Brief introduction to LCA

Carbon4PUR stakeholder meeting, Marseille Fos, 20 March 2019 – **Jeroen Guinée**

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Content

- Introduction
- LCA in a nutshell; LCA in one slide
- Life Cycle Assessment (LCA): what is it?
- Ex-ante LCA for guiding technology and product development
- Key messages

“Green” cannot just be claimed, but needs to be proven

There’s no such thing as a free lunch

some re … ds such as wind power
emit no … nstruction phase using
the cradle-to-grave approach of the complete production life cycle

Life cycle assessment in a nutshell

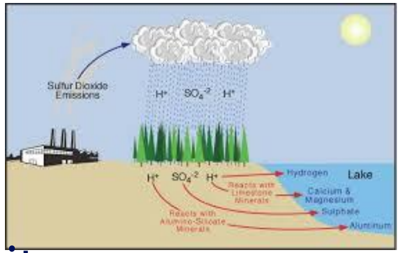
- Compilation and evaluation (
  environmental impacts of a p

- Complete picture to map and avoid potential problem shifting
  - whole life-cycle
  - All burdens and impacts

Climate change

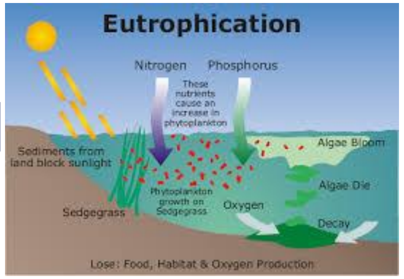
Str. ozone depl.

Acidification



Photochemical
ozone formation

Human toxicity



Ecotoxicity

Resource depletion

Water scarcity

Life Cycle Assessment (LCA)

- (Applied) science, not ideology
  - is an electric car indeed better ?
  - is recycling always a good idea ?

- Systems analysis
  - technosphere ('economy')
  - nature ('natural environment')

Complete picture: life cycle & all impacts

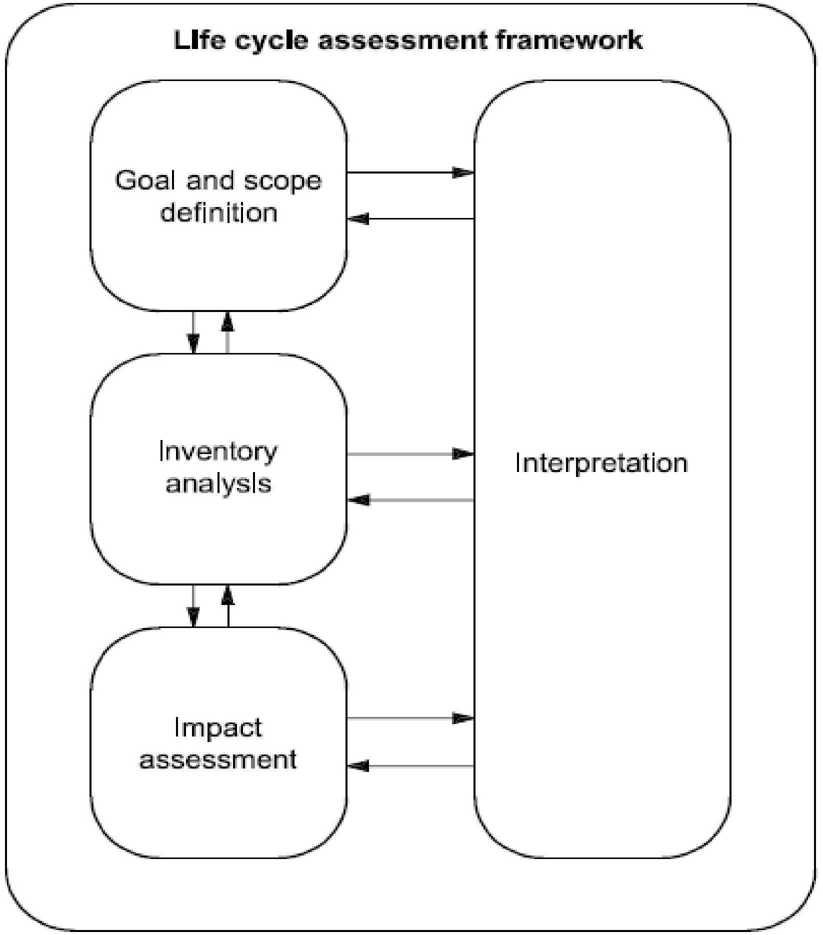
- **Avoid problem shifting (trade-offs):**
  - Other life cycle phases (zero emission car)
  - Other substances (CFC-free fridge)
  - Other countries (export of waste)
  - Other environmental impacts (unleaded petrol)
  - The future (nuclear power)
  - ...

- **Integral analysis:**
  - Whole life-cycle (any where)
  - All substances
  - All countries (any place)
  - All types of environmental impacts
  - Integrated over time (any time)
  - ...

Life Cycle Assessment (LCA): the method

- Standardized by ISO 14040 and ISO 14044

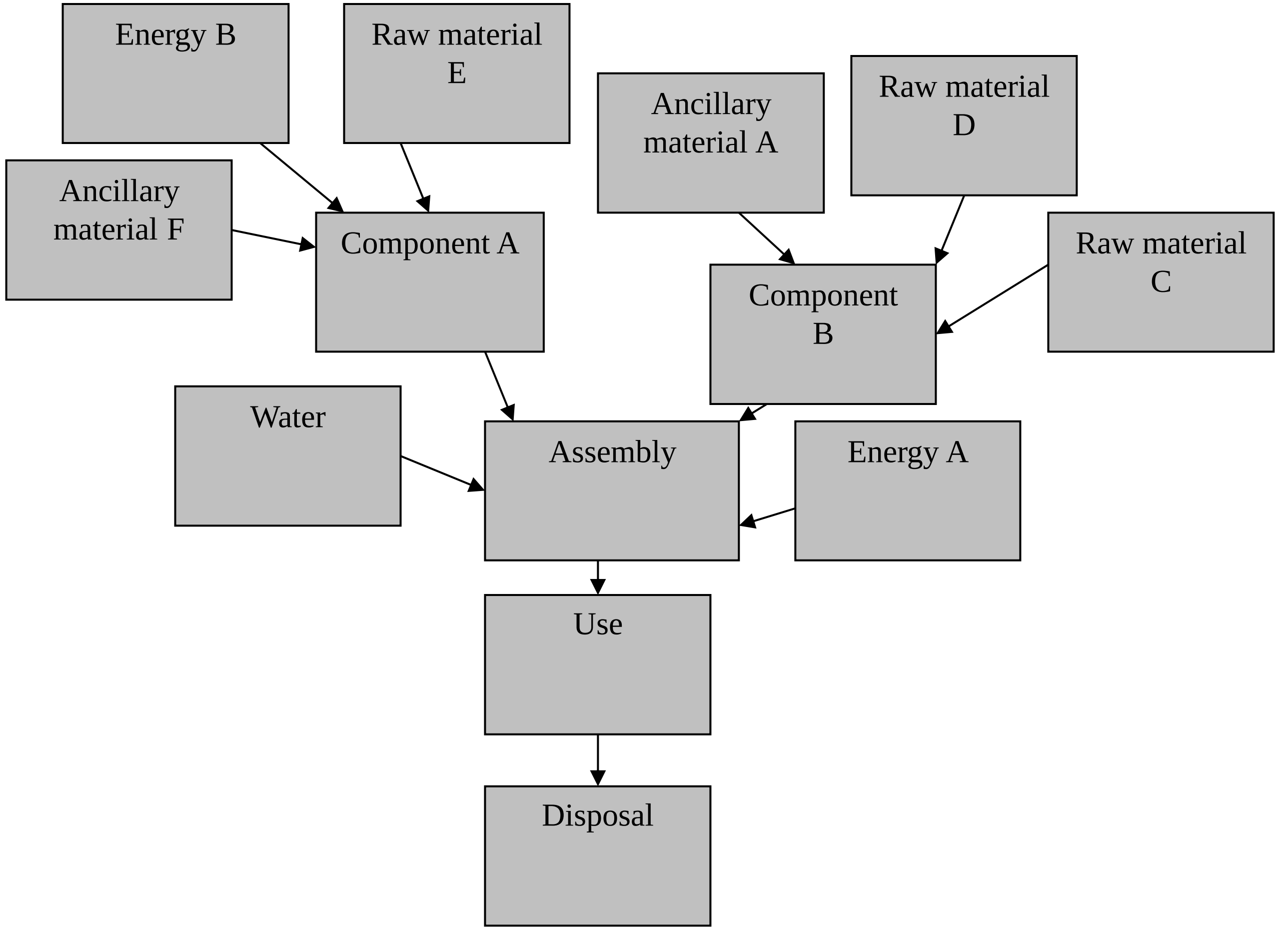
- Four phases:
  - Goal and Scope definition
  - Inventory analysis *(or Life Cycle Inventory - LCI)*
  - Impact Assessment *(or Life Cycle Impact Assessment – LCIA)*
  - Interpretation



Functional unit

- What are you comparing ?
  - not lamps, but hours of light
  - not a can of paint, or litres of paint, but square meters of painted wall …..and lifetime
  - etc.
- Functional unit: a quantified unit of function/service supplied by a product system, used as a basis of comparison in an LCA
  - 1000 hours of light with an intensity of 1250 lumen of white light
  - 100 km transport of two adults
  - 1000 liter packing of milk, in units between 1 and 2 liter
  - watching 55 inch screen color TV for 1 hour

Flowcharts



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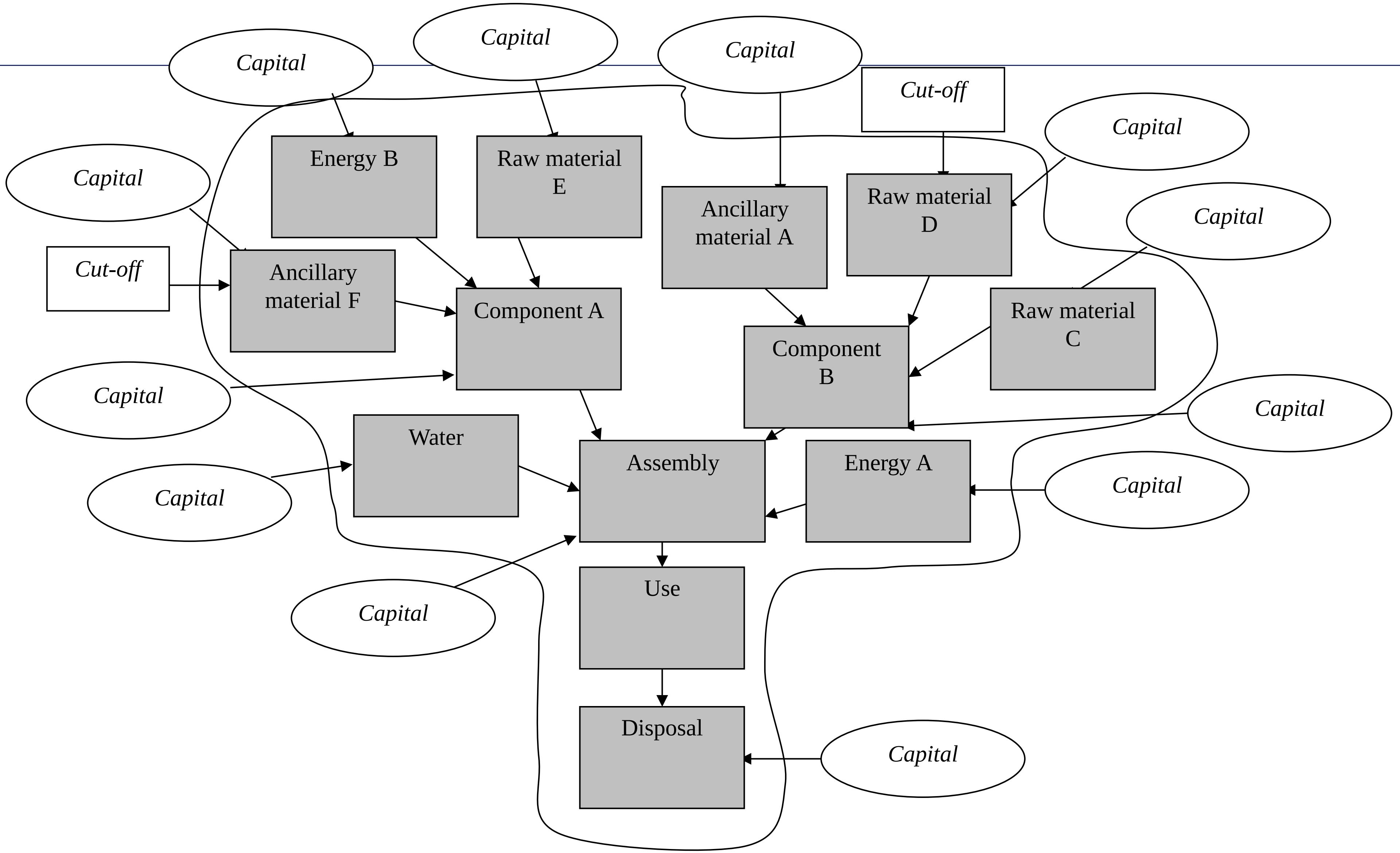
Capital
Capital
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Cut-off
Capital
Energy B
Raw material E
Ancillary material A
Raw material D
Capital
Capital
Cut-off
Ancillary material F
Component A
Component B
Raw material C
Capital
Capital
Water
Assembly
Energy A
Capital
Capital
Use
Capital
Disposal
Capital

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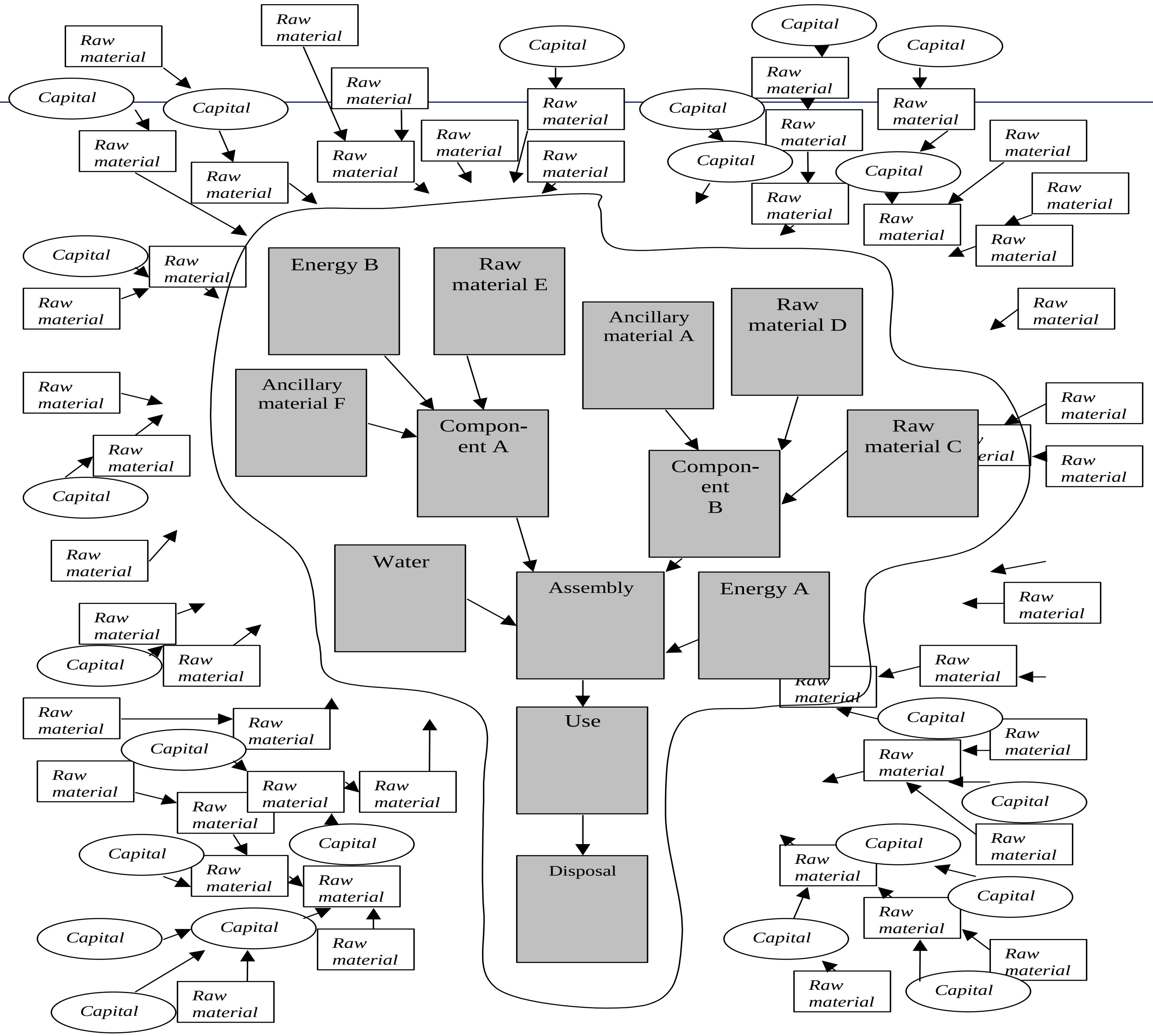
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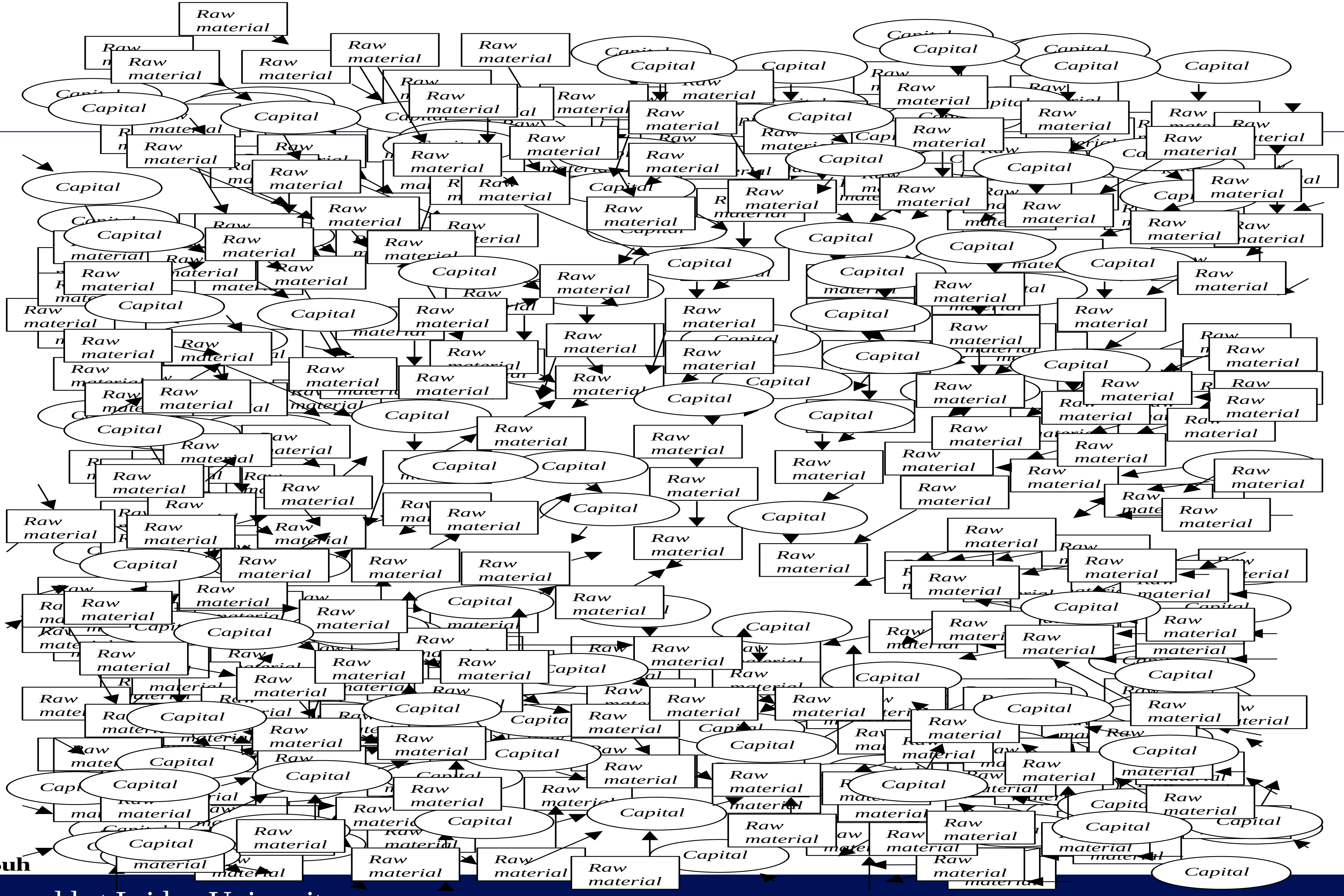

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Example of inventory results: inventory table

Elementary flows	Product 1	Product 2	Unit
NMVOC, non-methane volatile organic compounds, unspecified origin[air_high population density]	1.40E-06	4.57E-07	kg
Carbon dioxide, fossil[air_low population density]	0.283	0.0496	kg
Ammonia[air_high population density]	7.82E-07	2.68E-07	kg
Nitrogen oxides[air_high population density]	0.000376	6.24E-05	kg
Particulates, < 2.5 um[air_high population density]	3.87E-05	6.88E-06	kg
Particulates, > 10 um[air_high population density]	5.52E-07	1.04E-06	kg
Particulates, > 2.5 um, and < 10um[air_high population density]	6.87E-07	1.02E-06	kg
Zinc, ion[water_river]	4.69E-08	4.57E-08	kg
Lead[water_river]	3.59E-08	2.98E-07	kg
Nickel, ion[water_river]	9.84E-09	5.19E-09	kg
Mercury[water_river]	4.20E-10	4.22E-11	kg
Copper, ion[water_river]	5.97E-09	4.79E-09	kg
Chromium, ion[water_river]	7.10E-09	1.77E-08	kg
Cadmium, ion[water_river]	7.68E-10	1.56E-09	kg
Arsenic, ion[water_river]	3.15E-08	1.47E-08	kg
Phosphate[water_river]	1.83E-08	1.48E-08	kg
Ammonium, ion[water_river]	3.86E-07	2.18E-06	kg
Nitrate[water_river]	6.82E-06	1.02E-06	kg
Nitrate[air_high population density]	1.24E-09	3.42E-10	kg
Calcite, in ground[resource_in ground]	-0.00423	-0.00134	kg
Sylvite, 25 % in sylvinite, in ground[resource_in ground]	-9.76E-08	-2.53E-08	kg
Water, cooling, unspecified natural origin[resource_in water]	-0.0122	-0.00265	m3
Water, river[resource_in water]	-0.00238	-0.00556	m3
Sodium, ion[water_river]	0.000148	0.000106	kg
Potassium, ion[water_river]	5.21E-06	1.58E-06	kg
Chloride[water_river]	0.000545	0.000137	kg
Calcium, ion[water_river]	7.74E-05	1.97E-05	kg
Magnesium[water_river]	1.49E-05	3.25E-06	kg
Sulfur[water_river]	1.30E-07	4.61E-08	kg

Impact assessment

- Inventory analysis:
  - emission of CO_2, SO_2, NO_x, Hg, ...
  - extraction of iron-ore, crude oil, fish, ...

- Impact assessment:
  - Impact categories: Global warming, Acidification, Eutrophication, Aquatic ecotoxicity, Abiotic resource use/depletion, etc.
  - Characterization results: one score for global warming, one for acidification, etc.
  - Weighting: further aggregation of characterization results to a single index: footprint, ...

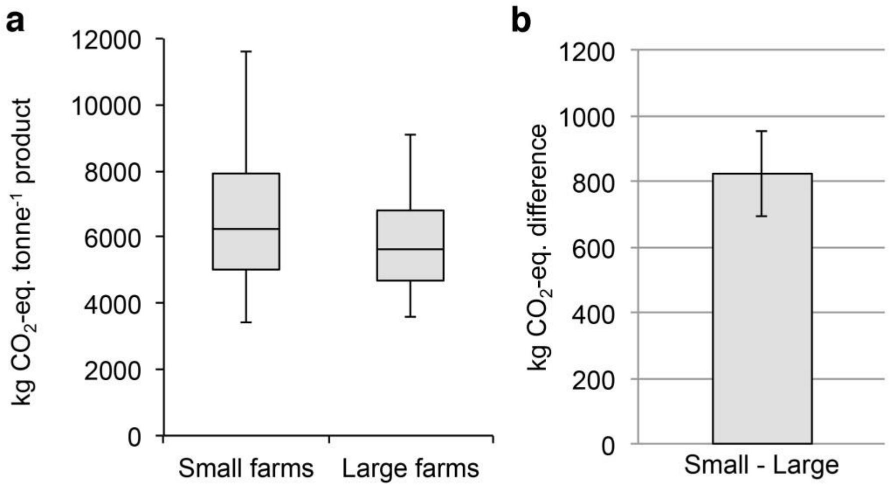
Example of characterization results

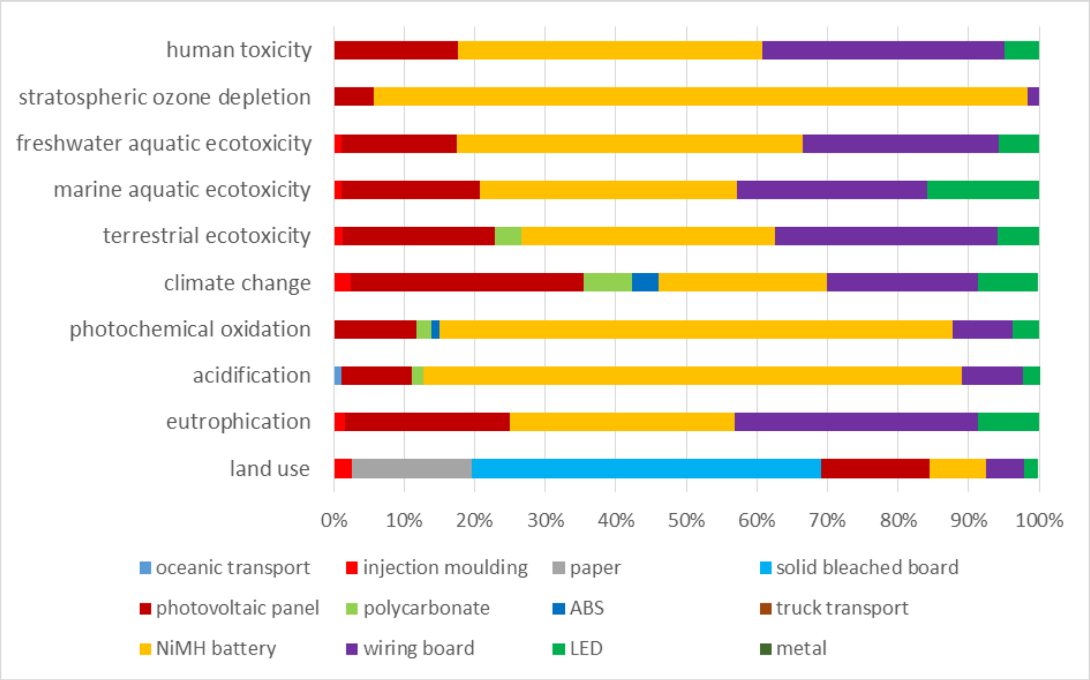
PEF recommended methods

Impact category (PEF)	Product 1	Product 2	Unit
climate change	6.77E-01	9.22E-02	kg CO2-Eq
freshwater and terrestrial acidification	1.22E-03	6.20E-04	mol H+-Eq
freshwater ecotoxicity	1.94E+00	6.52E-01	CTUh.m3.yr
freshwater eutrophication	2.66E-04	4.20E-05	kg P-Eq
marine eutrophication	3.95E-04	1.06E-04	kg N-Eq
terrestrial eutrophication	3.88E-03	1.06E-03	mol N-Eq
hh carcinogenic effects	2.26E-08	6.52E-09	CTUh
hh non-carcinogenic effects	7.68E-08	4.54E-08	CTUh
hh ozone layer depletion	2.62E-08	4.72E-09	kg CFC-11-Eq
hh photochemical ozone creation	9.69E-04	2.87E-04	kg ethylene-Eq
hh respiratory effects, inorganics	1.72E-04	6.50E-05	kg PM2.5-Eq
resources//land use	3.18E-01	8.19E-02	kg Soil Organic Carbon
resources//mineral, fossils and renewables	8.16E-07	4.26E-06	kg Sb-Eq

Interpretation

- Conclusions, recommendations, analyses, all related to goal and scope of the research
  - detailed analysis of results: where are the hot spots ?
    - contribution analysis



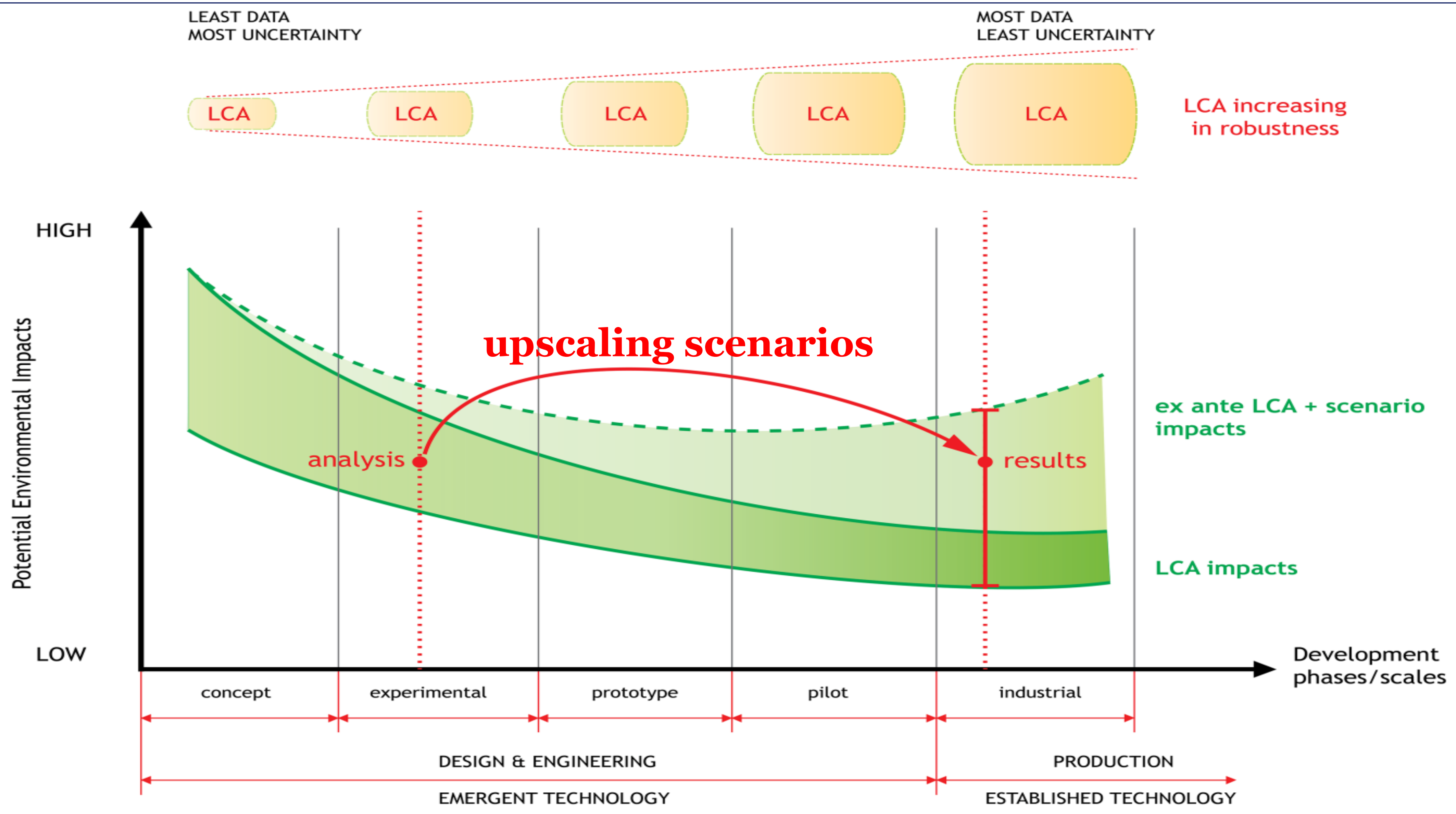


  - uncertainty analysis etc.

EX-ANTE
ANTICIPATORY
EARLY-ON
PROSPECTIVE

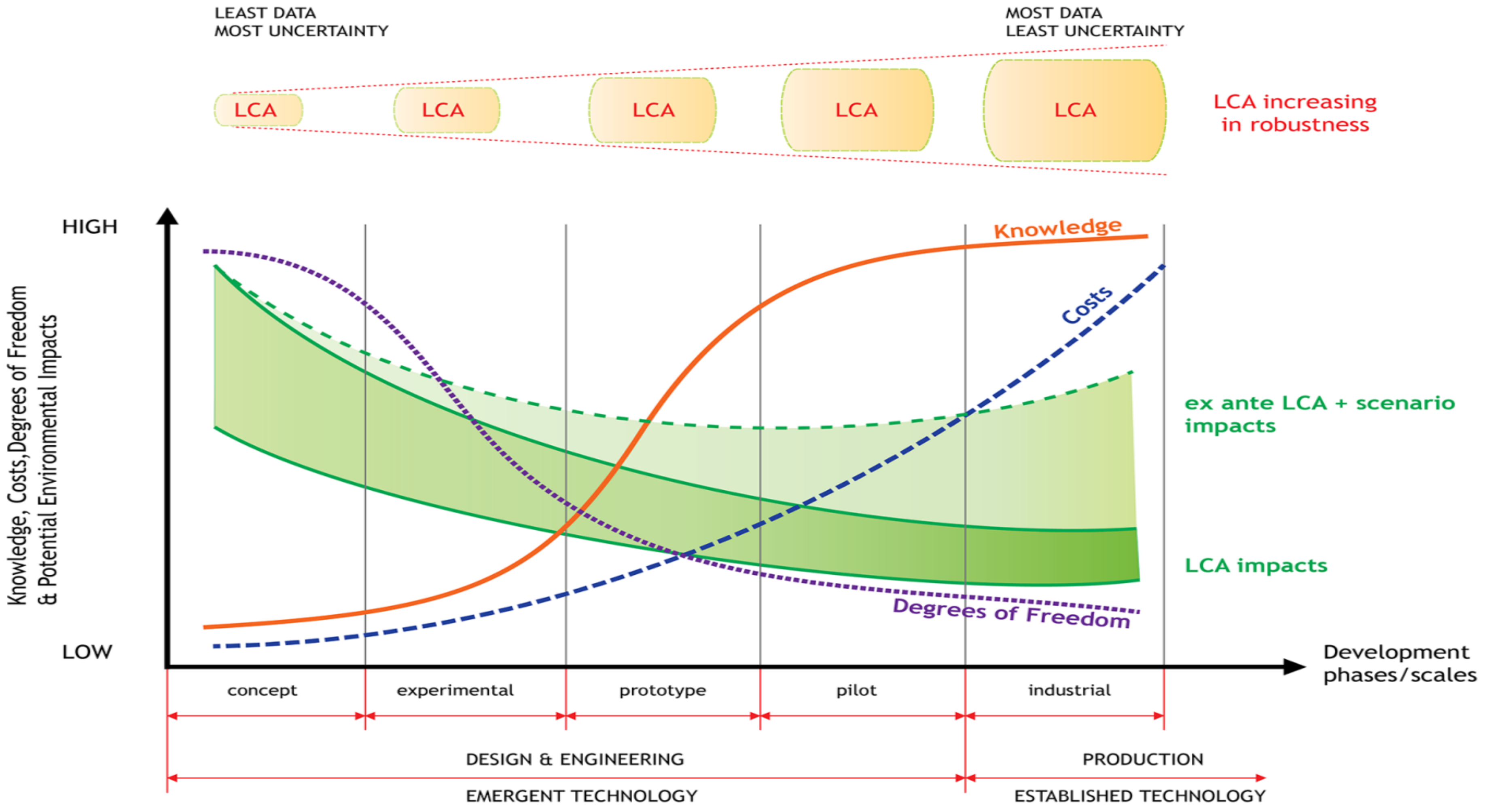
LCA FOR GUIDING PRODUCT & TECHNOLOGY DEVELOPMENT

Technology development & LCA



Source: composite diagram by Marco Villares, derived from Zschieschang et al. (2012), Hummen (2014) and Hetherington et al. (2013)

Technology development & LCA



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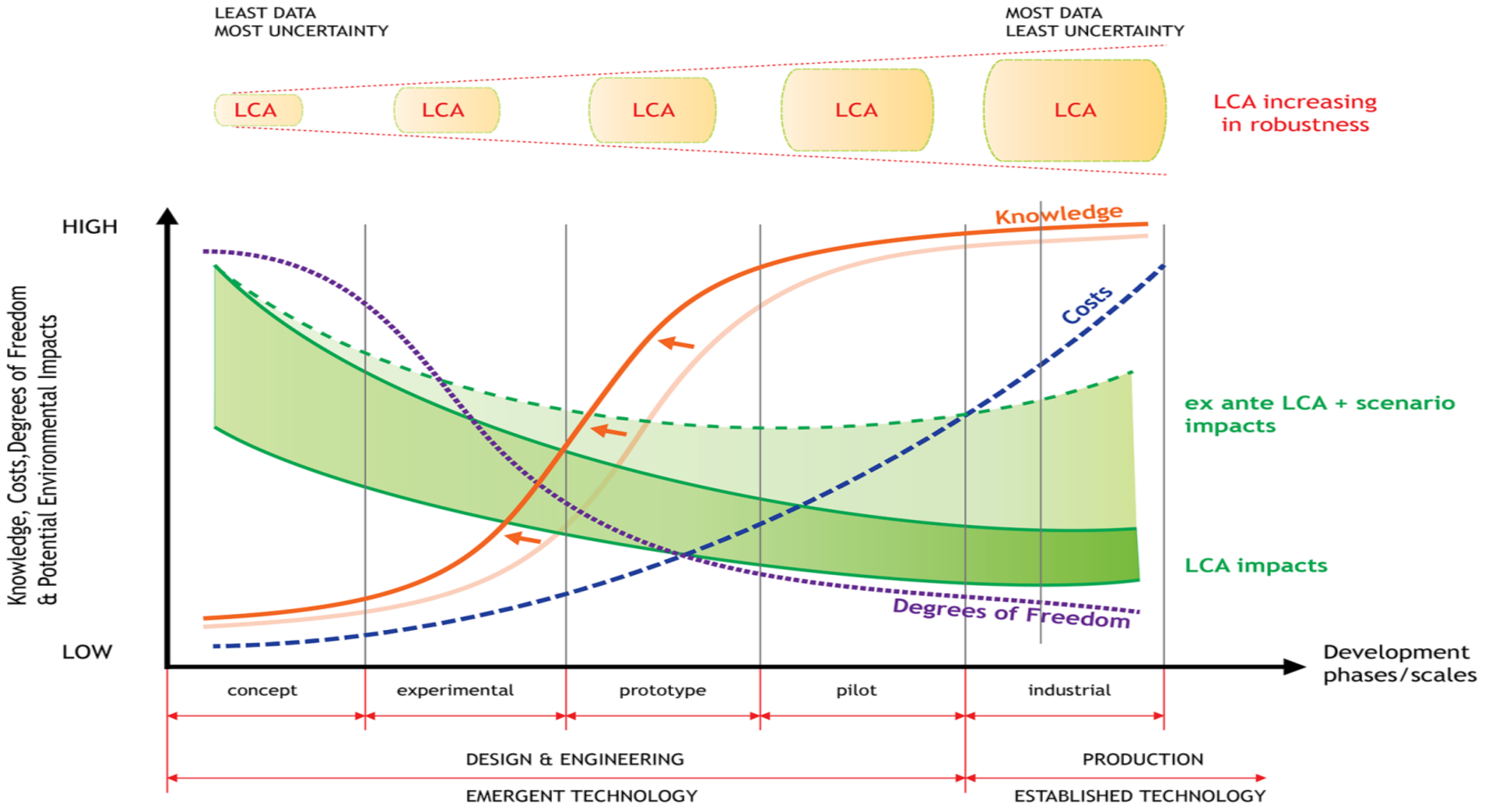
Technology development & LCA



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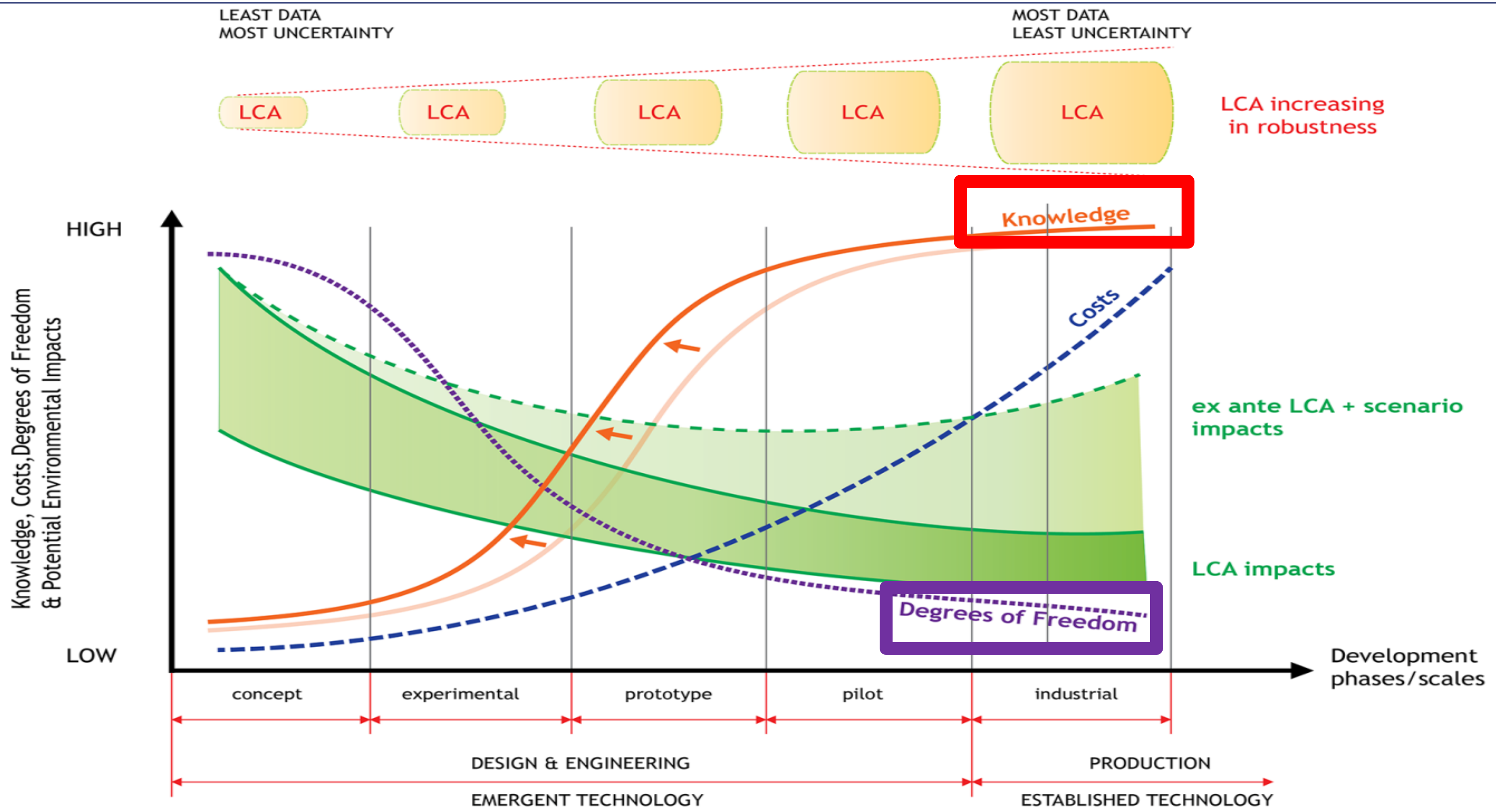
Technology development & LCA



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Key messages

- Don’t claim green, proof it
- LCA is accepted and standardized method for assessing product and technology systems
- LCA is more than just a ‘carbon footprint’
- Ex-ante LCA is emerging and useful for guiding technology development in more sustainable directions
- More sustainable solutions will have to come from *multidisciplinary cooperation* between engineering and sustainability/LCA communities