Global environmental losses of plastics across their value chains

With the increasing focus on marine plastic pollution, quantification of the environmental losses of plastics in the world, with differentiation into geographic regions, polymers and loss occurrences along the plastics value chains, is required. In this study, we make a global estimation of the losses of plastics to the environment across the entire plastic value chain, using existing literature and databases coupled with improved and additional methodological modelling of the losses. The resulting loss estimates are unprecedented in their detailed differentiations between polymers (23), plastic applications (13), geographical regions (11), and plastic value chain stages. Comprehensive sensitivity and uncertainty analyses were also conducted to identify key drivers in terms of plastic losses. We overall found that approximately 6.2 Mt (95% confidence interval, CI: 2.0–20.4 Mt) of macroplastics and 3.0 Mt (CI: 1.5–5.2 Mt) of microplastics were lost to the environment in 2015. The major macroplastic loss source was identified as the mismanaged municipal solid waste (MSW) management in low-income and lower-middle income countries (4.1 Mt). For microplastics, the major sources were abrasion of tyre rubbers, abrasion of road markings and plastics contributing to city dust generation. To curb marine plastic pollution, such quantified mapping as ours are needed to evaluate the magnitude of the plastics losses to environment from different sources and locations, and enable a further assessment of their environmental damage. Through our uncertainty and sensitivity analyses, we highlight plastics sources that should be prioritized in further research works to obtain a more comprehensive and accurate representation of global plastics losses.
Absolute sustainability assessment of a Danish water utility company

Pressures exerted by humans on the Earth are starting to affect and destabilize the Earth System as expressed by the Planetary Boundaries (PB) which delimits a safe operating space for humanity to act within. To ensure a stable Earth System and become sustainable in an absolute sense, humanity must reduce its pressures to be within within the safe operating space. This includes utility companies which supply water and treat wastewater. Thus, we sought to assess if the utility company VandCenter Syd (VCSyd) could be considered absolutely sustainable relative to the PBs. Absolute sustainability assessment requires three inputs: (i) the environmental footprint of the assessed activity; (ii) the environmental boundary; and (iii) the share of environmental boundary assigned to the assessed activity. To be absolutely sustainable, the activity’s footprint must not exceed the assigned share of the environmental boundary. As environmental boundary, the PBs as defined by Steffen et al. (2015) were used. Potential limitations of directly applying these are discussed. The environmental footprint of VCSyd was quantified using life-cycle assessment (LCA) which includes and inventories all resource used and emissions associated with VCSyd. The inventory was expressed in the metrics of the PBs by use of the Planetary Boundaries based life-cycle impact assessment methodology by Ryberg et al. (2018). To assess absolute sustainability, the share of the total safe operating space, that VCSyd can be considered entitled must be determined. Shares of safe operating space were assigned based on different sharing principles such as contribution to employment, revealed consumer preferences, and existing contribution to environmental impacts.

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Addressing bystander exposure to agricultural pesticides in life cycle impact assessment

Residents living near agricultural fields may be exposed to pesticides drifting from the fields after application to different field crops. To address this currently missing exposure pathway in life cycle assessment (LCA), we developed a modeling framework for quantifying exposure of bystanders to pesticide spray drift from agricultural fields. Our framework consists of three parts addressing: (1) loss of pesticides from an agricultural field via spray drift; (2) environmental fate of pesticide in air outside of the treated field; and (3) exposure of bystanders to pesticides via inhalation. A comparison with measured data in a case study on pesticides applied to potato fields shows that our model gives good predictions of pesticide air concentrations. We compared our bystander exposure estimates with pathways currently included in LCA, namely aggregated inhalation and ingestion exposure mediated via the environment for the general population, and general population exposure via ingestion of pesticide residues in consumed food crops. The results show that exposure of bystanders is limited relative to total population exposure from ingestion of pesticide residues in crops, but that the exposure magnitude of individual bystanders can be substantially larger than the exposure of populations not living in the proximity to agricultural fields. Our framework for assessing bystander exposure to pesticide applications closes a relevant gap in the exposure assessment included in LCA for agricultural pesticides. This inclusion aids decision-making based on LCA as previously restricted knowledge about exposure of bystanders can now be taken into account.

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Development of a life-cycle impact assessment methodology linked to the Planetary Boundaries framework

To enable quantifying environmental performance of products and technologies in relation to Planetary Boundaries, there is a need for life-cycle impact assessment (LCIA) methods which allow for expressing indicators of environmental impact in metrics corresponding to those of the control variables in the Planetary Boundaries framework. In this study, we present such a methodology, referred to as PB-LCIA. Characterization factors for direct use in the LCIA phase of a life cycle assessment, or other life-cycle based assessment, were developed for a total of 85 elementary flows recognized as dominant contributors to transgressing specific Planetary Boundaries. Exception was made for “biosphere integrity” and “introduction of novel entities” where a Planetary Boundary is yet to be defined for the latter and characterization models are considered immature for the former. The PB-LCIA can be used to quantify the share of the “safe operating space” that human activities occupy, as was illustrated by calculating indicator scores for about 10,600 products, technologies and services exemplifying several sectors, including materials, energy, transport, and processing. The PB-LCIA can be used by companies interested in gauging their activities against the Planetary Boundaries to support decisions that help to reduce the risk of human activities moving the Earth System out of the Holocene state.

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How to bring absolute sustainability into decision-making: An industry case study using a Planetary Boundary-based methodology

The Planetary Boundaries concept has emerged as a framework for articulating environmental limits, gaining traction as a basis for considering sustainability in business settings, government policy and international guidelines. There is emerging interest in using the Planetary Boundaries concept as part of life cycle assessment (LCA) for gauging absolute environmental sustainability. We tested the applicability of a novel Planetary Boundaries-based life cycle impact
assessment methodology on a hypothetical laundry washing case study at the EU level. We express the impacts corresponding to the control variables of the individual Planetary Boundaries together with a measure of their respective uncertainties. We tested four sharing principles for assigning a share of the safe operating space (SoSOS) to laundry washing and assessed if the impacts were within the assigned SoSOS. The choice of sharing principle had the greatest influence on the outcome. We therefore highlight the need for more research on the development and choice of sharing principles. Although further work is required to operationalize Planetary Boundaries in LCA, this study shows the potential to relate impacts of human activities to environmental boundaries using LCA, offering company and policy decision-makers information needed to promote environmental sustainability.

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LCA Applications
The chapter gives examples of applications of LCA by the central societal actors in government, industry and citizens, and discusses major motivations and challenges for the use of LCA to support science-based decision-making from their respective perspectives. We highlight applications of LCA in policy formulation, implementation and evaluation, present different purposes of LCA application in industry at both product and corporate levels, and discuss challenges for LCA applications in small- and medium-sized enterprises. Our synthesis demonstrates the importance of LCA as a tool to quantify environmental impacts of products and systems and support decisions around production and consumption and highlights factors that prevent its even more widespread application.

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Mapping of global plastic value chain and plastic losses to the environment: with a particular focus on marine environment

Plastics have become one of the most ubiquitous materials used globally, and global production has on average increased by about 9% per year since 1950. The plastic industry has become a major economic actor with revenue of about 1,722 billion Euros in 2015. The issue of plastics ending up in the oceans and harming marine lifeforms has been known since the 1970s. Research focusing on the impacts associated with exposure of organisms to marine microand macroplastics has been ongoing for years. However, studies linking the processes in the plastic value chain to plastics being released to the oceans are only starting to emerge. This report provides a comprehensive global mapping of plastic losses to the environment throughout the plastic value chain using 2015 as the reference year. This mapping covers plastics production and processing, use of plastics or plastic containing products, and disposal of the products. It differentiates 23 types of plastics and 13 plastic applications, including division between macro- and microplastics (incl. microbeads and microfibers). Global production was about 388 million tonnes (Mt) in 2015. Plastics are primarily produced and consumed in China, North America, and Western Europe. The majority of plastics are used for packaging (30%), building and construction (17%), and transportation (14%). The most used plastic polymers are polypropylene (PP; 16%), low density polyethylene & linear low density polyethylene (LDPE, LLDPE; 12%), polystyrene (PS; 11%), high density polyethylene (HDPE; 10%), and polyeylene terephthalate (PET; 5%) which in total account for more than 50% of total plastics usage. It was found that approximately 3.0 and 5.3 million tonnes of micro- and macroplastics, respectively, are annually lost to the environment. The largest sources of microplastic losses were from abrasion of tyres, and city dust, which include abrasion of plastics from e.g. shoe soles, exterior paints, and road markings. The primary sources of macroplastic losses stem from mismanaged municipal solid waste (i.e. open dumping and inadequate landfilling), accounting for about half of the macroplastics lost to the environment. Littering of plastic waste and loss of fishing gears and other equipment related to maritime activities were also major sources of macroplastic losses.

Prospective Assessment of Steel Manufacturing Relative to Planetary Boundaries: Calling for Life Cycle Solution

Steel, as one of the largest consumed materials, is a large contributor to climate change accounting for about 7% of annual human induced CO2 emissions. Using material in-use stock modelling and dynamic life-cycle assessment, this study predicted the share of the safe operating space for climate change that will be occupied by steel production between 2015 and 2100. Results show that if current practice is continued, steel manufacturing will occupy what corresponds to about 50% of the safe operating space for climate change by 2100, indicating an urgent need for impact reducing strategies to stay within the safe operating space.
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Advancing absolute sustainability assessments of products with a new Planetary Boundaries based life-cycle impact assessment methodology

The Planetary Boundaries (PB)-framework introduced quantitative boundaries for a set of biophysical Earth System processes. The PBs delimit a 'safe operating space' for humanity to act within to keep Earth in a Holocene-like state (Rockström et al 2009). The concept has gained strong interest from companies that want to assess and communicate the environmental sustainability of their products relative to the PBs. However, consistent methods for assessing environmental impacts of products and systems based on the PBs have, to date, not been developed (Ryberg et al 2016).

In this study, we developed an operational life-cycle impact assessment (LCIA) methodology where the definition of the impact categories is based on the control variables as defined in the PB-framework by Steffen et al (2015). This included the development and calculation of characterization factors for the Earth System processes considered in the PB-framework. The characterization factors cover environmental flows contributing to impacts on the Earth System processes (e.g. CO2 and its precursors contributing to ocean acidification) and are expressed in the units of the PB-framework's control variables (e.g. change in the aragonite saturation state per unit CO2 emission for ocean acidification). The use of these characterization factors for evaluating the environmental impacts of products in LCA ensures impact scores that are compatible with the PB framework. The impact scores can be related to either the full PBs or an allocated safe operating space. The latter reflect the share of the safe operating space the assessed products can be considered entitled to, thereby, allowing for quantifying the absolute environmental sustainability of the products.

This new Planetary Boundaries based LCIA methodology provides additional and complementary insights which cannot be achieved with traditional LCIA methodologies. The key added value is the ability to relate the impacts of a product to the Planetary Boundaries. This can be used for communicating a product's environmental performance and for setting reduction targets based on absolute environmental boundaries, thereby, advancing absolute sustainability assessments.

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Assessing environmental performance of hydrothermal carbonization of wet biomass at industry‐relevant scales

Challenges in implementing a Planetary Boundaries based Life-Cycle Impact Assessment methodology

Impacts on the environment from human activities are now threatening to exceed thresholds for central Earth System processes, potentially moving the Earth System out of the Holocene state. To avoid such consequences, the concept of Planetary Boundaries was defined in 2009, and updated in 2015, for a number of processes which are essential for maintaining the Earth System in its present state. Life-Cycle Assessment was identified as a suitable tool for linking human activities to the Planetary Boundaries. However, to facilitate proper use of Life-Cycle Assessment for non-global environmental management based on the Planetary Boundaries, there is a need for linking non-global activities to impacts on a planetary level. In this study, challenges related to development and operationalization of a Planetary Boundary based Life-Cycle Impact Assessment method are identified and the feasibility of resolving the challenges and developing such methodology is discussed. The challenges are related to technical issues, i.e., modelling and including the Earth System processes and their control variables as impact categories in Life-Cycle Impact Assessment and to theoretical considerations with respect to the interpretation and use of Life-Cycle Assessment results in accordance with the Planetary Boundary framework. The identified challenges require additional research before a Planetary Boundaries based Life-Cycle Impact Assessment method can be developed. Research on modelling the impacts on Earth System processes and on allocation of and entitlement to the ‘safe operating space’ appear to be most urgent for operationalizing a Planetary Boundaries based Life-Cycle Impact Assessment method. The results of a Planetary Boundaries based Life-Cycle Impact Assessment would be highly relevant and could provide novel insights on the environmental performance and sustainability of products and systems.
Environmental performance of hydrothermal carbonization of four wet biomass waste streams at industry-relevant scales

Hydrothermal carbonization (HTC) of green waste, food waste, organic fraction of municipal solid waste (MSW), and digestate is assessed using life cycle assessment as a potential technology to treat biowaste. Water content of the biowaste and composition of the resulting hydrochar are important parameters influencing environmental performance. Hydrochar produced from green waste performs best and second best in respectively 2 and 10 out of 15 impact categories, including climate change, mainly due to low transportation needs of the biowaste and optimized pumping efficiency for the feedstock. By contrast, hydrochar produced from the organic fraction of MSW performs best in 6 impact categories, but has high potential impacts on human health and ecosystems caused by emissions of toxic elements through ash disposal. The greatest potential for environmental optimization for the HTC technology is in the use of heat and electricity with increasing plant size, but its overall environmental performance is largely influenced in a given geographic location by the incumbent waste management system that it replaces. Impact scores are within the range of existing alternative treatment options, suggesting that despite being relatively immature technology, and depending on the geographic location of the plant, HTC may be an attractive treatment option for biowaste.

The development of an operational LCIA-methodology with impact categories based on the control variables in the Planetary Boundaries framework

This study presents a first attempt at an operational LCIA-methodology basing the definition of the impact categories on the control variables as defined in the Planetary Boundaries (PB) framework. The PB-framework introduced a set of biophysical Earth system processes and defined quantitative PBs that have to be respected for Earth to remain in the Holocene state. The concept is attracting a strong interest from in industry as companies seek to assess and communicate the environmental performance of their products relative to the PBs. The PB-framework has previously been attempted included in LCA as part of normalization and weighting. The limitations of both attempts are the lack of spatial differentiation for spatially differentiated PBs and the requirement for harmonizing the control variables with indicators already used in life-cycle impact assessment (LCIA). A way to overcome these limitations is to directly use the control variables in the PB-framework as impact categories in LCIA, which is also the objective of this study. This work defines a mathematical framework for a LCIA-methodology where Characterization...
Factors (CFs) are included for all Earth system processes in the PB-framework, for all substances contributing to effects on the Earth system processes and expressed in the units of the control variables. Except for novel entities and biosphere integrity which are currently excluded from the LCIA-methodology because the former is lacking a planetary boundary metric while a full understanding of the cause-effect chain is missing for the latter. The CFs were estimated by identifying the environmental models needed to model the control variables of the PB-framework and adapting these to fit the LCIA-framework. This work provides a full set of CFs for all the Earth system processes in the PB-framework. The new LCIA-methodology provides additional and complementary insights which cannot be achieved with traditional LCIA-methodologies. The results provide information on the environmental impacts of the assessed products and solves previous problems with approximative links between control variables in the PB-framework and current LCIA impact categories. The new insights can be used for communicating the product’s environmental performance and to support definitions of absolute reduction targets relative to the PBs.

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Opportunities and challenges for including Planetary Boundaries in Life-Cycle Assessment

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Power generation from chemically cleaned coals: do environmental benefits of firing cleaner coal outweigh environmental burden of cleaning?

Power generation from high-ash coals is a niche technology for power generation, but coal cleaning is deemed necessary to avoid problems associated with low combustion efficiencies and to minimize environmental burdens associated with emissions of pollutants originating from ash. Here, chemical beneficiation of coals using acid and alkali–acid leaching procedures is evaluated as a potential coal cleaning technology employing life cycle assessment (LCA). Taking into account the environmental benefits from firing cleaner coal in pulverized coal power plants and the environmental burden of the cleaning itself, it is demonstrated that for a wide range of cleaning procedures and types of coal, chemical cleaning generally performs worse than combustion of the raw coals and physical cleaning using dense medium separation. These
findings apply for many relevant impact categories, including climate change. Chemical cleaning can be optimized with regard to electricity, heat and methanol use for the hydrothermal washing step, and could have environmental impact comparable to that of physical cleaning if the overall resource intensiveness of chemical cleaning is reduced by a factor 5 to 10, depending on the impact category. The largest potential of the technology is observed for high-ash lignites, with initial ash content above 30%, for which the environmental benefits from firing cleaner coal can outweigh the environmental burden of cleaning for some impact categories. Overall, we recommend to policy makers that coal cleaning using acid or alkali–acid leaching procedures should not be considered for direct implementation as a coal beneficiation technology. We encourage further research on chemical cleaning and its optimization, however, as chemical cleaning has advantages that might make it attractive for cleaning of difficult to treat coals when compared to the less efficient option of physical cleaning.

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The need for an established allocation method when assessing absolute sustainability on a product level
Assessment of absolute sustainability within life cycle assessment (LCA) framework is operational on the country scale. However, it is difficult to apply the existing approaches to products, which are typically the scope of LCAs. How should we assess whether a chair is (absolutely) sustainable? If we assess the life cycle and relate the impact scores to the remaining capacity available for impacts, there is a risk that all products are seen absolutely sustainable. In addition, how should we decide on who can use the remaining capacity? To address these issues an allocation method is proposed for dividing the remaining capacity between and within product groups. The method is a two-step method developed based on the annual consumption pattern of an average person in the country and share of product sub-groups in the group. For example, in the first allocation step, the remaining capacity share allocated to furniture should correspond to the share of an average person’s income that is spent on furniture. In this way the impact of the chair is related to the remaining capacity allocated to this particular product group. In the second step, allocation is done between product sub-groups using allocation keys specific to each product group, e.g. mass for furniture, or economic revenue for IT. The proposed method facilitates assessment of absolute sustainability of products within the LCA framework.

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Assessing the environmental impacts of using demineralized coal for electricity generation

The energy sector is the source of two-thirds of global greenhouse-gas emissions, and is the main target of climate policies among authorities and governments. The share of fossil coals (hard coal and lignite) in world total net electricity generation is 40% in 2010. Demineralization or ash removal of the coal is thought to be beneficial for reducing ash-related problems, such as slagging and fouling in the combustion chamber, increasing the heating value, increasing thermal efficiency and reducing airborne emissions. A novel method for removing ash is alkali-acid leaching where the coal is washed in alkaline and acidic solution to dissolve and remove the ash. This process is well-studied on lab scale but has only to a small extent been tried on a full scale. This assessment is conducted as an aid for further developing the technology, allowing for early identification of environmental impacts and possible improvements. Experimental studies conducted so far have shown better performance of demineralized coal than its original raw coal during combustion, gasification, and coke making process. However a thorough analysis of the impacts from demineralization has not yet been conducted. We take a life cycle perspective, to assess the environmental impacts from removing ash in coal, and assess how this affects the combustion in terms of higher thermal efficiency. We assess 260 different data points applying alkali-acid leaching or acid leaching and assess how the treatment and subsequent energy generation will affect the environment. The results showed that demineralization in some cases were beneficial for regional impacts such as particulate matter formation because emission of particles and SO2 were reduced. In the contrary global impacts such as climate change did not benefit from demineralization because of the large energy use for running the demineralization process. Local and regional environmental impacts were shown to improve from demineralization for low ranking coals or lignite where the ash content is above ≈25% and the carbon content is less than ≈50%. Overall, it can be concluded that demineralization of coal is not advised for high quality coals as the additional energy required for removing the ash outweighs the benefits from the increase thermal efficiency.

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Updated US and Canadian normalization factors for TRACI 2.1
When LCA practitioners perform LCAs, the interpretation of the results can be difficult without a reference point to benchmark the results. Hence, normalization factors are important for relating results to a common reference. The main purpose of this paper was to update the normalization factors for the US and US-Canadian regions. The normalization factors were used for highlighting the most contributing substances, thereby enabling practitioners to put more focus on important substances, when compiling the inventory, as well as providing them with normalization factors reflecting the actual situation. Normalization factors were calculated using characterization factors from the TRACI 2.1 LCIA model. The inventory was based on US databases on emissions of substances. The Canadian inventory was based on a previous inventory with 2005 as reference, in this inventory the most significant substances were updated to 2008 data. The results showed that impact categories were generally dominated by a small number of substances. The contribution analysis showed that the reporting of substance classes was highly significant for the environmental impacts, although in reality, these substances are nonspecific in composition, so the characterization factors which were selected to represent these categories may be significantly different from the actual identity of these aggregates. Furthermore the contribution highlighted the issue of carefully examining the effects of metals, even though the toxicity based categories have only interim characterization factors calculated with USEtox. A need for improved understanding of the wide range of uncertainties incorporated into studies with reported substance classes was indentified. This was especially important since aggregated substance classes are often used in LCA modeling when information on the particular substance is missing. Given the dominance of metals to the human and ecotoxicity categories, it is imperative to refine the CFs within USEtox. Some of the results within this paper indicate that soil emissions of metals are significantly higher than we expect in actuality.
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Characterizing exposure of bystanders and residents to pesticides applied in agricultural fields

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Project: Research

Abso-vand: Absolute Sustainability Assessment of VandCenter Syd
Ryberg, M., PI, Department of Management Engineering, Quantitative Sustainability Assessment
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Collaborators: VandCenter Syd A/S
Project: Research
Assessing the absolute environmental sustainability of products and systems
Vea, E. B., PhD Student, Department of Management Engineering
Hauschild, M. Z., Main Supervisor
Ryberg, M., Supervisor
15/11/2018 → 14/11/2021
Project: PhD

Integration of boundaries for selected planetary threads into life cycle assessment
Ryberg, M., PhD Student, Department of Management Engineering
Hauschild, M. Z., Main Supervisor
Owsianiak, M., Supervisor
Cornell, S. E., Examiner
Richardson, K., Supervisor
Sala, S., Examiner
Technical University of Denmark
15/12/2014 → 30/09/2018
Award relations: Integration of boundaries for selected planetary threads into life cycle assessment
Documents:
Morten Ryberg_PhDthesis_Putting life-cycle indicators on an absolute scale
Project: PhD

Activities:

Better but good enough? – Putting numbers on sustainability with Absolute Environmental Sustainability Assessments
Period: 28 Aug 2019
Morten Ryberg (Invited speaker)

Sustainability
Quantitative Sustainability Assessment
Department of Technology, Management and Economics

Description
Life-cycle assessment (LCA) is a relative environmental assessment tool for comparing the performance of products and services that fulfill the same functions. Thus, LCA can support decisions by identifying the most environmentally friendly product among a suite of products. While LCA has helped reducing the overall environmental impact per product or service consumed, it is evident that total environmental pressure is still increasing. Hence, there is a need for moving from assessing if a product is getting relatively better or is better than the alternatives towards assessing if a product is actually good enough relative to absolute environmental boundaries. This type of assessment is referred to as Absolute Environmental Sustainability Assessment (AESA).

An AESA consist of three main steps: (i) identifying relevant environmental boundaries, (ii) assigning a share of the boundary to the assessed activity, and (iii) quantifying the environmental impacts of the activity in the metrics of the boundary. An activity can be considered absolutely sustainable if its environmental impact is less than the assigned share of the absolute boundary. If the activity exceed its assigned share of the boundary, the AESA can be used to define absolute reduction targets for the activity to become absolutely sustainable.

In this seminar, I will introduce you to the concept of absolute sustainability and how this can be quantified using AESA. I will discuss the added value of AESAs compared to LCA and the limitations of current AESA methods. Finally, I will present the current state-of-the-art in AESA and tell you about the ongoing research to further develop and improve AESAs.

Related external organisation
ETH Zürich
Switzerland
Activity: Talks and presentations › Talks and presentations in private or public companies and organisations

Putting Numbers on Sustainability
Period: 28 May 2019
Morten Ryberg (Panel member)
Sustainability
Quantitative Sustainability Assessment
Department of Technology, Management and Economics

Description
Introduction to methods for quantifying environmental sustainability of the built environment, including life-cycle assessment and Absolute Sustainability Assessments
Degree of recognition: Local

Related event
DTU Civil Engineering Department Seminar: UN sustainable development goals and construction
28/05/2019 → 28/05/2019
Activity: Talks and presentations › Talks and presentations in private or public companies and organisations

Operationalize Planetary Boundaries in LCA Workshop
Period: 13 Dec 2018
Morten Ryberg (Invited speaker)
Michael Zwicky Hauschild (Invited speaker)
Quantitative Sustainability Assessment
Department of Management Engineering

Related external organisation
European Commission Joint Research Centre Institute
Geel, Belgium
Keywords: Absolute Sustainability, Life cycle assessment, Sustainability
Activity: Talks and presentations › Conference presentations

Marine Plastics Value Chain Mapping, Plastic Losses, and Hotspots
Period: 15 Feb 2018
Alexis Laurent (Invited speaker)
Morten Ryberg (Invited speaker)
Michael Zwicky Hauschild (Invited speaker)
Quantitative Sustainability Assessment
Department of Management Engineering
Degree of recognition: International

Related event
UN Environment multi-stakeholder consultation workshop on a systemic approach to marine plastics
15/02/2018 → 16/02/2018
Paris, France
Activity: Talks and presentations › Talks and presentations in private or public companies and organisations

Press clippings:

Overtræk på klima-budgettet
Martin Marchman Andersen, Anjila Clara Wegge Hjalsted, Morten Ryberg & Michael Zwicky Hauschild
13/09/2019

Description
Kronik. Skal det lykkes os at bremse de globale klimaforandringer, er det ikke nok at fokusere på, hvor mange portioner havregryn der går på en flyrejse. Vi er nødt til at finde ud af, hvordan det enkelte menneske bliver bæredygtigt i absolut forstand.

Subject
Absolute sustainability, Climate change, Sustainability