An overview of life cycle assessment and carbon footprinting

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1. Background
2. What LCA does
3. Outline of approach
4. What is C footprinting?
5. Comparison with C footprinting
6. Concluding discussion

Some classic examples of LCA

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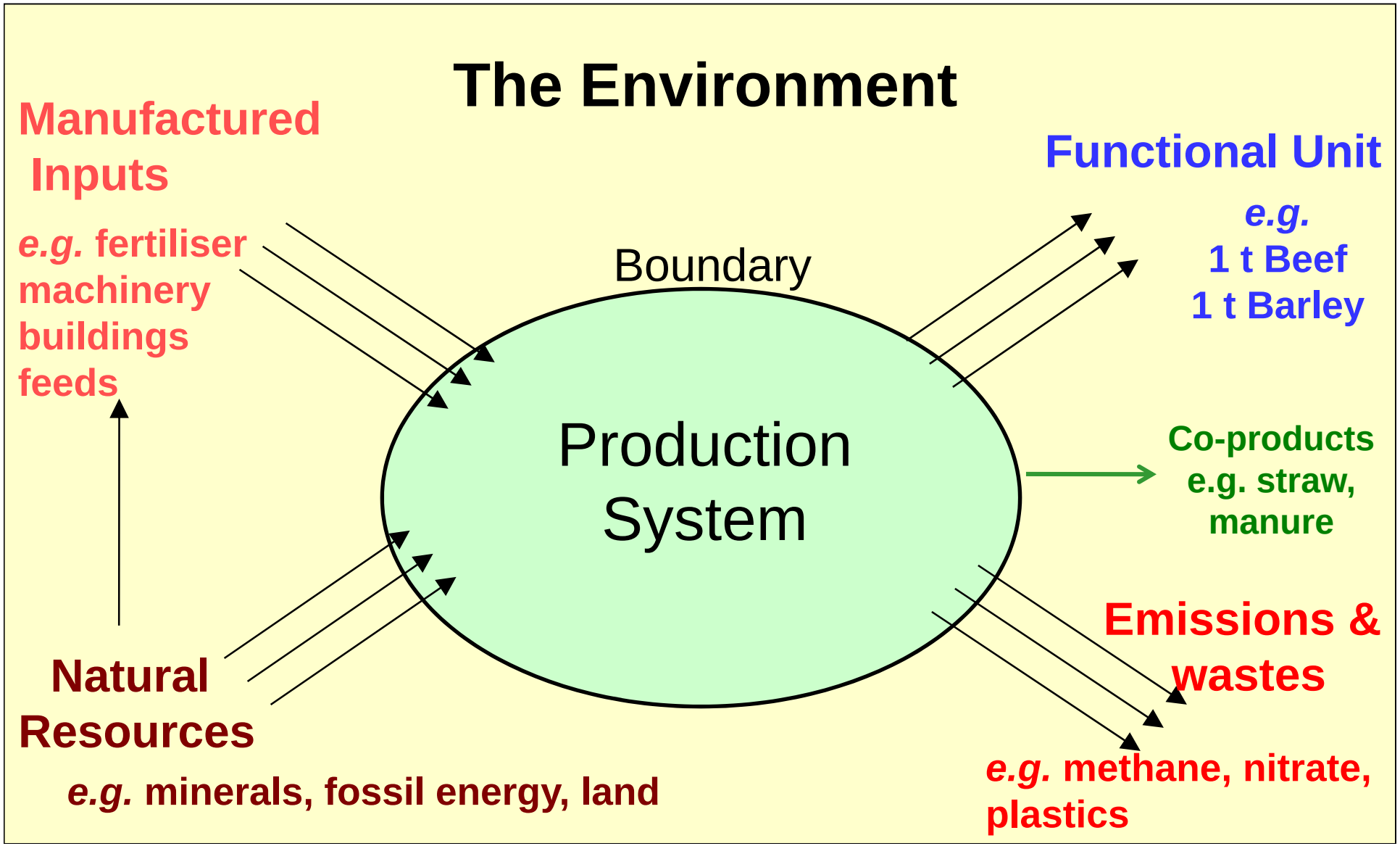
- Washable nappies versus disposable nappies
  - Landfill versus energy and water pollution
- Glass bottles versus aluminium cans
  - Recycling versus single use
- Low energy versus tungsten light bulbs
  - Fossil fuel versus mercury

None adequately resolved by C footprinting alone

The LCA Concept

A process to evaluate the environmental burdens associated with a product, process, or activity

Inputs = Outputs
Mass flows measured at the system boundary must balance.



Cradle to grave is fullest application of LCA

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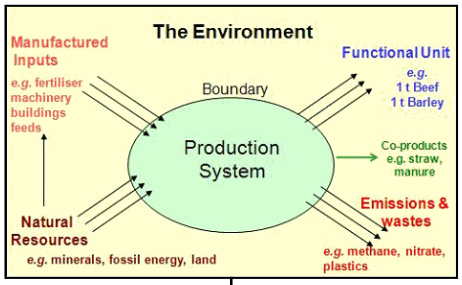
Production



Processing

Distribution

Consumption / use

Disposal

Each step has is own set of inputs and outputs like production

The Phases of LCA Process

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- **Goal and scope definition**
  - Define the purpose, limits, boundaries, F.U., audience
- **Inventory analysis**
  - Compile an **inventory** of relevant inputs and outputs of a system
- **Impact assessment**
  - Evaluating the potential environmental impacts associated with those inputs and outputs
- **Interpretation**
  - **Interpreting** the results of the inventory and impact phases in relation to the objectives of the study
  - e.g. assessing data quality, sensitivity & uncertainty analysis
  - Normalisation
  - Peer review
  - Reporting

Who decides and defines?

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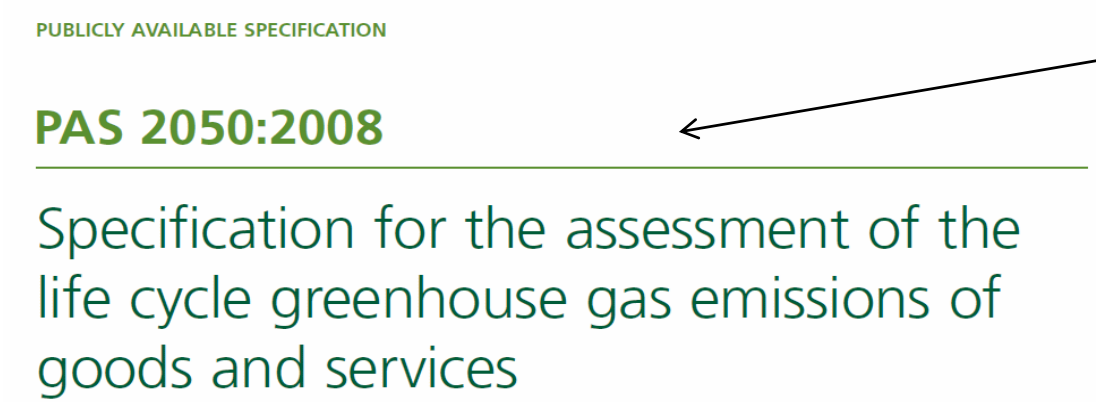
- The customers / commissioners
  - With negotiation and guidance by analysts

- **BS EN ISO 14040:2006 series *Environmental Management - Life Cycle Assessment***

  - **ISO 14040: Principles and Framework**
  - **ISO14044: Requirements and guidelines**
  - **ISO14048: Data documentation format**


PUBLICLY AVAILABLE SPECIFICATION

PAS 2050:2008

Specification for the assessment of the life cycle greenhouse gas emissions of goods and services

For GHG only

Functional Unit

- The measure of performance which the system delivers; it has to be clearly defined, measurable, and relevant to input and output data.

- 1 m^3 milk
- 1 t milk solids
- 1 m^3 milk with 4% fat (± 0.1%) at the farm gate
- 1 m^3 milk with 4% fat (± 0.1%) at the creamery with < x c.f.u./ml for 365 days/year
- 1000 l whole milk delivered to retail outlets
- 1000 l semi-skimmed milk consumed at home

Inventory analysis phase

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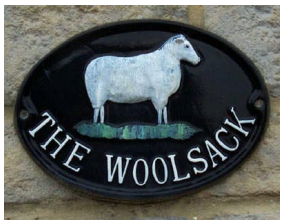
Inputs

- Direct energy
  - Diesel, electricity
- Feeds
- Fertilisers
- Machinery
- Buildings
- Materials

- Animals

Outputs

- **The F.U.**
- Co-products
- CO_2
- CH_4
- N_2O
- NO_3^-
- CH_3Br
- Wastes



Data sources

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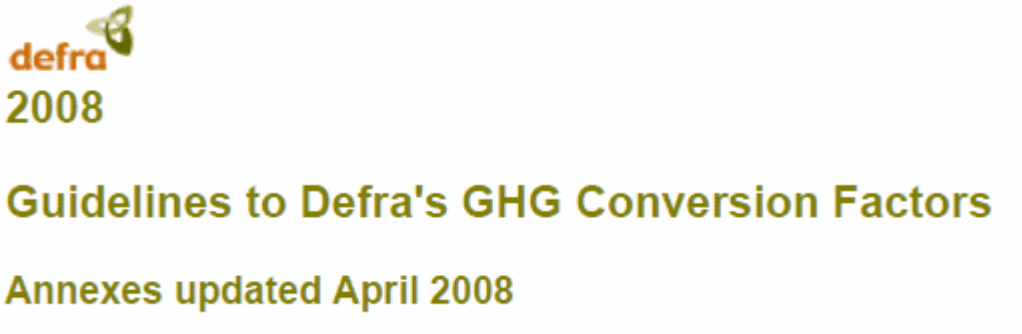
- Activity data
- Simulation and system models
- Literature
- ELCD: energy carriers
- IPCC: emission factors (Tiers 1 to 3)
- *Ecoinvent* (or other commercial sources)
- Harmonisation study (Audsley *et al*., 1997)
- CAHLCI (www.agrilca.org)

- **NOT**



Energy carriers – deliver process (useable) energy

defra
2008

Guidelines to Defra's GHG Conversion Factors

Annexes updated April 2008

Energy Carrier	Primary energy, MJ/MJ	GWP, kg CO_2e/MJ	[End of pipe CO_2] / [LCA GWP]	Proportion renewable	Abiotic Resource Use, kg Sb/MJ
Electricity (UK)	3.2	0.18	87%	1.6%	0.0011
Electricity HEP	1.3	0.0068		99.5%	0.00012
Diesel	1.2	0.085	86%	0.1%	0.00057

Energy carriers have embodied (or embedded) energy and GHG, as do steel and NH_4NO_3

Typical Impact categories

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- **Input related categories**
  - Abiotic resource depletion
    - NR Energy, minerals
  - Land
  - Water
- **Output related categories (mostly potentials)**
  - Global warming (20,**100** or 500 year time scale)
  - Acidification
  - Eutrophication
  - Ozone depletion
  - Toxicity: eco and human
- **Others**
  - Soil quality
  - Biodiversity
  - Working environment

Global Warming Potential (GWP) factors for major agricultural gases

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Global Warming Potential Factors for major gases using the IPCC (2006) values. kg CO_2e/kg			
Time scale, years	**20**	**100**	**500**
CO_2	1	1	1
CH_4	72	25	7.6
N_2O	289	298	153
NH_3	4	4	2
R404a		3800	

Typical of mobile refrigeration and retail

So what is the "carbon footprint"?

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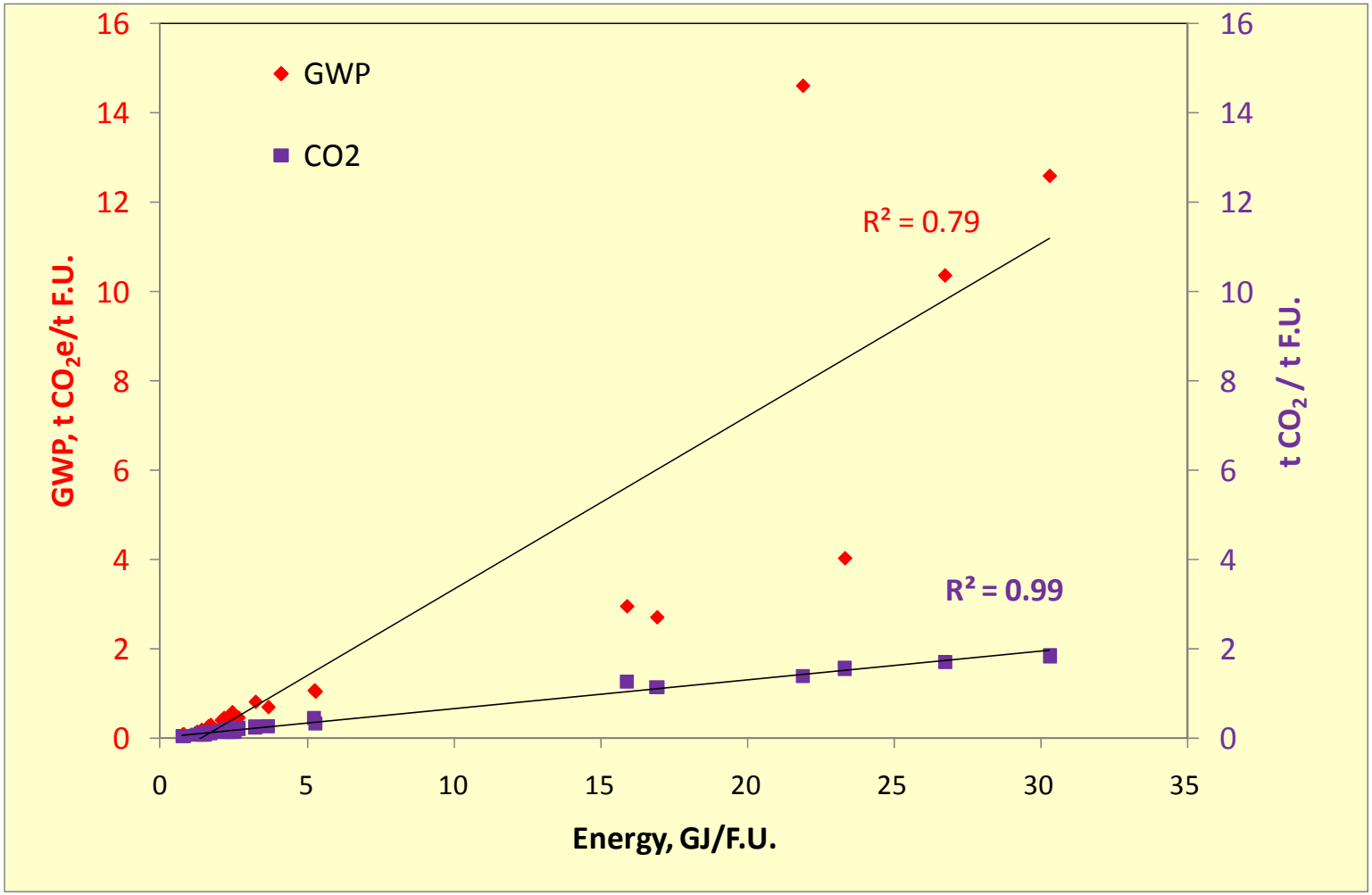
- **Not completely agreed**
- Wiedmann and Minx, 2007
    - only to CO_2 emissions with Life Cycle Perspective (LCP)
    - climate footprint for all GHGs as CO_2e
- Flachowsky (2008) CO_2-footprints (all GHG, with LCP)
- C-N footprint
- CO_2 only: with or without overheads
- All GHGs: with or without overheads
- PAS 2050 does not use term, but guide does
- CALM – end of pipe for farm or estate, but no outputs!
- **Need all GHG for agriculture with F.U. to be of use in mitigation**

Energy and "C footprints" for crops and animal products: CO_2 only and all GHG



Feed Processing and allocation

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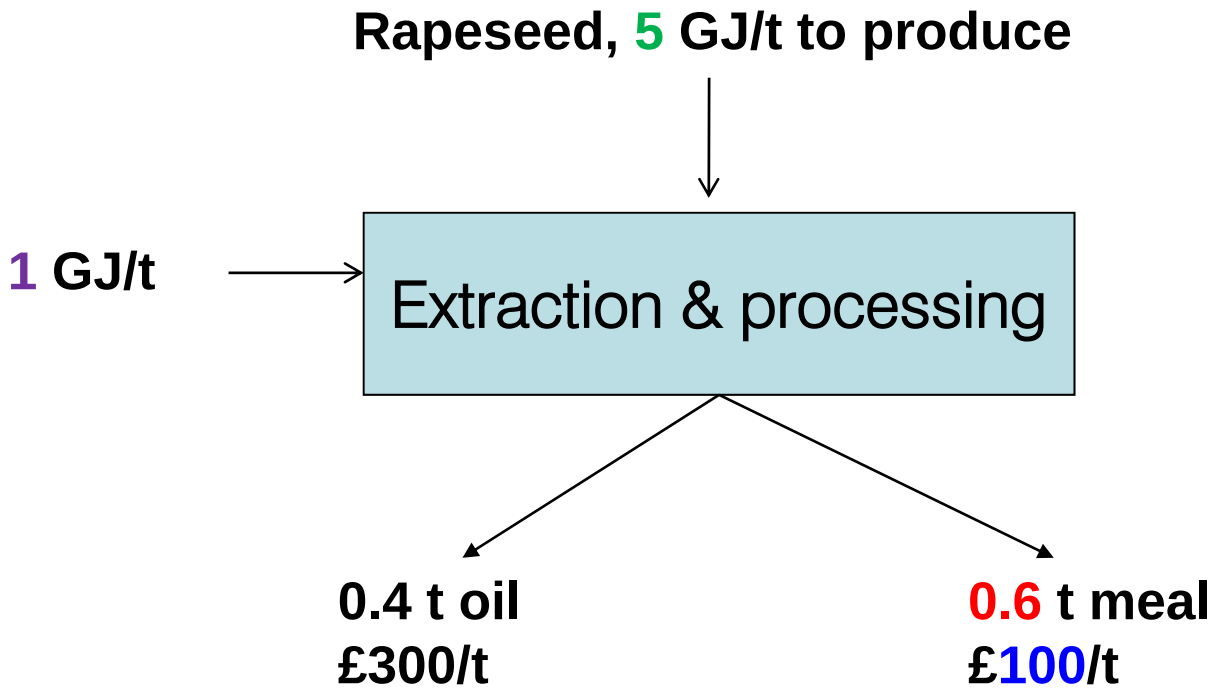
Example of economic allocation



System expansion can avoid allocation, but…

e.g. milk processing, leads to pigs!

Mass based Allocation to oil or meal is : (0.6 * (5 + 1) / 0.6) = 6 GJ/t

Would energy or CP be right?

Economic m'd: ((0.6 * 100) / (0.4 * 300 + 0.6 * 100)) * (5 + 1) / 0.6) = 3.3 GJ/t

Oil is thus 10 GJ/t

LCA and PAS 2050

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	PAS 2050	LCA
Functional Unit	Y	Y
Prescriptive approach to scope	Y	N
Cradle to gate	Y	Y
Cradle to grave	Y	Y
Embodied GHG	Y	Y
Capital overheads	N	Context
Primary (measured) data threshold	Y	N
Materiality threshold	Y	Probably
Soil C with LU	N	Possible
LUC biomass C	Mandatory rules	Flexible
Peer review	As certification of following the method	Yes
Secondary functions	N	Possible
Consequential?	N	Possible
Outputs	CO_2e/F.U.	Array of impacts/ F.U. up to DALY

Results for a field crop using the Cranfield LCA Model and PAS 2050

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Impacts & resources used per t	LCA	PAS2050 boundaries	PAS2050 results
Energy used, MJ	2,500	2,000	
Global Warming Pot'l, kg year CO_2e	280	250	250
Eutrophication Pot'l, kg PO_4^{3-} Equiv.	4.3	4.3	
Acidification Pot'l, kg SO_2 Equiv.	1.9	1.6	
Pesticides used, dose ha	1.1	1.1	
Abiotic depletion, kg antimony Equiv.	1.1	0.95	

Concluding discussion

- LCA > and ≠ C Footprinting
- LCA and PAS 2050 broadly similar, but
  - One criterion with PAS 2050
  - No capital in PAS 2050
  - PAS 2050 more prescriptive
- NH_3 is a GHG (albeit indirectly)!
- Gothenburg targets still there
- Product category rules (PCR) wanted
- Soil C - always contentious
- Need F.U. based assessments for improvement
- ACRED (Proposal for LINK)

Many thanks for funding from Defra