CCS/CCU and Life Cycle Assessment

UK CCSRC 'Emissions through CCS life–cycle' Cardiff, Sept 2014

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CES overview

- Formed in 1992 as spin out from Chem.Eng.
  - Apply ‘systems thinking’ to environment/sustainability questions
- 14 staff
  - Original disciplines: Chem Eng, Mech Eng, Env Eng, Electronic Eng, Physics, Chemistry, Biology, Sociology, Planning, Economics
  - Most staff are ‘transdisciplinary’
- Research close links to policy and business
- Postgraduate teaching focus
  - Modular MScs: Environmental Strategy; Sustainable Development; Corporate Environmental Management
  - 24 PhDs (13 UK, 11 overseas)
  - 40 Engineering Doctorate students in “Sustainability for Engineering & Energy Systems” in companies/organisations

CCS/CCU & LCA/LCSA

Three main aspects:-

1. BECCS/BECCU and ‘decoupling’

2. LCA development – use of the EC PEF/OPF

3. Life Cycle Sustainability Assessment (LCSA)

CCU and decoupling

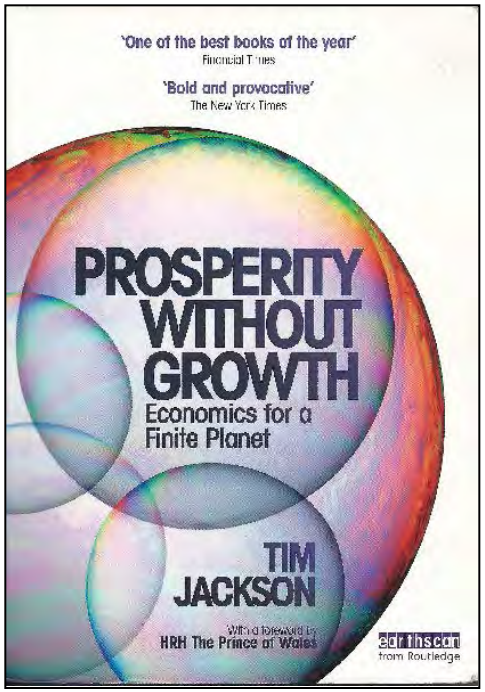
Decoupling:-

"enabling the growth of the economy without breaching ecological limits or running out of resources'

Tim Jackson

Prosperity without Growth: Economics for a Finite Planet

Earthscan 2009



Bioplastics and decoupling

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Relative Decoupling:- *improved efficiency of resource use/emissions per unit of economic output*

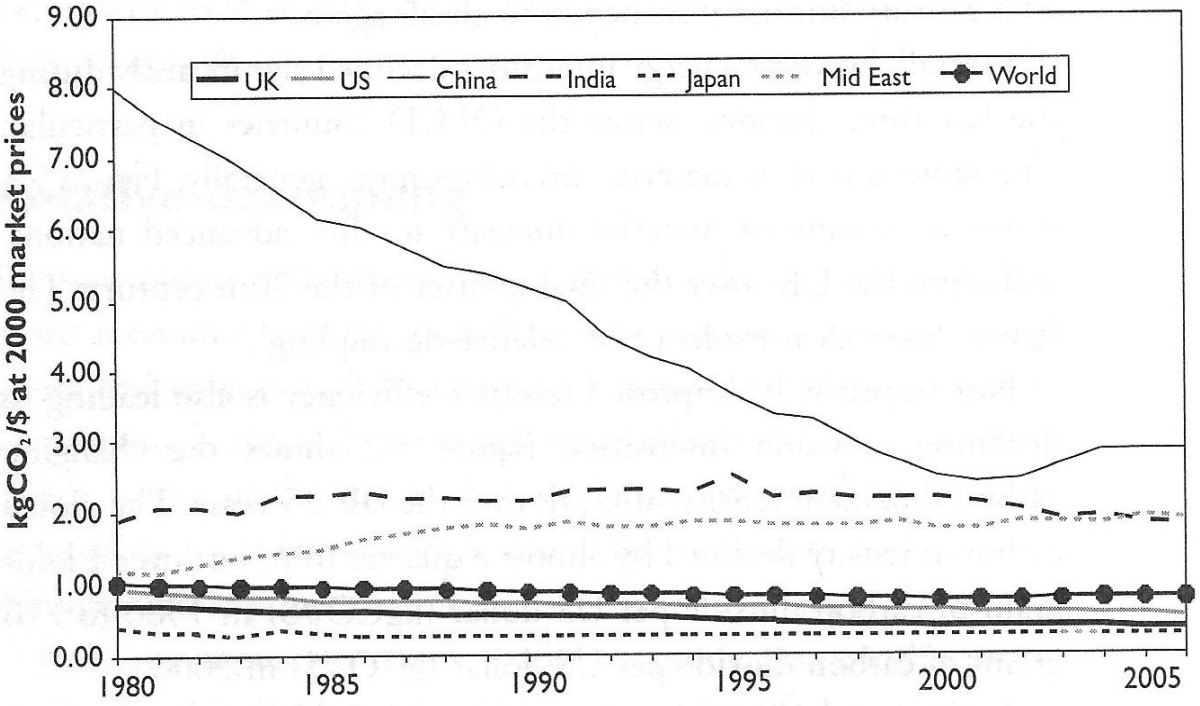
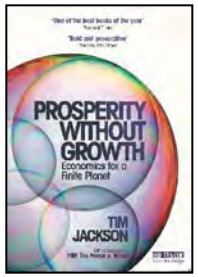


Figure 5.2 CO_2 intensity of GDP across nations: 1980–2006[8]

Source: see note 8.



Bioplastics and decoupling

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Absolute Decoupling:- *disconnection of resource use/emissions per unit of economic output*

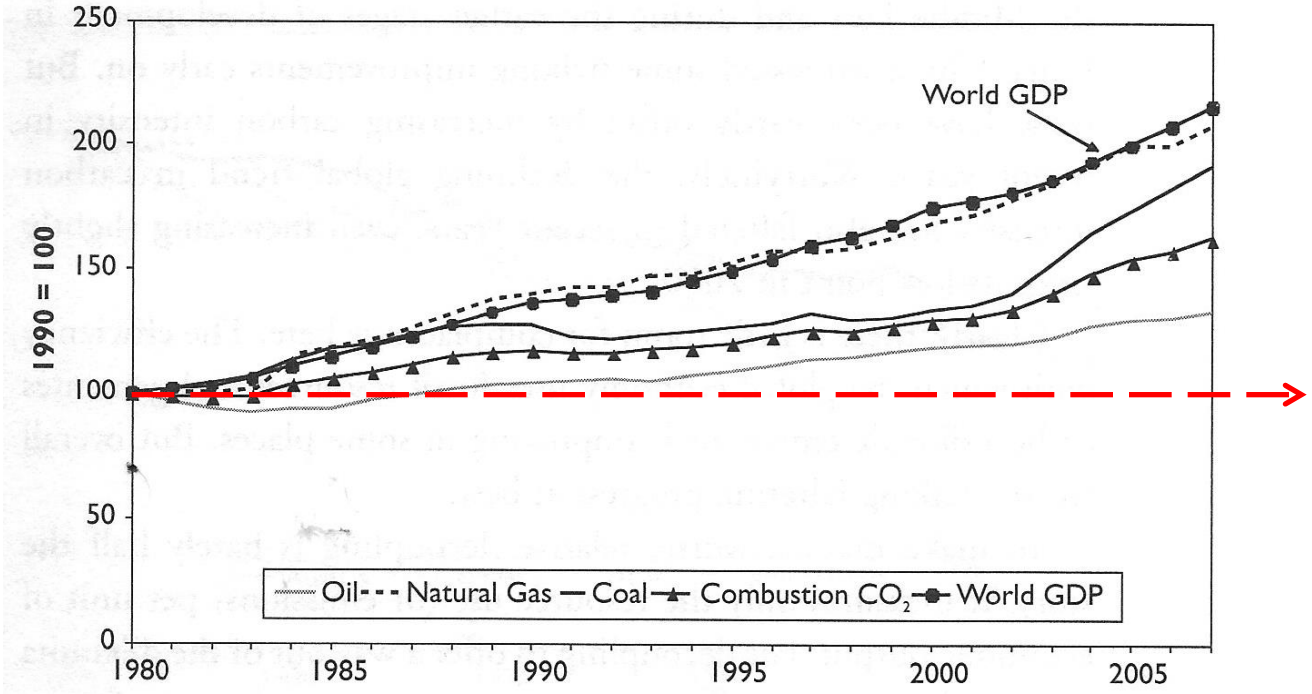
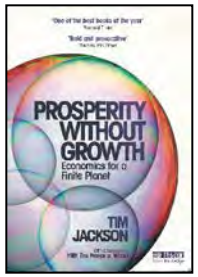


Figure 5.3 Trends in fossil fuel consumption and related CO_2: 1980–2007[9]

Source: see note 9.



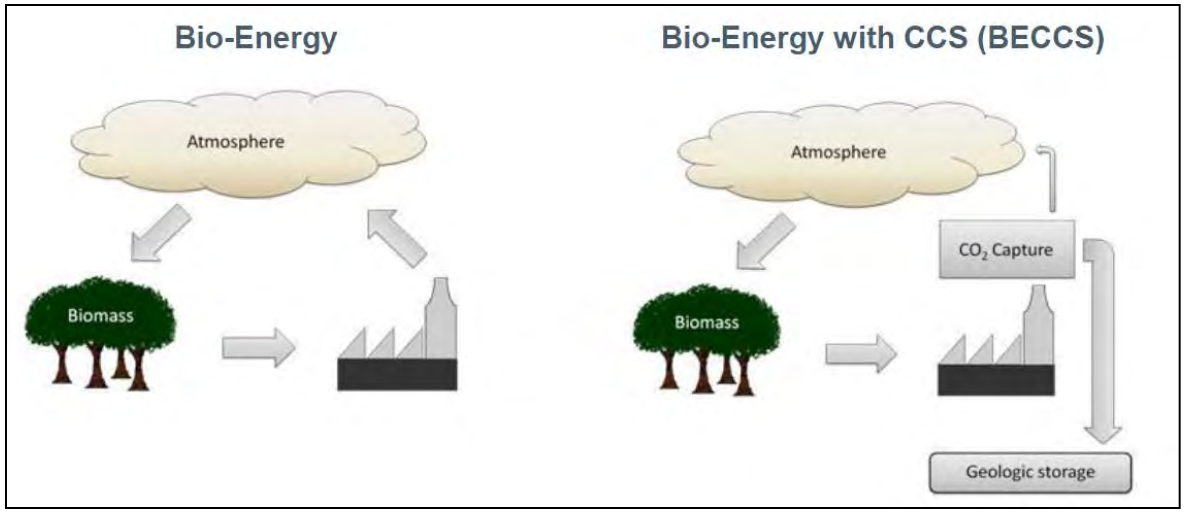
BECCU and 'bio'plastics etc - what can they offer ?

- **Distinguish bio-based and biodegradable**
- **Biodegradable tend not to be 'drop-in' and are generally moisture sensitive. 'C-neutral at best'**
- **Bio-based can be 'drop-in' e.g. 'Green PE' from Braskem GWP_{100}. Can be 'C-negative' *under non CCS/BECCS* saving something like -1 to -2.3 kg CO_{2e}/kg polymer (cradle-to-gate basis)**
- **The components may not all be bio-based e.g. Plant Bottle™ from The Coca Cola Company (green bio-MEG, petrochemical TPA – for now) savings approx. 10% of GWP_{100} vs petrochemical equivalent**

BECCU and 'bio'plastics etc

The 'negative' carbon footprints of bioplastics - more CO_{2e} can be removed from atmosphere than is emitted during their growth and manufacture - *is a very rare property*

In Energy, the only technology that offers similar is Bioenergy with Carbon Capture and Storage (BECCS)



BECCU and 'bio'plastics etc

Bioplastics etc with 'negative' carbon footprints *and careful life cycle management* offer the potential not only to *absolutely decouple* GHG emissions from economic growth but to go further and offer *"mitigation decoupling"* potential

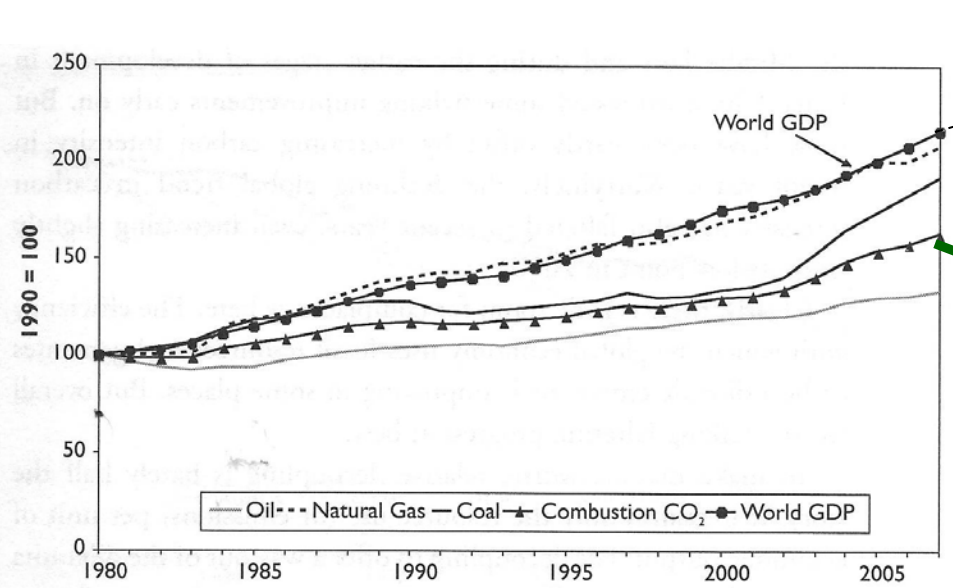


Figure 5.3 Trends in fossil fuel consumption and related CO_2: 1980–2007[9]

World GDP

Mitigation Decoupling w/ C-negative bioplastics, BECCS etc?

Important current LCA development

- The EC launched its own Product Environmental Footprinting (PEF) and Organisation Environmental Footprinting (OEF) scheme in 2013
- This is currently being ‘road-tested’ 2013 – 2015

- After this, and some modifications, it is likely to become ‘official’, and will be used in things like public purchasing decisions

Draft was issued 9 April 2013 by the EC)

EUROPEAN
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Brussels, XXX
[…](2013) XXX draft

COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT AND THE COUNCIL

Building the Single Market for Green Products

Facilitating better information on the environmental performance of products and organisations

(Text with EEA relevance)

Annex II specifies the 'rules' and methods to be applied… ….. *its only 140 pages*

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Brussels, XXX
[…](2013) XXX draft

ANNEX

ANNEX II : PRODUCT ENVIRONMENTAL FOOTPRINT (PEF) GUIDE

to the

COMMISSION RECOMMENDATION

on the use of common methods to measure and communicate the life cycle environmental performance of products and organisations

Annex II specifies the environmental impact categories

- the 'footprint' generated will therefore be broad / comprehensive, and is really a LCA profile

Table 2: Default EF impact categories (with respective EF impact category indicators) and EF impact assessment models for PEF studies

EF Impact Category	EF Impact Assessment Model	EF Impact Category indicators	Source
Climate Change	Bern model - Global Warming Potentials (GWP) over a 100 year time horizon.	kg CO_2 equivalent	Intergovernmental Panel on Climate Change, 2007
Ozone Depletion	EDIP model based on the ODPs of the World Meteorological Organization (WMO) over an infinite time horizon.	kg CFC-11 equivalent	WMO, 1999
Ecotoxicity for aquatic fresh water	USEtox model	CTUe (Comparative Toxic Unit for ecosystems)	Rosenbaum et al., 2008
Human Toxicity - cancer effects	USEtox model	CTUh (Comparative Toxic Unit for humans)	Rosenbaum et al., 2008
Human Toxicity – non-cancer effects	USEtox model	CTUh (Comparative Toxic Unit for humans)	Rosenbaum et al., 2008
Particulate Matter/Respiratory Inorganics	RiskPoll model	kg PM2.5 equivalent	Humbert, 2009
Ionising Radiation – human health effects	Human Health effect model	kg U^{235} equivalent (to air)	Dreicer et al., 1995
Photochemical Ozone Formation	LOTOS-EUROS model	kg NMVOC equivalent	Van Zelm et al., 2008 as applied in ReCiPe
Acidification	Accumulated Exceedance model	mol H+ eq	Seppälä et al.,2006; Posch et al., 2008
Eutrophication – terrestrial	Accumulated Exceedance model	mol N eq	Seppälä et al.,2006; Posch et al., 2008
Eutrophication – aquatic	EUTREND model	fresh water: kg P equivalent marine: kg N equivalent	Struijs et al., 2009 as implemented in ReCiPe
Resource Depletion – water	Swiss Ecoscarcity model	m^3 water use related to local scarcity of water	Frischknecht et al., 2008
Resource Depletion – mineral, fossil	CML2002 model	kg antimony (Sb) equivalent	van Oers et al., 2002
Land Transformation	Soil Organic Matter (SOM) model	Kg (deficit)	Milà i Canals et al., 2007

* CFC-11 = Trichlorofluoromethane, also called freon-11 or R-11, is a chlorofluorocarbon.
** PM2.5 = Particulate Matter with a diameter of 2.5 µm or less.
*** NMVOC = Non-Methane Volatile Organic Compounds
**** Sb = Antimony

In my view this will gain substantial acceptance over the next 2 years and become the 'default' methodological approach for the EU

Depending on the product system and intended application, users of this PEF Guide may elect to narrow the suite of EF impact categories considered. Such exclusions should be supported by appropriate documents, such as (non-exhaustive list):

- International consensus process;
- Independent external review;
- Multi-stakeholder process;
- LCA studies which have been peer reviewed;
- Screening step (see section 5.2).

REQUIREMENT FOR PEF STUDIES

The selection of EF impact categories should be comprehensive in the sense that they cover all relevant environmental issues related to the product supply chain of interest. For a PEF study, all of the specified default EF impact categories and associated specified EF impact assessment models shall be applied. Any exclusion shall be explicitly documented, justified, reported in the PEF report and supported by appropriate documents.

The influence of any exclusion on the final results, especially related to limitations in terms of comparability with other PEF studies, shall be discussed in the interpretation phase and reported. Such exclusions are subject to review.

Life Cycle Sustainability Assessment (LCSA) – *UNEP interest*

Sustainable Development =

Life Cycle Sustainability Assessment =

http://www.ey.com/US/en/Services/Specialty-Services/Climate-Change-and-Sustainability-Services/How-sustainability-has-expanded-the-CFOs-role
http://www.lifecycleinitiative.org/starting-life-cycle-thinking/life-cycle-approaches/life-cycle-sustainability-assessment/

Summary

- **BECCU represents a unique opportunity for ‘carbon negativity’ and ‘mitigation decoupling’ ‘better’ than petrol**
- **New LCA methodology, especially the EC PEF/OEF will need to be applied in CCS/CCU studies. CCS may have a weakness in the resource depletion category due to consumption of fossil resources**
- **LCSA may provide a useful framework to present ‘integrated assessments’ of CCS/CCU ‘projects’ and help encompass the social (~ s-LCA) dimension**

Acknowledgements

UK Research Councils: **BBSRC BSBEC-BioMASS Programme, NERC TSEC-Biosys Project, BBSRC UK-Taiwan Partnering Award**

EC Projects: **FP7 EnergyPOPLAR, Cost Action E9**

People: **Lei Wang, Jade Littlewood, Miao Guo, Mike Ray, Nick Brereton, James Joyce, Carly Whittaker, Sara Gonzalez-Garcia, Jem Woods**

Organisations: **Novozymes, INRA, Rothamsted Research, Porter Alliance**