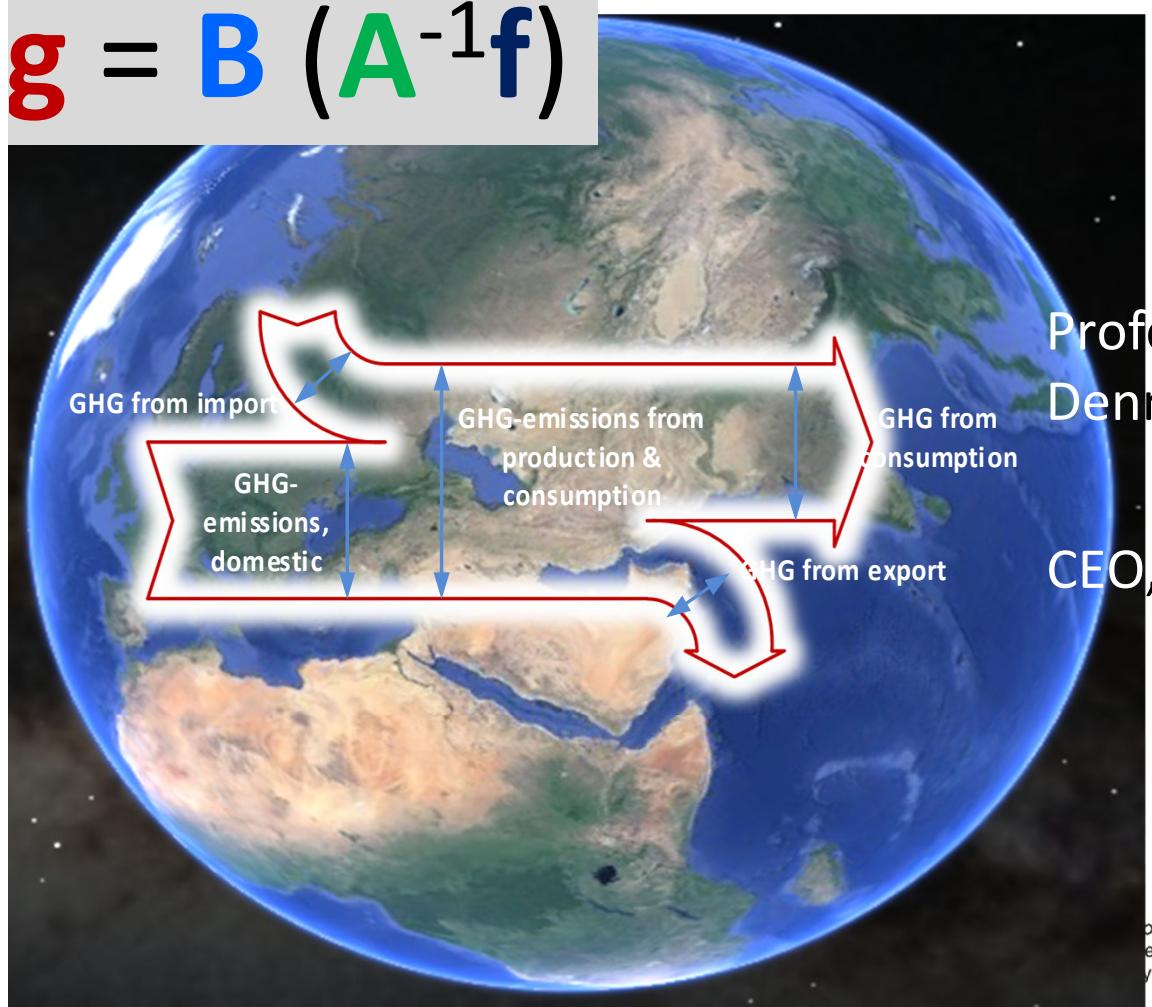


Input-output modelling

Introduction to hybrid LCA in SimaPro. Application examples of hybrid LCA

$$\mathbf{g} = \mathbf{B} (\mathbf{A}^{-1} \mathbf{f})$$



Jannick Schmidt

Professor, PhD, Aalborg University,
Denmark



CEO, 2.-0 LCA consultants



Agenda



- EXIOBASE v3 hybrid in SimaPro
- Application examples of hybrid LCA

- **Free download:** exiobase.eu
- **Granularity:** 200 products x 164 activities
- **Geography:** 43 countries + 5 RoW regions
- **Time:** 2000-2011
- **Extensions**
 - Waste: 17 homogenous fractions
 - Emissions: 62
 - Resources: 37
 - Land use
 - Value added (EUR)
 - Labor inputs (hours)
- **Unit of product flows:** EUR, kg, MJ

Can it be used as an LCA database?

- Available for SimaPro
- Scope
 - 7900 productive activities
 - 7900 national product markets
 - 290 final consumption activities
 - Adds up to global production and consumption (tonne, TJ, EUR)
- More consistent than process LCA (model, temporal, completeness)
- More aggregated than process LCA – but can be detailed
- True coverage of global supply-chains
- True industry baselines provided as part of the database

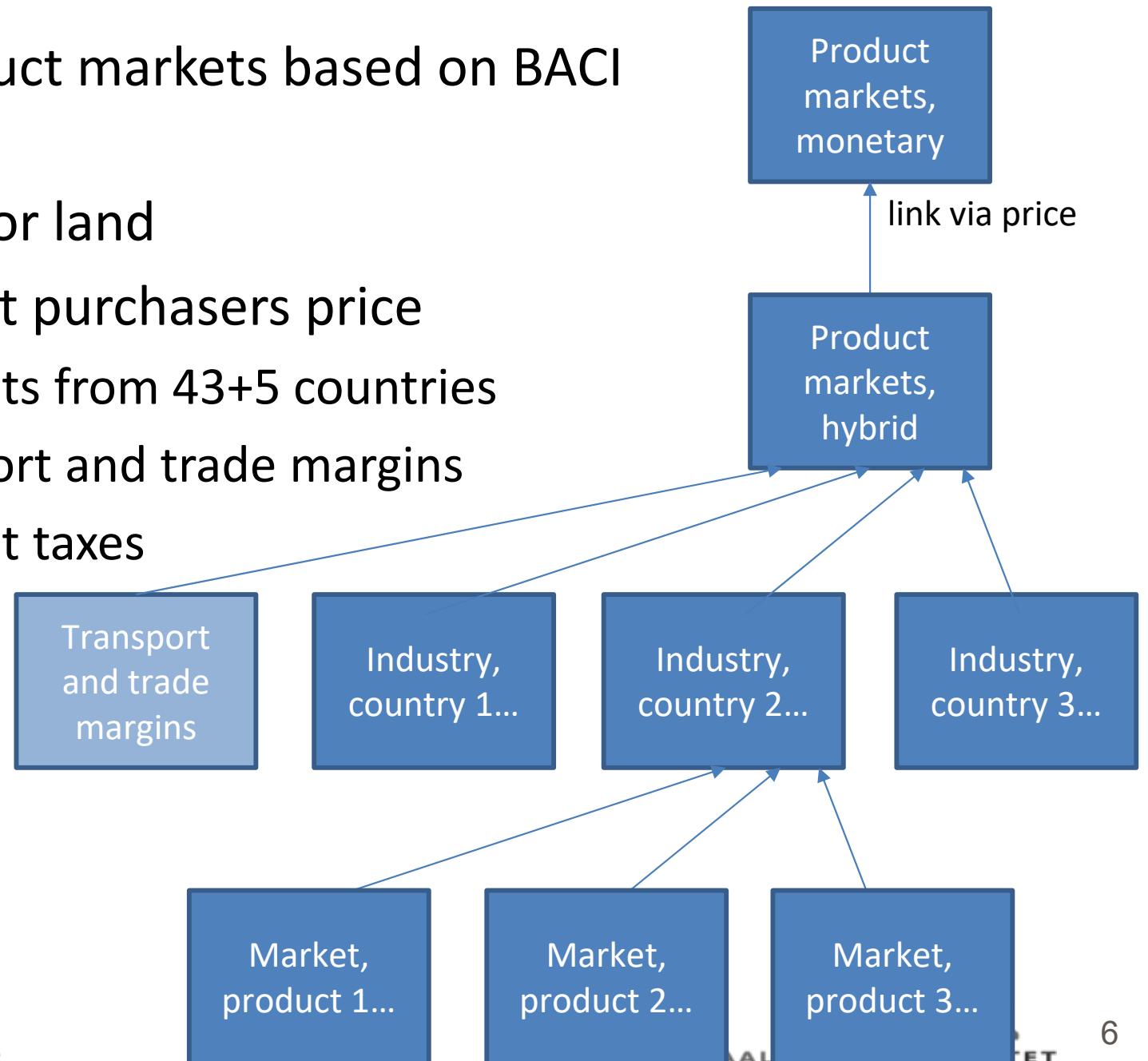
Exiobase v3.3.16-b2 in SimaPro

b2 = expanded version

- iLUC
- Marginal electricity markets
- Integrated investments in HIOT
- Improved water extensions
- Extensions prepared for social footprinting.

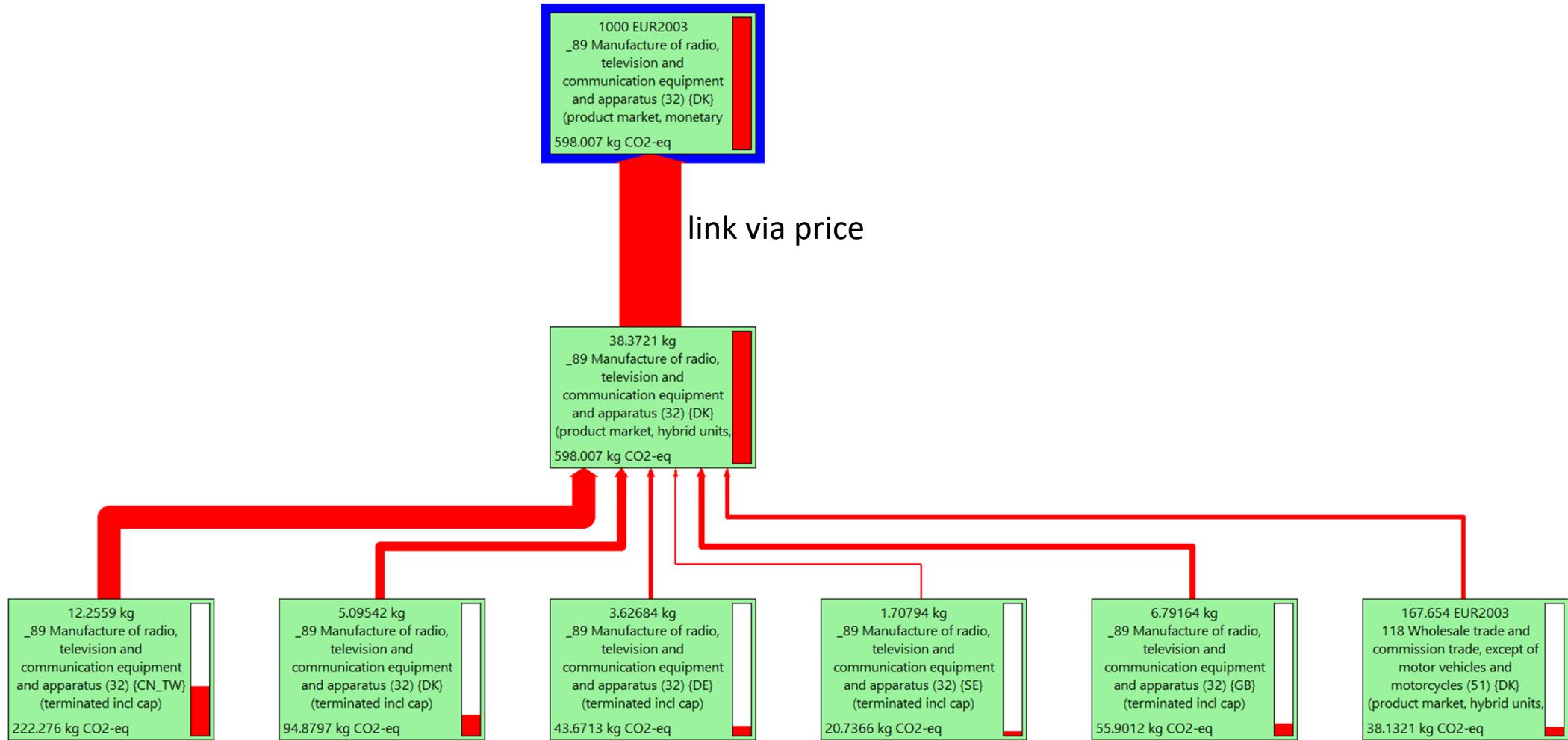
Product markets in EXIOBASE

- 152 national product markets based on BACI trade data
- 4 global markets for land
- Product markets at purchasers price
 - Inputs of products from 43+5 countries
 - Inputs of transport and trade margins
 - Inputs of product taxes



Product markets in EXIOBASE

- SimaPro example (1000 EUR television)



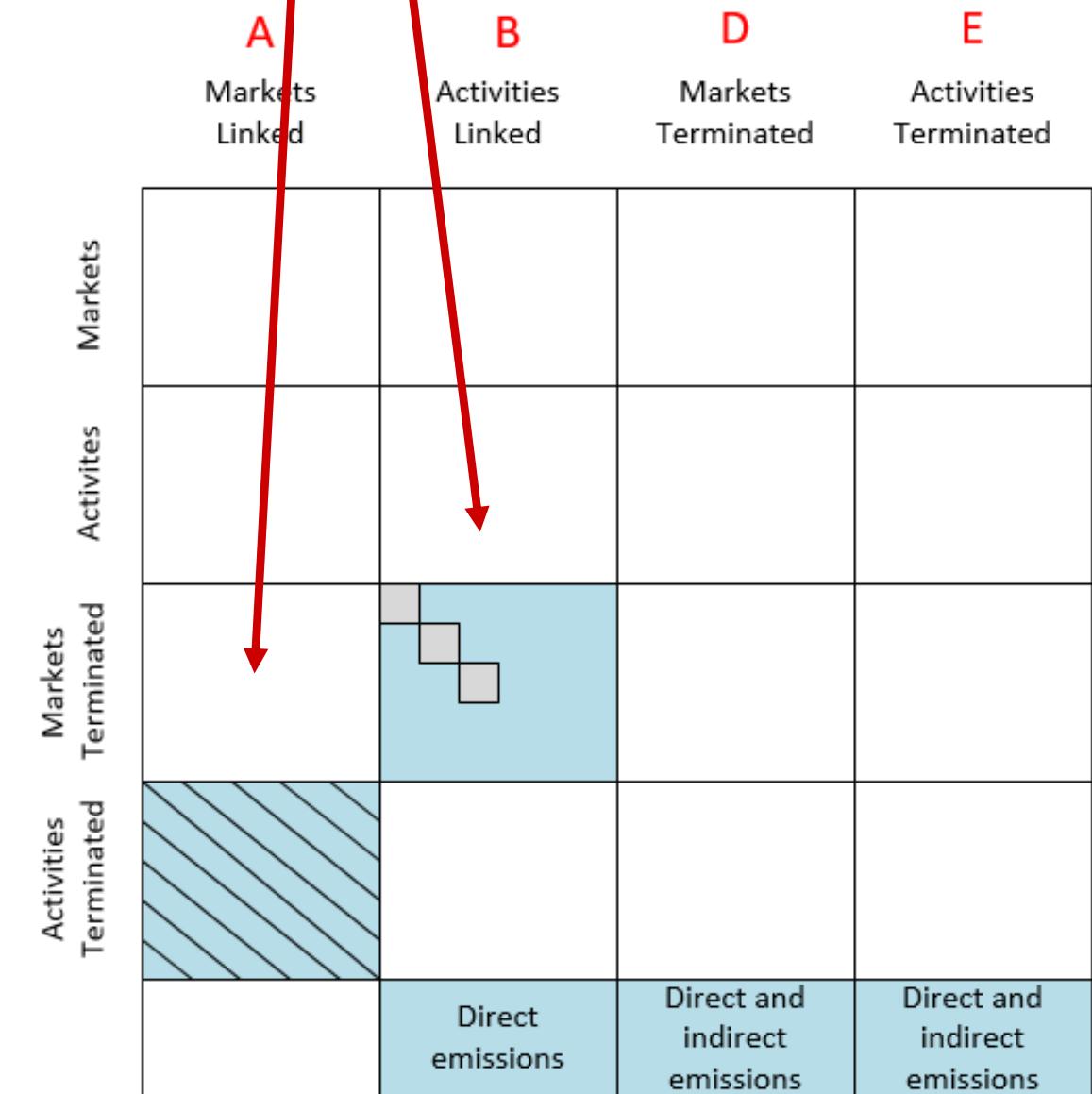
Exiobase in SimaPro

- Structure

- SimaPro cannot solve full DB
- Therefore, we use tiers
 - Tier 1: Links to tier 2
 - Tier 2: Terminated
- Transforming activities and markets:
 - Activities
 - Producing industries
 - Final demand
 - Markets

Product markets

Producing industries



Exiobase v3.3.16-b2 in SimaPro

Organization of data in SimaPro:

Folders

- Input-Output > Exiobase v3.3.16b2
- Under this folder, you should use the data in the folders:
 - **Linked database > Producing industries:** transforming activities (industries)
164 activities in 43+5 countries/regions. Reference flows: hybrid units.
 - **Linked database > Product markets, hybrid units:** product markets
164 products in 43+5 countries/regions. Reference flows: hybrid units.
 - **Linked database > Product markets, monetary units:** product markets
164 products in 43+5 countries/regions. Reference flows: monetary units.

LCA explorer

- Exiobase

Linked database (tier 1)

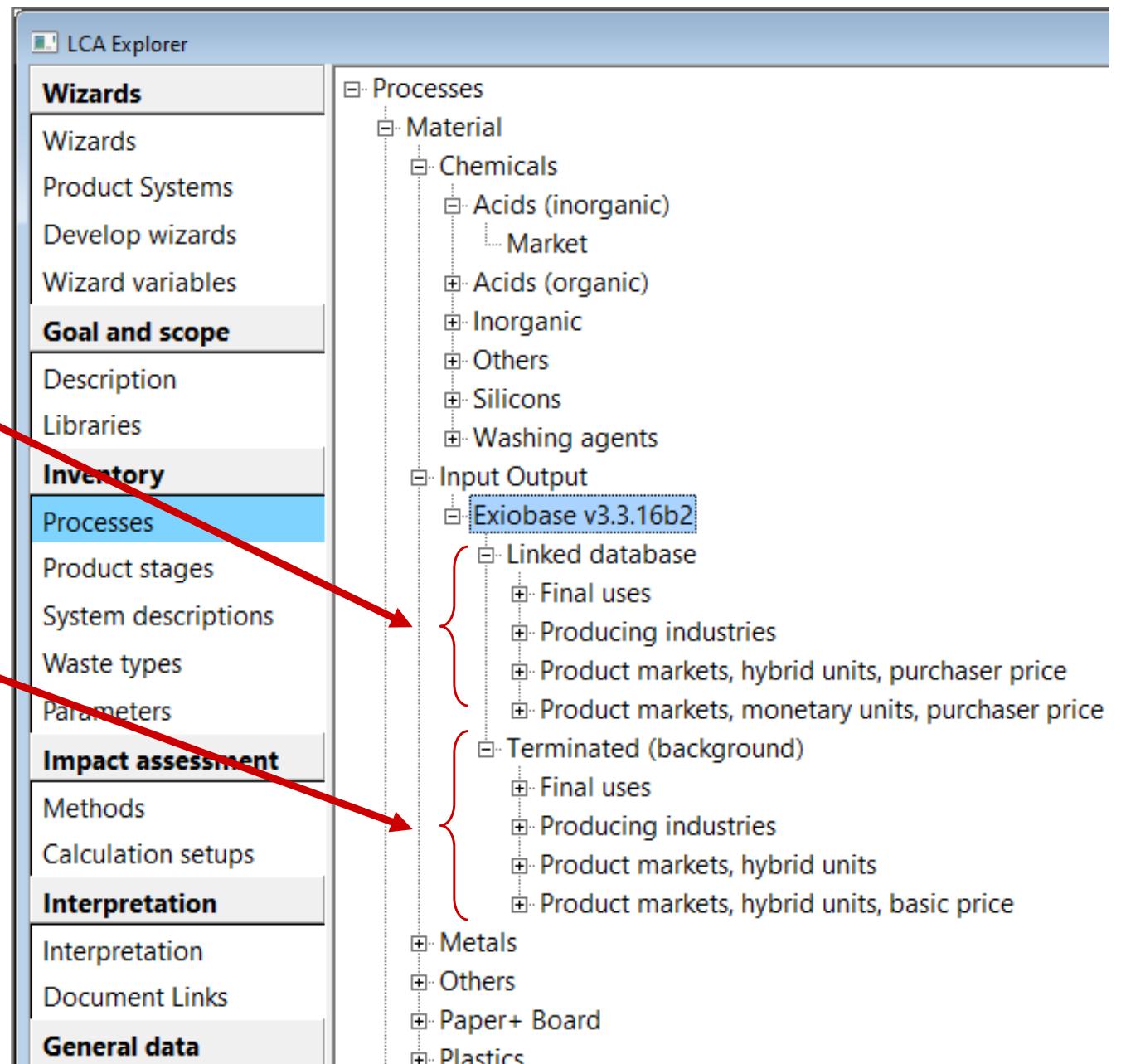
Good for contribution analysis.

Use this.

Background (tier 2)

System processes only used in background.

Do not use.



Agenda



- EXIOBASE v3 hybrid in SimaPro
- Application examples of hybrid LCA

Uses of IO-LCA

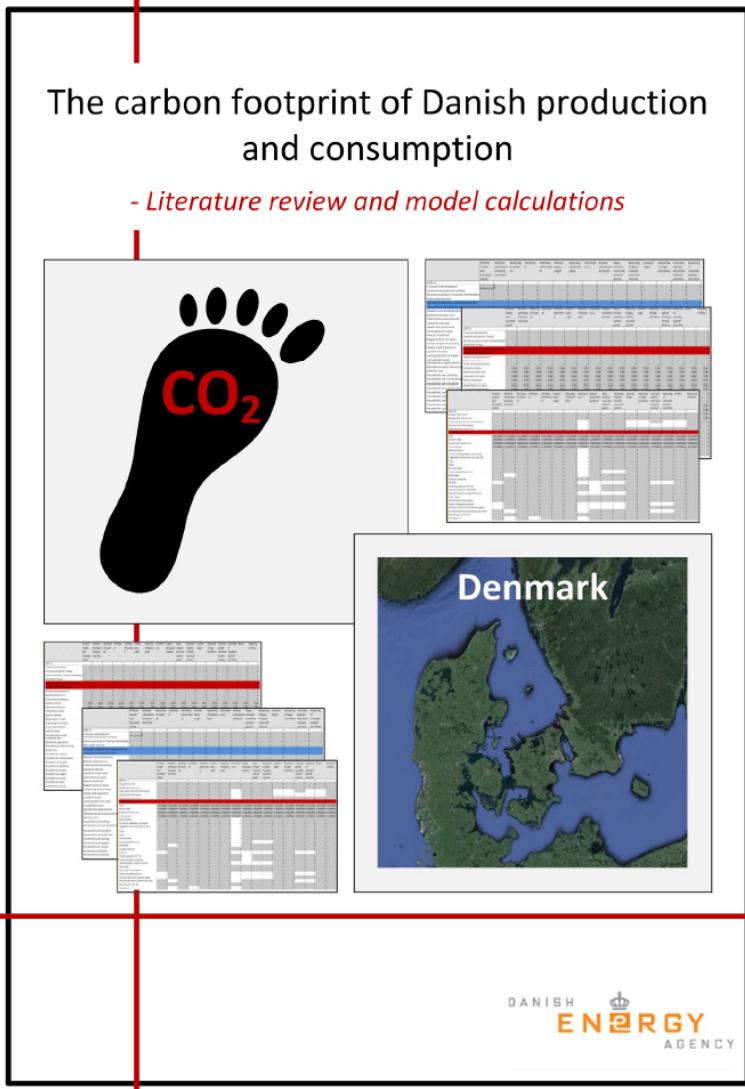
- Hybrid data as a replacement of traditional LCI database?
 - Transaction matrix more complete than process LCI (cut-off + geo)
 - Value added: Life cycle costing (LCC)
 - Extensions on wages, working hours etc. => Social LCI

Application areas of IO data

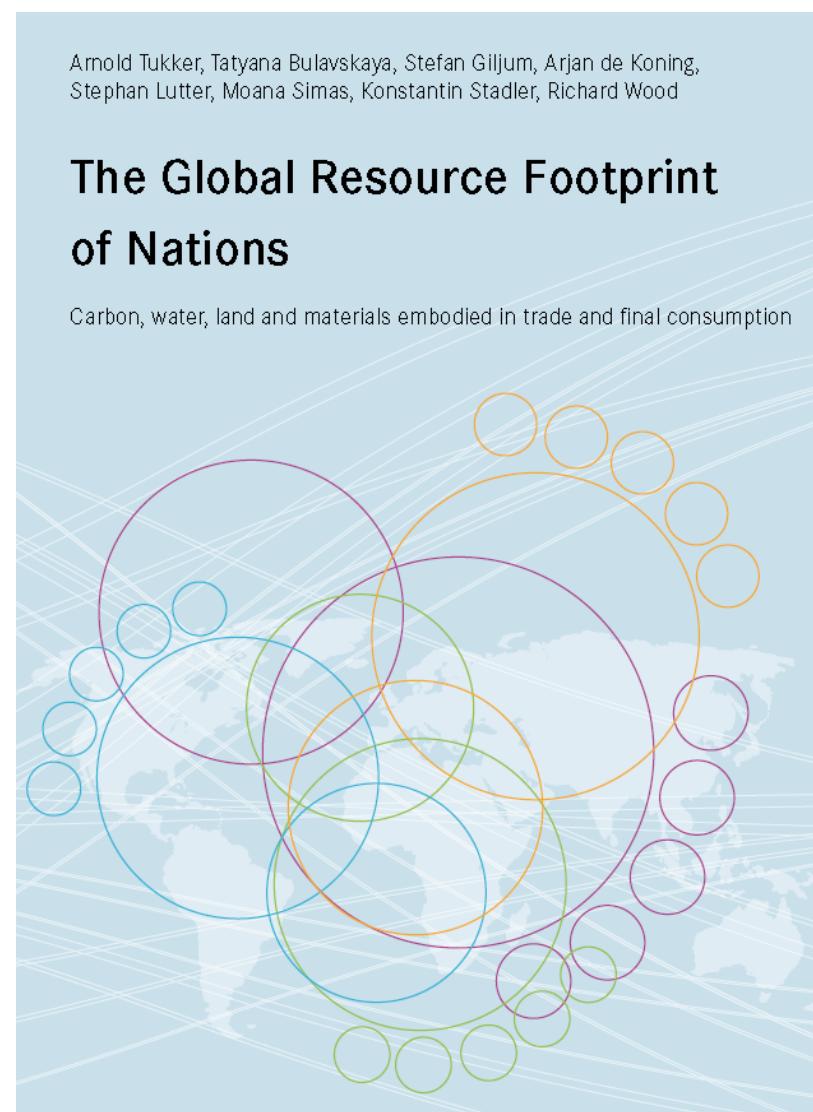
- Analysis of national/regional/global impacts related to:
 - Production & consumption, Trade, Use groups / basket of products, Waste
- Policy Impact (SEA) and EIA LCAs
 - Projects, programmes and policies
- Sector level Life cycle impact assessment
- Local level (municipal)
 - Public institutions
 - Economy-wide production and consumption at local level
- Corporate level LCAs and EP&Ls
- Product level LCAs

Application areas of IO data

- Analysis of national/regional/global impacts



Schmidt J, Muñoz I (2014). *The carbon footprint of Danish production and consumption – Literature review and model calculations*. Danish Energy Agency, Copenhagen <http://lca-net.com/p/961>



Tukker A, Bulavskaya T, Giljum S, de Koning A, Lutter S, Simas M, Stadler K, Wood R (2015). *The global resource footprint of nations*. The CREEA Booklet <http://lca-net.com/p/1859>

Application areas of IO data

- Regional/global impacts basket of products

Journal of Cleaner Production xxx (2016) 1–9

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Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro



Quantifying the environmental impacts of a European citizen through a macro-economic approach, a focus on climate change and resource consumption

Sofie Huysman ^{a,*}, Thomas Schaubroeck ^a, Małgorzata Goralczyk ^b, Jannick Schmidt ^c, Jo Dewulf ^{a,b}

^a Research Group ENVO, Ghent University, Coupure Links 653, B-9000 Ghent, Belgium
^b European Commission, Joint Research Centre, Via E. Fermi 2749, I-21027 Ispra (VA), Italy
^c Aalborg University, The Danish Centre for Environmental Assessment, Skibbrogade 5, 9000 Aalborg, Denmark

ARTICLE INFO

A B S T R A C T

Huysman S, Schaubroeck T, Goralczyk M, Schmidt J, Dewulf J (2016). Quantifying the environmental impacts of a European citizen through a macro-economic approach, a focus on climate change and resource consumption. *Journal of Cleaner Production* 124:217–225 <http://lca-net.com/p/2185>

are not available in Exiobase. To study more profoundly the impact on natural resources, we added the Cumulative Energy Extraction From the Natural Environment to the impact assessment. When comparing both approaches, it can be concluded that there is a considerable shift in the results. This means that the information obtained by a top-down approach could supplement the information base for policy support.

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1. Introduction

Today, sustainable development is one of the main challenges in many governmental policies, especially in that of the European Union (EU) (EC, 2009). To guide and monitor the transition towards a more sustainable society in terms of environmental performance, proper indicators are needed. The environmental impacts of an economic society are ultimately driven by consumption, either

these products (Tukker and Jansen, 2006). Hence, the indicators should provide a clear view on the links between final consumption and environmental impacts (EC, 2012a).

In 2006, the European Commission's Joint Research Centre (JRC) published a report on the environmental impacts related to the final consumption in the EU25 (Tukker et al., 2006). This report, together with the corresponding article of Tukker and Jansen (2006), includes a review of the 11 most relevant studies about

9th International Conference LCA of Food San Francisco, USA 8–10 October 2014

Life cycle assessment of the global food consumption

Jannick Hoejrup Schmidt*, Stefano Merciai

2.0 LCA consultants, Skibbrogade 5, 1, 9000 Aalborg, Denmark

* Corresponding author. E-mail: js@lca-net.com

ABSTRACT

Schmidt J, Merciai S (2014). Life cycle assessment of the global food consumption. Paper presented at the 9th International Conference LCA of Food San Francisco, USA 8–10 October 2014 <http://lca-net.com/p/1724>

KEYWORDS: Global food consumption, input-output LCA, GHG-emissions, Land-use, indirect land-use changes

1. Introduction

Food consumption is a major driver of global environmental impacts. Some studies give an indication of the overall magnitude of the global impact of food, e.g. sector specific LCAs (e.g. FAO 2006) and country/region specific input-output LCAs (e.g. Weidema et al. 2005). But yet, no studies have analyzed the total global life cycle environmental impacts from food consumption in detail.

This paper presents an analysis of the life cycle impacts caused by global food consumption based on the newly completed input-output model; Exiobase v2, which was created as part of the EU FP7 project CREEA (<http://creea.eu/>). Exiobase v2 is a multi-regional input-output database covering 43 countries plus five rest-of-world regions for 2007. Compared to other input-output models, the Exiobase v2 database also contains product flows in physical unit (mass and energy), and it is based on detailed mass balances for each product and industry, and it includes calculated quantities of food waste.

The functional unit of the study is the world's consumption of food in 2007. The included life cycle stages are cultivation/husbandry, processing, retail, preparation in households/restaurants and food waste disposal. The impact assessment focusses on GHG-emissions and land-use. In this respect it should be noted that a model of indirect land-use changes is integrated in the Exiobase v2 model used in this study, to account for GHG-emissions caused by the use of land. The results of the study are presented at the global scale, and they are broken down showing contribution analysis per food category, per life cycle stage, per sector, and per capita impact.

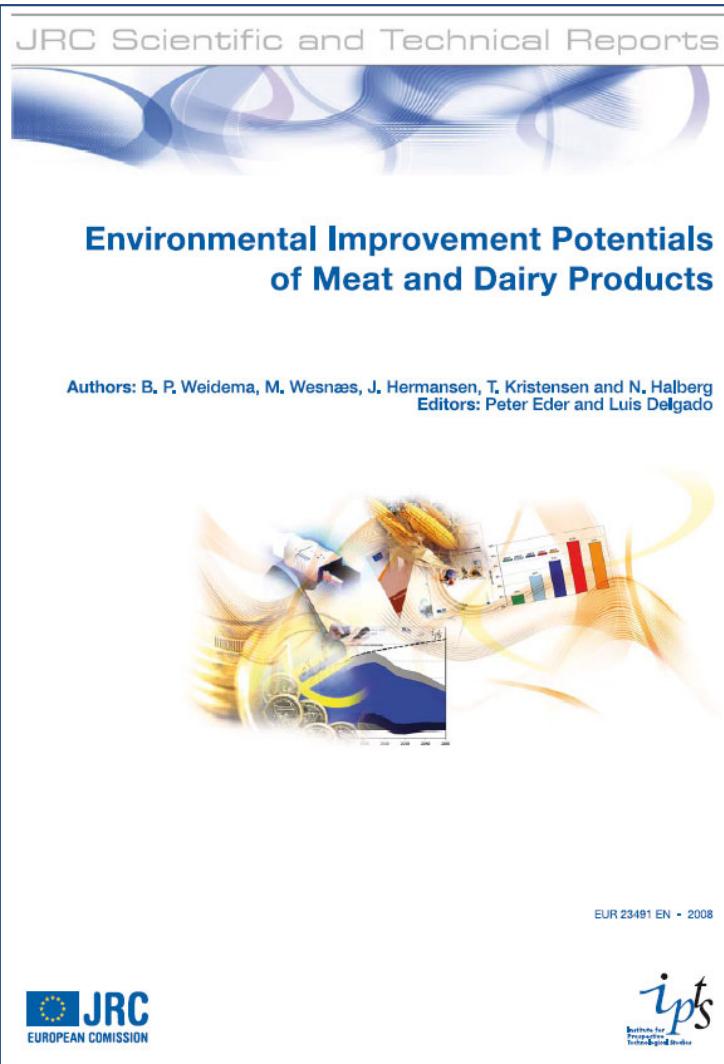
2. Methods and data

2.1. The Exiobase v2 input-output LCA model and mass flow analysis

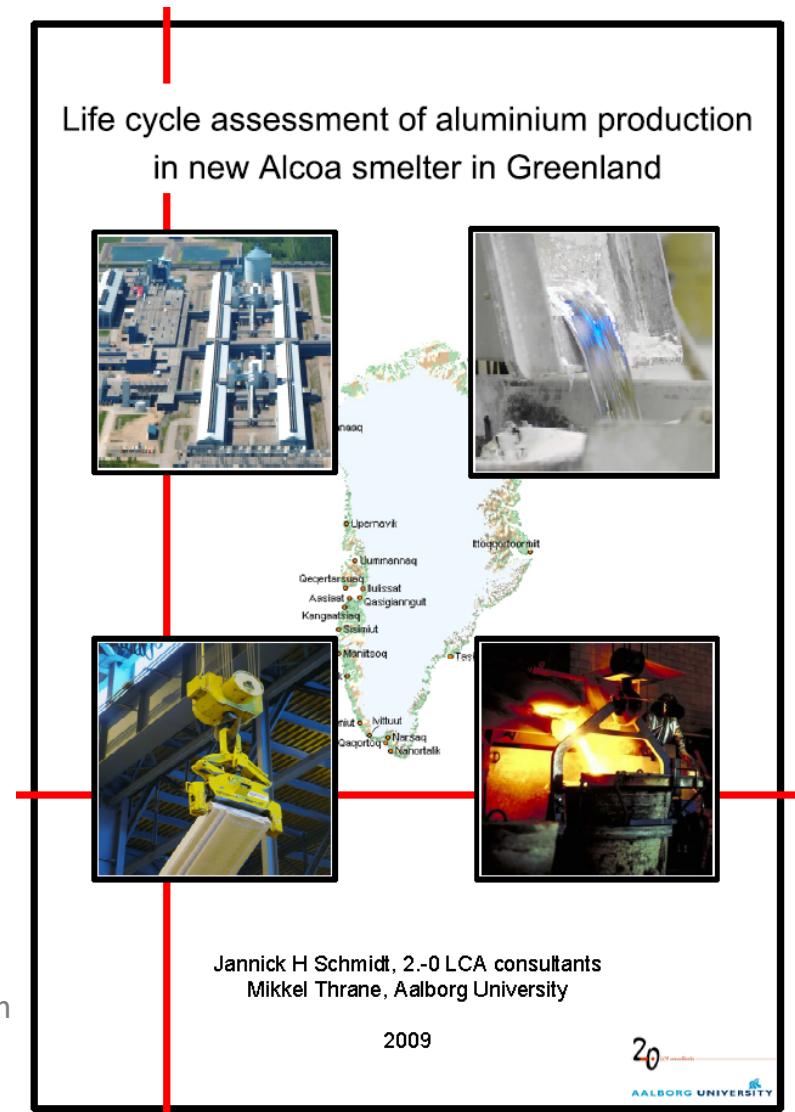
The basis of the LCA is a detailed mass flow analysis of all flows related to the world's food consumption. This mass flow analysis is carried out using the approach developed in the EU FP6 project FORWAST (<http://forwast.brgm.fr/>) and extensively implemented at the global scale in high level of detail in the EU FP7 project CREEA (<http://creea.eu/>). The input-output LCA model is based on the Exiobase v2 database, which is a multi-regional input-output database covering 43 countries plus five rest-of-world regions for 2007. The Exiobase v2 database contains product flows in physical unit (mass and energy), and it is based on detailed mass balances for each product and industry, and it includes calculated quantities of food waste.

Application areas of IO data

- Policy support (SEA) and EIA



Weidema B P, Wesnæs M, Hermansen J, Kristensen T, Halberg N (2008). *Environmental improvement potentials of meat and dairy products*. Eder P & Delgado L (eds.) Sevilla: Institute for Prospective Technological Studies. (EUR 23491 EN). <http://lca-net.com/p/171>



Schmidt J H, Thrane M (2009). Life cycle assessment of aluminium production in new Alcoa smelter in Greenland. Government of Greenland. <http://lca-net.com/p/183>

Application areas of IO data

- Policy support: Public procurement

- DK authorities use EXIOBASE for total public procurement GHG accounting
- Danish Defense use EXIOBASE for their GHG accounting

Application areas of IO data

- Sector level LCA



Miljøministeriet
Miljøstyrelsen

Danish apparel sector natural capital account

October 2014

Høst-Madsen N K, Damgaard C K, Jørgensen R, Bartlett C, Bullock S, Richens J, de Saxcé M, Schmidt J H (2014). **Danish apparel sector natural capital account**. Danish Environmental Protection Agency, October 2014 <http://lca-net.com/p/1746>

Textile sector
Based on Exiobase v1

Application areas of IO data

- Local level (municipal)

Odense Municipality

Based on FORWAST



Miljøministeriet
Miljøstyrelsen

Kjær L L, Mikkelsen K D, Høst-Madsen N K, Schmidt J (2011).
Miljøregnskab for pilotkommune – hovedrapport. Miljøprojekt nr.
1390, 2011 <http://lca-net.com/p/1908>

NIRAS

Mikkelsen K D, Høst-Madsen N K, Kjær L L, Kreilgaard L, Müller J,
Schmidt J, Madsen B, Zhang J (2011). *Klimafodaftryk fra borgere og
virksomheder i Region Hovedstaden, Hovedrapport*. Region
Hovedstaden. <http://lca-net.com/p/460>

Miljøregnskab

Louise Laumann Kjær, K
Høst-Madsen, NIRAS og
tants.

27. januar 2011

Version 4

KLIMAFODAFTTRYK

Region Hovedstaden som samfund
Klimafodaftryk fra borgerne og virksomhederne i Region Hovedstaden

Municipalities in the Capital
Region of Denmark
Based on FORWAST

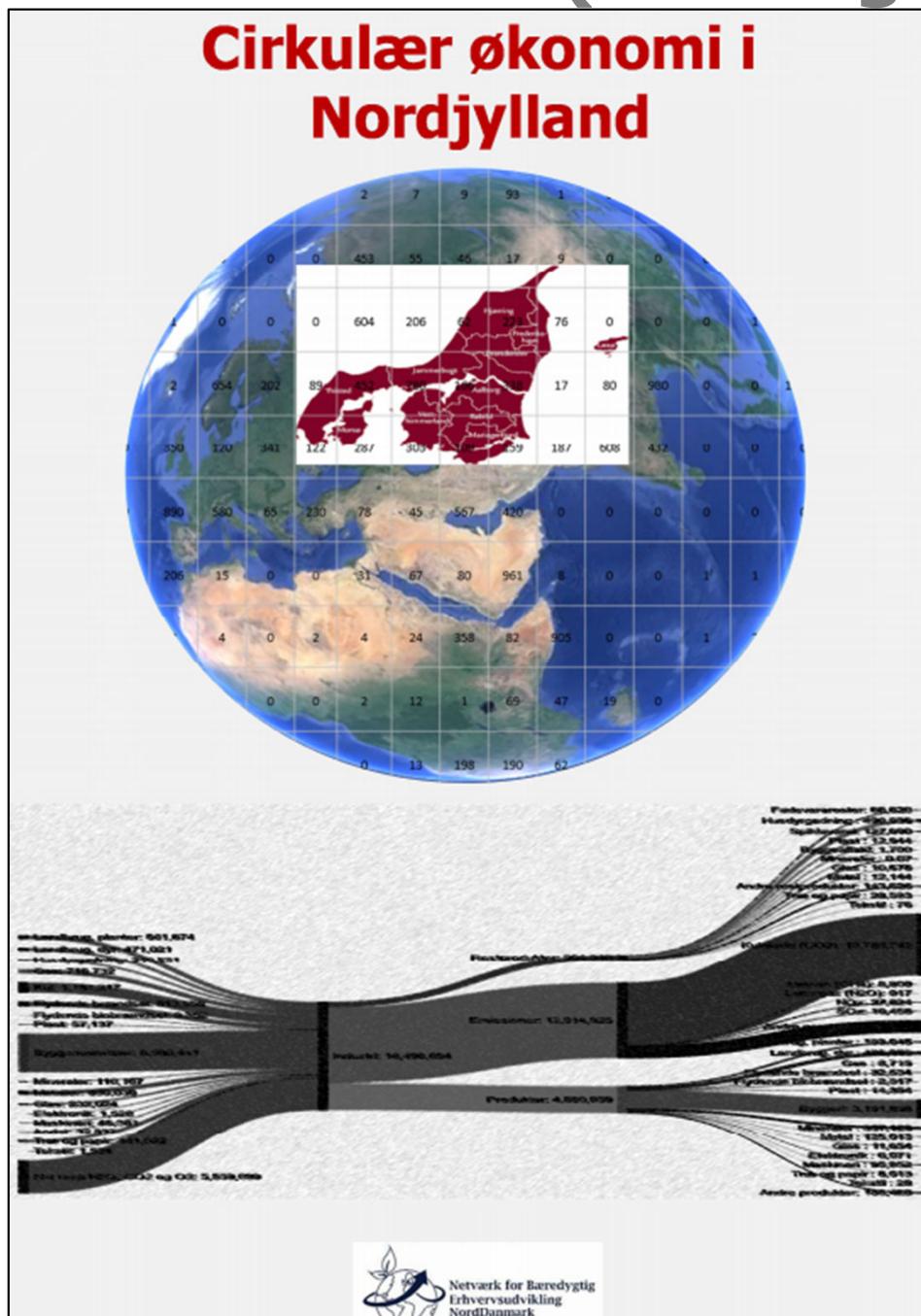


Sollentuna Municipality
Based on Eurostat

Wendin M and Schmidt J (2014). Sollentuna
Ekofootprint och Environmental Profit & Loss. Sollentuna.
<http://www.sollentuna.se/globalassets/bygga-bo-och-miljo/miljo-och-halsa/klimatstrategi/rapport-64-ecofootprint-and-epnl-sollentuna.pdf>

Application areas of IO data

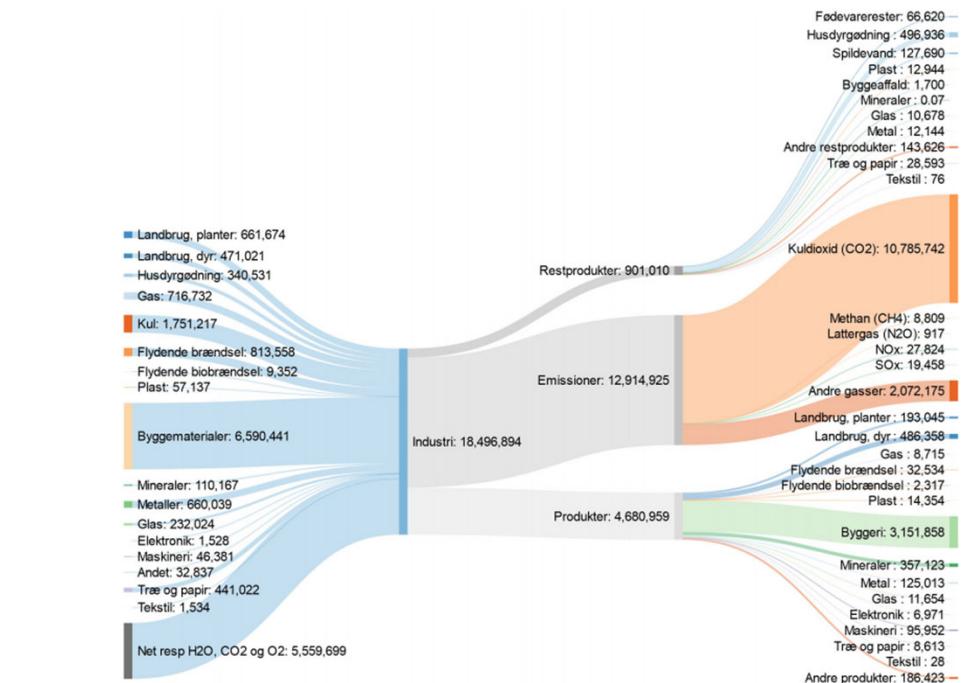
- Local level (sub-region of country)



Region of Northern Denmark

MFA account for 80,000 companies

GHG in production and consumption perspective



Schmidt J, Astudillo M, Merciai S og Trolle T S (2020). Cirkulær Økonomi i Nordjylland – opgørelse af massestrømme og LCA resultater. Denne rapport er udarbejdet for Netværk for Bæredygtig Erhvervsudvikling (NBE), Aalborg Kommune af 2.-0 LCA consultants juni 2019 til december 2020. <https://lca-net.com/p/4199>

Application areas of IO data

- Corporate level LCAs and EP&L



Danish Ministry of the Environment
Environmental Protection Agency

Novo Nordisk's
environmental
profit and loss
account

Novo Nordisk
2014
Based on FORWAST

Høst-Madsen N K, Damgaard C K, Szeler A, McManamon D, Bullock S, Taylor J, Sireyjol A, Schmidt J (eds.) (2014). Novo Nordisk's environmental profit and loss account. Danish Environmental Protection Agency. <http://lca-net.com/p/577>



Arla corporate account
Based on FORWAST



Schmidt J, de Saxcé M (2016). Arla Foods Environmental Profit and Loss Accounting 2014. Environmental project No. 1860, 2016. Danish Environmental Protection Agency, Copenhagen. <http://lca-net.com/p/2343>



Application areas of IO data

- Corporate level LCAs and EP&L

Nordic Alcohol Monopoly EP&L
account

Based on Exiobase



Weidema B P, de Saxcé M, Muñoz I (2016). Environmental impacts of alcoholic beverages – as distributed by the Nordic Alcohol Monopolies 2014. 2.-0 LCA consultants, Aalborg, 30th December 2016 <http://lca-net.com/p/2667>

**Environmental impacts of alcoholic beverages
as distributed by the Nordic Alcohol Monopolies 2014**

by Bo P. Weidema, Marie de Saxcé, and Ivan Muñoz
2.-0 LCA consultants, Aalborg, 30th December 2016

Application areas of IO data

- Product level LCA

Klima-fodafttryk for genbrug af hittegodscykler

- Carbon footprint for Baisikeli's genbrugsprojekt i Mozambique



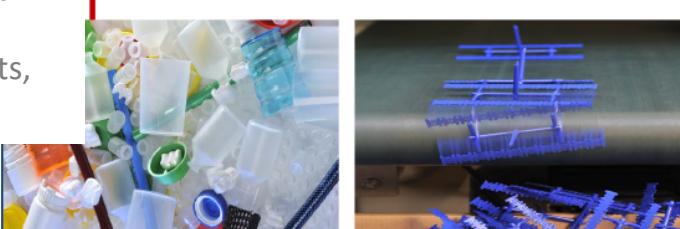
Weidema B P (2013). *Klima-fodafttryk for genbrug af hittegodscykler – Carbon footprint for Baisikeli's genbrugsprojekt i Mozambique*. 2.-0 LCA consultants, Aalborg, Denmark. <http://lca-net.com/p/456>



Bo P. Weidema
2013-09-17

Plastberegnert.dk - LCA tool for plastics converters in Denmark

Documentation of the tool and database



Schmidt J (2012). *Plastberegnert.dk – LCA tool for plastics converters in Denmark – Documentation of the tool and database*. Plastindustrien, Copenhagen. <http://lca-net.com/p/219>



LCA-screening af



mobiltelefoni leveret af



Schmidt J (2010). *LCA-screening af greentel mobiltelefoni leveret af Mobilevalue*. 2.-0 LCA consultants, Aalborg, Danmark. <http://lca-net.com/p/530>

Plastindustrien. Brancheforeningen for danske plastvirksomheder



Producent med støtte fra Life+
Life projekt "Green21" er et samarbejde mellem DI, Miljøministeriet, Green Cross Denmark og Aalborg Universitet.
Om projektet Fås i tilgangskatalogen



p Schmidt, 2-0 LCA consultants,
<http://lca-net.com/>

20
LOA consultants

Application areas of IO data

- Product level LCA



Article

Environmental and Economic Performance of an Li-Ion Battery Pack: A Multiregional Input-Output Approach

Javier Sanfélix ^{1,*}, Cristina de la Rúa ², Jannick Hoejrup Schmidt ³, Maarten Messagie ¹ and Joeri Van Mierlo ¹

Sanfélix J, de la Rúa C, Schmidt J, Messagie M, van Mierlo J (2016). Environmental and economic performance of an Li-Ion battery pack: A multiregional input-output approach. Energies 9(8):584 <http://lca-net.com/p/2285>

Academic Editor: Haolin Tang

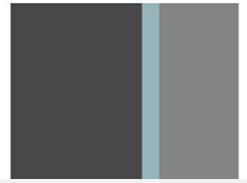
Received: 16 March 2016; Accepted: 13 July 2016; Published: 27 July 2016

Abstract: In this paper, the environmental and economic impacts of the life cycle of an advanced lithium based energy storage system (ESS) for a battery electric vehicle are assessed. The methodology followed to perform the study is a Multiregional Input–Output (MROI) analysis, with a world IO table that combines detailed information on national production activities and international trade data for 40 countries and a region called Rest of the World. The life cycle stages considered in the study are manufacturing, use and recycling. The functional unit is one ESS with a 150,000 km lifetime. The results of the MROI analysis show the stimulation that the life cycle of the EES has in the economy, in terms of production of goods and services. The manufacturing is the life cycle stage with the highest environmental load for all the impact categories assessed. The geographical resolution of the results show the relevance that some countries may have in the environmental performance of the assessed product even if they are not directly involved in any of the stages of the life cycle, proving the significance of the indirect effects.

Keywords: multiregional input-output analysis; life cycle assessment; batteries; electric vehicles



DAMVAD ANALYTICS



Damvad Analytics et al. (2016). Potentialer og barrierer for brugen af træ og bæredygtigt træ i byggeriet (English: Potentials and barriers for the use of timber in construction. Rapport fra DAMVAD Analytics, Havnegade 39, DK-1058 Copenhagen K. <http://lca-net.com/p/2935>



02-05-2016

Potentialer og barrierer for brugen af træ og bæredygtigt træ i byggeriet

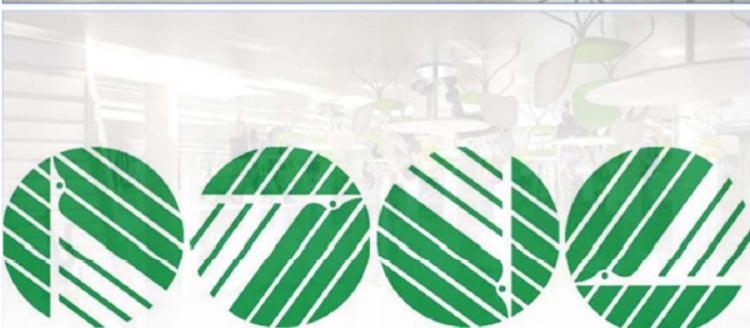
Application areas of IO data

- Product level LCA

Life Cycle evaluation of the effect of ecolabels Apartment buildings, canteens and laundry detergents



de Saxcé M, Schmidt J, Weidema B P (2015). Life cycle evaluation of the effect of ecolabels - Apartment buildings, canteens and laundry detergents. Ecolabelling Denmark, Copenhagen. <http://lca-net.com/p/1967>



Marie de Saxcé, Jannick H Schmidt, Bo P Weidema
2-0 LCA consultants, Aalborg
March 2015

Contents lists available at ScienceDirect
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journal homepage: www.elsevier.com/locate/jclepro

Certified palm oil reduces greenhouse gas emissions compared to non-certified

Jannick Schmidt*, Michele De Rosa
Aalborg University, Rendsburgsgade, 14 9000, Aalborg, Denmark

ARTICLE INFO

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Keywords:
Palm oil
Carbon footprint
Biodiversity
RSPO certified
GHG emissions

ABSTRACT

Consumers are increasingly demanding products containing palm oil produced without harm to the environment. The demand for certified palm oil has increased rapidly over the last decade. The aim of this study was to evaluate the environmental impact of certified palm oil production compared to non-certified palm oil production. The results show that RSPO certified oil reduces GHG emission by 35% compared to non-certified i.e. 3.41 (2.61–4.48) kg CO₂ eq./kg for certified vs 5.34 (3.34–8.16) kg CO₂ eq./kg for non-certified. Based on a thorough data quality assessment and uncertainty analysis, this result is deemed sufficiently robust and thus conclusive. Certified production achieves the largest GHG emissions reduction because of higher yields, i.e. less land use per unit of product, less oil palm cultivated on peat soil and higher share of palm oil mill effluents treated with biogas capture technologies. We also found that nature occupation is reduced by 20% in certified production while respiratory inorganic is slightly higher (3%) in certified production, due to the larger use of fertilisers. For other impact categories, results are associated with a larger uncertainty and therefore shall be considered as indicative. Similar results are found in attributional modelling.

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Application areas of IO data

- Product level LCA: 500 food items

the big **CLIMATE DATABASE**

Version 1

Climate database Bi...

Climate footprint calculated in kg. Click on column titles to sort.

Category▲	Food	CO2e pr kg	Agriculture	ILUC	Processing	Packaging	Transport	Retail		
Beverages	BITTER, Gammel Dansk Bitter Dram	2,04	1,10	-0,05	-0,11	0,37	0,72	0,01		
Beverages	Brandy, cognac	8,22	0,99	-0,02	4,80	0,37	2,07	0,01		
Beverages	Vodka	2,04	1,10	-0,05	-0,11	0,37	0,72	0,01		
Beverages	Aquavit, 40 % vol., average values	2,04	1,10	-0,05	-0,11	0,37	0,72	0,01		
Beverages	Apple juice	1,64	0,32	0,02	0,61	0,31	0,37	0,01		
Beverages	Icetea, peach	0,82	0,20	0,02	0,37	0,13	0,08	0,01		
Beverages	Energy drink	0,53	0,14	0,00	0,17	0,16	0,06	0,01		
Schmidt J, Merciai S, Muñoz I, De Rosa M, Astudillo M (2021). The Big Climate Database v1 – Methodology report. 2.-0 LCA consultants, Denmark .							0,21	0,19	0,07	0,01
https://denstoreklimadatabase.dk/en/background-information							0,53	0,19	0,08	0,01
							0,10	0,31	1,29	0,00
Beverages	Beer, lager, alc. 4,4 % by vol.	0,00	0,07	0,05	0,24	0,16	0,07	0,01		
Beverages	Beer, Danish household, low alcohol	0,60	0,07	0,05	0,24	0,16	0,07	0,01		
Beverages	Beer, strong, alc. 7,6 % by vol.	0,60	0,07	0,05	0,24	0,16	0,07	0,01		
Beverages	Tomatojuice, canned	1,26	0,13	0,02	0,20	0,22	0,68	0,01		
Beverages	Wine, white, average values	1,87	0,31	0,07	0,40	0,41	0,68	0,01		
Beverages	Wine, rosé	1,87	0,31	0,07	0,40	0,41	0,68	0,01		
Beverages	Wine, red	1,87	0,31	0,07	0,40	0,41	0,68	0,01		
Beverages	Wine, white, sparkling, champagne	1,87	0,31	0,07	0,40	0,41	0,68	0,01		
Beverages	Tea, leaves	8,41	2,50	1,61	1,87	1,94	0,47	0,01		

Application areas of IO data

- Social LCA

White paper

Social Footprint



Authors:

Urs Schenker, Nestlé Research
Bo Weidema, 2.-0 LCA consultants

Lausanne, September 2017



Schenker U, Weidema B P (2017). White paper – social footprint. White Paper from Nestlé Research, Lausanne, September 2017 <http://lca-net.com/p/2858>

... if you want to know more

- The International Life Cycle Academy (<https://ilca.es/>)
- Consequential LCA (<https://consequential-lca.org/>)