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Introduction LCA

BIM-LCA training activity

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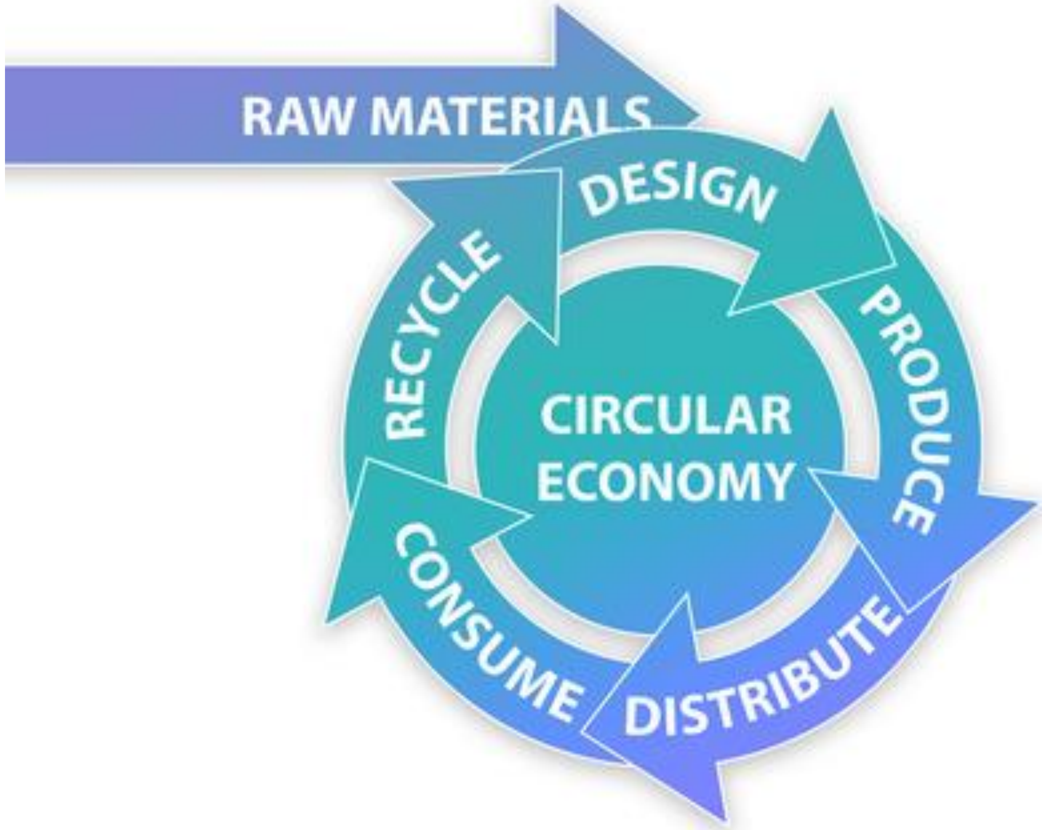
Life cycle assessment (LCA)



Assessment of environmental impact througout the value chain from raw materials extraction, transport, processing, use and end of life

Co-funded by the European Union

Functional unit for comparision

- Coca-Cola known for first LCA
- Energy accounting
- Compare beverage containers
- Plastic better than perception
- Aluminium recycling important

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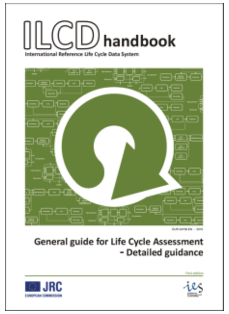
General LCA methods

- Standardised with ISO 14044 as general method
- UN Environment initiative: https://www.lifecycleinitiative.org/
- European Commission plattform for LCA: https://eplca.jrc.ec.europa.eu/



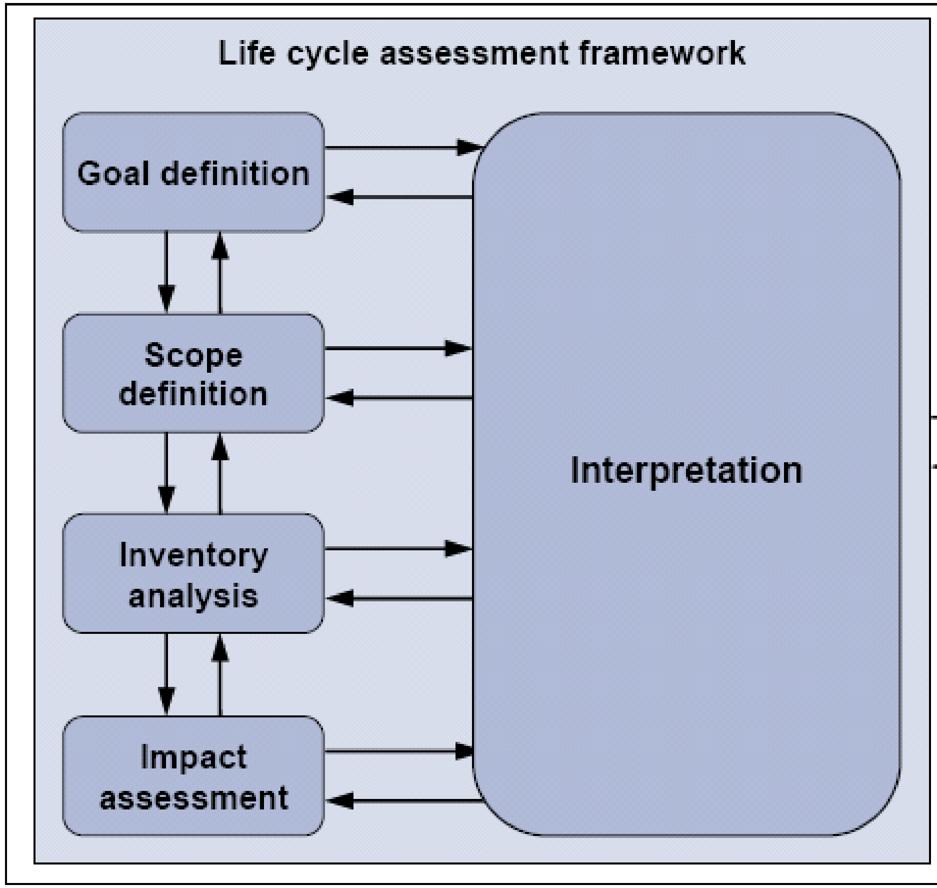
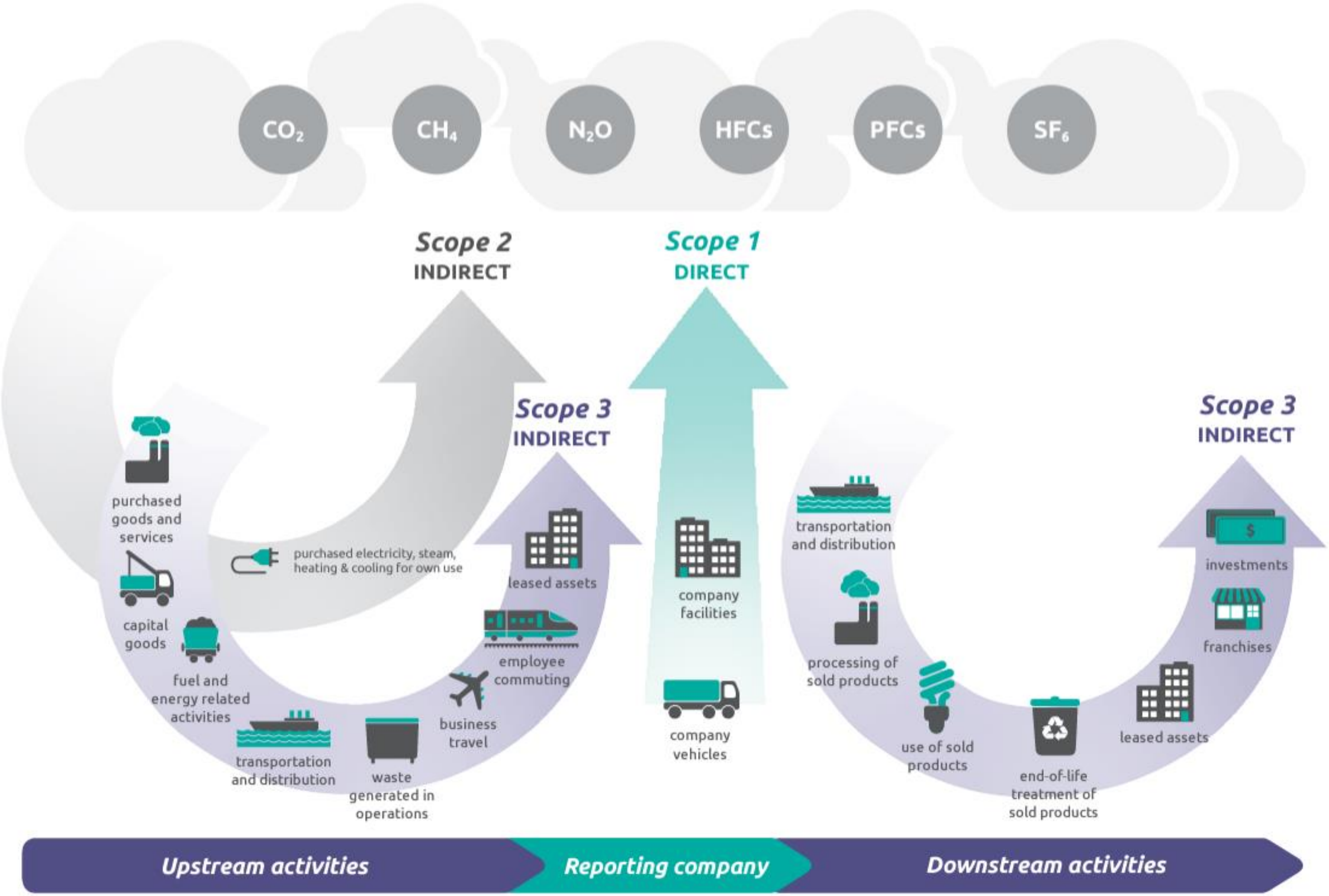


Figure 1 Framework for life cycle assessment (from ISO

LCA for carbon footprint

Figure [1.1] Overview of GHG Protocol scopes and emissions across the value chain



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Environmental product declarations (EPD)

- Results of LCA for one product
- Objective and verified
- Several standards available


ENVIRONMENTAL PRODUCT DECLARATION

I henhold til: ISO 14025 ISO 21930 EN 15804

epd-norge.no
The Norwegian EPD Foundation

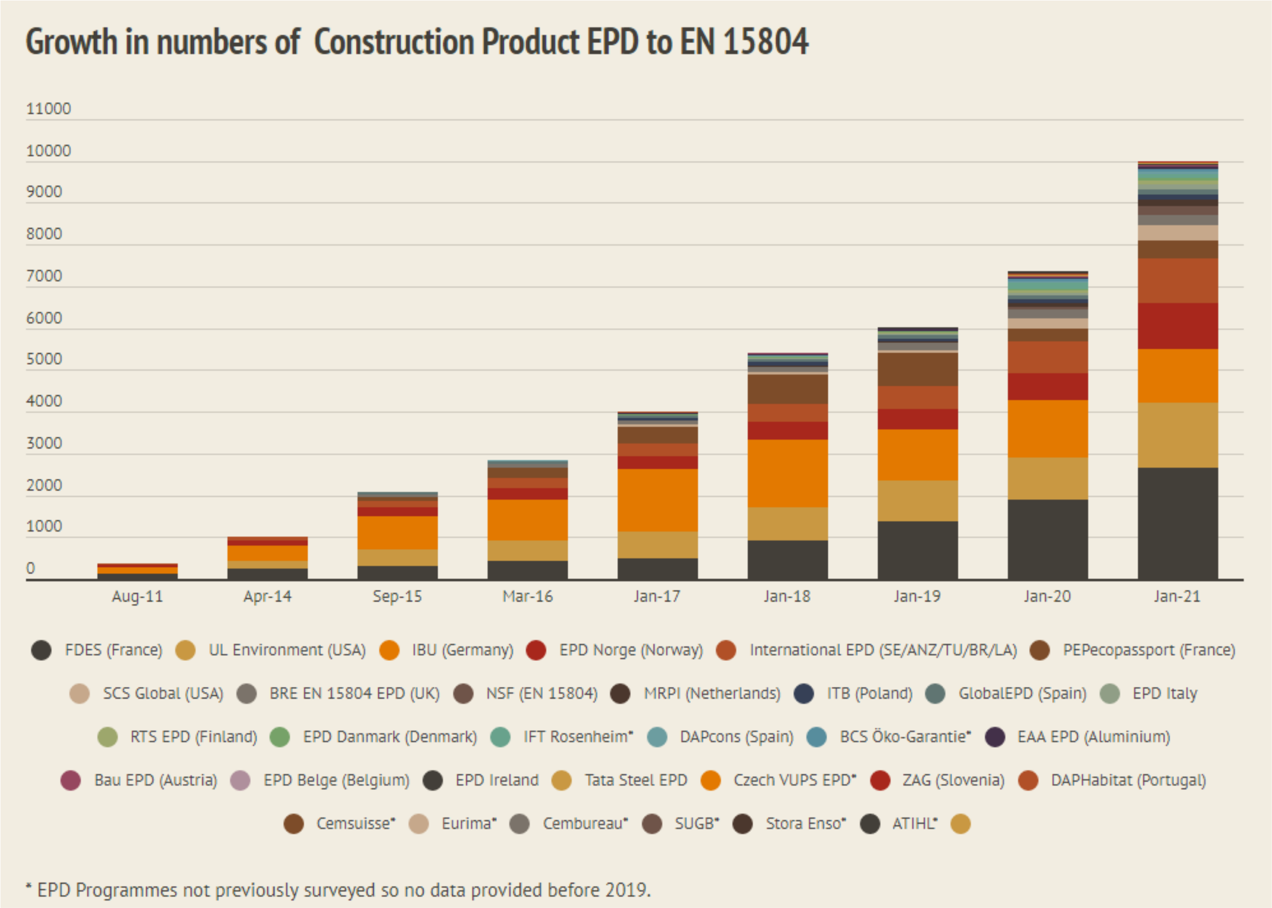
Eier av deklarasjonen	Marnar Bruk AS
Utgiver	Næringslivets Stiftelse for Miljødeklarasjoner
Deklarasjonens nummer	NEPD00294N
Godkjent dato	16.12.2014
Gyldig til	16.12.2019

Royalimpregnert trelast
Produkt

Marnar Bruk AS
Eier av deklarasjon

MARNAR BRUK

Environmental product declarations (EPD)



Anderson (2021)

Co-funded by the European Union

LCA in EPD, many impact indicators

Kjerneindikatorer for miljøpåvirkning

Indikator	Enhet	A1	A2	A3	A1-A3
GWP-total	kg CO2 ekv.	5,93E+00	2,14E+00	1,81E+00	9,87E+00
GWP-fossil	kg CO2 ekv.	2,15E+01	2,13E+00	1,76E+00	2,54E+01
GWP-biogent	kg CO2 ekv.	-1,56E+01	1,82E-03	3,85E-02	-1,56E+01
GWP-LULUC	kg CO2 ekv.	2,32E-02	8,56E-04	6,22E-03	3,02E-02
ODP	kg CFC11 ekv.	2,67E-06	4,98E-07	1,12E-07	3,28E-06
AP	mol H^+ ekv.	1,37E-01	1,74E-02	1,97E-02	1,74E-01
EP-ferskvann	kg P ekv.	9,16E-04	1,35E-05	9,73E-05	1,03E-03
EP-marint	kg N ekv.	2,82E-02	4,74E-03	2,27E-03	3,52E-02
EP-terrestrisk	mol N ekv.	3,42E-01	5,25E-02	2,90E-02	4,24E-01
POCP	kg NMVOC ekv.	1,07E-01	1,52E-02	8,33E-03	1,30E-01
ADP-M&M	kg Sb ekv.	2,77E-04	4,58E-06	2,76E-04	5,58E-04
ADP-fossil	MJ	3,49E+02	3,24E+01	1,93E+01	4,00E+02
WDP	m^3	1,67E+01	1,04E-01	5,76E-01	1,74E+01

Ressursbruk

Parameter	Enhet	A1	A2	A3	A1-A3
RPEE	MJ	2,29E+02	3,90E-01	7,53E+00	2,37E+02
RPEM	MJ	2,67E+02	0,00E+00	0,00E+00	2,67E+02
TPE	MJ	4,96E+02	3,90E-01	7,53E+00	5,04E+02
NRPE	MJ	3,49E+02	3,24E+01	1,93E+01	4,00E+02
NRPM	MJ	2,96E+01	0,00E+00	0,00E+00	0,00E+00
TRPE	MJ	3,49E+02	3,24E+01	1,93E+01	4,00E+02
SM	kg	0,00E+00	0,00E+00	0,00E+00	0,00E+00
RSF	MJ	0,00E+00	0,00E+00	0,00E+00	0,00E+00
NRSF	MJ	0,00E+00	0,00E+00	0,00E+00	0,00E+00
W	m3	4,77E-01	3,61E-03	3,59E-02	5,16E-01

Indikator	Enhet	A1	A2	A3	A1-A3
EP-ferskvann*	kg PO_4 ekv.	1,50E-02	1,82E-03	1,27E-03	1,81E-02
GWP-IOBC	kg CO_2 ekv.	2,15E+01	2,13E+00	1,77E+00	2,54E+01
GWP-BC	kg CO_2 ekv.	-1,56E+01	1,82E-03	3,85E-02	-1,56E+01
GWP	kg CO_2 ekv.	5,93E+00	2,14E+00	1,81E+00	9,87E+00

Supplerende indikatorer for miljøpåvirkning

Indikator	Enhet	A1	A2	A3	A1-A3
PM	Sykdomstilfeller	2,03E-06	2,25E-07	1,68E-07	2,43E-06
IRP	kBq U235 ekv.	7,81E-01	1,40E-01	6,05E-02	9,82E-01
ETP-fw	CTUe	5,94E+02	2,47E+01	1,25E+02	7,44E+02
HTP-c	CTUh	1,87E-07	7,85E-10	1,06E-08	1,98E-07
HTP-nc	CTUh	3,72E-07	2,59E-08	1,84E-07	5,82E-07
SQP	Pt	1,20E+03	3,33E+01	7,43E+01	1,31E+03

Livsløpets slutt - Avfall

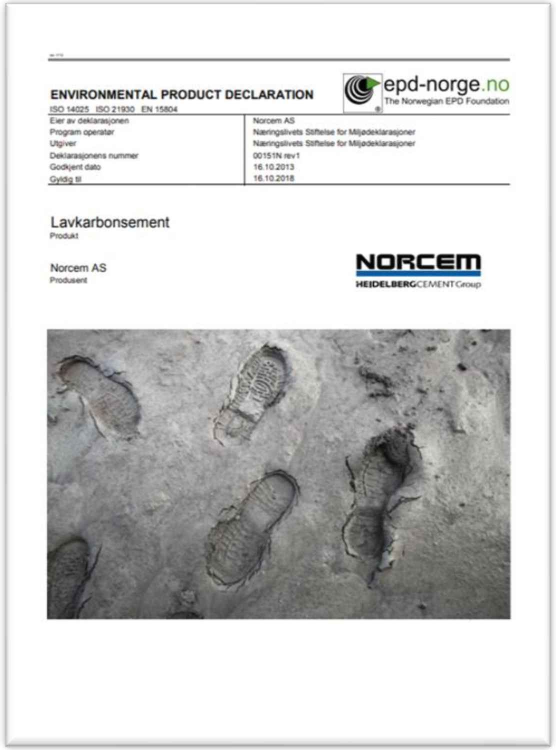
Parameter	Enhet	A1	A2	A3	A1-A3
HW	KG	7,34E-04	7,28E-05	8,46E-05	8,92E-04
NHW	KG	2,05E+01	2,87E+00	5,99E+00	2,94E+01
RW	KG	7,57E-04	2,20E-04	5,78E-05	1,04E-03

HW Avhendet farlig avfall; NHW Avhendet ikke-farli

Livsløpets slutt – Utgangsfaktorer

Parameter	Enhet	A1	A2	A3	A1-A3
CR	kg	0,00E+00	0,00E+00	0,00E+00	0,00E+00
MR	kg	0,00E+00	0,00E+00	2,22E-03	2,22E-03
MER	kg	0,00E+00	0,00E+00	6,53E-02	6,53E-02
EEE	MJ	0,00E+00	0,00E+00	2,87E-02	2,87E-02
ETE	MJ	0,00E+00	0,00E+00	3,16E-01	3,16E-01

Digital EPD data – from January 2019 EPD data will also be machine readable



ENVIRONMENTAL PRODUCT DECLARATION
ISO 14025 ISO 21930 EN 15804

epd-norge.no
The Norwegian EPD Foundation

Eier av deklarasjonen	Norcem AS
Program operatør	Næringslivets Stiftelse for Miljødeklarasjoner
Utgiver	Næringslivets Stiftelse for Miljødeklarasjoner
Deklarasjonens nummer	00151N rev1
Godkjent dato	16.10.2013
Gyldig til	16.10.2018

Lavkarbonsement
Produkt

Norcem AS
Produsent

NORCEM
HEIDELBERGCEMENT Group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    - <dataSetInformation>
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        </name>
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          constituents. When water is added to cement, a cement paste is formed, which sets and hardens by
          means of hydration reactions. After hardening, it retains its strength and stability even under water.
          The declared product is a cement conforming with the average composition of CEM I 52.5 R cements
          manufactured by Cementa in the plants Slite and Skövde in 2013. The calculation is based on plant-
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Atributional and consequential LCA

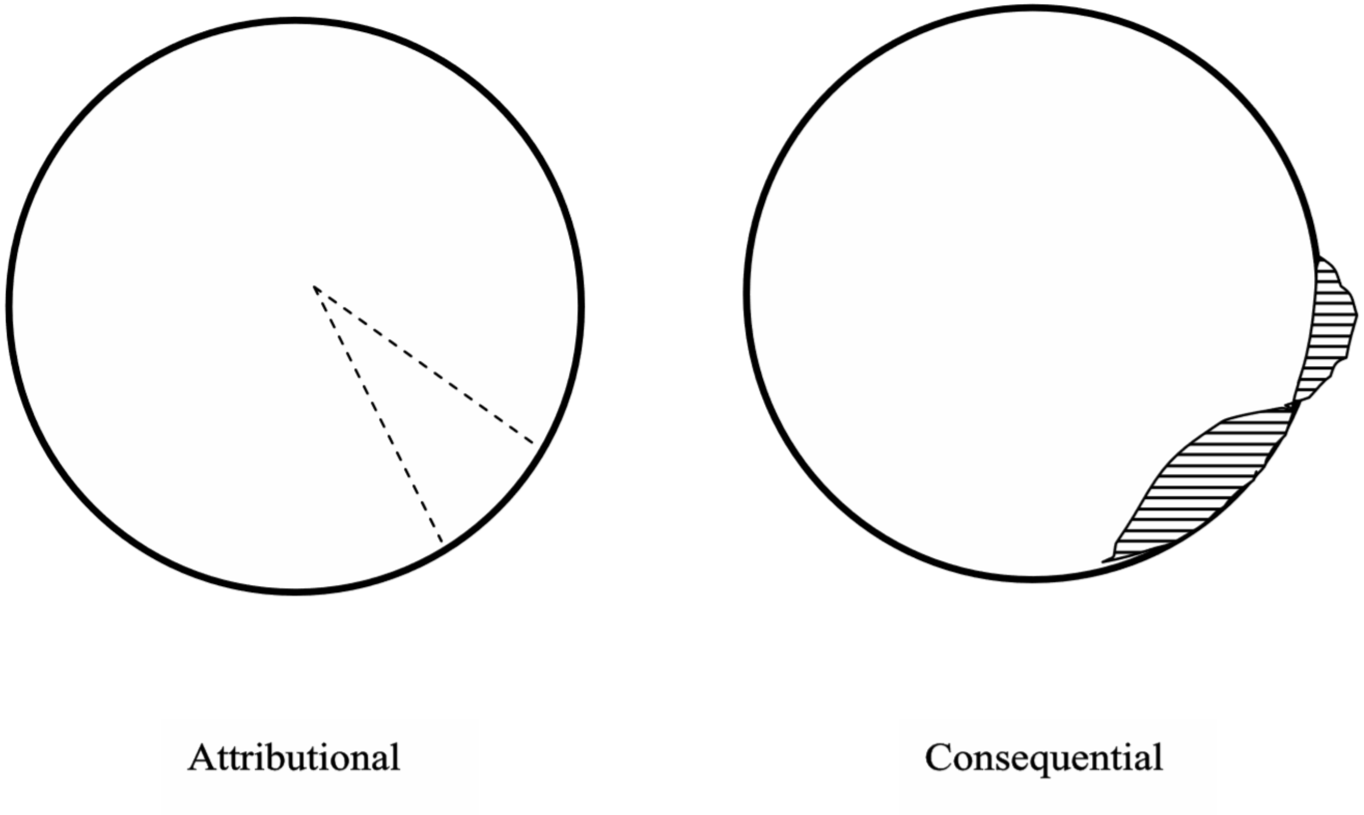


Illustration: Weidema (2003)

Inventory

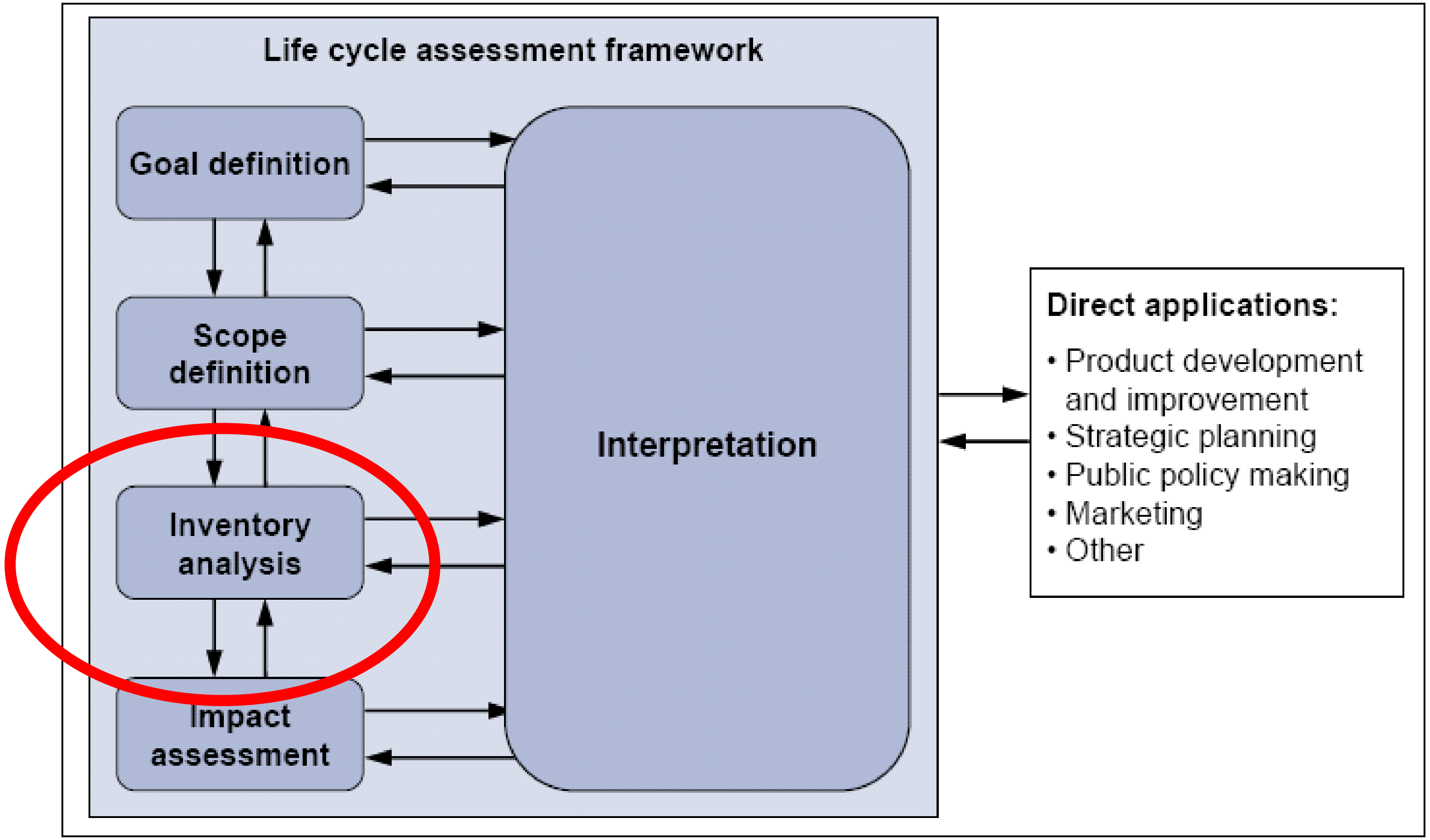
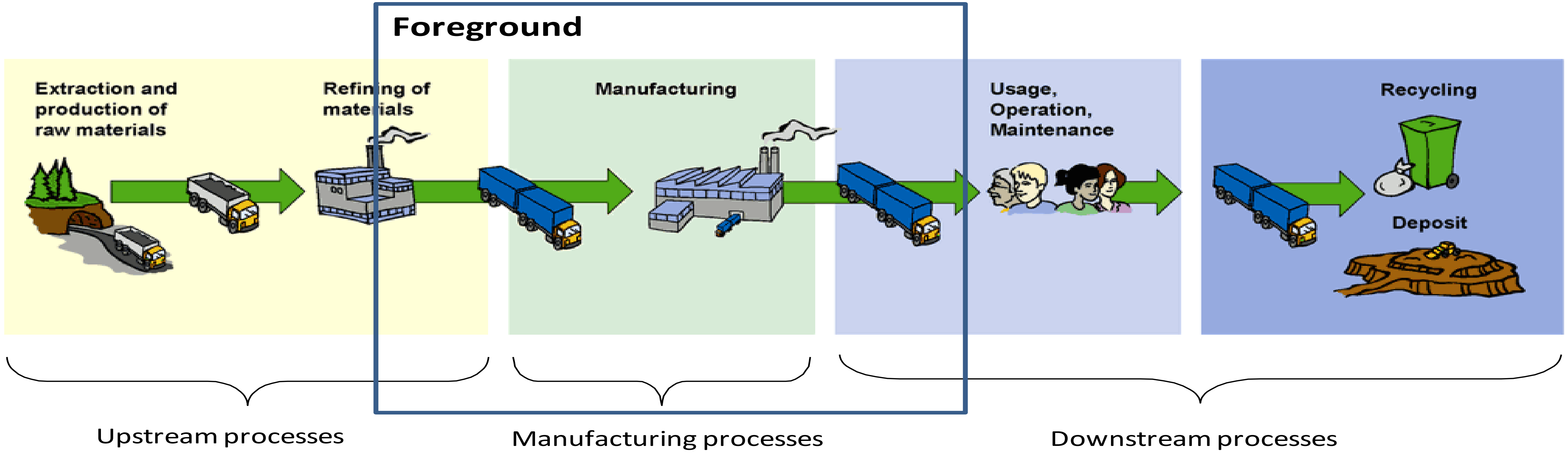


Figure 1 Framework for life cycle assessment (from ISO 14040:2006; modified)

Inventory based on database of background data



Unit process

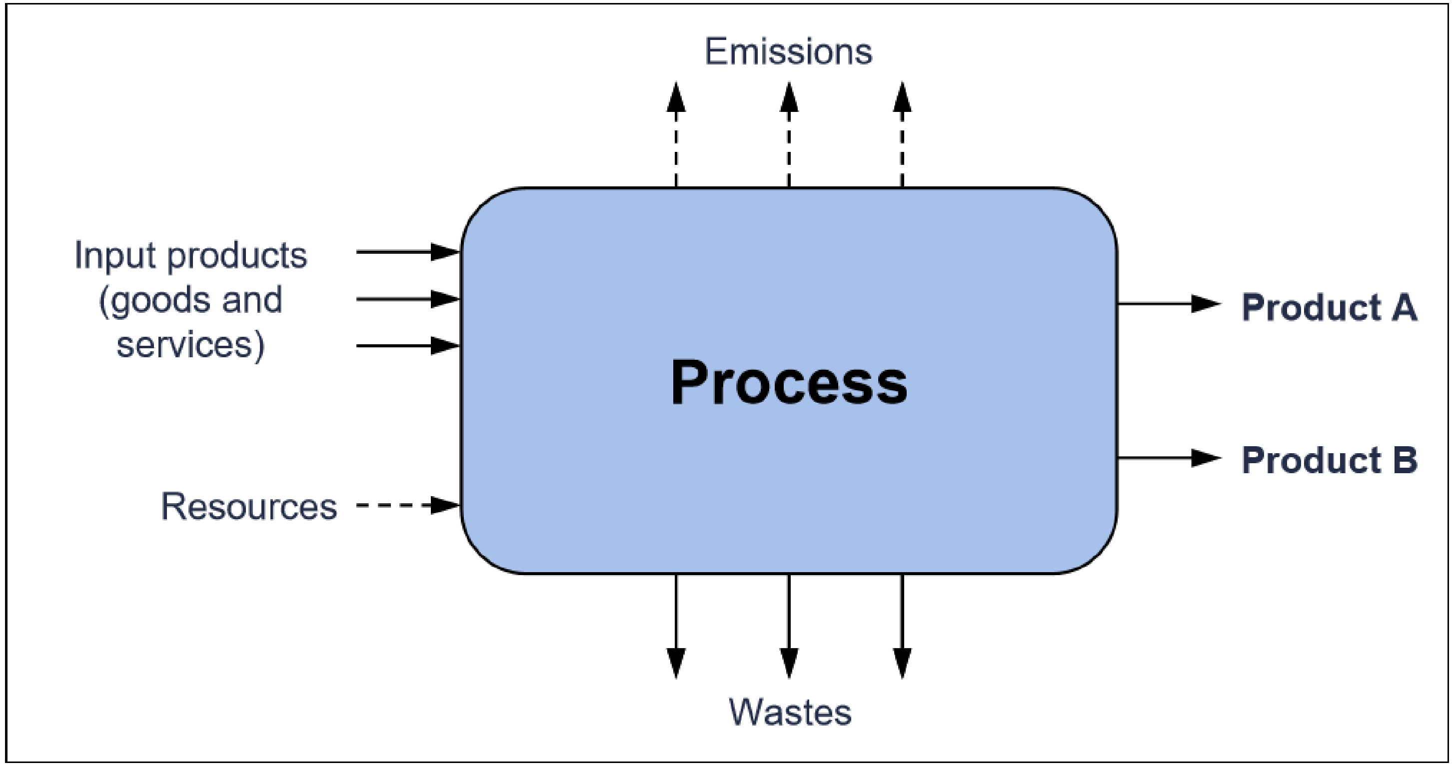


Figure 6 Multifunctional process with several input products and resources consumed and various wastes and emissions generated as well as providing the two co-products 1 and 2.

Example LCI data forestry in ecoinvent

Exchange summary

Reference product	Byproduct classif.	Amount
sawlog and veneer log, softwood, measured as solid wood under bark	allocatable product	1 m3
Inputs from technosphere		Amount
diesel, burned in building machine		15.8 MJ
forwarding, forwarder		0.0488 hour
gravel, crushed		9.34 kg
harvesting, forestry harvester		0.0979 hour
power sawing, without catalytic converter		0.106 hour
skidding, skidder		0.00134 hour
tree seedling, for planting		11.3 unit
Inputs from environment		Amount
Carbon dioxide, in air		8.88e+2 kg
Energy, gross calorific value, in biomass		1.00e+4 MJ
Occupation, forest, intensive		1.87e+3 m2*year
Occupation, traffic area, rail/road embankment		7.12 m2*year
Transformation, from forest, intensive		23.4 m2
Transformation, from traffic area, rail/road embankment		0.089 m2
Transformation, to forest, intensive		23.4 m2
Transformation, to traffic area, rail/road embankment		0.089 m2
Wood, soft, standing		1 m3

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Allocation – example from sawmills

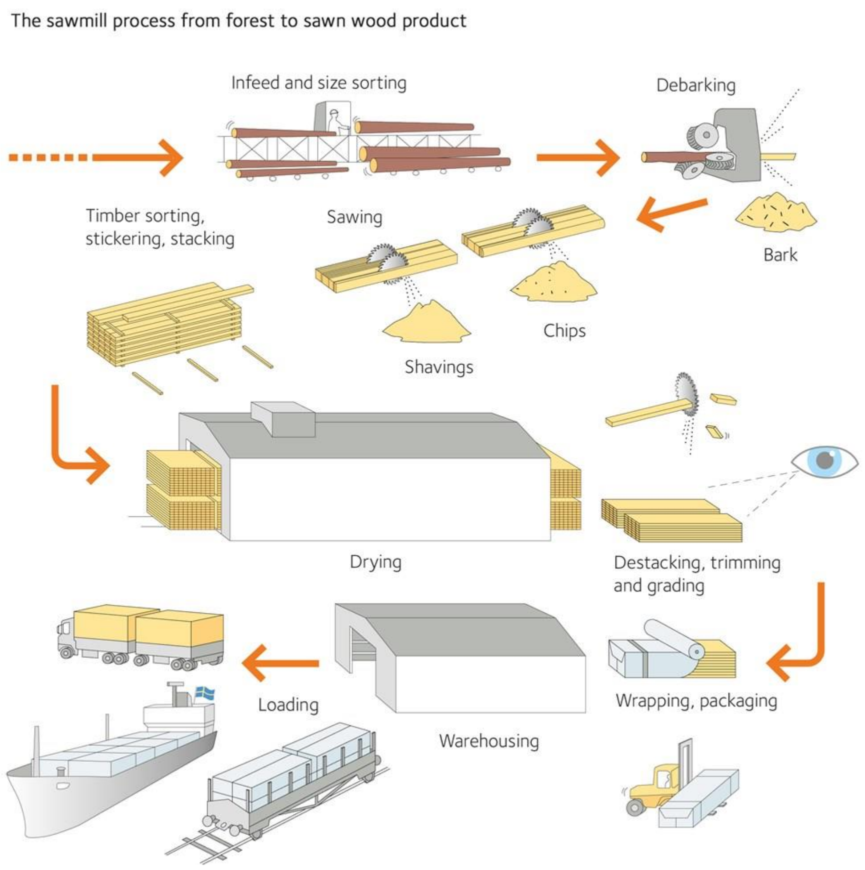
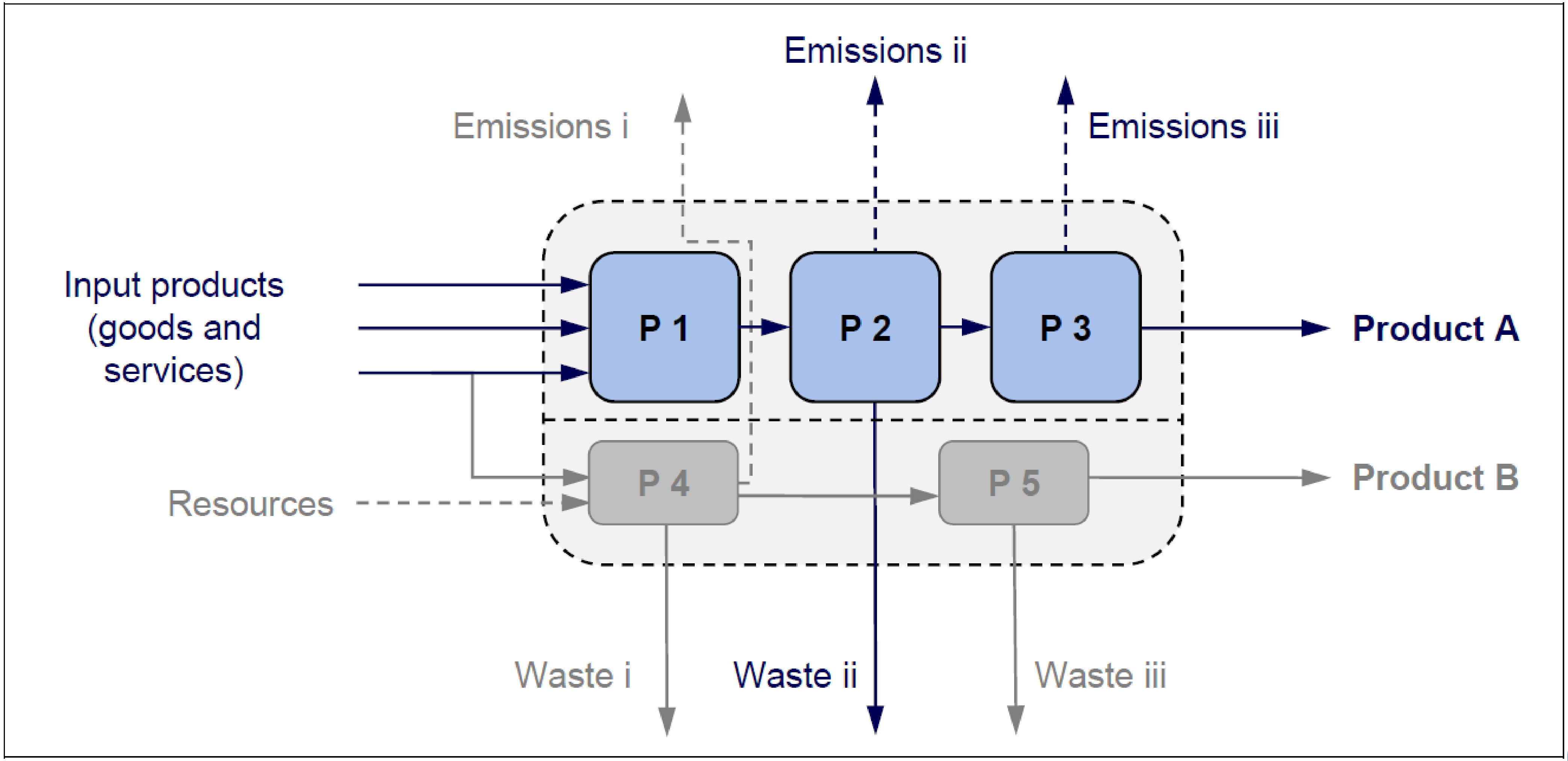
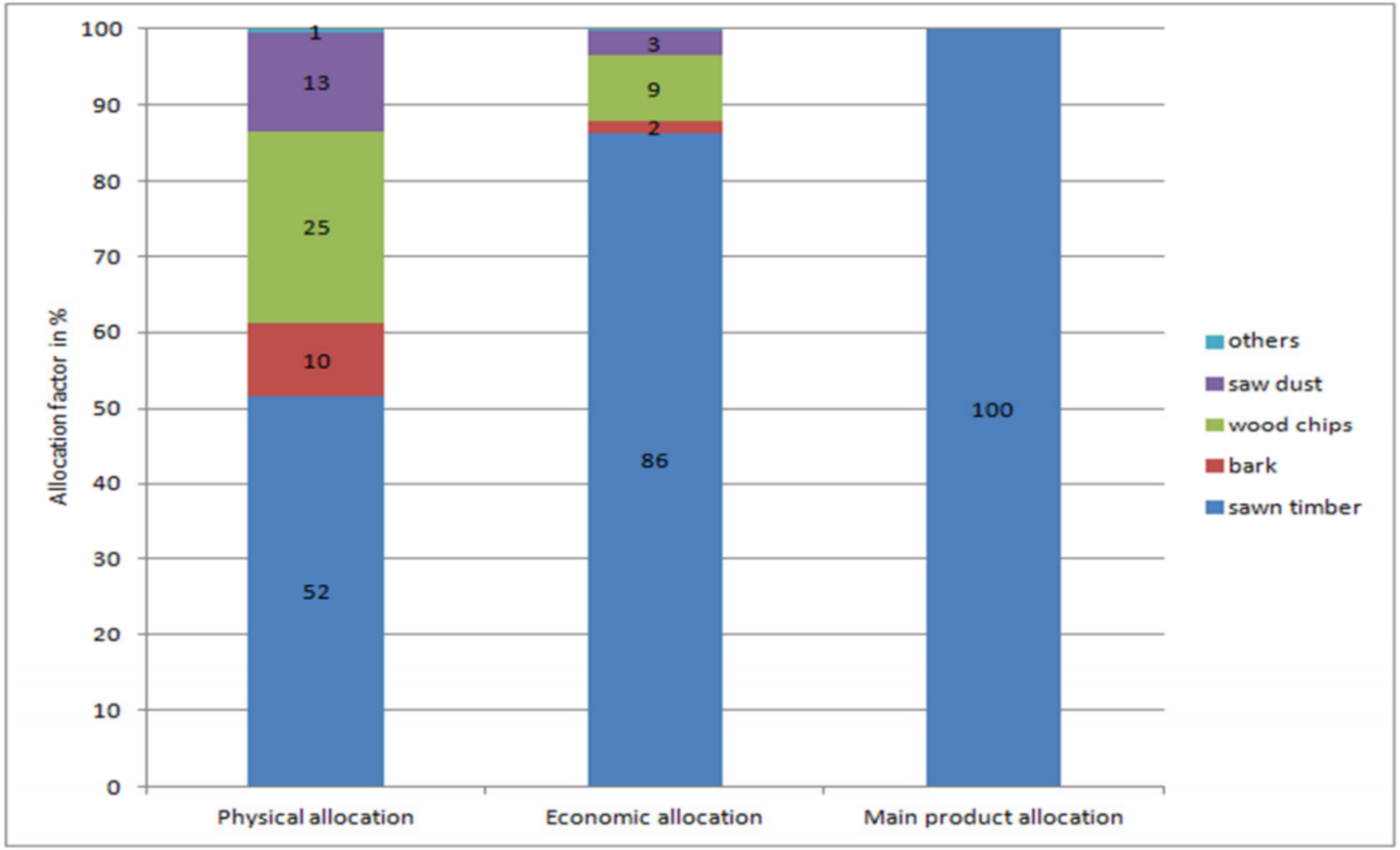


Illustration: Swedish wood

Allocation – preferably by sub division



Different allocation methods - sawmills



(Dolezal et al., 2014)

Impact assessment

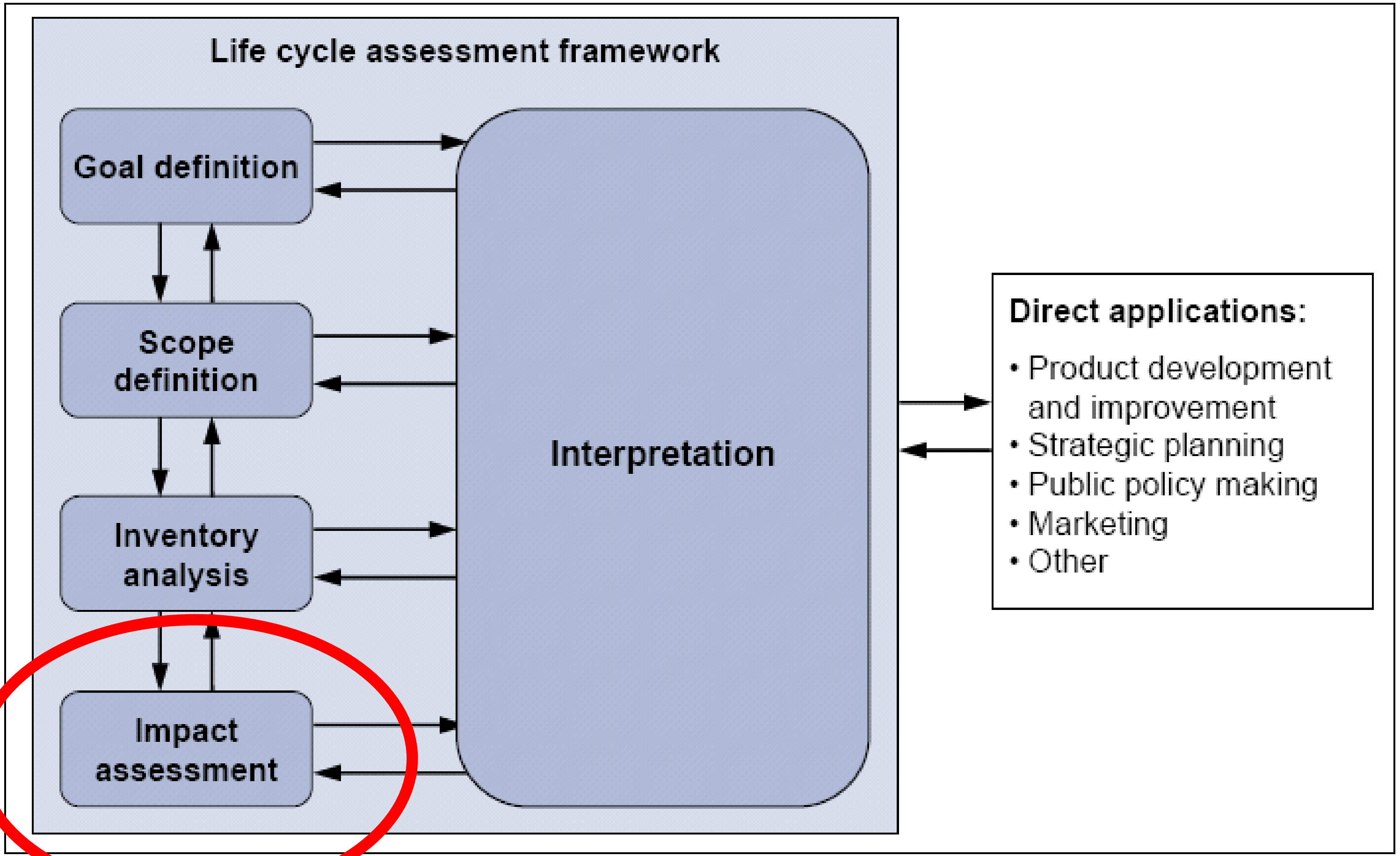


Figure 1 Framework for life cycle assessment (from ISO 14040:2006; modified)

Different types of envrionmental impacts

Acid rain?

Resource depletion?

Climate change?

Particle matter?

Toxicity?

Micro plastic?

Characterisation factors (CF) – climate change

Elementary flow (emission)	CF 20 years	CF 100 years
Carbon dioxide	1	1
Methane	85	30
Denitrogen oxide	264	265
PFPMIE (perfluoropolymethylisopropyl ether)	7500	9710

Impact categories and robustness

EF Impact category	Impact category Indicator	Unit	Characteri-zation model	Robust-ness
Climate change, total[23]	Radiative forcing as global warming potential (GWP100)	kg $CO_{2\,eq}$	Baseline model of 100 years of the IPCC (based on IPCC 2013)	I
Ozone depletion	Ozone Depletion Potential (ODP)	kg CFC-11 $_{eq}$	Steady-state ODPs as in (WMO 2014 + integrations)	I
Human toxicity, cancer	Comparative Toxic Unit for humans (CTU_h)	CTUh	USEtox model 2.1 (Fankte et al, 2017)	III
Human toxicity, non-cancer	Comparative Toxic Unit for humans (CTU_h)	CTUh	USEtox model 2.1 (Fankte et al, 2017)	III
Particulate matter	Impact on human health	disease incidence	PM method recomended by UNEP (UNEP 2016)	I
Ionising radiation, human health	Human exposure efficiency relative to U^{235}	kBq $U^{235}{}_{eq}$	Human health effect model as developed by Dreicer et al. 1995 (Frischknecht et al, 2000)	II
Photochemical ozone formation, human health	Tropospheric ozone concentration increase	kg NMVOC $_{eq}$	LOTOS-EUROS model (Van Zelm et al, 2008) as implemented in ReCiPe 2008	II
Acidification	Accumulated Exceedance (AE)	mol H+ $_{eq}$	Accumulated Exceedance (Seppälä et al. 2006, Posch et al, 2008)	II
Eutrophication, terrestrial	Accumulated Exceedance (AE)	mol N $_{eq}$	Accumulated Exceedance (Seppälä et al. 2006, Posch et al, 2008)	II
Eutrophication, freshwater	Fraction of nutrients reaching freshwater end compartment (P)	kg P $_{eq}$	EUTREND model (Struijs et al, 2009) as implemented in ReCiPe	II
Eutrophication, marine	Fraction of nutrients reaching marine end compartment (N)	kg N $_{eq}$	EUTREND model (Struijs et al, 2009) as implemented in ReCiPe	II
Ecotoxicity, freshwater	Comparative Toxic Unit for ecosystems (CTU_e)	CTUe	USEtox model 2.1 (Fankte et al, 2017)	III
Land use	• Soil quality index[24] • Biotic production • Erosion resistance • Mechanical filtration • Groundwater replenishment	• Dimensionless (pt) • kg biotic production • kg soil • m^3 water • m^3 groundwater	Soil quality index based on LANCA (Beck et al. 2010 and Bos et al. 2016)	III

https://eplca.jrc.ec.europa.eu/permalink/PEF_method.pdf

Costs of LCA

Table 1. Results of the cost survey

Task		Quartile (*$*) Lower	Median	Upper	*N*	Width of interquartile range
PCR	Scoping	485	1,693	3,375	6	2,890
	Research and drafting	2,114	5,928	17,563	8	15,449
	Review	1,013	5,072	8,587	7	7,574
	Total	2,738	15,000	25,625	9	22,887
EPD	LCA and EPD preparation	8,365	15,250	22,745	12	14,380
	Verification	2,108	2,447	3,413	12	1,305
	Registration	663	1,312	2,629	9	1,966
	Initial fees other than registration	528	750	947	6	419
	Annual running fee	587	973	1,531	10	944
	Total	10,309	12,826	30,001	15	19,692
Total of PCR and EPD		12,509	18,761	41,238	15	28,729

(Tasaki et al, 2021)

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LCA software – main types

- Excel can be used for simplifed LCA and carbon footprint
- General LCA software
  - Databases available
  - Possible to use different kind of impact assessment
  - For LCA-experts and research
- Specific LCA software
  - Available for eco-design, EPD, building-LCA, etc.
  - More efficient and user friendly, but less flexible and transparent

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Simplified general workflow LCA

- Goal and scope – read previous LCA from research
- Inventory – check ecoinvent processes in Simapro, then previous LCA from research, then collect own data
- Impact assessment – carbon footprint easy, ask LCA-expert if more indicators
- Interpretation – always explain simply what you have found and what are the uncertainties

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Sum up

LCA is very usefull to quantify environmental impacts

Software makes it easier, but also easier to get wrong results

Experience and good practice is important for robust results

Thank you

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Co-funded by the European Union