PERSPECTIVES OF INDUSTRIAL BIOREFINERIES IN THE GLOBAL BIOECONOMY – ROLE OF THE POLICY FRAMEWORK TO SUPPORT IMPLEMENTATION

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BETTER POLICIES FOR BETTER LIVES

Background

Biorefining policy needs to come of age

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After significant delays, the first commercial cellulosic biorefinery is open in Europe and three more are due this year in the USA, with others soon to follow. Although biofuels might be the mainstay, there has been a significant shift in emphasis towards bio-based chemicals. A major bio-based public–private partnership has launched in Europe, but obstacles to biorefining remain, and public policy is not yet directed at enabling the integrated biorefineries of the future.

Peplow, M. (2014) Cellulosic ethanol fights for life. Pioneering biofuel producers hope that US government largesse will ease their way into a tough market. *Nature* 507, 152

Trends in Biotechnology 32 (2014), 496-500

Programme of work and budget, 2015-2016

Bioeconomy work in three projects

- Biomass sustainability
- *Biorefinery models and policy*
- Replacing the oil barrel

Additionally

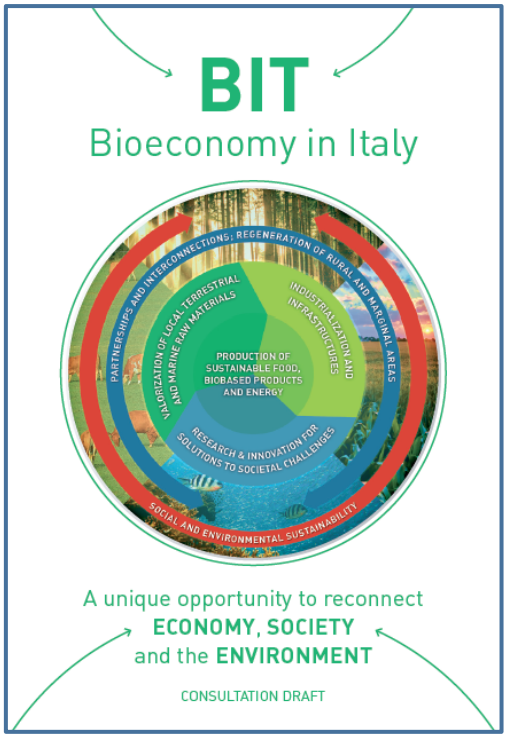
- Building a sustainable bioeconomy: towards a framework for policy

Final output

- A single book, first draft complete

Bioeconomy strategies: long on talk, short on policy

science & technology
Department:
Science and Technology
REPUBLIC OF SOUTH AFRICA



A Bioeconomy policy framework

Feedstock/Technology push	Market pull	Push and pull
Local access to feedstocks	Mandates and targets	Metrics, definitions, terminology
International access to feedstocks	Public procurement	Skills and education
R&D subsidy	Standards	Regional clusters
Pilot and demonstrator support	Labels, certification	Public acceptance, raising awareness
Flagship financial support	Fossil carbon taxes and incentives	Knowledge-based capital
Tax incentives for industrial R&D	Removing fossil fuel subsidies	Governance and regulation
Technology clusters		
SME and start-up support		

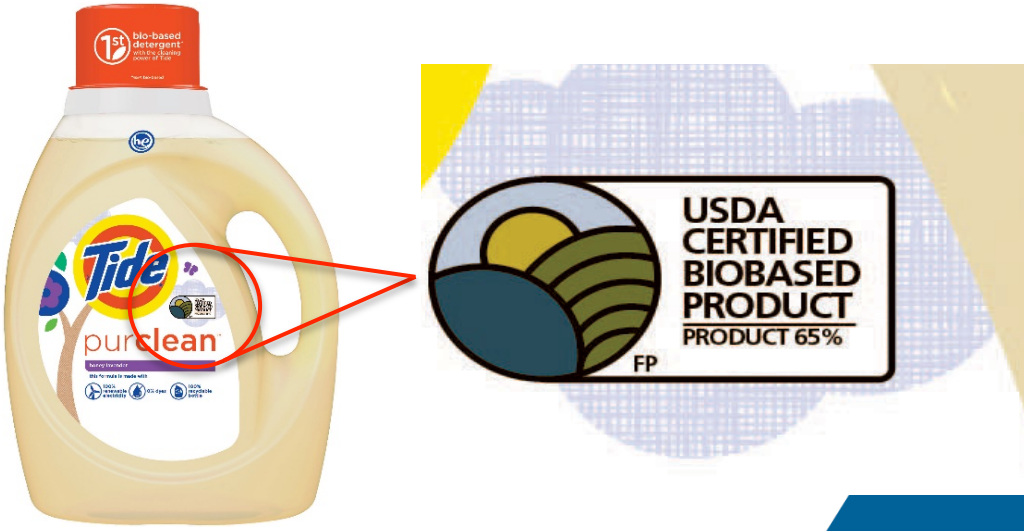
Based on presentation by M. Carus (2014)

Example: Public Procurement

- An explanation of what PP is
- Why it's important: OECD governments spend around 13% of GDP on PP

Example:

- Biopreferred Program of USDA
- Some 15,000 products in the catalogue
- Unique label



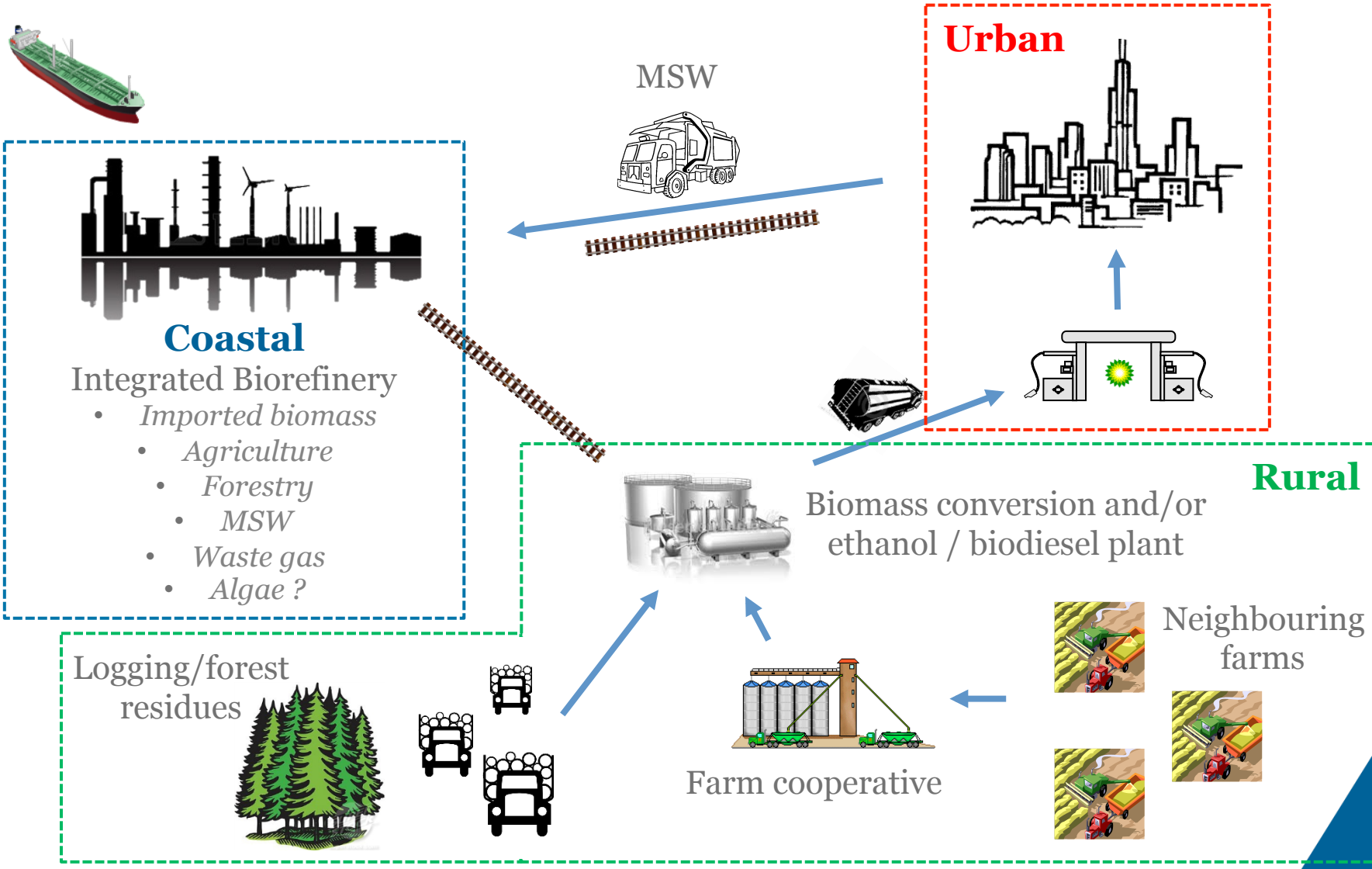
BIOREFINERY MODELS AND POLICY

Chapters

- WHAT IS A BIOREFINERY: DEFINITIONS, CLASSIFICATION AND GENERAL MODELS
- FINANCING BIOREFINERIES
- BIOWASTE BIOREFINING
- BIOREFINERY CASE STUDIES: DIFFERENT PERSPECTIVES FROM DIFFERENT COUNTRIES
- POLICY QUESTIONS REGARDING: R&D, FINANCING AND REGULATORY NEEDS AND OPPORTUNITIES FOR BOOSTING BIO-WASTE BIOREFINERY PRACTICES
- POLICY CONSIDERATIONS

General policy *considerations*

Integrated biorefinery logistics



Rural biorefining: "*soft*" issues

- Water requirements and river regulations
- Do rural biorefineries conflict with green-field policy ?
- Small *versus* large: economies of scale and petrochemicals competition
- Do city people want to move to the country ?
  - Towns and villages across England are losing basic services at "*their fastest rate ever*" [1]
- Do people already there want incomers ?
- Biomass imports – sea *then* overland to biorefineries
- Other infrastructure – pipelines, electricity, rail, road – is expensive and can be unpopular

1 *Daily Telegraph*, 14 Apr 2008

What about rural *and* coastal ?

- Build biomass pre-treatment and concentration plants rurally
  - Less environmental impact and infrastructure needs
  - Less impact on greenfield policies
  - Less public resistance ?
- Build integrated biorefineries near waste CO_2 sources
- Re-develop brown-field sites ?[1]
- Close to developed power and rail infrastructure
- Lesser water regulations ?
- Fewer transport issues ?
- Integrate with offshore wind energy ?
- *Choice of feedstocks* – including gas
  - Switch between available and cheaper feedstocks
  - Cut idle times
- Easier political sell than rural location ?

1 Example: Porto Torres, Sardinia

Ludwigshafen integrated chemicals complex, Germany

- Employees: 39,000
- Buildings: 2000
- Production plants: 200

https://www.basf.com/de/en/company/about-us/sites/ludwigshafen.html

Lessons from cellulosic flagships: unusual and complex projects, many stakeholders

- High CapEx
  - **Simultaneous commitment by many actors**:
  - Technology providers, R&D partners
  - Customers (e.g. equity investors)
  - Banks/financial institutions
  - Funding bodies (EU/Regions)
  - Local authorities
- Sustained investment
  - Investors (many ongoing negotiations)
  - Grants (PPP, DG RTD, Regional funds)
  - **Debt (main difficulty)**
- Flagships are not easily bankable

Cellulosic biorefinery, Crescentino, Italy.

BETARENEWABLES

Section 9003 Biorefinery, Renewable Chemical and Bio-based Product Manufacturing Assistance Program

- Replaced the Biorefinery Assistance Program (9003) in the Farm Bill (2014)
- USDA approved to use loan guarantees to **maximum of 15% of mandatory funds for bio-based manufacturing**
- Thus the **same policy mechanism** is now being used **to support both biofuels and bio-based products and materials**
  - This brings automatic political visibility to bio-based products
  - Streamlines administration of bio-based products and biofuels (no need for replication of effort and personnel)

Eligible projects

- Development, construction, or retrofitting of a commercial-scale biorefinery using eligible technology
- Loan guarantees **up to USD 250 million (and up to 80%)**
- Bio-based product manufacturing facilities
- New technologies to manufacture bio-based outputs

Financing through Climate Change and Emissions Management Corporation (CCEMC)

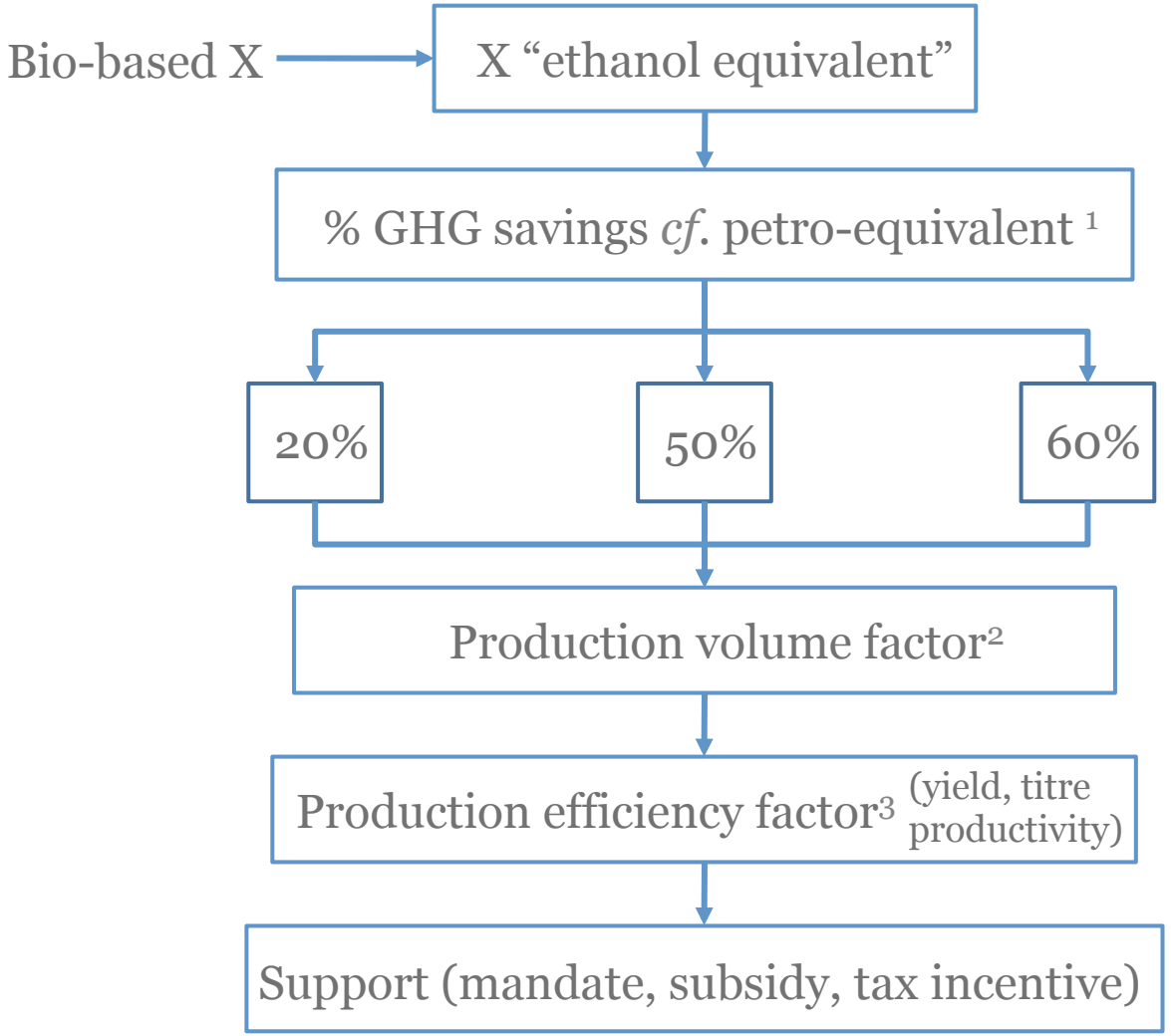
CCEMC

- CO_2 Solutions secured CAD 5.2 million from:
  - Government of Canada's ecoENERGY Innovation Initiative and
  - CCEMC
- Towards a CAD 7.5 million project for **biological CO_2 capture from oil sands** production
- 70% from public funding

Postscript: Government of Alberta outlined a plan in November 2015 for cutting the province's GHG emissions. The proposals include:

- End to coal-fired power generation
- Carbon price of CAD 30 per tonne to 2018 and rising in real terms

Bio-based chemicals policy



[1] **EISA biofuels reference**

Renewable fuel	20%
Advanced biofuel	50%
Biomass-based diesel	50%
Cellulosic biofuel	60%

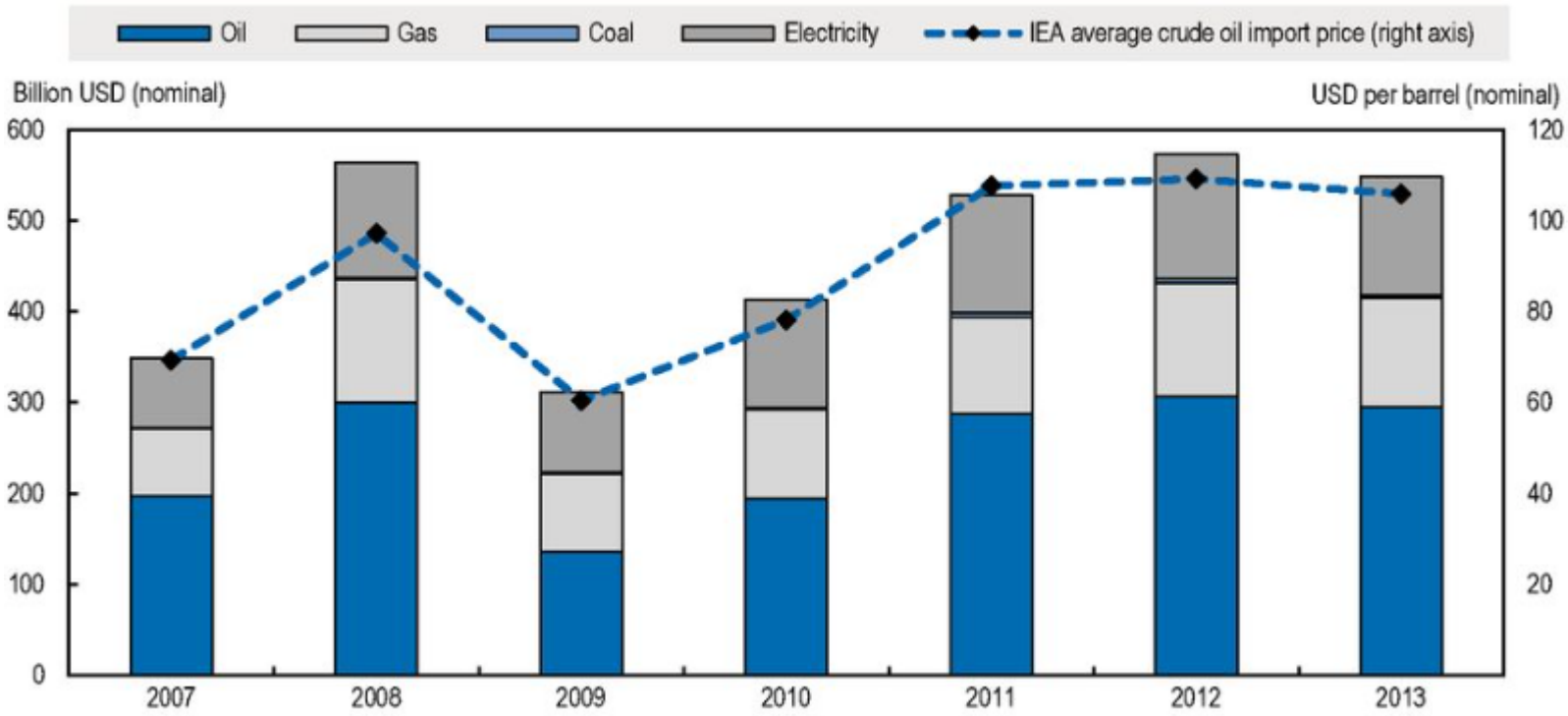
[2] Small volumes will not have significant total GHG emissions savings ⇒ inefficient

[3] Encourages innovation to improve efficiency

Philp (2015). *Energy & Environmental Science* 8, 3063-3068

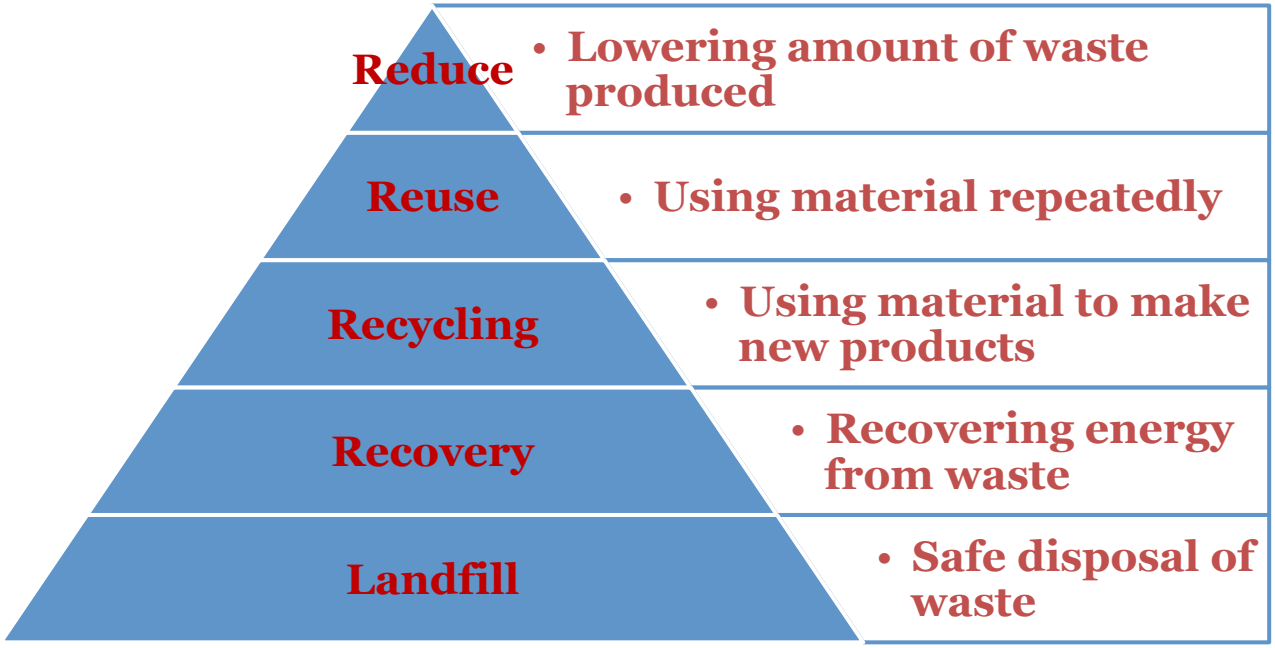
Fossil fuel subsidies: a level playing field is impossible

- IMF calculation: USD 5.3 trillion, or **6.5% of global GDP**, in post-tax subsidies in 2015



Waste hierarchy (EU Waste Framework Directive 2008/98/EC)

Waste = any substance or material that the holder discards, intends to discard or is required to discard



Where does bio-based production come in the heirarchy?

From Neste presentation, 24.8.2016

REPLACING THE OIL BARREL

Met. Eng.: Plenty of research success…

Class	Compound	Reference
Diols	1,3-Propanediol	Nakamura and Whited (2003); Maervoet et al. (2016)
	1,2-Propanediol	Clomburg and Gonzalez (2011); Lee et al. (2016)
	1,4-Butanediol	Yim et al. (2011); Burgard et al. (2016)
	2,3-Butanediol	Cho et al. (2015); Yang et al. (2016)
Bio-based plastics	Polyhydroxyalkanoates	Steinbüchel (2001); Escapa et al. (2011); Tokuyama et al. (2014); Chen et al. (2015); Chu et al. (2015); Kim et al. (2016)
	Polylactic acid	Jung and Lee (2011)
	PLGA	Choi et al. (2016)
Plastics intermediates	Muconic acid	Curran et al. (2013)
	Itaconic acid	Chin et al. (2015)
	1,5-Diaminopentane	Kind et al. (2014); Oh et al. (2015)
	1,3-Diaminopropane	Chae et al. (2015)
	5-Aminovalerate	Park et al. (2013); Rohles et al. (2016) ; Shin et al. (2016)
	3-Aminopropionic acid	Song et al. (2015)
	Gamma-aminobutyric acid	Dung et al. (2016)
Synthetic rubber	Isoprene	Lindberg et al. (2010); Ye et al. (2016)
Olefins (alkenes)		Chen et al. (2015); Kang and Nielsen (2016)
	1,3-Butadiene	EP2607340 (2013)
Spider silk		Xiaa et al. (2010); CEP (2015)
Biofuels	Butanol	Jang and Lee (2015); Gaida et al. (2016);
	Alkanes	Kageyama et al. (2015); Sheppard et al. (2016)
	Hydrocarbon fuels	Lee et al. (2015)
	Hydrogen	Srirangan et al. (2011); Tran et al. (2104); Rollin et al. (2015)

…but hardly any commercialisation

- 1,3-PDO, 1,4-BDO, 5-amino valerate (??), artemisinin

MATER BIOTECH

genomatica
sustainable chemicals

Sep 30, 2016: Inauguration of Mater-Biotech's plant in Bottrighe di Adria
30,000 tonnes per year of 1,4-BDO

The future?

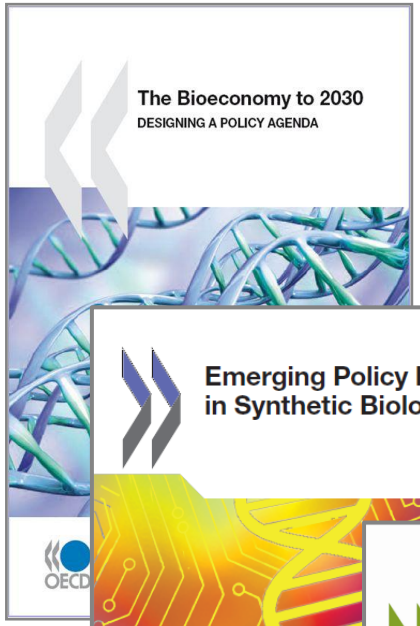
Biotechnology

Cell-free biotech will make for better products

A new type of biological engineering should speed up innovation

The Economist, May 06, 2017

Thank you for your time



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