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Workshop on 26 April 2021 on Nordic Dialog on life cycle assessment aspects of the EU Environmental Footprint methodology

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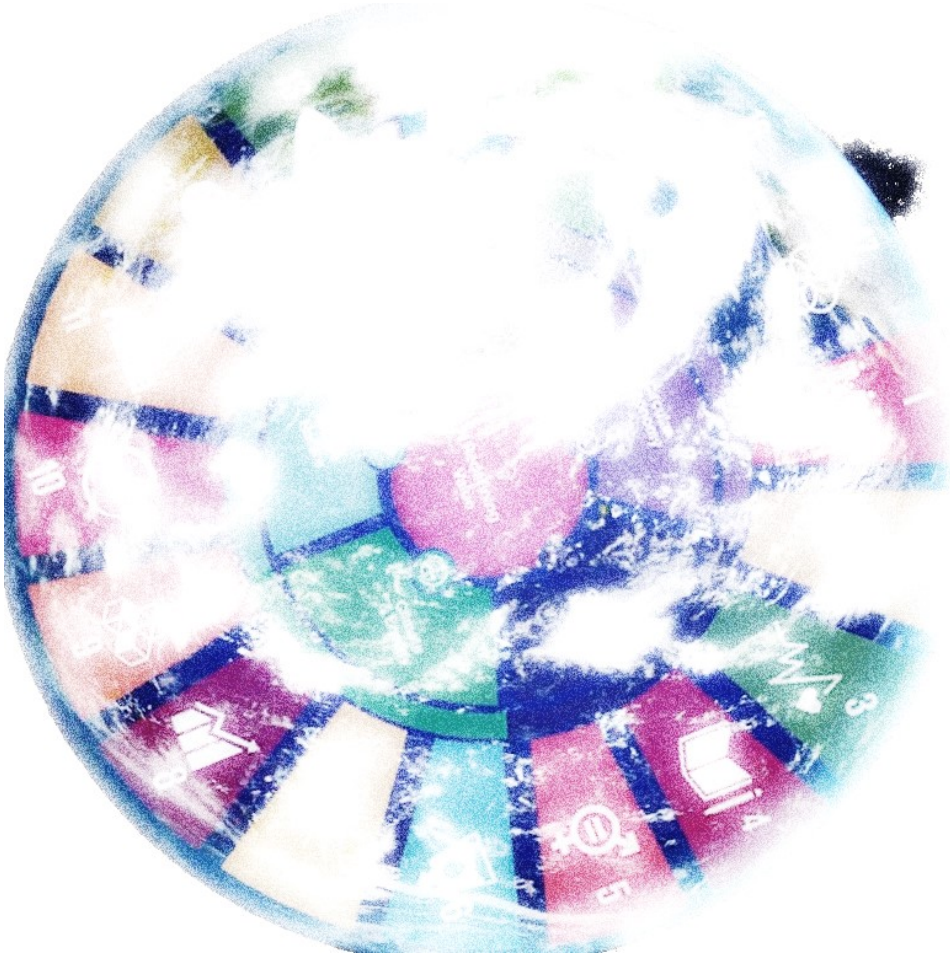
NorPEF-LCA – April 2021 Workshop Report

Workshop on 26 April 2021 on Nordic Dialog on life cycle assessment aspects of the EU Environmental Footprint methodology

Christian Poll

June 2021



NorPEF-LCA

Workshop Report 26 April 2021

Report

2021

By

Christian Poll

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Preface

This document reports the workshop held online on 26 April 2021 regarding Nordic cooperation on topics of life cycle assessment (LCA) in relation to the EU Environmental Footprint[1] (EF) development process. The EU-EF regime is divided into the Product Environmental Footprint (PEF) trail and the Organisational Environmental Footprint (OEF) trail.

The workshop was conducted by the Technical University of Denmark (DTU), Department for Technology, Management and Economics, Section for Quantitative Sustainability Assessment[2] (DTU Man QSA) by Senior Advisor Christian Poll assisted by the NorPEF-LCA Coordination Group. The group secretariat and the workshop was financed by a grant from the Nordic Expert Group for EU Environmental Footprint[3] (NEF) under the Nordic Working Group for Circular Economy[4] (NCE) under the Nordic Council of Ministers (NMR).

The NorPEF-LCA Coordination Group:

- Björn Spak, Naturvårdsverket (SE)
- Christian Poll, DTU Man QSA (DK, project manager)
- Christine Molin, DTU Man QSA (DK)
- Hanne L. Raadal, NORSUS (NO)
- Jáchym Judl, SYKE (FI)
- Michael Hauschild, DTU Man QSA (DK)
- Ólafur Ögmundarson, University of Iceland (IS)
- Stig Irving Olsen, DTU Man QSA (DK)

Furthermore, Preben Kristensen, PrebenK.dk in his role of NEF Group coordinator has acted as initiator and supervisor for the NorPEF-LCA Group (DK).

Lyngby, June 2021

Christian Poll

Senior Advisor

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[1] https://ec.europa.eu/environment/eussd/smgp/index.htm

[2] https://www.sustainability.man.dtu.dk/english/research/qsa

[3] https://www.norden.org/en/node/36795

[4] https://www.norden.org/en/nordic-working-group-for-circular-economy-NCE

Content

Summary

The workshop held online on 26 April 2021 regarding Nordic cooperation on topics of life cycle assessment (LCA) in relation to the EU Environmental Footprint[5] (EF) development process was attended by 44 participants from Denmark, Finland, Iceland, Norway and Sweden. Most of the participants were experts from Nordic universities, but also private companies, authorities, NGOs, EPD bodies and technical institutes were present.

First point of the agenda was a progress report from the European Commission on the EF initiative. After that, during seven sessions with seven topics, important aspects of LCA related to the EF were debated by the participants. The topics were:

- Session A1 on Biodiversity and land-use
- Session A2 on Environmental claims, eco-labelling and green procurement
- Session A3 on End-of-Life, waste, recycling and circular footprint formula
- Session B1 on Allocation between co-products
- Session B2 on Harmonisation EPD-PEF
- Session B3 on Electricity modelling, supplier specific vs grid mix
- Session B4 on Biomass, biochemical and biomaterials

The sessions did not conclude on the topics, as the purpose of the workshop was the dialog itself. Go to the session sections of this report to see further details on sub-topics.

[5] https://ec.europa.eu/environment/eussd/smgp/index.htm

1. Introduction

1.1 Purpose of the workshop

The overall purpose of the workshop is:

- To identify and develop common ground and mutual understanding among the Nordic countries, thus
- by debating important issues related to the way LCA is developed and implemented in the PEF process,
- the Nordic countries will be able to coordinate, negotiate and contribute better in the European cooperation on PEF.

As PEF is being suggested to be applied in European legislation, possibly taking over part of the role currently being held by EPDs, including eco-labelling, procurement criteria etc., it is of growing importance that the LCA methodology behind is thorough and balanced, reflecting key aspects in society and building on scientific knowledge. A stronger science based Nordic conversation will contribute to that.

Thus, there is no scientific or other concrete output of the workshop. Dialog and exchange of experience and insight was the purpose, and no agreements nor decisions were concluded during the workshop.

The workshop program was built around two breakout sessions during the day. The morning session was divided into three topics, the afternoon into four topics, see the program below. Participants were free to choose topic/session.

See list of participants in Enclosure A.

A few days after the workshop, a questionnaire was sent out to all participants. Based on the answers, the participants list was generated, including the distribution of participants in the seven breakout sessions. Furthermore, the questionnaire comprised some additional questions that provided some evaluation of the workshop. I general the participants expressed satisfaction with the workshop, and some gave valuable input for a future workshop on similar topics.

See the results of the evaluation questionnaire in Enclosure C.

1.2 Workshop program 26 April 2021

Time	Subject	Speaker
10:00	Welcome, introduction to the workshop	Christian Poll
10:10	Update on the green claims (PEF) initiative	Policy officer Imola Bedo from the EC.
10:30	Presentation of topics	Christian Poll
10:45	First breakout session (A) 1. Biodiversity and land-use (Moderator: Serena Ahlgren, Notetaker: Ólafur Ögmundarson) 2. Environmental claims, eco-labelling and green procurement (Moderator: Johanna Suikkanen, Notetaker: Christian Poll) 3. End-of-Life, waste, recycling and circular footprint formula (e.g. plastics case) (Moderator: Tomas Ekvall, Notetaker: Jáchym Judl)	Moderators and Notetakers. Breaks are managed by the moderators.
12:00	Plenary session with a 5 min. pitch from each of the three moderators on key issues from the discussions.	Moderators
12:30	Lunch break	
13:30	Second breakout session (B) 1. Allocation between co-products (Moderator: Tomas Ekvall, Notetaker: Stig Irving Olsen) 2. Harmonisation EPD-PEF (Moderator: Kristian Jelse, Notetaker: Christine Molin) 3. Electricity modelling, supplier specific vs grid mix (Moderator: Hanne L. Raadal, Notetaker: Björn Spak) 4. Biomass, biochemical and biomaterials (Moderator: Mikolaj Owsianiak, Notetaker: Ólafur Ögmundarson)	Moderators and Notetakers. Breaks are managed by the moderators.
14:45	Plenary session with a 5 min. pitch from each of the three moderators on key issues from the discussions.	Moderators
15:20	Plenary debate, cross-topics, additional topics	All, moderator: Christian Poll
16:20	Rounding off, thanks to everyone for active participation.	Christian Poll
16:30	End of workshop.	

2. Program parts

2.1 Welcome and introduction

By Christian Poll

"Good morning

It's a pleasure for me to be able to give a warm welcome to you all for this workshop on life cycle assessment (LCA) aspects related to the EU Product Environmental Footprint[6] (PEF) process

The group secretariat is financed by a grant for 2020 from the Nordic Expert Group for EU Environmental Footprint[7] (NEF) under the Nordic Working Group for Circular Economy[8] (NCE) under the Nordic Council of Ministers.

The grant is received by the Technical University of Denmark (DTU), Department for Technology, Management and Economics, Section for Quantitative Sustainability Assessment[9] (DTU Man QSA). Secretary is Senior Advisor Christian Poll.

You have been identified by NorPEF-LCA, possibly being interested in attending a workshop about LCA methodology, application and/or dissemination, or you have been recommended by some.

The overall purpose of the workshop is:

- To identify and develop common ground and mutual understanding among the Nordic countries, thus
- by debating important issues related to the way LCA is developed and implemented in the PEF process,
- the Nordic countries will be able to coordinate, negotiate and contribute better in the European cooperation on PEF.

As PEF is being suggested to be applied in European legislation, possibly taking over part of the role currently being held by EPDs, including eco-labelling, procurement criteria etc., it is of growing importance that the LCA methodology behind is thorough and balanced, reflecting key aspects in society and building on scientific knowledge. A stronger science based Nordic conversation will contribute to that.

The workshop program is built around two breakout sessions during the day. The morning session is divided into three topics, the afternoon into four topics, see the program below. You are free to choose the topic you like to attend at each session. So

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[6] https://ec.europa.eu/environment/eussd/smgp/index.htm

[7] https://www.norden.org/en/node/36795

[8] https://www.norden.org/en/nordic-working-group-for-circular-economy-NCE

[9] https://www.sustainability.man.dtu.dk/english/research/qsa

when we go into sessions, I will set up breakout rooms, and you may choose the subject, you prefer.

When you enter the breakout room, there will be a moderator and a notetaker, who will take you through the session. Please be helpful and understanding during the discussions. Notes from the debates are used by me to write the workshop report, that you will receive later in May.

I will send out a small questionnaire that will make it possible for us to share the participants list – please answer the three questions for that. Until the list is distributed, I suggest you use a few minutes in the breakout rooms to introduce yourselves.

Thus, speaking for the Core Group on Nordic dialog on this issue – the NorPEF-LCA group – we are looking forward to this day of hopefully a lot of lively debate.

By that I will give the floor to Policy officer Imola Bedo from the European Commission."

2.2 Update on the green claims (PEF) initiative

By Imola Bedo

Presentation slides in Enclosed B.1

Clarifying Q&A:

Q: The 458 eco-labels worldwide, mentioned in slide #5, are they ISO14040 Type I labels?

A: No, the number covers all kinds of environmental labels, including private labels.

2.3 Presentation of topics

By Christian Poll

Christian explained about the structure of the two breakout sessions and lined up the first three topics for session A.

2.4 First (A) breakout session

2.4.1 Session A1 on Biodiversity and land-use

Moderator: Serena Ahlgren
Notetaker: Ólafur Ögmundarson

Session participants

Anna Woodhouse	NORSUS	NO
Björn Spak	Naturvårdsverket	SE
Gert Søndergaard Hansen	Danish EPA	DA
Giovanna Croxatto Vega	SDU - University of South Denmark	DA

Hanna Tuomisto	University of Helsinki	FI
Jani Sillman	LUT University	FI
Katri Joensuu	Luke - Natural Resources Institute	FI
Kim Christiansen	EEB rep. and expert	DA
Laura Sokka	VTT Research	FI
Martin Erlandsson	IVL Environmental Research Institute	SE
Ólafur Ögmundarson	University of Iceland	IS
Preben Kristensen	PrebenK	DA
Serina Ahlgren	RISE Research Institute	SE
Søren Løkke	AAU - Aalborg University	DA

Introductory presentation by Serina Ahlgren

Presentation slides in Enclosed B.2

The session started with an introduction from Serina Ahlgren (RISE Research Institute, SE), on Biodiversity (BD) and Land-use (LU). The focus of the introduction was on BD, the methodology of (Chaudhary & Brooks, 2018) to measure BD and compare countries effect on BD, but the method is not as competent to compare organic vs. conventional farming.

Session debate

The discussion in the beginning was around biodiversity (BD) missing in PEF, and BD only being a voluntary assessment criteria (not an impact category). Søren Løkke pointed out that PEF lacks a solid way to deal with LU, iLUC (indirect land-use change) and BD, including increased pressure on the untouched (like South American rain forests). The discussion also included how to deal with LU-change and indirect land-use change, and it was emphasized that such methodological frameworks need to be developed specifically for the Nordics (or included in other methodologies) due to the differences in land-use types for example compared to Italian land-use.

It was pointed out that under the PEF initiative there is an agricultural working group (Gert Hansen) working on including BD and developing PEF for modelling agricultural practices.

When developing PEF methodologies for BD and LU, collaboration with other research disciplines like ecology/biology was encouraged and the necessity to bridge gaps between the different research fields to develop the most accurate impact factors for, for example, BD and LU.

Toward the end of the session, there were discussions on where to go and how to develop PEF, and an idea was the “global pressure of LU and BD in a Nordic perspective”. There is a need to define the short term and long term (future) development goals of PEF, where should the methodology go? On aspects mentioned was including positive effects of for example forestry (carbon sequestration).

2.4.2 Session A2 on Environmental claims, eco-labelling and green procurement

Moderator: Johanna Suikkanen
Notetaker: Christian Poll

Session participants

Ari Nissinen	SYKE Environment Institute	FI
Bergrós Arna Sævarsdóttir	Mannvit	IS
Christian Poll	DTU Man QSA	DA
Christine Molin	DTU Man QSA	DA
Ellen Riise	Essity	SE
Galyna Medyna	Luke - Natural Resources Institute	FI
Håkon Hauan	EPD Norge	NO
Jeppe Nothlev Nørtoft	Miljøstyrelsen	DA
Johanna Niemistö	SYKE Environment Institute	FI
Johanna Suikkanen	SYKE Environment Institute	FI
Juha-Matti Katajajuuri	Luke - Natural Resources Institute	FI
Kristian Jelse	Greendesk	SE
Linda Høibye	DK Green Investment Fund	DA
Morten Søes Kokborg	Teknologisk Institut	DA
Risto Soukka	LUT University	FI
Sara Palander	Chalmers University of Technology	SE
Vanessa Hoffmann	Abena	DA

Introductory presentation by Johanna Suikkanen

Presentation slides in Enclosed B.3

Session debate

The debate was structured according to Johanna's last slide, thus, first green claims, then GPP and finally eco-labels. A common topic across the debate was data – the quality and comparability of data, used behind claims, GPP and eco-labels.

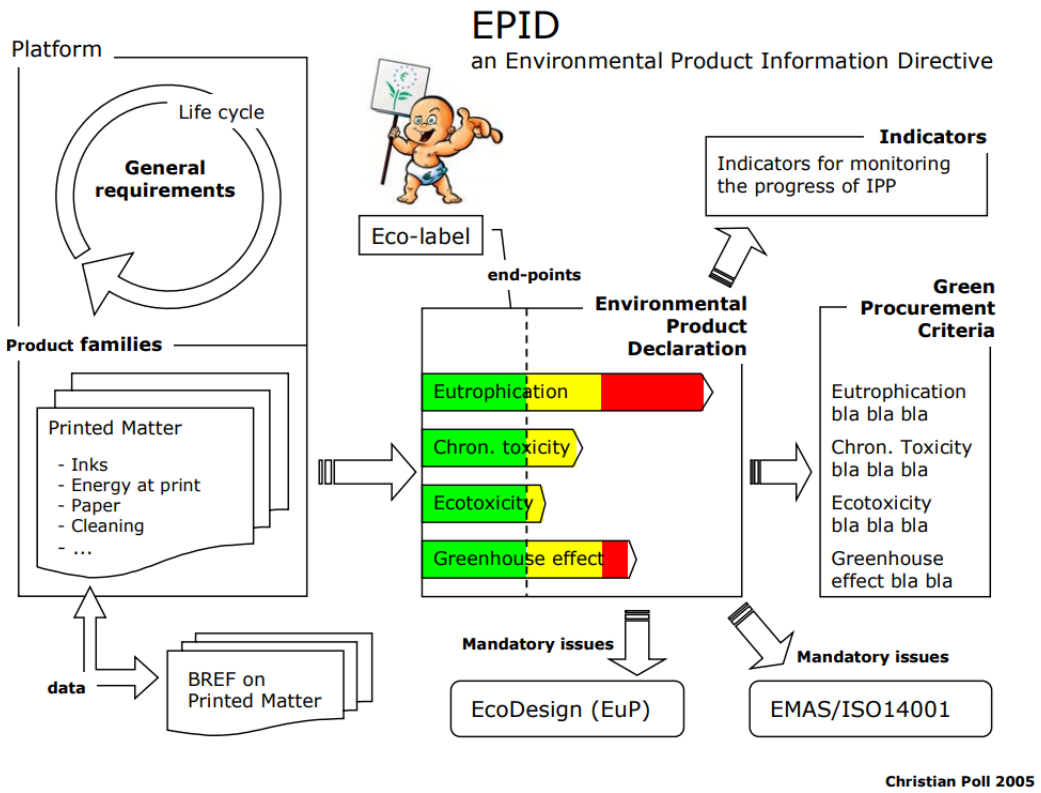
Green claims:

- Green claims are single parameter, few are life cycle based, so a full LCA approach is not relevant.
- In general there is not much documentation behind most claims.
- The development of PEFCRs are generally too slow for basing claims on.
- Although PEF may be methodologically standardised, there is still wide degrees of freedom for selecting which data to use. Therefore, PEF may not be much better in terms of getting unambiguous results related to claims.
- Also, bigger companies can put more resources into getting data that suits their needs.

- Single parameter claims will not disappear, but they are regulated by the Unfair Commercial Practices Directive, thus being documentable, relevant, proportional, timely etc.
- A reference regarding climate compensation was mentioned (Konsumentverket - KO, 2021)

Eco-labelling:

- Could PEF squeeze out established eco-label schemes? If PEF becomes tight enough and mandatory for some product groups, then the model from Johanne's presentation, slides #3 and #8, backed up by the provisions in the Unfair Commercial Practices Directive (The European Parliament and the Council, 2005) might substitute the criteria for eco-labelling. This approach has also been elaborated in the report (Poll, Vogt-Nielsen, Rubik, Jørgensen, & Jensen, 2005), the figure on page 139:



Thus, if PEF develop into both the methodological specifications, and an open data bank of data on materials and impacts, it could establish a broad base for the full palette of policy tools as indicated on the figure.

- Private labels (that by many consumers are mixed up with type I labels) normally have greater economic power behind than public type I labels, because they are invented and driven by large companies. It is in general difficult for public labels to compete in marketing powers, and the contribution from the many small label-holders comprise much of the marketing of the

public label. Therefore, it is important to acquire more money into public labels and promote the credibility of having type I labels.
- However, a Nordic report on textiles (Palm, et al., 2019) finds more than 30 labels for textiles, thus labels are widely used and may be difficult to get rid of.
- Overall there are about 500 different environmental related labels. Are any of these labels disappearing because of the PEF. “A law of marketing” may keep down the number of labels because you will be required to document your claims.

GPP:

- GPP is in general costly, as all bidders may have to gather documentation about the environmental performance of the services and products.
- The development of PEFCRs are generally too slow for basing GPP on.
- If PEF is used as e.g. tender selection, only companies having the PEF or PEF in progress can put in a bid on a tender. Is PEF operational in this context?
- However, for very large procurement rounds like trains or trams, GPP becomes more feasible, because documentation is only to be delivered as part of the contract after winning the call for tender. This practice may be used more widely and for smaller calls as well to make GPP becoming more feasible. There are numerous examples of that way of requesting documentation.
- There is a challenge with tenders, green public procurement in relation to PEF. This could be approved via “pilots”. Finland is working on this in the context of green procurement.
- If, for GPP, you use generic data, you can only compete on design. Specific data make it possible to compete at more levels. But specific data are costly to generate.

Thus in general:

- Data is the biggest challenge, company claims/labels not necessary LCA based, environmental related labels are a jungle of labels with varied transparency for the claims.

2.4.3 Session A3 on End-of-Life, waste, recycling and circular footprint formula

Moderator: Tomas Ekvall
Notetaker: Jáchym Judl

Session participants

Christofer Skaar	SINTEF	NO
Freja Nygaard Rasmussen	AAU - Aalborg University	DA
Hanne L Raadal	NORSUS	NO
Ivan Deviatkin	LUT University	FI
Jáchym Judl	SYKE Environment Institute	FI
Jouni Havukainen	LUT University	FI
Michael Hauschild	DTU Man QSA	DA

Mika Horttanainen	LUT University	FI
Stig Irving Olsen	DTU Man QSA	DA
Tomas Ekvall	Chalmers University of Technology	SE

Introductory presentation by Tomas Ekvall

Presentation slides in Enclosed B.4

As the circular footprint formula (CFF) captures all the topics of the session, the focus will be on it.

The CFF is complex, because it includes a lot, but when broken down it becomes more digestible. It consists of parts relates to:

- Use of virgin material – easy to understand
- Use of recycled material – more complex
- Recycling after use – ratio of recycling multiplied by the EOL processing minus credits from avoided virgin material production. Quality of secondary material is taken into account in this part.
- Energy recovery – long equation, but rather straightforward. Factor B is set to zero (this will be discussed later on); credits for substituted energy (heat and electricity)
- Disposal

The CFF works with:

- system expansion to account for substituted virgin material and substituted energy
- accounts for quality losses
- accounts for material-dependent markets

Limitations of the CF:

- It does not account for avoided disposal
- It is biased towards energy recovery (A>0; B=0). Material sent to energy recovery gives the product system full credits (B=0) but material sent for recycling gives only part of them (A>0).

More on the bias towards energy recovery:

- The formula for recycling and energy recovery, when simplified, looks pretty much identical. But the factor A varies between 0,2-0,8 and the factor B is set by default to 0.

Hypothetical case of plastics:

- Recycling is better than energy recovery (greater benefits).
- But with the factor A, part of the benefits will be allocated to the product that uses the recycled material. For energy recovery, all credits will be given to the

product that generates that waste. According to the CFF energy recovery will be the preferred form of treatment.

The factor A is defined by default for different materials in the Annex C.

Ekvall proposed a method for how to define the factor B so that it would not need to be zero by default.

Session debate

Debate topics:

- Factor B
- Allocation of disposal
- Factor A
- Factor Q

Q: How is quality defined?

- A: It is defined by the market value.

Q: What is the market area for that?

- A: It is at the point of substitution. E.g. price of fuel at a gas station. The price will vary between place and time.
- A: There are challenges with cascading materials across several life cycles.
- A: There is no challenge according to Tomas. The R1 factor takes care of this.

Practical application of the CFF

Tomas is involved in a project on renewable vehicle fuels. Env. impacts are calculated based on PEF, EPD and Renewable Energy Directive – e.g. a fuel from anaerobic digestion in PEF is not considered as recycling, but as energy recovery. Since the B is zero, then all impacts of the gas extraction is allocated to the producer of that biowaste. The biowaste is assigned environmental impacts of natural gas. Which is really strange.

- A: Troubles to make the CFF work in building sector. When applying the CFF at each life cycle stage separately, there were some gaps in the big picture.

Q: is there a guideline on different materials and what the point of substitution would be regarding the quality?

- A: No, not really. Tomas has not seen that. There is no definition of the point of substitution, we have to make that decision ourselves (perhaps). But this has an impact on results.

The topic of the point of allocation sparked a debate. We were not sure if there is a definition of this in the category rules. This can have a significant impact on the results – both including steps that are impact-intensive recycling processes, or including processes in the avoided material that are impacts-intensive (that would give great benefits).

Section 7.18.5 in the Guidance document: There is some text on the point of substitution, but it will still leave some space for interpretation.

- CFF formula tries to agree on that instead of having different recycling formulas, we will try to merge those into one – the CFF. The A factor favours recycling content at the EoL. Open questions: Do we think that the CFF should take over the other approaches? Do we need those other approaches? Are we moving towards "the recycling formula" in the LCA community.
- The division between ALCA and CLCA is important. So then you would need at least two formulas. The CFF tries to be more consequential, but is not really that. Recycling is a joint activity between the system that provides the secondary material and the one that uses it. They share the impacts. Each gets less than 100% of the benefits. So it is a challenge to model recycling in one system, even though it is connected to two (or more) systems. The SETAC code of practice said that recycling should be modelled as a join consequence of two systems.
- EPD methodologies care more about what you put into buildings, not so much what you get out of it. In this sense the A factor in the CFF is good. It will be interesting to follow up on how the values of the factor A will develop in the future. One workshop participant had to define quite a few values of the A factor.
- For textiles the value of the A factor is 0,8 and it is problematic, because it does not support recycling.
- Overall the CFF is very good approach to try as much as possible to include the things that are needed. It's been a good work in the development. But there are of course the challenges how to define the A, the B and the Q.
- From an initial reservations regarding the CFF, he is no more positive now. But e.g. Scandinavian district heating sector does not like it. They don't want to get burdens from burning waste for energy. When B is higher than zero, then some impacts of incineration of waste will be included.
- The more we move towards the CE, the better the CFF gets and the more importance it has. But how about the A factor? For example, for plastic it is by default 0,5, but plastics are different. Will they develop in the future?
    - A: The values of A are default and they can be changed. But that then poses challenged to the reproducibility.

Q: At VTT they have applied the CFF. When applying the CFF, it is not necessary to define whether a side stream is waste or co-product. In traditional LCA there is a difference in treating co-products and waste.

- A: The CFF is about post-consumer waste, not about side streams. So it might not really help with production waste, with side stream. You don't have the factor A for side streams. You have to apply the general allocation approach – so it will still matter whether a side stream is waste of a by-product.
- Q: Do you mean that the CFF is only applicable for post-consumer waste?
    - A: No, I hope not.

- We have applied the CFF on other than consumer products. The Swedish Life Cycle Centre has a project on this.

Q: Does anyone have an experience with how the results will change if the CFF is applied on renewable materials used to produce fuels, comparing to applying the RED?

- A: That's what they are at the moment working on in a project, but the work is ongoing. The differences will be big. For example, for HVO from waste cooking oil the virgin production of oil when applied PEF is included, but it is excluded when applying the RED.
- Q: "Tomas, you said the upstream of UCO is included in PEF, but what if UCO is regarded as a waste? Then no burdens are allocated to it before the point is taken in use, right?"
    - A: "Yes, it is regarded as waste, but as recycled waste. That's why PEF will include a part of the original production."

Q: Is there a repository for PEF cases? It is difficult to apply the formula and it would be nice to learn how others have applied it.

- A: Yes, but so far it is pretty much empty.

Q: Is it possible to use the EF data? How? Is there anything such as an official PEF study?

- A: EF package can be used strictly only for PEF/OEF studies carried according to the existing PEFCRs/OEFCRs.

Q: How are the substitution impacts of heat and electricity defined?

- A: The credits for electricity is the "residual national average". Not sure about heat. Impacts for incineration of mixed waste have to be recalculated for the specific product.

Factor B

Q: Is there an opinion on the factor B?

- The traditional view on waste incineration is that it's a good thing. The main function of waste incineration is to treat waste, so by default it is good.
- The logic that waste incineration is good, because we need to treat waste anyway and we need to heat anyway, starts to be a bit weak with increasing recycling.
- Q: Can the B factor result in serious double counting?

2.5 Plenary session A with brief reports from breakout sessions

Each Moderator gave a short presentation of sub-topics and points of debate from the session.

Further debate:

- There is a need to write about these factors, as allocation is crucial and the devil is in the detail. Some companies run into problems. The largest economic interest scores best.
- An official Repository of PEF and OEF studies is available on the wiki pages of the EC: https://webgate.ec.europa.eu/fpfis/wikis/ (Currently only two PEF/OEF studies have been published)
- Ecogrid (biodiversity) is too coarse. Only 804 ecoregions in the world. Looking at biodiv as a midpoint or an endpoint is important.

2.6 Second (B) breakout session

2.6.1 Session B1 on Allocation between co-products

Moderator: Tomas Ekvall
Notetaker: Stig Irving Olsen

Session participants

Galyna Medyna	Luke - Natural Resources Institute	FI
Ivan Deviatkin	LUT University	FI
Jáchym Judl	SYKE Environment Institute	FI
Jani Sillman	LUT University	FI
Jouni Havukainen	LUT University	FI
Juha-Matti Katajajuuri	Luke - Natural Resources Institute	FI
Martin Erlandsson	IVL Environmental Research Institute	SE
Risto Soukka	LUT University	FI
Stig Irving Olsen	DTU Man QSA	DA
Tomas Ekvall	Chalmers University of Technology	SE

Introductory presentation by Tomas Ekvall

Presentation slides in Enclosed B.5

Session debate

- Flexibility or lack of reproducibility when you can choose – a flexible guidance for PEFCRs is OK as long as the flexibility does not go into the CR.
- Is it possible to perform with an attributional approach i.e. without system expansion.
    - ISO is meant to fit for both attributional and consequential.
    - If substitution with average processes it is OK.
- What is system expansion:
    - Comparable functionalities i.e. expand with functionality (what is substituted) equal to crediting the system.

    - Distinction between multifunctional expansion or substitution/crediting.
- Attributional vs. Consequential system expansion.
- Made change where you want to study the consequences.
- Difference between system expansion and substitution.
- Can you do system expansion or substitution in attributional LCA – yes if using average data.
    - In waste management it is not always easy – e.g. if the results show that it is good to produce waste, e.g. because of energy recovery from incineration.
- How to verify that the chosen substitution is the correct choice – it will be up to the LCA practitioners choice.
    - But allocation involve value choices.
    - Both of these can be problematic since they are not either correct or not!
    - Order of preferences – in that case you need to prioritize and decided to what extent you can follow the first, second or third way.
- EPD try to avoid all random value choices by stating exactly how it should be done.
    - Substitution is not a choice in EPDs.
    - The PEF CR could do the same.
    - The PEFCr are allowed to twist the allocation approaches.
- A common problem that choices are not avoided in either EPD or PEFCR – the LCA approach should probably be more rigid.
    - In public procurement very rigid calculation rules are necessary.
    - PEFCr should directly address different questions and probably different methods are needed depending on the decision/application context in which it should be applied, e.g. public procurement vs. policy decisions.
    - Two categories : need for comparability (procurement decisions) – need for strategic decision information /policy support .
        - Need to provide specific guidance how to allocate/system expand in the two different situations.

2.6.2 Session B2 on Harmonisation EPD-PEF

Moderator: Kristian Jelse
Notetaker: Christine Molin

Session participants

Anna Woodhouse	NORSUS	NO
Ari Nissinen	SYKE Environment Institute	FI
Christine Molin	DTU Man QSA	DA
Christofer Skaar	SINTEF	NO
Ellen Riise	Essity	SE
Freja Nygaard Rasmussen	AAU - Aalborg University	DA

Håkon Hauan	EPD Norge	NO
Jeppe Nothlev Nørtoft	Miljøstyrelsen	DA
Johanna Suikkanen	SYKE Environment Institute	FI
Kim Christiansen	EEB rep. and expert	DA
Kristian Jelse	Greendesk	SE
Morten Søes Kokborg	Teknologisk Institut	DA
Preben Kristensen	PrebenK	DA
Sara Palander	Chalmers University of Technology	SE
Vanessa Hoffmann	Abena	DA

Introductory presentation by Kristian Jelse

Presentation slides in Enclosed B.6

Session debate

Debate questions:

- Are EPD and PEF already sufficiently harmonized for their intended purposes?
- What aspects should be further harmonized (and where is it not necessary)?
- How can such further harmonization be achieved?
- What topics for harmonization is especially important for the Nordic region?
    - How can we jointly work on them?
- Can the Nordic region harmonize EPDs and PEFs?

Methodology related discussions:

- Characterization factors are identical, so sufficient harmonized.
- How is e.g. land-use and biodiversity handled in EPD's, is it included or will it be included?
- Normalization and weighting is allowed in PEF but not in EPD's.
- Long discussion on co-products and system expansion. System expansion in some EPD cases.
- Critical review is not developed in PEF yet.
- Is the approach to secondary data the same in EPDs and PEF's?

PEF program operators and PEF scheme related discussion:

- The construction sector is attempting to harmonize EPDs and PEFs. Construction is the main driver for EPDs. Construction has well-functioning EPDs.
- In the Nordic countries there are program operators set up for PEF's. Are there any plans on EU level for program operators? Not defined yet by the EU commission, however they are open for suggestions.
- There are interesting ways illustrating how EPD's are used in Sweden.

- You can change the EPD result depending on which data is used. And PEF does not solve this, since consultants use different data, hence the problem is not solved.
- How will PEF schemes be run? One option is that EU would give mandate to licensed program operators. Another option that there will be one PEF scheme across EU.

What can we learn from the EPDs?

- Best with a one-stop point for companies.
- Better with one large program operator than many small.

Nordic collaboration related discussion:

- How can we collaborate better in the Nordic countries?
- One way could be to collaborate sector wise.
- More companies should do LCAs to know more about their products.

Notetaker's impression of take away messages

- Many open questions remain with regard to harmonization, more questions than solutions.
- There seem to be some kind of general need for organization and harmonization of program operators, e.g. license to operate.
- Data is an issue that pops up in all discussions around EPDs and PEF's.

2.6.3 Session B3 on Electricity modelling, supplier specific vs grid mix

Moderator: Hanne L. Raadal
Notetaker: Björn Spak

Session participants

Bergrós Arna Sævarsdóttir	Mannvit	IS
Björn Spak	Naturvårdsverket	SE
Gert Søndergaard Hansen	Danish EPA	DA
Hanne L Raadal	NORSUS	NO
Johanna Niemistö	SYKE Environment Institute	FI
Laura Sokka	VTT Research	FI
Linda Høibye	DK Green Investment Fund	DA
Marta Rós Karlsdóttir	Reykjavík Energy	IS
Mika Horttanainen	LUT University	FI
Serina Ahlgren	RISE Research Institute	SE

Introductory presentation by Hanne Raadal

Presentation slides in Enclosed B.7

Session debate

Points from Hanne Raadal:

- A need for a general understanding of the system - difference between market base and location based approach - which data to be used?
- Clarifying the guidelines - how to do the calculation - when are the minimum criteria met?
- Need for data requirements related to
    - Is specific data for electricity technologies needed or would it be sufficient to use generic data, e.g. for wind power
    - Residual mixes
- Review/verification process: what are the requirements for these processes, how to do the verification (e.g. control that supplier-specific electricity has been purchased - check the contract)?
- Backup power for intermittent electricity? Should this be taken into account when using e.g. wind/solar?

From notetaker: Björn Spak

Reflection on PEF hierarchy of electricity modelling – how to handle situation when verifying? If it's difficult to get the data – how is it followed up?

Problem today in conventional LCA – mix with location and market based resulting in double counting.

Big differences in residual grid mix in the Nordic countries according to EF Data 2.0

How to interpret "specific" data - will power producers be required to make LCAs of their specific production sites for their customers? Or will it be sufficient with the providing information on mode of power generation to be connected with generic power plant data in LCAs?

Among the participants there was agreement that for many types of electricity generation one site may not differ that much from another which is technically different why generic data would reflect production in different sites rather well. It was however identified that hydropower displays large differences due to the amount/type of land covered by dams. Also it was pointed out that the differences may be very large between different geothermal electricity plants.

Wind and solar power relies on supporting power plants to maintain the electricity supply in all weather conditions. Does the EF account for that when establishing impacts from electricity supply? According to Hanne and Björn no, it is possible to have a supply of 100% wind or solar. The exception would be if wind/solar PEFCRs are established specifying the inclusion of support power generation.

Is there any relation between EF and EU ETS? No direct but the higher the demand for renewable the easier it will be to steer towards.

How will the EF requirement of market based electricity be received?

For new/emerging technologies there is a lack of data which would need stimulus to be overcome.

The current common practice of using location based average country grids is easy because of its' availability in databases and popular in countries with a low climate impact average grid electricity.

The use of a market based approach is sometimes questioned, both by within the LCA community and from outside, with the argument that guarantees of origin doesn't provide additionality in renewable electricity supply.

Also clarifying, making the data available.

Conclusion on ideas to take further:

- Important that COM provides sufficient guidance for practitioners and reviewers to accurately model/review electricity supply in EF. Current guidance is not detailed enough, more detailed information on how to model in different markets is needed.
- Important to make sufficient data available for current electricity modelling.
- Important to clarify what is expected in terms of specificity – are specific supply mixes with generic generation data sufficient or is specific data from the respective electricity producing unit required?

2.6.4 Session B4 on Biomass, biochemical and biomaterials

Moderator: Mikolaj Owsianiak
Notetaker: Ólafur Ögmundarson

Session participants

Christian Poll	DTU Man QSA	DA
Giovanna Croxatto Vega	SDU - University of South Denmark	DA
Hanna Tuomisto	University of Helsinki	FI
Katri Joensuu	Luke - Natural Resources Institute	FI
Mikolaj Owsianiak	DTU Man QSA	DA
Ólafur Ögmundarson	University of Iceland	IS
Søren Løkke	AAU - Aalborg University	DA

Introductory presentation by Mikolaj Owsianiak

Presentation slides in Enclosed B.8

Session debate

The following points were discussed during the session:

- Temporary carbon storage and delayed GHG emissions = Credits can be given, depending on carbon stability (e.g. wood for biomass, construction).

- Other relevant time horizons and other relevant GHG emission metric = Methane emission from ruminants.
- Other relevant environmental impacts = Handling biodiversity and land use impacts, soil quality, soil carbon.
- Effects of cut-off in terms of by-product and modelling systems (e.g. wood chips) = What is waste and what is a resource shifts fast in bio economy, relevant for CCUS.
- Consideration of environmental boundaries of the Earth System = Environmental boundary for biotic resources (Impact is increasing the more we use biotic resource); Rebound effect.
- When implementing PEF and developing the methodology, it needs to be secured that disregarding is avoided as it might lead to wrong decisions. This could be counteracted by including uncertainty which is not the practice in PEF today and also by measuring biodiversity and land-use, and indirect land-use change.

Points prepared but not discussed:

- Upscaling and learning of biotechnologies = No consensual recommendations exist, and data can be limited.
- Geographic variability in life cycle inventory and impact assessment = Can make a difference for LCA results and resulting decisions.

2.7 Plenary session B with brief reports from breakout sessions

Each Moderator gave a short presentation of sub-topics and points of debate from the session. Nothing was further debated under this session.

2.8 Plenary debate, cross-topics, additional topics

No specific topic was debated under the cross-topic section. There was a broad debate on the generic problems, resulting from introducing a system more and more mandatory, which is characterised by lack of quality and transparency of data and of important issues like biodiversity still missing. It was pointed out by several participants that it would admirable to have a well-functioning PEF system with full transparency and consequent methodology on all impact categories, but that there is still a long way to go.

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Enclosed A - Participant list

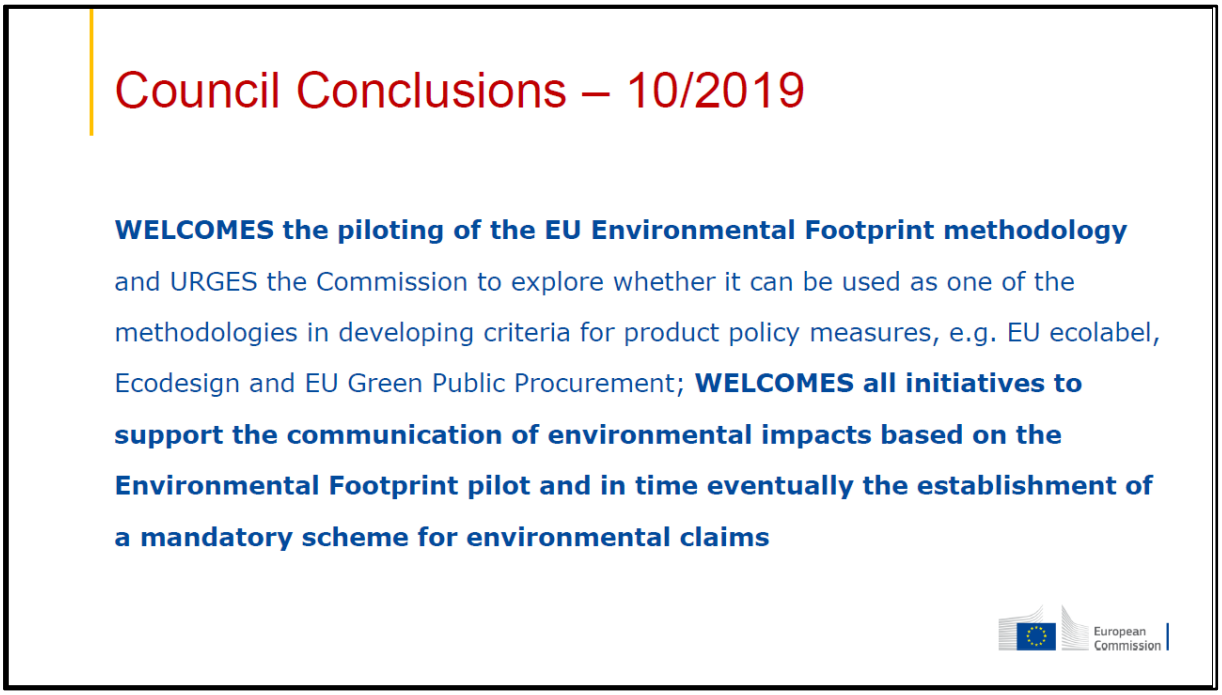
A.1. The following persons participated in the workshop

Name	Affiliation	Country
Anna Woodhouse	NORSUS	NO
Ari Nissinen	SYKE Environment Institute	FI
Bergrós Arna Sævarsdóttir	Mannvit	IS
Björn Spak	Naturvårdsverket	SE
Bodo Steiner	Helsinki University	FI
Christian Poll	DTU Man QSA	DA
Christine Molin	DTU Man QSA	DA
Christofer Skaar	SINTEF	NO
Ellen Riise	Essity	SE
Freja Nygaard Rasmussen	AAU - Aalborg University	DA
Galyna Medyna	Luke - Natural Resources Institute	FI
Gert Søndergaard Hansen	Miljøstyrelsen	DA
Giovanna Croxatto Vega	SDU - University of South Denmark	DA
Hanna Tuomisto	University of Helsinki	FI
Hanne L Raadal	NORSUS	NO
Håkon Hauan	EPD Norge	NO
Imola Bedo	European Commission	EC
Ivan Deviatkin	LUT University	FI
Jáchym Judl	SYKE Environment Institute	FI
Jani Sillman	LUT University	FI
Jeppe Nothlev Nørtoft	Miljøstyrelsen	DA
Johanna Niemistö	SYKE Environment Institute	FI
Johanna Suikkanen	SYKE Environment Institute	FI
Jouni Havukainen	LUT University	FI
Juha-Matti Katajajuuri	Luke - Natural Resources Institute	FI
Katri Joensuu	Luke - Natural Resources Institute	FI
Kim Christiansen	EEB rep. and expert	DA
Kristian Jelse	Greendesk	SE
Laura Sokka	VTT Research	FI

Name	Affiliation	Country
Linda Høibye	DK Green Investment Fund	DA
Marta Rós Karlsdóttir	Reykjavík Energy	IS
Michael Hauschild	DTU Man QSA	DA
Mika Horttanainen	LUT University	FI
Mikolaj Owsianiak	DTU Man QSA	DA
Morten Søes Kokborg	Teknologisk Institut	DA
Martin Erlandsson	IVL Environmental Research Institute	SE
Ólafur Ögmundarson	University of Iceland	IS
Preben Kristensen	PrebenK	DA
Risto Soukka	LUT University	FI
Sara Palander	Chalmers University of Technology	SE
Serina Ahlgren	RISE Research Institute	SE
Stig Irving Olsen	DTU Man QSA	DA
Søren Løkke	AAU - Aalborg University	DA
Tomas Ekvall	Chalmers University of Technology	SE
Vanessa Hoffmann	Abena	DA

Enclosed B – Presentations from the day

B.1. Presentation by Imola Bedo, The European Commission



European Green Deal – 12/2019

Reliable, comparable and verifiable information also plays an important part in enabling buyers to make more sustainable decisions and reduces the risk of 'green washing'. *Companies making 'green claims' should substantiate these against a standard methodology to assess their impact on the environment.*

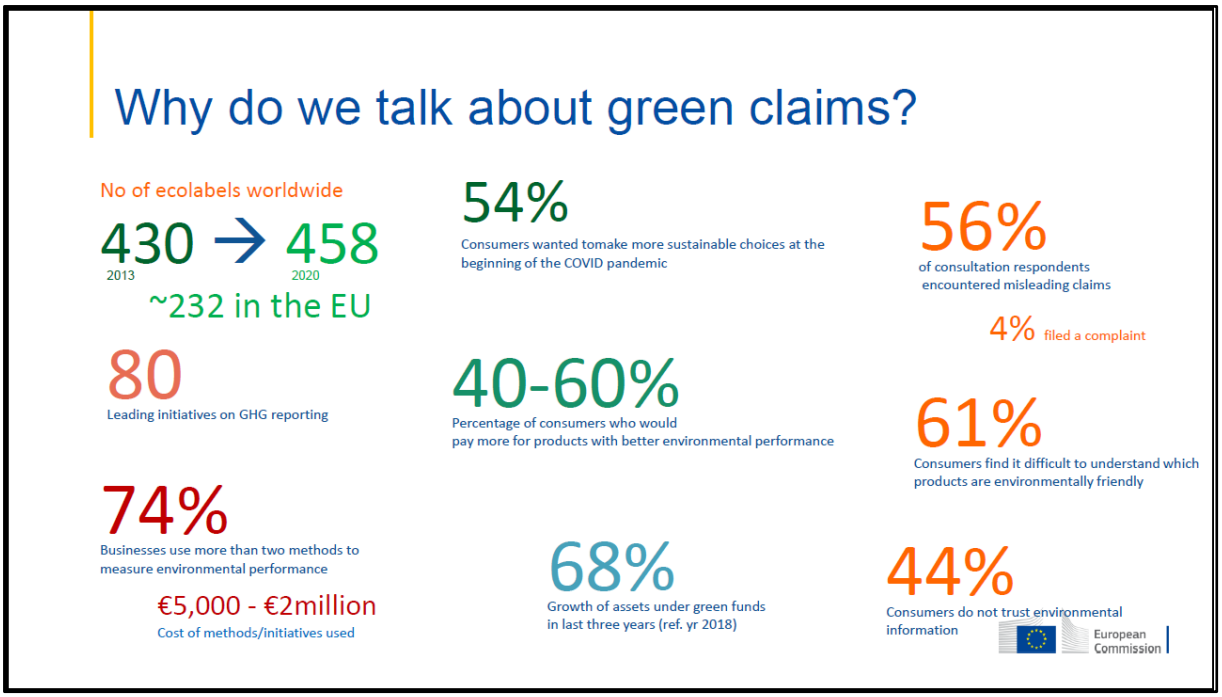
European Commission

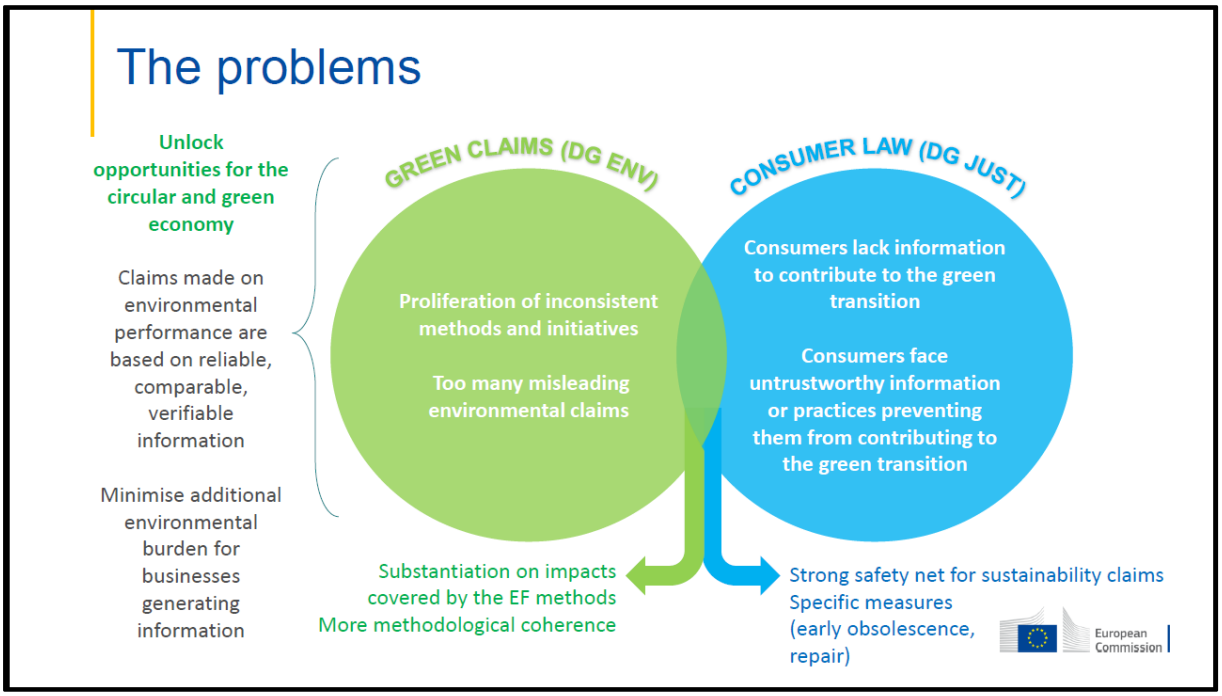
Circular economy action plan – 3/2020

The Commission will propose that companies substantiate their environmental claims using Product and Organisation Environmental Footprint methods. *The Commission will test the integration of these methods in the EU Ecolabel and include more systematically durability, recyclability and recycled content in the EU Ecolabel criteria.*

The review of the Ecodesign Directive as well as further work on specific product groups, under the Ecodesign framework or in the context of other instruments, will build, where appropriate, on criteria and rules established under the EU Ecolabel Regulation, the Product Environmental Footprint approach and the EU GPP criteria.

European Commission


Why do we talk about green claims?
No of ecolabels worldwide
430 → 458
2013
2020
~232 in the EU
80
Leading initiatives on GHG reporting
74%
Businesses use more than two methods to measure environmental performance
€5,000 - €2million
Cost of methods/initiatives used
54%
Consumers wanted tomake more sustainable choices at the beginning of the COVID pandemic
40-60%
Percentage of consumers who would pay more for products with better environmental performance
68%
Growth of assets under green funds in last three years (ref. yr 2018)
56%
of consultation respondents encountered misleading claims
4% filed a complaint
61%
Consumers find it difficult to understand which products are environmentally friendly
44%
Consumers do not trust environmental information
European Commission


The problems
Unlock opportunities for the circular and green economy
Claims made on environmental performance are based on reliable, comparable, verifiable information
Minimise additional environmental burden for businesses generating information
GREEN CLAIMS (DG ENV)
Proliferation of inconsistent methods and initiatives
Too many misleading environmental claims
CONSUMER LAW (DG JUST)
Consumers lack information to contribute to the green transition
Consumers face untrustworthy information or practices preventing them from contributing to the green transition
Substantiation on impacts covered by the EF methods
More methodological coherence
Strong safety net for sustainability claims
Specific measures (early obsolescence, repair)
European Commission

Why EF methods?

Cannot use LCA systematically in policy making

BUT

Same product

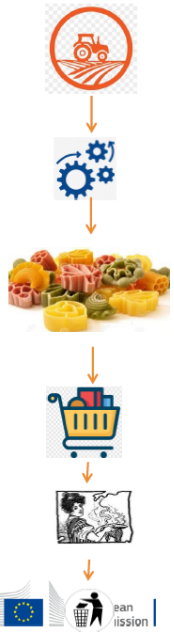
Different results

We need information that is reproducible, comparable, and verifiable

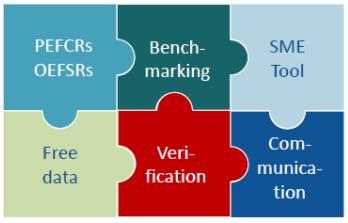
European Commission

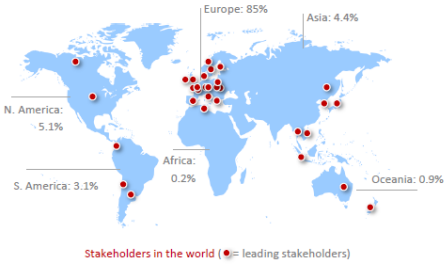
Features of the EF methods

- **Avoid trade-offs** between different value chain steps and between different environmental impacts (life cycle approach)
- **Tested** between 2013-18 with more than 250 leading stakeholders and more than 2000 stakeholders following the process
- **Based on international** best practice approaches BUT
  - Reproducible: methodological choices taken in method/ product- and sector-specific rules (PEFCRs/ OEFSRs) – this also leads to simplification
  - Materiality-driven: focus on the processes that are driving the environmental impact of a product/ organisation
  - Comparable: when PEFCRs exist, specific products' performance is comparable to a benchmark (average environmental performance)
  - Reliable: best practice methodological solutions discussed with experts and stakeholders, minimum verification requirements included in the method
  - Agreed: methodological choices taken based on input from experts (business, academia, public administrations, NGOs)
  - Less cost: Where secondary impact data is used, available for free to PEFCR/ OEFSR users



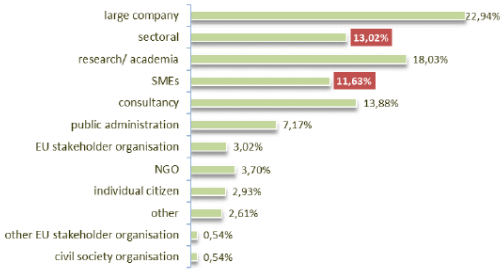
The pilot phase (2013-18)



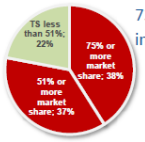


Stakeholders in the world (●= leading stakeholders)

Participants (27 pilots):
2219 individual stakeholders (5703 participations)



267 leading stakeholders in the 23 active pilots



The EU market is behind the pilots:
73% of pilots have the majority of industry in the lead

European Commission

PEFCRs/ OEFSRs

Finalised PEFCRs

- Batteries and accumulators
- Decorative paints
- Hot & cold water pipe systems
- Intermediate paper products
- IT equipment
- Leather
- Liquid household detergents
- Metal sheets
- Photovoltaic electricity generation
- Thermal insulation
- T-shirts
- Uninterrupted power supply
- Beer
- Dairy products
- Feed
- Packed water
- Pet food
- Pasta
- Wine
- Olive oil (pending)

Ongoing PEFCR development

- Apparel
- Cut flowers and potted plants
- Flexible packaging
- Synthetic turf
- Marine fish

Finalised OEFSRs

- Retail sector
- Copper sector

European Commission

Options landscape – green claims

- **Baseline**: No modification to the Recommendation and no further action.
- **Updating** the EC Recommendation with results from 2013-18 pilot phase; include recommendations on how to communicate results, how to develop PEFCRs/ OEFSRs…
- **Voluntary Environmental Footprint scheme**: legislation establishing a voluntary framework based on the PEF and OEF methods – existing methods/ initiatives are not affected

European Commission

Options landscape – green claims

- **Legislation on green claims**:
  requiring companies making green claims to substantiate them based on the Product and Organisation Environmental Footprint methods (PEF/ OEF). Substantiation via PEF category rules/ OEF sector rules (if existing) or the PEF/ OEF method (if no product- or sector-specific rules)
- Only claims covered by the method or product-/ sector-specific rules (e.g. claims on climate change covered, repairability not covered)

European Commission

Consultation activities

2018-19

- Targeted consultation (224 respondents)
- Public consultation (291 people) – section on EF of the consultation on the product policy framework for CE
- Stakeholder workshop (88)
- Final conference (456)

2020

- Feedback on the roadmap (20 July – 31 August, 193 responses)
- Open public consultation – ended 3 December 2020
  - Questions for the general public
  - Questions for experts
  - Stakeholder workshops (November 2020)
- Foreseen adoption: 2021

European Commission

B.2. Presentation from Session A1 by Serina Ahlgren

Biodiversity and land use

Introduction to the session

Nordic workshop on LCA aspects related to the EU PEF

2021-04-26

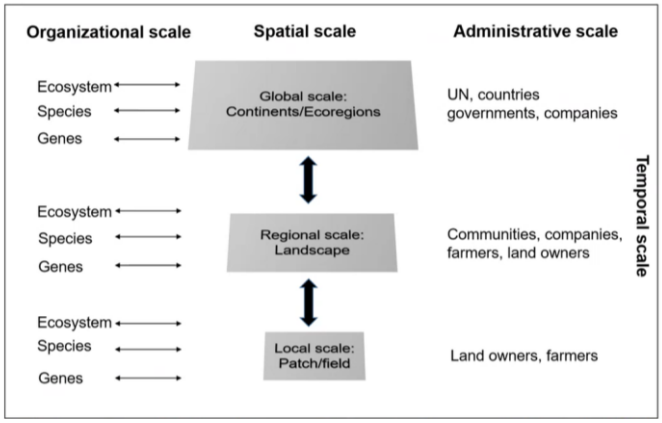
Serina Ahlgren, RISE

Ólafur Ögmundarson

Biodiversity

- Biodiversity can be defined as 'the variability among living organisms from all ecosystems and the ecological complexities of which they are part' (Millennium Ecosystem Assessment, 2005).
- Biodiversity is a prerequisite for ecosystem functionality, but is not an ecosystem service in itself

Biodiversity on different scales



From presentation by Stephanie Maier at LCA Foods 2020

Perspectives and units of measure

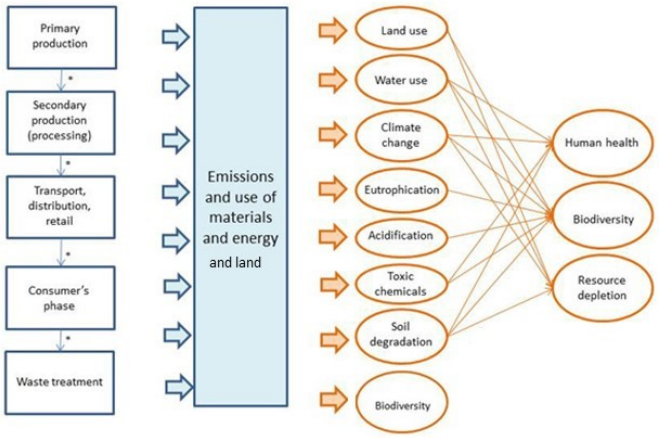
Species	Ecosystem /farm	Regional/ national/ global goals	Value chain LCA	Corporate
Number of species, prevalence of signal species, etc	Prevalence of signal species, habitats, etc → **Score**	Indicators, e.g. number hectares semi-natural pasture → **Distance to target/trend**	Indicators → **Often "artificial" unitless e.g. PDF or BVI**	?

Potentially Disappeared Fraction

Biodiversity Value Index

RISE — Research Institutes of Sweden

Biodiversity in LCA



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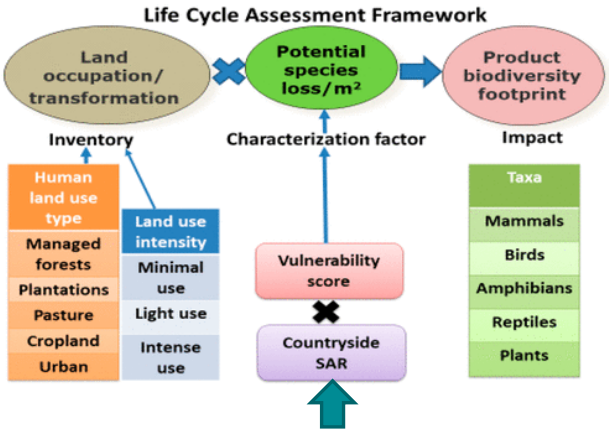
Chaudhary & Brooks 2018



Biodiversity data collected mainly from:
WWF Wildfinder database
IUCN Red list habitat classification scheme

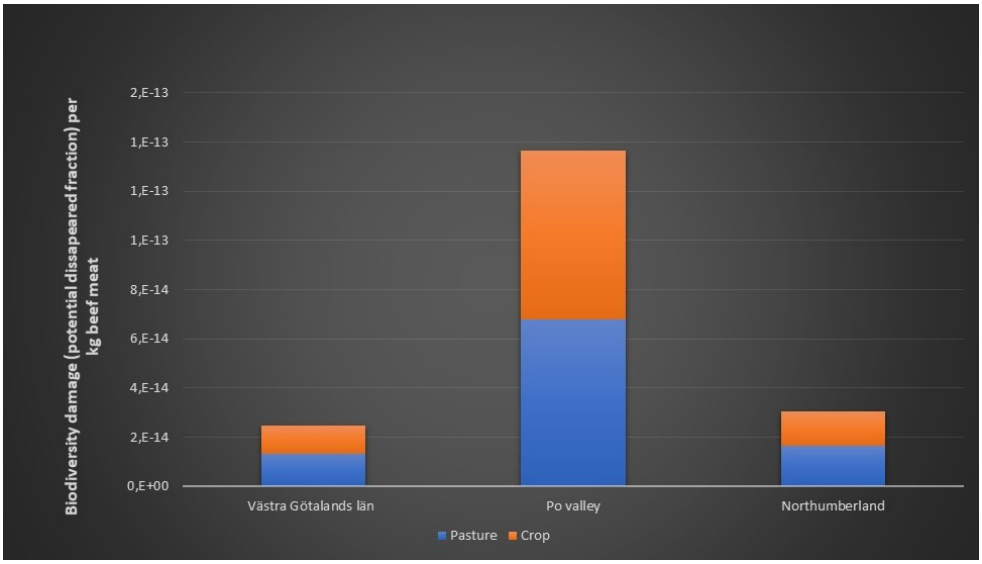
[redacted]

Land use intensity levels in the Chaudhary & Brooks (2018)

Land use	Intensity	Description
Pasture	Minimal use	Pasture with minimal input of fertiliser and pesticide, and with low stock density (not high enough to cause significant disturbance or to stop regeneration of vegetation).
	Light use	Pasture either with significant input of fertiliser or pesticide, or with high stock density (high enough to cause significant disturbance or to stop regeneration of vegetation).
	Intense use	Pasture with significant input of fertiliser or pesticide, and with high stock density (high enough to cause significant disturbance or to stop regeneration of vegetation).
Cropland	Minimal use	Low-intensity farms, typically with small fields, mixed crops, crop rotation, little or no inorganic fertiliser use, little or no pesticide use, little or no ploughing, little or no irrigation, little or no mechanisation.
	Light use	Medium intensity farming, typically showing some but not many of the following: large fields, annual ploughing, inorganic fertiliser application, pesticide application, irrigation, no crop rotation, mechanisation, monoculture crop. Organic farms in developed countries often fall within this category, as may high-intensity farming in developing countries.
	Intense use	High-intensity monoculture farming, typically showing many of the following features: large fields, annual ploughing, inorganic fertiliser application, pesticide application, irrigation, mechanisation, no crop rotation

[redacted]

Results of hypothetical study, per kg beef

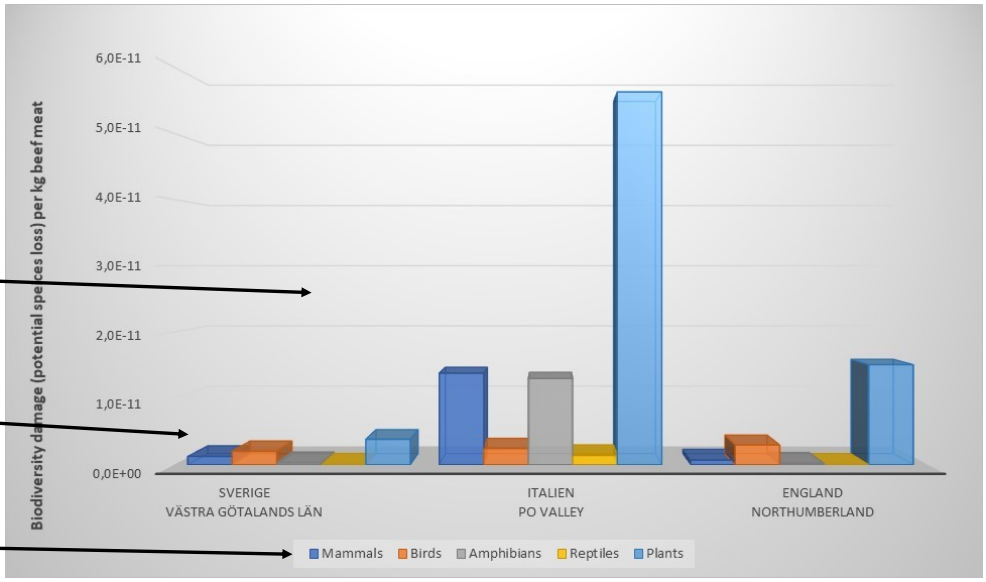


Results of hypothetical study, per kg beef

"…the reason for the small difference across the three intensity levels can be that most species are already wiped out once the natural vegetation of a region is cleared…"

Can not show positive effects

Insects not included



Reference situation

- Is the biodiversity status good or bad?
- Change in biodiversity, compared to what?

Vrasdonk et al 2019:

Natural counterfactual: a hypothetical situation that would have occurred nowadays without human interventions in the past.

Re-naturalization/natural regeneration: a future hypothetical state if all human interventions stop. It differs from the natural counterfactual because the re-naturalized state is partly a result of human activity in the past.

Limit references: established as limit reference that, if exceeded, indicate that the system or object will be subject to serious or irreversible harm, often used in conservation policy and practice.

Target reference: signal a state at which to aim, given ecological needs and socioeconomic and political possibilities.

[redacted]

Discussion topics

- What are your experiences with biodiversity-LCA calculations?
- How far has the work on biodiversity progressed in PEF?
- Opinions on reference situation
- Other methodological challenges
- Cooperation ecology/biology and LCA research?
- Other land use issues

→ Can we agree on any common grounds and mutual understanding among the Nordic countries?

[redacted]

12 RISE — Research Institutes of Sweden

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B.3. Presentation from Session A2 by Johanna Suikkanen

Single Market for Green Products: What next?

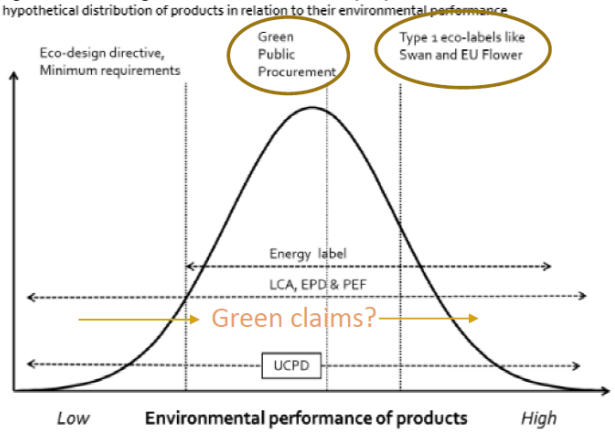
- The 2020 Circular Economy action plan states:
  - "the Commission will also propose that companies substantiate their environmental claims using Product and Organisation Environmental Footprint methods."
  - "The Commission will also consider further strengthening consumer protection against green washing setting minimum requirements for sustainability labels and for information tools"
  - The European Green Deal states "Companies making 'green claims' should substantiate these against a standard methodology to assess their impact on the environment".

2

SYKE

PEF in the context of product policy instruments

Figure 1: A schematic figure about the focus areas of some policy instruments in relation to a hypothetical distribution of products in relation to their environmental performance.

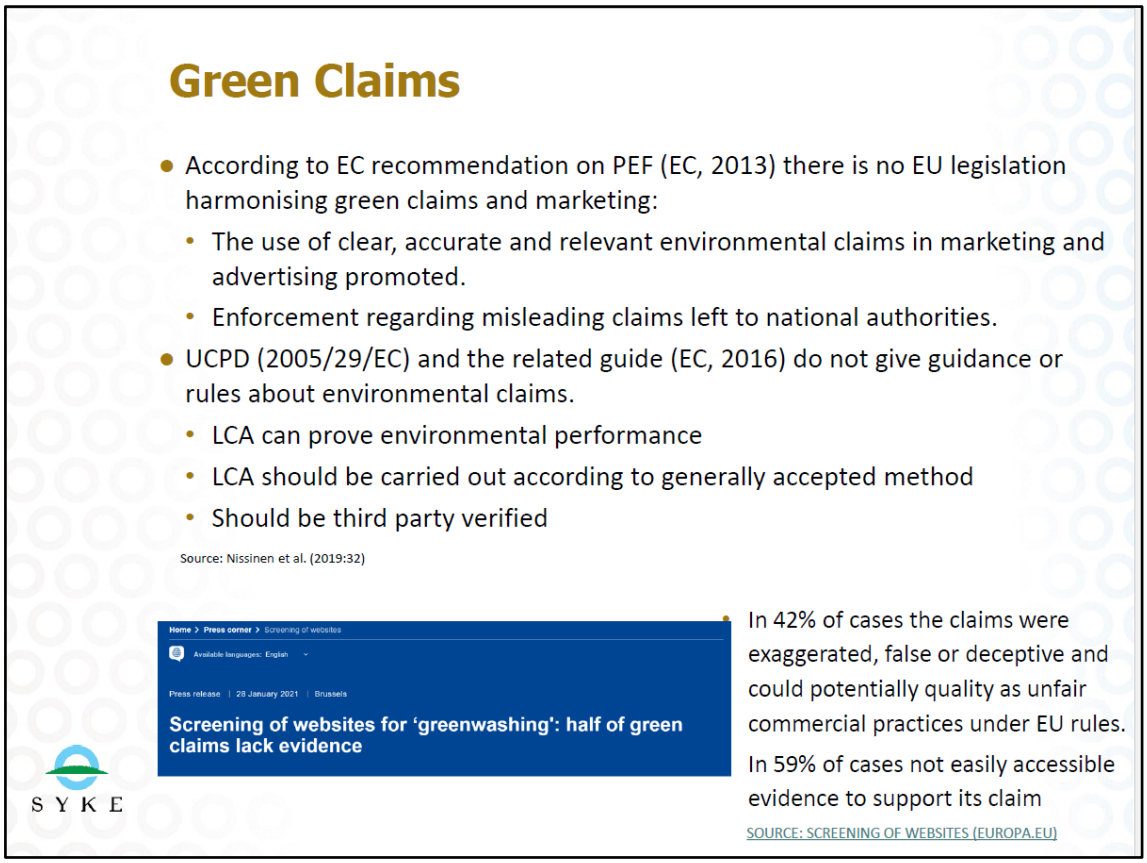


Source: Redrawn and slightly modified from Dalhammer (2007 p. 139), Galatola (2015) and the EC (2019a).

Nissinen, A., Suikkanen, J., Salo, H., 2019. Product Environmental Information and Product Policies. TemaNord.. doi:10.6027/tn2019-549

SYKE

Page 24 in (Suikkanen, Nissinen, & Salo, Product Environmental Information and Product Policies: How Product Environmental Footprint (PEF) changes the situation?, 2019)



Green Public Procurement

- LCA has been identified as an important source of environmental information in public procurement (EC, 2016)
  - Although not required in Directive (Directive 2014/24/EU).
- How environmental information can be used in procurement is quite specific: award criteria and in technical specifications
- PEF can be used for the comparison of products during competitive bidding:
  - Used as a comparison criteria for the economically most advangeous tender
  - **Possible when there is a PEFCR** → Comparability
- PEF data required from the selected supplier as part of procurement contract:
  - Also possible when no PEFCR → No comparison

SYKE

SOURCE: NISSINEN ET AL, 2019, SUIKKANEN &NISSINEN, 2020

Eco-labelling

- Type 1 Ecolabels such as the EU Ecolabel (Flower) or the Nordic Swan
  - Fulfilling criteria indicates superior environmental performance for environmental aspects and differentiates the product from others within the product group.
  - Criteria setting based on Life Cycle Thinking:
    - Relevance, Potential and Steerability
- Integrating PEF-based criteria into the EU Ecolabel is being tested by the European Commission.
- The EF pilot phase included a test of different communication vehicles, **including a PEF label**.
  - Concluded that of labels consumers prefer to have information as a 3-level scale

SYKE

PEF information: Possibilities for Type I eco-labels

I. USE READILY AVAILABLE PEF INFORMATION

PEFCRs and other readily available related material are used in defining which criteria to set.

II. CREATE PEF INFORMATION

PEF studies are carried out in setting criteria and given as an option to license-applicants to get points

III. REQUIRE PEF INFORMATION

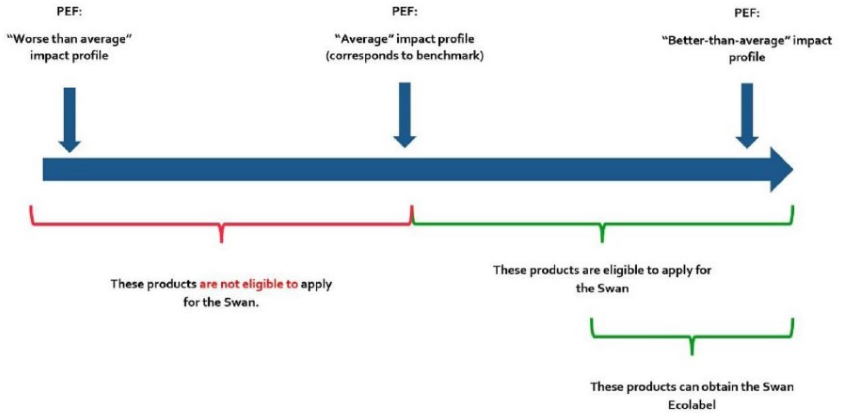
Criteria are PEF-based and a PEF study is required from companies.

JOHANNA SUIKKANEN, SYKE, 19-11-2019

SYKE

Source: Suikkanen et al. 2019

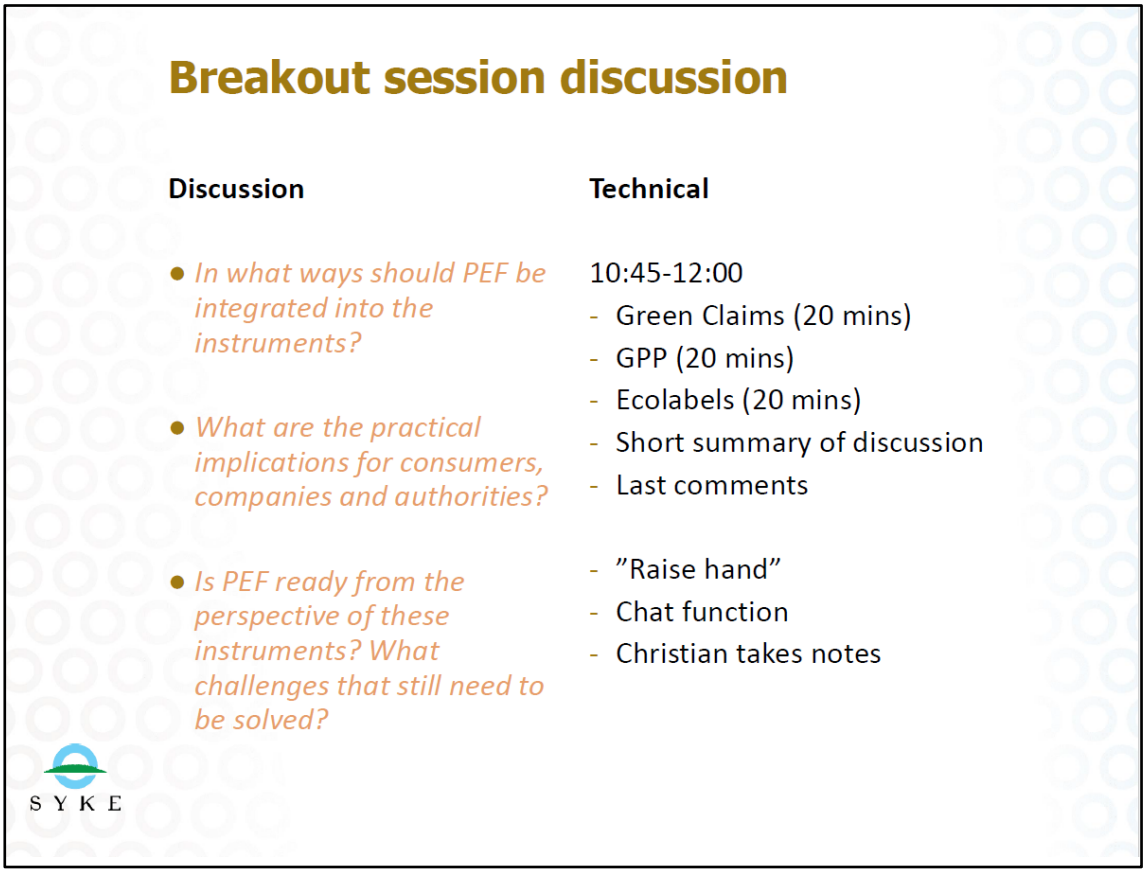
Figure 8: A hypothetical situation where a better-than average – PEF value is a prerequisite for ecolabel applicants



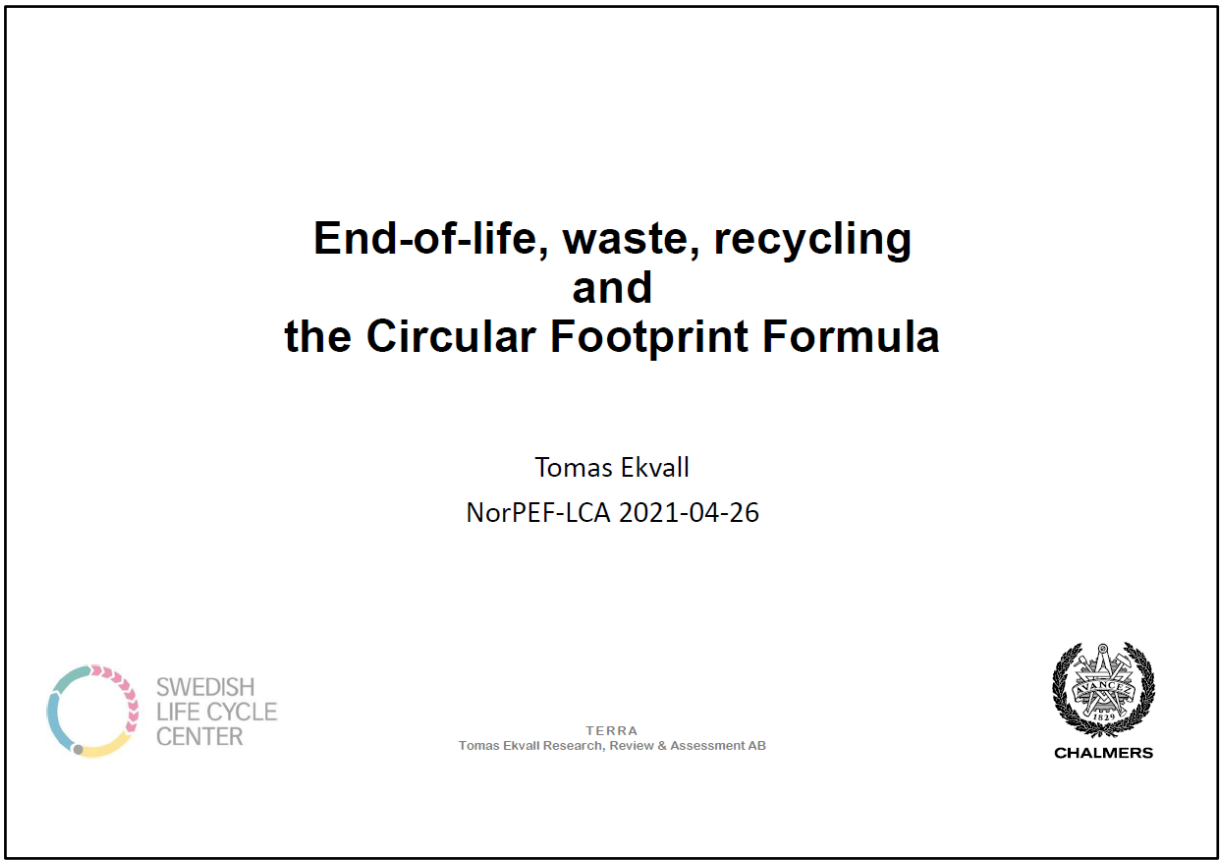
Suikkanen et al., 2019

SYKE

Page 102 in (Suikkanen, Nissinen, & Wesnæs, Nordic Swan Ecolabel and Product Environmental Footprint - Focus on Product Environmental Information, 2019)



B.4. Presentation from Session A3 by Tomas Ekvall



Circular Footprint Formula

Use of virgin material $(1 - \mathrm{R}_1)\mathrm{E}_\mathrm{V}$

Use of recycled material $\mathrm{R}_1 \times \left[A\mathrm{E}_\mathrm{recycled} + (1 - A)\mathrm{E}_\mathrm{V} \times \frac{Q_{Sin}}{Q_P}\right]$

Recycling after use $(1 - A)\mathrm{R}_2 \times \left(\mathrm{E}_\mathrm{recyclingEoL} - E_V^* \times \frac{\mathrm{Q}_\mathrm{Sout}}{\mathrm{Q}_\mathrm{P}}\right)$

Energy recovery $(1 - B)R_3 \times \left(E_{ER} - LHV \times X_{ER,heat} \times E_{SE,heat} - LHV \times X_{ER,elec} \times E_{SE,elec}\right)$

Disposal $(1 - R_2 - R_3)E_D$

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In the Circular Footprint Formula

- System expansion to account for
  - Substituted virgin material
  - Substituted energy
- Accounts for quality losses
- Accounts for material-dependent markets

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Limitations of the Circular Footprint Formula

- Does not account for avoided disposal
- Biased towards energy recovery (A>0; B=0)

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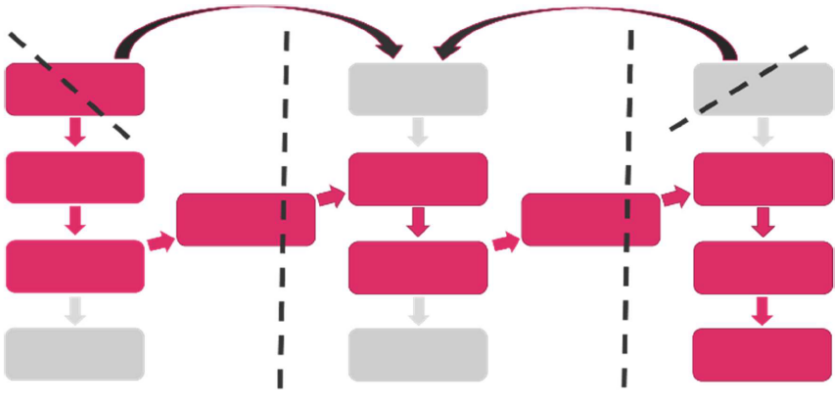
CFF applied to 2nd life cycle: avoided disposal not accounted for



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Circular Footprint Formula

Burdens and benefits of waste to recycling:

$$E_{WR} = (1 - A) \times (E_R - \frac{Q_S}{Q_P} E_V^*).$$

Burdens and benefits of waste to energy recovery:

$$E_{WI} = (1 - B) \times (E_{ER} - E_E^*).$$

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Source: EC (2018a)

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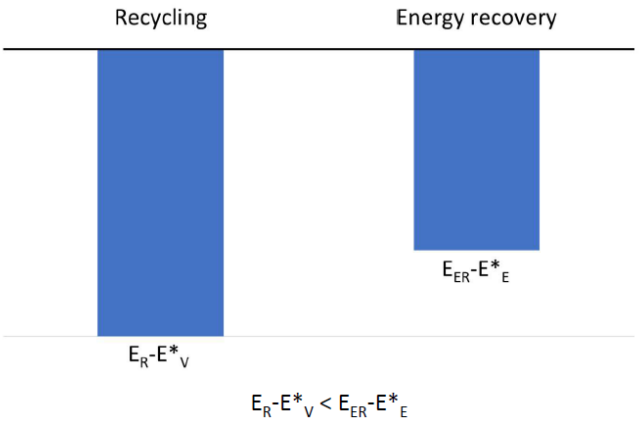
Net environmental benefits



E_R-E^*_V < E_{ER}-E^*_E

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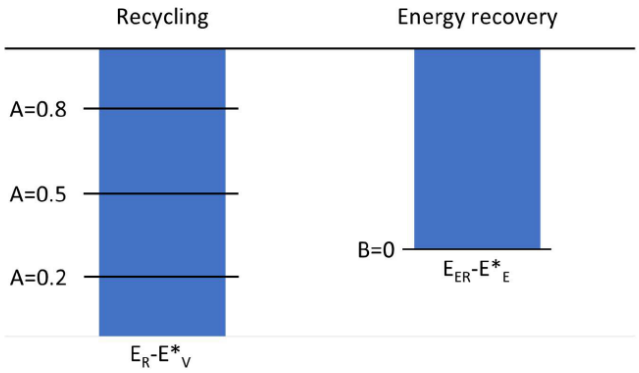
Comparative Product Environmental Footprints



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Source: EC (2018b)

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To discuss – tentative gross list

- Factor B
- Allocation of disposal
- Factor A
- Factor Q
- Other?

- Priority?

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B.5. Presentation from Session B1 by Tomas Ekvall

Allocation procedure PEF

1. Subdivision or system expansion to multifunction system
2. Allocation based on underlying physical relationships… or direct substitution
3. Allocation based on other relationships… or indirect substitution

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Allocation procedure ISO 14044:2006

1. Subdivision or system expansion
2. Allocation based on underlying physical relationships
3. Allocation based on other relationships

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Allocation procedure ISO 14044:2006/A2:2020

1. Subdivision or system expansion with substitution
2. Allocation based on underlying physical relationships
3. Allocation based on other relationships

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System expansion

ISO 14044:2006/A2:2020

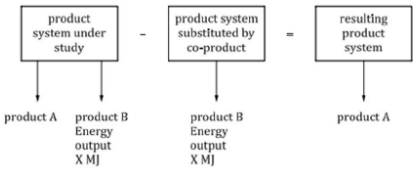

Figure D.1 — Example of avoiding allocation by expanding the system boundary

ISO/TR 14049:2012

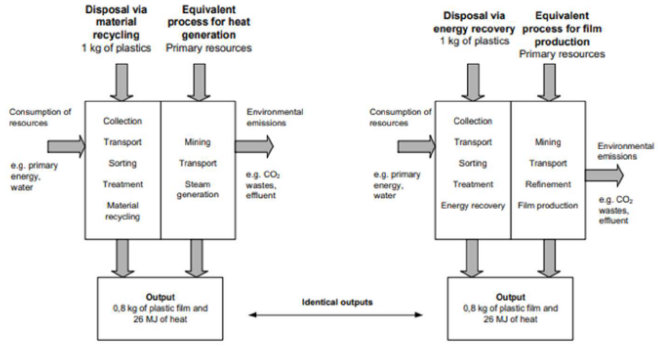

Figure 9 — Example of an expansion of the system boundaries

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To discuss – tentative gross list

- Flexibility vs. reproducibility
- Meaning of system expansion
- Meaning of underlying physical relationships
- Other?

- Priority?

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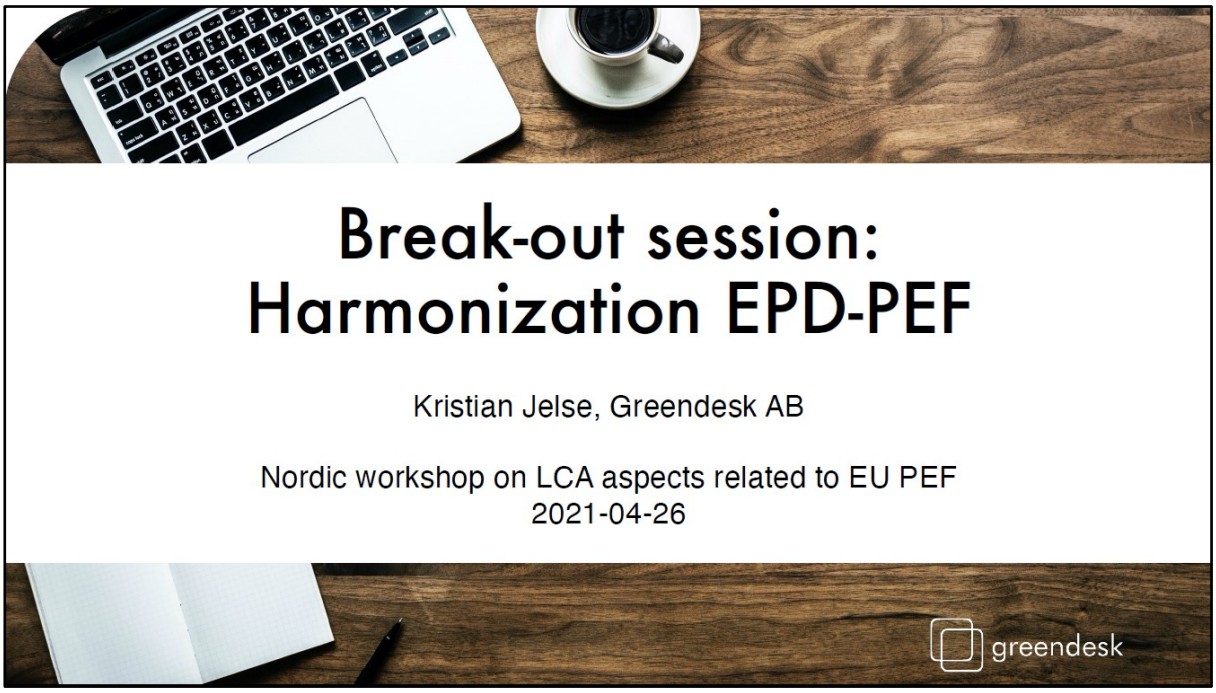
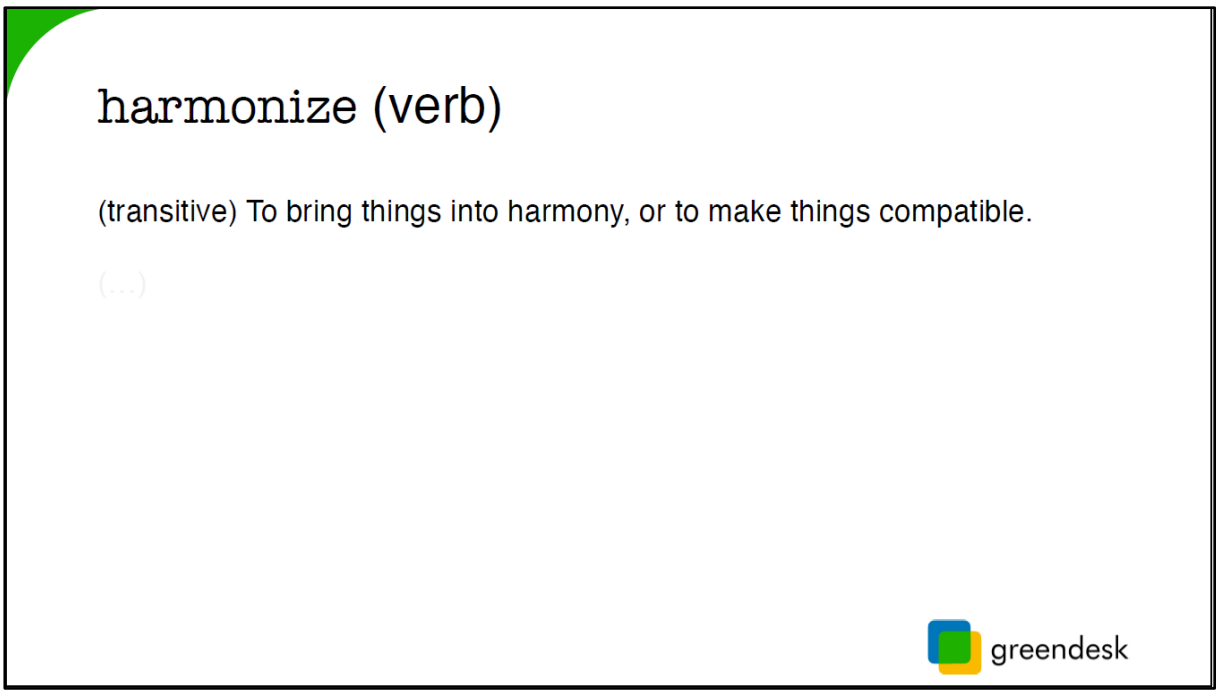
B.6. Presentation from Session B2 by Kristian Jelse





Background – *my personal perspective*

- "Analysis of Existing Environmental Footprint Methodologies for Products and Organizations: Recommendations, Rationale, and Alignment" (2011) contributed to:
  - perception that there are too many standards and labels with too low reproducibility
  - two new methods/frameworks are needed that should suit EU policy need => OEF/PEF
  - they should be better fit for purpose than what exists currently => harmonization with existing standards not a goal in itself
- However: EPD not one of the analyzed methodologies
- Since publication of EN 15804 and Construction Product Regulation (both in 2011) => large and growing momentum to publish and use EPD

greendesk

Current situation – *my personal perspective*

- "Tens of thousands" of EPD published (mainly construction products)
- Harmonization efforts:
  - PEF with ISO-LCA and EPD – increased during PEF pilot phase (2013-2018)
  - EPDs for construction product with PEF – increased after publication of new version of EN 15804 (2019)
  - EPDs for non-construction products with construction product EPDs – ongoing development, following lead by construction industry

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Proposed topics for discussion

1. Are EPD and PEF already sufficiently harmonized for their intended purposes?
   - Construction products
   - Other product categories
2. What aspects should be further harmonized (and where is it not necessary)?
   - Methodology, data, verification scheme, communication format, etc.
3. How can such further harmonization be achieved?
4. What topics for harmonization is especially important for the Nordic region? How can we jointly work on them?

greendesk

B.7. Presentation from Session B3 by Hanne Raadal

NORSUS
Norwegian Institute for Sustainability Research

NordPEF-LCA online workshop, April 26th 2021

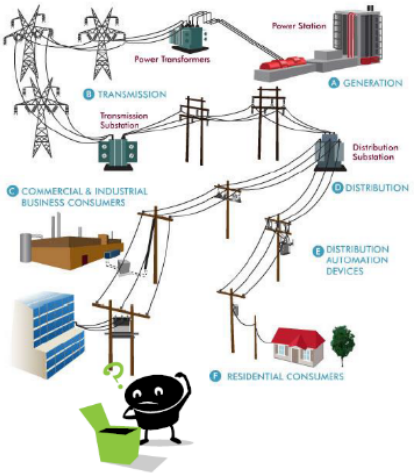
Electricity modelling in PEF
Supplier-specific vs grid mix

Hanne Lerche Raadal, Head of Research NORSUS

Suggestions for updating the Product Environmental Footprint (PEF) method (Zampori and Pant, 2019)

4.4.2 Electricity use

Electricity from the grid shall be modelled as precisely as possible giving preference to supplier-specific data. If (part of) the electricity is renewable it is important that no double counting occurs. Therefore, the supplier shall guarantee that the electricity supplied to the organisation to produce the product is effectively generated using renewable sources and is not available anymore for other consumers.



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Some definitions

- Supplier-specific electricity product*
  - Conveys the information about energy type for the unit of electricity produced
  - Based on a contractual instrument between the two parties for sale and purchase of the energy related attributes (e.g. Guarantees of Origin (GOs) and Renewable Energy Certificates (RECs)
- Residual grid mix, consumption mix = Residual consumption mix
  - Characterize the unclaimed, untracked or publicly shared electricity only.

Market based

- Consumption grid mix:
  - Reflects the total electricity mix transferred over a defined grid including green claimed or tracked electricity (~ "traditional" average grid mix)

Location based

* According to ISO 14067 and GHG Protocol Scope 2 Guidance

NORSUS

4.4.2.1 General guidelines (electricity for producing the product)

The following electricity mix shall be used (hierarchical order)

1. Supplier-specific electricity product (if minimum criteria are met)
2. Supplier-specific total electricity mix (if minimum criteria are met)
3. Country-specific residual grid mix
4. Average EU residual grid mix or region representative residual grid mix

Market based

- Supplier-specific electricity product*
  - Conveys the information about energy type for the unit of electricity produced
  - Based on a contractual instrument between the two parties for sale and purchase of the energy related attributes (e.g. Guarantees of Origin (GOs) and Renewable Energy Certificates (RECs)
- Residual grid mix, consumption mix = Residual consumption mix
  - Characterize the unclaimed, untracked or publicly shared electricity only.
- Consumption grid mix:
  - Reflects the total electricity mix transferred over a defined grid including green claimed or tracked electricity (~ average grid mix)

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Minimum criteria for supplier-specific electricty

1. Convey information about environmental attributes (e.g. energy type) for the specific electricityy produced
2. Be assured with a unique claim
   - Be the only instrument that carries the environmental attribute claim associated with that quantity of electricity generation.
   - Be tracked and redeemed by or on behalf of the company (e.g. Guarantees of Origin (GOs) and Renewable Energy Certficates (RECs)
3. Be issued and redeemed/cancelled as close as possible to the period of electricity consumption to which the contractual instrument is applied

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4.4.2.6 Electricity use at the use stage

- For the use stage the consumption grid mix shall be used. The electricity mix shall reflect the ratios of sales between EU countries/ regions.

Location based

- Supplier-specific electricity product*
  - Conveys the information about energy type for the unit of electricity produced
  - Based on a contractual instrument between the two parties for sale and purchase of the energy related attributes (e.g. Guarantees of Origin (GOs) and Renewable Energy Certificates (RECs)
- Residual grid mix, consumption mix = Residual consumption mix
  - Characterize the unclaimed, untracked or publicly shared electricity only.
- Consumption grid mix:
  - Reflects the total electricity mix transferred over a defined grid including green claimed or tracked electricity (~ average grid mix)

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U Directives and information requirements

Electricity Disclosure

- The Electricity Market Directive 2009/72/EC, Article 3(9)
- All suppliers of electricity are required to disclose their electricity portfolio with regards to energy source and environmental impacts (=attributes)
  - ⇨ Provide consumers with relevant information about power generation and to allow for informed consumer choice - not to be based on electricity prices alone

Guarantee of Origin (GO)

- Renewable Energy Directive (2009/28/EC)
  - Proof to a final customer that a given share or quantity of energy was produced from renewable sources as required by The Electricity Market Directive.
  - A tracking instrument for the electricity's origin.
- RED II (2018/2001) GOs extended to gas, heat and cooling
  - Ongoing revision of EN 16325:2013 Guarantees of Origin related to energy - Guarantees of Origin for Electricity

7

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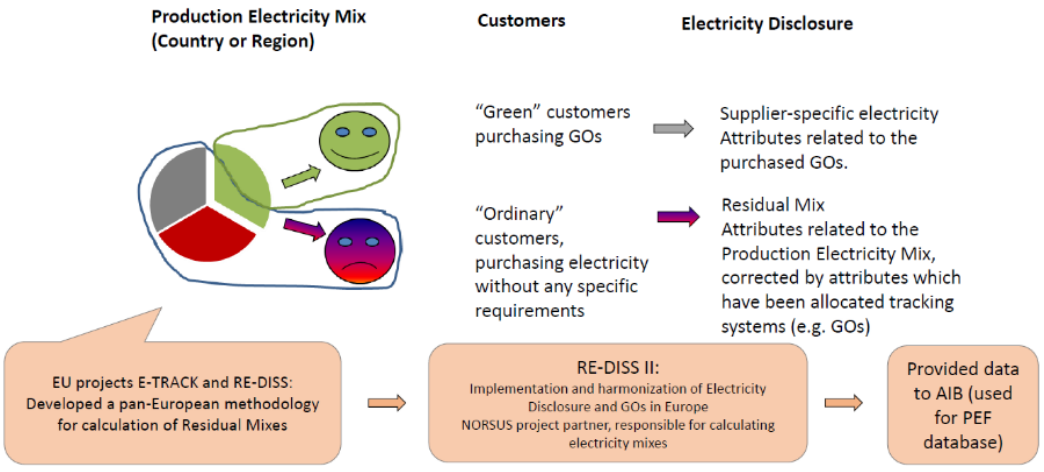
Connection GOs and Electricity Disclosure



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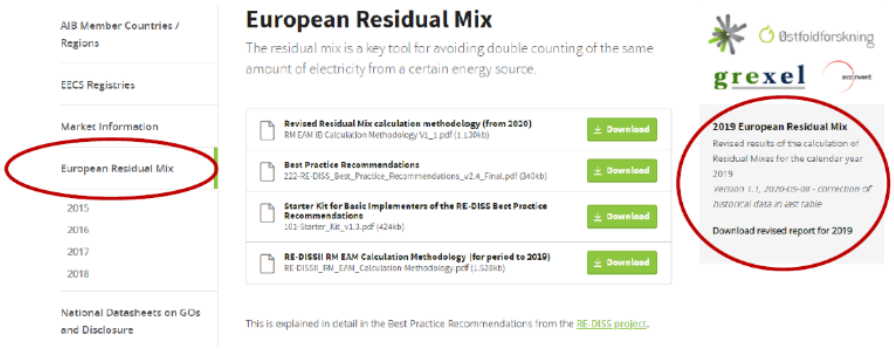
European Residual Mixes – annually calculated for all EU countries



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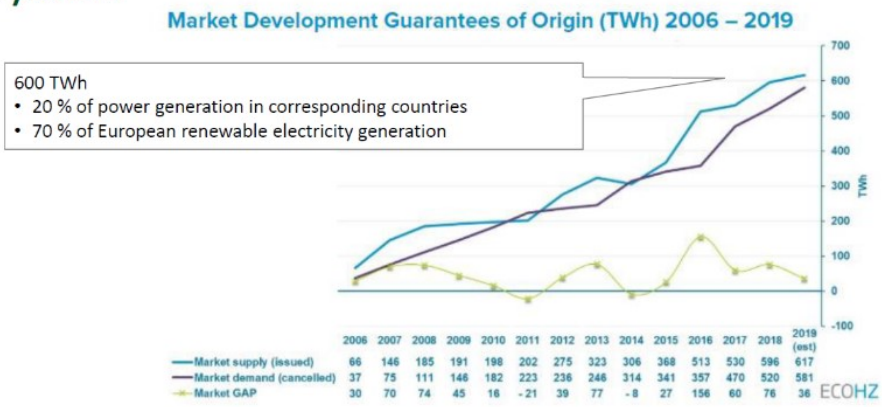
Statistics – The European Energy Certification System

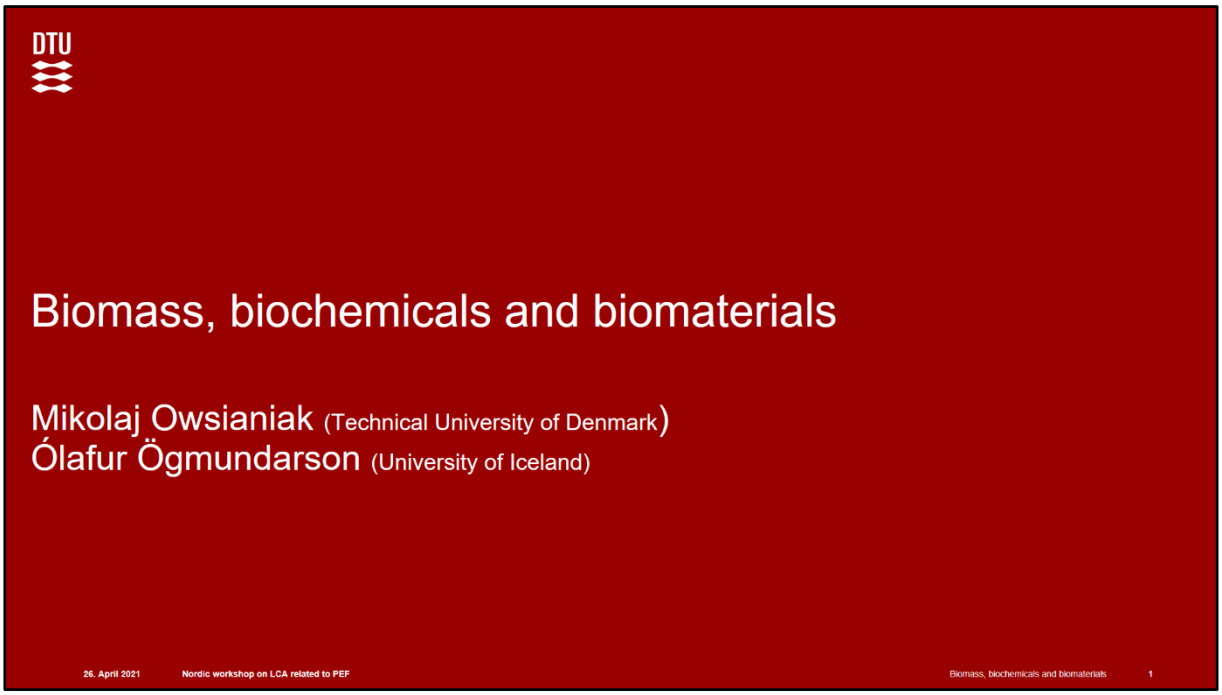


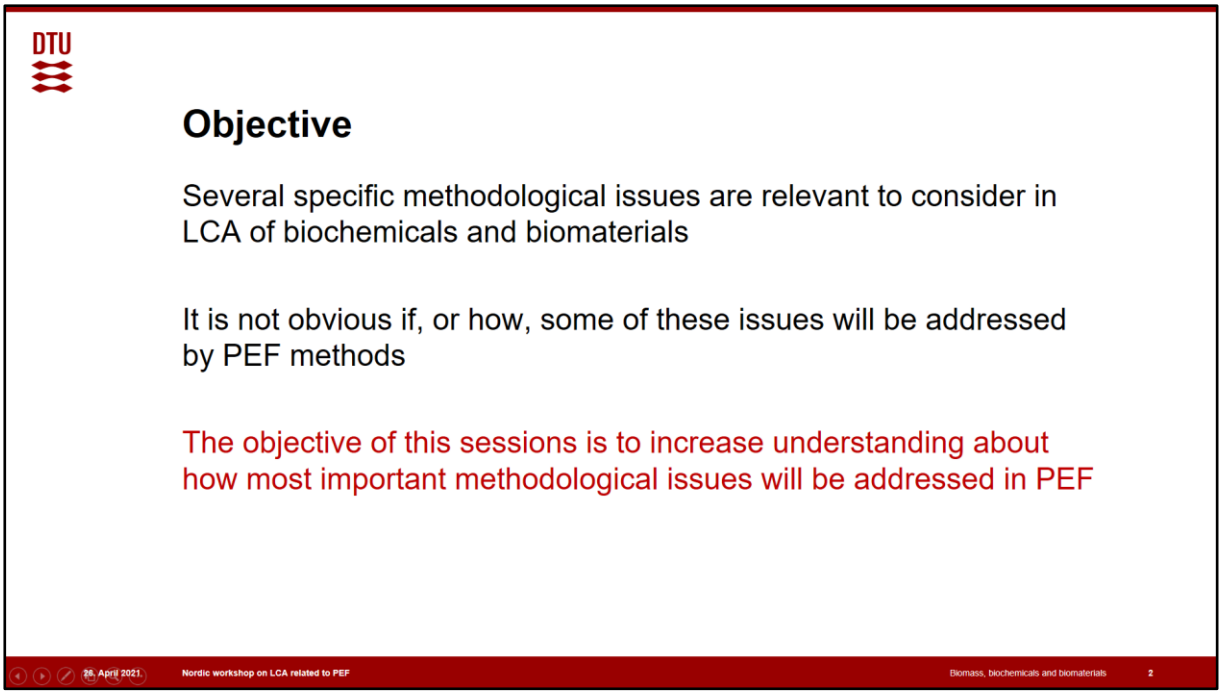
EECS = The European Energy Certification System

- A harmonised system for international trade of Guarantees of Origin (GOs)
- Cooperates with the national account keeping authorities (Statnett etc.)

Source: Association of Issuing Bodies and Ecohz, 2019
https://www.ecohz.com/press-releases/good-news-for-european-renewables/

B.8. Presentation from Session B4 by Mikolaj Owsianiak





Suggested format

13.30-13.40 Introduction

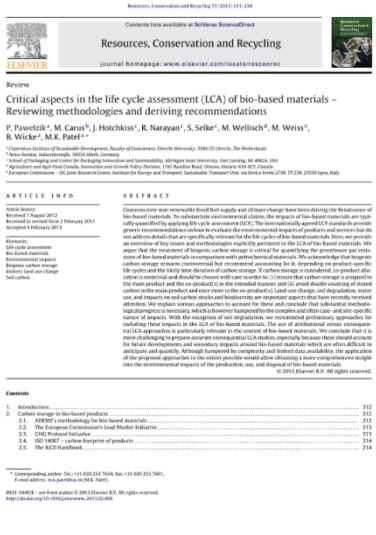
13.35-14.00 Identify main methodological issues relevant to environmental sustainability assessment of biomass, biochemicals and biomaterials

14.00-14.15 Break

14.10-14.45 Discuss the main issues one-by-one, indicating:

a) current and foreseen addressing by the PEF method

b) if not addressed, potential implications for PEF-based decision-support



Resources, Conservation and Recycling

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

Review

Critical aspects in the life cycle assessment (LCA) of bio-based materials – Reviewing methodologies and deriving recommendations

P. Pawelzik[a,*], M. Carus[b], J. Hotchkiss[c], R. Narayan[c], S. Selke[c], M. Wellisch[d], M. Weiss[e], B. Wicke[a], M.K. Patel[a,*]

ARTICLE INFO

ABSTRACT

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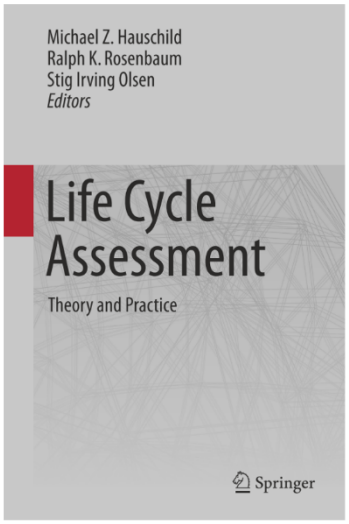
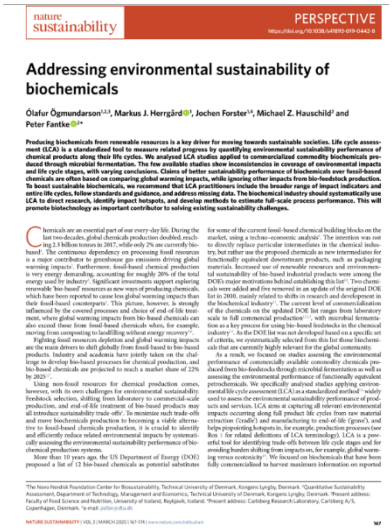


Michael Z. Hauschild
Ralph K. Rosenbaum
Stig Irving Olsen
Editors

Life Cycle Assessment

Theory and Practice

Springer



nature sustainability

PERSPECTIVE

https://doi.org/10.1038/s41893-019-0442-8

Addressing environmental sustainability of biochemicals

Ólafur Ögmundarson[1,2,3], Markus J. Herrgård[1], Jochen Forster[1,4], Michael Z. Hauschild[2] and Peter Fantke[2]*

Producing biochemicals from renewable resources is a key driver for moving towards sustainable societies. Life cycle assessment (LCA) is a standardized tool to measure related progress by quantifying environmental sustainability performance of chemical products along their life cycles. We analysed LCA studies applied to commercialized commodity biochemicals produced through microbial fermentation. The few available studies show inconsistencies in coverage of environmental impacts and life cycle stages, with varying conclusions. Claims of better sustainability performance of biochemicals over fossil-based chemicals are often based on comparing global warming impacts, while ignoring other impacts from bio-feedstock production. To boost sustainable biochemicals, we recommend that LCA practitioners include the broader range of impact indicators and entire life cycles, follow standards and guidance, and address missing data. The biochemical industry should systematically use LCA to direct research, identify impact hotspots, and develop methods to estimate full-scale process performance. This will promote biotechnology as important contributor to solving existing sustainability challenges.

Some methodological issues

Discussed during the breakout session:

Temporary carbon storage and delayed GHG emissions Credits can be given, depending on carbon stability (e.g. wood for biomass, construction)

Other relevant time horizons and other relevant GHG emission metric

methane emission from ruminants

Other relevant environmental impacts

Handling biodiversity and land use impacts, soil quality, soil carbon

Effects of cut-off in terms of by-product and modelling systems (e.g. wood chips)

what is waste and what is a resource shifts fast in bio economy

relevant for CCUS

Consideration of environmental boundaries of the Earth System

Environmental boundary for biotic resources (Impact is increasing the more we use biotic resource); Rebound effect

Not discussed:

Upscaling and learning of biotechnologies

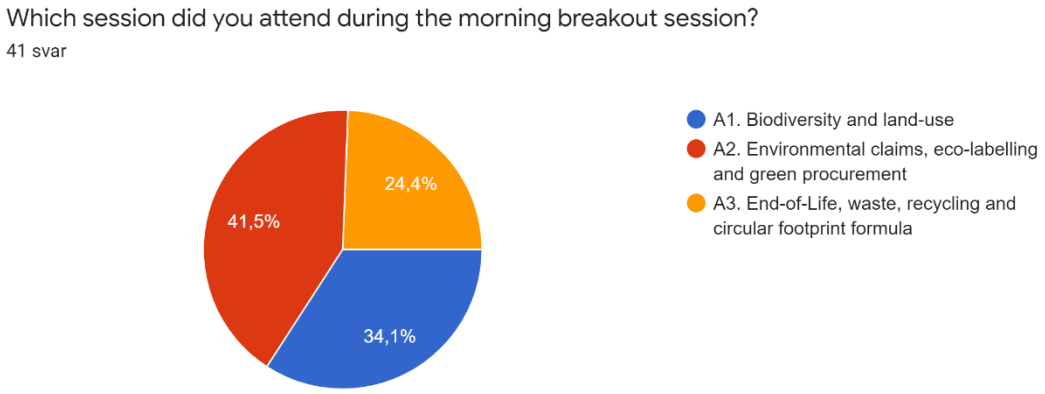
No consensual recommendations exist, and data can be limited

Geographic variability in life cycle inventory and impact assessment

Can make a difference for LCA results and resulting decisions

Enclosed C – Data from evaluation questionnaire

C.1. Question 1



C.2. Question 2

What do you think about the MORNING session? Did you learn something new? Did you understand other Nordic positions that you did not know of before? Can you refer some important points for you from the debate?

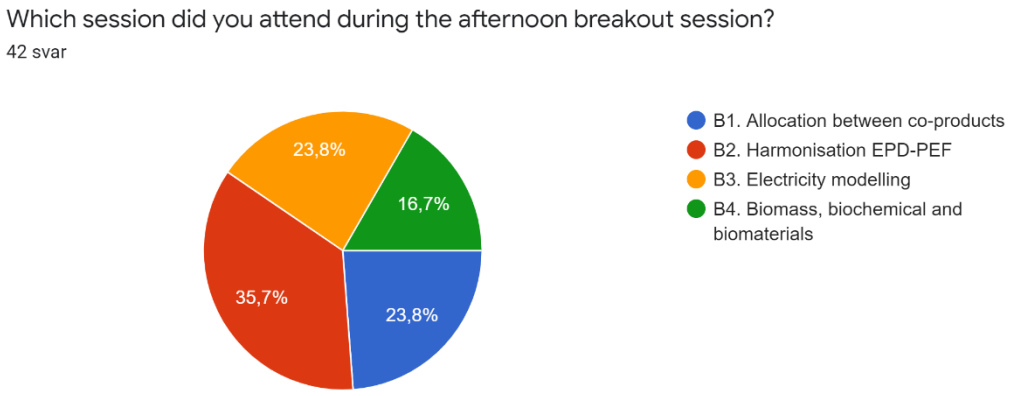
Answers

- I felt that I could deliver some important reflections since I've been working with PEF and labelling for quite some time.
- This was a great session. I learned a lot about the latest developments related to biodiversity impact assessment methods in LCA and work that is going on in the Nordic countries and at the Agriculture working group of PEF.
- I listened only the first introduction of the PEF situation. It was a good review to the state of the art in regulatory development of PEF. I had to select here the breakout session to get this done, because the questions were obligatory. My answers on those would have been the most interesting sessions for me.
- I largely share the view of the other participants on the current situation of the biodiversity LCA methods and that better methods need to be developed to be more suitable for the Nordic context.
- Nice with the presentation by Imola Bedo. More time to discuss and hear more from her side would have been very good.
- How to account for biodiversity in LCA complicated and the discussion did not result in any new conclusions or new knowledge for me personally.
- I've got a useful update on biodiversity but land-use and the LANCA method was not covered sufficiently to yield good hints on how to move forward with a common Nordic view.

- The morning session was inspiring. Nice to learn the willingness to cooperate, and the challenge of biodiversity requires this.
- It was very useful.
- The session was very good and I learned quite a lot. The CFF became one again clearer and we had a good idea about the different coefficients, especially the B coefficient. The discussion was vibrant and it was well led by Tomas Ekvall.
- I could not be present in the morning but as it was compulsory to answer the above question I marked the session I would have attended if I had been present.
- I think the morning session was really nice and people had some interesting points of view. Yes, I learned something new, like about a few methods that integrate biodiversity into LCA
- I learned there is a repository of PEF case studies, although it seems to include only two studies so far.
- it was useful. I have not been involved in the PEF process, so there were some new aspects.
- I think it was good and I learned some new things and I think that it is important to forward our knowledge and expertise in to the work by the Commission.
- Very interesting, learned new things and got other perspectives on the matter.
- Learnt more about interpretations of the CFF formula, which can vary quite a bit. A key challenge seems to be lack of practical experience with PEF calculations, which means that there are probably undiscovered issues to deal with when applying the formula in practice - in particular for consistent application of the formula in the LCA/PEF community. It provides a single result, but possibly at the cost of transparency if underlying assumptions.
- Increased knowledge about the importance of the B-factor in CFF
- Good data is many times time consuming to get for the PEF - secondary data and tools are needed.
- It was interesting to hear what others thought although I was not quite sure why the host decided to address each issue separately since they're very much linked - IMO, it stifled discussions. The most important part is definitely data standardization and also the fact that those with more money play a much easier game.
- Ongoing work in DG Just in addition to work in DG Environment.
- The conversation was interesting and outlined the importance of finding a common ground
- Very interesting and a good debate. Knowledgeable moderator in Ekvall. Quite technical discussion, so not much about Nordic positions per se. But good discussions about concepts such as point-of-substitution, determining the A-factor, development of the B-factor, allocation of burdens and benefits between systems and between producers/consumers
- The morning session resulted in a good discussion and for me a better understanding of the circular footprint formula. We particularly discussed the

B-factor (which allocates the burden and benefits of waste handling, e.g. incineration between the waste producer and the waste manager). The B-factor is by default 0, i.e. waste producer get all impact and benefits. But is that fair e.g. in a situation where demand for district heating is driving waste incinerators?

C.3. Question 3



C.4. Question 4

What do you think about the AFTERNOON session? Did you learn something new? Did you understand other Nordic positions that you did not know of before? Can you refer some important points for you from the debate?

Answers

- I felt that I could deliver some important reflections since I've been working with PEF and EPD for quite some time.
- I got some interesting updates about the PEF process, especially related to paper pilot. I also got to know more people working on PEF in the Nordic countries.
- Yes, I learned about the new requirements for energy modelling in PEF.
- Apparently EPD and PEF methodology are very similar, except for how to account for biogenic carbon emissions. However, I have now found out that PEF and EPD differs on many other points. Interesting discussion but I didn't take anything concrete with me from it.
- I learned a few things and taught a few things.
- Very, very successful
- Also interesting.
- I learned a lot.
- The session was a bit sleepy, probably because of the time after the lunch break. Also, more than half of the attendees were the same as in the morning

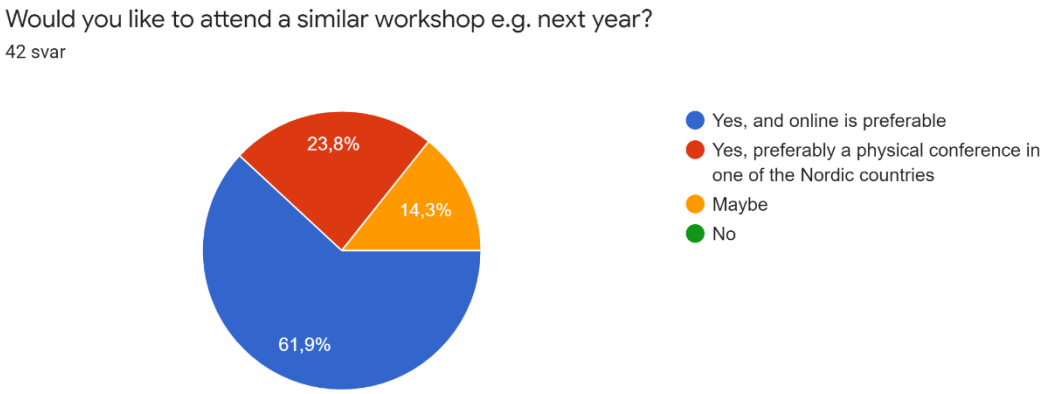
sessions and the moderator was the same, too. Some new participants also left the discussion after it started. However, after the slow start we had a good discussion on the different approaches towards allocation in PEF, EPDs, ISO 14044 and in ILCD. I learned quite a bit.

- I think that the afternoon session was very interesting. I haven't been following the PEF development too closely so I learned a lot during the session.
- Unfortunately, I was only able to attend it partially. But it was a really nice discussion
- In Group B1 we agreed that PEF has the potential to be used both for procurement decisions (environmental declarations etc.) and for policy-making (and other strategic decisions). This requires the general PEF methodology to be flexible enough to be adapted to the policy context, but the PEFCRs to be specific enough to ensure comparability and reproducibility.
- It was good that we found a common understanding of the issue that should be improved (the use purpose should be defined when suggestions as PEF allocation rules are given).
- I think it was good, it felt like an really open and inclusive workshop. I think it is important to really focusing on issues that needs to be solved in both EPD and PEF, e.g. biodiversity, bio mass balance etc.
- Very interesting, learned new things and got other perspectives on the matter. Learned how complex the life cycle approach on matter is. We also discussed if the backup electricity for solar and wind is taken into account and it seems not.
- Main focus on methodology, less focus on other requirements e.g. related to program operator, verification, communication, stakeholder engagement, etc. Beyond methodological aspects, the PEF appears quite undefined and very difficult to discuss any harmonization. The four possible paths outlined in the morning plenary shows that there is considerably uncertainty about which direction the PEF could go.
- Yes, interesting discussions but few experts present during the session - most of the attendees were there more to listen then to discuss. Maybe some prepared short presentations of the topics from each Nordic country would have been nice to have prior to the discussion. The most important points from the debate were raised in the summary session after the breakout sessions.
- Better basic knowledge about the situation in Nordic countries would have be good to have prior the session. Was interesting to hear about the positions, but difficult to contribute. Updated data about electricity emissions is essential to get valid calculations.
- It's such a technical question that by the end the only thing that really resulted was "well, those are the rules".
- Also a good session, with several aspects covered. The EPD program operators, especially, had the experience to bring up relevant topics, e.g. regarding third-party review, data quality, development of PEFCRs.
- We were fewer people but discussion was interesting. It focused particularly on choices between system expansion and substitution - which was distinguished

by the Swedish participants. From some of the Swedish guys it was said that the choice of systems for substitution could be subjective just like allocation principles. Since PEFs are intended to have many applications, a main input/position was that guidelines/CRs on this would be too rigid if only focused on one application area. Two different application were distinguished where it could be anticipated that different guides for system expansion/allocation could be relevant: Comparative e.g. procurement situations and strategic decision making.

- Yes

C.5. Question 5



C.6. Question 6

If you have suggestions on how to improve the workshop for next time, please write them here.

Answers

- Physical meeting is preferred, mainly because of networking potential and establishing contacts.
- The aims could be outlined clearer. It would be good to have more participants who have good knowledge of the latest PEF developments. The general discussions could be better facilitated and planned. Now the last general discussion was so broad that it was a bit difficult to initiate discussion within the large group. So, maybe better to have planned topics to discuss and a panel prepared to discuss those things. That would help others to join.
- I think it would be beneficial to discuss the themes more often than just once a year. We could also plan some research collaboration together before the next year's meeting.

- Appoint experts in the groups that know much more than the rest. In this way the level of knowledge among the participants can be higher.
- Perhaps giving the participants a few more focused discussion points to access before the workshop, stemming from the goals of the workshop
- For this number of participants on-line I think the number of break-out rooms should not be more than four, but with more participants it could possibly expand.
- Online is a good format in terms of accessibility, however, physical meeting would be good to deploy - at least every second time. I am not sure I would be able to find the time for a physical conference, but I know the benefit/outcome would increase compared to the online format...
- This was fine.
- I actually think that the workshop was very good. Christian did a very good job in calmly and clearly walking us through the different parts. Tomas was also a very good moderator. Somehow it was just all calm and clear. Perhaps a few more pee-breaks would have been good. Otherwise all good!
- The end discussion was quite long. If one wants to keep it so long, it might be good to think about discussion topics in advance, and prepare some participants for asking questions if spontaneous questions do not arise.
- Be sure that there are PEF experts leading the sessions
- It would be good if we can prepare the workshop part by sending out the questions to be discussed before the workshop. Then the startup will be shorter.
- I would prefer the workshop to be organized as a side-event to a conference.
- I would love more presentations in the panel session and more time for the breakout discussions with more prepared presentations on current status, case studies and highlighting the challenges. I felt that people on the workshop were highly skilled with different backgrounds but nonetheless a need to educate and "take off from the same page" during the workshop.
- Less breakout rooms in the last session (I think 4 in parallel were too much), Prepare some potential major topics for the last plenary session
- If the sessions could be announced a bit earlier, it would be possible to have a look about the study of the art regarding the issue if a participant is not very familiar with the topic?
- My main problem was that the two sessions I was most interested in happened at the same time... but these things happen. Overall I think it went very well.
- More clear next step in terms of output of the workshop. What is achieved by having these discussions?
- Open floors at plenary sessions are difficult. I think it would help the overall plenary discussion, if you selected for instance some questions for debate, a concrete PEF case, a conceptual drawing of the PEF process, open questions remaining in the PEF development etc.
- You did it very well.

C.7. Question 7

Please describe any case studies related to LCA and PEF that you know of, preferably with web link or scientific reference.

Answers

- https://op.europa.eu/da/publication-detail/-/publication/15bb40e3-3979-11e9-8d04-01aa75ed71a1
- Ongoing case studies in Swedish Life Cycle Centers project EF in Sweden, to be published this year: https://www.lifecyclecenter.se/projects/environmental-footprint-in-sweden-increased-competence-and-communication/
- More case studies should be produced and published!
- We have ongoing case studies on biofuels for cars: ethanol from corn, fatty acid methyl ester, biogas from food waste, HVO from used cooking oil, advanced ethanol from food waste and sawmill residues, and pyrolysis oil from used tires. The case studies are made by IVL, RISE, KTH and Chalmers, cooperating through the Swedish Life Cycle Center and funded through f3. The report should be completed before the end of this year. [Chalmers University of Technology]
- One of the most important result from this part is to prepare the Nordic market by showing real and concrete examples on how PEF will affect the Nordic companies.
- We are running case studies: one intermediate paper product focusing on 1) Climate change impact with focus on biogenic flows and flows due to land use and land use change (LULUC), 2) Land use impact category and 3) Energy with focus on electricity. [Chalmers University of Technology]
- Another case study that are being performed is one on a steel product where we will review and analyze differences in some chosen methodology issues between EPD and PEF: 1) Environmental impacts, highest focus on GWP, 2) Allocation methods for steel scrap (polluter pays principle vs circular footprint formula) 3) Generic vs specific data. [Chalmers University of Technology]
- More information about the project Environmental footprint in Sweden: https://www.lifecyclecenter.se/projects/environmental-footprint-in-sweden-increased-competence-and-communication/
- The project: Impacts on producers and customers of conflicting rules for LCA, https://www.lifecyclecenter.se/projects/impacts-on-producers-and-customers-of-conflicting-rules-for-lca/ is running a couple of case studies where the EU Renewable Energy Directive (RED), the EU framework for Product Environmental Footprints (PEF), and the frameworks of Environmental Product Declarations (EPD) will be tested.
- The H2020 - GEOENVI project has published LCA guidelines for geothermal projects where PEF is recommended. See e.g. https://www.geoenvi.eu/wp-content/uploads/2020/03/D3.2_LCA_Guidelines-for-geothermal-installations_February-2020.pdf

- https://www.lifecyclecenter.se/projects/environmental-footprint-in-sweden-increased-competence-and-communication/
- Good comparison of PEF/CEN approaches on a building case: https://link.springer.com/article/10.1007/s11367-020-01807-8
- I follow the PEF studies especially on agriculture.