Proceedings of the first openLCA user conference

openLCA.conf

held in

Berlin, Germany

15th – 16th April 2024

GreenDelta

Preface

Various software solutions are employed for conducting Life Cycle Assessments (LCAs). GreenDelta has been at the forefront of this field since 2006, developing the open-source software *openLCA*, which is highly suitable for LCA studies. Over the years, openLCA has gained global recognition as the most extensively used LCA software. It provides the broadest selection of databases for LCA software, boasting over 300,000 unique datasets. These databases encompass both environmental and socio-economic aspects, enabling reliable computations for Sustainability and Life Cycle Assessment.

In recent years, openLCA has seen significant advancements, not only as a standalone tool but also as a solution integrated with other sustainability tools and add-ons. Complementary tools, such as the LCA Collaboration Server, have facilitated cooperation among LCA practitioners and have also enabled the creation and publication of additional databases. Furthermore, due to its low entry barrier and the availability of resources, openLCA has been widely adopted for LCA studies, projects, and research worldwide.

This document encapsulates the proceedings of the inaugural openLCA conference, held in Berlin, Germany, on the 15th and 16th of April, 2024. openLCA.conf serves as a networking and exchange platform for openLCA users and enthusiasts. The conference emphasizes the participants' engagement with the software and sheds light on the latest advancements.

The following topics were discussed at the conference:

- Case studies and use cases
- openLCA in Industry
- LCIA methods
- Data (inventory and impacts)
- Environmental Product Declarations
- Tooling, supporting tools for openLCA and integration of openLCA in larger IT systems
- Collaboration in openLCA
- Advanced Topics

All abstracts presented in this document were peer reviewed by experienced LCA professionals.

Content

Preface III
Decarbonizing Direct Air Capture with Solar Power 7
PSILCA database for Social Life Cycle Assessment: Worker hours vs. raw values approach 9
Small Change big impact: A comparative LCA of disassembly with recycling methods ofclosed loop denim. 10
Techno-economic and life cycle assessment of hybrid renewable energysystem: Case study in Finland 11
Microplastic emissions from rubbers in LCA: A case study on artificial turffootball pitches 12
Dynamic LCA used for evaluating production of abrasives 13
Successful EPD creation – choice of EPD programme, software, anddevelopment approach 14
Life cycle assessment of cultured meat: Mapping of an unknown system 15
Using USLCI and Federal LCA Commons Resources in openLCA 16
Development of a data migration interface for interoperability betweenGREET and openLCA 17
Automatized LCA of Parametrizable Passenger Car Glider Models 18
Applying a new resource indicator to manufacturing of water electrolysiscells 19
Illuminating the Transition: Leveraging Life Cycle Assessment for CircularEconomy-Centric Advancements in Automotive Headlamp Design 20
Sustainability Assessment of Electric Vehicle Charging Techniques in the UK 21
Sustainability assessment of different type of solar cells manufacturing inthe new energy context .. 22
How to best assess sustainability within the framework of Life CycleSustainability Assessment 24
Indicators that need to be assessed in the sake of sustainability. 24
Parametric Life Cycle Inventory of energy systems applied to geothermalresources. 25
Comparing waste treatment options: A LCA case study on paper and boardfrom lightweight packaging waste 26
Automation of agri-food systems environmental impact calculations withMEANS-InOut and OpenLCA 27
Towards a general framework for integrating concrete work noise impact in BIM-life cycleassessment method. 29
Why Model Net-Positive Environmental Benefits? 31
Comparative Life Cycle Analysis (LCA) of novel NiZn battery technology from Cradle toGrave. 32
Driving Sustainable Design for Additive Manufacturing through OpenLCA 33
Integrating OpenLCA in the Analysis of Transport System Decarbonization 37
A screening assessment of biodiversity impacts for large organizations: anLCA approach. 38
Life Cycle Analysis of Laparoscopic Scissors: Evaluating EnvironmentalImpact and Circular Strategies for Carbon Reduction 39
Overall Sustainability Assessment of large scale salmon farming systems 40

Social Life Cycle Analysis for plant-based beverage 42
pilot scale production in Ireland 42
Life Cycle Assessment of Basse Brazil Nuts 43
Study of Carbon Capture Utilization and Storage Implementation Potential on Ammonia Production in Indonesia using Life Cycle Assessment Approach 45
Social LCA for textile supply chains 46
Global warming potential of electrochemical hydrogen production based onCSP/PV hybrid power plants 47
Life Cycle Assessment of male and female lines of a dual-purpose chicken breed usingopenLCA 49
Developing an assessment framework for sustainable extraction andutilization of agricultural residues with spatially resolved LCIA results 50
Consistency analysis on life cycle impact assessment (LCIA) methods implemented indifferent LCA software 51
Transferring OpenLCA project to Brightway2, library openlca2bw 53
Comparative LCA of virgin and recycled materials to assess thesustainability of paved surfaces in agricultural environment 54
Ecological risks and opportunities of biological methanation in power-to-methane systems 55
Streamlining Life Cycle Assessment using OpenLCA for a medium-sizedUK-based Manufacturer 56
Advancing Circular Economy strategies in urban construction using acombined MFA and LCA approach. 57
Life cycle sustainability assessment of hydrogen from solid oxideelectrolysis coupled with a concentrated solar power plant 59
Up-to-date guidelines for life cycle sustainability assessment of hydrogenenergy systems 60
The role of Open-LCA in supporting the development of sustainableagriculture 61
Life Cycle Sustainability Assessment of Industrialized Renovation Solutions 63
Calculating GHG emissions of offshore windfarms from a lifecycleperspective: case study 64
openLCA and OpenSemanticLab 65
Using OpenLCA for microalgae production systems 66
Automated generation of Life Cycle Assessment models from enterprisedata 67
The Crucial Role of HVAC Life Cycle Inventory Templates 68
Analysis of the potential contribution of disease-resistant grape varieties tosustainable agriculture: a case study in South Tyrol 70
Synergy between LCA and AMC for more science-based informed decisions:a case study in agrifood mountain value chains 71
Role of Open-LCA in sustainable aquaculture development 72
Life cycle assessment for a small onshore 600W wind turbine 74
Environmental Assessment of Interior Components in Vehicle throughopenLCA 75
Life Cycle Assessment of Kerosene from HEFA Process 76

Life Cycle Assessment of Tap Water of Annaba City - Algeria 77
Hotspot Analysis of Keratin Production from Chicken Feather Waste 78
Overview on new and upcoming ISO documents related to LCA modelling 79
The Role of *n*-Generation Carbon Sources on Environmental Footprints ofBiodegradable Polyesters Produced by Fermentation 80
Carbon footprint of solvent-based and innovative UV-based coatings 81
OpenLCA Integrated tool to 83
openLCA in SH2E: A dedicated tool for Life Cycle Sustainability Assessmentof Hydrogen Systems 84
Defining Comprehensive Guidelines for Lifecycle Sustainability Assessment of Fuel CellHydrogen Systems: Environmental and Social Dimensions 85
Optimizing Lifecycle Inventory Databases through AI-Enabled SemanticAnalysis and Data Integration Techniques 86
Spatially explicit life cycle assessment of solar power in Gansu, China in2020 87
SH2E project : Case study application : FCEV and BEV 88
How to model chemical reactions with secondary data in openLCA:A general modelling approach based on metal-organic frameworks 89
Social Life Cycle Assessment of Plastic Value Chains 90
Green Packaging Materials for Long-term Storage of Paper Collection 91
Increasing transparency for inventory data of plastic production bymodeling the olefin supply chain 93
Joint GREET and openLCA to guide the flexible energy layouts for sustainable transportation: a well-to-wheel case study of methanol andhydrogen fuel cell vehicles 94
Integrating OpenLCA and AWS Sustainability Insights Framework to enable CorporateCarbon Accounting 96
How automatise life cycle analysis in the context of electrical equipmentand electronic 97
Accounting for ecosystem services in Life cycle assessment: case study of acommunity garden in Prague 98
Environmental impact analysis for electric bus batteries including second-life application 100
Synergy between LCA and AMC for more science-based informed decisions:a case study in agrifood mountain value chains 101

Decarbonizing Direct Air Capture with Solar Power

Prats-Salvado, Enric[1,2*]; Jagtap, Nipun[1]; Monnerie, Nathalie[1]; Sattler, Christian[1,2]

[1] German Aerospace Center (DLR), Institute of Future Fuels. Linder Höhe, Cologne, Germany.

[2] RWTH Aachen University, Chair for Solar Fuel Production. Templergraben 55, Aachen, Germany.

*Corresponding author E-mail: enric.pratssalvado@dlr.de

Abstract

Direct air capture (DAC) of CO_2 is a technology that separates and concentrates atmospheric carbon dioxide. In addition to its potential as a carbon dioxide removal approach, DAC is one of the most promising carbon feedstocks for the growing industry of carbon utilization in synthetic chemicals and fuels. However, to avoid compromising the carbon neutrality of the final products, the indirect emissions caused by the capture process must be offset. This challenge is compounded by the fact that the most mature technology to date, liquid DAC (L-DAC), requires the combustion of natural gas for high-temperature carbonate calcination. The additional CO_2 produced in this step is captured and mixed with atmospheric CO_2, but due to its fossil origin, this CO_2 must be sequestered, reducing the cost-effectiveness of this technology compared to other DAC approaches.

We propose an alternative design that replaces the natural gas with a solar calciner, with the goal of eliminating the fossil CO_2 fraction in the final product while minimizing indirect emissions. To evaluate the performance of the solar-powered DAC, we combined the results of an internally developed Aspen Plus® model with data available in the literature to build a Life Cycle Inventory (LCI). For this purpose, we used the openLCA® software together with the ecoinvent 3.7.1 database and ReCiPe as the impact assessment method. To increase the realism of our model, we included a cost estimation and analyzed different locations around the world, incorporating local meteorological data and adjusting the providers in the LCI.

The results show, on the one hand, that the climate change impact category is notably reduced when the calciner is powered by solar energy instead of natural gas without compromising its economic viability. This can be explained by the fact that the upstream emissions from natural gas production and transportation largely outweigh the emissions caused by the construction of the solar equipment, regardless of the analyzed location. Moreover, even when considering operation in areas with high solar irradiation that tend to be arid, the solar-powered alternative has a comparatively lower water consumption over its life cycle.

We can conclude that the solar-powered L-DAC can be a promising approach, as most of the impact categories were positively influenced and the carbon capture efficiency was clearly improved. Furthermore, we believe that this case study can serve as an example of the potential of solar thermal energy to decarbonize other high-temperature chemical processes.

Keywords: *Direct air capture, Life cycle assessment, Solar energy, Solar calcination, Decarbonization, Carbon-neutrality*

PSILCA database for Social Life Cycle Assessment: Worker hours vs. raw values approach

Sally K. Springer[1], Christina Wulf[1], Petra Zapp[1]

[1] Forschungszentrum Jülich GmbH, Institute of Energy and Climate Research – Systems Analysis and Technology Evaluation, Germany

Abstract

Social Life Cycle Assessments (S-LCA´s) can either be conducted with a database or without. Available databases, e.g., the Product Social Impact Life Cycle Assessment database (PSILCA), use activity variables. Worker hours as an activity variable are used to reflect the relative significance of a process. Within the S-LCA community they are an established measure, but at the same time criticized, e.g., for their lack of correlation between the number of hours worked and the impact of a unit process. Besides that, the variable is related to working conditions and thus restricted to workers as a stakeholder group, even though it is common to use it also for other stakeholders, e.g., the local community or society. To address these issues, GreenDelta, the developers of PSILCA, invented, next to the established PSILCA database relying on worker hours, a new PSILCA database approach,which calculates with raw values instead of an activity variable. It is using a direct quantification approach, which calculates the weighted average of the indicator raw values.

Both PSILCA database approaches rely on the same economic and social data, but their handling in openLCA differs. The goal of this work is to present these differences as well as advantages and shortcomings. Besides method specifications for openLCA and PSILCA, a case study is used to generate knowledge. The differences of the database approaches affect the way of modeling of the product system by the practitioner of the study, i.e., there are different modelling requirements to ensure a correct calculation of results in openLCA. This implicates a consequence for the interpretation. In addition, the mathematical logic inside the software as well as the expression of results are different.

Three major differences are identified. E.g., for the calculation with raw values, the amount of the reference flow in the output always has to equal “1 USD”. Second, (the same) social indicator flows must be added to every unit process. Third, the number of unit processes has an influence on the results. Neither of these aspects are advantageous nor adverse, but the knowledge about their existence is key to conduct a correct calculation. When it comes to the results, impact category specific medium risk hours are the unit in the worker hours approach. As the raw value approach uses the raw values directly in the calculation, the results are expressed in the initial unit of the indicator, e.g., % or USD. This analysis will be continued and expanded.

Keywords: *Social Life Cycle Assessment, worker hours, activity variable, direct quantification, raw values, PSILCA*

Small Change big impact: A comparative LCA of disassembly with recycling methods ofclosed loop denim.

.

Ammar Rawaa[1], Vanhoeck Cedric[2], Leite Davidson[3]

[1] Resortecs. Quai Fernand Demets 23, 1070 Brussels, Belgium City, rawaa@resortecs.com[2]
Resortecs. Quai Fernand Demets 23, 1070 Brussels, Belgium City, cedirc@resortecs.com[2]
Resortecs. Quai Fernand Demets 23, 1070 Brussels, Belgium City, dave@resortecs.com

Abstract

The textile industry is one of the world's top 5 most polluting sectors, generating over 1.2 billion tons of CO2 eq./year (10% of global emissions) and accounting for a material loss worth € 432 billion/year. An EU citizen consumes 26 kg of textile and generates 11 kg of waste each year, yet only 1% of the material used in textile production is recycled. Textile products are not designed for disassembly (DfD) and the existing recycling solutions are inefficient, complicated and expensive. Disassembly processes are done manually or mechanically, wasting up to 52% of the original fabric material. A comparative Life Cycle Assessment (LCA) was conducted between the different disassembly (manual, mechanical and thermal) and textile recycling methods available. The LCA quantified the environmental impact (CO2 emissions, water use, land use and chemical use) of recycling a pair of denim jeans using a combination of different technologies. This LCA was created with the OpenLCA software (10.3) and the Ecoinvent database 3.6 (2019), using a cut-off system Model. It was shown that a product DfD, made with Active Disassembly and coupled with an effective recycling method at end of life can generate 80% less waste and 50% less CO2 emissions compared to a product that ends up incinerated. When compared to a recycled product, the CO2 footprint of a mechanically recycled pair of denim jeans also varies significantly according to the disassembly method adopted: 18.2 kg of CO2 eq. per jeans if mechanically disassembled, 16.6 kg of CO2 eq. per jeans if manually disassembled, and 15.2 kg of CO2 eq. per jeans in the case of Active Disassembly (thermally disassembled, i.e. Resortecs). If the European garment share were thermally disassembled and recycled, the fashion industry would generate 60.3 million less tons of CO2 and save up to € 2.3 billion per year.

Keywords: *Disassembly, Ecodesign, Circularity, Fashion, LCA, Recycling*.

Techno-economic and life cycle assessment of hybrid renewable energy system: Case study in Finland

Akhtari, Mohammadreza; Hu, Xiang; Karlström, Oskar

Industrial engineering and management, University of Turku, Turku, Finland.

E-mail: mohammadreza.akhtari@utu.fi.

Abstract

A microgrid is a network of interconnected consumers and energy sources, which plays a crucial role in achieving reliable energy generation and climate neutrality. The current study optimizes and evaluates a small-scale microgrid using hybrid renewable energy resources namely solar and wind energy together with battery energy storage. The system is optimized for Turku climatic conditions representative of Nordic countries, as the southern and western coastline of Finland enjoys a considerable wind speed. The techno-economic assessment presents the optimized configuration based on the components' life-cycle costs, demonstrating the possibility of clean electricity generation at a competitive cost compared to the conventional electricity production methods according to the first preliminary studies. Life cycle assessment as a method to quantify the environmental impact of a system will be used to evaluate the potential CO2 equivalent emissions of the renewable-based electricity generation system during its lifetime in a representative of Nordic climatic conditions. Results will be discussed for a considered functional unit as a reference defined as a unit of generated electricity (kWh). In other words, the economic assessment, which is the delivered electricity price per kWh, and the environmental analysis, which is the emitted CO2 per kWh for an optimized combination of an energy system will be explored.

Keywords: *Techno-economic assessment; Life-cycle assessment*; Wind energy; climate neutrality; Hybrid renewable energy

Acknowledgement: The project was financed by the Academy of Finland (project: 355914 and 321598), and Business Finland financed the project Data-Driven Sustainability Management.

Microplastic emissions from rubbers in LCA: A case study on artificial turf football pitches

Zeilerbauer, Lukas[1,2,3]; Lindorfer, Johannes[1]; Paulik, Christian[2]; Fischer, Jörg[3];

[1]Energieinstitut an der JKU Linz, Linz, Austria. *E-mail: zeilerbauer@energieinstitut-linz.at.*

[2] Johannes Kepler University Linz, Institute for Chemical Technology of Organic Materials (CTO), Linz, Austria

[3] Johannes Kepler University Linz, Institute for Polymeric Materials and Testing (IPMT), Linz, Austria

Abstract

Introduction:

The European authorities recently followed the ECHA recommendation put forward several years ago and are phasing out infills made from polymeric materials in artificial turf sport pitches. Those materials are seen as problematic as the overwhelming majority is made from end-of-life tires (ELT), which are considered microplastics (particles < 5 µm) and are known to contain chemicals which are believed to be toxic. Characterization of microplastics is still a challenge in LCA, although first characterization factors (CFs) on the physical effectson biota were recently published. Rubbers were not found in this list except for tire and road wear particles. CFs for ELT and EPDM (for virgin infill material) were derived and withinthe existing framework to see the contribution of microplastics in the context of sport fieldsto the endpoint of ecosystems damage. To benchmark those results, a biobased infill alternative and natural grass fields were also investigated.

Methodology:

OpenLCA 1.11 was used for the modelling of the systems. Background data came from the ecoinvent database v3.9.1 (cut-off) and the LCIA was performed with ImpactWorld+. Data on the football fields was mostly derived from the work of Itten et al., [1] CFs were derived using experimental and LCA literature.

Results and Discussion:

Distributing the influence on the life cycle over 30 years, the results showed that microplastics and their physical effects on biota have a minor contribution to the endpoint category of ecosystem damage and toxicity-related impacts prevail. A sensitivity analysis onthe end of life of the different infill types revealed low contributions, even in pessimistic scenarios, confirming results obtained beforehand. In terms of climate change and many other midpoint categories the biobased infill alternative presented itself as the best alternative compared to natural grass, ELT, or virgin EPDM.

Keywords: *Microplastics; impact assessment; development of characterization factors; rubber; waste management; End-of-Life*

[1] Itten, R., Glauser, L., & Stucki, M. (2020). Ökobilanzierung von Rasensportfeldern: Natur-, Kunststoff-und Hybridrasen der Stadt Zürich im Vergleich.

Dynamic LCA used for evaluating production of abrasives

Xiang Hu[1]; Oskar Karlström[2]

[1] University of Turku, Industrial Engineering, Department of Mechanical and Materials Engineering. Yliopistonmäki (Vesilinnantie 5), Agora, Turku, Finland. E-mail: xiang.hu@utu.fi.

[2] University of Turku, Industrial Engineering, Department of Mechanical and Materials Engineering. Yliopistonmäki (Vesilinnantie 5), Agora, Turku, Finland. E-mail: oskar.karlstrom@utu.fi.

Abstract

Life Cycle Assessment (LCA) is a crucial tool for gauging environmental impacts in manufacturing. Traditionally, LCA relies on static data, but its accuracy in reflecting real- world manufacturing environmental impacts is sometimes a subject of concern. In variableindustrial processes, static data only provides a snapshot of production at one point in time,making it difficult to adapt and optimize manufacturing processes in real time to reflect the true environmental impact. There is a growing need for simultaneous data collection and analysis to offer a more comprehensive view of, for example, energy consumption and support agile decision-making for production enhancement and optimization of processes.The move from static data to concurrent data analysis enables timely analysis of environmental impacts, which will benefit the decision-making process. However, most LCAs are based on static assumptions, although it is recognized that more dynamic assumptions may be needed for the inventory analysis of some LCAs.

The primary objective of this article is to undertake a comparative analysis of environmental impact assessments, utilizing Life Cycle Inventory (LCI) based on common static assumptions, but also dynamic input information. The industrial manufacturing case investigated here is production of abrasives. Impacts are analyzed both for static and dynamic inventory data, particularly within the context of manufacturing coated abrasive machines as its standard production function. Intriguingly, this study explores the differences in data collection methods, such as static and dynamic data derived from simulations of thermal energy consumption and electricity consumption in one week. Static data and dynamic data results will be compared in order to find potential improvement methods for Life Cycle Inventory process.

Keywords: *Dynamic LCA, Manufacturing Industry, Life Cycle Inventory Analysis, Data gathering, Data Simulation*

Successful EPD creation – choice of EPD programme, software, and development approach

Schneider, Luke[1]

[1] uniconsult GmbH. Tiergartenstraße 138, Hannover, Germany. E-Mail: Luke.Schneider@unico.de

Abstract

When creating an Environmental Product Declaration (EPD), the most important factors for effectiveness and efficiency are found in the setting and defining of the goal, scope, and the calculation procedure. This is not surprising but is crucial to understand for those who are dealing with the creation of an EPR for the first time.

The right choice of the EPD programme is decisive for the course of the EPD creation: Depending on the product and its intended application, it is important to identify already existing suitable EPD creation standards (product category rules or PCR) or, if they do not exist, to select a different EPD programme. Creating new PCR for products without existing ones requires tremendous effort and dialogues with multiple stakeholders.

An EPD includes an underlying life cycle assessment (LCA) which requires a structured approach with methodological knowledge of the LCA software and databases as well as the requirements for LCA spelled out in the well-known standards ISO 14040 and ISO 14044. This represents a major hurdle for many, as the benefits of investing in licenses and employee training are difficult to estimate but necessary for developing EPDs. Increasing efficiency of the LCA calculation procedure avoids unnecessary effort and ensures transparency and transferability to other products / product groups.

Since new insights and experiences are constantly being generated during development of an EPD, rigid project planning should be avoided. Agile project management enables a resource-saving and goal-oriented approach. It is also important to accept mistakes in the planned approach and to change plans. An iterative process lays the groundwork of LCA development.

In this presentation, the considerations regarding EPD programme, PCR selection, LCA software and procedural approaches will be explained in a comprehensible way with concrete practical examples.

Keywords: *EPD programme; PCR; LCA; software; databases; agile project management*.

Life cycle assessment of cultured meat: Mapping of an unknown system

Risner, Derrick [1]; Siegel, Justin[2]; Spang, Edward[3]

[1] University of California, Davis, One Shields Avenue CA 95616, USA E-mail: drisner@ucdavis.edu
[2] University of California, Davis, One Shields Avenue CA 95616, USA E-mail: jbsiegel@ucdavis.edu
[3] University of California, Davis, One Shields Avenue CA 95616, USA E-mail: esspang@ucdavis.edu

Abstract

Several methods or system alternatives have been proposed to reduce the environmental impact of human-consumed proteins including alternative protein production, regenerative agriculture, and bovine methane reduction ("clean cow") efforts. During the last five to ten years, alternative proteins or meat alternatives have gained popularity with a multitude of stakeholders. One proposed alternative protein production system is animal cell-based meat (ACBM). The core concept of ACBM production is that animal cells such as pluripotentstem cells can be proliferated in industrial scale bioreactors (>1,000 L), differentiated into avariety of cell types (e.g. adipocytes, myotubes, fibroblasts), and then processed for humanconsumption in place of conventionally produced meat

Interest in ACBM or cultured meat as a viable environmentally conscious replacement for livestock production has been increasing, however a life cycle assessment for the current production methods of ACBM has not been conducted. Currently, ACBM products are being produced at a small scale and at an economic loss, however ACBM companies are intendingto industrialize and scale-up production. A key economic barrier to mass production of ACBM is the cost of the growth medium which provides the animal cells with nutrients necessary for proliferation. A cradle-to-production gate life cycle assessment was conducted on Essential 8™, a well-established animal cell growth medium which contains over 50 growth medium components. OpenLCA software was utilized to track the life cycleinventory for each media component and to inform a broader life cycle impact assessmentof ACBM production. A scenario analysis was then utilized to understand the impact of refining growth medium components via comparison of the utilization of laboratory grade vs. food-grade components in animal cell culture.

The results indicate that the environmental impact of near-term ACBM production could be orders of magnitude higher than median beef production if a highly refined growth medium is utilized for ACBM production. The study also highlighted the unknowns related to life cycle inventory databases concerning the refinement of materials for laboratory or pharmaceutical use. In conclusion, the study provided insight into the environmental challenges of ACBM production while showcasing the strengths of utilizing OpenLCA for cradle-to-gate production systems with multiple inputs and outputs.

Keywords: *Bioreactor; Cultured meat; Growth medium; Life Cycle Assessment; Alternative Protein*

Using USLCI and Federal LCA Commons Resources in openLCA

Weiler, Paige[1*]; Cashman, Sarah[1]; Namovich, Jake[1]; Young, Ben[1]

[1] ERG. Concord, MA, USA.

*Presenter. Paige.weiler@erg.com.

Abstract

The National Renewable Energy Lab (NREL) in conjunction with Eastern Research Group (ERG) supports the U.S. Life Cycle Inventory (USLCI) database on the Federal LCA Commons (FLCAC). USLCI is an open-source database housing North American LCI data contributed by industry groups, government and academic researchers, as well as privatecompanies. The database which is published quarterly through the FLCAC collaboration server was developed on the OpenLCA platform and is primarily worked with by data users in openLCA.

To be more aligned with international and U.S. federal government LCI data standards and conventions, USLCI and other FLCAC repositories are now publishing according to, and being retrofitted to align with, emerging FLCAC data guidelines. The implementation of these guidelines has involved the following key components: aligning elementary flows with the Federal Elementary Flow List (FEDEFL), integrating the EPA's data quality schema with openLCA and requiring its completion for USLCI data submission, as well as adhering to the FAIR data management standards. These actions along with the utilization of the EPA's LCIA formatter tool which aligns LCIA methods in the U.S. and across FLCAC have advanced the interoperability and transparency of FLCAC repositories.

USLCI developed a comprehensive online data publication handbook and online support tools to help implement a streamlined, transparent, user-focused publication workflow. The handbook and support tools outline how to prepare data for publication to USLCI, including: data extractions, file export and conversions, flow mapping, metadata descriptors, nomenclature, categorization, and the representation of flows and processes. There are also detailed descriptions on how to use openLCA to prepare your data, and how NREL/ERG will support the publication of your work. The USLCI represents both an application of openLCA for data curation of datasets provided by diverse industry stakeholders and also collaboration to move towards interoperability with broader U.S. government data sources on the Federal LCA Commons.

The objectives of this presentation are to 1) provide an overview of the USLCI framework, data submission requirements, and current datasets and 2) review the FLCAC resources and discuss how to navigate and obtain North American public data for use in participants' openLCA databases.

Keywords: *USLCI; Federal LCA Commons; open-source data*

Development of a data migration interface for interoperability between GREET and openLCA

Ou, Longwen[1]; Cai, Hao[2]; Wang, Michael[3]

[1] Argonne National Laboratory. 9700 S Cass Ave, Lemont, IL, USA. E-mail: oul@anl.gov.

[2] Argonne National Laboratory. 9700 S Cass Ave, Lemont, IL, USA. E-mail: hcai@anl.gov.

[3] Argonne National Laboratory. 9700 S Cass Ave, Lemont, IL, USA. E-mail: mwang@anl.gov.

Abstract

The Greenhouse gases, Regulated Emissions, and Energy use in Technologies (GREET) Model developed by the U.S. Argonne National Laboratory is a tool for analyzing the life- cycle energy use and emissions of various vehicle and fuel systems, as well as chemicals and materials in major economic sectors. GREET has been used by many researchers for scientific research as well as by government agencies, organizations, and industry to address greenhouse gases (GHG) emissions and other environmental issues. Through decades of active development, GREET now encompasses hundreds of fossil and renewable fuel pathways including conventional fossil fuels such as gasoline and diesel aswell as promising renewable energy pathways including renewable natural gas, sustainable aviation fuel, and clean hydrogen.

GREET comprises two platforms, one is based on Microsoft Excel and the other is based on Microsoft .Net Framework. The Excel-based model excels at data transparency and traceability, while the .Net-based model highlights an easy-to-use graphical user interface to allow quick analysis of new pathways.

GREET has accumulated a comprehensive database of energy systems over the years and attracted a large user base. Yet, its database has not been interoperable with other popular life-cycle analysis (LCA) software like openLCA. In order to enhance the positive impact of GREET on the LCA community and benefit GREET from broader LCA databases and methodologies, we are developing an interface and an openLCA-compatible data schema for data exchange between GREET and other tools such as openLCA. The openLCA-compatible GREET database will also be part of the U.S. federal LCA commons data repository which hosts a collection of databases for LCA. This work connects the two popular LCA tools, openLCA and GREET, and enriches the existing LCA data repositories like openLCA Nexus and U.S. Federal LCA Commons. With the new tool, LCA researchers

and practitioners will be able to extract GREET databases for a specified year and use it for analysis with openLCA.

Keywords: *GREET, openLCA, interoperability, data schema, data migration*

Automatized LCA of Parametrizable Passenger Car Glider Models

Weber, Philipp[1]; Toedter, Olaf[1]; Koch, Thomas[1]

[1] Karlsruhe Institute of Technology / Institute of Internal Combustion Engines. Kaiserstraße 12, Karlsruhe, Germany, E-mail: philipp.weber@kit.edu

Abstract

Detailed Life Cycle Assessment (LCA) studies on passenger cars frequently focus on vehiclesof one or several powertrain types. Moreover, the indicated studies usually address one segment, e.g. the "Golf class", which mostly defines the so-called glider, i.e. the "rest of the vehicle" after subtracting the powertrain. At the same time, publications considering more vehicle variety tend to lack in level of detail owing to inaccessible primary data. In this work,we present a methodology to model and automatically calculate and evaluate variable detailed passenger car components by the example of a glider.

The mentioned openLCA glider model is based on mass calculation formulae from literatureon vehicle concepts. Hereby, several equations are implemented, which consider vehicle features, such as dimensions, body type and trim level and materials. This allows the user to distinguish, for instance, between a hatchback and a sports utility van along with different equipment features. Technically, this is realized via the Python API olca-ipc. Apartfrom the initial creation of the flexible process, the interface is used to parametrize the model, conduct calculations and evaluate the results with regard to different impactcategories and levels of depth in terms of system/subsystems.

In combination with a vehicle database of several thousand models loaded into a Python script, a large variety of results can be produced. In contrast to existing, less detailed glider models, this approach allows to identify impact hot spots in glider production.

With regard to greenhouse gas emissions, the results of the created model are similar to the "standard" ecoinvent dataset, whose emission per kg glider is slightly underestimated. Some combinations of segment (e.g. the A/Mini segment) and body type show slightly larger deviations. In some cases, the parameter models yield implausible mass values. Both observations can be partly explained by the range of validity of the utilized equations. Owing to the large number of parameter variations, the calculation time increases significantly, which is currently dealt with by batchwise starting of calculations.

All in all, the presented methodology allows to create a large amount of LCA results, which can be used to better describe entire passenger car fleets. Further developments involve expansions towards powertrain models.

Keywords: *LCA, passenger car, glider, parameterizable models, olca-ipc*

Applying a new resource indicator to manufacturing of water electrolysis cells

Schreiber, Andrea[1]; Zapp, Petra[1]; Wulf, Christina[1]

[1] Forschungszentrum Jülich. 52425 Jülich, c.wulf@fz-juelich.de

Abstract

Given the relevance of addressing material criticality in life cycle assessment (LCA) of fuel cell and hydrogen systems, a newly defined indicator is developed in the SH2E project. Following the logic of LCA, the new criticality indicator is used as a characterization factor to link material quantity and criticality. Based on the repetitive criticality assessment of the European Commission an indicator is proposed considering the supply risk (*SR*) of a materialin relation to its consumption (*C*) within the EU, the EU import reliance (*IR*), and the countermeasure recycling input rate (EoL_{RIR}).

The manufacturing of 1 m^2 of cell area (functional unit) for alkaline water electrolysis (AEL), proton exchange membrane electrolysis (PEM-EL) and solid oxide electrolysis (SOEC) is usedas a case study to test the proposed criticality indicator.

The results show that nickel and molybdenum for AEL, iridium for PEM-EL, and gadoliniumfor SOEC are critical hotspots for cell manufacturing in the EU. Considering the hydrogen production capacity of the three cell types as well it can be stated that the AEL performs best regarding the new criticality indicator (1.22E-5 points), of which about 85% is caused by nickel and 14% by molybdenum. The criticality of PEM-EL is significantly higher with approx. 1.3E-2 points, exceeded by 2.5E-2 points for SOEC. A high EU consumption is the main thread for criticality, when the import reliance is high, and end-of-life recycling is nothappening within the EU. However, these parameters have a much smaller effect on the overall result.

This new indicator is supplemented by the resource depletion impact category from the European Environmental Footprint (EF 3.1) – Abiotic depletion potential (ADP), ultimate reserves, ADP to add an ecological scarcity perspective. As expected, the ADP indicator shows a different picture than the criticality approach as it focuses on resource availability.In contrast to the criticality approach, ADP highlights platinum in the case of PEM-EL and chromium in the case of SOEC.

Keywords: *Criticality, Life Cycle Assessment, Electrolyzer, SH2E*

Illuminating the Transition: Leveraging Life Cycle Assessment for Circular Economy-Centric Advancements in Automotive Headlamp Design

Flekler, Alexander[1]

[1] Fraunhofer IEM. Zukunftsmeile 1, Paderborn, Germany. E-mail: alexander.flekler@iem.fraunhofer.de.

Abstract

As sustainability pressures increase, new legislation such as the CSR Directive and the EU Taxonomy are becoming mandatory for industrial companies. They're already working to improve their environmental performance strategically and operationally. In the automotive industry, electric vehicles represent this shift, but continuous improvement is crucial for competitiveness. Monitoring long-term environmental impacts is essential and the potential for circular design in all vehicle components needs to be assessed to move towards a circular economy. Unfortunately, comprehensive Life Cycle Assessment (LCA) case studies for automotive headlamps are lacking.

Therefore, the primary objective of this paper is to establish an appropriate LCA study design to serve as a framework for comparative studies of different headlamp designs. At present, there is uncertainty about the data required and useful assessment frameworks for the whole life cycle of a headlamp. There is also no EPD programme that provides product category rules1 for this product group. Consequently, the focus of this work is on the study design and data structure. The model presented in this paper covers the entire

product life cycle (from cradle-to-grave) and is modularised according to life cycle stages. It will use parameters to ensure that it is flexible enough to adapt quickly to new headlamp designs and environmental settings. This is particularly important in the context of new headlamp product development, as it enables engineers and researchers to make meaningful comparisons between a wide range of headlamp designs. This includes variations in design, materials and technology choices that can have significantly different environmental impacts in different regional environments and future scenarios. In more detail, this paper goes beyond a mere presentation of the model; it extensively documents all the study design choices made throughout the modelling process. This documentation is accompanied by thorough explanations of the rationale behind each choice, providing the reader with valuable insights into the methodological decisions that guided the conduct of the study. The results will provide the basis for a focused evaluation of strategies to reduce environmental impacts and improve end-of-life management for this specific product group, particularly in the context of a complex circular economy where trade-off decisions are essential. In addition, the lessons learnt from the project will form the basis for an outlook on the development of product category rules that will enable the creation of Environmental Product Declarations for headlamps in the future.

Keywords:

Automotive Headlamp; Life Cycle Engineering; Life Cycle Assessment; Parameterisedreference model; Product category rules; Automotive industry

[1] The product category rules for passenger cars are only just being developed (see https://environdec.com/pcr-library).

Sustainability Assessment of Electric Vehicle Charging Techniques in the UK

Wu, You

WMG, University of Warwick. Coventry CV4 7AL, United Kingdom. E-mail: you.wu.8@warwick.ac.uk.

Abstract

The United Kingdom is striving towards a greener future by bolstering its electric vehicle (EV) infrastructure. As of April 2023, the nation has established 40,150 public EV charging devices. These charging devices can be broken down into different speed categories: 19% are classified as rapid (25 kW and above), the largest proportion of 56% are categorised asfast (7 kW to 22 kW), and the remainder are slow (3 kW to 6 kW). In relation to their installation locations, 47% are designated for specific destinations, while 34% are on- street chargers. Although starting from a smaller base, ultra-rapid chargers (100 kW and above) have experienced a significant 16% growth, representing the most substantial rise among all categories. With the rapid growth of the EV sector in the UK, it is imperative to investigate the environmental and economic implications of bolstering EV charging infrastructure. This research seeks to examine the environmental impact, economic models, and the trade-offs between performance and costs of various charging point configurations. Life Cycle Assessment (LCA) was used to evaluate the environmental impacts of EV charging devices, setting an environmental impact baseline for charging devices. This assessment incorporated data from the product manual (foreground data) and used ecoinvent 3.9 for background data. Concurrently, a techno-economic analysis was applied to examine the levelised cost of charging options. This includes evaluations of capital, operational, electricity costs, and charger utilisation. Preliminary results highlight the variegated environmental footprints and costs associated with different charging speeds and installation locations. The study has indicated some significant challenges, notably the impact of an insufficient charging network on EV investments. The findings also demonstrate a potential dichotomy between a charging station's performance and its levelised cost, raising questions on the optimal charging solutions that balance both environmental and economic considerations. The research emphasises the pressing need for a sustainable and economically viable expansion of the UK's EV charging infrastructure. This study presents a holistic perspective on the trade-offs and synergies inherent in advancing the EV charging frontier, thereby guiding policymakers, stakeholders, and investors towards optimal decision-making for the EV charging infrastructure.

Keywords: *Life Cycle Assessment; Techno-economic assessment; Electric Vehicles; Charging Points;Levelised cost.*

Sustainability assessment of different type of solar cells manufacturing in the new energy context

Patricio Iván Cano[1], Lucía Doyle[1], Sebastian Ospina-Corral[1], Marin Gheorghe[2], Olivier Durand[3], Germán Cavero[1], Mircea Modreanu[4]

[1] Blue Synergy, Calle Maudes 51, 8ª Planta, 28003, Madrid, Spain. E-mail: admin@bluesynergy.eu.

[2] NANOM MEMS SRL, Strada George Cosbuc 9, 505400, Rasnov, Romania. E-mail: info@nanom-mems.com.
[3] Université de Rennes, INSA Rennes, CNRS, Institut FOTON - UMR 6082, F-35000, Rennes, France. E-mail: olivier.durand@insa-rennes.fr.

[4] Tyndall National Institute-University College Cork, Lee Maltings, Dyke Parade, T12R5CP, Cork, Ireland. E-mail: mircea.modreanu@tyndall.ie.

Abstract

The current situation in Europe relating to the energy share is going to be modified in the following years, since the EU has decided to support the replacement of the fossil fuel dependence by the introduction of renewable sources. These renewable sources allow the simultaneous increasing of the energy autonomy and reduction of the environmental impact in comparison to fossil fuel energy. Nevertheless, the sustainability of the renewable energy sources must be validated throughout the life cycle of the different types of renewable sources.

In line with this energy transition, the EU has funded the project NANO-EH for the development of a smart nanomaterials that are non-toxic, lead- and rare earth-free materials. This device will use multi-source ambient energy such as radiofrequency, piezoelectricity or solar energy for a battery-free energy supply. In this way, the current study is focused on the environmental impact and the economic costs of different type of NANO-EH's related solar cells manufacturing by means of Life Cycle Assessment (LCA) and CAPEX/OPEX analysis at small scale. The flowchart and boundaries in both studies have been based on the experimental and technical background of the researchers involved in the assessment and data recollected in well-recognized peer-reviewed articles.

The LCAs have been implemented in accordance to the ISO 14040:2006 standards. The "Cradle-to-Grave" approach has been included to consider the material extraction and the end-of-life. In line with these assumptions, the Eco-invent database was used.

Financial considerations encompassed both CAPEX (capital investment) and OPEX (the ongoing costs of materials, labor, and utilities). This dual approach ensured a holistic assessment of the solar cell manufacturing processes.

The deposition of silver during the manufacturing of spherical solar cells have been highlighted. Thus, the silver substitution by copper can reduced the impact on the environment. The share of renewable energy consumed during the manufacturing will reduce the environmental footprint associated with the cell manufacturing. In addition, the reduction of the Energy Payback Time has been evaluated in the different scenarios and the different alternatives associated with the waste treatment. In short, all the categories related to the

toxicity showed the highest contribution on the environmental impacts.

Key materials like glass capillary, silver ink, energy consumption and others play a pivotal role in influencing costs. The integration of these components with the broader CAPEX and OPEX framework necessitates a comprehensive financial strategy to ensure the sustainable and cost-effective production of NANO-EH related solar cells.

Keywords: *Solar Cells, LCA, costs assessments, "Crade-to-Grave", Environmental impact quantification, CAPEX/OPEX.*

How to best assess sustainability within the framework of Life Cycle Sustainability Assessment.

Indicators that need to be assessed in the sake of sustainability.

Griebler, Alexander[1]

[1] Montanuniversität Leoben/ Resources Innovation Center. Franz-Josef-Straße 18, 8700 Leoben, Austria.

E-mail: alexander.griebler@unileoben.ac.at

.

Abstract

Sustainability science recognizes the imperative of transforming the existing human-earth system to adhere to the fundamental principles of sustainability for the sake of future generations. To effectively align human actions, supply chains, products, and services with sustainability criteria, a qualitative definition of sustainability and a corresponding set of qualitative indicators are essential. This presentation aims to explore and test historical and current sustainability concepts and derive potential indicators for a comprehensive LifeCycle Sustainability Assessment (LCSA). While planetary boundaries and the Sustainable Development Goals (SDGs) offer a preliminary framework for global sustainabledevelopment, their applicability at regional levels and their validation remain ambiguous. Furthermore, recent years have witnessed the emergence of novel concepts defining a just,good, or decent life for all. The World Happiness Report, the Doughnut Economy, and theDecent Standards of Living introduce prospective indicators that warrant measurement andvalidation to secure sustainable living across society and the entire product and servicevalue chain.

In pursuit of a holistic sustainability assessment, the research presented will conduct a complete LCSA, incorporating an indicator set drawn from existing literature and insights from expert interviews, both within and beyond the LCSA community. The focus will be puton the evaluation of iron ore as a case study, with the overarching objective of establishinga universal set of indicators suitable for diverse product types and sectors.

This presentation will also emphasize the assessment of the biogenic CO_2 storage capacity of the biosphere, a topic often overlooked in current literature. Understanding the potentialfor CO_2 storage in terrestrial ecosystems is crucial for mitigating the impacts of climate change. Lastly, an essential facet of this research involves exploring methods to compare environmental impacts with social impacts, a pivotal requirement for LCSA. This involves monetary valuation and comparison, ensuring that the monetary value assigned to impacts reflects their actual costs, including external effects.

In the long term, the comprehensive sustainability assessment presented here could serveas a foundation for decision-making based on the precautionary principle and sustainable criteria. Ultimately, Life Cycle Sustainability Assessment plays a vital role in advancing the transition toward a more sustainable society by promoting responsible production and consumption, minimizing environmental harm, and enhancing social well-being and economic prosperity.

Keywords: *LCSA, SDGs, Indicators, Cross-sector, Cross-products, Interdisciplinarity*

Parametric Life Cycle Inventory of energy systems applied to geothermal resources.

Claudio Zuffi[1], Andrea Paulillo[2], Giampaolo Manfrida[1], Daniele Fiaschi[1].

[1]Sustainable Energy Research Group, Department of industrial Engineering, University of Florence.

Engineering School. Via di S.Marta, 3 - 50139 Florence, Italy.

[2] Department of Chemical Engineering Faculty of Engineering Science, University College London. 232 Torrington Place – WC1E7JE London, UK.

E-mail: claudio.zuffi@unifi.it.

Abstract

Life cycle analysis is now widely used in the context of renewable energy systems to assess renewable energy systems are truly sustainable, and whether the energy they produce compensates for the environmental impacts generated during their life cycle. For this reason, energy systems using geothermal resources have been extensively studied and analyzed to highlight what environmental impacts are characteristic of these systems. Information about the environmental effects of geothermal power plants throughout theirLife Cycle seems that the specific impact can vary depending on the scale and type of technology being studied. While there are some data available for the broader geothermalenergy production sector, it's important to note that each technology involved in this process encounters its own unique set of environmental challenges. One of the key hurdlesfaced in comprehensively assessing the environmental impacts is the scarcity of comprehensive Life Cycle Inventories (LCI). These inventories are either confidentially held,and they might not be readily usable due to a lack of structured data. The typical assumptionmade is to use a reference process and scale linearly or with some empirical correlation with respect to the reference unit of that process. In this work, we show the approach used to build a parametric LCI to assess the environmental impact of a surface power generationfacility for geothermal resource exploitation. In particular, the focus is on the construction and installation phase of the specific mechanical components: turbine, condenser, evaporative tower, heat exchangers, pumps. The methodology applied is based on selectingfrom an Ecoinvent database a mechanical component construction process as a reference, to define the relative material percentage. The second step is to collect extensive data regarding the component and obtain a correlation linking total system weight and size in terms of power installed. The third step is to use these correlations in the reference processand evaluate the environmental impact. A comparison between the obtained model resultsand models in the literature is carried out to determine which approach is closest to real cases. This approach is being used in the development of a geothermal tool to analyze the sustainability of these systems, which relates to the European project LEAP-RE | Europe-Africa Partnership for Renewable Energy.

Keywords: *geothermal energy, power generation facility, parametric life cycle inventory*

Comparing waste treatment options: A LCA case study on paper and board from lightweight packaging waste

Köhler, Hannah[1]; Spies, Alena Maria[1]; Hegemann, Natalie[1]; Raulf, Karoline[1]; Greiff, Kathrin[1]

[1] RWTH Aachen University, ANTS. Wüllnerstr. 2, 52062 Aachen, Germany.
E-Mail (corresponding author): hannah.koehler@ants.rwth-aachen.de.

Abstract

The paper industry ranks third among the most energy-intensive industries in Germany[1]. Using recycled paper and board (following referred to as paper) instead of primary pulp wasidentified as the main driver to a sustainable paper industry[1]. Additionally, legal regulationsaim for higher recycling quotas to enhance circularity – e.g., German Packaging Act: 90% recycling quota for packaging paper from 2025. Therefore, recycling of yet unexploited secondary material sources, like paper from the lightweight packaging (LWP) collection, moves into focus. To determine if recycling paper from LWP is the environmentally best option, the environmental impacts must be assessed.

Thus, the aim of this study was to give insights, under which circumstances the recycling of paper from LWP is environmentally beneficial compared with incineration. We assessed the recycling of paper from LWP via Life Cycle Assessment (LCA) in OpenLCA to determine the break-even point of benefits and efforts. The case study involved the cardboard production from 20% paper from LWP and 80% paper from separate paper collection in a standard cardboard production process. As a baseline scenario, the cardboard production from 100% paper from separate paper collection and incineration of paper from LWP was selected.

Primary data for the Life Cycle Inventory was collected in a sampling campaign at a LWP sorting plant, a paper sorting plant and at a carton production plant. Lacking data came from literature and the ecoinvent v3.9.1 database. Since material substitution has a major impact on the results, two substitution scenarios were considered. For the Life Cycle Impact Assessment (LCIA), the LCIA method *ReCiPe Midpoint (H)* was used focusing on the main impact categories of the paper industry – Climate Change and Water Consumption and Land Use.

First results showed that the developed recycling process leads to higher environmental impact in the impact category Climate Change mainly due to the necessary substitution of energy generated from incinerating paper from LWP. However, concerning impact categories Land Use and Water Consumption, the recycling of paper from LWP is environmentally beneficial due to substituting primary fibers. Next, these impacts will be complemented with additional impact categories and substitution scenarios.

With the described approach, a case study was conducted to environmentally assess two different waste treatments – incineration and recycling – of paper from LWP. The resultsare crucial for decision making as they show how targets and legal regulations around waste recycling affect environmental impacts.

[1]DIE PAPIERINDUSTRIE - Leistungsbericht PAPIER 2023.

Automation of agri-food systems environmental impact calculations with MEANS-InOut and OpenLCA.

Malnoë, Caroline[1]; Auberger, Julie[2]; Rostain, Guilhem[3]; Geneste, Christophe[4]

[1] INRAE, Institut Agro, SAS. 35000 Rennes, France. E-mail: caroline.malnoe@inrae.fr

[2] INRAE, Institut Agro, SAS. 35000 Rennes, France. E-mail: julie.auberger@inrae.fr

[3] CIRAD, DSI, 34398 Montpellier, France. E-mail: guilhem.rostain@cirad.fr

[4] INRAE, Institut Agro, SAS. 35000 Rennes, France. E-mail: christophe.geneste@inrae.fr

Abstract

Introduction

MEANS-InOut, developed by INRAE and CIRAD, is a software used for creating life cycle inventories of agri-food systems. To calculate the environmental impacts of these systems, LCA (Life Cycle Assessment) software is required to apply a characterization method and link to background processes. Initially, an Ecospold export module allowed for manual linkage between MEANS-InOut and Simapro. However, this solution did not align with the MEANS platform's more ambitious objectives. Thus, a partner consultancy firm needed automated impact calculations, and our collaborators in the Global South with limited resources preferred an open-source solution. In response to these demands, we developed interoperability between MEANS-InOut and OpenLCA, enabling both embedded use and the use of an open-source LCA software.

Materials and Methods

Initially, users had to manually import generated LCIs (Life Cycle Inventories) in Simapro, select the calculation method, and calculate the impacts. The dual challenge was, therefore,twofold: - To automate the import and configuration phase and provide the user with a one- click output file containing impact results and the contribution tree for result analysis directly from MEANS-InOut. - To allow expert users to modify inventories or calculation parameters directly within an open source LCA software with a graphical user interface OpenLCA was chosen to meet these requirements. Since MEANS-InOut is a Java application, we embedded the calculation and output modules (olca-core and olca-io) to initiate calculations from our application. The initial Ecospold format was used to construct LCIs (product systems) for automatic import into OpenLCA. We developed a mapping service to automate the transformation of Ecospold datasets into product systems compatible with the OpenLCA format and a specific module for configuring calculations and generating Excel files for results.

Results and conclusion

From MEANS-InOut, users obtain an Excel file with one click containing environmental impact results for their productions (including contribution trees) and a file that can be re- imported into OpenLCA, allowing them to leverage all its capabilities. This solution is currently used by our partner to evaluate and support hundreds of French farms.

To further advance this, optimizations will be needed to reduce calculation time and improve

output files for easier interpretation. Additionally, for research purposes, we aim to utilize impact spatialization features.

Keywords: *Automated impact calculations, interoperability, agri-food systems*

Towards a general framework for integrating concrete work noise impact in BIM-life cycleassessment method.

Rabaka Sultana 1, Taslima Khanam 1, * Ahmad Rashedi 1, *.

1 College of Engineering, IT & Environment, Charles Darwin University, Ellengowan Drive, Casuarina, Northern Territory 0810, Australia; rabaka.sultana@cdu.edu.au,

* Correspondence: mabrur.rashedi@cdu.edu.au (A.R.); taslima.khanam@cdu.edu.au (T.K.)

Abstract:

Concrete, as a cornerstone material in construction, plays a pivotal role in the built environment. However, the life cycle of concrete, from production to disposal, imparts substantial environmental repercussions, including a frequently overlooked facet—noise pollution. The deleterious environmental implications of noise pollution are manifold, with profound ramifications for human well-being and ecosystems. These include auditory effects, hearing impairment, and non-auditory health consequences, including hypertension and ischemic heart ailments. Moreover, psychological afflictions manifest in annoyance, sleep disturbances, diminished concentration, impaired mental well-being, restricted cognitive development, and compromised cognitive task performance. Remarkably, despite the evident significance of noise pollution, contemporary life cycle assessments (LCAs), which offer a comprehensive perspective on environmental impacts, routinely exclude noise-relatedeffects.

This study advances a novel conceptual framework for quantifying the environmental consequences of noise pollution within the context of LCAs, specifically focusing on concrete construction activities. Moreover, it extends the LCA paradigm to encompass timber flooringas an alternative construction material, enabling comparative evaluations. Central to this framework is integrating building information modeling (BIM) to enhance precision in ascertaining concrete and timber consumption, thereby refining impact assessments. Health indicators, notably annoyance and sleep disturbance, are leveraged to facilitate the quantitative assessment of health impacts attributable to concrete construction activities, with health damages quantified through disability-adjusted life years (DALYs).

To concretize the utility of this framework, a case study scrutinizes regions of varying population densities, exemplified by Darwin and Sydney, to delineate the nuanced environmental effects of noise pollution. Midpoint impact indicators underscore an increased prevalence of highly annoyed and sleep-deprived individuals owing to the integration of noiseimpact considerations in concrete construction. In quantifiable terms, Darwin and New SouthWales (NSW) register 6,378 and 134,405 highly annoyed individuals, respectively, and 3,285 and 76,091 highly sleep-deprived individuals, respectively. Incorporating noise impact elevates DALY metrics to 0.078 for NSW and 0.0311 for Darwin, in contrast to the baseline DALY value of 0.02 for 174 square meters of concrete work devoid of noise considerations. Remarkably, timber flooring demonstrates a comparatively reduced environmental footprint, with DALY values of 0.0525 in NSW and 0.0061 in Darwin.

This research underscores the pivotal role of material selection, particularly the utilization of reused materials, in mitigating environmental impacts. This paper lays the foundation for a comprehensive structural proposal and paves the way for future explorations in assessing noise pollution emanating from diverse construction-related activities.

Keywords: *Life cycle assessment; Dose-effect characteristics; exposure-response relationship; BIM; LCIA; DALY;*

Nature Positive Environmental Declarations

Delwyn Jones[1], David Baggs[2], Mathilde Vlieg[3]

[1] The Evah Institute, Tamborine Mountain QLD Australia. E-mail: delwyn@evah.com.au

[2] Malaika LCT, San Sebastian, Spain. E-mail: mathilde@malaikalct.com

[3] Global GreenTag International (GGTI) Brisbane Australia. E-mail: david.baggs@globalgreentag.com

Abstract

The UN Nature Positive Program (N+) provides a global impetus at local national and global levels to consider positive climate and biodiversity outcomes. The authors aim to illustrate core numeracy and literacy for scientific inquiry and ways to quantify N+ security, wellness and viability gains. This is to fill gaps where, despite risks, humanity faces, loss-messaging about accelerating climate change, extinctions and supply disruption unintentionally elicits prevailing bad news, greenwash, disinformation and inaction.

The justified scientific and political negative literacy and numeracy that stops at zero loss like, Life Cycle Impact Assessment (LCIA) does hinder positive responses. The problem is that the vital focus on damaging loss is too short-sighted to clearly view beneficial gains. This blinds sightlines to net-positive communications. Such negative conventions, however well-justified, also disempower circular and regenerative initiatives.

To address this problem the authors show Life Cycle Benefit Assessment (LCBA) methods covering gain beyond zero damage and loss outcomes. Quantification frameworks show LCIA of damage and loss supplemented by LCBA conforming to ecolabelling standards.

Methods and examples show measuring viability gains in climate, wellness and supply security. LCBA measures gain from system recovery, recycling, renewal, resilience, reforestation, regeneration & restoration. Studies reveals climate and biodiversity security benefits from renewable feedstocks, biogenic aragonite minerals, and recycled feedstocks. Real-world third-party-certified LCA case studies and N+ Environmental Products Declarations (EPDs) shown are new tools for marketing and procurement.

It discusses how revealing benefits enables truer market assessments and a good news focus free of greenwash. LCBA is just one response to UN calls for a nature-positive world demand extending scientific sightlines beyond net-zero damage outcomes to quantify regenerative gain. It offers conventional communication positive words, data and evidence it needs to support regeneration at personal, local, national and global levels.

The work discusses tools for initiatives beyond less pollution, damage and loss to guide and assess nature-positive development, plans and policy that need integrated repair, benefit and net gain messaging, measures and metrics. It offers complementary damage and benefit indicator frameworks for creating less harm to repair adding benefit and producing net-gain within planetary boundaries. Such sightlines beyond zero offers hope to inspire wider action knowing that only huge gains can restore planetary controls.

It concludes that positive metrics and net-positive results also offer evidence against charges of greenwash and bad news.

Keywords: *Nature-Positive; Benefits; Security; Wellness; Net-gain*

Why Model Net-Positive Environmental Benefits?

Mathilde Vlieg[1], Delwyn Jones[2] and Shoka Ashar[2]

[1] Malaika LCT, San Sebastian, Spain. E-mail: mathilde@malaikalct.com

[2] The Evah Institute, Tamborine Mountain QLD Australia. E-mail: delwyn@evah.com.au

Robust Life Cycle Assessment (LCA) methods and standards are available for calculating environmental damage. Given current rates of anthropogenic climate change and extinction assessing less damage is not enough. Now United Nations Nature Positive programs and Circular Economy both need positive outcomes. But environmental Life Cycle Impact Assessment (LCIA) is limited to damage to zero loss outcomes. So there is a need for robust LCA to quantify positive environmental benefit and gain outcomes. Such methods need capacity to reveal benefits versus damage to beyond-zero loss as well as net-positive benefit. The objective is to show scalable Life Cycle Benefit Assessment (LCBA) methods to define and quantify benefit and gain versus damage and loss.

Methods are depicted of LCIA covering zero to gross damage versus LCBA from zero to capacity gain. ReCiPe LCIA and Evah LCBA concepts, theory and practice are compared. LCIA covers human, ecosystem and resource loss categories from air, land and water pollution forcing climate change and land use change forcing extinction rates. Whereas LCBA wellness, habitat and resource security gain categories arise from sequestering emissions from air, land and water and regenerating resource supply, habitat and biodiversity.

Third-party certified case studies of post-consumer recyclate (PCR) show LCIA results that lacked capacity to model or show it had any benefits let alone net-positive gains. Next LCIA results show less-worse PCR damage versus primary material but even by manipulating results all outcomes are still negative. A further LCBA study tabled damages versus benefits with very significant land use and wellness benefits from reclaiming instead of landfilling scrap and quarrying. So PCR net-positive outcomes were only evident by tabling benefits versus damages, compared to LCIA revealing only damage or only less damage.

Discussion is presented around unstainable, sustainable and regenerative development in charts of net-damages and net-benefits Leiden IE master's students developed under the author's supervision. They show how preferences may differ when benefits are revealed and communicated transparently alongside of damages. This offers a transformational step in understanding how to transition toward sustainable consumption-production systems. without risking double counting or greenwashing.

Employing methods to count benefits versus damage can show losses compared to gains. These can demonstrate net damages as well as net benefits considering unstainable, sustainable, and regenerative development. Preferences can change considering benefits. The work shows how benefits can be communicated alongside damages to avoid double counting or greenwashing while potentially inspiring action and confidence.

Keywords*: Regenerative; Unsustainable: Sustainable; Security; Benefits; Net-positive*

Comparative Life Cycle Analysis (LCA) of novel NiZn battery technology from Cradle toGrave.

Malviya, Ashwani Kumar[1,3]; Li, Jinping[2]; Santarremigia, Francisco E.[1];Molero, Gemma Dolores[1]; Olmos, Jesús Irles[1]; Sanchis, Ignacio Villalba[3]; Yepes, Víctor[3] [1]AITEC, Parque tecnológico. C/Charles Robert Dawrin, 20. 46980 Paterna -Valencia, Spain;.

Email: akmalviy@doctor.upv.es, amalviya@aitec-intl.com.

[2]Optima Technology GmbH. Einsteinstraße 59, 89077 Ulm, Germany. Email: jinping.li@optimatechnology.de.
[3]School of Civil Engineering, Universitat Politècnica de València, Camino de Vera, s/n 46022 Valencia, Spain;.
E-mail: igvilsan@cam.upv.es.

Abstract

The aim of this study is to analyse the state of the art regarding LCA (life cycle analysis) andLCCA (life cycle cost analysis) from cradle to gate (from resource extraction until the disposalphase) of the nickel zinc battery, and of other electrochemical battery technologies currently in the market or under development and to analyse the environmental impacts produced along the life of the new NiZn batteries, according to ISO 14040:2006 and ISO 14044:2006. A comparative LCA study has been performed for the environmental impacts produced by new NiZn battery and compared with other two battery product systems, which are widely used in Battery Energy Storage System (BESS): Lead-acid and threechemistries of lithium-ion batteries (LFP/NMC532/NMC622).

The types of electrochemical batteries selected to be analysed were based on the databasefrom the European Union (EU) Open Data Portal (Directorate-General for Energy, 2020) andinclude: nickel zinc (NiZn), sodium sulphur (NaS), lead acid, sodium nickel chloride, lithium-ion, lithium-metal-polymer, nickel cadmium, nickel metal hydride, zinc iron redox flow batteries, vanadium redox flow batteries and zinc bromide redox flow battery. The literature review concluded that it is easier to obtain data of manufacture, recycling and use of batteries whose technology is more mature, such as Lead-acid and Li-ion. Likewise, as these are the two technologies for which more information can be obtained and it is easier to make a comparative LCA study.

The methodology followed in this study and LCI modelling are according to ISO 14040:2006 and ISO 14044:2006 in the comparative LCA of the new NiZn battery which has been compared with other two battery product systems widely used in Battery Energy Storage System (BESS): Lead-acid and lithium-ion batteries, from cradle to grave. The battery modelling was done in three phases: cradle-to-gate, including the selection of resources, battery manufacturing and transport to end-user, use and end-of-life. For data quality we use the existing one, namely the ecoinvent data quality system, which is directly available in openLCA.

With all, the analysis of full LCA in this study finds that NiZn batteries has a low contribution to environmental impact with ca. 14 MJ to CED result and 0,82 kg CO2 eq to Global Warming related to the 1 kWh released energy, which is the best performance among all the battery types included in our study.

Keywords: *Life Cycle Analysis (LCA); Environmental Impact; Energy Storage System; NiZn Battery; BESS*

Driving Sustainable Design for Additive Manufacturing through OpenLCA

Okhovat, Rasool[*1]; Syré, Anne[*2]; Maier, Otto[*3]; Göhlich, Dietmar [*4]

[*]Chair of Methods for Product Development and Mechatronics, Technische Universität Berlin. Straße des 17. Juni 135, Berlin, Germany

E-mail: rasool.okhovat@tu-berlin.de
E-mail: a.syre@tu-berlin.de

E-mail: otto.maier@tu-berlin.de

E-mail: dietmar.goehlich@tu-berlin.de

Abstract

Performing life cycle assessments (LCAs) is a complex task for engineers and industry professionals. This work aims to change the approach to LCAs by providing engineers and industry professionals with an easy-to-use tool for conducting LCAs, thereby transforming this task into a more accessible and efficient practice for them.

To create the tool, a basic framework is developed, following the DIN EN ISO 14040 and DINEN ISO 14044 standards. The life cycle assessment can be carried out by using a simple Excelfile for entering process inputs and outputs and thus creating adapted inventories. The data can alternatively be retrieved directly from the software of the respective measuring devices. The next step involves creating a Python framework, which enables the implementation of a life cycle assessment using the tool within the openLCA software.

To assess the functionality and suitability of both the created tool and the Python program code, we applied the tool to a case study involving the life cycle assessment of various Additive Manufacturing methods, including Powder Bed Fusion with both Laser (LPBF) and Electron Beam (PBF-EB) techniques and Wire Arc Additive Manufacturing (WAAM) of high-temperature components in comparison with conventional subtractive and casting methods.

The results of the case study indicate that the primary aspect of this tool is its ability to present potential environmental impacts in a short time. Additionally, the tool offers several key advantages, including simplifying comparisons among various processes, identifying environmental hotspots through enhanced visualizations, and visualizing the impacts of upstream processes along with their contributions to overall environmental footprints. The tool is designed to focus specifically on cumulative energy demand and global warming potential. This feature is particularly valuable for inexperienced users and early stages of development, requiring minimal background knowledge.

In summary, the created tool and the implemented Python program provide a solid foundation for simplifying and automating the life cycle assessment process for industrial applications. Its user-friendly approach is well-suited for diverse industrial sectors and various production phases. It serves as a valuable aid for decision-making processes and lays a foundation for future research aimed at simplifying LCAs in the industrial context.

Keywords: *Life Cycle Assessment; Additive Manufacturing, Inventory Data Management;Python; Openlca*; *Simplified Industrial LCA*

Is the PV modules assembly an ecofriendly process?

Hernandez-Padilla, Flor[1*]; Vázquez, Valeria[2]

[1] School of Engineering, National Autonomous University of Mexico, Circuito Escolar C.U., Coyoacán 04510, Mexico. E-mail: flor.hernandez@ingenieria.unam.edu.
[2] School of Engineering, National Autonomous University of Mexico, Circuito Escolar C.U., Coyoacán 04510, Mexico. E-mail: valeria.vaz.2000@gmail.com

Abstract

Introduction

Although photovoltaic technologies are considered environmentally friendly, they also cause environmental impacts (Urbina, 2022; Frischknecht et al., 2020). The present study performs Life Cycle Analysis of two scenarios of PV manufacturing wastes to find the step of the process with the greatest environmental load. The scenarios evaluated are unsanitary landfill and recycling.

Methodology

First, visits and sampling of two PV panel manufacturing companies were developed to integrate the LC inventory. The process was structured in openLCA software V1.10.3, using Impact World+ (Continental Latin America_Damage 1.431) and the ecoinvent v.3.9.1 database. Were analyzed two waste scenarios: unsanitary landfill and recycling. The stepsof the process studied were: 1.PV cells selection, 2.Welded, 3. Inspection, 4. Encapsulation, 5. Test, 6.Repair, 7. Lamination, 8. Final assembly, 9. Test, 10. Packaging.

Table 1 LC inventory (abstracted)

Item	Qty	FU 1 m^2
PV cell	36.3	unit
Broken PV cell (waste)	11	unit
Finished and tested PV panel	1	m^2
$AlMg_3$	1558	g
Corrugated cardboard corners	1.120	g
Stretch wrap 60 gauge polyethylene	8.955	g
Wooden platform	0.050	unit
SnPb solder bars	145.43	g

Results and discussion

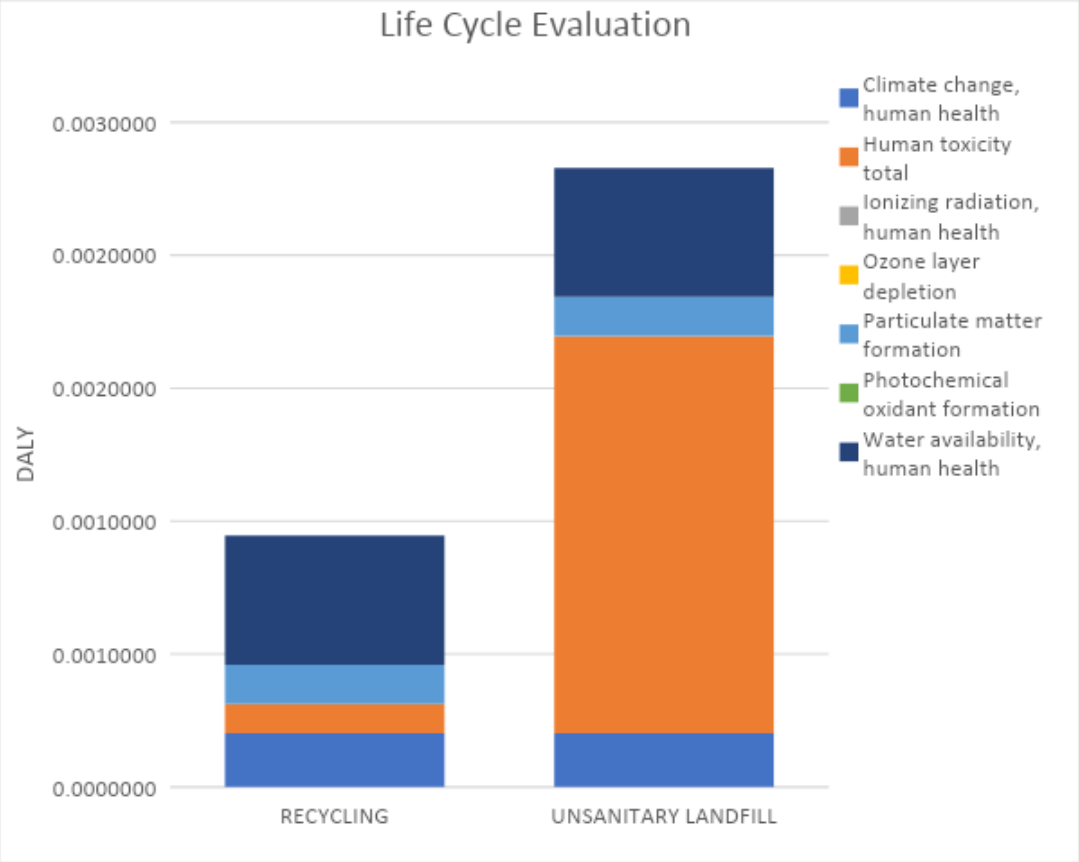


Figure 1 Life Cycle Evaluation

The results show that the disposal of unsanitary landfill is the scenario with the greatest impact (0.002329 DALY). The categories human toxicity cancer, long term and human toxicity non-cancer, long term sum 0.001492 DALY, which is presented in the Figure 1 as human toxicity total. The impacts are distributed as follow, the final disposal of broken cells and ribbons and busbars in unsanitary landfill account 64.09% of the human toxicity due to the metals disposed in agricultural land as lead, copper, silver, etc. The production of PV cells has 6.3% of the particulate matter impacts and 8.7% of the climate change impacts due to electricity consumed by the monocrystalline silicon block production by Czochralski process and the of silicon solar grade production processes. The Water availability category represents 20.8% because of water used along the PV cell supply chain from raw materials production. While the recycling scenario generates the least impact (0.000945 DALY). For their part, Rashedi and Khanam (2020) concluded that the production PV cell process has the highest impact, but they did not include unsanitary landfill scenario to the PV waste, and they did not develop field work of the manufacturingprocess or final disposal. However due to ecoinvent database has not all data about the recycling process such as lead solder, cells or some raw material packaging materials, this scenario does not show conclusive results.

Conclusions

In PV modules production LCA studies, the production normally dominates the scenarios if unsanitary landfill is not considered in the study but the authors carried out the comparison among the recycling and final disposal scenarios. As can be seen, the PV cells broken and disposed in an unsanitary landfill have the most impacts in Human Health category due to Human toxicity in short term. Open LCA is a powerful software for LCA modeling. Its robustness and accessibility allowed us to structure a model that responds satisfactorily to the project. Because there is no data in ecoinvent about the recycling process, it is necessary to continue working to complete the data in collaboration with other universities.

Keywords: *PV modules manufacturing, PV cells, PV industry waste, PV Mexican industry*

References

Frischknecht R., Stolz P., Krebs L., de Wild-Scholten M., Sinha P., Fthenakis V., Kim H. C., Raugei M., Stucki M. (2020) Life Cycle Inventories and Life Cycle Assessment of Photovoltaic Systems, International Energy Agency (IEA) PVPS Task 12, Report T12-19:2020.

https://iea-pvps.org/wp-content/uploads/2020/12/IEA-PVPS-LCI-report-2020.pdf

Rashedi A. and T. Khanam (2020) Life cycle assessment of most widely adopted solar photovoltaic energy technologies by mid-point and end-point indicators of ReCiPe method. Environmental Science and Pollution Research (2020) 27:29075–29090https://doi.org/10.1007/s11356-020-09194-1

Urbina,A. (2022). Sustainable Solar Electricity., https://doi.org/10.1007/978-3-030-91771-5

Integrating OpenLCA in the Analysis of Transport System Decarbonization

Syré, Anne*[1]; Okhovat, Rasool*[2]; Maier, Otto*[3]; Göhlich, Dietmar*[4]

*Chair of Methods for Product Development and Mechatronics, Technische Universität Berlin, Straße des 17. Juni 135, 10623 Berlin, Germany.

[1] E-mail: a.syre@tu-berlin.de

[2] E-mail: rasool.okhovat@tu-berlin.de

[3] E-mail: otto.maier@tu-berlin.de

[4] E-mail: dietmar.goehlich@tu-berlin.de

Abstract

The pressing challenges of climate protection, local air quality preservation, limited urban space, and resource scarcity have driven the imperative need to adapt for the transition ofthe transport system. While single-vehicle life cycle assessments (LCAs) allow us to compareindividual vehicles, they may overlook the broader influences and opportunities within entire transport systems. To model the behavior of future transport systems, integrating new technologies, vehicles, and strategies such as demand-responsive transport or autonomous vehicles, we rely on the agent-based transport simulation such as MATSim. Inaddition, for specific bus schedule planning, we develop and employ the simulation tool eflips (integrated fleet and depot planning). The outcomes of these simulations must undergo evaluation in terms of cost and environmental impacts. Our objective is to integrate OpenLCA into this framework using the Python package olca ipc, to conduct LCAsof various transport scenarios.

The olca ipc package facilitates the integration of OpenLCA into our framework, enabling usto utilize simulation outputs from MATSim and eflips as inputs for LCAs. This automation allows us to compute environmental impacts for diverse transport scenarios and drive traintechnologies. The olca ipc package not only grants easy access to OpenLCA's inventories and impact assessment methods but also streamlines the process for engineers. Their directintegration within simulations can be time-consuming, often due to the intricacies of transport simulations rather than OpenLCA's functionality. While the package is already valuable in its current state, providing the full functionality of OpenLCA would even increase the useability for us. One limitation we acknowledge is that OpenLCA can be challenging forengineers without a solid foundation in LCA. However, the integration via the olca ipc package simplifies the process, allowing engineers to adjust specific parameters and automate the LCA, making it highly advantageous.

In summary, the integration OpenLCA in the analysis of transport system decarbonization, simplifies and automates our work and allows comparative analysis of different transport scenarios. We believe that further enhancements in Python access to all OpenLCA's functions would be a significant improvement. In the future, cost and emission data should be applied through jsprit (toolkit for solving rich traveling salesman and vehicle routing problems) within MATSim to optimize truck and freight schedules or within eflips tooptimize bus schedules and charging infrastructure. As part of our future approach, we willgenerate environmental impact inputs for our simulations and integrate them using the olcaipc package.

Keywords: *OpenLCA, Life Cycle Assessment, Transport Simulation, Fleet and Depot Planning, Python olca ipc, Decarbonization*

A screening assessment of biodiversity impacts for large organizations: an LCA approach.

Correa-Cano, Maria Eugenia[1]; Yan, Xiaoyu[2] & Hails, Rosie[3]

[1] Environment and Sustainability Institute, University of Exeter, Penryn Campus, Cornwall, TR10 9FE, UK, E-mail: m.e.correa-cano2@exeter.ac.uk

[2] Environment and Sustainability Institute, University of Exeter, Penryn Campus, Cornwall, TR10 9FE, UK, E-mail: Xiaoyu.Yan@exeter.ac.uk

[3] National Trust, Heelis, Kemble Drive, Swindon, SN2 2NA, email: rosie.hails@nationaltrust.org.uk

Abstract

Introduction. Biodiversity is declining at an alarming rate, with several organizations estimating the lowest numbers of wild species and their populations since 1970 (Living Planet Report, 2022; IPBES, 2019). To maintain societal demands including food production,maintenance of ecosystem services, and human health and well-being, it is imperative to understand the distribution of impacts across ecosystems and along supply chains. Involvement of all actors in society is crucial and large organisations will need to assess theeffects of their activities on biodiversity in addition to climate change. A spatialized approach will enable a better understanding of the impact of human activities, allowing organisations to target actions to the affected ecosystems. A Life Cycle Assessment (LCA) approach offers a systematic and standardised method to estimate environmental impacts.Recent developments in regionalization of Life Cycle Impact Assessment methods might allow the location of potential biodiversity losses along supply chains. In this study, we aimto assess the biodiversity impacts of the activities of one large organisation by applying a spatialized LCA approach.

Method. We considered the National Trust in the UK as a case study. This is a charity founded in 1895 *"for the purposes of promoting the permanent preservation for the benefitof the nation of lands and tenements (including buildings) of beauty or historic interest andas regards lands for the preservation of their natural aspect features and animal and plant life".* In addition, the National Trust also has a sizeable commercial arm and is landlord to around 1400 tenants.

We followed the general framework for organisations developed by Correa-Cano et al. (in prep.) to assess their biodiversity impacts, which is based on the ISO 14040 and 14044. Wegenerated a Life Cycle Inventory based on the greenhouse gas dataset and selected an implemented spatialized LCIA: World Impact+. We used Ecoinvent as the backgrounddataset and conducted our analysis in openLCA ver. 2.0.3.

Results and conclusions. Preliminary results show that agricultural activities are responsiblefor the largest proportion of potential biodiversity loss through the direct impacts of land use in the UK, and through the use of land in other countries (e.g. Brazil) producing fodderfor consumption by livestock on UK farms. Although our data need further adjustments, this method can help organisations to assess their direct and indirect impacts on biodiversity, to locate highly susceptible ecosystems, and to develop management plans that include targeted actions to stop biodiversity loss.

Keywords: *spatialization, WorldImpact+, openLCA, biodiversity impacts*.

Life Cycle Analysis of Laparoscopic Scissors: Evaluating Environmental Impact and Circular Strategies for Carbon Reduction

Jindal, Swati[1]; Mardina, Zahrina[1]; Rahimfard, Shahin[2]; Culmer, Peter[1]

[1] University of Leeds. Woodhouse Lane, Leeds, UK.

[2] Loughborough University. Loughborough, UK.

Corresponding Author: Peter Culmer: E-mail: p.r.culmer@leeds.ac.uk

Abstract

Laparoscopic scissors are specialized surgical instruments used in minimally invasivesurgeries, enabling precise cutting and dissection of tissues with minimal trauma.

However, the widespread use of single-use laparoscopic instruments has led to excessive waste generation with a significant environmental impact. With increasing attention beingplaced on sustainability in healthcare, exemplified by the ambitious 'net carbon-zero' targets in the UK NHS, there is a critical need to explore strategies which harness circular economy principles, to reduce the environmental impact of such surgical instrumentation.In this study, we combined product-level cradle-to-gate life cycle analyses (LCAs) of typical laparoscopic scissors with circularity metrics (c-metrics) to identify pragmatic strategies for reducing environmental impact.

The LCA analysis considered the life cycle from raw material extraction to manufacturing the laparoscopic scissors. We used OpenLCA with the EcoInvent database (v3.9.1) to model and quantify carbon emissions during typical usage. Using this approach we investigated the outcomes of modifying the products using circularity principles of slowing, narrowing and closing resource loops. This included light-weighting, substituting materials and design improvements in robustness. We then combined this with c-metrics, adapting the Materials Efficiency Metric (MEM) to map material flow, assuming constant transport and usage logistics. The results of the LCA analysis will be of particular interest to manufacturers of medical devices, as it provides a basis for comparing and contrasting different strategies to achieve net-zero targets and enhance sustainability commitments. Additionally, stakeholders across various industries can benefit from the analyzed data on the environmental impact of laparoscopic scissors, enabling informed decision-making andpromoting sustainable practices.

In conclusion, this study presents a pragmatic approach to assess and improve the environmental impact of surgical tools like laparoscopic scissors. By combining life cycleanalyses with circularity metrics, we show that circularity can provide a powerful framework to identify and guide opportunities for carbon reduction in medical devices, thus working towards a more sustainable healthcare industry.

Keywords: *Medical device, circular economy approach, material resource, sustainability, healthcare industry*.

Overall Sustainability Assessment of large scale salmon farming systems

Petridi, Angeliki[1]; Boukouvalas, Christos[2]; Tryfon Kekes[2]; Krokida Magdalini[2]; Sveinsdóttir, Hildur Inga[3]; Papadaki, Sofia[1]

[1] Dignity Private Company, 30-32 Leoforos Alexandrou Papagou, Zografou 15771, Athens, Greece. E-mail: info@dignity.com.gr

[2] Laboratory of Process Analysis and Design, School of Chemical Engineering, National Technical University of Athens, 9 Iroon Polytechneiou St. Zografou Campus, Athens, 15780, Greece. E-mail: mkrok@chemeng.ntua.gr

[3]Matis, Department of Research and Innovation, Vínlandsleið 12, Reykjavík, 113, Iceland. E-mail: hilduringa@matis.is

Abstract

Aquaculture is the fastest growing field of food industry and a crucial economic sector for numerous countries. The growing sector has highly contributed to enhancing the accessibility and the affordability of fish products and to gradually achieve to meet the needs of the increasing population.

Nevertheless, aquaculture systems, especially inland systems, are accused for numerous of environmental problems, such as overconsumption of water, high energy demands and high emissions of greenhouse gases. Moreover, the uncontrolled rapid development of thesector has led to concerns regarding its sustainability. It's important to notice that accordingto FAO, in 2020 the 70% of the aquaculture production originated from Asia. Many countriesof Asia do not have the appropriate legislation to protect workers and society. This phenomenon raises questions regarding the social aspects of the aquaculture industry, suchas the working conditions and the influence of the industry to the local communities.

The aim of this work is to conduct a complete Sustainability Assessment of a large scale aquaculture system, in order to identify, analyze and discuss over the hotspots of each of the three pillars of Life Cycle Assessment, Environmental LCA, Economic LCA and Social LCA. The analysis uses OpenLCA v1.11.0 Software and the database Soca v2, which combines PSILCA v.3 and ecoinvent v.3.7.1. The data for the assessment were collected, through questionnaires and interviews of the value chain actors, for an existing Atlantic salmon aquaculture system.

Preliminary results of the analysis revealed that there are critical points in the aquacultureprocess that accumulate a substantial environmental footprint. Based on the outcomes, theaquaculture products emit significant amounts of greenhouse gases and they have an important impact to the eutrophication of water. The most energy and water consuming process is recognized to be the cultivation tanks, which need electricity for the lamps and pumps and high amounts of fresh and salt water.

Similarly, the LCC and the S-LCA highlighted significant issues that should be considered. Social LCA pinpointed that, although salmon farming methods are firmly entrenched, thereare some critical issues that need to be improved. The LCC revealed that some processes are costly and need to be updated.

Consequently, the Sustainability assessment has determined that achieving sustainable development necessitates significant modifications and interventions in the aquaculture process. These changes are essential to diminish environmental footprint, to promote economic growth and to protect social standards.

Keywords: *Aquaculture industry, Sustainability Assessment, LCC, S-LCA, Soca v2, OpenLCA*

Social Life Cycle Analysis for plant-based beverage pilot scale production in Ireland

Petridi, Angeliki[1]; Fenelon, Mark[2];Ricardo Uribe Alvarez[2]; Papadaki, Sofia[1]

[1] Dignity Private Company, 30-32 Leoforos Alexandrou Papagou, Zografou 15771, Athens, Greece. E-mail: info@dignity.com.gr

[2] Teagasc, Agriculture And Food Development Authority, Oak Park, Carlow, R93 XE12, Ireland. E-mail: Mark.Fenelon@teagasc.ie

Abstract

The beverage industry stands as a vital economic sector with a profound impact on local and global economies. According to Statista, in 2022, the revenue from the beverage industry globally reached 172.00 billion USD, while in 2027, it is expected to reach 303.9 billion USD. Simultaneously, the growing preference for plant-based protein indicates a significant shift in dietary habits and consumer choices. This movement is driven by a combination of factors, including health consciousness, environmental concerns, and ethical considerations. Within this context, a European Project aims to combine these two aspects, developing a plant-based beverage. However, both the cultivation phase and the production process have raised concerns over their social impacts. Hence, the aim of this work is to develop a Social Life Cycle Assessment in order to identify the critical areas of concern within both the plant cultivation stage and the production process, in pilot scale, and suggest strategies for their mitigation.

The initial phase of the analysis involved identifying the stakeholders within the beverage life cycle. In this assessment, four primary stakeholder groups were considered: workers, value chain actors, local community, and society. Given the numerous subcategories and social indicators associated with each stakeholder, we initially selected the most relevant indicators for our system. Subsequently, a questionnaire containing these selected indicators was designed and distributed to the stakeholders to measure the significance of each indicator from their perspective.

The software used was OpenLCA, with Soca v2 database. When working with Soca v2, it is crucial to identify the risk level of its indicators. Thus, we created a survey containing both qualitative and quantitative questions, which was distributed among our partners for their responses. Following the data input and computation of working hours for each process in the software, we applied the Social Impacts Weighting method to obtain results. The preliminary results unveiled that although certain social standards receive protection, given both the cultivation and industrial processes taking place in Europe, there remain inequities in social aspects. The analysis exposed issues such as a gender wage gap and workplace accident rates as critical concerns during the cultivation phase, while in the industrial process, embodied CO2 footprint and the monthly wage within the sector emerged as more pressing issues. Given the results, measures are proposed to eliminate these inequities in order to achieve a more socially accepted plant-based beverage production.

Keywords: *Soca v2, Social LCA, Enriched protein beverage production, Plant based proteins, OpenLCA*

Life Cycle Assessment of Basse Brazil Nuts

Ben Haim, Lavi[1]; Lieberman Ido[2]; Runyan, Serena[3]; Sztokman, Elana[4]; Zvi, Liat[5]; Negi, Rajhans[6]; Lifshitz, Jessica[7]; Blass, Vered[8]

[1]Porter School of the Environment and Earth Sciences, Tel Aviv University, Tel Aviv 69978, Israel. E-mail: lavibenhaim@mail.tau.ac.il

[2]Porter School of the Environment and Earth Sciences, Tel Aviv University, Tel Aviv 69978, Israel. E-mail: idol3@mail.tau.ac.il

[3]Porter School of the Environment and Earth Sciences, Tel Aviv University, Tel Aviv 69978, Israel. E-mail: serenarunyan@mail.tau.ac.il

[4]Porter School of the Environment and Earth Sciences, Tel Aviv University, Tel Aviv 69978, Israel. E-mail: sztokman@mail.tau.ac.il

[5]Porter School of the Environment and Earth Sciences, Tel Aviv University, Tel Aviv 69978, Israel. E-mail: liatzv@tauex.tau.ac.il

[6]Porter School of the Environment and Earth Sciences, Tel Aviv University, Tel Aviv 69978, Israel. E-mail: rajhans@tauex.tau.ac.il

[7]Basse Nuts, Laval, Quebec H7P4W6, Canada. E-mail: jessical@bassenuts.com

[8]Porter School of the Environment and Earth Sciences, Tel Aviv University, Tel Aviv 69978, Israel. E-mail: vblass@tauex.tau.ac.il

Abstract

Brazil nuts are unique food crop as they grow in the amazon rainforests and are self- cultivated. The growing stage of Brazil nuts does not include massive water use, land use change, fertilizers/pesticides, and machinery for harvesting which makes them a relatively low-impact product. Being a healthy alternative, the nuts are collected and transported forits consumption in different parts of the world. Apart from its long-distance transportation, various post-harvesting processes contribute to the environmental impacts. In this study, we perform life cycle assessment (LCA) of Basse Brazil nuts, which are shipped from South America and processed to be consumed in Canada. The functional unit (FU) of this study was one 1.5 lb. bag of Brazil nuts for retail. The system boundary included the supply chainof nuts from the port to the store. The processes included in the assessment were: boxing and sorting, shipping, manufacturing, and delivery to store. The life cycle inventory was developed by students in a LCA project-based learning course in Tel Aviv University during the last year. The work included collecting the primary data about the use of diesel, electricity, packaging, and other inputs used in the process chain of the product from the official records of the Basse Nuts company. The LCA was performed in the openLCA v1.11.0 software with Ecoinvent and Agribalyse databases used for the background data inventory. ReCiPe Midpoint (E) V1.13' was used as the impact assessment method and we analyzed eight relevant impact categories. The total global warming potential of the product systemwas estimated to be 0.45 $kgCO_2eq$ per FU. The transportation process for the delivery of Brazil nuts contributed significant share of 57% of the total global warming potential. The transportation also contributed to ozone depletion, terrestrial acidification, and fossil depletion. Packaging of nuts used PET bags, aluminum foils and cardboard boxes led to eutrophication, human toxicity, and water depletion impacts. Roasting of nuts shared 59%of total marine eutrophication impacts, due to the oil used in the process. To enhance the robustness of

the findings we also performed sensitivity and uncertainty analysis. The study points out the environmental hotspots in the process chain and provides recommendationsto be adopted for sustainable operation and consumption of Basse Brazil nuts.

Keywords: *LCA Food, Brazil Nuts, Case study*.

Study of Carbon Capture Utilization and Storage Implementation Potential on Ammonia Production in Indonesia using Life Cycle Assessment Approach

Putra, Agus Adi [1]; Zen, Muhammad Rizky [2]; Noviarini, Chairunnisa[2]; Jumas, Rizki Julia[2]; Rismawati, Fauziah[2]; Rahman, Muhammad Miftahur[2]

[1]Chalmers University of Technology. Johanneberg, Gothenburg, Sweden. E-mail: agusa@student.chalmers.se

[2]Ailesh Green Consulting (AGC). Gg. Antasena 2, Kabupaten Sleman, Indonesia. E-mail: zen@ailesh.id.

Abstract

Over the past decades, ammonia has played a significant role as the basic substance in fertilizer and other chemical product manufacturing processes around the world. Evidence suggests that ammonia production is among the largest CO_2 emitters in the chemical industry. Moreover, life cycle assessment provides a useful account of how to assess environmental impact and environmental improvement potential in ammonia production. This study aimed to do the cradle-to-gate life cycle assessment method using openLCA v.2.0software to pinpoint the environmental performance of the process and the analysis of carbon capture utilization and storage (CCUS) implementation potential. The system boundary included raw material extraction, raw material transportation, and ammonia production processes of a 700,000-ton ammonia production facility with a declared unit of1-kg ammonia product. During the study, primary data based on actual industry data and secondary data from Ecoinvent 3.8 database were used to perform LCIA with impact indicators at the mid-point evaluated using the CML-IA, Recipe (H) 2016, Impact 2002+, and AWARE Life Cycle Impact Assessment (LCIA) methods. In addition, the effects of carbon capture potential on the LCIA were defined through sensitivity analysis. LCA results showed that CO_2 removal and electricity generation (power plant) processes are the most significant contributors to environmental impact. The first set of analyses examined environmental impact categories including the global warming potential, abiotic depletion potential (fossilfuels), human toxicity, acidification, carcinogenic, land use change, and water use. The impact of Global Warming Potential involved in producing ammonia decreased by 43% after sensitivity analysis was conducted by varying the CO_2 output parameters at 10% and 70% reduction as the simulation of applying CCUS technology on the plant.

Keywords: *Life cycle assessment; ammonia production; cradle-to-gate; sensitivity analysis; carbon capture utilization and storage;*

Social LCA for textile supply chains

Hildenbrand, Jutta

[1] Research Institutes of Sweden RISE AB. Borås, Sweden. E-mail: jutta.hildenbrand@ri.se

Abstract

Introduction

The Herewear project aims to reduce sustainability impacts of European fashion industry, utilizing biobased, circular and locally produced garments as means to mitigatenegative consequences of trends such as fast fashion. Moreover, textile supply chains are noted for poor working conditions, and the term sweatshop was originally coined todescribe the situation for this sector in 1850. One of the expected outcomes of transferring production to EU countries is an overall improvement of the work environment performance. This is however not based on a broad mapping of supply chain social risks, but rather on events. Another approach to reduce social risks is to actively establish labour standards such as among others free choice of employment, no discrimination, no exploitation of child labour and more, which is pursued by the NGO fair wear foundation (FWF) with more than 100 members and suppliers from different countries, predominantly East Asia and Eastern Europe. FWF uses a scoring system to measure the performance and progress of members and publishes results. Investigating social impacts for different manufacturing locations and for suppliers that have established labour standards vs average is a requirement to understand the effectsof decisions and provide a roadmap.

Methodology or methods

For the assessment of the Herewear approach several objectives are investigated, socialimpacts for supply chains from East Asia and Eastern Europe based on country/sector average. Countries are selected based on supply chains that are used by Herewear project members and FWF members with a similar product portfolio and different score levels (leaders – needs improvement). Data are retrieved from the PSILCA database andcombined with information from the analysis of selected FWF reports (archetypes) and Herewear member/stakeholder data collected in workshops.

Main results and discussion

A systematic social LCA approach relevant for the textile industry where scattered idealistic initiatives and visions for improving sustainability dominate. The analysis and workshops will be performed in the coming three months and results will be added. Expected results include also whether the PSILCA database together with FWF and Herewear data provides sufficient content for relevant supply chains to differentiate between business as usual and improved labour standards.

Conclusion

Will be added as they available from the study.

Keywords: *social LCA, PSILCA, textile supply chain, hybrid study*

Global warming potential of electrochemical hydrogen production based on CSP/PV hybrid power plants

Rosenstiel, Andreas[1,2]; Wirtz-Dürlich, Karolina[1]; Neumann, Nicole Carina[1]; Monnerie, Nathalie[1]; Sattler, Christian[1,2]

[1] Deutsches Zentrum für Luft- und Raumfahrt, Institute of Future Fuels, Linder Höhe, 51147 Köln, Germany. E-Mail: andreas.rosenstiel@dlr.de.

[2] Faculty of Mechanical Engineering, RWTH Aachen University, 52074 Aachen, Germany.

Abstract

Global trade of green hydrogen and its derivatives is seen as an important factor in reducingglobal greenhouse gas emissions by replacing fossil fuels with chemically bound renewableenergy. This could make the enormous potential of solar energy in the Earth's sunbelt avail- able to industrialised countries with high energy needs. CSP/PV hybrid power plants are a promising approach to provide electricity for solar hydrogen production through electro- chemical water splitting. Photovoltaics (PV) can provide electricity at very low cost. Thermalenergy storage (TES), used in concentrated solar power (CSP) plants, offers a cost-effectiveway to store solar energy and thus adapt electricity production to demand. When needed, e.g. during night operation, the thermal energy is taken from the storage and used in a steam cycle to generate electricity. By combining CSP and PV, the full load hours of the electrolyser system can be significantly increased and standby operation can also be se- cured, which can increase the economic efficiency of solar hydrogen production. Based onan energy system model, the advantages of this concept were demonstrated before and the system design was optimised for minimum levelized cost of hydrogen.

However, the production process of the technologies under consideration also leads to greenhouse gas emissions, and careful consideration must be given to how these compare with the emissions of the fossil feedstocks used today. Only if a significant improvement in environmental impact is achieved, especially in terms of global warming potential (GWP), it makes sense to replace fossil fuels with solar hydrogen on a large scale.

To determine the specific GWP and the potential for reducing greenhouse gas emissions, the entire life cycle from “cradle to gate” of the produced solar hydrogen is analysed. In this way, it is possible to find out which processes or components have a major impact on the greenhouse gas emissions. The LCA study was conducted using openLCA software 2.0.2 and the ecoinvent database. In addition to electricity generation through PV and CSP, the elec- trolyser system and water supply are also considered. This study also examines the influ- ence of the solar resource and shows how choosing a good location with increased solar irradiation leads to a lower GWP of the hydrogen produced.

Keywords: solar hydrogen; life cycle assessment; global warming potential; photovoltaics; concentrated solar power; alkaline electrolysis

Life cycle assessment of mid-scale production of beverages distilled from Agave in different regions of Mexico

Camou, César[1]; Bonales-Revuelta, Joel[2]

[1] EarthShift Global LLC. Kittery, Maine, United States. E-mail: cesar@earthshiftglobal.com

[2] EarthShift Global LLC. Kittery, Maine, United States. E-mail: joel@earthshiftglobal.com

Abstract

The purpose of this work is to evaluate the environmental impacts of mid-scale production of distilled beverages from Agave in different regions of Mexico. The contribution of waste management (bagasse combustion and vinasse discharge to the soil), as well as energy efficiency strategies for biomass, were analyzed.

The study was conducted under the conceptual framework of ISO 14040 and the general guidelines of ISO 14044, in addition to an analysis of mass and energy flows, in a cradle-to- gate approach. The functional unit considered was 0.75 l of distilled agave beverage bottled and labeled according to compliance with Mexican official standards for this alcoholic distillate. The impact methodology was ReCiPe midpoint (H) and the model was performed in OpenLCA 2.0 software. Analyses were conducted in six agave processing plants, and descriptive surveys were carried out in cooperation with local farmers. The results show that bioenergy constitutes between 60%-90% of the total energy used in production. The main factor influencing the generation of fine particulate matter (PMFP) is the distillation process, accounting for more than 40%. Stillage contributes approximately 40%-70% to the freshwater eutrophication category (FEP). In terms of global warming potential (GWP), bagasse contributes approximately 15-35%. Although the carbon dioxide produced from biomass is considered biogenic, the overall impact is still considerable due to the presence of other compounds such as methane. In addition, alternative biofuel use scenarios were developed for the distillation and refining stages. From this analysis, it can be deduced that the use of energy from biomass plays an essential role in improving the environmental performance of agave distilled beverage production.

Keywords: Life Cycle Assessment; OpenLCA; Waste Management; Distilled beverages; Agave

Life Cycle Assessment of male and female lines of a dual-purpose chicken breed usingopenLCA

Mehri, Maryam[1]; Pauling, Simone[2]

[1] Faculty of Life Sciences, Rhine-Waal University of Applied Sciences, Marie-Curie-Straße 1, 47533 Kleve, Germany. E-Mail: maryam.mehri@hochschule-rhein-waal.de

[2] Faculty of Life Sciences, Rhine-Waal University of Applied Sciences, Marie-Curie-Straße 1, 47533 Kleve, Germany. E-Mail: simone.pauling@hochschule-rhein-waal.de

Abstract

Following the ban of culling the day-old male chicks of the layer lines since January 2022 in Germany, farmers are considering dual-purpose chicken breed as an alternative. In dual breeds, females are kept for laying eggs and the males are raised for meat production.

In addition to the development of various marketing strategies for increasing consumer acceptance, several diet practices have been adopted as well to improve feed conversion rate and escalate profitability in such breeds. In comparison with conventional broilers andlayers, dual breed chicken performance in feed conversion rate, especially in the cut-ups, islower and the need of natural resources is assumed to be higher. However, the environmental impacts of the complete system including both lines have not been studiedso far. Thus, the current research has been carried out using the data of performance, feed& resources use, and waste products of Lohmann Dual (layer and broiler), Lohmann Brown,and Ross 308 for a cradle-to-farm-gate life cycle assessment in openLCA open source software. Kg Breast Meat (BM) and Egg Mass per starting hen (EM) are considered as the functional unit of broiler and layer line. The objective of this research is to explore the environmental impacts of each production system such as eutrophication, acidification andclimate change under similar housing conditions. The results show that lower performanceboth in dual broiler and in layer leads to higher amount of feed intake, CO2eq and greater environmental impact factors.

Keywords: *OpenLCA*, *Life cycle assessment, Environmental Impacts, Lohmann dual, Lohmann Brown, Ross*

Developing an assessment framework for sustainable extraction and utilization of agricultural residues with spatially resolved LCIA results

Siol, Christoph[1]; Thrän, Daniela[2]

[1] Deutsches Biomasseforschungszentrum gGmbH - DBFZ, Department of Bioenergy Systems, Torgauer Straße 116, 04347 Leipzig, Germany. Christoph.siol@dbfz.de.

[2] Helmholtz Centre for Environmental Research—UFZ, Permoser Straße 15, 04318 Leipzig, Germany.

Daniela.thraen@ufz.de

Abstract

Increasing exploitation of residual biomasses to produce bio-based energy and materials raises the question of limits and trade-offs regarding sustainability. There is a controversial debate on this topic, not least because of vague requirements for farmers and operators to monitor the complex effects on soil health and fertility resulting from an extraction of residual biomasses from agriculture. A previous investigation (Siol et al. 2023) has shown that there is a need for an advanced and comprehensive assessment framework which is capable of addressing complex interactions from a life-cycle sustainability perspective, focussing on assets and drawbacks of different management practices and utilization strategies depending on site-specific conditions. Extraction and utilization of residual biomasses could either be a promising way of decoupling economic activity from resource use and environmental impacts or a lost opportunity to preserve planetary boundaries.

Against this background, the objective of this research is to provide a framework for life-cycle sustainability assessment, based on a set of appropriate indicators and methods, which allows scientists to face the various uncertainties and shortcomings of conventional life-cycle assessments and contributes to the ongoing debate about benefits and trade-offs of sustainable utilization of residual biomasses from agriculture. Therefore, spatially resolved information about soil and weather conditions as well as management practices are combined with soil and agroecosystem models to predict actual and site-specific impacts and benefits of residual biomass extraction from a strong sustainability perspective with regionalized LCIA results.

Keywords: Agricultural residues; Life-Cycle Sustainability Assessment; Soil organic carbon (SOC); Circular bioeconomy; Regionalized LCSA; Sustainable Soil Management

References

Siol, Christoph; Thrän, Daniela; Majer, Stefan (2023): Utilizing residual biomasses from agriculture and forestry: Different approaches to set system boundaries in environmental and economic life-cycle assessments. In: Biomass and Bioenergy 174, S. 106839. DOI: 10.1016/j.biombioe.2023.106839.

Consistency analysis on life cycle impact assessment (LCIA) methods implemented indifferent LCA software

Susie Ruqun WU [1] ; Changliang Shao [2]

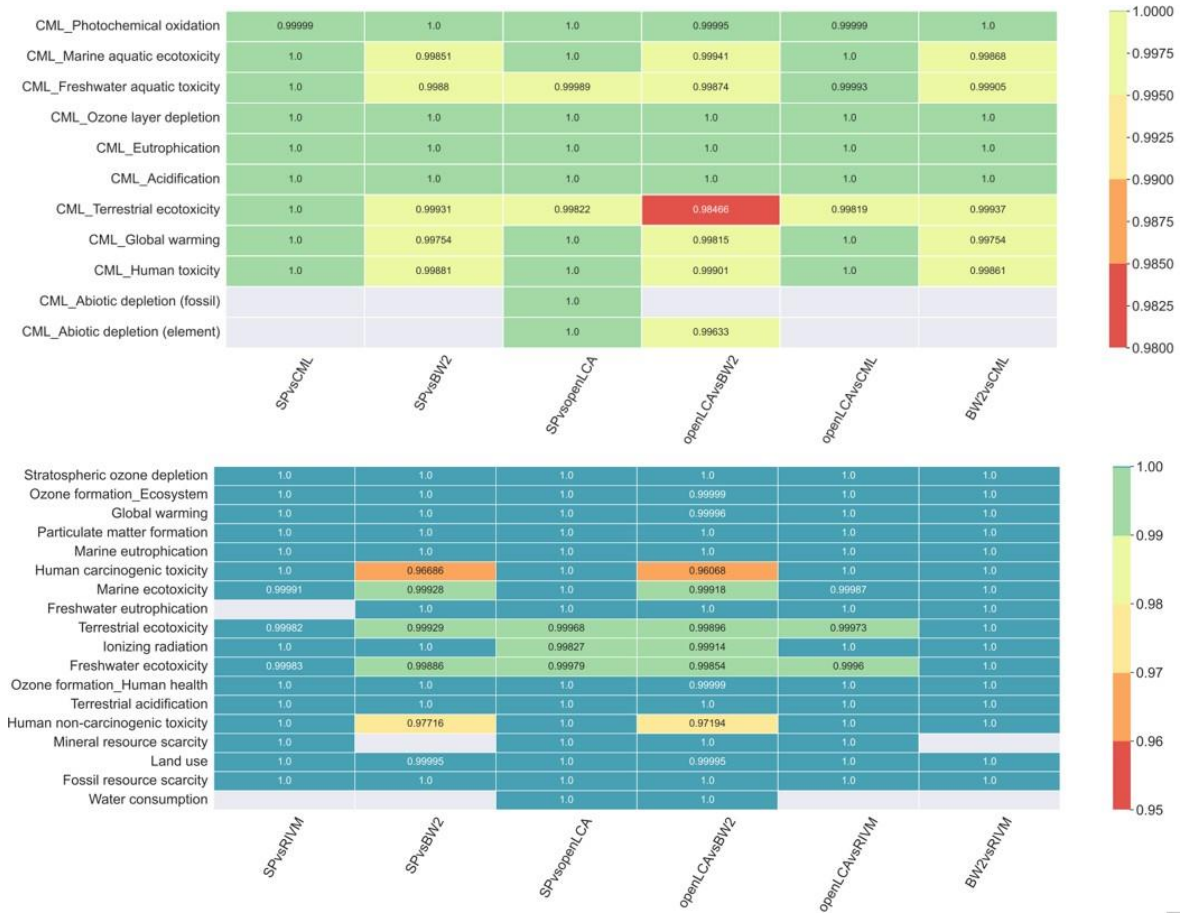
[1] SusDatability Ltd., Shenzhen, China. E-mail: sw@susdatability.com

2 Chinese Academy of Agricultural Sciences, Beijing, China. E-mail: shaochangliang@caas.cn

Abstract

With the growing number of life cycle assessment (LCA) studies published, demands for improving LCA data consistency and interoperability have emerged. The lack of standardized protocols for implementing life cycle impact assessment (LCIA) methods in various LCA software (i.e. software-LCIA method combinations) has been a known issue. Focusing on two widely-used LCIA methods (ReCiPe 2016 and CML-IA baseline), this study aims to compare their implementation in three software tools (SimaPro, openLCA, and Brightway2) in addition to their respective official documentation. Consistency analysis was conducted on elementary flows (EFs) nomenclature, followed by pairwise comparisonof all EFs and their characterization factors (CFs). The results indicate that a lack of consistent EF nomenclature and the absence of a common list of environmental compartments remain crucial issues, which could lead to information loss during data migration. The pairwise comparison indicates that while an overall correlation between each compared LCIA source was relatively high, outliers did emerge, especially for toxicity-ICs. Ecotoxicity-ICs of ReCiPe received the highest inconsistency, where a comparison ratio of over 100 was observed on CFs of the same EF in extreme cases. In addition, LCA practitioners should be aware of the differences in results obtained from different versions of the same LCIA method. Despite these shortcomings, progress toward data harmonization, especially across SimaPro and openLCA, is satisfactory. A complete list of EFs with different CFs assigned from different software-LCIA method combinations is provided to inform LCA software and data developers, even though they still manage dataindependently.

Graphic Abstract



Keywords: Life Cycle Assessment, Life Cycle Impact Assessment, LCA software, Dataconsistency and interoperability

Transferring OpenLCA project to Brightway2, library openlca2bw

Francois Cyrille[1]

[1] Univ Gustave Eiffel, MAST-GPEM, Bouguenais, France. E-mail: cyrille.francois@univ-eiffel.fr

Abstract

Introduction.

OpenLCA and Brightway2 are the two main open-access LCA softwares available today. Onone hand, OpenLCA is seen as a good software for teaching advanced LCA, achieve complete LCA studies, alone or in collaboration, with a nice User Interphase and no need for coding skill. On the other hand, Brightway2 is seen as a more advanced LCA software with faster calculation and numerous additional functions through Python language (Temporal LCA, Prospective LCA …). Openlca2bw python library aims to ease transfer from OpenLCA to Brightway2 in order to facilitate collaboration and open possibility for even more complex model and analysis.

Method.

Brightway2-io (bw2io) offers possibilities to import data related to various formats, Ecospold1, Ecospold2, SimaPro csv or Excel (based on a specific format). But bw2io do not include yet an import process for OpenLCA databases. Openlca2bw library is based on eitherthe IPC connexion or the JSON-LD archive options from OpenLCA. The ongoing version of this package performs the reading, the conversion and the writing of the imported OpenLCAelementary flows, LCIA methods, processes, with parameters, uncertainties and formulas into a Brightway2 project.

Discussion.

Available through Github or with PiP, the last version of openlca2bw now handles the 2.x versions of OpenLCA and Brightway2.5. Nonetheless, work need to be continued to transfer from brightway2 to OpenLCA and also to maintain this library.

Keywords:

Python package; Project transfer; Brightway2; Open-access LCA softwares

Comparative LCA of virgin and recycled materials to assess the sustainability of paved surfaces in agricultural environment

The title must be short, concise and informative.

Enrica Santolini[1], Marco Bovo[1], Alberto Barbaresi[1], Daniele Torreggiani[1], Patrizia Tassinari[1]

[1] Department of Agricultural and Food Sciences, Alma Mater Studiorum Università di Bologna, Bologna, Italy.

E-mail: enrica.santolini2@unibo.it

Abstract

The construction sector is currently characterized by high raw material consumption but also by the production of high volume of wastes that could be valorised promoting the use of recycled aggregates in substitution of raw aggregates. The agricultural context, characterized by specific transports and need to balance performance and integration with the environment, is suited for the use of these materials for paved surfaces since it can promote, in several cases, the adoption of rural circular processes internal to the farm and then a promising application for recycled aggregates is for the realization of rural roads and pavements. However, if on one hand the adoption of recycled aggregates could increase the sustainability of the sector, on the other hand it could increase the environmental loads if the whole process is not properly organized. For instance, the negative effects of transportation operations can cancel the environmental benefits if high distances between the production and the destination sites are present. This work reports the results of the Life Cycle Assessment, from cradle-to-gate, of four different aggregate classes that can be used for the realization of roads, forecourts, and paved areas in agricultural environment. Three materials are recycled aggregates from construction and demolition waste whereas the fourth type refers to gravel aggregates from virgin resources. The Life Cycle Assessment was realized using site-specific primary data from the local territorial context and paying particular attention to transportation-related impacts, land use, avoided landfill and preservation of non-renewable resources. The results of the work clearly show that the environmental impacts in case of use of recycled aggregates are lower than the impacts calculated for the case considering virgin aggregates. In fact, except for the marine eutrophication between the midpoint categories, the recycled materials proved to be more virtuous.

Keywords: LCA, Construction and demolition waste, Agricultural paved surfaces, Recycled aggregates, Sustainability

Ecological risks and opportunities of biological methanation in power-to-methane systems

Elhaus, Nora[1]; Kolb, Sebastian; Müller, Jakob; Karl, Jürgen; Herkendell, Katharina

[1] Friedrich-Alexander-Universität Erlangen-Nürnberg, Chair of Energy Process Engineering, Fürther Straße 244f, 90429 Nürnberg, Germany. E-mail: nora.elhaus@fau.de

Abstract

Biomethane plays a crucial role in achieving European climate goals and replacing natural gas. Biological methanation is one of the technologies offering the possibility to produce biomethane from CO_2 and H_2 and at the same time provide valuable storage and congestion solutions for the electricity grid.

The study examines the ecological risks and opportunities of utilizing CO_2 from anaerobic digestion by means of biological methanation by carrying out a comparative life cycle assessment. A particular focus is placed on analyzing the role of different feedstocks for anaerobic digestion as carbon sources, as the assumed ecological impacts of the CO_2 play a decisive role for the ecological footprint of the produced biomethane. Another focus is on analyzing different options for the provision of electricity to produce hydrogen for the synthesis. Finally, the effects of individual assumptions are analyzed in a sensitivity analysis. Results indicate that the biological methanation with CO_2 from the anaerobic digestion of manure has in total the lowest greenhouse gas emissions, although the attributed emissions are higher than compared to the anaerobic digestion only scenario. However, the biological methanation can achieve a great reduction in emissions when using energy crops. By reducing the amount of feedstock needed for the functional unit, the overall emissions are also reduced. In the base scenario which represents the current state of technology, biogas from maize without an additional methanation step produces 151.8 kg_{CO2eq}/MWh_{CH4}. In combination with biological methanation, biomethane can be produced in the future with CO_{2eq} emissions of 121.4 kg_{CO2eq}/MWh_{CH4}. The main drivers of emissions are the electricity demand for the electrolysis and fugitive methane emissions. Finally, the ecological risks and opportunities of biological methanation are discussed in terms of its role in the future energy system. Aspects such as the displacement of fossil natural gas, current political discussions as the “plate or tank” discussion, scarcity of available biomass and the role in the provision of balancing energy and storage are considered.

The study shows that there is a great ecological potential in biological methanation, especially in the future when more renewable energies have penetrated the German energy system and technological advances in electrolysis and biological methanation have been achieved.

Keywords: *Life Cycle Assessment; Biological Methanation; Power-to-Methane; Power-to-Gas; Biomethane; Methanogenesis*

Streamlining Life Cycle Assessment using OpenLCA for a medium-sized UK-based Manufacturer

Mazzei, Irene[1,2]

[1] Stoane Lighting Ltd, Bilston Glen Industrial Estate, 20 Dryden Road, Loanhead EH20 9LZ.

[2] Edinburgh Napier University, School of Computing, Engineering & The Built Environment, 10 Colinton Road, Edinburgh EH10 5DT

E-mail: irene@mikestoanelighting.com

Abstract

Due to the urgency of the environmental crisis, policymakers are progressively introducingmore regulations on environmental assessment, reporting and validation of green claims made by companies. Small and medium-sized enterprises are disadvantaged because of the fewer resources available to invest in these practices compared to larger organisations, andto challenges related to the highly-paid and highly-specialist LCA knowledge. This contribution illustrates a strategy established to facilitate the application of the LCA methodology for a medium-sized lighting manufacturer, thanks to the partnership betweenthe manufacturer and a UK-based academic institution and the wise of use of taxpayers' money.

The strategy applied consisted first and foremost in the identification of the materials and processes involved in the production of all luminaires in the company, and the subsequent collection of data from in-house operations. Secondly, a collection and processing Excel-based tool was created to elaborate the data relative to a single product for each of its life cycle stages, and produce a streamlined output with simplified information for the specific product. Using openLCA equipped with the Ecoinvent database, a model applicableto luminaires produced by the manufacturer was created, ready to be populated with the tool's output for each specific product. The LCIA method chosen for the model was EN 15804 + A2.

The rules followed during the creation of the data tool and openLCA model were compliantwith the product category rules (PCRs) required by a program operator of choice; therefore,the results obtained are suitable for the use of the LCA study for the generation of EPDs.

This is a process specifically tailored to the manufacturer, which will have control of the data and openLCA model without relying on external consultancy firms. At the same time, as the process was created following PCRs, it is aligned with common rules, ensuring consistency and robustness of the results. Ultimately, this will allow the manufacturer to (i)substantially reduce the time and costs needed to produce LCA results for products, (ii) be able to store LCA results in the format required by the EPD program operator, therefore facilitating their production, (iii) facilitate environmental communication with customers and specification community and (iv) allow for high-impact process identification in internal operations and decision making based on environmental information.

Keywords: *Life Cycle Assessment (LCA), industry, built environment, data collection,openLCA, Small and Medium Enterprise (SME)*

Advancing Circular Economy strategies in urban construction using a combined MFA and LCA approach.

Reynaud, Camille[1]; Horak, Daniel[1];
Gebetsroither, Ernst[1]; Augiseau, Vincent[2];
Hainoun, Ali[1]

[1] Austrian Institute of Technology (AIT). Giefinggasse 4
1210 Vienna, Austria. E-mail: camille.reynaud@ait.ac.at.

[2] CitéSource, 81 mail François Mitterrand

35000 Rennes, France. E-mail: v.augiseau@citesource.fr

Abstract

According to the IPCC, the building sector was responsible for around 21% of global greenhouse gas (GHG) emissions in 2019, with 18% of those attributed to embodied emissions, calling for urgent actions in this sector to meet decarbonization goals and reach net-zero emissions by 2050. The growing share of embodied energy and emissions due to the increase in building efficiency highlights the need for a transition from the current linear "build, use, demolish, dispose" model in the construction sector to a circular approach, entailing promising potentials regarding reduction of primary energy and resource consumption, waste generation, and associated GHG emissions.

This work aims to address a critical research gap regarding the application of life cycle assessment (LCA) in decision-making processes in the construction sector. It provides reliable assessments of environmental benefits associated with circular economy (CE) strategies, particularly the recycling and reuse of construction materials.

The modeling approach developed within the ERA-NET project CREATE is a scenario-based assessment methodology combining a Material Flows Analysis (MFA) with a LCA model. The MFA component quantifies material flows for different construction and demolition scenarios, co-created with local stakeholders including urban developers, construction companies, and city representatives. The LCA performed using OpenLCA, compares the environmental impacts of different end-of-life (EOL) scenarios and different shares of secondary materials in the construction scenarios for the estimated flows obtained with the MFA.

The development of both circular economy and business-as-usual (BAU) scenarios is driven by technical, economic, governance, regulatory, and social factors. The BAU scenario serves as a benchmark for comparing the developed circular scenarios in terms of energy consumption, raw material saving, and CO2 emissions reduction. The assessment focuses on on-site recycling and reuse of building materials and components new construction and renovation works. Besides,

the model also captures the benefits of material reuse and recycling beyond system boundaries, accounting for diverse applications for secondary materials. The technical scope includes processes from transportation, treatment, and disposal of waste for the EOL modeling on the one hand, and raw material extraction, building material manufacturing, and transportation to construction sites for the new construction modeling on the other.

The proposed methodology is being developed and tested within the framework of several case studies established for four cities within CREATE. The first two case studies examined in this work refer to urban redevelopment projects in Rennes Métropole and Vienna.

Keywords: LCA, MFA, Stakeholder engagement, Circular Economy, Scenario development

Life cycle sustainability assessment of hydrogen from solid oxide electrolysis coupled with a concentrated solar power plant

Iribarren, Diego[1]; Campos-Carriedo, Felipe[1,2]; Abelleira, Santiago[1,2]; Martín-Gamboa, Mario[1,2]; Dufour, Javier[1,2]

[1] IMDEA Energy. Av. Ramón de la Sagra 3, 28935 Móstoles, Spain. E-mail: diego.iribarren@imdea.org; felipe.campos@imdea.org; santiago.abelleira@imdea.org; javier.dufour@imdea.org.

[2] Rey Juan Carlos University. St. Tulipán s/n, 28933 Móstoles, Spain. E-mail: mario.mgamboa@urjc.es.

Abstract

In order to effectively contribute to the overall goal of sustainability, hydrogen solutions have to be carefully assessed from a life-cycle perspective within a multi-dimensional framework. To that end, the guidelines for life cycle sustainability assessment (LCSA) of hydrogen-related systems developed within the project SH2E facilitate this task. This work addresses the LCSA of a hydrogen production system following these guidelines.

In particular, the goal of this LCSA study is to evaluate the life-cycle sustainability profile of hydrogen produced through solid oxide electrolysis (SOE) coupled with a concentrated solar power (CSP) plant. This high-temperature electrolysis technology, which is expected to reach maturity by 2030, was selected as representative of a relevant and emerging hydrogen production technology since it may involve efficiency advantages and lower electricity consumption compared to more mature pathways such as alkaline or proton- exchange membrane electrolysis. The SOE section of the system was modeled according tothe expected technical key performance indicators for 2030, while the CSP operating parameters and the integrated performance of the CSP-SOE system were based on the useof process simulation tools. The functional unit of the study was defined as the production,in Spain, of 1 kg of hydrogen with purity ≥ 99.999% (vol), at 700 bar and 40 ºC. A cradle-to-gate approach, reaching hydrogen compression, was followed. Background databases (e.g., premise and PSILCA) were used to complement foreground inventory data. The resultant life-cycle inventories were implemented in specific software tools such as openLCA to estimate a complete set of environmental (e.g., carbon footprint), economic (levelized cost)and social (e.g., health expenditure) indicators.

Although the prospective carbon footprint of the assessed hydrogen option confirms its qualification as a low-carbon alternative, trade-offs were identified not only within the environmental dimension but also with respect to the economic and social dimensions. For instance, a relatively high levelized cost of hydrogen was found, identifying several economic hotspots (electrolyzer cost, CSP plant cost, wages, etc.). Nevertheless, these LCSAresults should be understood as specific to the case study (e.g., regarding the geographicallocation of the CSP-SOE plant). Finally, it is acknowledged that this work was carried out in the context of the project SH2E, which has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking (now Clean Hydrogen Partnership) under Grant Agreement No 101007163. This Joint Undertaking receives support from the European Union's Horizon2020 Research and Innovation program, Hydrogen Europe and Hydrogen Europe Research.

Keywords: *hydrogen; levelized cost; life cycle sustainability assessment; prospective life cycle assessment; social life cycle assessment; solid oxide electrolysis*.

Up-to-date guidelines for life cycle sustainability assessment of hydrogen energy systems

Iribarren, Diego[1]; Martín-Gamboa, Mario[1,2]; Campos-Carriedo, Felipe[1,2]; Dufour, Javier[1,2]

[1] IMDEA Energy. Av. Ramón de la Sagra 3, 28935 Móstoles, Spain. E-mail: diego.iribarren@imdea.org; felipe.campos@imdea.org; javier.dufour@imdea.org.

[2] Rey Juan Carlos University. St. Tulipán s/n, 28933 Móstoles, Spain. E-mail: mario.mgamboa@urjc.es.

Abstract

Hydrogen-related products are expected to play an important role within the current context of transition towards a sustainable energy system. In order to robustly support decision-making processes in this field, up-to-date methodological approaches that allow comprehensively checking the sustainability of hydrogen energy solutions are needed. In particular, this work focuses on the development of the latest guidelines available for life cycle sustainability assessment (LCSA) of hydrogen-related systems within the framework of the SH2E project.

The main outcomes already delivered within SH2E include not only well-defined frameworks for environmental (LCA), economic (LCC) and social (S-LCA) life cycle assessment and benchmarking of hydrogen systems, but also their consistent integration into a sound LCSA framework. Moreover, for the sake of practicality and extended use of the guidelines, open-access software tools and illustrative case studies based on openLCA have been developed. The SH2E-LCSA guidelines deal with key aspects typically addressed in life-cycle studies (functional unit, system boundaries, multifunctionality approach, data quality, indicators, etc.), as well as with underdeveloped topics such as materiality assessment, raw material criticality and prospective assessment and benchmarking of hydrogen systems.

Overall, the delivered SH2E-LCSA guidelines constitute a milestone in the provision of methodological solutions supporting decision-making processes on sustainable hydrogen-related products. They successfully provide a harmonized (i.e., methodologically consistent)multi-dimensional framework for a transparent and up-to-date LCSA of hydrogen systems,as well as for a fair comparison between competing technical solutions. Furthermore, theymay serve as a basis for future standardization. Finally, it is acknowledged that this work was carried out in the context of the project SH2E, which has received funding from the FuelCells and Hydrogen 2 Joint Undertaking (now Clean Hydrogen Partnership) under Grant Agreement No 101007163. This Joint Undertaking receives support from the European Union's Horizon 2020 Research and Innovation program, Hydrogen Europe and Hydrogen Europe Research.

Keywords: *guidelines; hydrogen; life cycle assessment; life cycle costing; life cycle sustainability assessment; social life cycle assessment*.

The role of Open-LCA in supporting the development of sustainable agriculture

Elena Tamisari[1], Daniela Summa[2], Giuseppe Castaldelli[1], Elena Tamburini[1]

[1] Department of Environmental and Prevention Sciences, University of Ferrara, Via L.Borsari, 46 Ferrara,Italy

. E-mail: elena.tamisari@unife.it; ctg@unife.it; tme@unife.it

[2] Department of Chemical, Pharmaceutical and Agrarian Sciences, Via L.Borsari, 46 Ferrara,Italy .

E-mail: daniela.summa@unife.it

Abstract

Introduction

Life cycle thinking has arisen increasingly interest as a key concept for ensuring a valuable transition towards more sustainable agriculture. Nowadays, this sector is among the leadingdrivers of impacts on the environment, contributing to climate change, deforestation, biodiversity loss, water consumption, eutrophication, soil degradation, and release of largeamounts of pollutants that affect ecosystem quality. If nothing changes in the way we produce food, and in light of the need to increase production in the next few decades to feed around ten billion people worldwide, the environmental impacts associated with agriculture systems will become even more severe. Improving the sustainability of agricultural systems is at the heart of any strategy on sustainable development from both environmental and socio-economic perspectives.

Methods

LCA has been extensively used to assess impacts of agricultural productions and compare alternatives *from field to fork*. Notwithstanding the efforts, several methodological aspects of life cycle assessment still need further improvement in order to ensure adequate and robust support for decision making in production, business and policy contexts. The intrinsic characteristics of agriculture requires dedicated modelling approaches, such as addressingissues related to the distinction between technosphere and ecosphere, the choice of mostappropriate functional unit, seasonality, rainfall, temperature and crops yield, that overall account for the high level of complexity of natural agricultural systems and typically have not to be included within LCA scheme of industrial processes. Moreover, data availability, timescale and interpretation of the results are other issues requiring further attention.

The software Open-LCA® v. 2.0 has properly contributed to the calculation of environmentalimpact of agricultural production. Recently, it has been usefully applied to the evaluation of environmental impacts of different cultural systems in the Po valley, Northern-East of Italy,the largest agricultural area of Italy and one of the most productive in Europe. In order to verify the most sustainable option to increase soil fertility, a comparison among the use oforganic digestate and cover crops, as well as different tillage techniques (zero tillage, minimum tillage and plowing), has been carried out using Open-LCA, using Ecoinvent®

and Agribalyse® 6.3, as database. A study area of 3 ha, corresponding to one farm, cultivated with maize, has been monitored for fiveteen months.

Discussion

The results have shown how LCA-based sustainability assessment can be a useful tool for measuring environmental impact, identifying environmental hot-spots, for improvement analysis, and helping in orienting toward a full sustainable perspective.

Keywords: *agriculture, maize production, LCA, soil fertility, environmental hot-spots*

Life Cycle Sustainability Assessment of Industrialized Renovation Solutions

Halstenberg, Friedrich[1]; Avesani, Stefano[2]; Gubert, Martino[2]; Ciroth, Andreas[1]

[1] GreenDelta GmbH. Kaiserdamm 13, 14057 Berlin, Germany. E-mail: halstenberg@greendelta.com.

[2] Eurac Research, Via A. Volta 13/A39100 Bozen/Bolzano, Italy.

Abstract

The building and construction sector account for approximately 40% of total energy consumption in the EU and contribute to 36% of greenhouse gas emissions from energy. While renovation significantly reduces building energy consumption and associated emissions, the current average rate of energy renovation in the EU stands at a mere 1% per annum. The Commission aims to double this rate by 2030, simultaneously enhancing the average gains in energy efficiency. Off-site prefabrication of multifunctional building envelopes has demonstrated technical viability to augment the rate and quality of deep renovation in residential buildings. However, these technologies are still in early stages of application and necessitate thorough analysis and improvement.

This paper presents findings from a Life Cycle Sustainability Assessment (LCSA) study conducted on a residential building renovation project in Tuscany, Italy. The study incorporates an environmental Life Cycle Assessment (LCA), Life Cycle Costing (LCC) analysis, and Social LCA (S-LCA). Three distinct systems were evaluated and compared. System 1 represented the performed renovation utilizing newly developed technologies in the project: an eco-compatible passive green envelope, energy and fresh air distribution, smart windows, building-integrated photovoltaic (BIPV) and solar-thermal (BIST) panels, and a building management system. System 2 involved a building renovated through a traditional retrofitting approach, featuring high energy efficiency and low energy requirements mostly fulfilled by renewable sources. This system considered renovation based on common practices, excluding off-site prefabrication of retrofitting technologies and multifunctional envelopes. System 3 represented a building in its current state with no renovation, serving as a baseline for comparison. Various scenarios were developed to investigate different aspects of renovation.

The study reveals that industrialized renovation is a potent strategy for reducing environmental emissions. The primary driver for lowering emissions is the renovation rate. The substantial contribution of installed PV panels to environmental performance is evident, albeit posing challenges in terms of investment costs. Component re-use mitigates emissions from manufacturing and end-of-life treatment. The utilization of wood-based façade elements has the potential to sequester biogenic carbon emissions. Nevertheless, when evaluated individually, industrialized renovation surpasses traditional renovation in only a few impact categories. The LCSA study facilitates the derivation of appropriate policies to incentivize industrial renovation while emphasizing the potential for continual improvement in industrial renovation technologies throughout their entire lifecycle.

Keywords: *Industrial renovation, industrial retrofit, life cycle sustainability assessment, lifecycle costing, green envelopes*

Calculating GHG emissions of offshore windfarms from a lifecycle perspective: case study

Milerova, Katerina[1]; Garcia Sanchez, Rosa[2]

[1] Ørsted, Nesa Allé 1, 2820 Gentofte, Denmark. E-mail: kamil@orsted.com

[2] Ørsted, Nesa Allé 1, 2820 Gentofte, Denmark. E-mail: rosgs@orsted.com

Case study of an offshore wind farm

The poster is visualizing the use of LCA to assess GHG emissions of offshore wind farms, to highlight emission hotspots, and to present the results from a project-specific case study.

The LCA calculation was made to quantify GHG emissions of one of Orsted's offshore windfarms. The reason for this study is to assess GHG emissions of the wind farm as part of the company's decarbonization program to track the development in GHG emissions of assets and to implement low-carbon options throughout the various lifecycle stages. This calculation also supported our ESG obligation to report on GHG emissions in a project specific manner.

The LCA calculation was performed by using an Orsted internal LCA model that was developed by GreenDelta in collaboration with Orsted. The software used was openLCA, the impact assessment method used was "Environmental Footprint 3.0" and database wasecoinvent 3.8.

Keywords: LCA, offshore wind, asset LCA, case study, UK, decarbonisation

openLCA and OpenSemanticLab

- Autocreate Inventories from Scientific Knowledge Graphs.

Stier, Simon[1]; Carniello, Sara[2]

[1] Fraunhofer ISC. Neunerplatz 2, Würzburg, Germany. E-mail: simon.stier@isc.fraunhofer.de.

[2] JOANNEUM RESEARCH. Waagner-Biro-Strasse 100, Graz, Austria. E-mail: sara.Carniello@joanneum.at.

Abstract

Safety and sustainability by design (SSbD) is nowadays an important aspect in material science. Nevertheless these key aspects are seldom included in early stage development, where critical decisions about the paths to explore are made. This is due also to the disconnection of both the human experts and the data structures in the technical and sustainability domains. To overcome the lack of a common language we have created a linked data schema for an electronic lab notebook which is compatible to the openLCA dataschema.

The platform is based on JSON-LD shaped with JSON-SCHEMAs which are also used to generate a web user interface with the OpenSemanticLab software stack.

The user interface enables any team member to feed data (processes/materials) directly from the lab, requiring only a web browser and no specific know-how neither on JSON-LD nor on openLCA.

The interface to openLCA is based on simple python app that allows to query and select process entities, map them to the target format and downloads the result as openLCA ZIP-Archive. While doing so, existing openLCA definitions like properties, units and existing flows are referenced and not duplicated by using mapping terms or user annotations.

This allows materials researchers to create a knowledge graph of their experimental setupswhich can be converted automatically to openLCA flows and processes. Semi- or fully automated predefined assessments by LCA experts can then evaluate various scenarios andprovide an early and fast feedback to the materials researcher. In this talk we demonstratethis approach for the use case of paper-based electronics and elaborate on the potential ofa strong coupling between materials and sustainability research from an early developmentstage.

Keywords: ontology, linked data, safety and sustainability by design (SSbD)

Using OpenLCA for microalgae production systems

Bradley, Tom[1]; Forbes, Jonathan[2]; Speranza, Lais[3]

[1] Decerna, Decerna House, Cramlington, NE23 7BF, UK. E-mail: tom.bradley@decerna.co.uk.

[1] Decerna, Decerna House, Cramlington, NE23 7BF, UK. E-mail: jonathan.forbes@decerna.co.uk.

GreenCoLab, Universidade do Algarve, Campus de Gambelas, Ed. 2, Gab. 2.1, 8005-139 Faro, Portugal. E-mail: lsperanza@greencolab.com.

Abstract

OpenLCA has been disseminated and used to calculate the environmental impact of various sectors and projects. Over the past five years, Decerna and GreenCoLab have used OpenLCA for a wide range of European, Portuguese and private funded microalgae production projects. Some examples are MAGNIFICENT, REALM, MicroBoost, and AlgaCycle.

In this specific application to the microalgae sector, a large Life Cycle Inventory of related information was built, and the main impact hotspots were identified. During microalgae production, the most significant impacts are from the energy use and nutrients for its cultivation. These two issues can be addressed through a) using renewable energy and b) using recycled nutrients from agriculture, for example. In terms of carbon capture, microalgae can work as an overall carbon sink using the right technologies.

The most recent project, REALM, focuses on creating a linked agriculture/aquaculture/microalgae system. In this configuration, the microalgae are produced at Necton, which recycles nutrients from greenhouses and has a large solar array for energy generation. This accounts for data from previous LCA studies of the sector to make a more sustainable approach to food and microalgae production.

During the OpenLCA application to these models, various advantages and disadvantages of its use were identified. These include the behaviour of the software when undertaking Monte Carlo analysis, the issues of creating feedback loops, and the ability to create parameterized models to allow multiple scenarios analysis. Therefore, the large application of the same methodology and software to a range of projects in the same sector was able to demonstrate the difficulties, the achievements, and how the learnings from modelling in OpenLCA have been taken forward.

Keywords: Type your keywords here, separated by semicolons, provide a maximum of 6 keywords.

Microalgae, agriculture, fertilizers, green chemistry

Automated generation of Life Cycle Assessment models from enterprise data

Tschiltschke, Till[1]; Weiher, Nils[1]; Bassam, Hamza[1]; Riedelsheimer, Theresa[1]; Dr. Lindow, Kai

[1] Fraunhofer Institute for Production Systems and Design Technology (IPK), Berlin, Germany. E-Mail: hamza.bassam@ipk.fraunhofer.de, nils.weiher@ipk.fraunhofer.de, till.tschiltschke@ipk.fraunhofer.de, Theresa.riedelsheimer@ipk.fraunhofer.de, kai.lindow@ipk.fraunhofer.de

Abstract

In the context of Sustainable Development, the assessment of the environmental impact of product systems and processes is a crucial step. While Life Cycle Assessment (LCA) is widely adopted for the evaluation of environmental impacts, the creation process demands significant resources, including knowledge and time. Within the presented research a framework was developed that harnesses existing system and production datawithin enterprises to automatically generate LCA models. The framework enables automated assessment of various product configurations in early design stages. By automating data extraction and analysis, the framework significantly alleviates the workload of LCA practitioners, rendering the assessment process more accessible and efficient. The degree of automation achieved depends on the level of digitalization withinthe enterprise, internal process adaptations to LCA, and database organization efforts.

The approach is applied to the production of hydrogen cells for validation of theframework.

Keywords: Life Cycle Assessment; OpenLCA; Sustainability; Digitalization; Automation

The Crucial Role of HVAC Life Cycle Inventory Templates

Unger, Scott[1]; Feraldi, Rebe[2]; Johnston, Kasey[3]; Bixler, Taler[4]; Hickcox, Kate[5]

[1] Pacific Northwest National Laboratory. 902 Battelle Boulevard, P.O. Box 999, MSIN K7-68, Richland, WA 99352, USA. E-mail: scott.unger@pnnl.gov

[2] Pacific Northwest National Laboratory. 902 Battelle Boulevard, P.O. Box 999, MSIN K7-68, Richland, WA 99352, USA. E-mail: rebe.feraldi@pnnl.gov

[3] Pacific Northwest National Laboratory. 902 Battelle Boulevard, P.O. Box 999, MSIN K7-68, Richland, WA 99352, USA. E-mail: kasey.johnston@pnnl.gov

[4] Pacific Northwest National Laboratory. 902 Battelle Boulevard, P.O. Box 999, MSIN K7-68, Richland, WA 99352, USA. E-mail: taler.bixler@pnnl.gov

[5] Pacific Northwest National Laboratory. 902 Battelle Boulevard, P.O. Box 999, MSIN K7-68, Richland, WA 99352, USA. E-mail: kathryn.hickcox@pnnl.gov

Abstract

As the global emphasis on sustainable practices intensifies, industries are under increasing pressure to address their environmental footprint. Within this context, the HVAC (Heating, Ventilation, and Air Conditioning) industry stands as a key player within buildings, responsible for a substantial share of energy consumption and overall environmental impacts. To navigate the complex landscape of environmental sustainability, there arises an urgent need for comprehensive Life Cycle Inventory (LCI) templates tailored to the unique characteristics of HVAC systems.

The HVAC industry's current lack of standardized LCI templates poses challenges in assessing the true environmental impact of HVAC equipment across its life cycle stages. Without a uniform framework, companies struggle to generate comparable data, hindering industry-wide benchmarking and impeding efforts to identify areas for improvement. Recognizing this gap, our funded project seeks to address this pressingissue by developing functional, transparent, and standardized HVAC LCI templates.

The benefits of such templates are multifold. A standardized LCI template will enhance transparency, providing stakeholders with a clear and consistent methodology for assessing the environmental impacts of HVAC systems. This transparency is crucial not only for meeting regulatory requirements but also for fostering consumer trust and loyaltyin an increasingly eco-conscious market.

The development of an industry-approved template also facilitates comparability among different HVAC products. This comparability is pivotal for establishing industry benchmarks and averages, enabling companies to gauge their performance relative to peers and identify opportunities for efficiency gains. Moreover, it empowers consumers tomake informed choices by considering the environmental impact alongside traditional factors such as cost and

performance.

A functional LCI template will also support compliance with established sustainability standards, such as those set by the American Center for Life Cycle Assessment (ACLCA) and programs like BuyClean. By aligning with these standards, HVAC manufacturers not only demonstrate their commitment to environmental responsibility but also gain a competitive edge in a market where sustainability considerations increasingly influence purchasing decisions. These templates not only streamline the assessment of environmental impacts across the life cycle but also lay the foundation for a more sustainable and transparent industry.

Keywords: *HVAC; Life Cycle Inventory; Standardization; Template; BuyClean; Transparency*

Analysis of the potential contribution of disease-resistant grape varieties to sustainable agriculture: a case study in South Tyrol

Sacco, Pasqualina[1]; Orzes, Guido[2]

[1] Indipendent Researcher and Consultant. Bolzano/Bozen, Italy. E-mail: pqlsacco@gmail.com.

[2] Free University of Bozen-Bolzano. Piazza Università 1, Bolzano/Bozen, Italy. E-mail: guido.orzes@unibz.it.

Abstract

In the context of the SUWIR project, LCA is used to estimate the life-cycle environmentalimpacts of different wines.

SUWIR (Towards sustainable viticulture: a case study on wines from resistant grape varietiesin South Tyrol) is an interdisciplinary research project of the Free University of Bozen- Bolzano aimed at studying the value of wines obtained from disease resistant grapevarieties in the framework of a more 'green' and sustainable viticulture according to the 2030 goal of the EU to reduce pesticide use by 50%.

The main goals and activities of the project is to compare wines from disease-resistant grape varieties grown in South Tyrol (Souvignier gris, Solaris, Bronner, Johanniter, Cabernet eidos, Muscaris and other minor varieties) with conventional wines. The comparison is carried outwith regard to the organoleptic properties of the wine, the environmental impacts of theirproduction and the consumer acceptance.

The functional unit on which to apply the analysis is a liter of wine, ready for bottling. The whole life cycle starts with the field activities and considers the complete winemaking processes in the cellar as well. Where possible, primary data are used, collected by interviewing farmers about their on-field activities, especially in relation to crop protection.

The data of interest are mainly focused on agrochemical treatments in a production season:the type and quantity of agrochemical, the amount of water and the amount of gasoline. Other context information is collected, to make consideration on toxicity issues related to the final product, the waiting time before harvest, the boundaries constrains (e.g., distancefrom organic farms or houses).

With the support of OpenLCA software and some LCI and methods libraries, secondary dataare used to fill data gaps and to estimate impacts. In line with the EU recommendation andthe sector state of the art studies, all the relevant impacts (GHGs emissions, water use, toxicity, etc.) are investigated and the main hot spot in the production system are highlighted. The LCA results, at the end, contribute to rise knowledge about diseaseresistant grape varieties and their potential to be grown in South Tyrol. Well-established and globally recognized analysis methodologies such as LCA are essential to support policychoices as well. In the case of South Tyrol, for example, they can help manage the objectivesof the 2030 Agriculture Plan in a scientifically informed way.

Keywords: sustainable agriculture; disease-resistant grape varieties; informed decisions.

Synergy between LCA and AMC for more science-based informed decisions: a case study in agrifood mountain value chains

Mazzetto, Fabrizio[1] ; Sacco, Pasqualina[2]

[1] Free University of Bozen/Bolzano, P.zza Università 1, Bozen/Bolzano, Italy. E-mail: fabrizio.mazzetto@unibz.it.

[2] Independent researcher & consultant, Bozen/Bolzano, Italy. E-mail: pqlsacco@gmail.com.

Abstract

In the context of the valorisation of marginal mountain areas an emerging theme concernsthe re-introduction of cereal cultivation in areas typically affected by critical due to both their orographic and climatic conditions. This is done through new production models thatprovide: 1) processing of primary production directly at the farm (with a focus on bread and beer); 2) consequent elimination of transport activities between primary and processed products; 3) adoption of new mechanisation solutions to manage the field cultivation phases, which are largely precluded to the conventional machinery currently available on the market. These aspects require an integrated approach to assess the performance of alternative food value chains through life cycle assessment (LCA) and multi-criteria analysis (MCA).

For the agrifood sector, the latter is also useful to deal with policy interactions at different levels. Indeed, many policy-driven decisions could contribute to promote more integrated sustainable approaches through targeted interventions at economic (e.g. income support), social (e.g. working conditions) and environmental (e.g. pesticide reduction) levels.

LCA is one of the most widely used methodologies for estimating impacts as it is able toavoid transferring negative impacts in time and space, effectively neglecting them.

However, information obtained from technical analyses, such as LCA, is not always easy to interpret and use in decision-making contexts.

The MCA enables transparent decision-making processes within complex systems (typical of agrifood), where even very conflicting priorities may prevail among the decision-makersinvolved. Fundamental is the construction of the MCA impact matrix, which represents the "objective" component of the analysis and is the junction with the assessments obtainable from LCA. This enables more science-based decision making processes.

In the case study four alternative supply chains compatible with the prevalently mountainous territory of South Tyrol were considered: rye-bread, barley-beer, cow's milk-cheese, goat's milk-cheese. A comparative LCA was performed (OpenLCA software) on thefunctional unit of a hectare of cultivated land. Data were obtained by field trials, expert estimation and secondary data where needed. The results of this preliminary analysis were used in MCA. The main results show that on farm cereal-bread value chain is an interesting alternative, but very much linked to the climatic risk – e.g. loss of primary production; preferred by decision makers with strong environmental interests and low labor effort. On the contrary, alternatives linked to animal husbandry are less risky, and preferred by decision-makers whit a low-risk investments profile.

Keywords: *agrifood value chains, multi-criteria analysis, decision making processes,mountain agriculture*

Role of Open-LCA in sustainable aquaculture development

Daniela Summa[1], Julie Webb[2], Ben Winterbourn[2], Elena Tamisari[3], Mark Walton[2], James Wilson[4], Giuseppe Castaldelli[3], Lewis Le Vay[2], Elena Tamburini[3]

[1] Department of Chemical, Pharmaceutical and Agrarian Sciences, Via L.Borsari, 46 Ferrara, Italy. daniela.summa@unife.it

[2] School of Ocean Sciences, Bangor University, Menai Bridge, United Kingdom. j.webb@bangor.ac.uk; l.levay@bangor.ac.uk; b.winterbourn@bangor.ac.uk; m.walton@bangor.ac.uk

[3] Department of Environmental and Prevention Sciences, University of Ferrara, Via L.Borsari, 46 Ferrara, Italy. elena.tamisari@unife.it; ctg@unife.it; tme@unife.it

[4] Deepdock Ltd, Bangor, UK. jamesmussels@gmail.com

Abstract

Aquaculture production has doubled every decade for the past fifty years, representing the fastest growing food sector. This increase reflects the expansion of production areas, increased know-how in husbandry and advances in production technologies. As an alternative food source to wild fisheries, aquaculture shows a great potential to help meet the growing demand for seafood and animal protein. A clear distinction must be done between the two principal aquaculture systems. Intensive fish farming (i.e. salmon, sea bass, tilapia) implies higher animal productivity. To intensify the culture, production factors, such as feed, additives and drugs, are widely used, producing an over-exploitation of natural resources and hence raising concern on environmental distress, on environment as well as potential risks for human health. On the other hand, extensive aquaculture usually refers to fish and mollusks farming (i.e., clam, mussel, oyster) conducted in medium- to large-sized ponds or water bodies, and relies merely on the natural productivity of the water which is only slightly or moderately enhanced. Externally supplied inputs are avoided and the quantity of fish produced per unit area is lower.

LCA has become the leading tool for identifying key environmental impacts of seafood production systems. A LCA evaluates the sustainability of diverse aquaculture systems quantitatively from a *cradle-to-grave* perspective. It provides a scientific basis for analysing system improvement and the development of certification and eco-labelling criteria. Current efforts focus on integrating local ecological and socio-economic impacts into the LCA framework. A LCA can play an important role in informing decision makers in order to achieve more sustainable seafood production and consumption. Although large progress have been made in reaching standardized tools for LCA in aquaculture, their use in policy formulation and decision making requires more efforts to develop adequate methods in aquaculture. The limited resources and standard processes currently included in Ecoinvent v.3.8 related to aquaculture productions, make often difficult to apply such a tool to the environmental sustainability performance of different production systems, especially in the field of extensive aquaculture, further away from industrial systems, such as intensive fish farming.

The software Open-LCA has been suitably used to evaluate the environmental impact of mollusks farming in the Po river delta (Northern Adriatic sea), the most productivearea for clam farming in Europe and in the Menai Strait (Northern Wales), where mussel farming is particularly developed. Moreover italian oyster culture and welsh benthic musselfarming has been assessed.

LCA results can be also integrated with carbon storage capacity of bivalves mollusks,in order to obtain an overall environmental sustainability assessment.

Keywords: *aquaculture, mollusks farming, carbon storage*

Life cycle assessment for a small onshore 600W wind turbine

Nassef, Ghaidaa[1]

[1] Environmental Engineering Program, Zewail City of Science and Technology, Plot 12578, Ahmed Zewail Road, October Gardens, 6th of October City, Giza 12573, Egypt.

E-mail: s-ghaidaa.abdelkader@zewailcity.edu.eg

Abstract

Fossil fuels contribute to nearly 80% of the global electricity supply, with their combustion releasing greenhouse gasses contributing significantly to global warming. Comparably, wind energy produces no direct harmful emissions while operating to produce electricity. However, the production of wind turbines can have an environmental impact. This study focuses on performing a Life Cycle Assessment (LCA) for a single 600W onshore wind turbine in Egypt to evaluate its potential environmental impact over a 20-year lifespan. The future mass production of the wind turbine is targeted for farms, agricultural lands, eco-friendly villas, hotels in the tourism sector, and signal towers in Egypt. The production of the wind turbines takes place locally in Egypt. The assessment aims to identify the primary sources of emissions for the unit production of 600W wind turbine from cradle to grave, focusing on its main components and stages. The potential impact of the wind turbine was assessed by using openLCA software and ecoinvent-3.7.1 databases. LCA by components covered the turbine tower, hub, nacelle, and blades, which were chosen to be representative of the entire wind turbine. The nacelle part includes the generator, yaw system, control electronics and cables. The life cycle stages included the manufacturing process, wind turbine set-up, operation and maintenance, and end-of-life. The materials utilized in the investigation for the small wind turbine with a unit weight of 19 kg consist of steel (80%), aluminum (10%), and glass fiber (10%). The impact categories for each component and stage were climate change long-term, human carcinogenic toxicity, human non-carcinogenic toxicity, terrestrial ecotoxicity, water consumption, land use and freshwater ecotoxicity. The results of the conducted LCA showed that the nacelle is the most contributing component to the environmental impact categories accounting for more than 60% of the total components emissions due to the many subcomponents and materials as steel included in the nacelle. Following the nacelle, the steel tower, the blades and the hub. Furthermore, the manufacturing phase is the dominant stage at all the potential environmental impact categories. A share of over 90% of the emissions were caused by the manufacturing stage resulting in 77.5 kgCO2eq for the single 600W wind turbine. The contributions of the operation and maintenance and installation stages were deemed negligible. The amount of CO2 emitted per kWh is estimated to be 6.1 gCO2/kWh. The study highlighted the need for further investigations to mitigate the environmental impact of the manufacturing phase, potentially through the use of more environmentally friendly materials. It emphasized that greener manufacturing and material choices could significantly reduce the environmental impact of wind turbines, particularly during the manufacturing and end-of-life phases. This underscores the importance of sustainable practices and materials in wind turbine production to minimize environmental impact and promote the adoption of cleaner energy sources.

Keywords: *Small wind turbines; Life Cycle Assessment; Sustainability; Clean energy*

Environmental Assessment of Interior Components in Vehicle through openLCA

Cho, Hee-Sun[1]; Yang, Yoonmo[2]; Park, Young-Choong[3]

[1] Korea Electronics Technology Institute / VR·AR Center, Seoul, Korea. elegsun@keti.re.kr.
[2]Korea Electronics Technology Institute / VR·AR Center, Seoul, Korea. yym064@keti.re.kr
[3] Korea Electronics Technology Institute / VR·AR Center, Seoul, Korea. ycpark@keti.re.kr.

Abstract

The “E” in ESG has become imperative issue in recent years and Life Cycle Assessment (LCA)is considered as a tool for environmental impact analysis in terms of materials and processes for sustainable product development. This study is to calculate the environmentalimpact of Bezel Assembly as a part of interior component in vehicle and to suggest improvement considerations of Bezel Assembly throughout its entire life cycle. The database used for LCA is Ecoinvent 3.9.1, and the software used is openLCA v2.0 that allowsthe quantification of impact derived from inputs and outputs. The impact of raw materials acquisition stage is higher than both manufacturing and distribution stage, the contributionis above 98% in all impact categories. A significant impact regarding global warming comesfrom the electricity consumption of the manufacturing and transportation by truck, as wellas raw materials acquisition. However, the characterization of impact is mostly insignificantin both manufacturing and distribution stage. The relative characteristics impact of bio- composite materials is lower than base materials and it implies that environmentally friendly substitute materials are in the considered to correspond to ESG issue in the near future.

Keywords: ESG, Environmental Assessment, LCA, Sustainable Product Development,Vehicle

Acknowledgments

This paper is supported by Korea Evaluation Institute of Industrial Technology (KEIT) fundedby the Korea government (MOTIE). [Project No: 200236484 / Name: Development of ESG Management Consulting Support Services for SMEs].

Life Cycle Assessment of Kerosene from HEFA Process

Silva Ortiz, Pablo[1]; Li, Chenghui[2]; Jocher, Agnes[3]

[1] Technical University of Munich (TUM), School of Engineering and Design, Boltzmannstr. 15, 85748 Garching, Germany. E-mail: pablo.silva@tum.de

[2] Technical University of Munich (TUM), School of Engineering and Design, Boltzmannstr. 15, 85748 Garching, Germany. E-mail: chenghui.li@tum.de

[3] Technical University of Munich (TUM), School of Engineering and Design, Boltzmannstr. 15, 85748 Garching, Germany. E-mail: agnes.jocher@tum.de

Abstract

In the past decade, significant efforts have been dedicated in the aviation sector to reducing greenhouse gas (GHG) emissions and the transition towards an environmentally sustainable approach. To pave the way for further emission reductions in Germany's aviation industry,a life cycle assessment (LCA) model has been developed for evaluating the emissions of a promising sustainable aviation fuel (SAF) pathway and its potential for implementation. Thiswork focuses on the Hydrogenated Esters and Fatty Acids (HEFA) process and outlines threepractical scenarios for SAF production in Germany. SAF holds undeniable significance withinthe aviation sector with the HEFA process currently playing a vital role in its production. Aligned with the European Union's SAF quota, targeting a blending ratio of 63% by 2050, the environmental impact of the ReFuelEU proposal has been investigated. Hence, it is imperative to recognize that achieving complete emission neutrality through this technology alone is a complex task, primarily due to the cultivation of oil crops. Therefore, to attain sustainability criteria, other complementary technologies, such as Alcohol-to-Jet (AtJ), Biomass-to-Liquids (BtL), and Gas-to-Liquids (GtL) could be integrated with HEFA, thusenabling the aviation industry to further reduce its fossil fuel dependency and chart a path towards a more sustainable future. Key findings include: i). Assessment of GHG emissions throughout the cradle-to-gate life cycle of SAF produced using the HEFA process, ii).Estimation of fuel production costs, iii). Analysis of emission reduction rates with varying blending ratios, and vi). Exploration of future emission reduction potential.

Keywords: *Sustainable Aviation Fuel, Life Cycle Assessment, Hydrogenated Esters and FattyAcids*.

Life Cycle Assessment of Tap Water of Annaba City - Algeria

Belhani, Mehdi[1]; Boutaghane, Hamouda[2]

[1] National Higher School of Technology and Engineering, Department of Mining Metallurgy and Materials, L3M, 23005, Annaba, Algeria. E-mail: m.belhani@ensti-annaba.dz.

[2] Laboratory of soils and hydraulic, Badji Mokhtar Annaba University, PoBox 12. Annaba, 23000, Algeria. E-mail: hamouda.boutaghane@univ-annaba.dz.

Abstract

The Life Cycle Assessment (LCA) was carried on the urban water system of Annaba, on the east coast of Algeria. The system includes the sources of water, which are two dams and several boreholes, the treatment process in two stations, and the supply to 700,000 inhabitants. The tap water in Annaba was affected by limited rainfall and deterioration of infrastructure network, resulting in leakages. Consequently, the population turned toutilizing household tank-pump setups for water storage and predominantly relied onbottled and spring water for their drinking needs.

The aim was to evaluate the Global Warming Potential (GWP) and resource depletion impacts of the tap water in the current conditions (82,5 L/person day) and in the optimal conditions (150 L/person day) after network rehabilitation. It was assumed that the HDPE substitute 20% of the deteriorated distribution network. The environmental impacts of theInhabitant Equivalent were analyzed in relation of the tap water system constraints and theconsumer behaviors. This work was conducted using OpenLCA software and the ecoinventv3.5 databases in the attributional form. The data of the urban water system were obtainedfrom the National Water Agency and Water stations, whereas the consumption pattern of the Inhabitant Equivalent was performed through survey analysis. The Recipe (H) midpoint method were used for the potential impacts evaluation.

The results showed that the tap water use phase consumed 0.143 kg Oil-eq/m^3 of fossil resources, 0.4 g Fe-eq/m^3 of metals and generated 0.346 kg CO_2-eq/m^3 in the current condition. The supply energy and household pumps contributed 33% and 16% respectivelyto the GWP. The bottled water accounted for 9% of the Equivalent Inhabitant GWP, while the mobility required to collect spring water was responsible for 41% on the GWP. In the optimal condition, the Inhabitant Equivalent consumed 18.12 g Oil-eq of fossil resources and generated 43.75 g CO_2-eq. The rehabilitation reduced the GWP impacts of the tap waterlife cycle by 27% but introduced 9% to the infrastructure impacts. This operation reduced the GWP impacts of the Inhabitant Equivalent life cycle by 13%, but increased infrastructureimpacts by 15%. The environmental impacts of the urban water system were affected by the geological and aquatic conditions of the dams, as well as the leakage in the supply network. The quality management of the tap water and the decrease in reliance on spring water would be mitigated the environmental burdens of the inhabitant equivalent.

Keywords: *Algeria, Drinking water, Energy mix, LCA, Water resources*.

Hotspot Analysis of Keratin Production from Chicken Feather Waste

Vanderlei, Rafael Marques[1,2,3]; Mattoso, Luiz H. Capparelli[2]; Moreira, Francys K. Vieira[3]

[1] Federal University of Sao Carlos, Graduate Program in Materials Science and Engineering, São Carlos, SP, Brazil. E-mail: rafaelmarquesvanderlei@gmail.com

[2] Federal University of Sao Carlos, Department of Materials Engineering, São Carlos, SP, Brazil

[3] Embrapa Instrumentation, National Nanotechnology Laboratory for Agribusiness, São Carlos, SP, Brazil

In recent years, the surge in poultry meat production has led to a significant increase in by-products, particularly chicken feathers. This by-product poses a substantial risk to the environment and human health due to potential pathogen contamination. Over the past few decades, researchers have explored various applications for this waste, including scaffolds, fibers, and films. The key to valorizing this waste lies in the extraction of its primary component — keratin. However, traditional keratin extraction methods involve the use of toxic and/or expensive reagents, often coupled with dialysis for purification. Unfortunately, dialysis is time-consuming and largely limited to laboratory-scale operations. In this scenario, a cradle-to-gate life cycle assessment (LCA) was conducted with the objective of identifying the main environmental hotspots in lab-scale keratin production when replacing conventional dialysis with a scalable precipitation technique. The functional unit for evaluation was set at 1 ton of keratin, equivalent to the daily production of a small slaughterhouse. The product system initiated with the production of chicken feather waste by the poultry industry. Subsequent processes included sanitization, drying, and grinding. The cleaned feathers underwent extraction through a greener route (sulfitolysis). Keratin was precipitated by hydrochloric acid (HCl), citric acid, sodium chloride (NaCl), or acetone, followed by centrifugation and lyophilization. The impact categories were evaluated using ReCiPe 2016 Midpoint (H) method, implemented in OpenLCA v1.10.3 software, while the secondary life cycle inventory data were selected from the Ecoinvent database v3.7. The environmental hotspots were very consistent for the HCl, citric acid, and NaCl precipitations. These methods presented poultry farming and electricity as the primary environmental bottlenecks, contributing to an average of 35 - 38% to the environmental impacts, followed by urea (14%) and ethanol (8%) inputs. The precipitating agents had a minor influence on the environmental footprints (less than 5%), but acetone stood out, contributing with 46% to the environmental impacts of keratin production due to its large- volume usage. Therefore, this LCA case study highlighted that the environmental impact associated with keratin production is closely tied to poultry farming and the intensive use of energy. Among the precipitating agents, only acetone displayed poor environmental performance, indicating the need for new strategies to mitigate the environmental impact of keratin production, such as organic solvent upcycling.

Keywords: Biomass waste; chicken feather; hotspots; keratin; protein precipitation.

Overview on new and upcoming ISO documents related to LCA modelling

Wimmerova, Lenka[1]

[1]Czech University of Life Sciences Prague, Faculty of Environmental Sciences, Kamycka 129, CZ-165 00 Prague, Czechia. E-mail: wimmerova@fzp.czu.cz

Abstract

The objective of the proposed presentation is to give a general overview on the current development of a methodological support of the life cycle assessment (LCA) given by new or updated ISO standards and technical guidelines.

The methodological support for the LCA tool is very important regarding the current demand placed on it broaden applications, partially resulting from the recent changes in legacy obligations (e.g., an eco-modulation principle or non-financial reporting), as well as a fragmentation of current methodologies, especially in the case of footprints, such as carbon and water. The attention will be also paid to documents related to verification and validation and verification of environmental statements.

The presentation will focus mainly on the following documents: ISO 14017 (verification and validation of water statements), ISO 14066 (competence requirements for teams validatingand verifying environmental information), ISO/FDIS 14075 (framework of social life cycle assessment), and ISO/WD TS 14076 (eco-technoeconomic analyses). Partially will be also mentioned ISO 14071 (critical review processes and reviewer competencies), ISO 14072 (organizational life cycle assessment), ISO/TS 14074 (normalization, weighting, and interpretation), ISO/DIS 59014 (secondary materials), and related to greenhouse gases reporting and carbon neutrality, water footprint, as well as for addressing environmental aspects within an environmental topic area (i.e., water, climate, resources, and waste).

Keywords: *standard, guideline, environmental, social, techno-economic, footprints*

The Role of *n*-Generation Carbon Sources on Environmental Footprints of Biodegradable Polyesters Produced by Fermentation

Dela Corte, Guilherme Castro[1, *] and Moreira, Francys Kley Vieira[1, #]

[1] Multifunctional Packaging Group (GEF[m]), Department of Materials Engineering (DEMa), Federal University of São Carlos (UFSCar). Rod. Washington Luís, km 235, 13565-905, São Carlos (SP), Brazil.

E-mails: *guilhermedelacorte@gmail.com, #francys@ufscar.br

Abstract

Many industries seek alternative materials that could replace non-biodegradable plastic, while increasing overall quality, safety and cost effectiveness, which raises discussions regarding the environmental sustainability of current production models. Possible solutionsto this issue already lie in biodegradable plastics such as polyhydroxyalkanoates (PHAs,) especially poly(3-hydroxybutyrate-co-3-hydroxyvalerate) (PHBV). These promising natural- occurring biodegradable polymers obtained from renewable resources through low eco- impact chemical processes, such as bacterial fermentation, however, are still absent from open data life cycle inventories (LCIs), and so this case study aims to bridge the gap in literature concerning first, second, third and fourth generation carbon sources - respectively sugarcane sucrose, used vegetable oil, wastewater and waste biogas - as biomass input forPHBV synthesis, as well as explore its different possible polymer recovery and solvent recovery techniques. An ultimate LCI considering several input uncertainties was built by gathering data currently available in the literature, with product systems modelled with openLCA v2.0 bounding carbon source generation, fermentation, and PHBV recovery processes. All background data were selected from the Ecoinvent database, version 3.2 andthe LCIA stage was implemented using the ILCD 2011 midpoint+ method (International Reference Life Cycle Data System) targeting environmental footprints within planetary boundaries' framework, namely climate change, land use, ozone depletion, freshwater use,ocean acidification, ecotoxicity and aerosol pollution, with functional unit set to 1 ton of PHBV. Results indicated that the impacts tend to be larger for PHBV derived from 4th gen carbon sources, noticing that 2nd and 3rd gen impacts were almost identical. Overall, the useof heavier solvents tends to promote higher environmental impacts, except for the greenhouse gases indicator, where sugarcane production to extract ethanol is deemed a carbon sinkhole. We underscore the need for further research and data reporting to enhance accuracy and reliability of LCA towards sustainable biodegradable plastic production.

Keywords: *Food Packaging; Biopolymer; Ecological Footprint.*

Carbon footprint of solvent-based and innovative UV-based coatings

Gransinigh Sara[1]; Cantino Giorgio[1], Demicheli Fabio[2], Chiogna Guido[2]

[1] University of Eastern Piedmont, Department for Sustainable Development and Ecological Transition, piazza S. Eusebio, 5, Vercelli, Italy. E-mail: giorgio.cantino@uniupo.it (corresponding author)

[2] Metlac s.p.a. – SS 35 Bis dei Giovi 53, Bosco Marengo, Italy. E-mail: Guido_Chiogna@metlac.com

Abstract

Introduction

Nowadays, the growing of businesses must go hand by hand with the reduction of related environmental impacts. In fact, a decoupling is essential to address the current climate crisis. To this, Companies are assessing the impacts of their production activities to developstrategic plans towards better environmental performances.

METLAC Group is a leading Company in the sector of metal packaging coating for food and beverages. It aims at developing innovative formulations that reduce the use of rawmaterials from fossil sources. In 2022, METLAC started a project with University of EasternPiedmont to support R&D area towards sustainability-driven decisions.

Methodology

Two Carbon Footprint (CFP) studies were conducted on variants of transparent coatings forcrown caps. The traditional formulation is solvent-based, while the innovative one is a prototype solid, UV-based, and compliant to ESP Regulation by EUPIA. Studies were compliant with ISO 14067 and "PCR-2021-0005 for Paints, Varnishes and Coatings".

Considered system boundaries were both from-cradle-to-gate with a functional unit of 1 kgof varnish. Included process units were subdivided into "upstream processes", when related to supply-chains, and "core" if performed at METLAC's. There were excluded the contributions of equipment and buildings' construction, any by-products, and waste- treatment processes. It was applied a weight-based cut-off for the raw materials constituents and products with a contribution <0.1%.

Calculation models were built with openLCA v1.11 and ecoinvent database v3.8 - EN 15804add-on. According to ISO, impacts were assessed using the LCIA Methodology "IPCC 2013 GWP 100".

Results and discussion

Results of the traditional coating shown highest emissions of fossil GHGs. The majority of total contributions are related to production processes of raw materials. The separate assessment of core processes also shown highest fossil GHGs emissions, followed bybiogenic ones. Related major contributions are linked to the production of thermal and electric energy, according to the secondary datasets taken as reference.

Impacts of the UV-based coating were lower than the ones of traditional formulation. Theywere directly linked to the efforts made by METLAC towards eco-design. However, they were affected

as well by the quality of data from suppliers.

Conclusion

Generally, LCIA results were useful to identify hotspots related to the formulation of the innovative UV-based varnish, helping METLAC in the product-design phase. Results of core processes could be positively affected by improving the quality of primary data (e.g., using meters). Moreover, METLAC is strengthening the quality of data from suppliers by providingthem with a structured procedure.

Keywords: *Coatings; Industry; eco-design*.

OpenLCA Integrated tool to Environment for modelling, Simulation and Optimization

Miyoshi, Simone[1]; Secchi, Argimiro[1]

[1] Chemical Engineering Program - COPPE, Universidade Federal do Rio de Janeiro, Mailbox 68502, CEP 21941-972, Rio de Janeiro, RJ, Brazil. E-mail: smiyoshi@peq.coppe.ufrj.br.

[2] Chemical Engineering Program - COPPE, Universidade Federal do Rio de Janeiro, Mailbox 68502, CEP 21941-972, Rio de Janeiro, RJ, Brazil. E-mail: arge@peq.coppe.ufrj.br.

Abstract

In nowadays society, the monitoring, control and design of industrial processes within the sustainability principles are fundamental. The use of renewable inputs is not enough to justify that a process is green, but also it is necessary to quantify the emissions by a Life Cycle Assessment (LCA). LCA quantifies the environmental impact of mass and energy flowsduring the product life cycle. Although there are several softwares for LCA, these available LCA suites do not have integration with process simulation, control and optimizationenvironments. In this work, it is proposed a platform for integration LCA tools with the Environment of Modeling, Simulation and Process Optimization (EMSO). EMSO has fast simulation time when compared to commercial simulators, which is suited for real-time applications. It also has interfaces with the Python, Matlab and Scilab environments. The proposed platform, named EMSO_OLCA, enables the online assessment of emissions basedon industrial production data; optimal process design based on environmental metrics; environmental techno-economic assessment of industrial processes; optimization and control of process based on environmental metrics. The EMSO_OLCA was developed in C++and follows the ISO14040 Life Cycle Assessment Principles. It integrates EMSO with OpenLCA LCIA databases and with OpenLCA assessment methodologies. The available impact assessment methodologies are: IPCC 2013 methodology, which assesses the Global Warming Potential over a 100-year horizon, CML 2001, ReCiPe 2016 and also other 98 methodologies, totaling 1479 impact categories. All types of elementary flows, including the emissions, waste and use of natural resources, are inputs in EMSO, then the amount ofthese inputs is calculated by the process simulator. EMSO communicates with EMSO_OLCA that processes the LCA and communicates with the OpenLCA elementary flows impacts database and gets the OpenLCA impact assessed from the inputs. The main advantage of EMSO_OLCA is that the tool fully integrates with the EMSO environment and allows all functionalities such as simulation, design, optimization, sensitivity analysis and parameter estimation. Tests performed to calculate the LCA of an industrial sugarcane ethanol plant, from the EcoInvent 3.8 library, showed that the tool reproduces the values calculated by OpenLCA with an average percentage error of 0.0453% and an elapsed time of 0.296 seconds, with is ideal for real-time applications.

Keywords: *LCA, EMSO-OLCA, EMSO Simulator*

openLCA in SH2E: A dedicated tool for Life Cycle Sustainability Assessment of Hydrogen Systems

Andreas Ciroth[1*], Michael Srocka[1], François Le Rall[1]

[1] GreenDelta GmbH, Berlin

*E-mail: ciroth@greendelta.com

Abstract

The SH2E project develops methodology and guidelines for Life Cycle Sustainability (LCSA) specifically suited for hydrogen systems, i.e. technical systems producing or using hydrogen. openLCA is extended and revised in the project to reflect the guidelines, and user guidancein the software is added. This allows users to apply the guidelines in a user friendly, powerful, and free and open source software. Guidance in the software aims to reduce thenecessary expert level of users, so that the tool can be used more broadly, also by non-LCSAexperts.

The presentation gives three examples for the extensions and adaptations of openLCA: social indicators, time in the inventory, and wizards. We explain the implementation and practical use with help of a case. Further, we will explain the handling of the release of thesoftware as a new branch for the openLCA code, and discuss how some parts of the new development become integrated into the main branch of openLCA. We will conclude with a consideration of the future development of this new SH2E hydrogen tool.

Keywords: SH2E, hydrogen, LCSA, openLCA, dedicated tool

Defining Comprehensive Guidelines for Lifecycle Sustainability Assessment of Fuel CellHydrogen Systems: Environmental and Social Dimensions

Hamed, Ashrakat[1*], Ciroth, Andreas[1];

[1] GreenDelta GmbH. 14057 Berlin, *ashrakat@greendelta.com

Abstract

Hydrogen is poised to play a pivotal role as a sustainable global energy carrier. However, alongside technological advancements, there is an imperative for methodological frameworks that rigorously assess the suitability of Fuel Cell Hydrogen (FCH) systems from a life-cycle perspective, providing decision-makers with empirically grounded insights.

These contributions necessitate adherence to well-defined guidelines to ensure a robust and replicable assessment and benchmarking of FCH systems. Consequently, there is a pressing need for comprehensive guidelines in the Life Cycle Sustainability Assessment (LCSA) of FCH systems.

Initiated in 2020, the SH2E EU-funded Project is actively developing guidelines that encompass the environmental (LCA), economic (LCC), and social (SLCA) dimensions of life cycle assessment and benchmarking for FCH systems.

Regarding the environmental guidelines, practitioners are provided systematic guidance on navigating all methodological aspects of an LCA, encompassing the functional unit, system boundaries, and advanced topics specific to FCH systems, such as capital goods considerations, end-of-life considerations, biogenic carbon emissions, carbon sequestration, and material criticality. In terms of SLCA, practitioners are directed on handling methodological aspects (functional unit, system boundaries, cut-off, and more) and specific FCH system-related topics (such as, supply chain segmentation or data sources). The application of these guidelines through real-life case-studies relating to hydrogen production and use led to a revision and refinement of the recommendations given in these guidelines.

This presentation will summarise key methodological aspects contained in the guidelines for environmental and social LCA in SH2E, and address the latest advancements and developments in the social and environmental guidelines in SH2E, tailored for stakeholders and LCA practitioners in the dynamic and crucial field of hydrogen systems.

Keywords: Life Cycle Sustainability Assessment, Environmental Lifecycle Assessment, Guidelines, Social Lifecycle Assessment, Hydrogen Systems

Optimizing Lifecycle Inventory Databases through AI-Enabled Semantic Analysis and Data Integration Techniques

The title must be short, concise and informative.

Chang, Huimin[1]; Li, Nan[2]; Qi, Jianchuan[3]; Guo, Jing[4]; Xu, Ming[5];

[1] School of Environment, Tsinghua University, Beijing 100084, China. E-mail: huiminchang@tsinghua.edu.cn
[2]School of Environment, Tsinghua University. Beijing 100084, China. E-mail: li-nan@tsinghua.edu.cn
[3]School of Environment, Tsinghua University. Beijing 100084, China. E-mail: jcqi@tsinghua.edu.cn

[4]School of Environment, Tsinghua University. Beijing 100084, China. E-mail: guo_jing@tsinghua.edu.cn

[5] School of Environment, Tsinghua University. Beijing 100084, China. E-mail: xu-ming@tsinghua.edu.cn

Abstract

Developing comprehensive Lifecycle Inventory (LCI) databases is crucial for effective carbon and environmental footprint management. This study aims to revolutionize LCI database creation using artificial intelligence (AI), addressing the need for high-quality, transparent, and globally applicable unit process data.

The methodology employs AI for the automation of unit process data aggregation, crucial for Lifecycle Assessment (LCA). Key to this approach is the integration of Large Language Models (LLMs) to build sophisticated flow and process recommenders. These LLMs enable semantic full-information retrieval across vast datasets, ensuring efficient data extraction and organization. They also support cross-language search capabilities, crucial for international data applicability. Additionally, the methodology involves developing AI tools for transforming tabular data into the International Reference Life Cycle Data System (ILCD) structure, ensuring standardized data presentation and ease of integration into existing LCA frameworks.

The application of AI and LLMs significantly enhances the efficiency and accuracy of LCI databases. Our method allows for high-resolution data distinction at both spatial (city-scale) and technical (unit-scale) levels. This approach is exemplified in the Tian Gong project, where AI-driven tools effectively manage and process vast amounts of data, ensuring detailed and relevant environmental impact assessments. The innovation provides a more reliable and comprehensive database compared to existing international databases, often limited by openness, transparency, and quality inconsistencies. Tian Gong serves as a practical embodiment of this methodology, demonstrating its potential and real-world applicability.

Utilizing AI in building LCI databases marks a significant shift in lifecycle assessment methodologies. This study highlights the potential of AI in creating more transparent, standardized, and globally relevant LCI databases. Such advancements are essential for the true proliferation and practical application of carbon and environmental footprint management, contributing to a global transition towards low-carbon and green economies. The results emphasize the role of AI in empowering sustainable development decision- making, with Tian Gong standing as a testament to these capabilities.

Keywords: Sustainable Development, Life Cycle Assessment, Life Cycle Inventory, Artificial Intelligence, Large Language Model

Spatially explicit life cycle assessment of solar power in Gansu, China in 2020

Shuning Shi[1], Xiaoyu Yan[2]

1 Environment and Sustainability Institute & Engineering Department, Faculty of Environment, Science and Economy, University of Exeter, Penryn, Cornwall TR10 9FE, UK. ss1382@exeter.ac.uk

2 Environment and Sustainability Institute & Engineering Department, Faculty of Environment, Science and Economy, University of Exeter, Penryn, Cornwall TR10 9FE, UK. xiaoyu.yan@exeter.ac.uk

Abstract

The expansion of solar power in China's power sector has shown the benefits of reducing carbon emissions. However, other associated environmental impacts should also be assessed in a spatially explicit way to understand not only the environmental benefits (i.e.,carbon emission reduction) but also the adverse consequences. This study investigated the spatial pattern of Freshwater Eutrophication caused by solar power in Gansu province,China in 2020 from a cradle-to-grave life cycle. The spatially explicit life cycle inventories (LCI) of China's solar power at the provincial level have been established in OpenLCA, witha special focus on the spatially explicit data of the upstream supply chain of solar panels. Freshwater Eutrophication in IMPACT World+ was implemented with the original resolution of 2°×2°to evaluate the spatially explicit impact. The impact of solar power generation is widespread both domestically and internationally. Over 60% of the impact was distributed outside China, scattering across Russia (37%), Rest of the world (17%), Global (3%), and other regions. Such impact is mainly caused by petroleum production as a major energy source of thousands of background processes, wastewater treatment of panel production, and production-related chemical supplies. Within China, the spatial pattern of impact is dominated by silicon and wafer production, mainly distributed in Jiangsu (9%), Xinjiang (7%), Yunnan (5%), and Inner Mongolia (4%). Gansu province itself isonly affected by 0.0002% of the total impact. Compared to conventional LCA that attributes all the impact to the power generation province, our study captures spatial hotspots of the Freshwater Eutrophication by performing the spatially explicit LCA and avoiding environmental burden transfer along the supply chain. With the higher and higher renewable penetration in China's power sector in the future decades, both benefitsand environmental burdens will continue to expand. This study helps policymakers gain a more comprehensive understanding of environmental concerns brought about by solar power and assists in formulating reasonable policies on energy transition in China.

Keywords:

life cycle assessment (LCA); spatially explicit; solar power; energy transition

SH2E project : Case study application : FCEV and BEV

Jade Garcia[1]; Hugues Boucher[1] ; Ashrakat O Hamed[2] ; Emmanuelle Cor[3] ; Pierre Rigaud[3] ; Dario Cortes[4]

[1] Symbio. 10, rue Specia, 69190 Saint-Fons, France. E-mail: jade.garcia@symbio.one

2 GreenDelta GmbH. Kaiserdamm 13, 14057 Berlin, Germany. E-mail : Ashrakat@greendelta.com

[3] CEA Liten. 17 Avenue des Martyrs, 38000 Grenoble, France. E-mail: Emmanuelle.cor@cea.fr

4 Fundación Hidrógeno en Aragón. Parque Técnológico Walqa, 22197 Cuarte (Huesca), Spain.

Abstract

In order to test the SH2E LCA guidelines on FCH systems provided by the previous tasks of the SH2E project, a case study have been conducted on a current fuel cell system for the use of hydrogen in a passenger car application : PEMFC (proton-exchange membrane fuel cell) electric car and compared with a Battery Electric Vehicle (BEV).

The main goal is not to compare the two vehicles precisely but to model them following the guidelines and to make feedbacks and remarks on the recommendations that have been made.

For this case study, a segment D passenger car is considered with a driving distance of15 000km/year during 15 years. The OpenLCA software has been used and the EF 3.1 method from the European Commission was applied.

Primary data were provided directly by industry partners for PEMFC vehicle and supplemented with secondary information from the ecoinvent v3.9 APOS (Allocation at the Point of Substitution) database. For the BEV, the data comes from a literature review for the same type of vehicle.

The modeling of the two vehicles was successfully done following all the steps and recommendations proposed in the LCA guideline.

The results show that the manufacturing phase is the more impacting step on almost all indicators (except land use and photochemical ozone formation), and represent around 60% for climate change for FCEV (Fuel Cell Electric Vehicle) and for BEV. The complete results will be presented.

Some improvements have been proposed for the guideline concerning for example the management of missing data or the choice of indicators.

The feedbacks from this case study will be integrated in the LCSA guideline that will be produced at the end of the project, gathering all recommendation for LCA, LCC and SLCA for FCH systems.

Keywords: *PEMFC, BEV, test, guideline, openLCA*

How to model chemical reactions with secondary data in openLCA: A general modelling approach based on metal-organic frameworks

Conrad Spindler[1*], Loay Radwan[1], Andreas Ciroth[1]

[1] GreenDelta GmbH. Kaiserdamm 13, Berlin, Germany

[*]E-mail: spindler@greendelta.com

Abstract

The absence of primary data for purchased chemicals often hinders the Life Cycle Assessment (LCA) process or results in inaccurate impact assessments through the use of proxies. Similar challenges emerge when dealing with laboratory-scale primary data in fundamental research, where industrial-scale data for chemicals is often not yet available. Various approaches in the literature address the need for incorporating best practices in modeling chemicals in LCA and scaling up laboratory recipes to potential industrial quantities.

Within the European research project MOST-H2, lab-to-industrial scale up methodologies are implemented in openLCA to calculate the environmental impacts of commonly involvedchemical synthesis steps. Drawing from the project experience of chemical reactions for theproduction of metal-organic frameworks, this presentation provides exemplary use cases and modelling guidelines to ensure more accurate data in case no primary chemical industry data is available. The openLCA modelling includes generalized parameters for easy-to-use stoichiometric chemical mixtures and incorporates non-linear equations to account for theenergy demands in the non-linear scale up of industrial-sized reactor quantities.

All data sets can be shared via the openLCA format and used for chemical assessments in different materials and projects. Ultimately, selected environmental impact results will be tested against available data from ecoinvent datasets, allowing for conclusions to be drawn regarding data uncertainty of the modelling approach.

Keywords:

Chemicals; Modelling; Parameters; Formulas; Secondary data; Metal-organic frameworks

Social Life Cycle Assessment of Plastic Value Chains

Krajnc Damjan[1]; Čuček Lidija[1], Yee Van Fan[2]

[1] University of Maribor, Faculty of Chemistry and Chemical Engineering, Maribor, Slovenia, damjan.krajnc@um.si, lidija.cucek@um.si

[2] Brno University of Technology – VUT Brno, Faculty of Mechanical Engineering, Brno, Czech Republic, fan@fme.vutbr.cz

Abstract

This paper delves into the critical analysis of social risks within sustainable value chains, focusing mainly on the production of plastic materials. Utilizing the SOCA database for social assessment and the Ecoinvent database for environmental insights, this study presents an approach that efficiently identifies and evaluates social hotspots in plastic material production.

The methodology used, characterized by its simplicity and effectiveness, leverages these databases to integrate environmental and social evaluations, providing a nuanced comparison of various plastic materials. This comparison not only elucidates the intricate relationship between environmental and social impacts across different life cycle stages but also brings forth pivotal findings that reshape our understanding of the social impacts of plastics production.

Central to our study is the emphasis on data availability and clarity. We address the data collection and interpretation challenges, especially concerning labour hours, raw material demands, and the socio-economic conditions in production locales. The paper underscores our findings' practical and theoretical implications, advocating for their integration into sustainable development strategies. Our research provides vital insights for sustainability practitioners and policymakers, aiming to foster a more informed and practical approach to sustainable development of plastic materials."

Keywords: *Social LCA; SOCA; Ecoinvent; Plastics; LCA*

Green Packaging Materials for Long-term Storage of Paper Collection

Deraz, Randa[1]; Di Gianvincenzo, Fabiana[1]; Mitevski, Ivan[2]; Anders, Manfred[3]; Schuhmann, Katharina[3]; Malešič, Jasna[4]; Strlič, Matija[1,5]; Elnaggar, Abdelrazek[1]

[1] Heritage Science Lab Ljubljana (HSLL), Faculty of Chemistry and Chemical Technology, University of Ljubljana, Slovenia. E-mails: Randa.Deraz@fkkt.uni-lj.si. Fabiana.DiGianvincenzo@fkkt.uni-lj.si

.matija.strlic@fkkt.uni-lj.si. Abdelrazek.Elnaggar@fkkt.uni-lj.si.

[2] Faculty of Chemistry and Chemical Technology, University of Ljubljana, Slovenia. E-mail: im5543@student.uni-lj.si .

[3] ZFB – Zentrum für Bucherhaltung GmbH, Germany. E-mails: anders@zfb.com. k.schuhmann@zfb.com.

[4] National University Library (NUK), Slovenia. E-mail: jasna.malesic@nuk.uni-lj.si

[5] UCL Institute for Sustainable Heritage, University College London, United Kingdom.

The long-term storage of historical paper collections is a critical problem for decision- makers in museums, libraries, and archives which significantly affects conservation management standards of paper collections. It is still unspecified which type of packaging materials (plastic/cardboard, lignin-free/lignin-containing boxes) is more protective for paper collection and environmentally preferable. This research aims to promote green approaches to the environmental and socio-economic management of stored paper collections in archives using life cycle assessment (LCA) and citizen science.

Different types of new packaging boxes with different configurations provided by several suppliers (ZFB, Germany; Klug, Germany; JPP, UK), were selected for analysis. In addition, recycled-by deacidification archival boxes used for storage of the National University Library's collection (NUK), Slovenia. In this research, different methods will be implemented as follow;

Determination of VOC emissions in different environmental conditions for the differenttypes of boxes prior to gas chromatography–mass spectrometry (GC–MS) and ion chromatography (IC) analysis.

Evaluation of the degradation of stored heritage paper collection to assess the long- term storage in indoor environmental conditions. Accelerated aging will be carried out by subjecting the boxes to temperature cycles while monitoring the VOC emissions. The decrease in the degree of polymerization (DP) of reference paper will also be measured.New boxes will be chosen for the assessment from the long-term storage perspectives and compared to the recycled boxes from NUK.

LCA will help to formulate green packaging boxes for paper collections by quantifying the following environmental and socio-economic hotspots (raw materials, energy, emissions, stakeholders, and cost). Participatory research with conservators, key decision-makers & stakeholders to assess and refine the green solutions and define market expectations with respect to sustainability will be carried out.

Preliminary results obtained from VOC emissions testing show the presence of formic and acetic acids. It has also shown that the age and type of packaging materials have an impacton the quantity of the emitted components during accelerated aging in different environmental conditions. This is reflected also on the impact on the preservation of paperobjects stored in proximity with such materials, as shown by the changes in the DP of reference paper exposed to the emissions.

The outcome of this research is to model qualitative and quantitative guidelines for conservation decision-makers, based on the environmental and health impacts of the packaging materials in storage areas of paper collections, using LCA and the results will be visualized and presented to the stakeholders, decision makers and practitioners regarding the collection demography in libraries and museums.

Keywords: Social-life cycle assessment (S-LCA), cultural heritage database, emissions, energy saving, cost effectiveness, environmental management decision making.

Acknowledgement:

The authors acknowledge Ms. Marta Kozole, Faculty of Chemistry and Chemical Technology, University of Ljubljana, for her contribution to the analysis of organic emissions from cardboard boxes. Also, the authors acknowledge Ms. Ivana Štular, Heritage Science Lab Ljubljana (HSLL), Faculty of Chemistry and Chemical Technology, University of Ljubljana, Slovenia for her help with VOC's emission tests.

Funding:

This work is funded through the GreenArt project (Horizon Europe Framework Programme-grant no 101060941).

Increasing transparency for inventory data of plastic production by modeling the olefin supply chain

Jonas Hoffmann[1], Andreas Ciroth[1]

[1] GreenDelta GmbH. Kaiserdamm 13, Berlin, Germany. E-mail: hoffmann@greendelta.com

Abstract

By 2050, it is anticipated that plastic production will triple, exceeding 1100 Gt per year and accounting for 15% of the annual global greenhouse gas (GHG) emissions[1]. Hence, the Life Cycle Assessment (LCA) of plastics is pivotal in understanding and mitigating the environmental footprint. However, assessing the full life cycle of plastics encounters challenges due to a lack of primary data for plastic precursors (olefines), hindering accurate impact assessments. This limitation often forces practitioners to use available data that is often aggregated and possibly outdated, leading to potential inaccuracies and intransparency in evaluating the environmental impacts of plastic production along the whole supply chain.

Hence, we created a model in openLCA 2.0 for the olefine production via steam cracking of naphtha followed by Ziegler-Natta polymerization. The foreground processes are based on secondary data from Plastics Europe and Franklin Associates, which are connected to ecoinvent v3.9.1 processes in the cut-off system model. To test our model, a comparative study (cradle-to-gate) of the virgin polyethylene (PE) production was performed, using the Environmental Footprint v3.1 method for impact assessment.

The results indicate that our model for PE production yields similar impacts compared to the existing ecoinvent data sets, which proves its validity. However, in the meantime, we could obtain supply chain data for the PE production. In particular, the raw material extraction gained our focus, since natural gas venting and usage of Halons contribute massively to the environmental impacts and are not accounted for in the fully or partly aggregated datasets from several sources (ecoinvent v3.9.1, Carbon Minds or Plastics Europe).

This research underscores the necessity for more detailed chemical production data in LCA studies and the need to utilize transparent and comprehensive models instead of relying only on existing datasets. Furthermore, the recent release of the ecoinvent database v3.10 is now including the full olefin supply chain, which will be used for further comparisons withour own modeling approach.

[1] World Economic Forum, Ellen MacArthur Foundation, *The New Plastics Economy:Rethinking the future of plastics* (**2016**).

Keywords: *Chemicals; Secondary data*; *Olefins; Plastic*

Joint GREET and openLCA to guide the flexible energy layouts for sustainable transportation: a well-to-wheel case study of methanol and hydrogen fuel cell vehicles

Jiaxuan Li[1,2], Xun Zhu[1,2*], Yang Yang[1,2], Dingding Ye[1,2], Qiang Liao[1,2]

[1] Key Laboratory of Low-grade Energy Utilization Technologies and Systems, Chongqing University, Chongqing, China. E-mail: Jiaxuan Li @20171002031t@cqu.edu.cn.

[2] Institution of Engineering Thermophysics, School of Energy and Power Engineering, Chongqing University, Chongqing, China. E-mail: Xun Zhu @zhuxun@cqu.edu.cn.

Abstract

As the pressure for carbon reduction in the global transportation sector continues to grow,more research is aimed at finding sustainable and environmentally friendly alternatives to fossil fuels, thus evaluating the life cycle energy consumption, environmental impact and cost of the potential alternative fuels and utilization techniques becomes particularlly important. Methanol and hydrogen fuel cell vehicles have emerged as potential options. The operational process of hydrogen fuel cell vehicles (HFCV) is highly efficient and environmentally friendly by emitting only water, but the upstream chain of hydrogen playsa significant role in restricting its development. Comparatively, methanol is an excellent liquid carrier of hydrogen, which can realize efficient storage and transportation. Although CO_2 will be emitted from the tailpipe of the on-board hydrogen production system, it can be re-captured and synthesized to methanol, thus realizing the "Carbon Cycle". In this study,a well-to-wheel (WTW) LCA model and database for methanol and hydrogen fuel cell vehicles are developed based on GREET® to evaluate their energy consumption, emission and costs. Furthermore, five midpoint environmental impact categories including Global Warming Potential (GWP), Eutrophication Potential (EP), Photochemical Production Potential (POCP), Human Toxicity Potential (HTP) and Acidification Potential (AP) are assessed by coupling with the LCIA method CML 2001 embedded in openLCA. The GREET® model provides a high pricise assessment of the direct emissions, energy consumptions bymass and energy balance, which takes into account the key processes of raw material extraction, fuel production, vehicle manufacturing, recycling and operation. The openLCA is an open source model to further analyze the environmental and social impacts by plentyof LCIA methods. By coupling the GREET® and openLCA, our study integrates accurate transportation database (GREET databse, government reports, reaserch papers, etc.) and assessment method database (ecoinvent database etc.) for a more comprehensive and flexible LCA in transportation sector. In the study, a uniform functional unit of 100 km driving distance per vehicle is utilized. The results show that MFCVs overwhelm HFCVs in terms of energy efficiency, environmental impact and cost, indicating the greater potentialof the green methanol fuel cell technology. Our research can provide meaningful referencesfor policy makers, stakeholders and researchers, and contribute to the healthy development of sustainable transportation energy systems in the future.

Keywords: *Well-to-wheel; GREET; openLCA; fuel cell vehicle; methanol; hydrogen*

Acknowledgements:

The authors acknowledge the financial supports of the Innovative research group project of National Natural Science Foundation of China (No.52021004).

Integrating OpenLCA and AWS Sustainability Insights Framework to enable CorporateCarbon Accounting

Hart, Dean

[1] Amazon. E-mail: deanhart@amazon.com

Abstract

Introduction:

Corporate carbon accounting plays a pivotal role in sustainability strategies, necessitating precise measurement and reporting. This presentation introduces the AWS Sustainability Insights Framework (SIF) as a tool for automating corporate carbon accounting. The session focuses on the integration between SIF and OpenLCA, leveraging a centralized supply chain modeling approach within OpenLCA, applying a strategic tagging system, and elucidating the import process and allocation of Product Carbon Footprint (PCF) values to the wider corporate.

Methodology:

The integration between SIF and OpenLCA is elucidated through a step-by-step walk- through. This includes utilizing OpenLCA's centralized supply chain modeling to define life cycle stages, implementing a tagging strategy to determine what and how to import carbon emission data into SIF, and illustrating the allocation of product carbon emission data into an organization's carbon footprint by correlating with sales and/or production data. The presentation dives deep into the software architecture of this integration, emphasizing techniques such as the automated deployment of OpenLCA Collaboration Server within AWS, running the Collaboration Server headless, and utilizing Amazon ECS for on-demand hosting.

The session extends beyond traditional methods of creating LCA's by introducing the publication "CaML: Carbon footprinting of household products with zero-shot semantic text similarity". This innovative approach incorporates machine learning for Environmental Impact Factor (EIF) selection, a critical step in carbon footprinting. The presentation showcases how CaML functionality has been added to SIF to accelerate the creation of EIO- LCA's for household products just using a provided name or description. The architecture of CaML integration is explored, offering insights into its adaptability for other databases.

Conclusion:

In conclusion, this presentation underscores the synergy between SIF and OpenLCA in corporate carbon accounting. The integration's architectural insights and innovative techniques demonstrate a significant leap towards more streamlined and efficient carbon accounting. The incorporation of CaML showcases the potential for machine learning in reducing the time required in creating LCA's, thus allowing organizations to expand their LCA coverage across their product suite paving the way for a more sustainable future.

How automatise life cycle analysis in the context of electrical equipment and electronic

Bertrand, Axelle[1,2] ; Bauer, Tom[3] ; Charbuillet, Carole[3] ; Bonte, Martin[2] ; Voyer, Marie[2]; Perry, Nicolas[1]

[1] Arts et Métiers, CNRS, Université de Bordeaux, I2M. Esplanade des Arts et Métiers, 33405 Talence, France. E-mail: axelle.bertrand@ensam.eu ; nicolas.perry@ensam.eu.
[2] Qweeko, 150 rue Mondenard, 33000 Bordeaux, France. E-mail: martin@qweeko.io ; marie@qweeko.io.
[3] Institut Arts et Métiers, I2M. 4 rue du Lac Majeur, 73375 Le Bourget-du-Lac, France. E-mail: tom.bauer@ensam.eu ; carole.charbuillet@ensam.eu.

Abstract

The current regulatory framework for Electrical and Electronic Equipment (EEE) in Franceis evolving, particularly with RE2020, progressively compelling manufacturers to communicate the environmental performance of their products. Consequently, manufacturers are required to undertake a Life Cycle Assessment (LCA) process for their entire product catalog. LCA is a standardized and scientifically recognized method for quantifying the environmental impact of activities. However, due to the complexity of LCA,which is a time-consuming and expensive process, automation appears to be an appropriatestrategy.

Data acquisition is a recognized issue, but automatic modeling of the life cycle inventoryis seldom discussed in the literature. Our objective is to explore the feasibility and usefulness of automatic modeling for EEE subject to RE2020. We perform an analytical

interpretation of the LCA method to identify critical points and propose simplification solutions. A review of existing simplification approaches is conducted, and the results are analyzed to assess potential benefits. These knowledge are used to guide our thinking in developing an efficient automation method. Our solution is based on the development of a code-based tool linked to LCA tools, building on existing work and integrating new ideas. It operates in two steps: first, it allows reconciliation between environmental data andcustomer data from the Bill Of Materials (BoM) through semantic analysis. Then, the data is automatically integrated and modeled within the OpenLCA LCA software.

Preliminary results demonstrate the potential for reducing the need for manual compilation, as well as time savings through modeling in just a few minutes, allowing LCA practitioners to enhance their efficiency by carrying out a lot of LCA in a short time. This allows experts to focus more on interpretation tasks rather than operational tasks.

In conclusion, our research aims to meet the changing requirements of EEE regulations in France by automating a portion of the LCA process. This provides a practical andinnovative solution for manufacturers while contributing to effective communication of product environmental performance.

Keywords: *Life Cycle Assessment, Life Cycle Inventory, EEE, Automation, Massively*

Accounting for ecosystem services in Life cycle assessment: case study of a community garden in Prague

Guillaume, Aurore[1,2]; Geeraerd, Annemie[2]; Appels, Lise[2]; Kočí, Vladimír[1]

[1] University of Chemistry and Technology. Technická 5, Dejvice 166 28, Prague 6, Czech Republic. E-mail: auroremorgane.guillaume@kuleuven.be.
[2] KU Leuven. Willem de Croylaan 42, 3001 Leuven, Belgium.

Abstract

Introduction

Agriculture is responsible for about 30% of global greenhouse gas emissions and other environmental pressures. In parallel, farmers live the most below the national poverty line compared to other professions. Simultaneously, the low affordability of healthy food may turn consumers to resource-intensive agricultural products; hence there is a need for a drastic transformation of our food system to solve these challenges. Nature-based solutionssuch as community gardens can be seen as a response to these environmental, social and economic challenges. A comprehensive approach to the assessment of non-conventional systems such as community gardens accounting for the different ecosystem services (provisioning, maintenance and regulation, and cultural) is missing in the literature. Thus, this project aims to assess social and environmental impacts of a community garden using Life Cycle Assessment (LCA).

Methodology

We apply an LCA from cradle-to-gate to a community garden in Prague. For this case study,we use primary data from the garden and background processes from the Agribalyse database. To account for the multi-functionality of community gardens, three functional units were used:

1 kg of harvested crops to account for the provisioning function of the garden,

1 kg of harvested crops using allocation factors to account for the maintenance and regulation ecosystem services,

1 ha of land used to account for cultural ecosystem services.

Results were compared to average conventional agriculture for the Czech Republic and other types of green infrastructure in urban areas.

Results and discussion

Results show that the community garden scores better compared to average conventional agriculture in the Czech Republic in some impact categories linked to the non-inputs in pesticides and energy resources like ecotoxicity, water use and resource use of fossils. Yet,due to a high quantity of biomass composted, the impact categories of acidification, climatechange, terrestrial eutrophication and particulate matter are higher for the community garden. When accounting for maintenance and regulation ecosystem services, burdens in most impact categories are not counterbalanced but could be lowered by improved agricultural practices. Finally, accounting for cultural ecosystem services and compared to other uses of urban space providing the same function, the community garden is a beneficial way of land space occupation.

Conclusion

Results suggest that community gardens could help mitigate local environmental pollutionand use of resources provided that good agricultural practices are followed. It shows that other ways of producing and distributing food are possible and could help mitigate global and local environmental impacts with social benefits. The outputs help LCA practitioners tocarry out LCA of urban agriculture and farmers to improve their practices while guiding localpolicies on the role that community gardens can play in strengthening the resilience of ourfood system at a city level.

Keywords:

Life cycle assessment, urban agriculture, community garden, local environmental impacts, social impacts, ecosystem services

Environmental impact analysis for electric bus batteries including second-life application.

Lin, Lan[1]; Hewa Dewage, Harini[2]

[1] Hitachi Europe GmbH, Niederkasseler Lohweg, 40547 Dusseldorf, Germany. E-mail: lan.lin@hitachi-eu.com
[2] Hitachi European R&D Centre, 12th Floor, 125 LondonWall, London EC2Y 5AJ, United Kingdom. E-mail: harini.hewadewage@hitachi-eu.com

Abstract

This study rigorously conducts a Life Cycle Impact Assessment (LCIA) of lithium-ion batteriesin a leasing model, with a focus on the entire lifecycle, excluding manufacturing. The urgency arises from the imperative to integrate environmental data into key performance indicators (KPIs) for informed business and operational decision-making. Companies are increasingly compelled to quantify their environmental impact, aligning sustainability objectives with economic profitability.

The imminent introduction of a European battery passport, mandated from 2026 onward, adds further impetus to comprehensively assess environmental impacts. This passport, emphasising environmental considerations, requires meticulous collection and interpretation of battery data. The study aligns its goals with these forthcoming requirements, conducting an LCIA to determine key environmental metrics, including the ecological footprint.

The study performs a detailed comparative analysis of remanufacturing and repurposing from an environmental perspective for electric vehicle (EV) bus batteries, considering first and second-life use and recycling phases. The methodology involves selecting battery typeand region, defining functional units and system boundaries, and discussing the intricacies of repurposing and remanufacturing options. OpenLCA and EcoInvent databases were usedin order to estimate the global warming potential of the target use case. Additionally, a sensitivity analysis systematically analyses parameters like daily travelled distance, state of health (SOH) values post-remanufacturing, different regions for second-life application, and varied years of application, providing insights into their influence on the overall environmental impact of the EV battery.

This LCIA of lithium-ion batteries underscores the positive impact of extended battery use on environmental performance. Reusing batteries can significantly reduce greenhouse gas emissions, potentially resulting in a negative overall value over the lifecycle. Remanufacturing proves more effective than repurposing, although attention must be given to additional environmental impact from battery transport and processing. The electricity emission factor is a key influencer in life cycle assessment outcomes.

In conclusion, adopting second-life concepts for batteries offers a promising approach to minimise environmental footprints. Success hinges on strategic logistics, transportation measures, and a substantial shift towards renewable energy and stationary battery storage systems for energy supply. Addressing these factors ensures the tangible and sustainable realisation of environmental benefits from second-life battery applications.

Keywords: lithium-ion *batteries, second-life battery, environmental impact, electricvehicle, remanufacturing, repurposing*

Synergy between LCA and AMC for more science-based informed decisions: a case study in agrifood mountain value chains

Mazzetto, Fabrizio[1] ; Sacco, Pasqualina[2]

[1] Free University of Bozen/Bolzano, P.zza Università 1, Bozen/Bolzano, Italy. E-mail:fabrizio.mazzetto@unibz.it.
[2] Independent researcher & consultant, Bozen/Bolzano, Italy. E-mail: pqlsacco@gmail.com.

Abstract

In the context of the valorisation of marginal mountain areas an emerging theme concernsthe re-introduction of cereal cultivation in areas typically affected by critical due to both their orographic and climatic conditions. This is done through new production models thatprovide: 1) processing of primary production directly at the farm (with a focus on bread and beer); 2) consequent elimination of transport activities between primary and processed products; 3) adoption of new mechanisation solutions to manage the field cultivation phases, which are largely precluded to the conventional machinery currently available on the market. These aspects require an integrated approach to assess the performance of alternative food value chains through life cycle assessment (LCA) and multi-criteria analysis (MCA).

For the agrifood sector, the latter is also useful to deal with policy interactions at different levels. Indeed, many policy-driven decisions could contribute to promote more integrated sustainable approaches through targeted interventions at economic (e.g. income support), social (e.g. working conditions) and environmental (e.g. pesticide reduction) levels.

LCA is one of the most widely used methodologies for estimating impacts as it is able toavoid transferring negative impacts in time and space, effectively neglecting them.

However, information obtained from technical analyses, such as LCA, is not always easy to interpret and use in decision-making contexts.

The MCA enables transparent decision-making processes within complex systems (typical of agrifood), where even very conflicting priorities may prevail among the decision-makersinvolved. Fundamental is the construction of the MCA impact matrix, which represents the "objective" component of the analysis and is the junction with the assessments obtainable from LCA. This enables more science-based decision making processes.

In the case study four alternative supply chains compatible with the prevalently mountainous territory of South Tyrol were considered: rye-bread, barley-beer, cow's milk-cheese, goat's milk-cheese. A comparative LCA was performed (OpenLCA software) on thefunctional unit of a hectare of cultivated land. Data were obtained by field trials, expert estimation and secondary data where needed. The results of this preliminary analysis were used in MCA. The main results show that on farm cereal-bread value chain is an interesting alternative, but very much linked to the climatic risk – e.g. loss of primary production; preferred by decision makers with strong environmental interests and low labor effort. On the contrary, alternatives linked to animal husbandry are less risky, and preferred by decision-makers whit a low-risk investments profile.

Keywords: *agrifood value chains, multi-criteria analysis, decision making processes,mountain agriculture*

Automatized LCA of Parametrizable Passenger Car Glider Models

Weber, Philipp[1]; Toedter, Olaf[1]; Koch, Thomas[1]

[1] Karlsruhe Institute of Technology / Institute of Internal Combustion Engines. Kaiserstraße 12, Karlsruhe, Germany, E-mail: philipp.weber@kit.edu

Abstract

Detailed Life Cycle Assessment (LCA) studies on passenger cars frequently focus on vehicles of one or several powertrain types. Moreover, the indicated studies usually address one segment, e.g. the "Golf class", which mostly defines the so-called glider, i.e. the "rest of the vehicle" after subtracting the powertrain. At the same time, publications considering more vehicle variety tend to lack in level of detail owing to inaccessible primary data.

In this work, we present a methodology to model and automatically calculate and evaluate scalable detailed passenger car components with openLCA by the example of a glider.

On the one hand, the mentioned openLCA glider model is based on mass calculation formulae from literature on vehicle concepts. Hereby, several equations are implemented, which consider vehicle features that are mostly publicly available, such as dimensions, body type, trim level and material options. On the other hand, further literature is used to amend component masses with information on materials and manufacturing processes so that models can be created in openLCA on the basis of ecoinvent datasets.

As the entire workflow proves to be effortful, most of the tasks involved are automated. Technically, this is realized via the openLCA Python packages olca-ipc and olca-schema. In addition to the initial creation of the flexible model via several Excel sheets and a Python script, the libraries are used to parametrize the model, conduct calculations and evaluate the results.

As a basis for the calculation, characteristic data (length, width, etc.) of more than 1000 passenger car models is used to create individual parameter sets, which are fed into "CalculationSetup" objects. The results of the calculations are evaluated at different system levels from top (level 0, entire glider life cycle) to bottom (level 4, material/energy contributions to components), including different life cycle stages (production, usage, end-of-life) as well as subsystems and components. In order to enable the correlation of input and result data, both data sources are then saved in a single HDF5 file, which is later read into further postprocessing scripts.

With regard to greenhouse gas emissions, the results of the created model are similar to, but slightly underestimate the GWP100 results of the "standard" ecoinvent passenger car dataset.

All in all, the presented methodology allows to conduct LCA studies of passenger car gliders with:

- an extended level of detail, including "hot spot analysis",
- without access to detailed vehicle parts lists,
- parameterizable with mostly publicly available technical parameters,

in a mostly automatized preprocessing, calculation and postprocessing data pipeline, which uses the openLCA Python libraries.

Some of the challenges of the current approach involve the initial effort to set up the model in an Excel sheet, as well as the uncertainties introduced by using the mentioned mass formulas, which requires further validation of intermediate and final results.

Subsequent development includes an expansion of the methodology towards powertrain models.

Keywords: LCA, passenger car, glider, parameterizable models, olca-ipc, scalable LCI

Imprint

Report created by:

GreenDelta GmbH

Alt-Moabit 130

10557 Berlin

Germany

Editors:

Friedrich Halstenberg

Andreas Ciroth

Loay Radwan

www.greendelta.com

Managing director: Dr. Andreas Ciroth

Phone: +49 030 4849 6030

Email: gd@greendelta.com