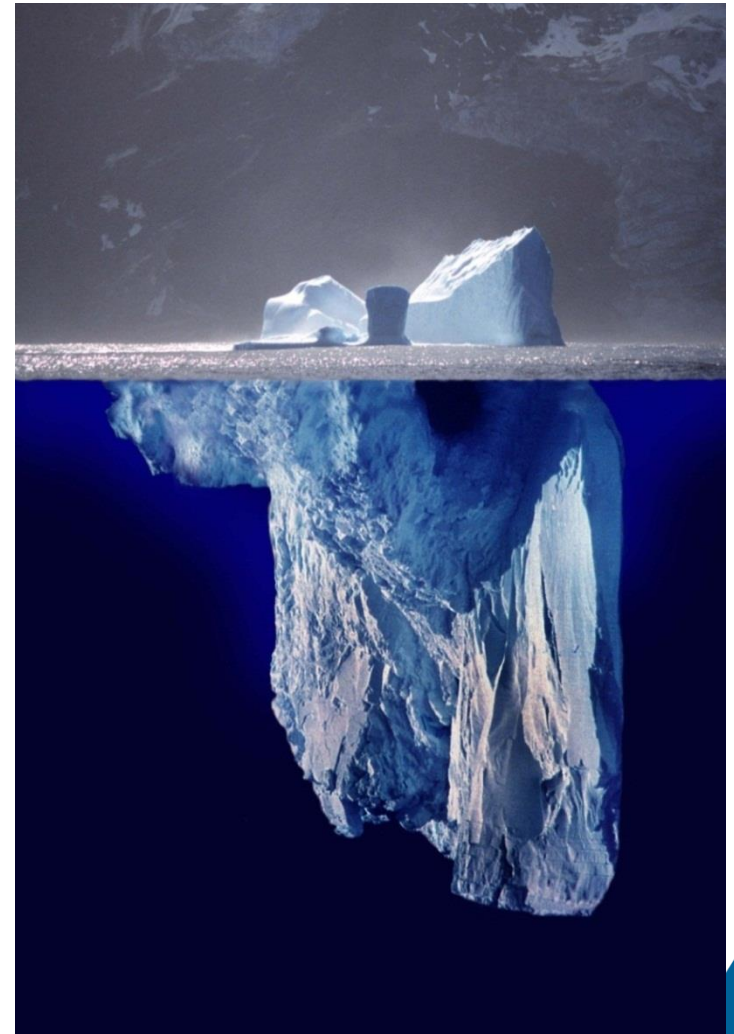


Washington University in St Louis researchers have taken the first proof-of-principle steps toward inserting the genes needed to fix nitrogen into the cells of crop plants. <http://news.wustl.edu/news/Pages/25585.aspx>



Marine biotechnology: a huge untapped potential

- The **DNA polymerase** world market is currently more than USD 350 million and growing (2012) (www.in-pharmatechnologist.com)
- **High value chemical markets** e.g. anti-oxidant carotenoids of around Euro 77 billion
- The European market for **cosmetics** is booming, at over Euro 27.6 billion per year, and the US market is USD 35 billion
- Multi-billion dollar **nutraceutical** market e.g. ω -3 fatty acids market had reached USD 13 billion in 2008
- Potential in **biofuels** dwarfs all commodity chemicals, but many technology barriers to overcome





Wood and lignocellulose utilisation

- Lignocellulose conversion is widely seen as *the* sustainable option
- Whilst expensive, the costs have been dropping
- Demonstrator plants are the key facilities

BUT

- They are difficult to finance



Chempolis Biorefining Park, Oulu, Finland



Oregon: Woody biomass to acetic acid and ethyl acetate



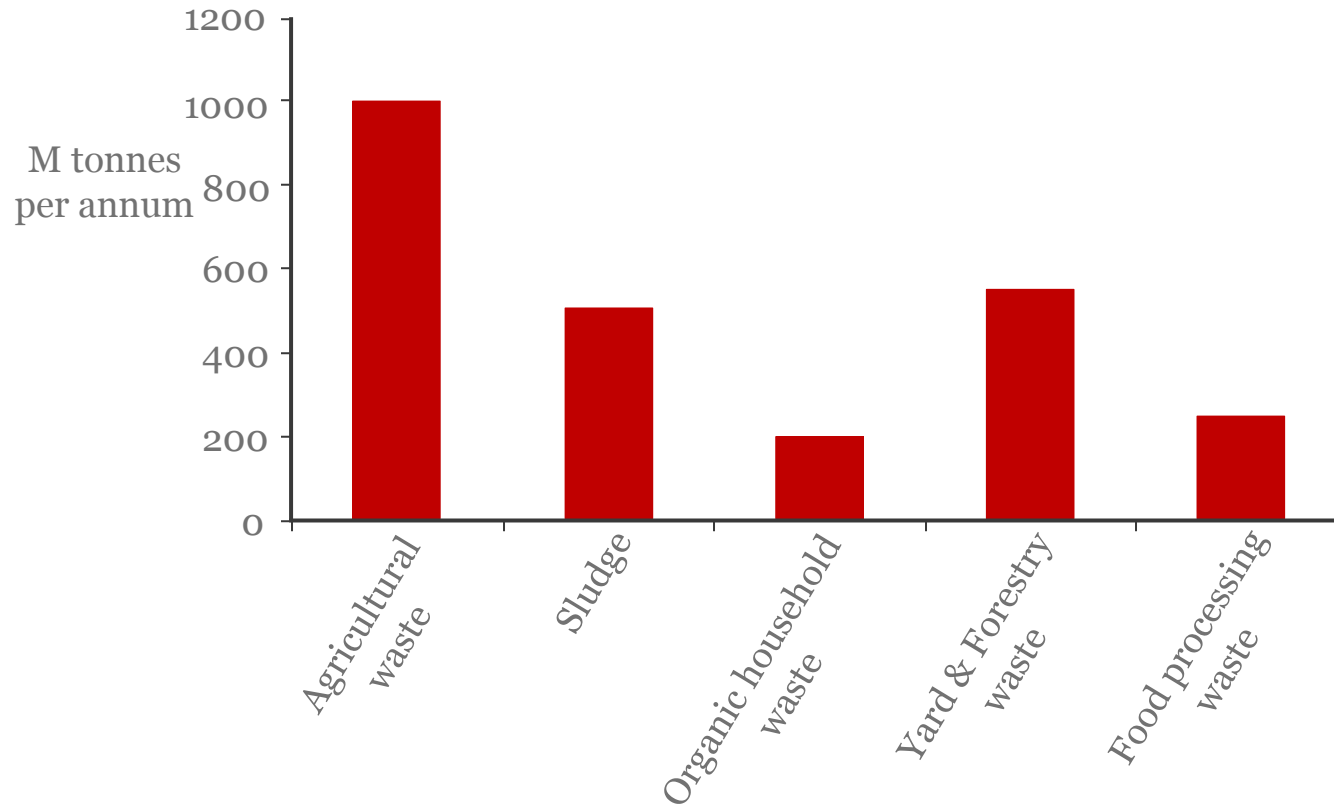
Denmark to establish world's first biomass-based plant to produce a marine biofuel

- 50-100,000 tons fuel annually to cover only part of the potential
- 2-3 times as much wood will be sourced, mainly from abroad
- Research effort will be directed at locally sourced feedstocks, such as
 - short rotation coppice,
 - manure
 - pulp and paper waste
 - straw
 - forestry waste





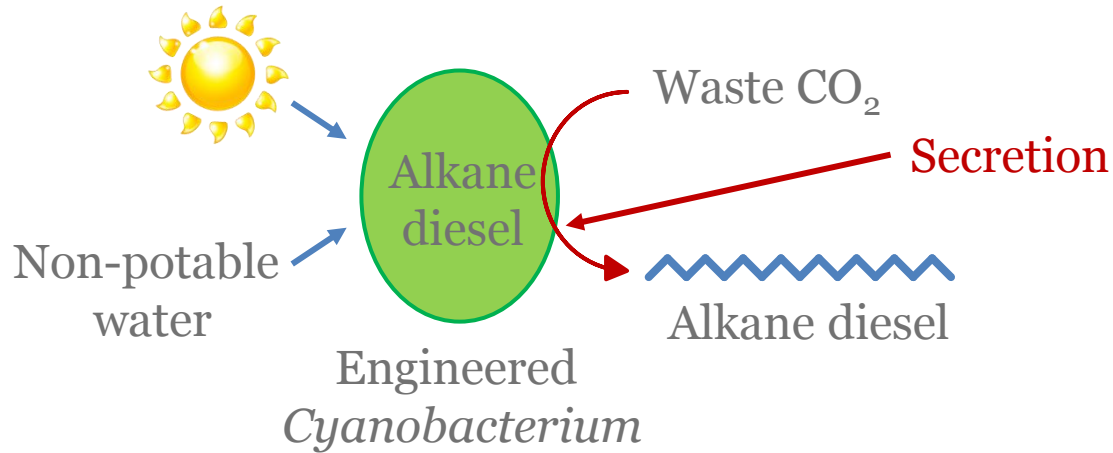
Annual organic waste streams in the EU



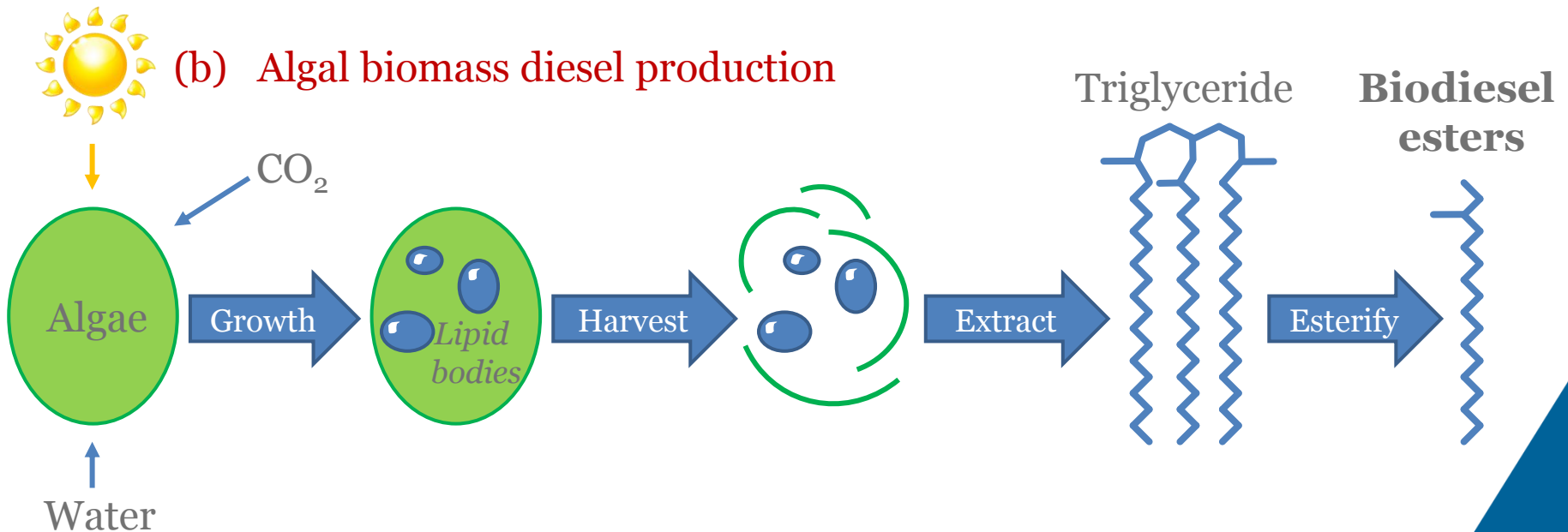


The industrialisation of photosynthesis

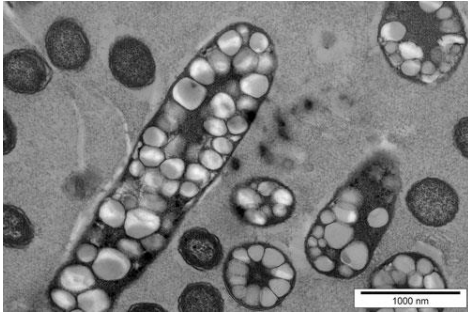
(a) Direct, continuous process for renewable diesel production



(b) Algal biomass diesel production



EU bioplastics issues: Full scale production



Bioplastics R&D

Doing fine...

- Diverse projects and strategies under FP7, CIP etc.
- Budget increase planned in “*Horizon 2020*”

Demonstration

On the way...

- Support growing, importance recognised
- First biorefinery prototypes completed

Implementation

...Missing !

- No supportive framework in place
- Lack of visible strategy

- **Result:** *Scale-up may not happen in the EU*
- *Capacity building is occurring in Asia and Brazil*



Thank you for your time

james.philp@oecd.org



The Bioeconomy to 2030
DESIGNING A POLICY AGENDA



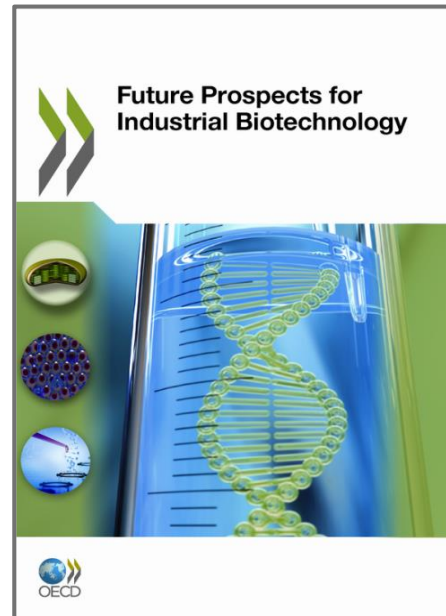
Symposium on Opportunities and Challenges in the Emerging Field of Synthetic Biology

SYNTHESIS REPORT



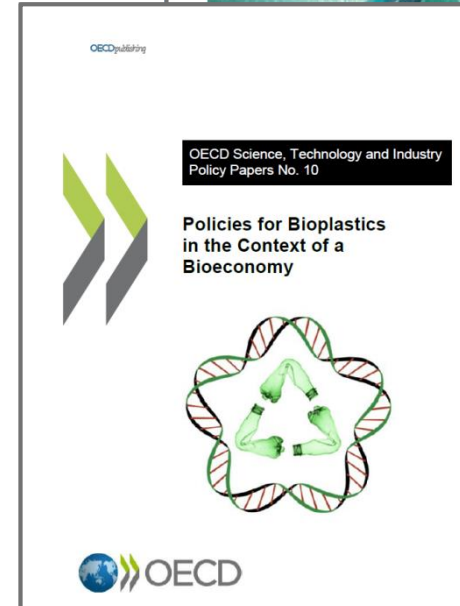
Marine Biotechnology
ENABLING SOLUTIONS FOR OCEAN
PRODUCTIVITY AND SUSTAINABILITY

OECD



Future Prospects for Industrial Biotechnology

OECD



OECD Publishing

OECD Science, Technology and Industry
Policy Papers No. 10

Policies for Bioplastics in the Context of a Bioeconomy

OECD