Role of Open-LCA in sustainable aquaculture development

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

[1] Department of Chemical, Pharmaceutical and Agricultural Sciences, University of Ferrara, Via L. Borsari 46, 44121 Ferrara, Italy
[2] School of Ocean Sciences, Bangor University, Menai Bridge, United Kingdom
[3] Department of Environmental and Prevention Sciences, University of Ferrara, Via L.Borsari, 46 Ferrara
[4] Deepdock Ltd, Bangor, UK.
* daniela.summa@unife.it

Introduction

Over the past five decades, aquaculture production has rapidly increased, doubling every ten years and emerging as the fastest-growing food sector. This growth is attributed to expanded production areas, improved husbandry knowledge, and technological advancements. With rising demand for seafood and animal protein, aquaculture offers a promising alternative to wild fisheries. Two main aquaculture systems exist: intensive, focusing on high animal productivity with species like salmon, sea bass, and tilapia, and extensive, involving species such as clam, mussel, and oyster, relying on natural water productivity [1]. Life Cycle Assessment (LCA) plays a vital role in evaluating the environmental impacts of aquaculture, though challenges remain in standardizing LCA tools, particularly for extensive systems [2]. The software Open-LCA has been used to assess the environmental impact of mollusk farming in the Po river delta (Northern Adriatic sea), the most productive area for clam farming in Europe and in the Menai Strait (Northern Wales), where mussel farming is particularly developed, aiding in overall environmental sustainability assessment by integrating with bivalves' carbon storage capacity.

Materials and Methods

F.U. 1 ton of clam or mussel at the port gate.

System boundaries: raw material production (cradle) to bivalve at the port (grave)

LCA Method: ReCiPe midpoint (H) v.1.12.

Uncertainty analysis: Monte Carlo simulation (1000 iteraction and 95% significance level).

Northern Adriatic Sea (Po River Delta) — *R. philippinarum*

8-10 months

1. Area preparation
2. Seed Fishing and Sowing
3. Husbandry → Steel boat 7.5 m + Diesel consumption
4. Harvest

Do biological processes affect the **GWP**?

Northern Wales (Menai Strait) — *M. edulis*

33-36 months

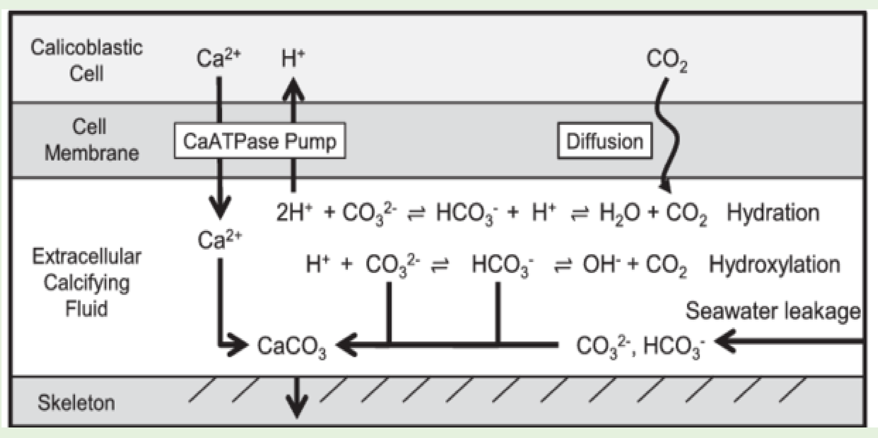
1. Seed Fishing and Sowing
2. Husbandry → Aluminum boat 43 m + Diesel consumption
3. Harvest

CO_2 sequestrated in shell of 1 kg of **clams**

$$(CCD_s) = R_S \times W_S \times MW_{CO2}$$

R_s: **shell weight** (g)
Ws: $CaCO_3$ content in the shell (%)
MW_{CO2}: molecular weight of CO_2 (g/mol)

Shell formation [3]



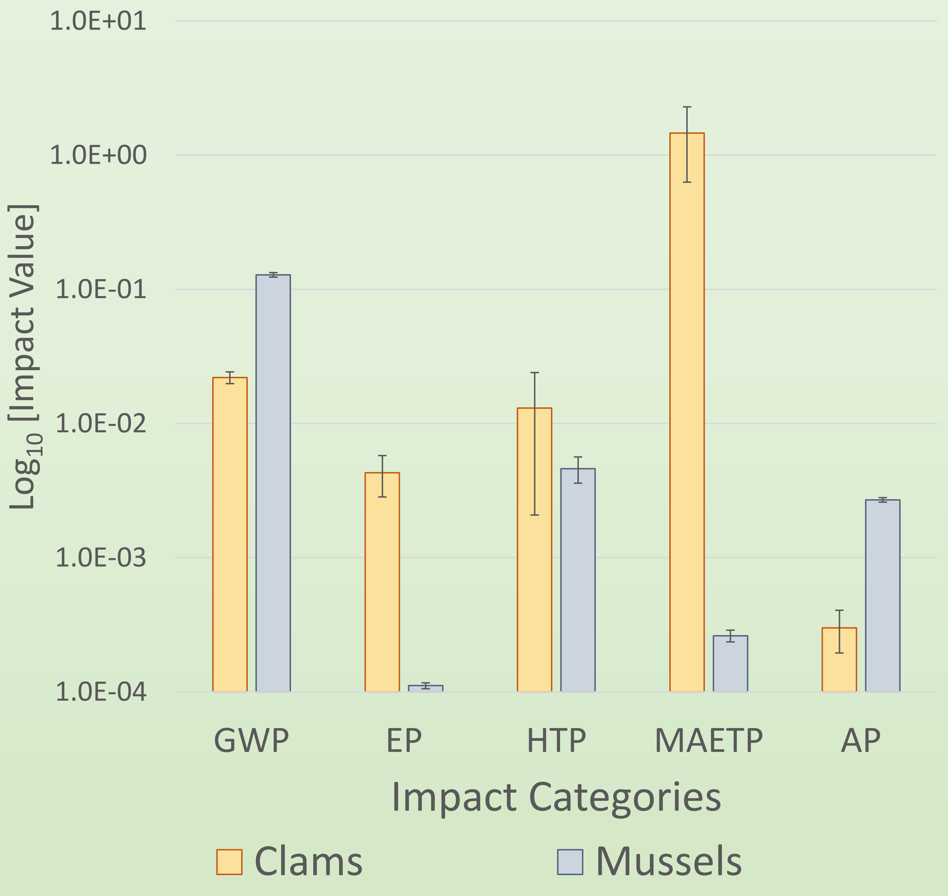
CO_2 sequestrated in shell of 1 kg of **mussels**

$$(MCD_s) = C_S \times MW_{CO2}$$

C_s: **shell carbon weight** (g)
MW_{CO2}: molecular weight of CO_2

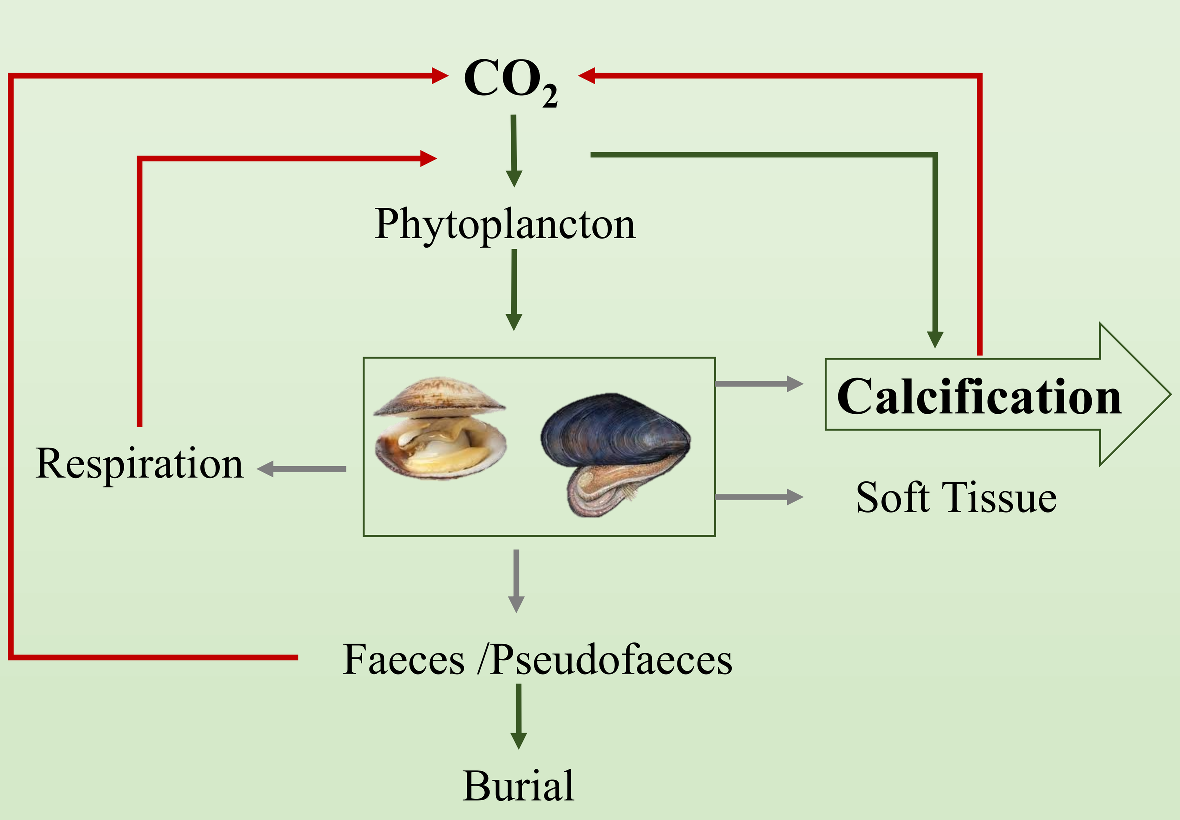
Results

LCA



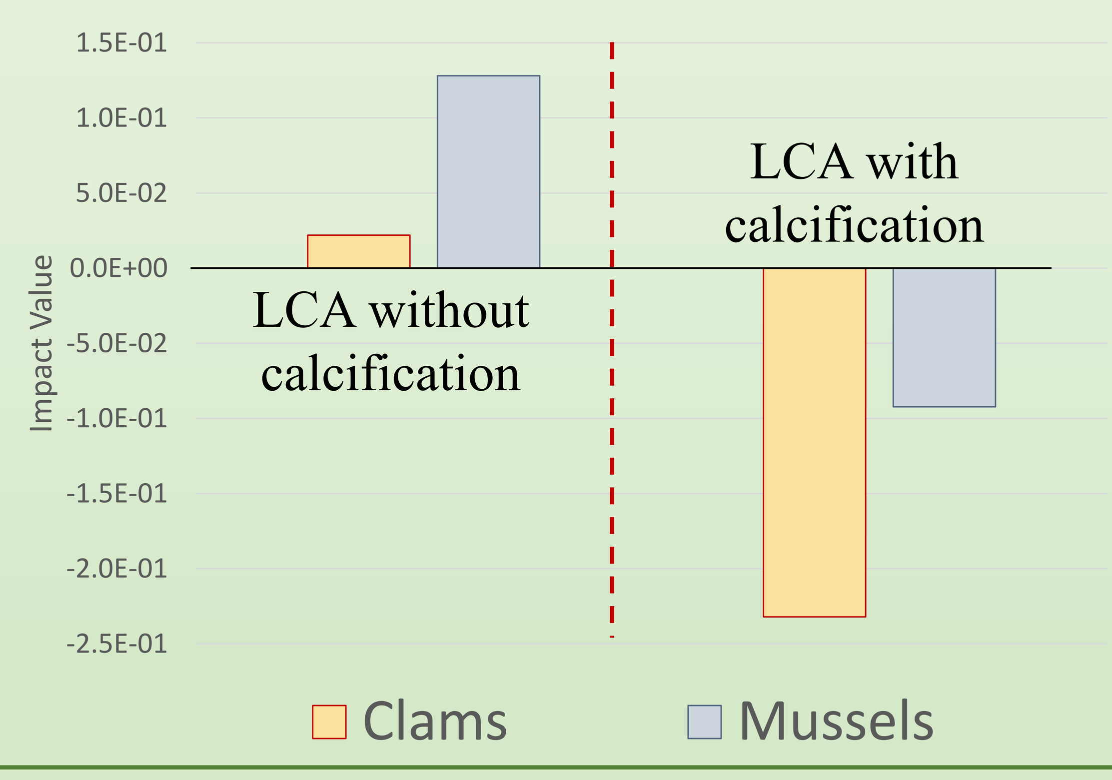
Biological process and CO_2 fluxes

Calcification is a net contributor to long-term carbon storage as bivalves are harvested for food consumption.



GWP

Shell weight	Shell carbon weight
0.562 Kg/Kg bivalve	0.060 Kg/Kg bivalve
CO_2 storaged	**CO_2 storaged**
0.254 kg/kg bivalve	0.220 kg/kg bivalve



Conclusions

Life Cycle Assessment (LCA) is recognised as a valuable tool for conducting environmental impact analyses within the mussel and clam farming industry. In addition, the inclusion of carbon sequestration during the calcification process of mussels and clams highlights the significant contribution of biological processes to the overall impact and emphasises the need to establish a database that facilitates the inclusion of these aspects in LCA analyses.

References

[1] The State of World Fisheries and Aquaculture 2020; FAO, 2020; ISBN 978-92-5-132692-3.
[2] Henriksson, P.J.; Guinée, J.B.; Kleijn, R.; de Snoo, G.R. Life Cycle Assessment of Aquaculture Systems—a Review of Methodologies. The International Journal of Life Cycle Assessment 2012, 17, 304–313.
[3] Spooner, P. T., Guo, W., Robinson, L. F., Thiagarajan, N., Hendry, K. R., Rosenheim, B. E., & Leng, M. J. (2016). Clumped isotope composition of cold-water corals: A role for vital effects?. Geochimica et Cosmochimica Acta, 179, 123-141..

Green Packaging Materials for Long-term Storage of Paper Collection

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

[1] Heritage Science Lab Ljubljana (HSLL), Faculty of Chemistry and Chemical Technology, University of Ljubljana, Slovenia.
[2] Faculty of Chemistry and Chemical Technology, University of Ljubljana, Slovenia.
[3] ZFB – Zentrum für Bucherhaltung GmbH, Germany.
[4] National University Library (NUK), Slovenia.
[5] UCL Institute for Sustainable Heritage, University College London, United Kingdom.

INTRODUCTION

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. The aim of this research is to promote sustainable green approaches to the environmental and socio-economic management of stored paper collections. Life cycle assessment (LCA), life cycle costing (LCC) and social life cycle assessment (S-LCA) will be used as advanced quantitative tools for sustainability assessment.

METHODS

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 different types 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, LCC and S-LCA as quantitative assessment tools will help to formulate sustainable packaging boxes for paper collections by quantifying the following environmental and socio-economic hotspots (raw material extraction, manufacturing, transport, use, recycling, disposal, energy consumption, emissions, stakeholders, and costs).

Fig 1. Archival boxes from NUK

Fig 2. Deacidification of old cardboard boxes from NUK

Fig 3. New cardboard box

- 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

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 impact on the quantity of the emitted components during accelerated aging in different environmental conditions. This is reflected also on the impact on the preservation of paper objects stored in proximity with such materials, as shown by the changes in the DP of reference paper exposed to the emissions.

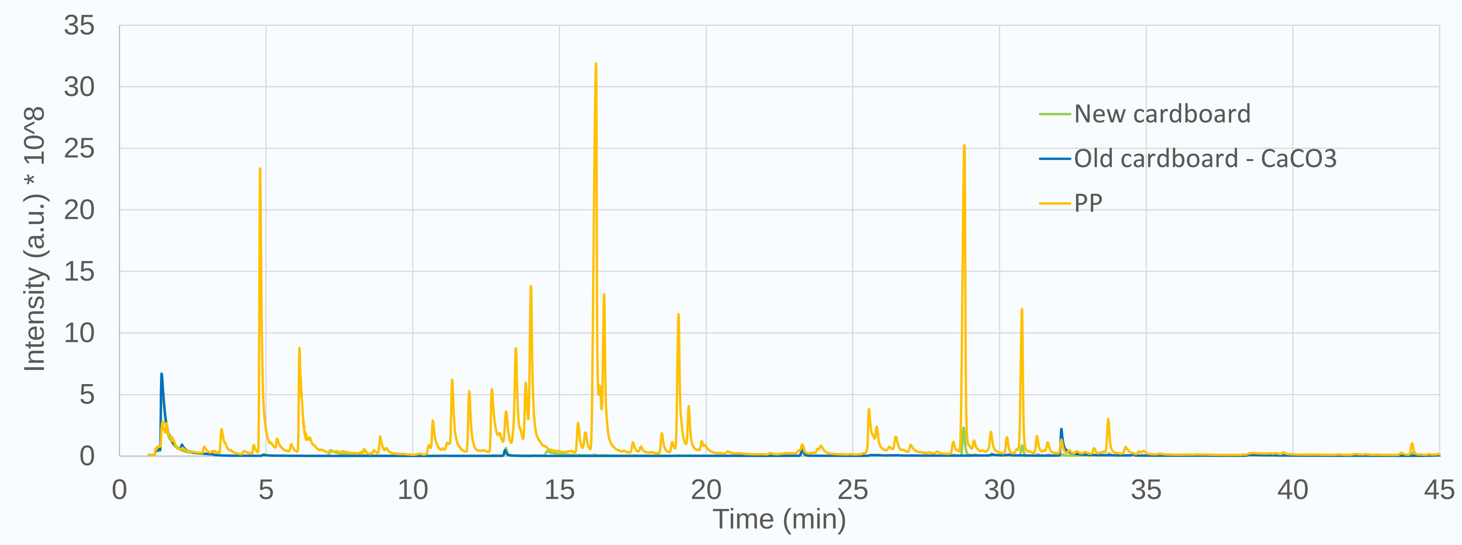


Fig 4. GC-MS chromatograms (0-45 min) for all samples obtained with the SPME approach.

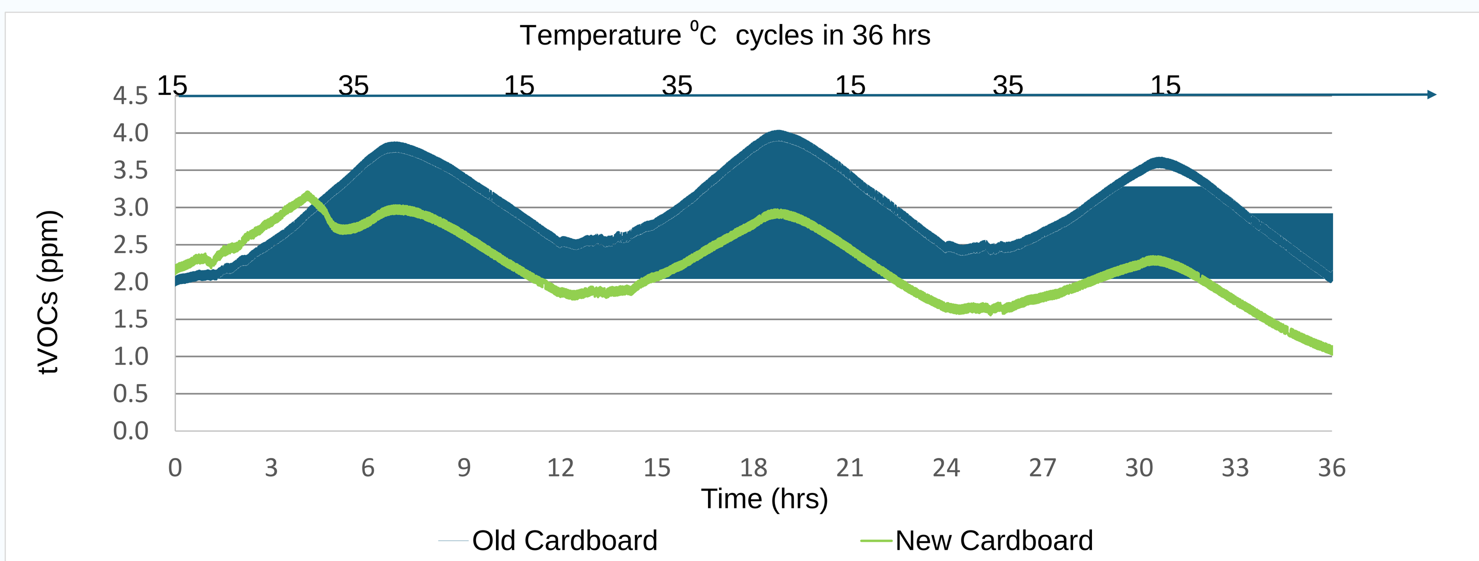


Fig 5. tVOCs emitted from different airtight packaging boxes through three repeated temperature cycles in consonant humidity 65%.

OUTCOMES

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.

ACKNOWLEDGEMENT

The authors acknowledge Ms. Ivana Štular & Ms. Marta Kozole, Faculty of Chemistry and Chemical Technology, University of Ljubljana, for their contributions to the VOCs emission tests.

FUNDING

Funding provided by the European Union (GREENART project, Horizon Europe research and innovation program under grant agreement no. 101060941). The work supported by the programme group of "N-DAD: Non-destructive Analysis and Diagnostics" (P1-0447).

ZFB

HERITAGE SCIENCE LAB LJUBLJANA

UNIVERSITY OF LJUBLJANA FACULTY OF CHEMISTRY AND CHEMICAL TECHNOLOGY

NATIONAL AND UNIVERSITY LIBRARY

Driving Sustainable Design for Additive Manufacturing through OpenLCA

Okhovat, Rasool; Syré, Anne; Maier, Otto; Göhlich, Dietmar
Chair of Methods for Product Development and Mechatronics, Technische Universität Berlin

This work introduces a tool designed to streamline and simplify the process of conducting life cycle assessments (LCAs) for engineers and industry professionals. By providing an easy-to-use framework adhering to ISO standards, which includes both an Excel-based interface for data entry and a Python-based implementation within the openLCA software, the tool aims to enhance the accessibility of performing LCAs. Applied to a case study on additive manufacturing methods in high-temperature applications, it has been demonstrated that the primary advantage of this approach lies in its rapid visualization of environmental impacts, with particular focus on energy demand and global warming potential. Overall, this tool offers a user-friendly solution for conducting LCAs in diverse industrial sectors, particularly during decision-making stages, and lays a foundation for future research in simplifying LCAs for industrial applications.

Motivation and Approach

- **Integrated LCA using openLCA and Python:** Users input process data into Excel (or are taken directly from measuring device), Python seamlessly integrates these inputs into openLCA for efficient calculations.
- **Improve result visualization:** Enhance clarity for non-experts to track and understand LCA outcomes

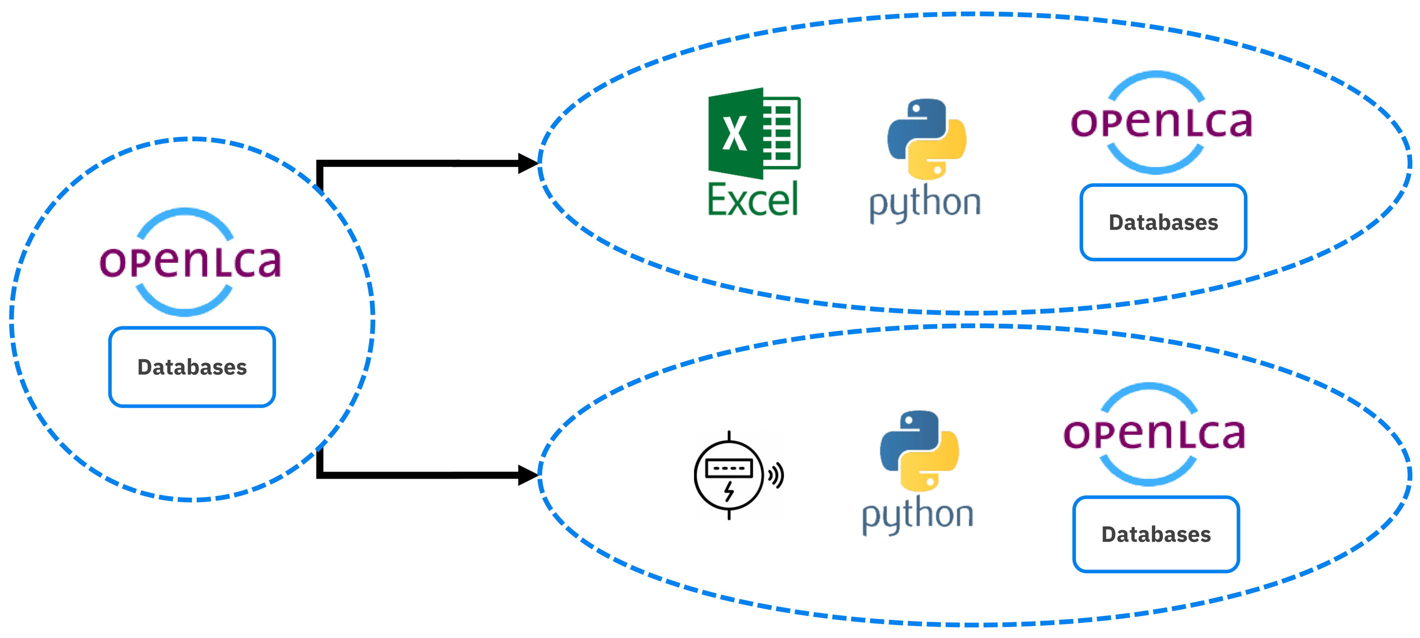


Fig. 1: Python Integration for OpenLCA Enhancement

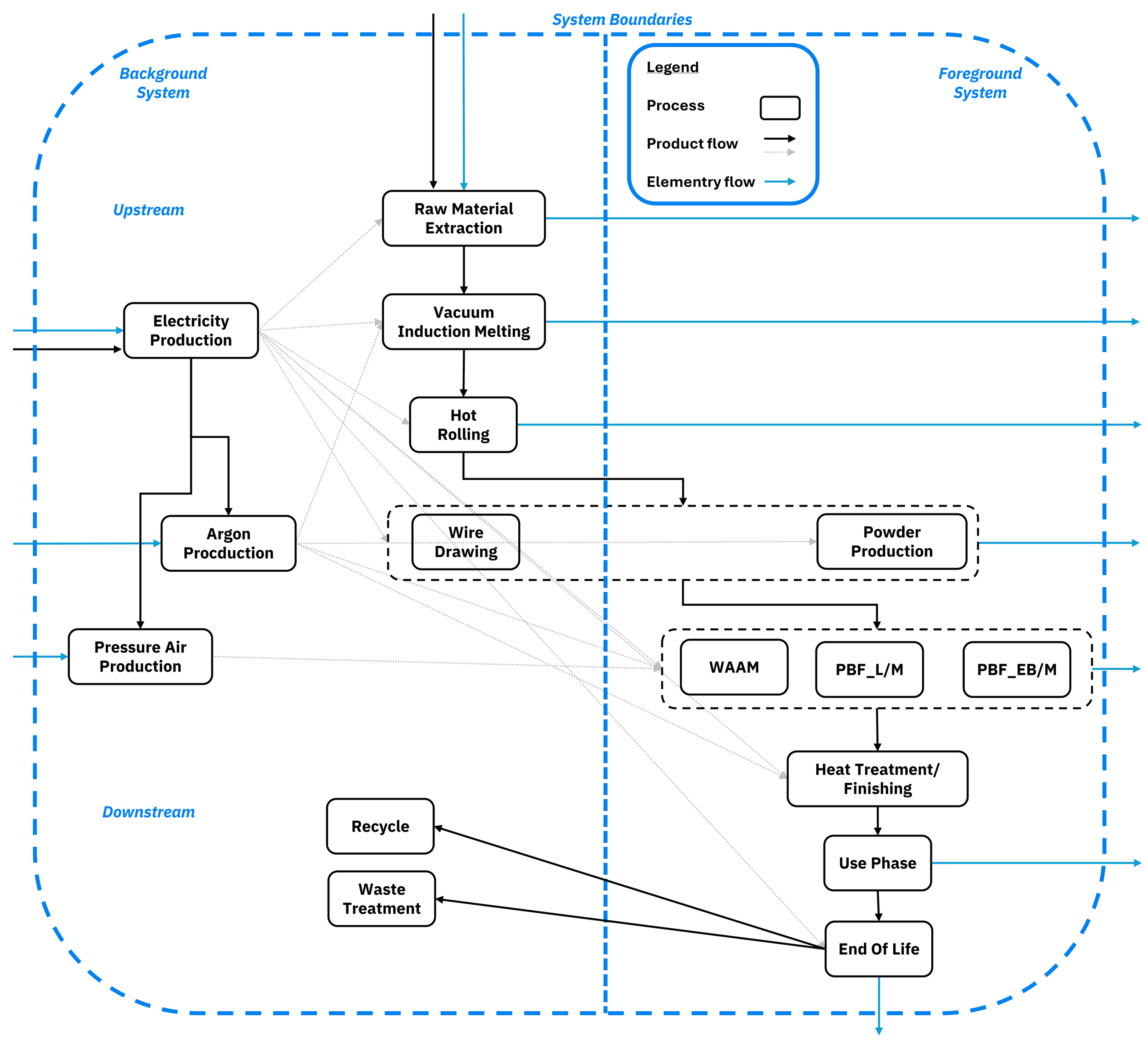


Fig. 3: Product System of Additive Manufacturing processes

Methodology

1. **Data Input:** Data is entered in an excel table or alternatively exported from the measuring device software.
2. **Data Processing:** Processing of the data is done using Python, to be compatible with openLCA's import formats.
3. **Data Import:** Automation of data import into openLCA is achieved through using openLCA Python API.
4. **Data Integration in OpenLCA:** Once imported into openLCA, the data is integrated into LCA models for calculation of environmental impacts.
5. **Visualization:** The outcomes from OpenLCA are transferred to another Python script for visualization.

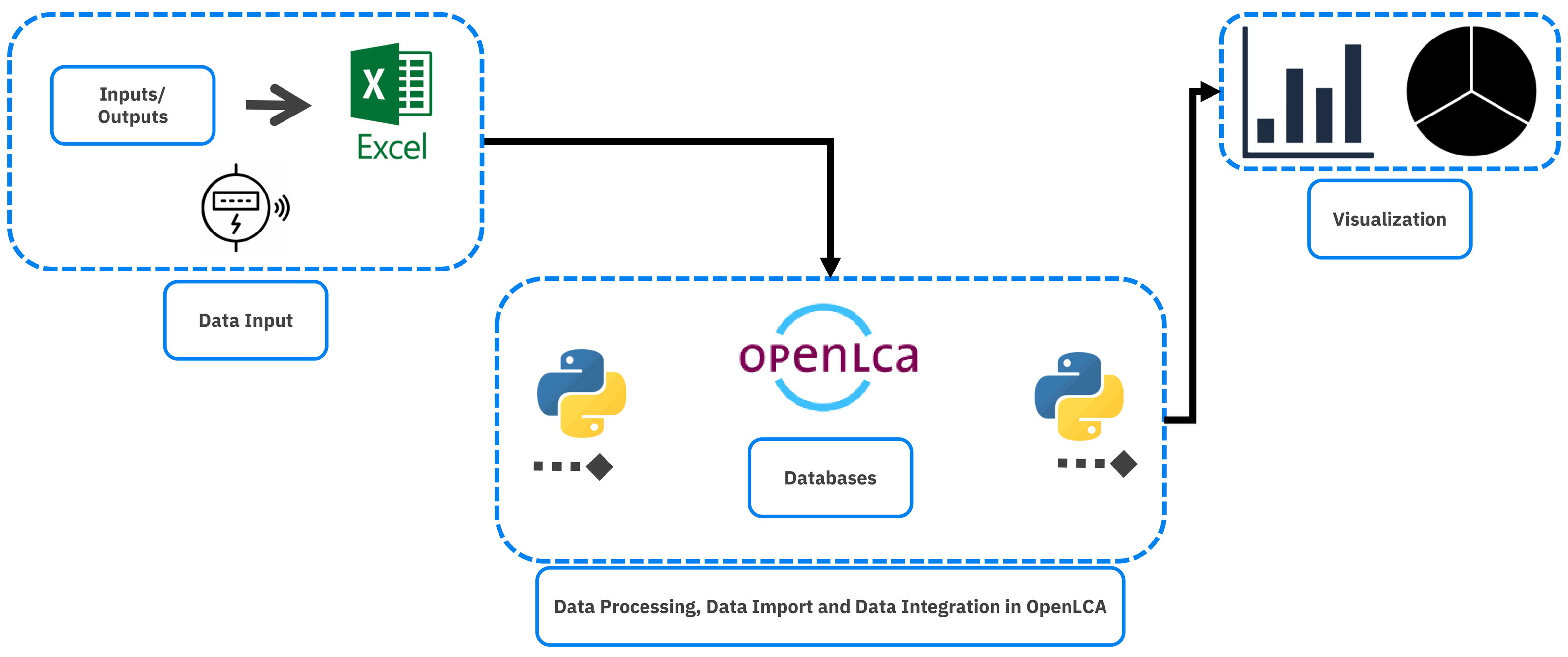


Fig. 2: Schematic of the Sequential Steps in the Tool's Operation

Results

After defining the process chains of the case study within Excel tables, severe procedures from data input to result visualization are streamlined through an integrated Python script. The outcomes derived from calculations within the OpenLCA software (CED and CO2-Eq emissions) are illustrated. The interactive interface, enables users to explore upstream/downstream processes with a simple click. Furthermore, a unified diagram will display a defined process in different methodologies.

Application of the tool to this case demonstrated that its rapid visualization of environmental impacts serves as a valuable aid, facilating the camparisons across different manufacturing methods.

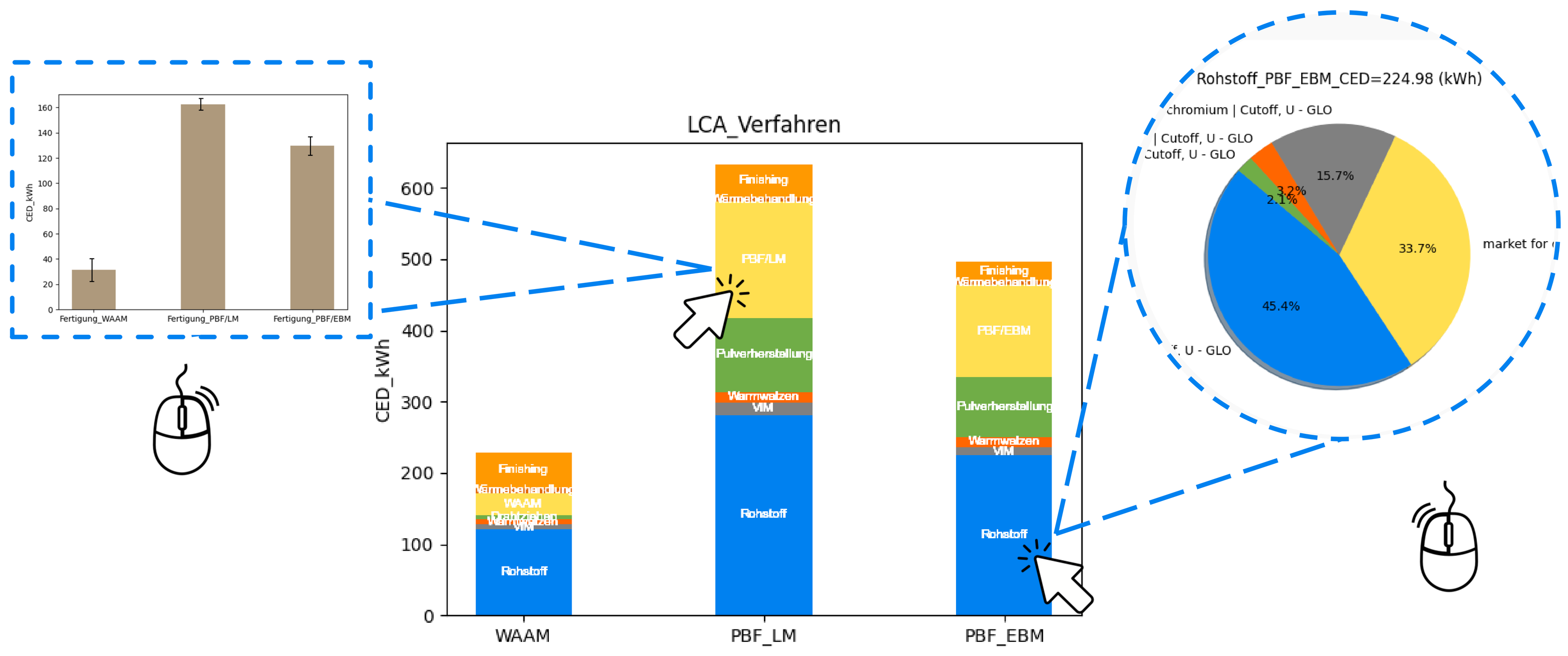


Fig. 4: Interactive Visualization of Results

Case Study

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

Conclusion

In summary, the created tool and the implemented Python program provide a solid foundation for enabling and automating the process of conducting life cycle assessments for industrial AM 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 enhancing LCAs in the industrial context.

Rasool Okhovat, M. Sc.
Rasool.okhovat@tu-berlin.de

Werner-von-Siemens Centre for Industry and Science
Funded by the European Union
MPM Methods for Product Development and Mechatronics
TU berlin

Spatially Explicit Life Cycle Assessment of Solar Power in Gansu, China in 2020

Shuning Shi[1], Xiaoyu Yan[2]

[1,2] Environment and Sustainability Institute & Engineering Department, Faculty of Environment, Science and Economy, University of Exeter, Penryn, Cornwall TR10 9FE, UK

Contact: ss1382@exeter.ac.uk

University of Exeter

Introduction

China's power system experienced significant expansion over the last decade, with the total generation rising from 4.2PWh in 2010 to 7.6PWh in 2020. During this period, solar power generation increased from 0.3TWh (less than 0.01% of the total generation) in 2010 to 261TWh (3.6% of the total generation) in 2020.

The expansion of solar power in China's power sector has shown benefits of reducing carbon emissions. However, other associated environmental impacts should also be assessed to understand not only the environmental benefits (i.e., carbon emission reduction) but also the adverse environmental concerns of the current solar power system.

Life cycle assessment (LCA) is a well-established method to evaluate the environmental impact associated with the full life cycle of a product or system. It has been widely applied to assess environmental impacts of China's power system in existing papers. However, there is no study evaluating a comprehensive set of environmental impacts as well as their spatial distribution caused by China's current solar power system at the provincial and national levels.

Therefore, this study used Gansu province in China as an example and evaluated its full life cycle environmental impacts in 2020, considering the upstream supply chains of both solar panels and key materials (i.e., iron and steel, aluminium, copper, and concrete). It can help policymakers gain a more comprehensive understanding of the magnitude and spatial distribution of environmental impacts brought by solar power in Gansu province and design appropriate policies on power transition in provinces of China.

Method

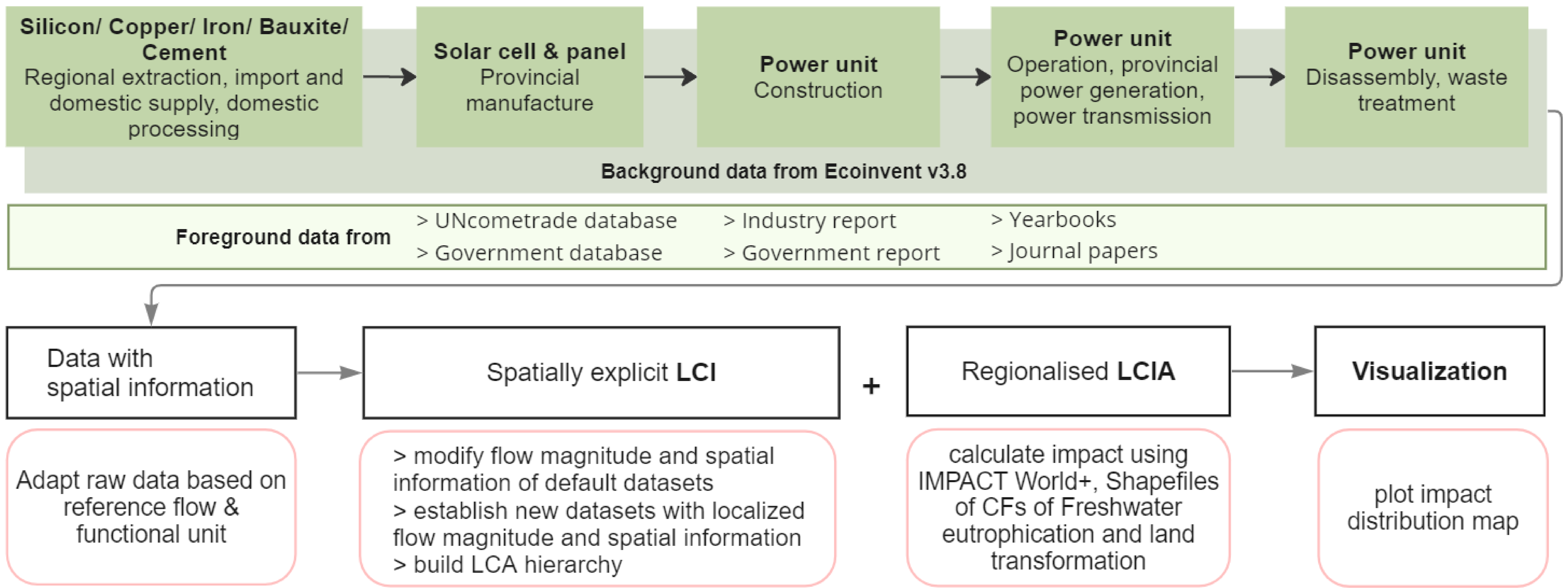


Figure 1. The workflow of this study.

- The target system is the solar power generation in Gansu province, China. The system boundary includes all key life cycle stages of solar power in Gansu province, such as raw material extraction, manufacture, construction, operation, and end of life.
- A functional unit of 1kWh electricity generated is used to facilitate comparisons between studies.
- The regionalized LCIA method used here is IMPACT World+, the impact categories analyzed are Global Warming Potential (GWP), Particulate Matter Formation (PM), Mineral Resource Use, Land Transformation (biodiversity), and Freshwater Eutrophication. The regionalized characterization factors are manually matched with elementary flows for the last two categories.
- The magnitude of the impacts is assessed at a provincial level. The resolution of the spatial distribution of impacts is at a provincial level within China and a national level outside of China.

Results

Table 1. Impacts caused by generating 1kWh solar power and coal power in Gansu province

Impact category	Solar power	Coal power	Unit
Global warming potential	33.74	1143.45	g CO_2 eq/kWh
Particulate matter formation	0.01	0.25	g PM2.5 eq/kWh
Land transformation, biodiversity	5.99	43.37	mm² arable land eq/kWh
Mineral resources use	0.12	0.10	g deprived/kWh
Freshwater eutrophication	0.27	0.19	mg PO_4 P-lim eq/kWh

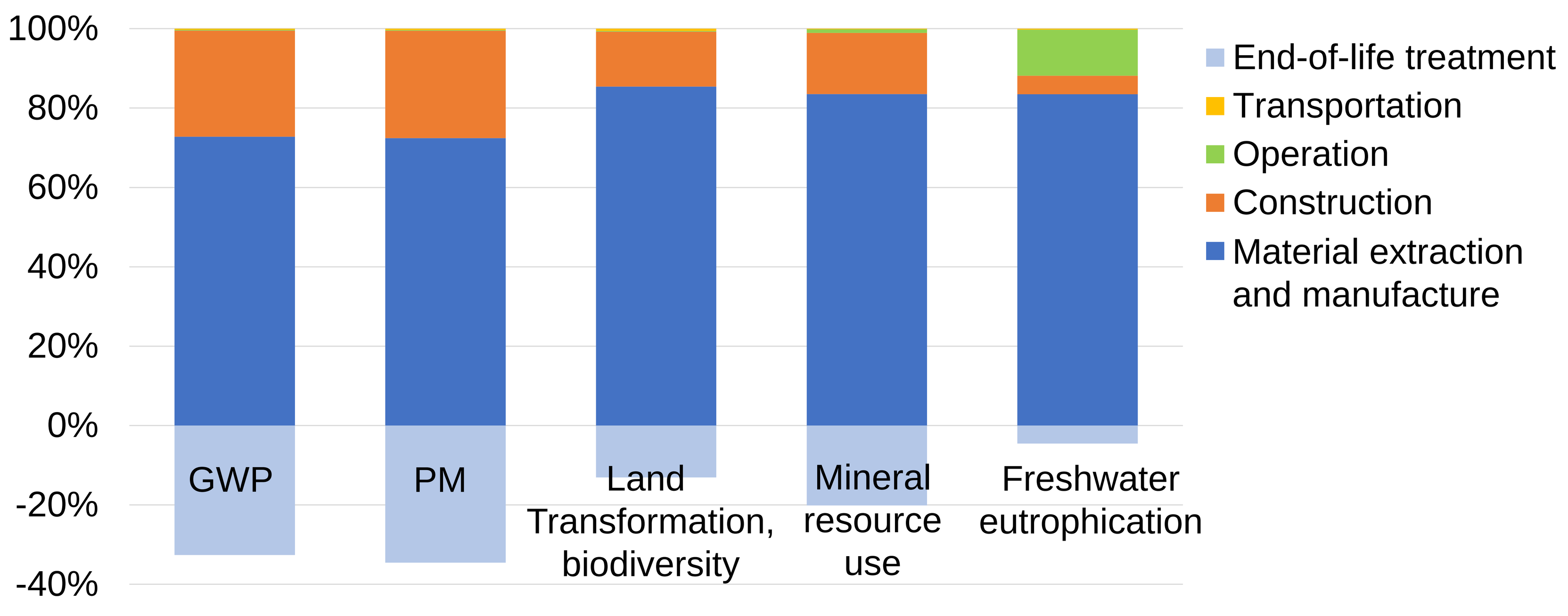


Figure 2. Impacts from life cycle stages of solar power (in percent).

For 1 kWh power generation, solar has significantly lower Global Warming Potential, Particulate matter formation, and Land transformation and higher Mineral resource use and Freshwater eutrophication.

Material extraction and manufacture contributes the most in all life cycle phases, among all categories (Figure 2). The operation stage contributes significantly to the Freshwater eutrophication due to wastewater from routine panel cleaning.

In Figure 3, the Freshwater Eutrophication of solar power generation is widespread both domestically and internationally. Within China, the impact distribution is dominated by silicon wafer production which discharges wastewater containing high concentration of BOD and COD, distributing in Jiangsu (9%), Xinjiang (7%), Yunnan (5%), and Inner Mongolia (4%). Gansu accounts for only 0.0002% of the total impact. Over 60% impact was outside China, scattering across Russia (37%), Rest of the world (17%), Global (3%), Switzerland (1.9%), Europe (1.6%), Middle East (1.1%).

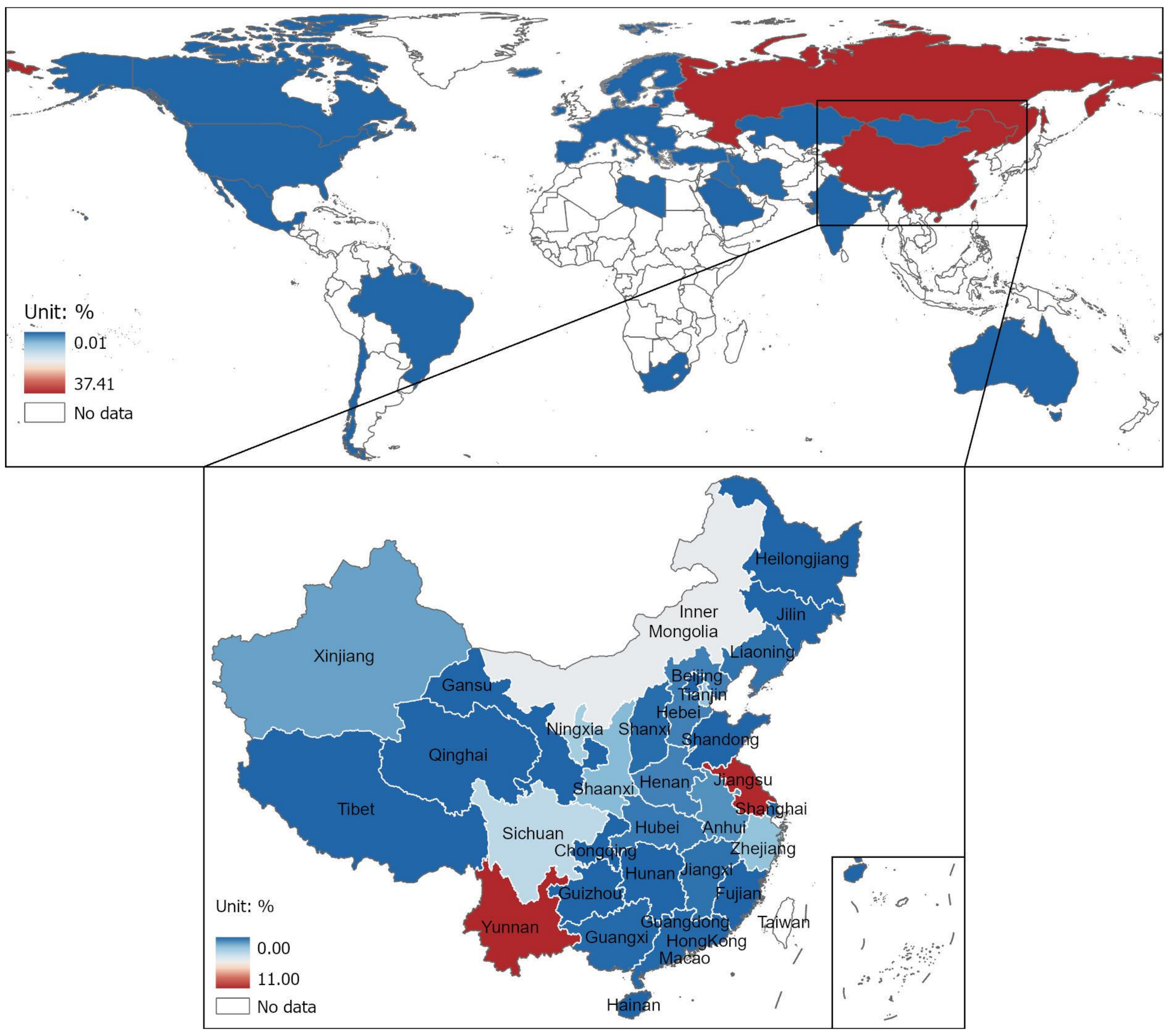


Figure 3. Spatial distribution of Freshwater Eutrophication by solar power generation in Gansu. The colour depth indicates the magnitude of impact share on each area. The impact shares of Rest of World, Global are 16.6% and 2.5%, which are not shown on the map. The Impact share of China, average takes up 4.1%。

In conclusion, the result indicates the risk to mineral supply and freshwater quality brought by the future expansion of solar power, despite its carbon reduction benefits. Also, the spatial distribution of Freshwater Eutrophication indicates the environmental hotspot is in certain provinces in China, but also in some other countries such as Russia.

Parametric Open Data for Life Cycle Assessment (POD | LCA)

ARPA-E Award No. DE-AR0001624

UNIVERSITY of WASHINGTON

Funding opportunity from ARPA-E


arpa·e
VIEW AVAILABLE FUNDING | Search... | SEARCH
ABOUT · TECHNOLOGIES · TECHNOLOGY-TO-MARKET · NEWS & MEDIA · EVENTS · CAREER · FAQS

Press Release

Home / News & Media / Press Releases

HESTIA

U.S. Department of Energy Announces $39 Million for Research and Development to Turn Buildings Into Carbon Storage Structures

Funding Will Support 18 Projects Aiming to Develop Building Materials that Decarbonize the Atmosphere

06/13/2022

WASHINGTON, D.C. — The U.S. Department of Energy (DOE) today announced $39 million in awards for 18 projects seeking to develop technologies that can transform buildings into net carbon storage structures. Led by DOE's Advanced Research Projects Agency-Energy (ARPA-E), selectees for the Harnessing Emissions into Structures Taking Inputs from the Atmosphere (HESTIA) program will prioritize overcoming barriers associated with carbon-storing buildings, including scarce, expensive and geographically limited building materials. Decarbonization goals for the HESTIA program mirror President Biden's plan to reach zero emissions by 2050 and aim to increase the total amount of carbon stored in buildings to create carbon sinks, which absorb more carbon from the atmosphere than released during the construction process.

"There's huge, untapped potential in reimagining building materials and construction techniques as carbon sinks that support a cleaner atmosphere and advance President Biden's national climate goals," said **U.S. Secretary of Energy Jennifer M. Granholm**. "This is a unique opportunity for researchers to advance clean energy materials to tackle one of the hardest to decarbonize sectors that is responsible for roughly 10% of total annual emissions in the United States."

Greenhouse gas (GHG) emissions associated with material manufacturing and construction, renovation, and disposal of buildings at the end of their service life are concentrated at the start of a building's lifetime, making them essential to address given the urgency of meeting national energy and environmental

In addition to the HESTIA program, ARPA-E recently announced $5 million in funding through the HESTIA Exploratory Topic to two universities working to develop the necessary life cycle assessment tools and frameworks associated with transforming buildings into net carbon storage structures. Learn more about this funding on the HESTIA Exploratory Topic webpage.

ARPA-E = Advanced Research Projects Agency-Energy

HESTIA = Harnessing Emissions into Structures Taking Inputs from the Atmosphere

"... prioritize overcoming barriers associated with carbon-storing buildings..."

"... aim to increase the total amount of carbon stored in buildings to create carbon sinks..."

"There's a huge, untapped potential in reimagining building materials and construction techniques as carbon sinks..."

"...$5 million in funding... two universities working to develop the necessary life cycle assessment tools and frameworks..."

Two universities =
- University of Washington
- University of California, Davis

Link:
https://arpa-e.energy.gov/news-and-media/press-releases/us-department-energy-announces-39-million-research-development

Collaborators

HESTIA Teams

Team group	#	Project name (shortened)	Lead	Partners
Insulation composite teams	1	Insulation Panels from Bio-Based Feedstock	U of Buffalo	U of Maryland, NREL, ORNL, CleanFiber
	2	High Performance, Carbon Negative Building Insulation	Aspen Products Group	Saint Gobain
	3	Celium: Cellulose-Mycelium Composites	NREL Alaska	U of Alaska, VTT Finland, USDA Forest Products Lab
	4	Lignin-Derived Carbon Storing Foams	UT Knoxville	SUNY-ESF, Clark Atlanta University, UC Riverside
Other composite teams	5	CO2mposite: Carbon Nanotubes + Biomass Composite Panels	SkyNano	Endeavor Composites, UT Knoxville
	6	C3: Cellulose Cement Composite	OSU	WoodSyn, LLC, Purdue, U of Maine, Synergos, Humphreys & Partners Architects
Concrete/ cement teams	7	Carbon-Negative Concrete from Biofuel Byproducts	NREL Colorado	Carbon Upcycling Technologies, CU Boulder, Colorado School of Mines, SAFFIRE Renewables, LLC
	8	Photosynthetic Carbon-Negative Cement	CU Boulder	Minus Materials, NREL, U of North Carolina Wilmington
	9	Carbon-Negative Concrete through Direct Air Capture	U of Wisconsin	Penn State, U of Illinois Chicago
Wood-ish teams	10	Bamboo-Wood Hybrid Wall System	Bamcore	
	11	Living Wood (wood + microbes)	Purdue	Michigan State University
Building design teams	12	Circular Home: Reusable Residence	PNNL	Green Canopy Node, WSU
	13	Mass Timber Floor System	Clemson U	
	14	Hempcrete 3D-Printed Buildings	Texas A&M	
	15	4C2B: CLT Diaphragms + Steel Buildings	Northeastern U	Simpson, Gumpertz & Heger, UMass Amherst, Swarthmore, OPAL
	16	3D-Printed Funicular Systems	UPenn	KierenTimberlake, CUNY York

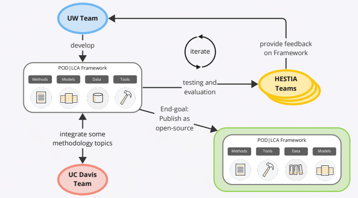
UC Davis Team

UC Davis · **UC Berkeley** · **Lawrence Berkeley National Lab**

Project name: Carbon-Negative Buildings Assessment and Tool (CaNBAT)

Project goal: The UC Davis team will develop novel frameworks to analyze and guide life-cycle environmental assessment of novel building materials with the aim to sequester GHGs.

Method of collaboration



Problem statement, project goal, target users, and impacts

POD|LCA: Parametric Open Data for Life Cycle Assessment

Problem statement

Carbon-storing construction materials have the potential to reduce greenhouse gas emissions on a global scale.

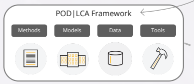
However, the environmental data and assessment methods for novel carbon-storing materials is currently limited.

Due to the unknowns, building designers are hesitant about adopting these materials in their building designs.

Manufacturers of carbon-storing materials are struggling to gain traction at scale.

Project goal

We will create a suite of methods and tools to assess the environmental impacts of novel carbon-storing materials and building designs in the rapid prototyping and design process.



Users

Material scientists and manufacturers of novel carbon-storing materials

Design teams who want to use these materials

Policymakers who want to have accurate and fair comparisons of materials for policy programs

Anticipated wider impacts

Reduced life cycle GHG emissions of building materials

More carbon storage in buildings materials

Expanded market for carbon-storing materials

Policy incentives for use of carbon-storing materials

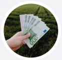
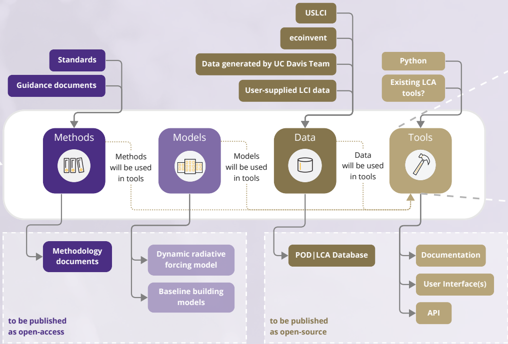
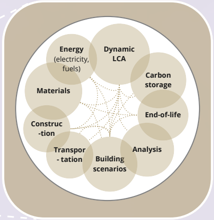


Image sources:
https://www.pexels.com/photo/green-tea-farm-during-golden-hour-2582652/, https://www.pexels.com/photo/question-marks-on-paper-crafts-5428824/, https://www.pexels.com/photo/scientist-in-lab-3735706/, https://www.pexels.com/photo/three-people-sitting-beside-table-416405/, https://www.pexels.com/photo/gray-concrete-building-937524/, https://www.pexels.com/photo/black-ship-on-body-of-water-screenshot-929382/, https://www.pexels.com/photo/macro-photography-of-green-leaf-4593897/, https://www.pexels.com/photo/multi-colored-folders-piled-up-159519/, https://www.pexels.com/photo/crop-farmer-showing-money-in-green-summer-field-in-countryside-4497591/

POD|LCA Framework: Inputs and outputs



POD|LCA tool modules



Project team

Kathrina Simonen - Principal Investigator (PI), Stephanie Carlisle - Co-Investigator (Co-I), Francesca Pierobon (Co-I), Indroneil Ganguly (Co-I), Tomás Méndez Echenagucia (Co-I), Chris Meek (Co-I), Monica Huang (Research Engineer), Teresa Moroseos (Post-Doc), Ethan Ellingboe (Research Engineer), Mel Chafart (Research Engineer), Anber Rana (Post-Doc), Lieke Droog (Graduate Research Assistant), Meng-Yen Lin (Graduate Research Assistant), Mahsa Torabi (Graduate Research Assistant), Christina Bjarvin (Graduate Research Assistant), Mohammad Tabatabaei Manesh (Graduate Research Assistant)
(gray = past team member)
Website: www.carbonleadershipforum.org/podlca-project/
E-mail: clfdata@uw.edu

April - May 2024

Integrating OpenLCA in the Analysis of Transport System Decarbonization

Syré, Anne; Okhovat, Rasool; Maier, Otto; Göhlich, Dietmar
Chair of Methods for Product Development and Mechatronics, Technische Universität Berlin

The urgent need to transition the transport system for climate protection motivates our aim to integrate OpenLCA into transport simulations for comprehensive life cycle assessments (LCAs). Through the olca ipc package, we seamlessly incorporate LCAs into our framework, streamlining the analysis of diverse transport scenarios and driving technology choices. Although OpenLCA integration simplifies the process, future efforts will focus on optimizing schedules and infrastructure for sustainability using cost and emission data within transport simulations, evaluating the decarbonization potential of transport system.

Motivation and Approach

- Climate protection, local air quality, limited urban space, and resource scarcity drive the need for transport system adaptation.
- Single-vehicle LCAs may overlook broader influences within entire transport systems.
- Integration of new technologies like demand-responsive transport relies on agent-based simulations such as MATSim and for specific bus schedule planning, we utilize the simulation tool eflips.
- Simulation outcomes require evaluation for cost and environment.
- Objective: Integrate OpenLCA into the framework using the Python package olca ipc for conducting LCAs of various transport scenarios.

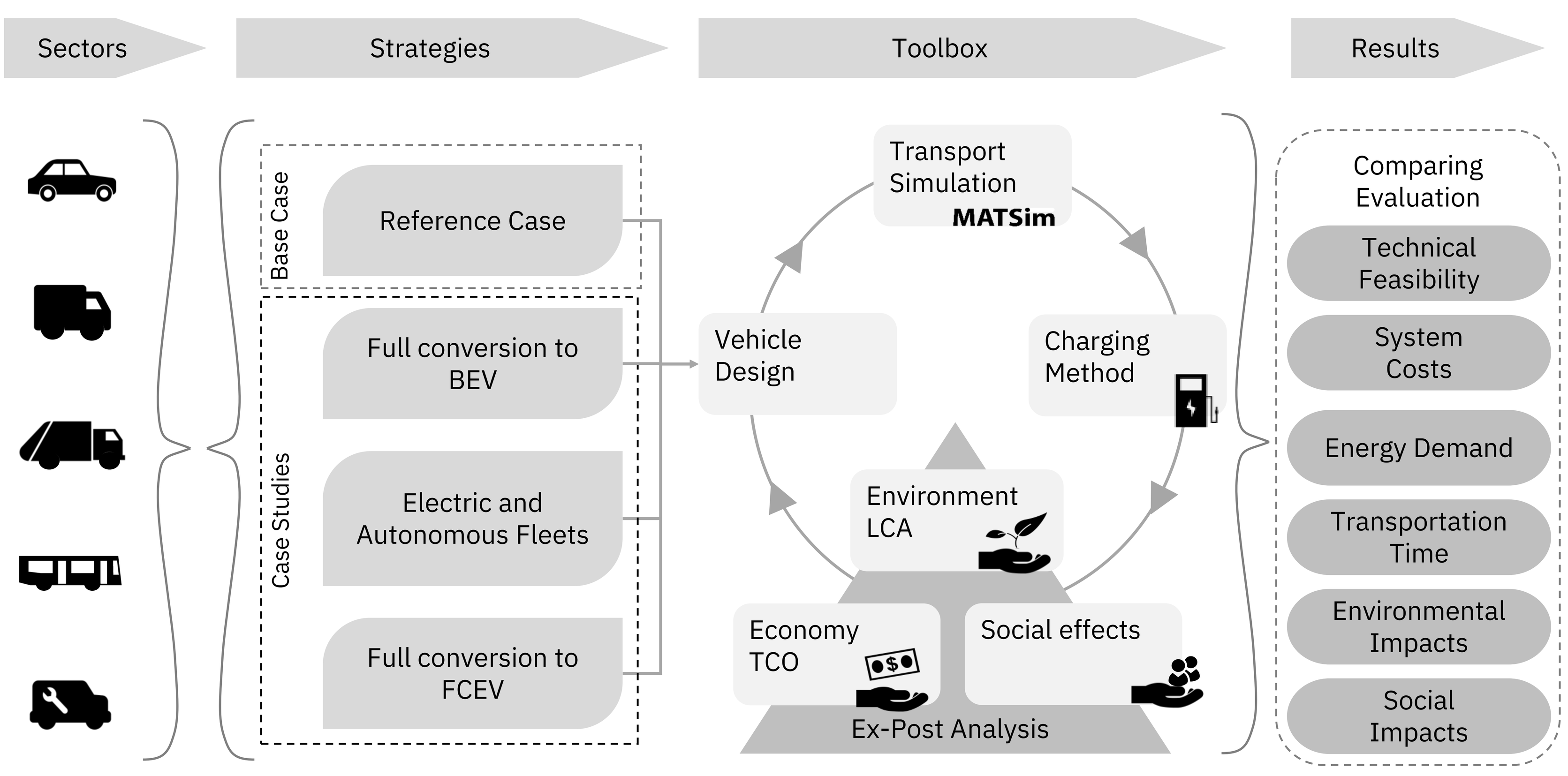


Figure 1: zeroCUTS Methodlogy [1]

OpenLCA and olca in zeroCUTS

- The olca package enables utilizing simulation outputs for LCAs
- Computes environmental impacts for diverse transport scenarios
- Direct integration within simulations can be time-consuming
- Mainly due to transport simulation intricacies
- OpenLCA can be challenging without a solid LCA foundation
- Streamlines the process for engineers
- Allows engineers to adjust parameters and automate LCAs

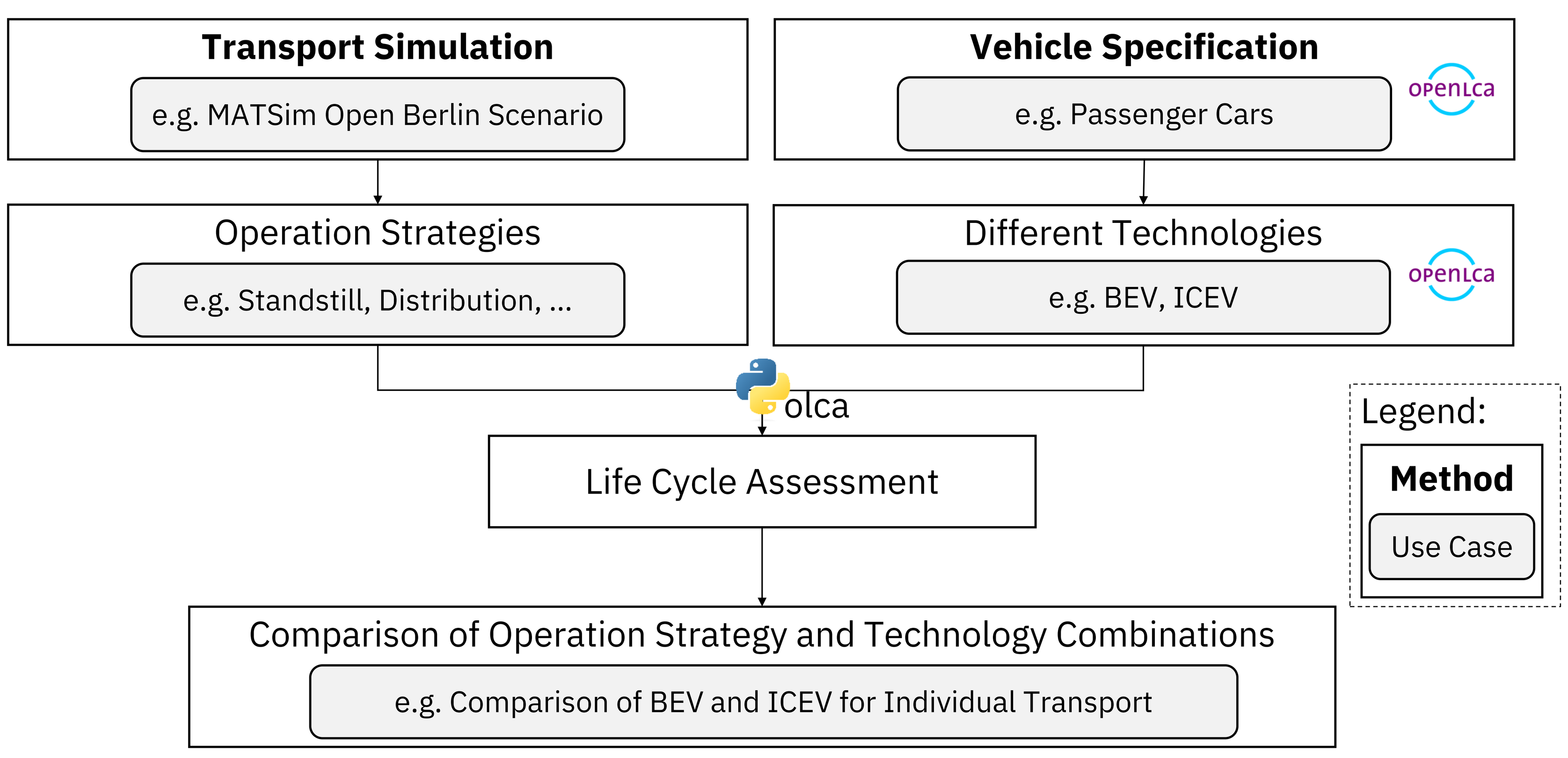


Figure 2: OpenLCA and olca in zeroCUTS [1, adapted]

Motorized Individual Transport

- The sole transition of drive trains is insufficient for a complete decarbonization of transport.
- However, there is a considerable decarbonization potential with higher shares of renewable energies, a different vehicle distribution and a higher lifetime mileage.

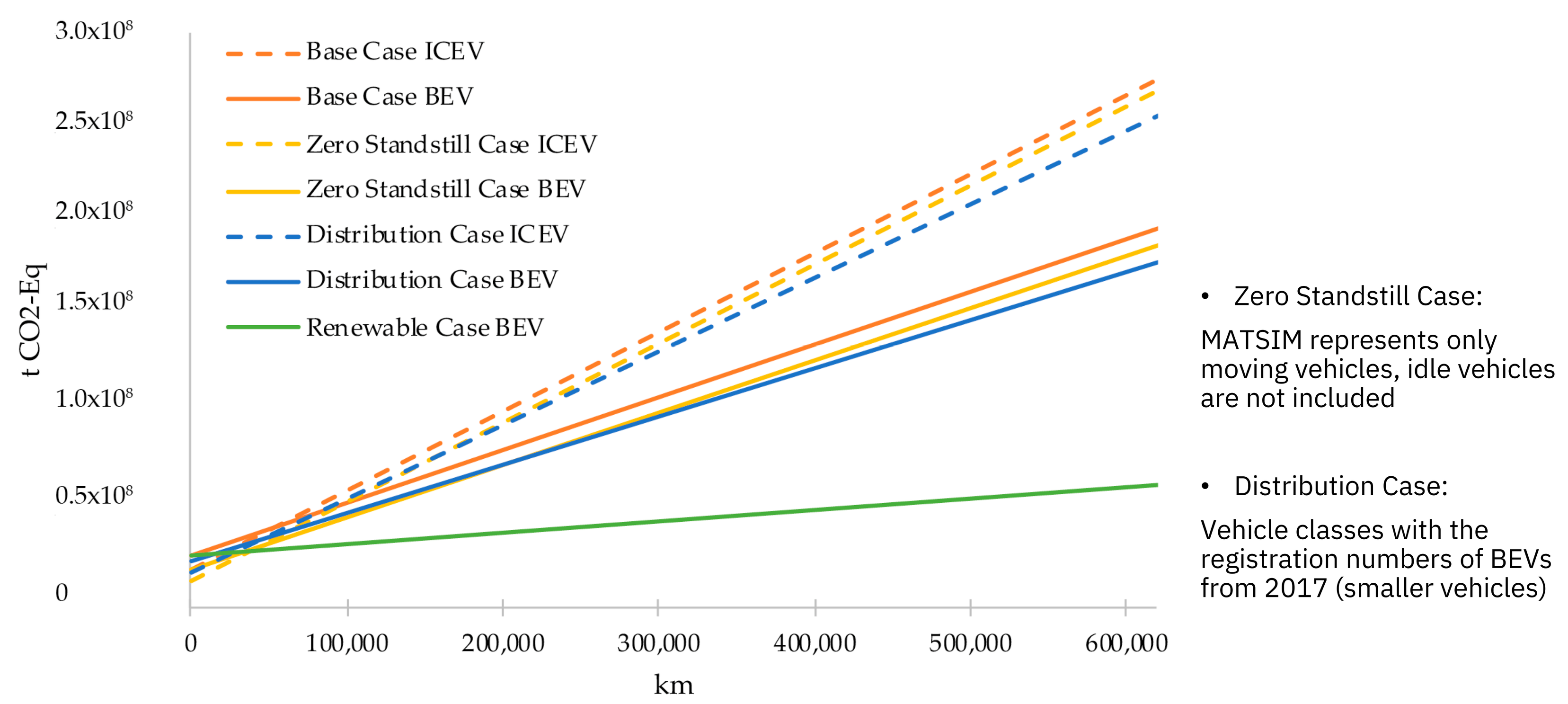


Figure 3: GHG Emissions Motorized Individual Transport [2]

Heavy-Duty Long-Haul Transport

- FCEV have highest life cycle emissions, BEV with high-power chargers follow, due to large batteries, BEV using electric road systems exhibit lowest emissions.
- Decision between BEV and FCEV depends on vehicle-to-infrastructure ratio and routes.

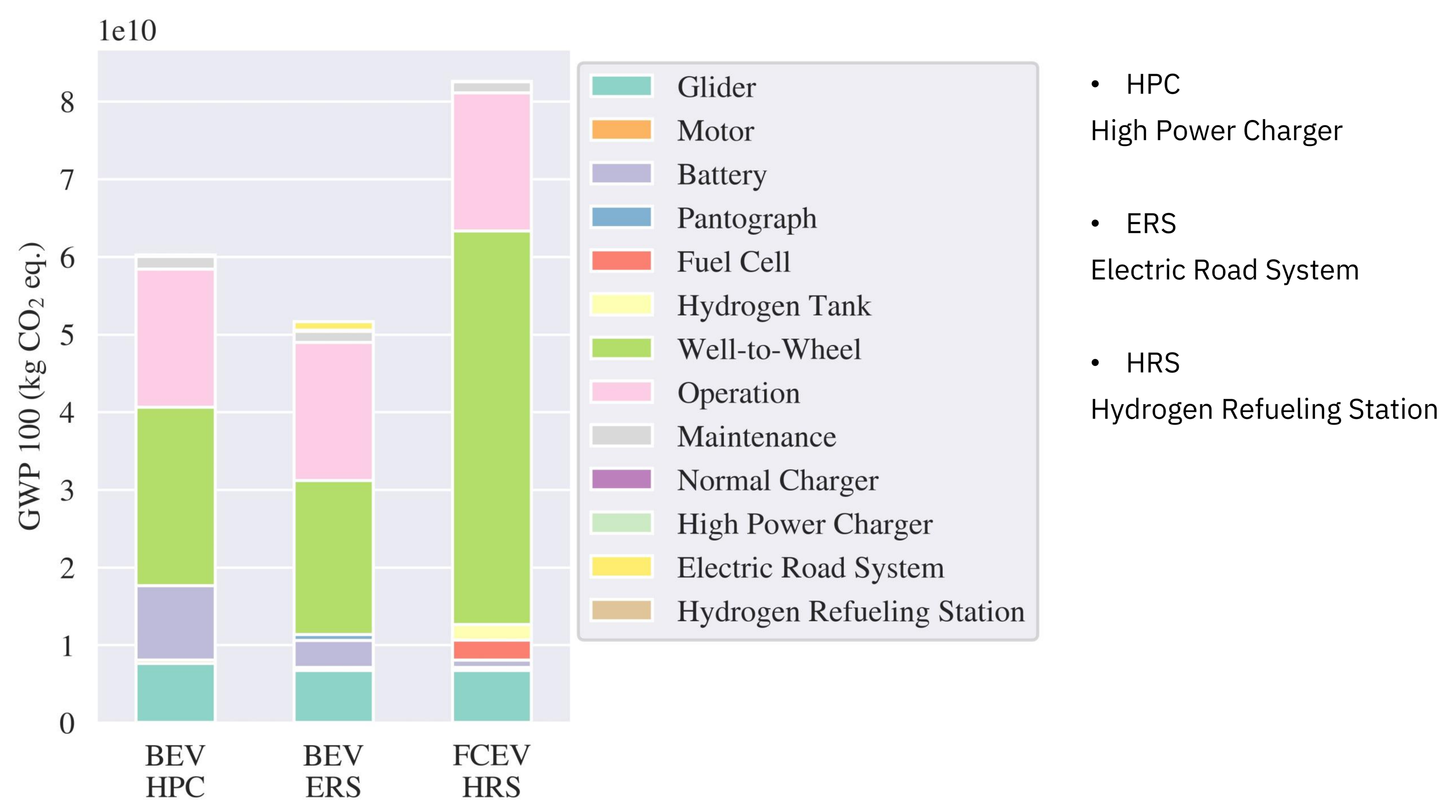


Figure 4: GHG Emissions Long-Haul Trucks incl. Infrastructure [3]

Conclusion and Outlook

The integration of OpenLCA in the analysis of transport system decarbonization allows for an automated comparative analysis of different transport scenarios.

LCA of Urban Bus Fleets
Eflips – Calculation of LCCA, Support of decision making in the electrification of Berlins public transport and decarbonization

Emission Optimization
Emission data applied through jsprit within MATSim to optimize truck and freight schedules

Creation of Product System via olca
Integration of a simplified product system creation model
Development of simplified adoptable product system

References

1. Göhlich et al. (2021): Integrated Approach for the Assessment of Strategies for the Decarbonization of Urban Traffic. *Sustainability*
2. Syré et al. (2020): Method for a Multi-Vehicle, Simulation-Based Life Cycle Assessment and Application to Berlin's Motorized Individual Transport. *Sustainability*
3. Syré and Göhlich (2024): Life Cycle Assessment of Battery and Fuel Cell Electric Heavy-Duty Trucks including Infrastructure Demand. *EVS37 Symposium*, COEX, Seoul, Korea

Anne Magdalene Syré, M. Sc.
a.syre@tu-berlin.de

The "zeroCUTS" project is funded by the Deutsche Forschungsgemeinschaft (DFG), project number: 398051144.

DFG Deutsche Forschungsgemeinschaft

MPM Methods for Product Development and Mechatronics

Using openLCA for microalgae production systems

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

[1] Decerna, Decerna House, Cramlington, NE23 7BF, UK.
[2]GreenCoLab, Universidade do Algarve, Campus de Gambelas, Ed. 2, Gab. 2.1, 8005-139 Faro, Portugal.

Over the past five years, Decerna and GreenCoLab have used OpenLCA in a range of microalgae focused projects. In terms of funded work, this has included Horizon Europe and Portuguese funded projects. Some examples are MAGNIFICENT, REALM, MicroBoost, and AlgaCycle. In terms of commercial work, at Decerna we have used openLCA to conduct a detailed due diligence of the Brilliant Planet Carbon Dioxide Removal system in Morocco.

By employing OpenLCA in these projects, we have developed a comprehensive Life Cycle Inventory (LCI) specific to microalgae production, enabling us to identify key impact hotspots and explore potential solutions for enhancing the sustainability of the microalgae sector.

Algae production in Portugal

Decerna and GreenCoLab have undertaken a range of LCAs for microalgae production projects for a range of uses, which have utilised the production systems at Necton in Olhão and Allmicroalgae in Pataias.

Reusing Effluents from Agriculture to unLock the potential of Microalgae
Grant agreement ID: 101060991

The process
- Drain water from agriculture is captured
- This is used for the production of microalgae
- This microalgae is then processed to produce products for agriculture and aquaculture
- The CO2 for the facility is captured from the air, and solar energy is used to run the facility.

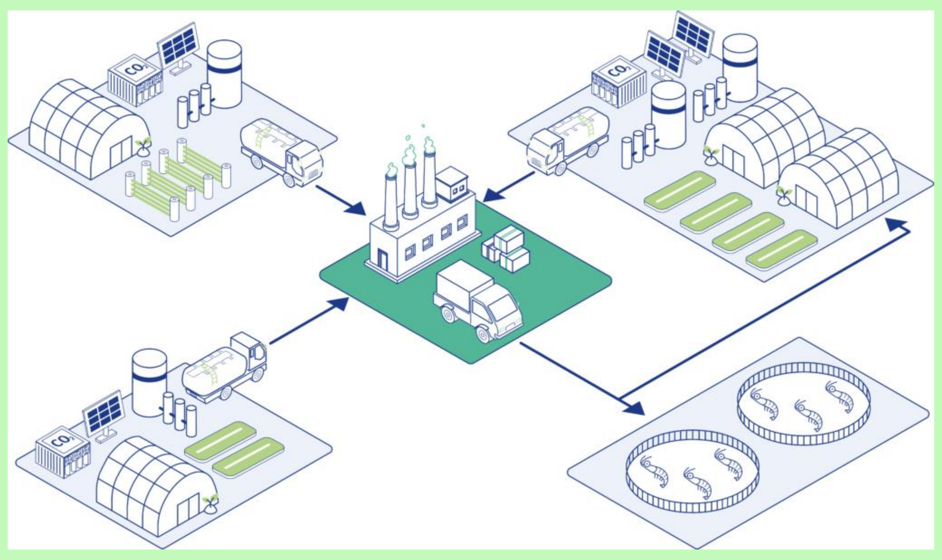


Figure 1: Illustration the REALM concept

The LCA
- A large model of the integrated agricultural/aquaculture/microalgae system is being produced
- So far, the Goal and Scope is complete, and the full LCI is underway.

Other related projects include;

Commercial: Brilliant Planet

Brilliant Planet is developing a Carbon Capture system based around microalgae production, drying, and burial. The organisation currently runs a three-hectare facility in Akhfennir, Morocco, intending to construct a 30-hectare facility in 2024 and a 1000-hectare facility in 2025. For this to be a viable system, in terms of impacting climate change and commercial income, a vital part of this is to understand the climate change impacts of the operation and construction of the site throughout the whole supply chain. For the Brilliant Planet facility to succeed, it must sequester more carbon than it emits.

The Life Cycle Assessment of the 30-hectare microalgae Carbon Capture system followed the ISO 14040/44 standards. Data is based upon a mixture of real data, collected at the existing three-hectare site in Akhfennir, scientific assumptions, literature data, and secondary data from the Ecoinvent 3.8 database.

Models were constructed within openLCA. The functional unit was to understand the environmental impacts of the sequestration of **one tonne of CO2.**

Three scenarios were modelled to evaluate the influence of different energy sources and carbon utilization options:

1. Moroccan electricity grid-based with an existing Ecoinvent 3.8 model
2. Solar farm-based electricity
3. Wind farm-based electricity

Each scenario included sub scenarios where improvements were made to the infrastructure

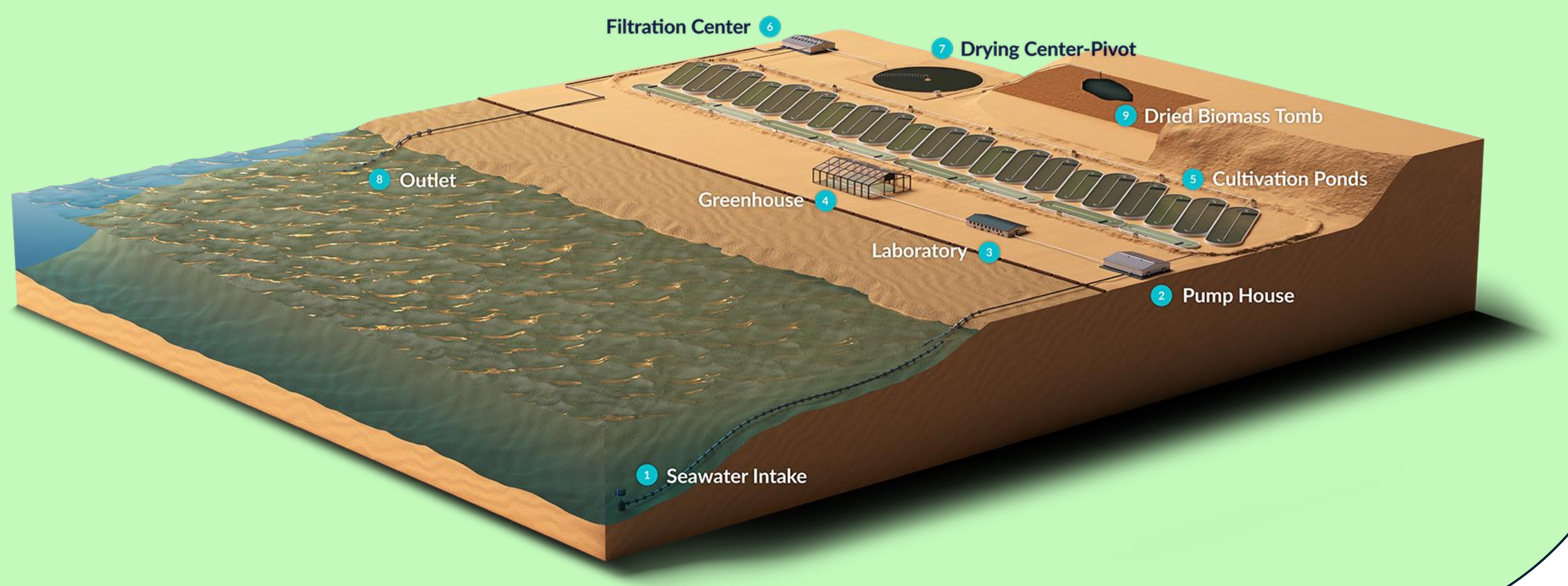


Figure 2: Illustration the site layout of Brilliant Planet system.

Results and observations

Algae production in Portugal

- When comparing microalgae with other protein sources, it became clear the water use for soy is not correct within Ecoinvent
- Modelling of protein sources, that can help displace destruction of the Amazon, or production of EPA/DHA rich oils that help displace Antarctic trawling, have impacts outside of standard ReCiPe or other impact categories. We need more biodiversity-based indicators, so we can demonstrate how microalgae production on low quality low biodiversity land can prevent damage in more biodiverse or fragile ecosystems by displacing damaging industries.
- Moving from PMMA to glass based photobioreactors, for the photobioreactor based projects, have improved the infrastructure impacts
- Demonstrations of the Monte Carlo analysis using distributions based on Pedigree Matrix data can provide different results for comparing scenarios to a basic arithmetic calculation, leading to different decisions.
- Whatever the type of microalgae production, the core issues across projects is always from energy use and fertilisers
- Implementing Collaboration Server is the only sensible way to create models with a large team

Brilliant Planet

- Complex intake pipeline system was identified as an environmental hotspot on the previous site, so this was re-evaluated and changed to a beach well intake system, then a breakwater intake system.
- Material choices were changed, and differing scenarios were examined as a result of the original LCA.
- Steel and nutrient models for the construction of the facility and for the cultivation of the algae were altered. Alternative steel sources were found, resulting in a reduction in the impacts associated with the construction of the site.
- Nutrients for the microalgae were also identified as an environmental hotspot in the original 30ha site. Using the findings from the original report it was clear that alternative nutrients/creation methods were required
- When using low carbon energy, the Brilliant Planet is a clear absorber of carbon
- For a system powered by wind, and choosing infrastructure materials wisely, the Brilliant Planet system emits 133kgCO2e for every 1000kg sequestered, giving an efficiency of 87%. Further infrastructure and increases in productivity will improve this figure.

Elements developed within these models, and observations of openLCA

- When modelling low carbon electricity options, such as photovoltaics, the energy outputs estimated by Ecoinvent are variable in accuracy. We have created a new photovoltaic model based on literature data and using the productivity data from site specific PVSyst modelling. We are supplementing this now with models of batteries, that include their number of cycles per year.
- Whatever the type of microalgae production, the core issues across projects is always from energy use and fertilisers
- A large Life Cycle Inventory of microalgae related technology has been compiled by Decerna and GreenCoLab, with an increasing level of specific carbon capture models
- All models are fully parametrized, to allow for multiple scenarios, and to deal with the issue of designs of early stage technologies changing rapidly
- Switches are included to turn on and off elements of the models, such as infrastructure, and to wholesale change energy or chemical providers across models

Conclusions

Microalgae has been investigated across these projects for a range of uses. The most promising options are "integration with other systems and applications, such as food/feed production and carbon capture. Reducing energy and nutrient use, or increasing the productivity, and the consistent main options for improving the LCA of microalgae, with a range of infrastructure improvements also identified in these projects.

REALM was Co-funded by the European Union

AlgaCycle and MircoBoost were was Co-funded by the European Economic Area (EEA) Agreement

Social Life Cycle Assessment (SLCA) of a district cooling plant in Vienna

Schauer, R.; Piringer, G.; Rixrath, D.; Weber, R., University of Applied Sciences Burgenland, Austria
Zisser, G.; Buchner, S., Wien Energie GmbH, Austria

FH Burgenland
UNIVERSITY OF APPLIED SCIENCES

Introduction

With the increasing importance of sustainability considerations in infrastructure development, understanding the social implications of energy systems is crucial. District cooling systems can be important components of climate adaptation strategies, particularly in urban environments. This study aims at providing preliminary results of a Social Life Cycle Assessment (SLCA) of a district cooling plant (DCP) in Vienna, Austria (Fig. 1). It compares the cooling plant's social impacts to those of a benchmark large compression chiller (CCM), and it pinpoints hotspots of social impacts within the systems.

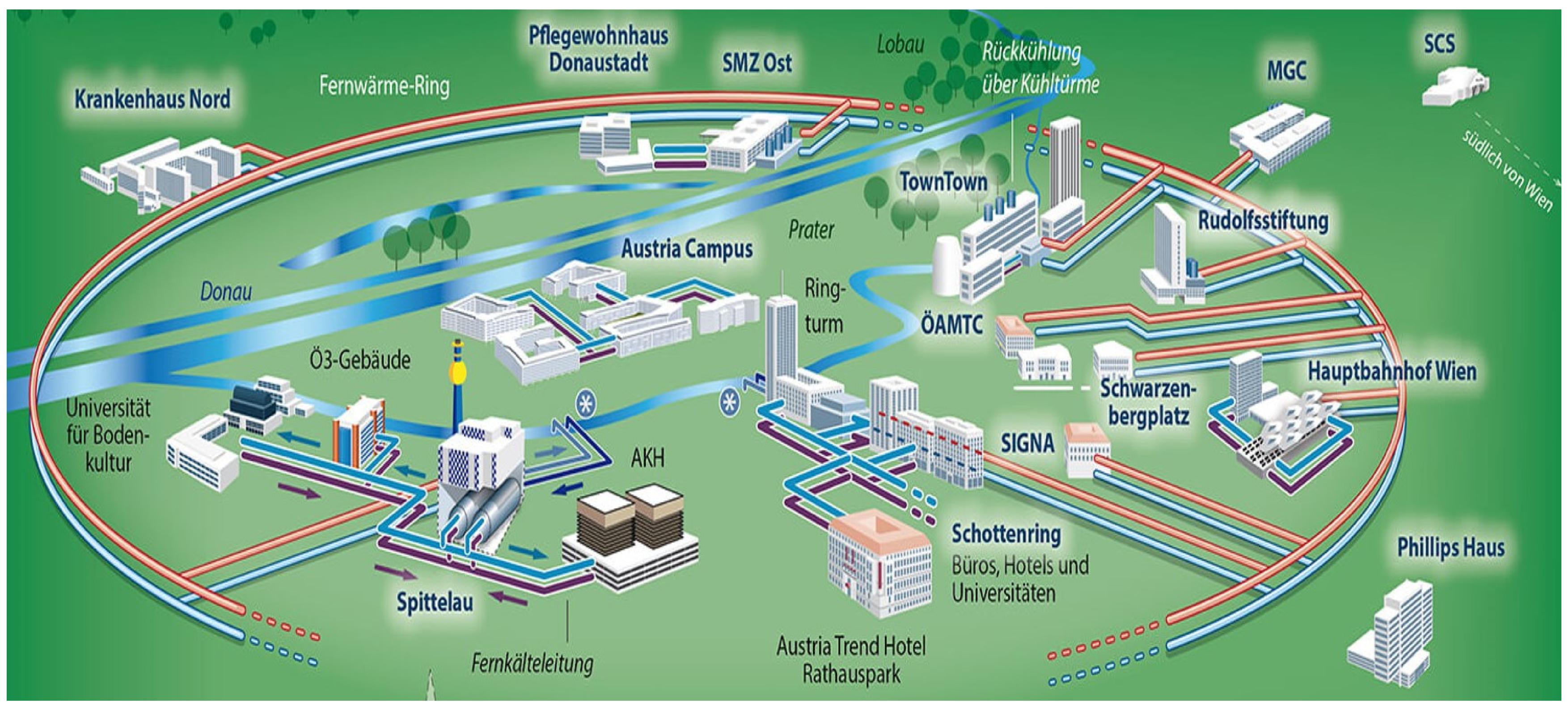


Figure 1: District cooling network including district cooling plants of the Wien Energie utility in Vienna [1]

Materials & Methods

The study models an existing DCP consisting of three compression chillers and two absorption chillers, the latter supplied by district heat. The model supports an SLCA based on the ISO 14040 standard [2] for life cycle assessment, using the Soca v2.0 database and the "Social Impacts Weighting Method [3], as well as the OpenLCA (GreenDelta GmbH, Berlin, Germany) software. The functional unit was chosen to be 1 MWh of cooling energy supplied at the plant boundary, without the subsequent cooling network. The nominal cooling capacity of the DCP is 13.1 MW_{th}, yielding an annual cooling output of 16 795 MWh_{th} from a total annual electricity supply of 1 181 MWh_{el} and a total annual district heating supply of 14 719 MWh_{th}. The energy supply for the chillers was based on 2019 hourly data for the district heating mix [4] and on 2019 hourly electricity mix data from ElectricityMap [5].

Results

The DCP scores worse than the CCM in 45 of the 55 categories analyzed. Table 1 shows the four categories with the highest impacts – they are the same for both systems. In these four categories, the difference between DCP and CCM ranges from just over 5% (CCM = 100%) in the "fair salary" impact category to 45% in the "biomass consumption" category.

Table 1: Social impacts per MWh_{th} cooling, combined district cooling plant (DCP) vs cooling with a compression chiller (CCM) only. Four categories with highest risk hours are shown.]

Impact category	DCP	CCM	Unit/MWh_{th}
Fair Salary	268.73	255.42	FS med risk hours
Drinking water coverage	267.49	204.04	DW med risk hours
Public sector corruption	260.15	178.35	C med risk hours
Biomass consumption	256.73	181.55	BM med risk hours

With both systems, most of the impacts are caused during the operation (Fig. 2). The contributions to the DCP's impacts for all but one of the categories in Table 1 are distributed evenly among three subsystems: electricity demand,

Results (continued)

district heat demand, and construction/end of life (EoL)/maintenance. The only exception is the impact category "Fair Salary", where the share of construction/EoL/maintenance is significantly lower. Impacts from cooling by a CCM are dominated by its electricity consumption (80% of the total; only in the "Fair Salary" category the share is 97%).

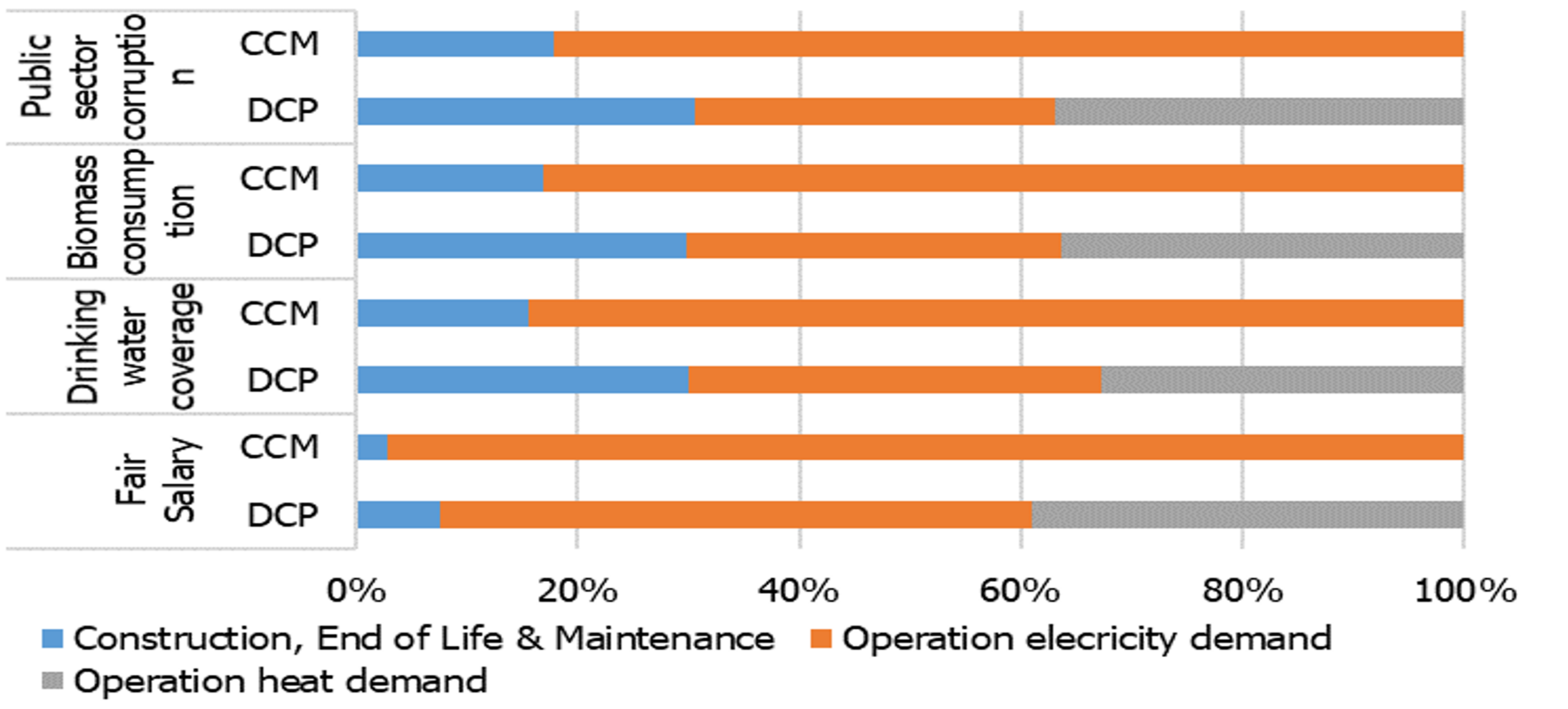


Figure 2: Contribution analysis by life cycle stage, four highest impact categories, per MWh cooling provided. Engine room infrastructure not included. DCP = district cooling plant, CCM = compression chillers.

A more detailed breakdown by processes (Fig. 3) reveals that the impacts are mainly due to the construction of the components required for the plant's energy supply, as well as to the consumption of natural gas.

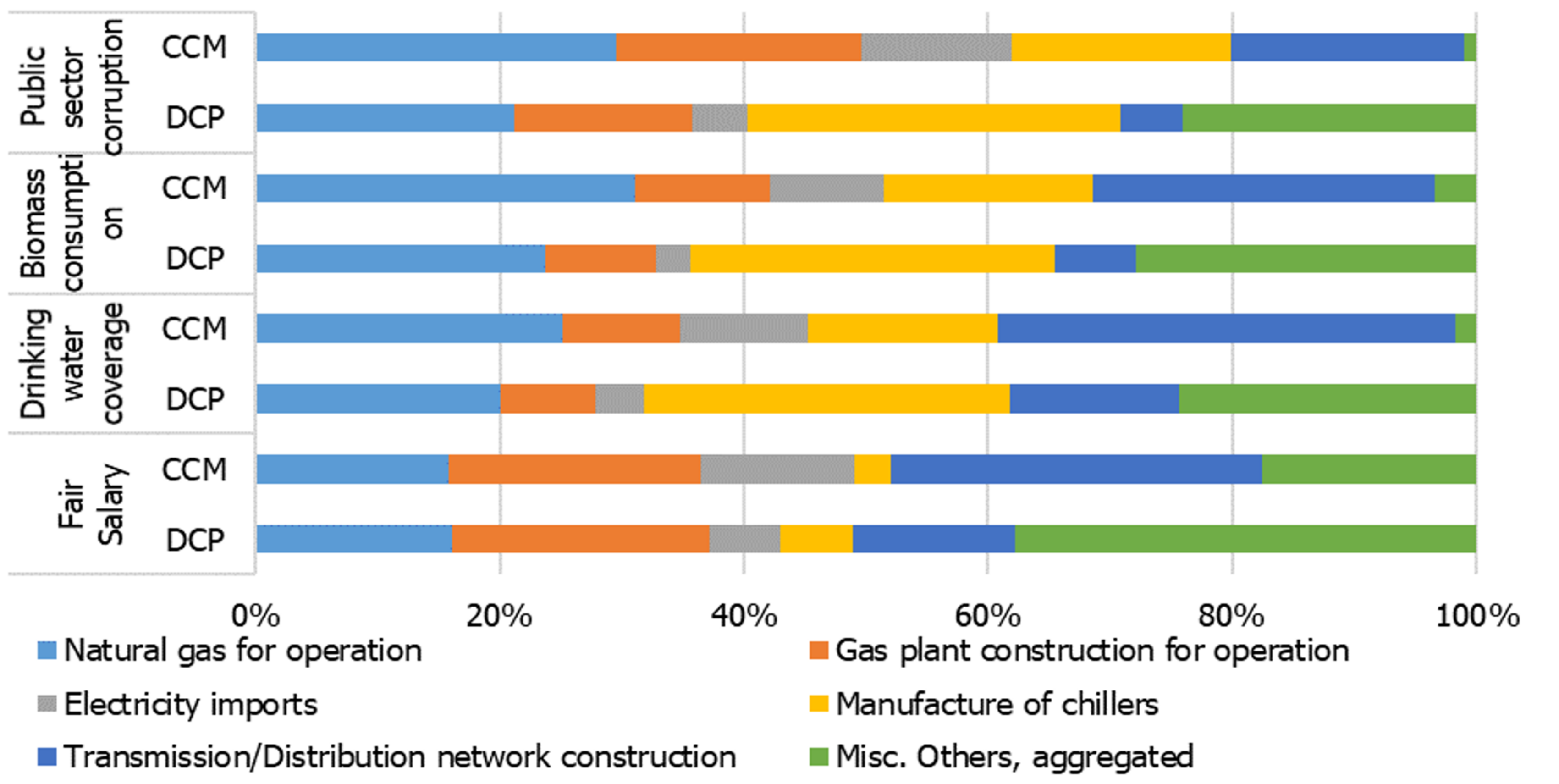


Figure 3: Contribution analysis by main contributing subsystem, per MWh cooling provided.

Conclusions

The provision of cooling by the DCP mix of absorption chillers and compression chillers has a higher social impact than cooling by the CCM compression chiller, in 45 of 55 social impact categories, including the four analysed in more detail. The main impacts of both systems are caused during operation. Besides natural gas consumption during operation, the impacts are driven by the manufacture of the chillers themselves and the manufacture of their energy supply infrastructure. Overall, application of the Soca database and impact assessment method to the energy system in question was found feasible, yielding useful insights into the social impacts of the system's supply chain.

REFERENCES

[1] Wien Energie GmbH, Ausbau der Fernkältezentrale in Spittelau, **2019**.

[2] A. Standards, ÖNORM EN ISO 14040, **2021**.

[3] GreenDelta GmbH, Soca v.2 add-on – Adding social impact information to ecoinvent, **2021**.

[4] Wien Energie GmbH, Unpublished technical documents and monitoring data from Wien Energie GmbH. **2022**.

[5] Electricity Maps, Electricity Data. Electricity Maps Data Portal. **2022**.

ACKNOWLEDGEMENT & PARTNERS

Federal Ministry Republic of Austria Climate Action, Environment, Energy, Mobility, Innovation and Technology
FFG Promoting Innovation.
Christian Doppler Forschungsgesellschaft
WIEN ENERGIE
Burgenland Energie

MORE INFORMATION

Raphael Schauer
FH Burgenland
Energy & Environment
Thermal Energy Technologies
raphael.schauer@fh-burgenland.at
Tel.: +43 5 7705 4141

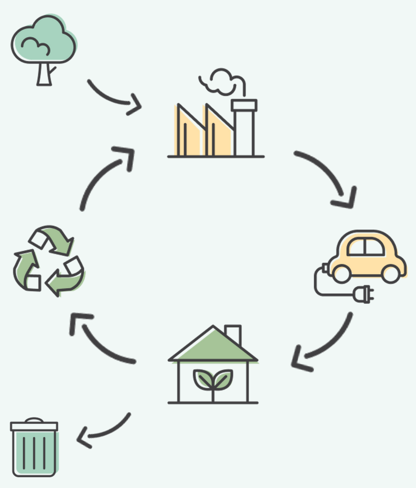
https://www.fh-burgenland.at/

How to automate Life Cycle Assessment (LCA) in the context of Electrical and Electronic Equipment (EEE)

Axelle Bertrand[1,2] (axelle.bertrand@ensam.eu)
Tom Bauer[1,3], Carole Charbuillet[1,3], Martin Bonte[2], Marie Voyer[2], Nicolas Perry[1]
1 Arts et Métiers, CNRS, Université de Bordeaux, I2M. Esplanade des Arts et Métiers, 33405 Talence, France.
2 Qweeko, 150 rue Mondenard, 33000 Bordeaux, France.
3 Institut Arts et Métiers, I2M. 4 rue du Lac Majeur, 73375 Le Bourget-du-Lac, France.

Challenges in the EEE sector

- PhD thesis in partnership with the start-up Qweeko :
  - Meet the need for massive generation of environmental declarations on EEE products
- Regulations :
  - France : RE2020, Climate Law
  - Europe : European EPD, PEF
- Limitations of LCA :
  - Expensive : 10 to 15K€
  - Complex : Hundreds of components
  - Long :
    - Complete LCA : ≈ 6 months
    - Data reconciliation and modelisation : 3-5 days
  - Lack of data and expert



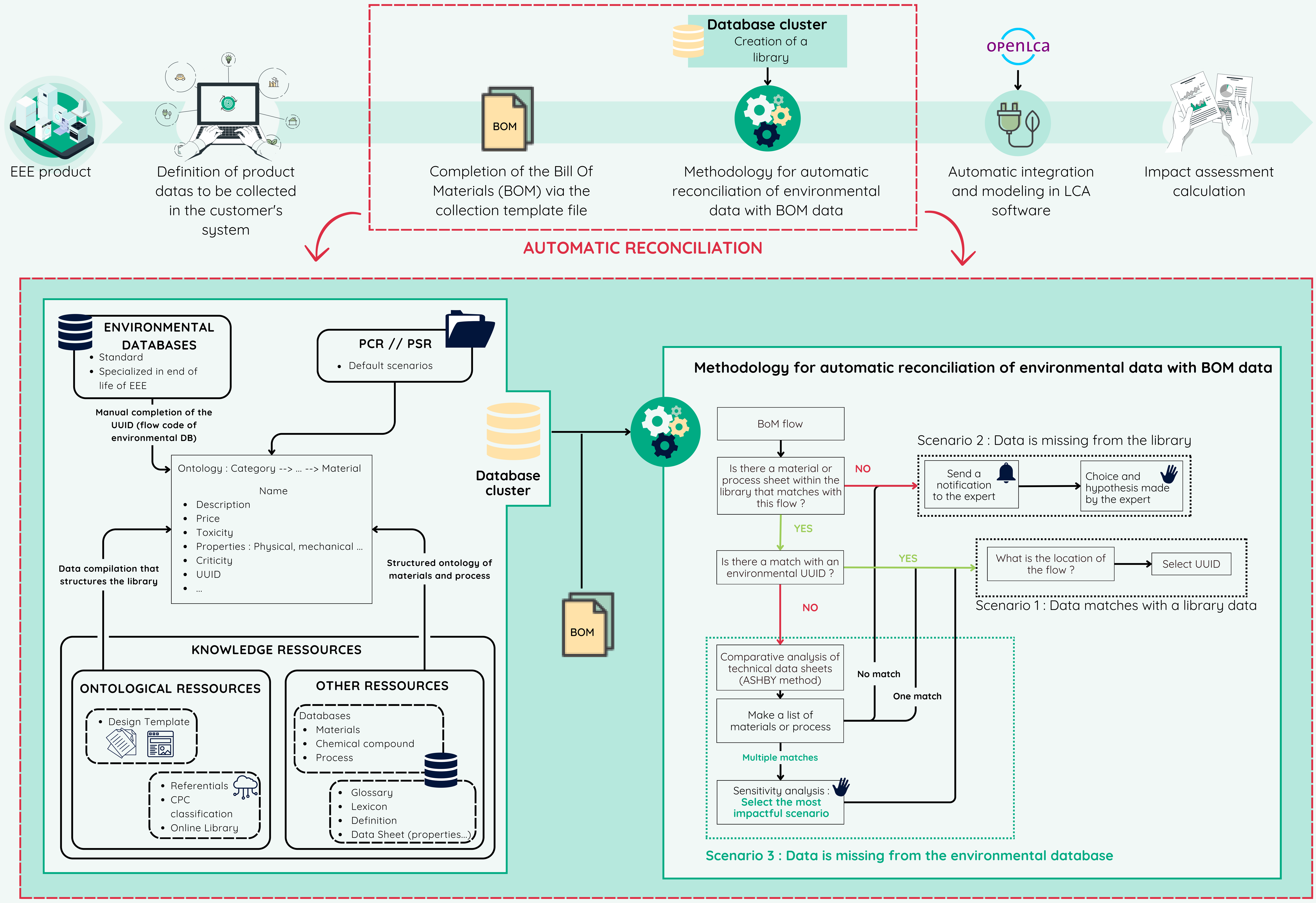
How to design and implement an automated LCA method?

How can we effectively automate inventory data reconciliation in LCA ?

Research methodology

- State of the art of methods for **simplification** and **automation** of the life cycle inventory :
  - Limitations : Lack of documentation in LCA, Process Opacity (Black Box), Partially automated (potential not fully explored)
  - Advantages : Reducing LCA time, suitable for complex models (supervised, unsupervised), multiple approaches available
- Adaptation of the selected method :
  - Literature : Method of selecting materials in product design (≈ 20 articles)
  - Preparation and test the questionnaire : How the expert makes his reconciliation and modeling choices in the LCA software
  - Interviews : Semi-structured interviews with 10 experts
- Validate the method :
  - **Processing time**
  - Scalability : Ability to manage the data source, ability to manage a large amount of data
  - Precision
  - Consistency
  - Reproducibility and repeatability

Proposed method for automatic data reconciliation



Preliminary results

Analysis criterias	Results
[1] Processing time of LCI data reconciliation on approximately 500 data items and for 5 LCAs	[1] **Automatic LCI : 1 hour** Manual LCI : 3/5 days
[2] Scalability • Ability to manage the data source • Ability to manage a large amount of data	[2] In progress
[3] Precision	[3] In progress Manually assess the accuracy of the lifecycle stages, modules and quantities within the LCA software, using the data collection file as reference
[4] Consistency	[4] In progress Compare manual and automated LCA : Identify and analyse gaps, and suggest adjustment. Use the Weidema matrix criterion to improve the consistency of the results. Repeat with around twenty validated LCAs
[5] Reproductibillity and repeatability	[5] In progress Perform around ten LCAs with the same input data. This measure aims to guarantee the stability of the results produced by the methodology

Conclusion

- Massification is possible with the life cycle inventory automation tool
- Data reconciliation still requires manual intervention at this stage

Perspectives

- Analyze the following criterias : Precision, Consistency, Reproducibility
- Article : "An approach to automate the modeling of life cycle inventory data" being submitted
- Environmental communication :
  - EPD : PEP sheet and report
  - Environmental display : ICED article "Environmental labeling of electrical electronic equipment (EEE) in France : information for consumers"

Comparative Social Life Cycle Assessment of Beverage Packaging Alternatives

Damjan Krajnc[1], Yee Van Fan[2], Kristijan Brglez[3], Rebeka Kovačič Lukman[3,4], Čuček Lidija[1]

[1] University of Maribor, Faculty of Chemistry and Chemical Engineering, Maribor, Slovenia, damjan.krajnc@um.si
[2] Brno University of Technology – VUT Brno, Faculty of Mechanical Engineering, Brno, Czech Republic,
[3] Faculty of Natural Sciences and Mathematics, University of Maribor, Koroška c. 160, 2000 Maribor, Slovenia
[4] Faculty of Logistics, University of Maribor, Mariborska c. 7, 3000 Celje, Slovenia

1. INTRODUCTION

This study comprehensively assesses the social impact of beverage packaging systems, focusing on polyethylene terephthalate (PET) bottles, glass bottles and aluminium cans. By leveraging the SOCA database, which provides extensive data on social indicators across various sectors, and insights from beverage producers, our methodology systematically identifies and assesses critical areas within the packaging life cycle that have significant social impacts, such as labour practices and community impacts associated with these packaging alternatives.

2. OBJECTIVES

The aim of this study is to assess the potential social impact of the following packaging production systems: **polyethylene terephthalate (PET)** bottles, **glass bottle (GL)** and **aluminum can (ALU).**

3. METHODS AND MATERIALS

3.1 FUNCTIONAL UNIT

The functional unit of the study was defined as the packaging, necessary for filling and distribution of 1000 L of filled beverage. The reference flow of a product system included the actual beverage packaging, labels and closures, transport packaging (reusable bottles, corrugated trays, shrink-wrap for disposable containers, pallets).

3.2 LCA METHOD

The study has been carried out using the OpenLCA 2.0 software tool for Life Cycle Assessment (LCA) modelling. Data have been sourced from SOCA 2.0 databases as well as beverage manufacturers. The Social impacts have been estimated according to the Social impact weighting method.

3.3 SYSTEM BOUNDARIES

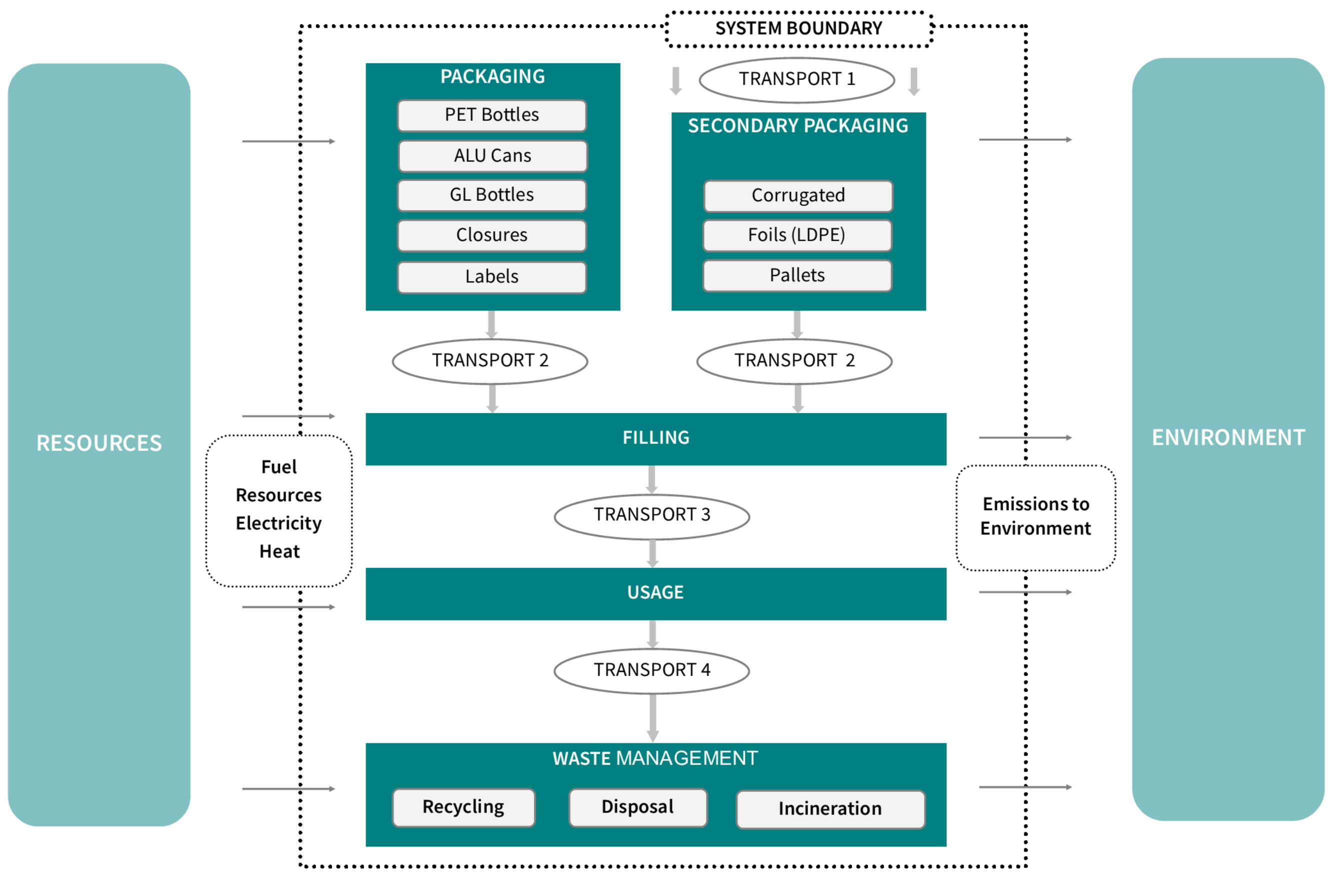


Figure 1: Representation of system boundaries. The following activities were excluded from the system boundary: (1) mass flows contributing less than 1 % to total mass flows, (2) transportation of consumers to buy drinks.

4. LIFE CYCLE INVENTORY

4.1 PROCESS SCHEMES

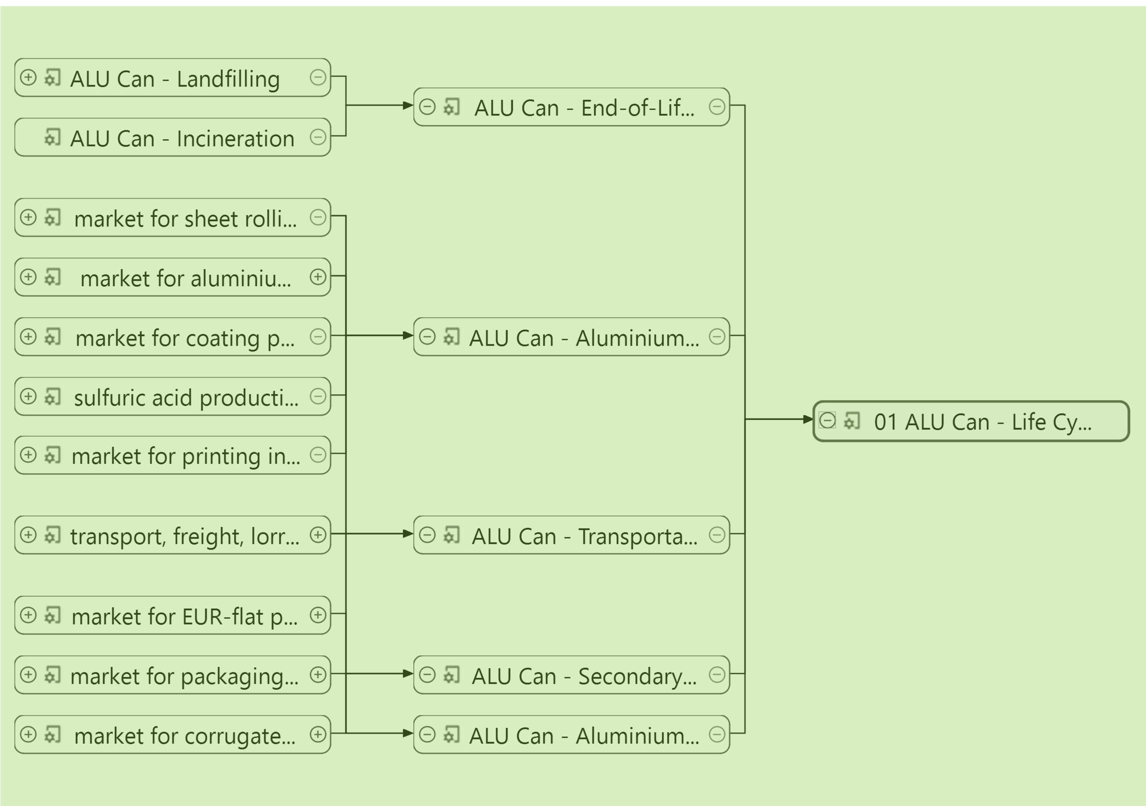


Figure 2: Process scheme of the life cycle of aluminium can containers.

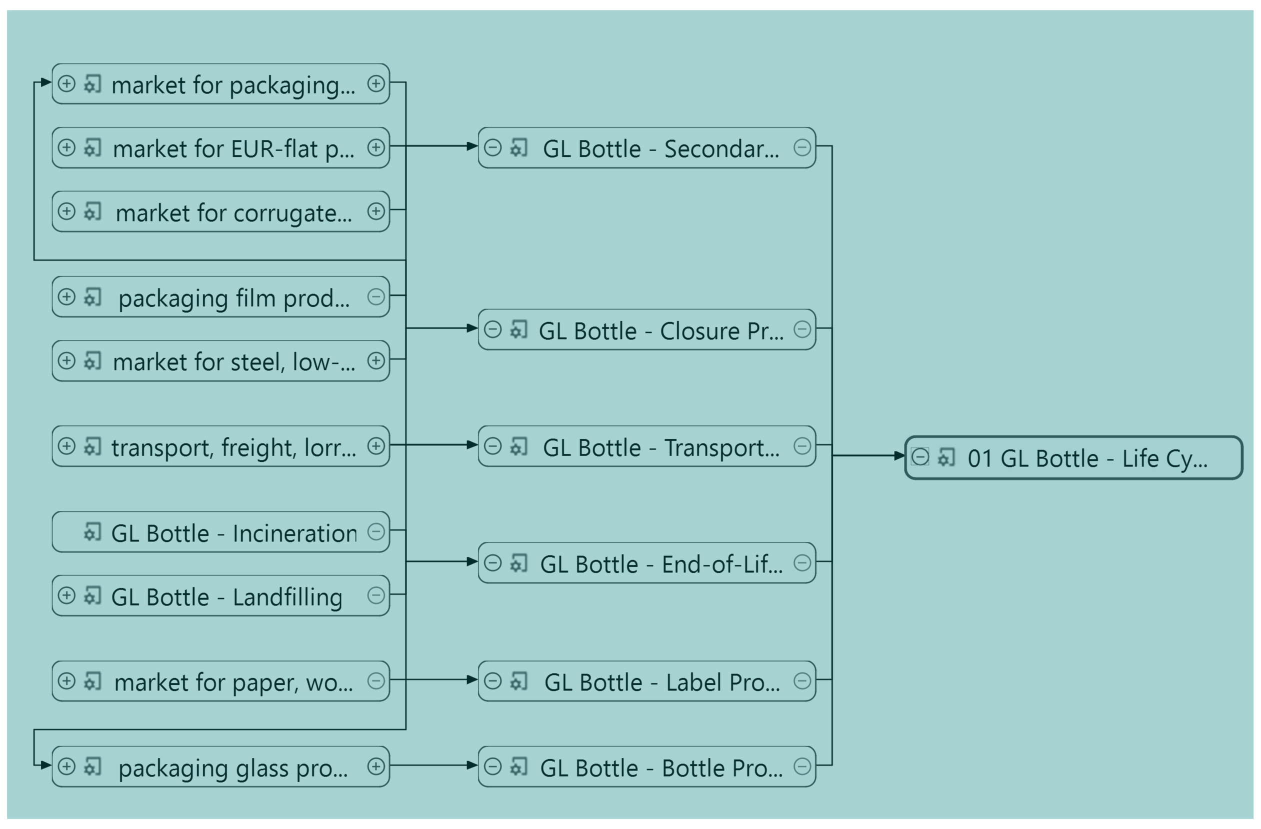


Figure 3: Process scheme of the life cycle of glass containers

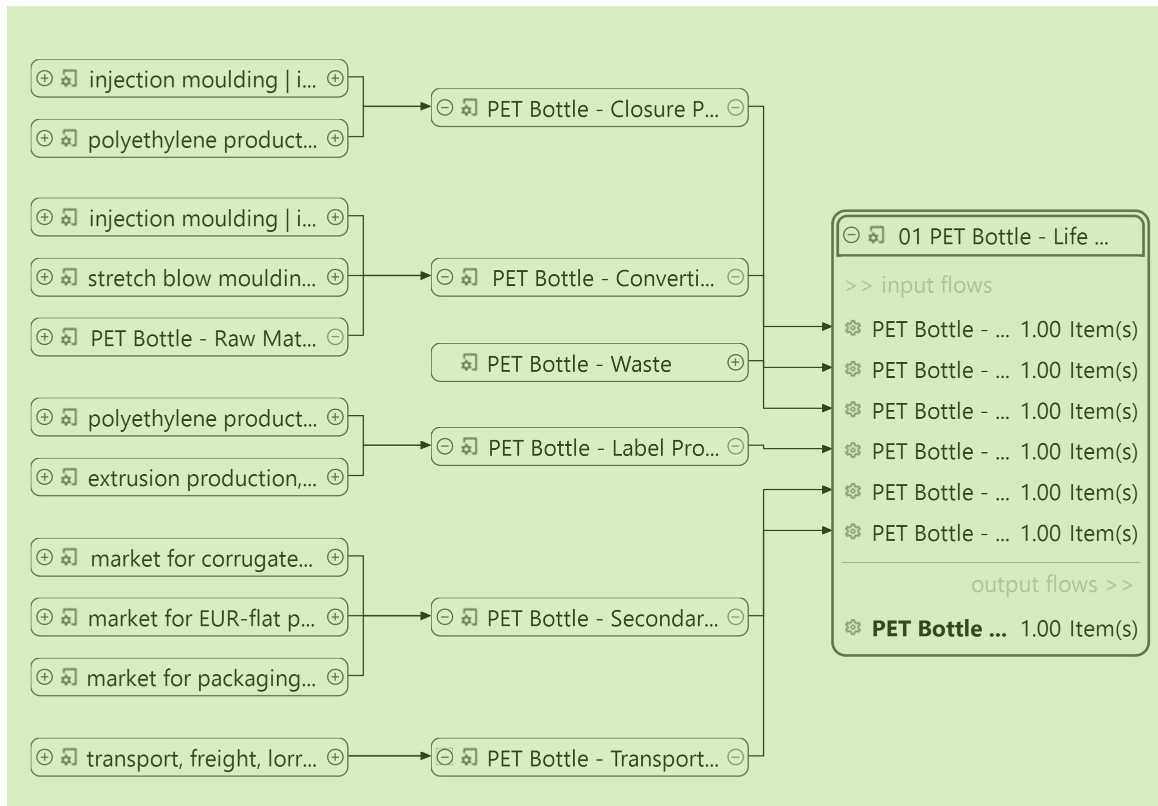


Figure 4: Process scheme of the life cycle of PET containers

4.2 INVENTORY DATA

Table 1: Transport distances by truck 16-32 tons, EURO 5:

Transportation routes	Segment	Distance [km]
Transport 1	Transport to production site	230
Transport 2	Transport to the filling of the drink	30
Transport 3	Transport to the point of sale	133
Transport 4	Transport to the waste centre	20
	TOTAL:	**413**

Table 2: Inventory data.

Packaging components	Amount [kg/FU] **ALU**	Packaging components	Amount [kg/FU] **GL**	Packaging components	Amount [kg/FU] **PET**
PRIMARY PACKAGING	**34.19**		**966.04**		**56.95**
Body (ALU)	26.60	Glass (green GL)	960.00	Bottle (PET)	49.3
Closure (ALU)	5.70	Closure (84 % alu alloy and 16 % LDPE)	4.04	Closure (HDPE)	6.03
Coatings	1.83	Labels (kraft paper)	2.10	Labels (LDPE)	1.62
Inks	0.06				
Sulfuric acid	0.40				
SECONDARY PACKAGING	**14.31**		**28.79**		**9.61**
Corrugated cardboard	13.60	Corrugated cardboard	25.20	Corrugated cardboard	8.90
Foil (LDPE)	0.71	Foil (LDPE)	3.59	Foil (LDPE)	0.71
Pallets (mass in kg)	25.0	Pallets (mass in kg)	25.0	Pallets (mass in kg)	25.0
Pallet type	EUR	Pallet type	EUR	Pallet type	EUR
Number of bottles per pallet	1848	Number of bottles per pallet	320	Number of bottles per pallet	960
Number of pallets per FU	0.54	Number of pallets per FU	3.13	Number of pallets per FU	1.04

5. RESULTS

Table 3: Potential social impact of assessed packaging production systems:

S-LCA (Med risk hours/FU)	ALU	GL	PET
Local Community	63186	34094	8815
Value Chain Actors	52306	20114	6126
Workers	91410	38916	11177
Society	71521	27761	8938
TOTAL S-LCA	**278424**	**120885**	**35056**

6. DISCUSSION OF RESULTS

The Social Life Cycle Assessment (S-LCA) provides a quantifiable comparison of the social impacts associated with the production systems of three types of beverage packaging: polyethylene terephthalate (PET) bottles, glass bottles (GL), and aluminum cans (ALU). This study, rooted in thorough data from the SOCA database, presents a comprehensive picture of the social footprint of each packaging type across different stakeholders, including the local community, value chain actors, workers, and broader society.

The S-LCA results measured in med risk hours indicate that aluminum cans (ALU) exhibit the highest total social impact, followed by glass bottles (GL), and finally, PET bottles. The elevated scores for ALU in the 'Local Community' and 'Workers' categories suggest that aluminum can production may demand more attention regarding community engagement and labor practices. Conversely, PET bottles show the least social impact, which could be attributed to lighter logistics requirements or more streamlined production processes.

In the context of sustainability, these findings advocate for a nuanced approach to selecting beverage packaging materials. While PET bottles have the lowest social impact in this study, the environmental implications, such as the carbon footprint and recyclability, must also be weighed. The comparatively higher impacts of ALU and GL call for industry-wide strategies to enhance labor conditions and community relations, possibly through better corporate social responsibility initiatives or process optimization.

7. CONCLUSIONS

This S-LCA contributes valuable insights into the social implications of beverage packaging options. It underscores the necessity for businesses to broaden their sustainability criteria beyond environmental concerns to also include social factors. A balanced consideration of both sets of criteria could promote a more holistic approach to sustainable packaging decisions in the beverage industry. Moving forward, it will be essential for companies to not only consider the findings of such assessments but to actively integrate them into their strategic planning to mitigate adverse social impacts while also meeting environmental sustainability goals.

8. REFERENCES

Recycling rate of aluminum cans in Europe in 2020. Published by: Statista. https://www.statista.com/statistics/239315/recycling-quota-of-aluminum-cans-in-europe/

Recycling rate of glass packaging in the European Union (EU-27) from 2005 to 2021. Published by: Statista. https://www.statista.com/statistics/1258851/glass-recycling-rate-in-europe/

M. Haupt, T. Kagi and S. Hellweg, 2018. Life cycle inventories of waste management processes. Data in Brief 2018, Vol. 19, Pages 1441-1457.

S. Markward, F. Wellenreuther, A. Drescher, J. Harth and M. Busch, 2017. Comparative Life Cycle Assessment of Tetra Pak carton packages and alternative packaging systems for liquid food on the Nordic market. Institution: ifeu.

The OpenLCA Conference 15° - 16°-17° April 2024

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

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

Introduction

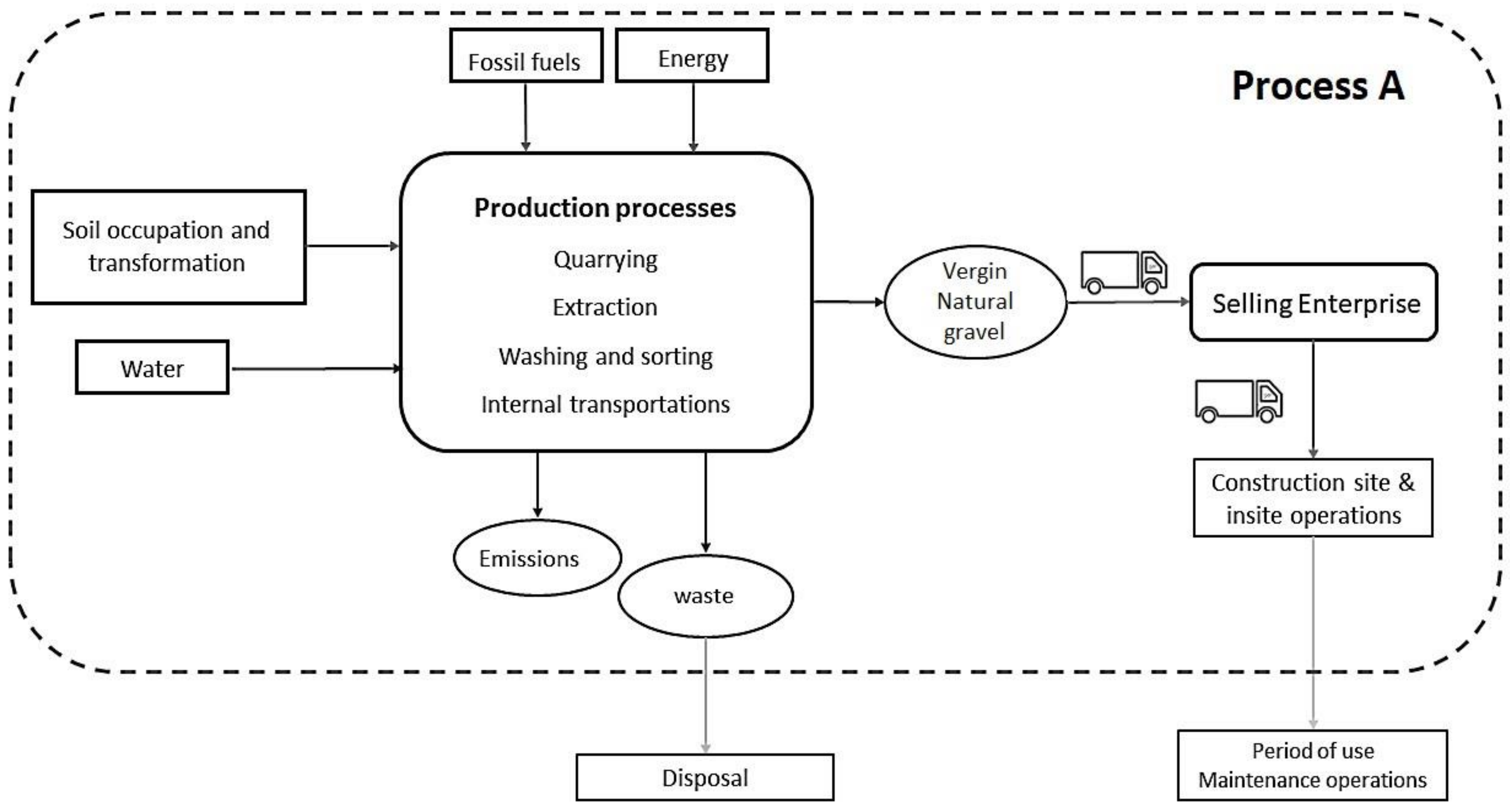
The significant impact of the construction industry on the environment, highlighting its consumption of natural resources, energy, and generation of waste [1,2]. It notes that construction and demolition waste (C&DW) make up a substantial portion of total waste [3,4], with a majority ending up in landfills despite recycling potential. European Union directives aim for at least 70% recycling of C&DW by weight, but challenges exist due to energy-intensive recycling processes [5,6] . To assess the environmental benefits, a Life Cycle Assessment (LCA) was conducted comparing recycled and virgin aggregates for rural pavement construction [7,8]. The LCA considered various factors such as transportation impacts, land use, and resource preservation. The study provides valuable insights for selecting environmentally friendly materials in construction.

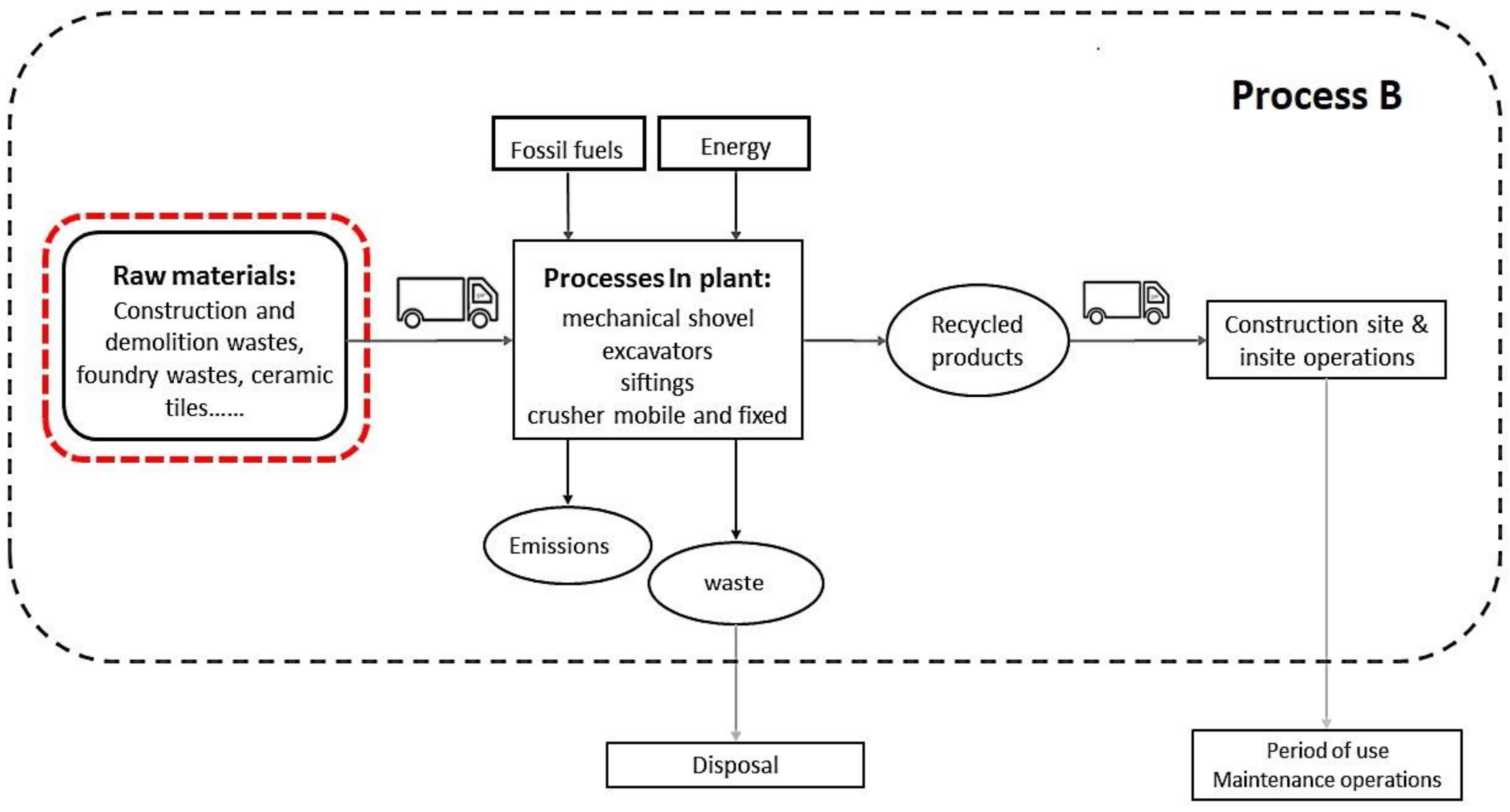
LCI (Inventory)

Recycled stabilized cement (RSC): concrete/cement waste, diameter of 0/30 mm, double grinding process; it is the 8 % of the global production;

Recycled stabilized cement and asphalt (RSCA):concrete and asphalt waste, as a 50-50 % mixture, diameter of 0/30 mm, double grinding process; it is the 4-6 % of the global production;

Recycled ground stone (RGS): mixed wastes of generic demolition waste at 50 %, ceramic/tiles at 30 % and foundry waste at 20 %, diameter of 0/30 mm, double grinding process; it is the 18 % of the global production.





Methods and Materials

Focus on comparing the impacts of various materials used for paving a working area on a farm. The study primarily utilizes data from a company called C.A.R. in Imola, Italy, regarding recycled materials. Three types of recycled materials are compared with virgin aggregates: recycled stabilized cement, recycled stabilized cement and asphalt, and recycled ground.

The functional unit of the study is the volume (m3) of material needed to construct 10 meters of rural pavement. The analysis utilizes the Ecoinvent 3.6 database to configure the inventory of materials and production models, considering factors like fuel, electricity, machine operations, and virgin natural aggregates production. Then, the environmental impacts analysis has been based on a "from cradle to gate" approach. Two different models have been carried out for recycled products:

A. waste materials enter into the systems as raw material without previous environmental burdens (model 1);
B. waste materials have been removed from the disposal chain, assuming the role of avoided wastes (model 2).

The LCIA methods selected have been **ReCiPe 2016 Midpoint and Endpoint, with IPCC 2013.**

Table 1. Life Cycle Inventory of the three recycled materials.

Production Data	Amount	Unit
Total production of the plant	142000	t/y
Total amount of incoming materials	195000	t/y
Electric mill energy consumption	112945	kWh/y
Offices energy consumption	50000	kWh/y
Wheel loader working time	1500	h/y
Excavator working time	1000	h/y
Mobile mill and vibrating screen working time	600	h/y
Electric mill working time	800	h/y
Fuel consumption for plant machine	115936	l/y

Table 2. Impact assessment values calculated for the ReCiPe 2016 midpoint (H) method, with highlighted the best results.

	Model 1			Model 2			
Categories	**RGS**	**RSCA**	**RSC**	**RGS**	**RSCA**	**RSC**	**NGA**
Fine particulate matter formation (kg PM2.5 eq)	69.58	75.07	75.45	66.2	74.54	72.9	80.64
Fossil fuel scarcity (kg oil eq)	21849.93	23540.74	23641.81	21150.73	23448.93	23362.56	25216.06
Freshwater ecotoxicity (kg 1,4-DCB)	1455.21	1570	1578.42	1414.61	1429.67	1145.89	1688.6
Freshwater eutrophication (kg P eq)	4.67	5.04	5.07	4.5	5.018	4.83	5.53
Global warming (kg CO2 eq)	63560.64	68593.4	69005.55	61689.54	67422.36	68056.53	73399.08
Human carcinogenic toxicity (kg 1,4-DCB)	1313.56	1422.13	1433.1	1269.85	1398.8	1342.34	1532.16
Human non-carcinogenic toxicity (kg 1,4-DCB)	37122.83	40089.14	40373.27	36091.43	39673.11	25481.20	42941.56
Ionizing radiation (kBq Co-60 eq)	1471.38	1585.68	1593.85	1434.02	1577.98	1558.86	1736.47
Land use (m2 a crop eq)	1983.26	2139.65	2150.36	1904.03	2126.69	2129.36	2292.66
Marine ecotoxicity (kg 1,4-DCB)	2320.24	2503.5	2517.12	2255.52	2312.82	1911.55	2688.9
Marine eutrophication (kg N eq)	0.39	0.49	0.56	0.38	-3.12	0.48	0.46
Mineral resource scarcity (kg Cu eq)	7.57	8.15	8.18	7.35	8.11	7.98	8.98
Ozone formation, human health (kg NOx eq)	206.98	223.5	224.83	195.51	222.13	218.23	239.05
Ozone formation, terrestrial ecosystems (kg NOx eq)	212.58	229.57	232	200.9	228.18	224.18	245.52
Stratospheric ozone depletion (kg CFC11 eq)	0.048	0.052	0.052	0.047	0.05	0.051	0.055
Terrestrial acidification (kg SO2 eq)	158.17	170.6	171.5	151.23	169.33	167.83	183.03
Terrestrial ecotoxicity (kg 1,4-DCB)	837492.94	927768.5	928010.14	861497.66	927768.5	928010.14	993381.4
Water consumption (m3)	54137.75	58452,13	58834.5	52566.74	58095.17	57529.13	63496.9

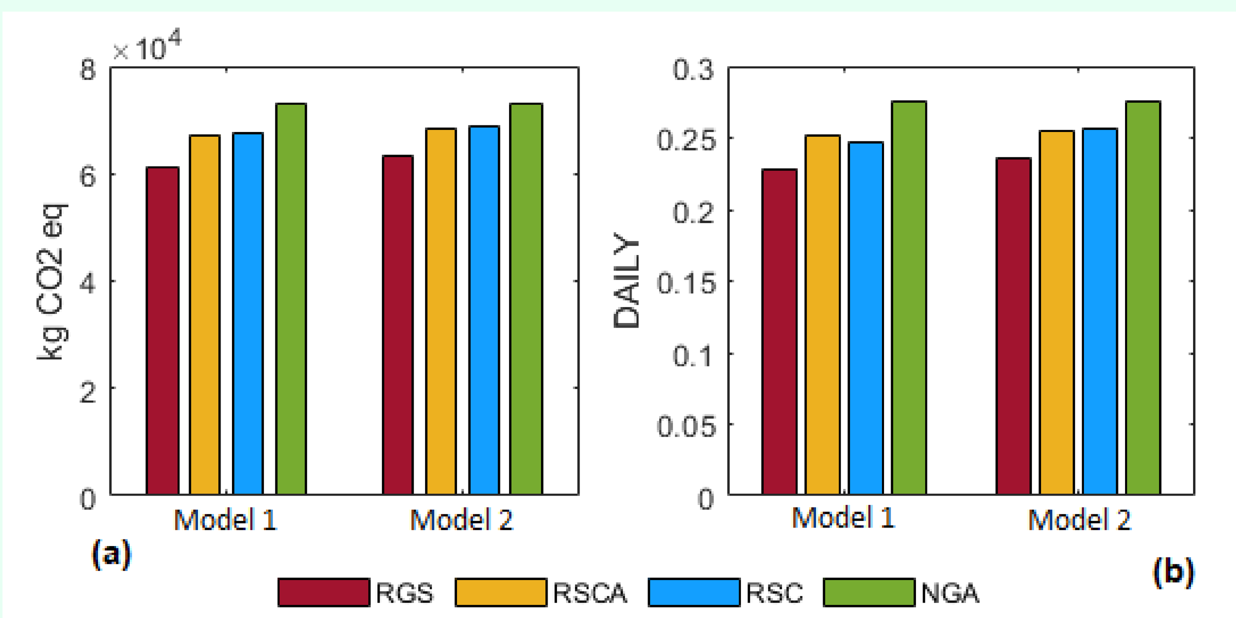
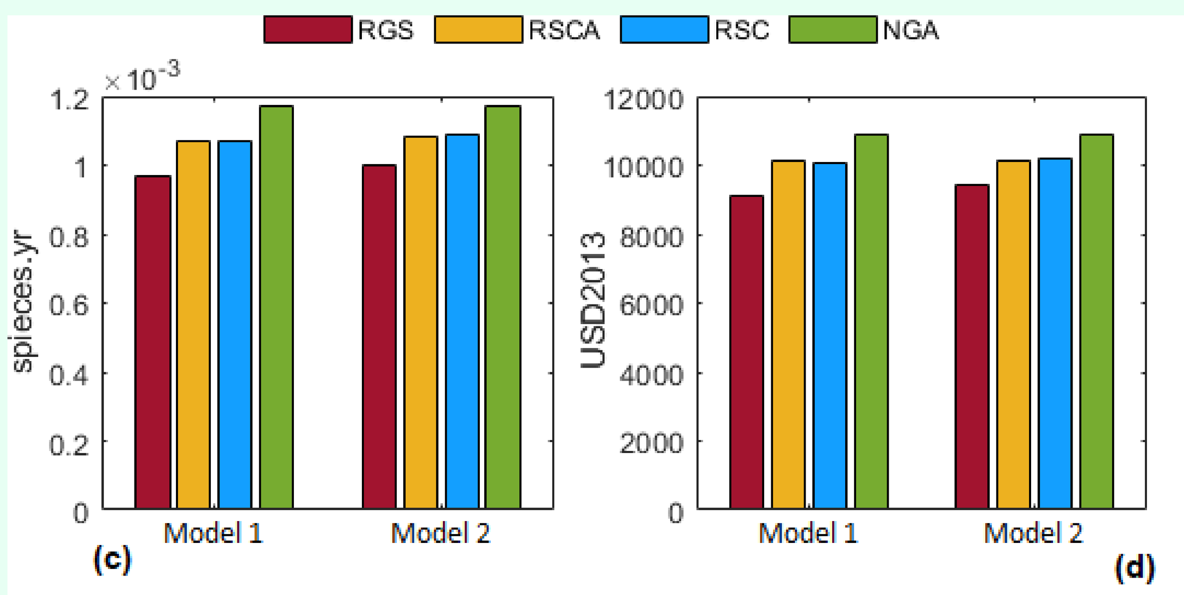


Figure 1. Results of IPCC 2013 GWP 100a and Recipe endpoint



Results and Discussion

- Four materials **have similar impact values** in just few categories: freshwater eutrophication, stratospheric ozone depletion and mineral source scarcity.
- **Model 1 results:** RGS demonstrated to have the lower impacts in whole the Impact categories (see Table 2).
- **Model 2 results:** RGS has the best performances in the majority of the indicators except for four where has a better results RSC and then RSCA (see Table 2)
- **Endpoint method results (Figure 1):** independently from the model, **RGS has the lowest impact in all the categories,** compared to the recycled and natural materials.
- **Process contributions analyses:** transports is the main impact voice in the environmental indicators analyzed
- **Sensitivity analysis:** variation of the distance of the incoming end of wastes of the recycled aggregates keeping all parameters unchanged. **The results have shown that the recycled materials, having the same mechanical properties of virgin aggregates, can be a solution for rural pavements with less environmental impacts, even if the materials come from long distance (within a radius of 300 km).**

Conclusions

Use of recycled materials for a rural pavement construction could lead to a consistently lower impact for this type of groundwork. the whole recycled aggregates have a lot of leeway to be more sustainable than virgin natural aggregates, even if the end-of-waste materials come from demolition sites far from the production plant.

Between the recycled products, considering the most sensitive impact categories such as climate change and damage to the environmental sectors, **the recycled ground stone has the lowest environmental impacts.** Further investigations, based on different and bigger geographical area, could give a wider and complete idea on the sustainability of the recycled inert materials, also considering the impact of the transportation detected in the study.

References

1. Oikonomou, Nik. D. 2005. "Recycled Concrete Aggregates" 27: 315–18. https://doi.org/10.1016/j.cemconcomp.2004.02.020.
2. Anik, David, Chiel Boonstra, and John Mak. 1996. Handbook of Sustainable Building: An Environmental Preference Method for Selection of Materials for Use in Construction and Refurbishment. James \& James.
3. Tojo, Naoko, and Christian Fischer. 2011. "Europe as a Recycling Society. European Recycling Policies in Relation to the Actual Recycling Achieved." ETC/SCP Working Paper. European Topic Centre on Sustainable Consumption and Production.
4. Zhang, Chunbo, Mingming Hu, Xining Yang, Brenda Miranda-xicotencatl, Benjamin Sprecher, Francesco Di, Xiaoyang Zhong, and Arnold Tukker. 2020. "Upgrading Construction and Demolition Waste Management from Downcycling to Recycling in the Netherlands." Journal of Cleaner Production 266: 121718. https://doi.org/10.1016/j.jclepro.2020.121718.
5. Colangelo, Francesco, Ilenia Farina, Cinzia Salzano, Marta Travaglioni, Marco de Pertis, Raffaele Cioffi, and Antonella Petrillo. 2022. "Climate Change Impact Assessment of Geopolymer Mortars." Key Engineering Materials 919: 210–17.
6. European Commission. 2008. Direttiva 2008/98/CE DEL PARLAMENTO EUROPEO E DEL CONSIGLIO Del 19 Novembre 2008 Relativa Ai Rifiuti e Che Abroga Alcune Direttive.
7. Cárcel-Carrasco, Javier, Elisa Peñalvo-Lòpez, Manuel Pascual-Guillamón, and Fidel Salas-Vicente. 2021. "An Overview about the Current Situation on C&d Waste Management in Italy: Achievements and Challenges." Buildings 11 (7). https://doi.org/10.3390/buildings11070284.
8. Irshidat, Mohammad R, Nasser Al-Nuaimi, Wasee Ahmed, and Mohamed Rabie. 2021. "Feasibility of Recycling Waste Carbon Black in Cement Mortar Production: Environmental Life Cycle Assessment and Performance Evaluation." Construction and Building Materials 296: 123740. https://doi.org/https://doi.org/10.1016/j.conbuildmat.2021.123740.

Full Text

SCAN ME

Contact

Enrica Santolini, Ph.D

University of Bologna

Email:
enrica.santolini2@unibo.it

Website:
https://www.unibo.it/sitoweb/enrica.santolini2

The open openLCA LCA Conference
Berlin 15-16th April, 2024
Life cycle assessments and sustainability: cases, methods, data, developments, community

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

Cantino Giorgio (1); Chiogna Guido (2); Demicheli Fabio (2); Gransinigh Sara (1) - E-mail: giorgio.cantino@uniupo.it (corresponding author)

(1) University of Eastern Piedmont, Department for Sustainable Development and Ecological Transition, piazza S. Eusebio, 5, Vercelli (IT) - (2) Metlac s.p.a. – SS 35 Bis dei Giovi 53, Bosco Marengo (IT)

INTRODUCTION

METLAC Group is a leading Company in the sector of metal packaging coating for food and beverages, committed to finding innovative formulations in line with eco-design principles. From 2022 R&D area has been supported by University of Eastern Piedmont in the assessment of impacts related to production activities.

OBJECTIVE

To identify the most sustainable formulation of transparent coatings for crown caps, there were studied the impacts on Climate change of two variants:

- traditional formulation solvent-based, to be cured by thermal drying
- innovative prototype solid cured by UV-LED technology, and compliant to ESP Regulation by EUPIA.

METHODOLOGY - PRODUCTION PHASE

Impacts of production phase were assessed by two Carbon Footprint studies, compliant with ISO 14067 and PCR-2021-0005. Considered system boundaries were both from-cradle-to-gate (C2G) with a functional unit of 1 kg of varnish. Calculation models were built with openLCA v1.11 and ecoinvent database v3.8 - EN 15804 add-on. According to ISO, impacts were assessed using the LCIA Methodology "IPCC 2013 GWP 100".

METHODOLOGY - USE PHASE

To estimate the consumption of thermal and electric energy for coatings' curing, there were collected data directly from METLAC's customers.

The yearly emissions in kg CO_2 eq. of these processes were then calculated based on both national and European Emission Factors.

RESULTS

DISCUSSION

UPSTREAM + CORE

For both products, total contributions are mainly related to raw materials' production.

C2G impacts of the UV-based coating were lower than the ones of traditional formulation, except for the category "Climate change-fossil". The innovative prototype generates almost double fossil GHG emission than the ones of the traditional formulation.

Referring to the solid prototype, the 40% of total fossil GHG emissions (C2G) come from an epossidic resin produced in China. With no primary data and proper ecoinvent datasets, the contribution of this last material was included on the basis of a 1956 Patent. Further research will thus be needed to improve the quality of such secondary data, as well to identify alternative suppliers.

CORE

Separate gate-to-gate assessments generally highlighted higher impacts for traditional formulation. The highest contribution is related to the emissions of fossil GHG (24% of total C2G results), due to the consumption of both electric and thermal energy over the processing operations. Conversely, the UV/LED's production requires less electric energy (ca 45%).

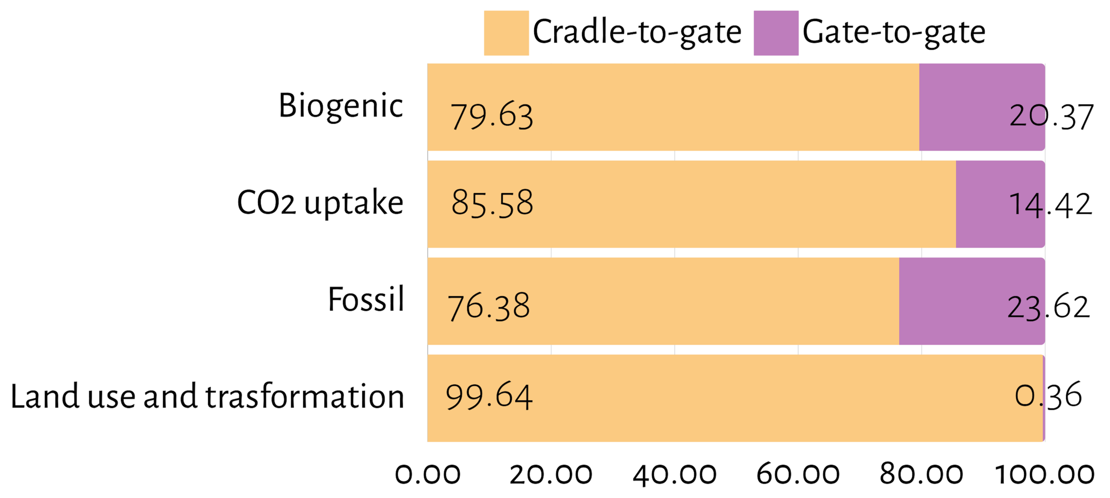
Primary data of core processes were mainly estimated on the basis of the whole yearly production. The consumption of electric energy was further elaborated in respect to the specific requirements of machineries involved. Results could thus be positively affected by improving the quality of primary data, as well as by switching to renewable energy sources.

USE PHASE

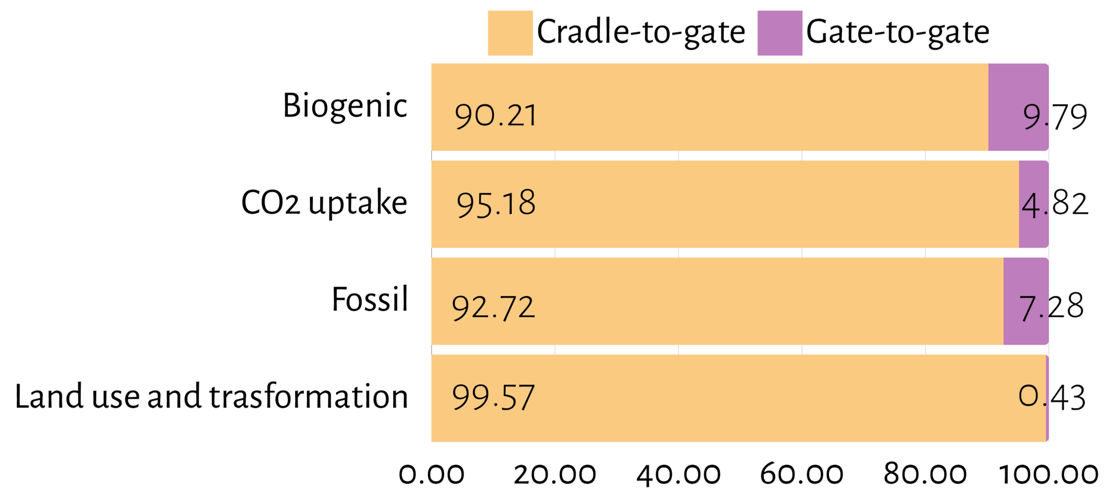
The traditional formulation's thermal drying consumes almost 1300kWh, including both electricity and thermal energy from natural gas, with the emission of nearly 260 kgCO_2 eq/curing cycle. The UV/LED curing of the solid prototype consumes only electric energy (about 270kWh), thus emitting 76 kgCO_2 eq/cycle.

Total impacts generated by the application of the UV/LED coating are about the 30% of the ones of the traditional formulation. Moreover, the process rate is three times faster than the thermal one, thus being more efficient. Further analyses of other consumers' plants have already been planned to improve the statical coverage of these primary data.

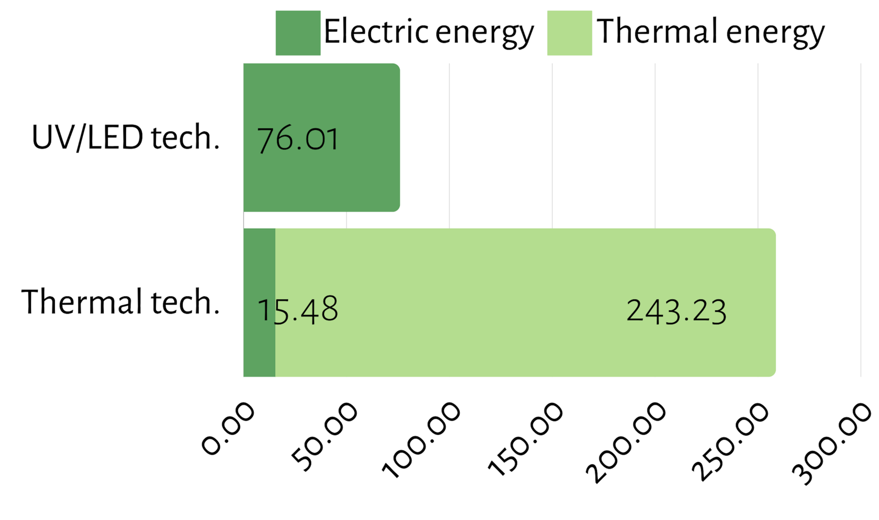
Emissions from traditional formulation's production (%)



Emissions from UV/LED's production (%)



Emissions from curing process (kg CO_2 eq/cycle)



CONCLUSION

Recorded results highlighted that a detailed assessment of each life-cycle stages of a production process is important to effectively implement eco-design strategies.

Except for fossil GHG emissions, switching to the innovative formulation allows to reduce the emissions of METLAC's production sites. This could bring a significant emissions' reduction over the following external curing process too.

ECO-DESIGN

Improving the quality of primary data could positively affect the results of both CFP studies. This should encompass both data from suppliers (e.g., by proving structured procedures for data collection) and the ones related to core operations (e.g., using meters).

RELATED LITERATURE

UNI EN ISO 14067:2018, Gas ad effetto serra – Impronta climatica dei prodotti (Carbon footprint dei prodotti) – Requisiti e linee guida per la quantificazione
PCR-2021-005, Paint, varnishes and coating - UN CPC code: 3511
Rapporto ISPRA 317/2020, Fattori di emissione atmosferica di gas a effetto serra nel settore elettrico nazionale e nei principali Paesi Europei

UNIVERSITÀ DEL PIEMONTE ORIENTALE

UNIVERSITY OF CHEMISTRY AND TECHNOLOGY PRAGUE

KU LEUVEN

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

Aurore Guillaume, Annemie Geeraerd Ameryckx, Lise Appels & Vladimír Kočí

1

Community gardens (CG) can provide 3 types of ecosystem services (ES) replying to environmental, social and economic challenges

LCA of community gardens is missing in the literature

We carried out a LCA of a community garden accounting for the 3 ES types

2

Case study

Location: Prague, CZ

Annual harvest: 460 kg

Land use: 700 m²

Crop diversity: ~ 30 types

 # volunteers: ~ 10

System boundaries: cradle-to-gate

Impact method: EF 3.0.

Software: OpenLCA 1.10.3

Data: primary and Agribalyse 3.0.1

3

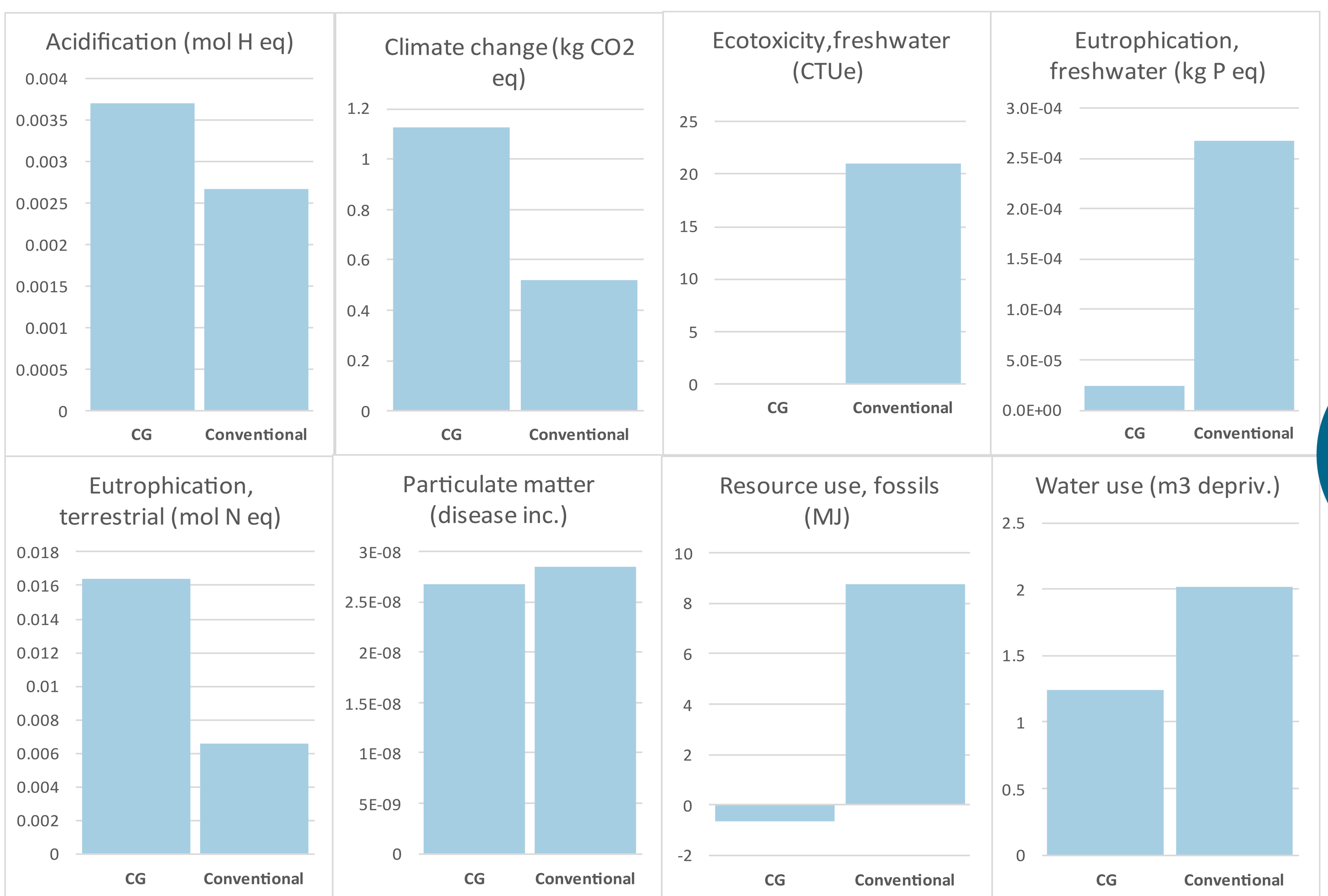
CGs are a beneficial way of urban land use to bring cultural ES

Infrastructure	CG	Urban park [1]	Urban green space [2]
Climate change ($kgCO_2eq/ha$)	-1,349	-2,733	-2,739

but could be improved by increasing vegetation

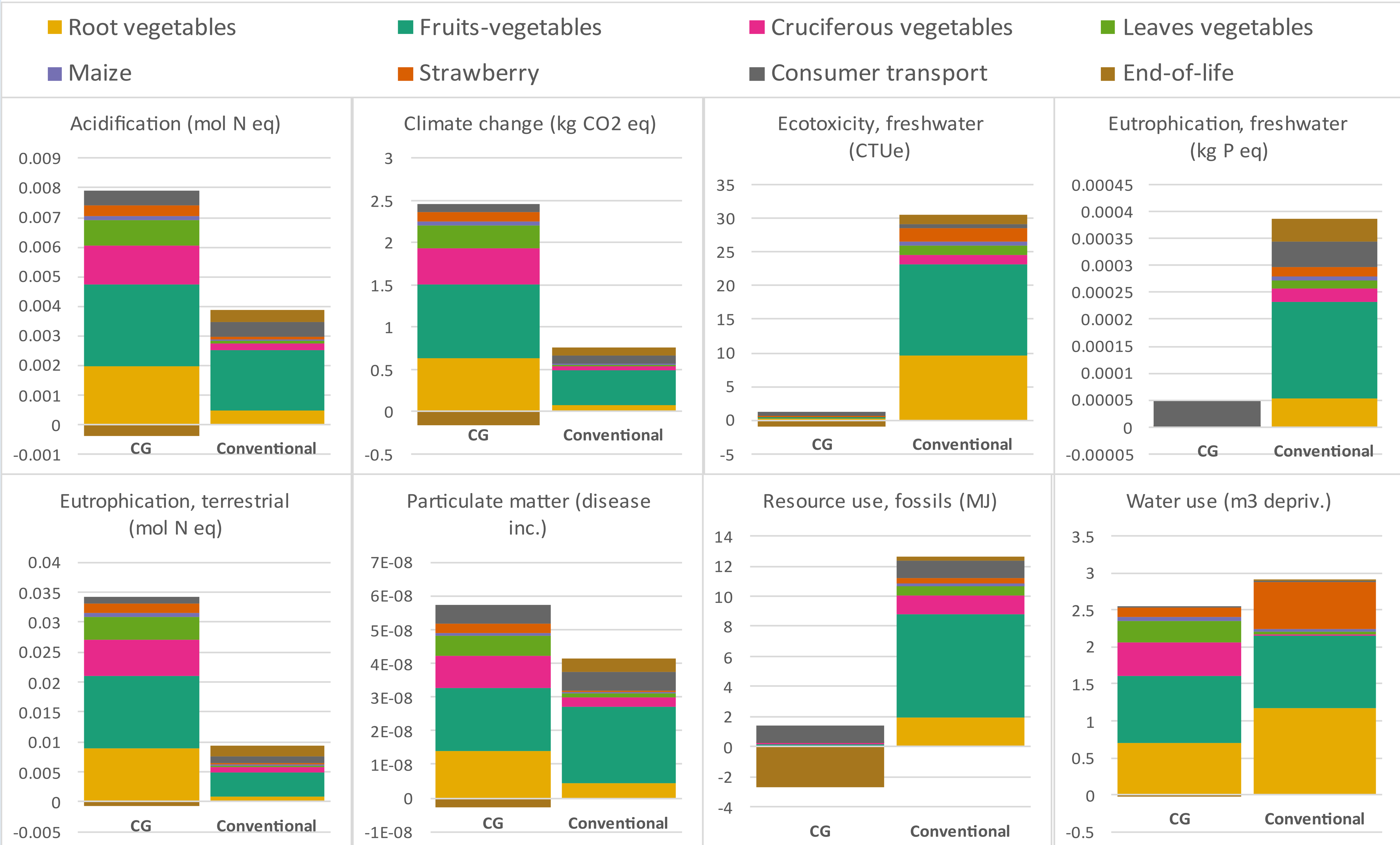
FU: 1 ha of land used as urban social space

Accounting for maintenance and regulation ES does not counterbalance impacts



FU: 1 kg of harvested crops using allocation factors from [3]

Chemical, energy inputs and composting influence the most provisioning ES



FU: 1 kg of harvested crops

4

- The use of different FU can help to capture the **multi-functions** of non-conventional systems such as CGs
- Community gardens are a beneficial way of providing food and occupying urban space, provided that good agricultural practices are in place

References

[1] Nicese, F. P., Colangelo, G., Comolli, R., Azzini, L., Lucchetti, S., Marziliano, P. A., & Sanesi, G. (2021). Estimating CO2 balance through the Life Cycle Assessment prism: A case – Study in an urban park. *Urban Forestry & Urban Greening*, *57*, 126869. https://doi.org/10.1016/j.ufug.2020.126869

[2] Strohbach, M. W., Arnold, E., & Haase, D. (2012). The carbon footprint of urban green space—A life cycle approach. *Landscape and Urban Planning*, *104*(2), 220–229. https://doi.org/10.1016/j.landurbplan.2011.10.013

[3] Boone, L., Roldán-Ruiz, I., Van linden, V., Muylle, H., & Dewulf, J. (2019). Environmental sustainability of conventional and organic farming: Accounting for ecosystem services in life cycle assessment. *Science of The Total Environment*, *695*, 133841. https://doi.org/10.1016/j.scitotenv.2019.133841

This work was supported by the grant of Specific university research – grant No A2_FTOP_2023_11.

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

Hannah Köhler, M. Sc., Alena Maria Spies, M. Sc., Natalie Hegemann, B. Sc., Dr.-Ing. Karoline Raulf, Prof. Dr. Kathrin Greiff

Motivation

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 was identified as the main driver to a **sustainable paper industry** [1]. Additionally, legal regulations aim for higher recycling quotas to enhance circularity – e.g., German Packaging Act: 90% recycling quota for packaging paper from 2025. Therefore, new sources of **secondary materials for recycling**, like paper from the lightweight packaging (LWP) waste, are becoming focus. To determine if recycling the paper fraction from LWP is the **environmentally favorable option**, the environmental impact of different waste treatment routes must be assessed.

» In this study, we evaluated the efforts and benefits to recycle paper from LWP compared to incineration via Life Cycle Assessment (LCA).

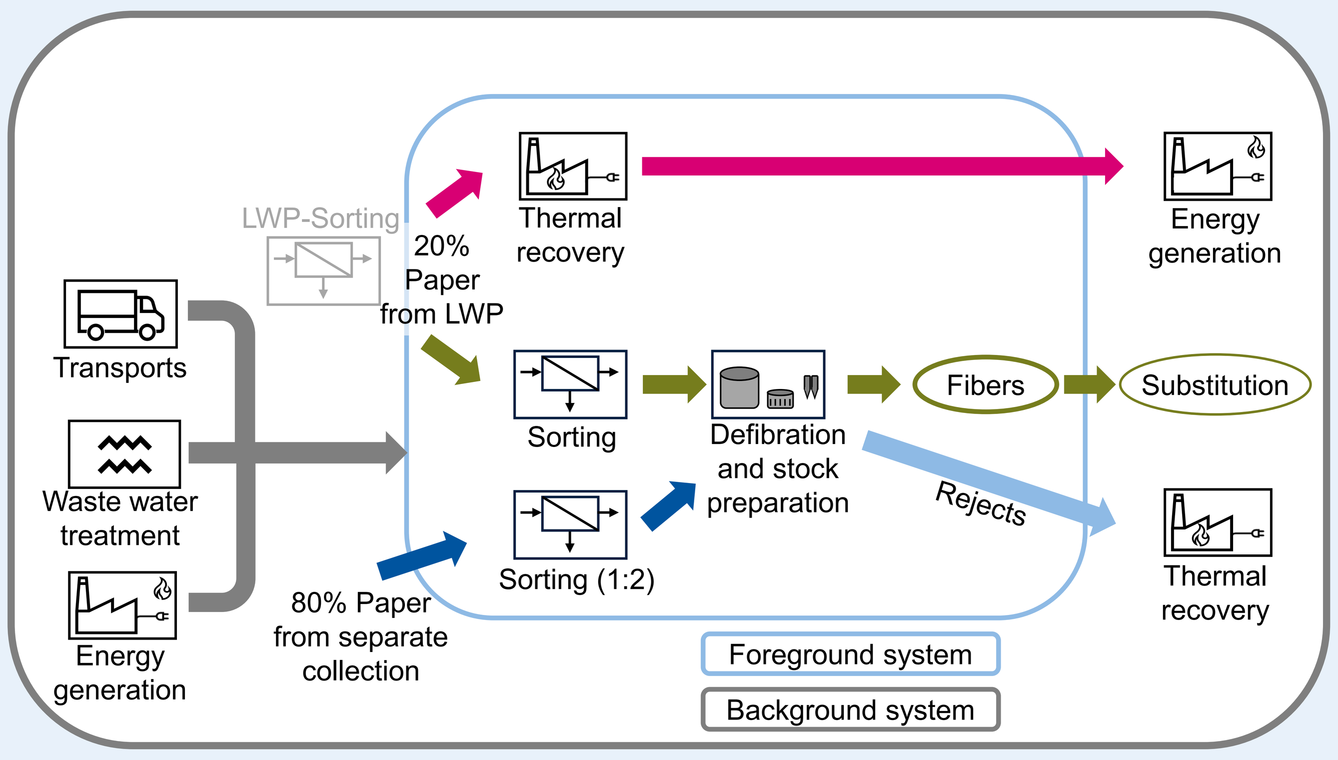


Figure 1: System boundaries

Methods

[2]

Goal and scope
- Comparative LCA of treating paper from LWP (**Incineration** and **recycling**)
- Sorting plant and carton production plant in Germany
- **FU:** treatment of 1 t of paper (0.2 t from LWP, 0.8 t from separate collection)

Life Cycle Inventory
- Primary data from EnEWA project
  - Properties of paper from LWP
  - Sorting process
  - Carton production process
- Missing data comes from literature and ecoinvent v3.9.1 (modified to 2023)

Life Cycle Impact Assessment
- Method: ReCiPe Midpoint (H) [3]
- Impact categories
  - Global Warming Potential (GWP)
  - Land Use (LOP)
- Scenario analysis for three substitution potentials (energy, primary fibers, none)

Interpretation
- 4 impact categories, 2 categories presented
- No weighing and combining of indicators
- Hotspots in process chain
- Product quality
- Substitution potential
- Data consistency
- Evaluation of scenarios

Results

Substitution scenarios:
- **S1:** Status quo – incineration of paper from LWP
- **S2:** Recycling paper from LWP – no substitution effect
- **S3:** Recycling paper from LWP – substituting primary fibers (EU)

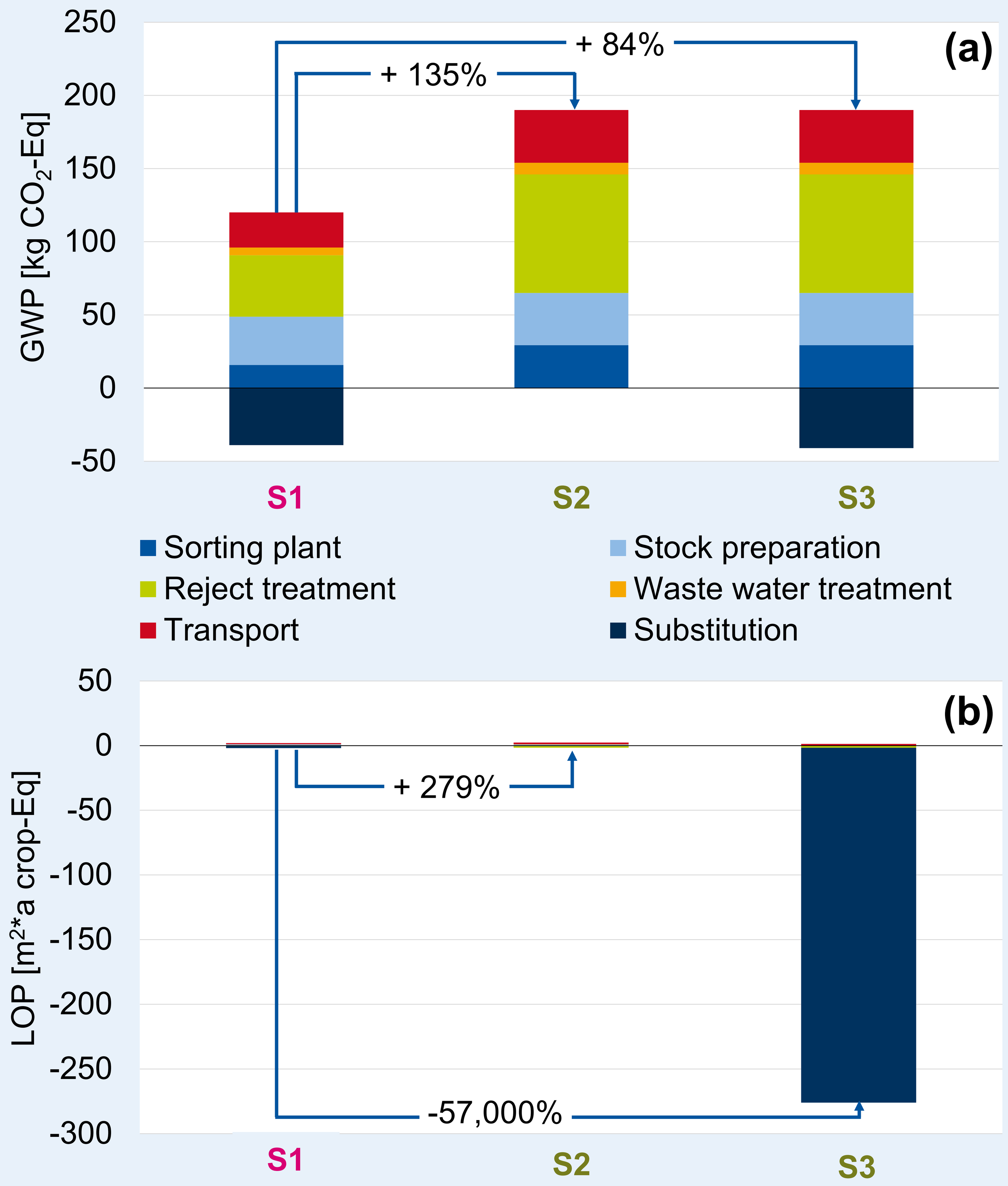


Figure 2: Results for GWP (a) and LOP (b) for **S1**, **S2** and **S3** - Assessment for one carton production plant in Germany

Conclusion

Incineration
- Lower GWP due to
  - substituting non-renewable energy sources in German energy mix
  - shorter transport distances reduce emissions
  - no efforts for sorting and stock preparation of paper from LWP
- No significant effect on LOP by substituting energy mix

Recycling
- Higher GWP due to
  - additional efforts for processing paper from LWP
  - low avoided burden from substituting primary fibers against effort
- Substituting primary fibers significantly reduces the LOP due to avoided cultivation areas for primary materials

» Results highly depend on substitution scenarios

Research Demand

Plant-scale:
- Further investigation of influencing factors such as reduction of imports and substitution of plastic packaging
- Investigation of further impact categories (water, energy, toxicity)
- Sensitivity and uncertainty assessment
- Adapted waste water treatment

System-scale:
- Effect on German/European paper market
- Additional efforts needed (e.g. for hygienization)
- Transferability to other plants and applications
- Future trends on paper and energy markets

Figure 3: Paper from LWP

References

[1] DIE PAPIERINDUSTRIE – Leistungsbericht PAPIER (2023)
[2] DIN EN ISO 1440/44 (2006)
[3] Huijbregts, M.A.J. et al. ReCiPe2016. Int. J. Life Cycle Assess 22, 138–147 (2017)

Extended reference list:
https://rwth-aachen.sciebo.de/s/CZKs6zrhRIFxNjf

RWTH Aachen University
Department of Anthropogenic Material Cycles
Hannah Köhler, M.Sc.
Wüllnerstraße 2, 52062 Aachen
hannah.koehler@ants.rwth-aachen.de
http://www.ants.rwth-aachen.de

The conference attendance and the presented results are part of the research project "EnEWA – Energieeinsparung bei der Papierproduktion durch Erschließung der Wertschöpfungsketten Altpapier aus Leichtverpackungen, Restabfall und Gewerbeabfall", which is funded by the Federal Ministry for Economic Affairs and Climate Action and the PTJ Jülich.

Supported by: Federal Ministry for Economic Affairs and Climate Action on the basis of a decision by the German Bundestag

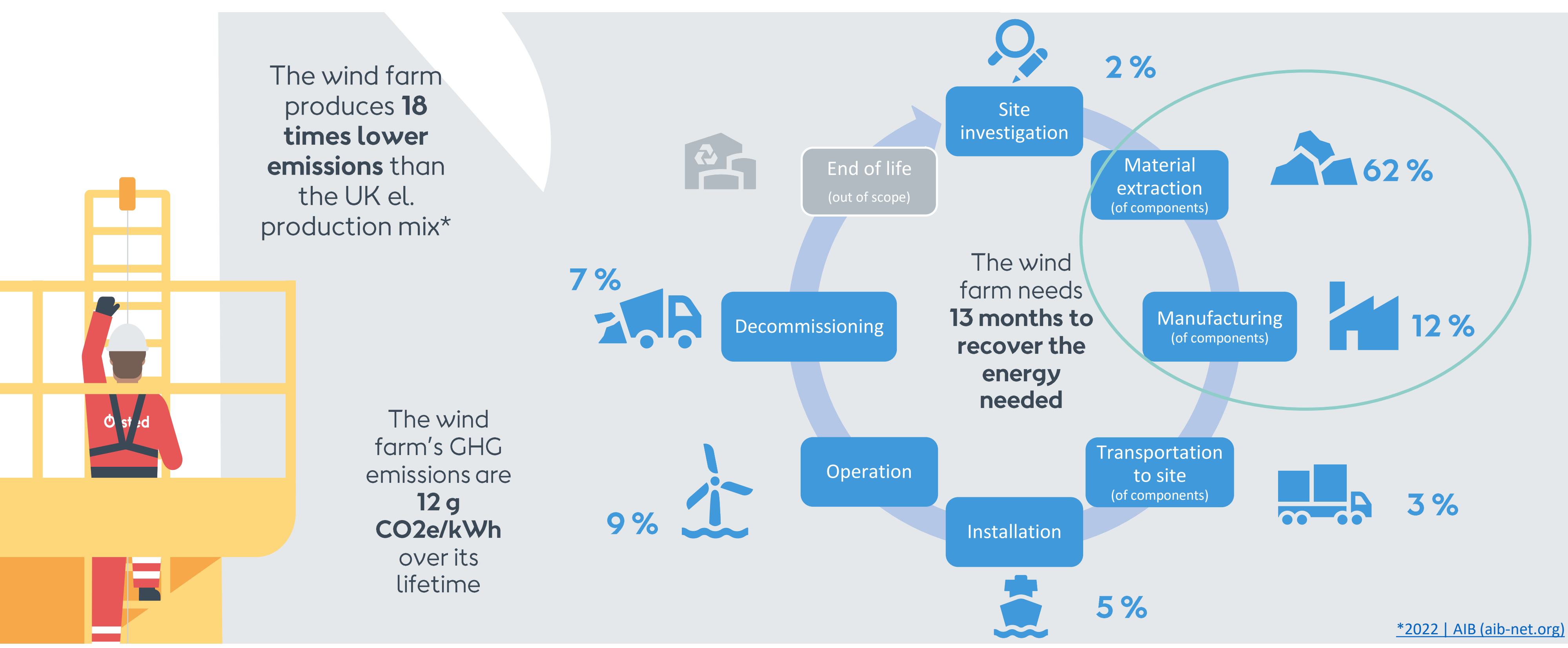
Decarbonisation of our wind farms

A part of Ørsted's journey to reach its climate ambitions

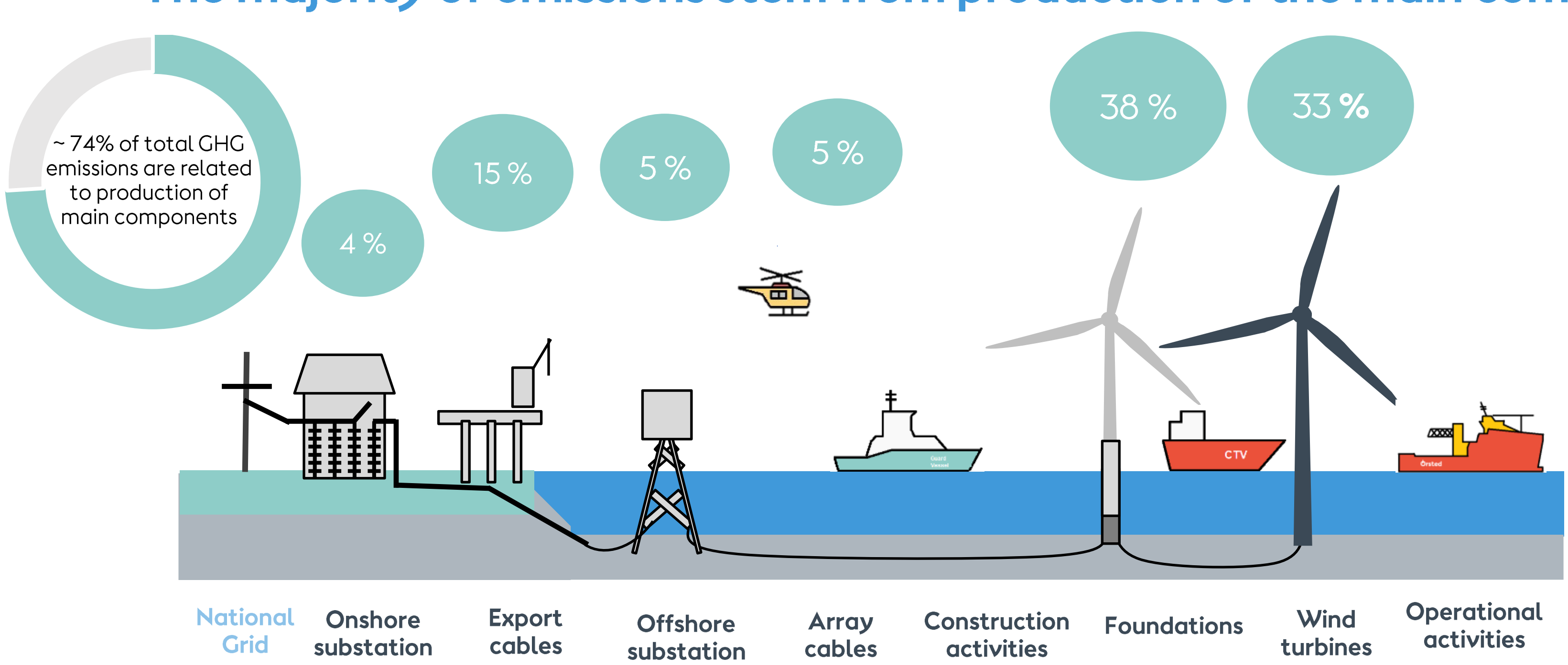
2030 77 % reduction in scope 1-3 emissions intensity, excl. gas sales (from 2018)

2040 99 % reduction in scope 1-3 emissions intensity, excl. gas sales (from 2018)

Calculating GHG emissions over the lifecycle of a wind farm (a case study)



The majority of emissions stem from production of the main components



1 tonne of steel for a foundation emits approx. two tonnes of CO2e

Successful EPD Creation

Choice of EPD Programme, Software, and Development Approach

1 Select an Environmental Product Declaration (EPD) programme

epd-norge

EPD® THE INTERNATIONAL EPD® SYSTEM

Institut Bauen und Umwelt e.V.

Criteria for which to choose:

- ✓ Viable product categories listed
- ✓ Language of choice represented
- ✓ Cost per published EPD

✓ Acceptance within the intended audience of the EPD

2 Choose a Product Category Rule (PCR) from EPD Programme

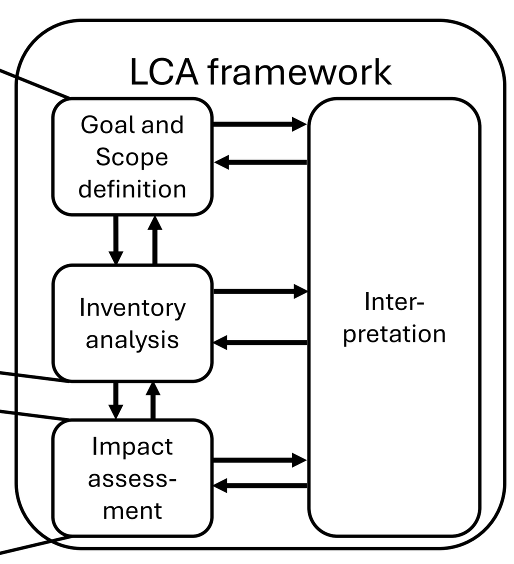
LCA	PCR	Result
Many assumptions, options & choices leading to differing results	Rule set clarifying most aspects of LCA creation and publication	Comparable EPDs with equal underlying assumptions

Good to know:
The EN 15804:2012+A2:2019
Is the basis for most construction based EPDs

3 Conduct the Life Cycle Assessment

Standardized Life Cycle Stages in an EPD:	
A1 – A3	Product Stage
A4 – A5	Construction Process Stage
B1 – B5	Use Stage, product emissions
B6 – B7	Use Stage, operational emissions
C1 – C4	End-Of-Life Stage
D	Benefits and Loads beyond system

Standardized Emission Factors according to EN 15804+A2	GWP, ODP, AP, EP-terrestrial, EP-marine, EP-freshwater, POCP, ADP, WDP, ...



4 Write the background report and EPD document

Content:

- ✓ Company Information
- ✓ Product Information
- ✓ LCA information (goal, scope, assumptions, ...)
- ✓ Impact Indicators:

Potential environmental impact – mandatory indicators according to EN 15804

Results per functional or declared unit									
Indicator	**Unit**	**A1-A3**	**A4**	**A5**	**C1**	**C2**	**C3**	**C4**	**D**
GWP-fossil	kg CO_2 eq.	1,0E+02	7,3E+01	1,4E+01	1,2E+01	3,0E+00	4,8E+00	5,1E-02	-1,6E+02
GWP-biogenic	kg CO_2 eq.	-7,5E+02	2,1E-02	4,9E+00	3,5E-03	9,7E-04	6,3E+02	1,0E+00	-3,2E+00
GWP-luluc	kg CO_2 eq.	9,7E-01	8,5E-04	3,1E-04	3,0E-04	2,5E-05	5,7E-04	2,0E-05	-1,3E-01
GWP-total	kg CO_2 eq.	-6,5E+02	7,3E+01	1,8E+01	1,2E+01	3,0E+00	6,3E+02	1,1E+00	-1,6E+02
ODP	kg CFC 11 eq.	2,0E-05	1,6E-05	2,7E-06	2,7E-06	7,2E-07	2,8E-07	7,9E-09	-8,4E-06
AP	mol H^+ eq.	8,7E-01	1,2E+00	1,3E-01	1,3E-01	1,1E-02	6,3E-02	6,3E-04	-1,0E+00
EP-freshwater	kg P eq.	3,5E-02	3,1E-04	9,5E-05	7,3E-05	1,2E-05	2,4E-03	1,3E-05	-7,5E-02
EP-marine	kg N eq.	2,5E-01	3,2E-01	5,9E-02	5,9E-02	3,4E-03	3,5E-02	3,2E-03	-1,5E-01
EP-terrestrial	mol N eq.	2,6E+00	3,5E+00	6,5E-01	6,5E-01	3,7E-02	3,4E-01	3,0E-03	-1,6E+00

Example of impact indicators following the layout of EPD International

5 Verify the EPD with an external verification body

Product Model, EPD and background report will be checked, if they align and conform with ISO and PCR requirements.

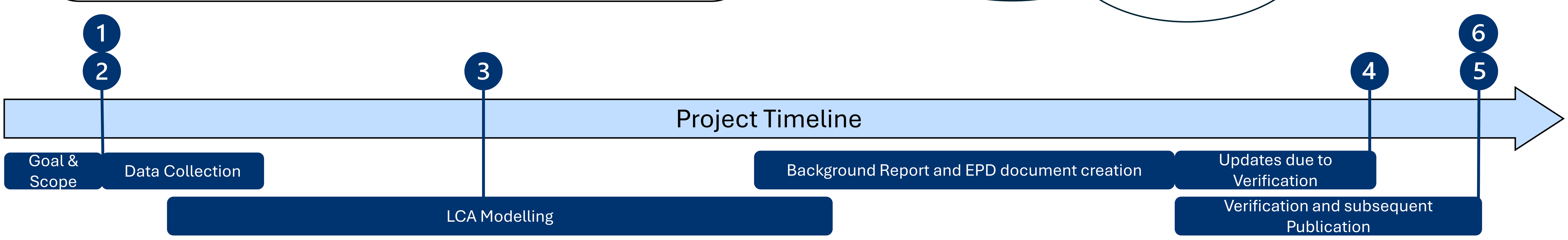
6 Publish the EPD at the website of the EPD programme

The EPD will be published on the EPD programme website and will be valid for five years.

Which LCA Software do I use?

openLCA, sphera™, One Click LCA, umberto® know the flow., SimaPro, Ecochain

... and many more with different advantages and disadvantages ...



✓ Be flexible! ✓ Plan ahead! ✓ Document everything! ✓ Be conservative in your time management!

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

unibz
Fakultät für Ingenieurwesen
Facoltà di Ingegneria
Faculty of Engineering

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

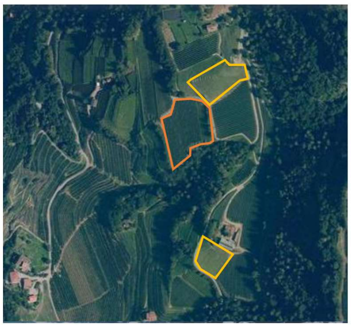
Pasqualina Sacco and Guido Orzes

Free University of Bozen-Bolzano. Piazza Università 1, Bolzano/Bozen, Italy
Contacts: psacco@unibz.it - guido.orzes@unibz.it

The case study

Sauvignon:
- planting year 2018 and 2002
- average yield 9180 kg/ha

Souvignier Gris (PIWI):
- planting year 2020 and 2019
- average yield 7780 kg/ha



- Vineyards located at 560 m, high slope.
- Guyot training system.
- Data refers to 2022 and 2023 seasons.

Material and methods

The analysis presented here focuses on the aspect of the system related to grape cultivation. It is worth noting that winemaking processes are not significantly influenced by whether they involve PIWI grape varieties or not. The main disparities between PIWI and non-PIWI varieties lie in the management of field operations.

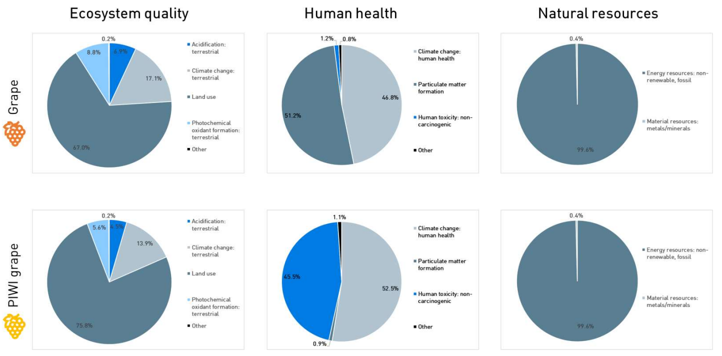
The data of interest mainly revolve around agrochemical treatments during the investigated production seasons: types and quantities of agrochemicals, water usage, and gasoline consumption. Additionally, contextual information is gathered to address toxicity concerns associated with the final product, waiting times before harvest, and constraints such as proximity to organic farms or residential areas.

Whenever possible, primary data collected through interviews with farmers regarding their on-field activities, especially in relation to crop protection, are utilized. Supplementary data from LCI databases and method libraries are employed to fill data gaps and estimate impacts.

The analysis was conducted using the OpenLCA software, employing the ReCiPe Endpoint and ReCiPe Midpoint methods. The functional unit is 1 kg of harvested grape.

Results

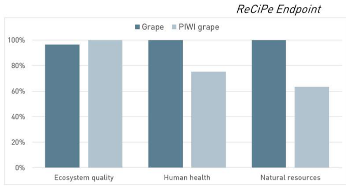
ReCiPe Endpoint



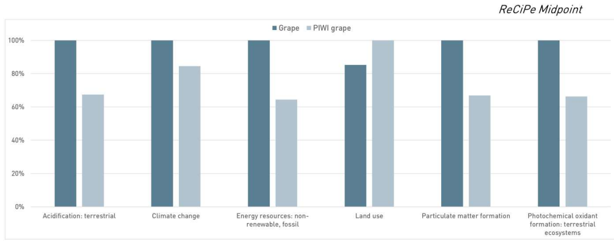
The most significant impacts are observed in the following categories:
- For Ecosystem quality: Acidification (terrestrial), Climate change, Land use and Photochemical oxidant formation
- For Human health: Climate change, Particulate matter formation and Human toxicity: non-carcinogenic
- For Natural resources: Energy resources

The cultivation of grapes from PIWI grape varieties shows lower impacts compared to traditional varieties. Regarding Ecosystem Quality, the slightly higher impact of PIWI varieties is probably due to the fact that heavy metal cycles associated with agronomic practices have not been considered in the analysis. However, Land use is higher due to lower yield.

ReCiPe Endpoint



ReCiPe Midpoint



Next steps

From an initial analysis of the value chain, particularly focusing on the grape cultivation phase, it has emerged that there is a need to investigate the following **site-specific** aspects in greater detail:

- Distinguishing intrinsic variability in the grape-to-wine chain from differences attributable to PIWI varieties.
- Refining the model for estimating agricultural operations, especially mechanized ones.
- Refining the model for estimating nutrient, synthetic molecules and heavy metals cycles.

Furthermore, the cultivation impacts will be evaluated in relation to the entire value chain, considering vinification and bottling.

The LCA results, at the end, contribute to rise knowledge about disease resistant 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 policy choices as well. In the case of South Tyrol, for example, they can help manage the objectives of the 2030 Agriculture Plan in a scientifically informed way.

SUWIR Project

SUWIR (Towards sustainable viticulture: a case study on wines from resistant grape varieties in 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 grape varieties 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 goal of the project is to compare wines from disease-resistant grape varieties grown in South Tyrol with conventional wines.

The comparison is carried out with regard to the organoleptic properties of the wine, the environmental impacts of their production and the consumer acceptance.

More about SUWIR Project

Acknowledgments: We thank the Provincial Land Agency for their collaboration
This contribution is part of research activities of the project SUWIR funded by the Free University of Bozen/Bolzano with ID2021 call (CUP I55F21002110005)

The open openLCA conference for life cycle assessments and sustainability: cases, methods, data, developments, communities. Berlin 2024.

Grant Agreement number: 951761 — NANO-EH — H2020-FETPROACT-2019-2020 / H2020-EIC-FETPROACT-2019

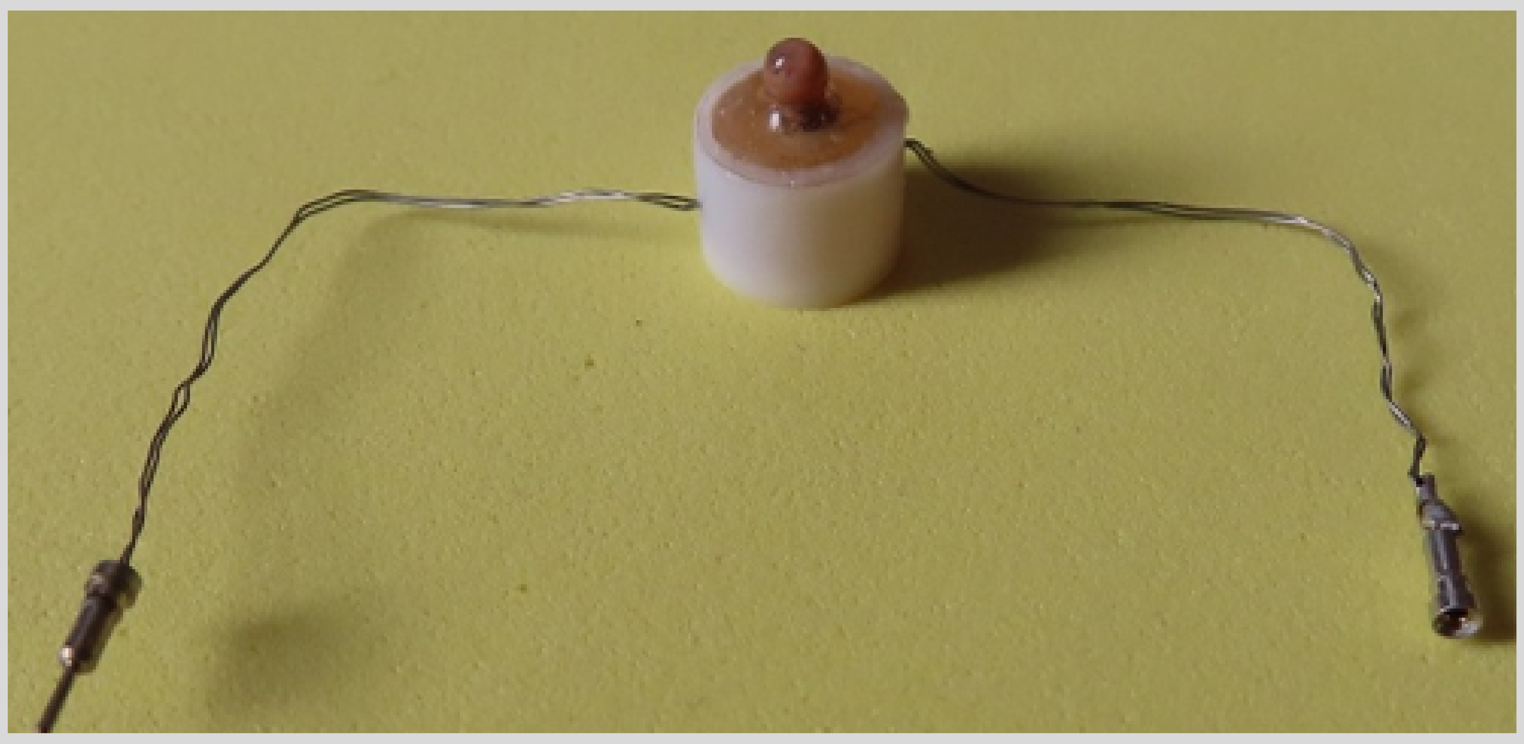
SUSTAINABILITY ASSESSMENT OF DIFFERENT TYPE OF SOLAR CELLS MANUFACTURING IN THE NEW ENERGY CONTEXT

AUTHORS

P.I. Cano[1], L. Doyle[1], S. Ospina-Corral[1], M. Gheorghe[2], O. Durand[3], G. Cavero[1], M. Modreanu[4].

INTRODUCTION

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 dependence on fossil fuels 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.



METHODOLOGY

1.Establish Baseline Scenario: Identify environmental and economic hotspots for both solar cell types.

2.Perform Cost Analysis: Analyze raw materials and energy consumption costs.

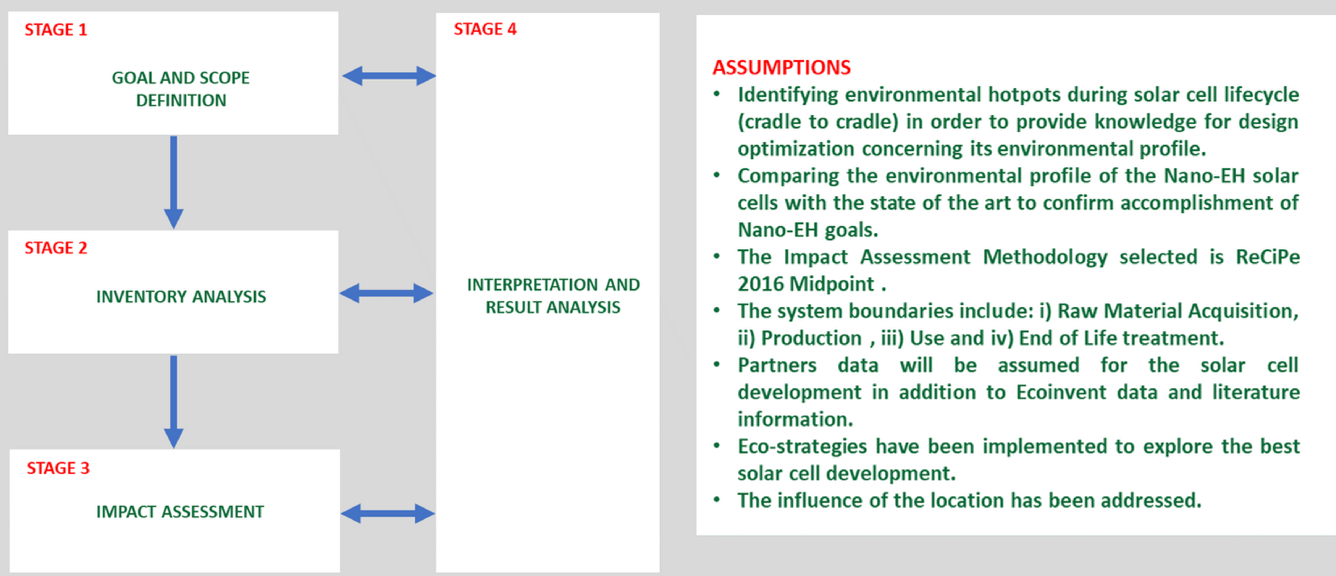


Figure 1. 4 stages involved in LCA execution according to the ISO 14040/14044 Principles and goal and scope.

3.Identify and Substitute Hotspots: Replace the identifyed hostpots with possible solutions that could enhance the environmental friendliness of the device.

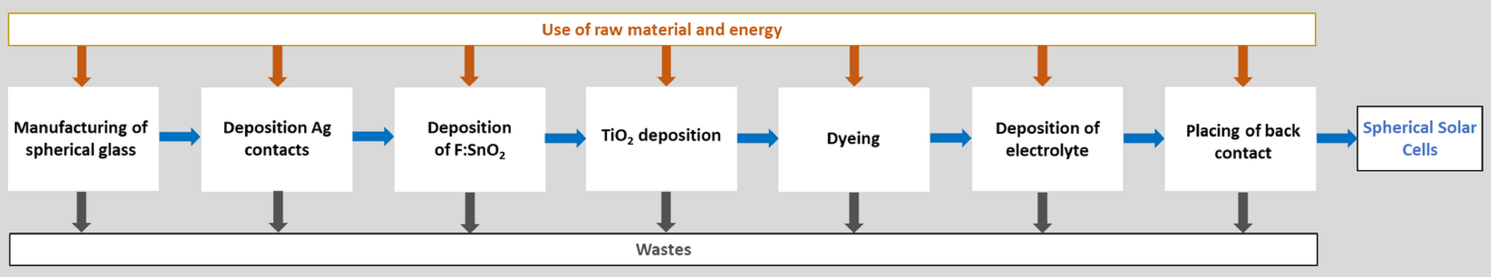


Figure 2. Flowchart for the manufacturing of the Nano-EH solar cell.

4. Silicon Impact Analysis: Specify benchmark for standard heterojunction solar cell; assess the proportion of environmental impact attributable to Silicon use.

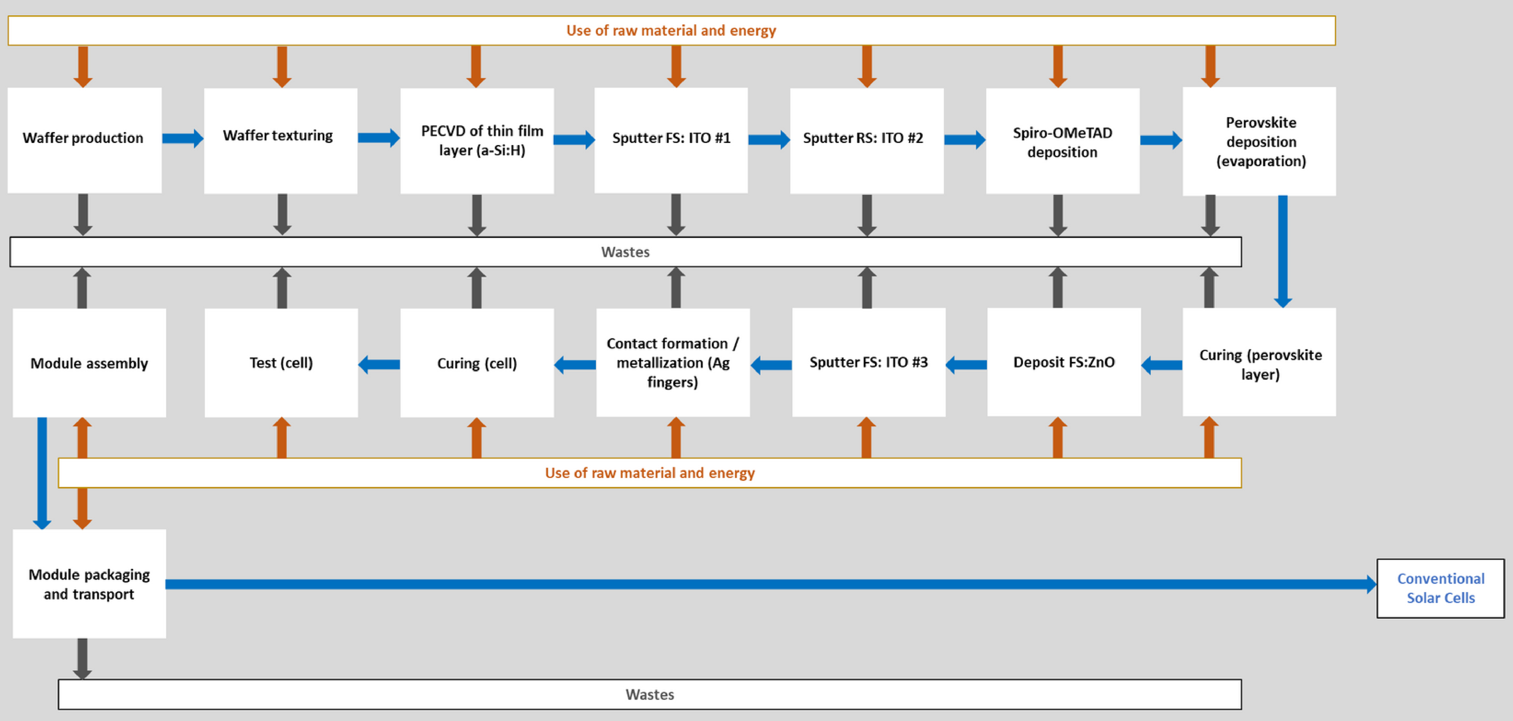


Figure 3. Flowchart for the manufacturing of the conventional sollar cells based on the literature: Roffeis et al. (2022).

RESULTS

1. The base scenario based on the current development of spherical cells in the project has been assessed. This base scenario allows the comparison with previous references (related to industrial development) and scenarios derived from the application of eco-design principles.

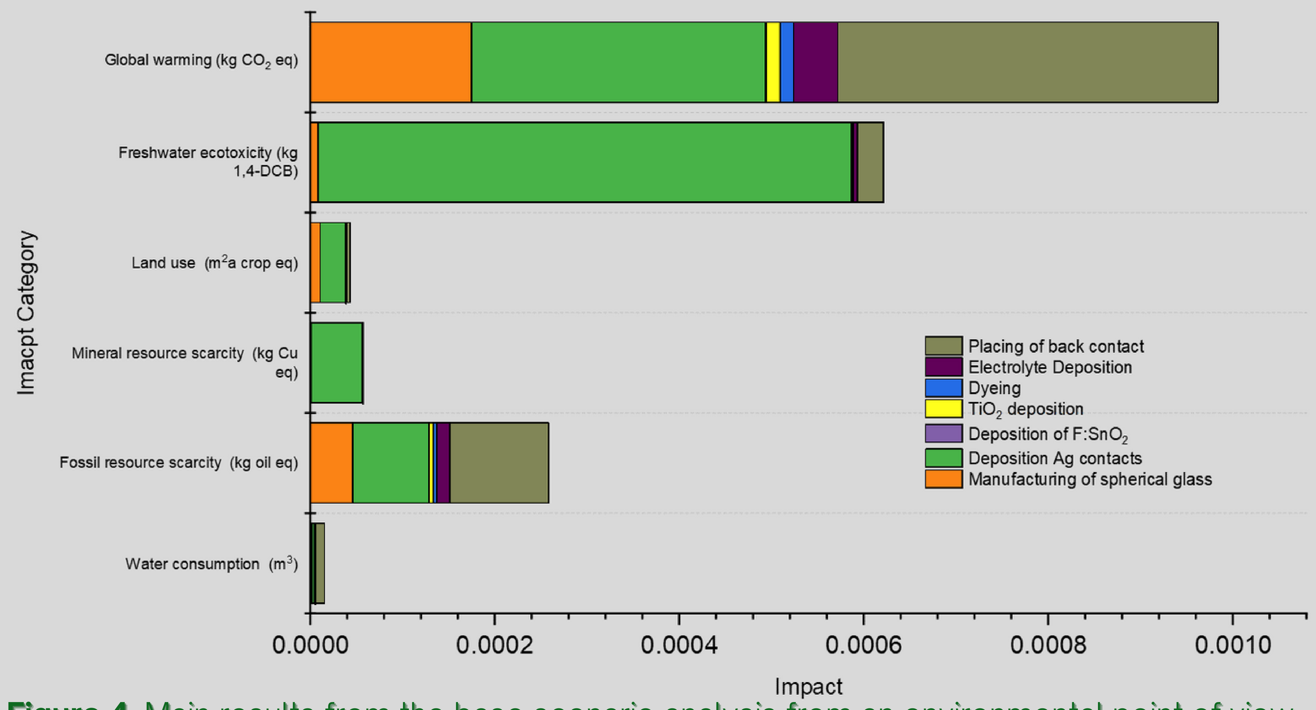


Figure 4. Main results from the base scenario analysis from an environmental point of view.

2. The material and energy usage cost assessment revealed an initial cost of fabrication of 1.26€/solar cell. Which is allocated as shown in Figure 5.

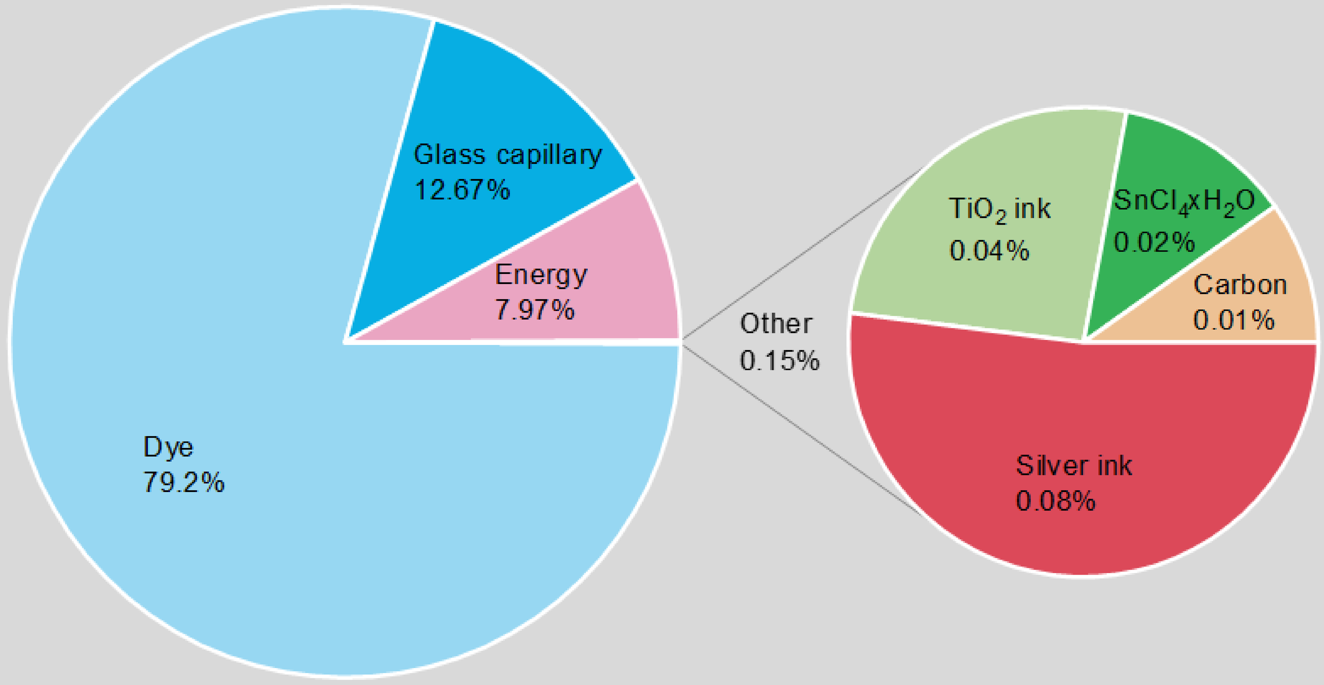


Figure 5. Identified cost for the NanoEH Solar Cell

3. The base scenario analysis has pointed out the high contribution from the use of silver. Hence, based on the silver functionality, it has been decided to replace the use of silver by copper in oder to assess the improvement derived from this substitution.

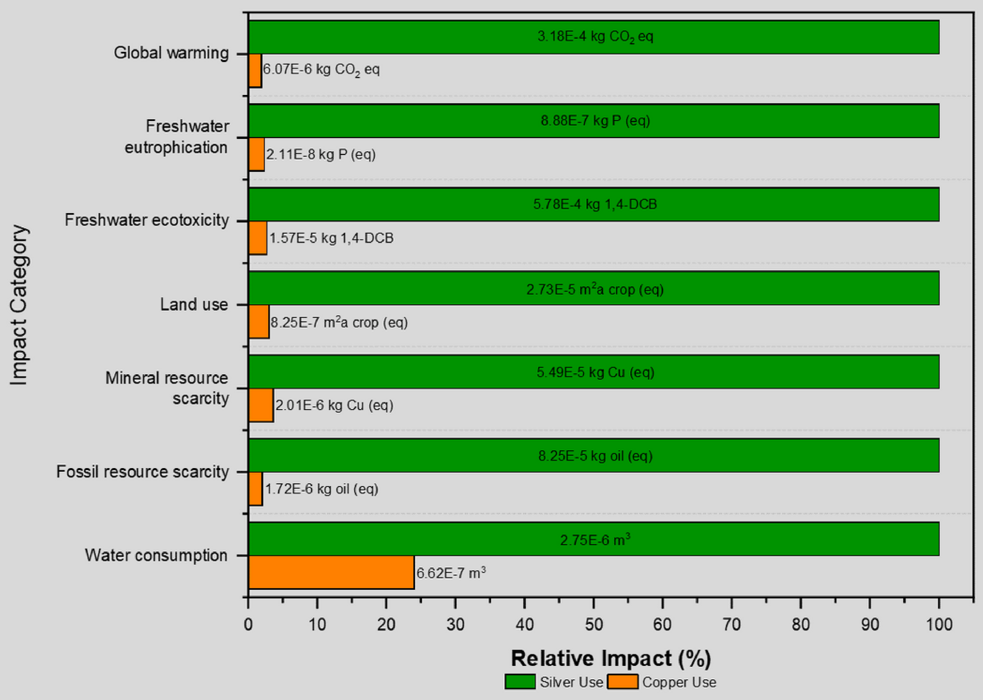


Figure 6. Main results from the scenario based on the silver replacement by copper.

4. The analysis suggests that Silicon is one of the main contributors of environmental impacts, especially in fossil resource and water use, pointing to potential environmental advantages in seeking alternative materials.

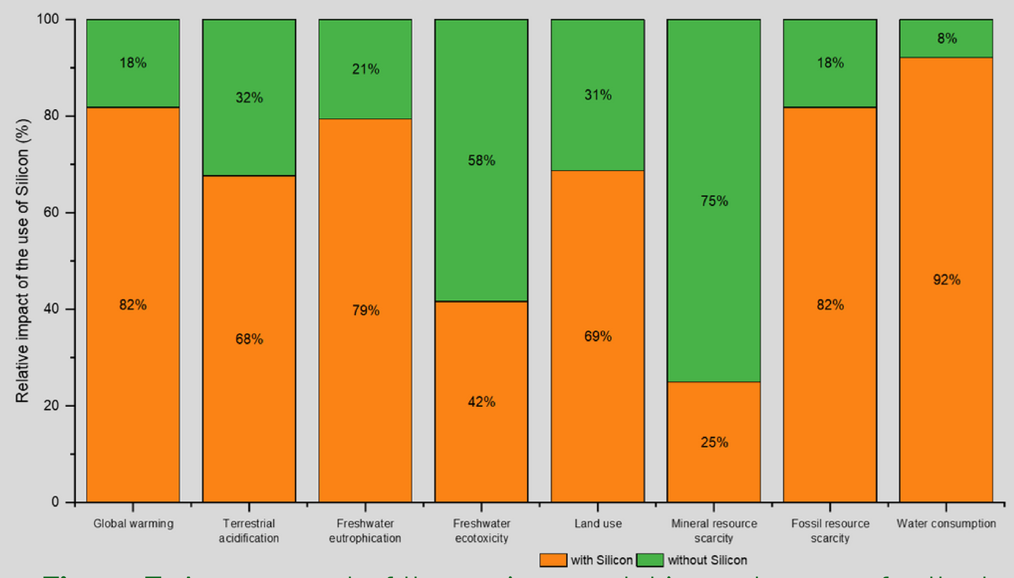


Figure 7. Assessment of the environmental impact source for the benchmark.

NEXT WORK

- Characterizing the functionality of the device to compare with the benchmark.
- Continueing the assessment and implementation of eco-design principles and applications (eco-strategies) to reduce the environmental impact from the Nano-EH solar cells in comparison to the benchmark.

AFFILIATIONS

[1] Blue Synergy, Calle Maudes 51, 8ª Planta, 28003, Madrid, Spain

[2] NANOM MEMS SRL, Strada George Cosbuc 9, 505400, Rasnov, Romania

[3] Université de Rennes, INSA Rennes, CNRS, Institut FOTON - UMR 6082, F-35000, Rennes, France

[4] Tyndall National Institute-University College Cork, Lee Maltings, Dyke Parade, T12R5CP, Cork, Ireland

LITERATURE

M. Roffeis, S. Kirner, J.-C. Goldschmidt, B. Stannowski, L. Miranda-Perez, C. Case, M. Finkbeiner, 2022. New insights into the environmental performance of perovskite-on-silicon tandem solar cells – a life cycle assessment of industrially manufactured modules. Sustainable Energy and Fuels 6, 2924".

CORRESPONDING E-MAIL

admin@bluesynergy.eu

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

Sally K. Springer*, Christina Wulf*, Petra Zapp*
***Forschungszentrum Jülich GmbH | Institute of Energy and Climate Research |** Wilhelm-Johnen-Straße, 52425 Jülich, Germany
s.springer@fz-juelich.de

General information

The Product Social Impact Life Cycle Assessment (PSILCA) database is available with two different approaches. The worker hours (WH) approach, which uses worker hours as an activity variable and the raw values (RV) approach, which calculates with the raw value of the inventory indicator directly [1]. Both approaches rely on the same economic and social data, but their handling in openLCA differs. The differences affect the inventory, impact assessment and interpretation of results. In addition, the approaches involve different modeling aspects of the product system by the practitioner of the study. Both of them bringing along advantages and shortcomings, which are presented in addition to the differences in this work. The elaborations are based on an article under review by Springer et al. 2024 with the same title.

Worker hours (WH) approach

Raw values (RV) approach

Inventory

Worker hours (WH) approach

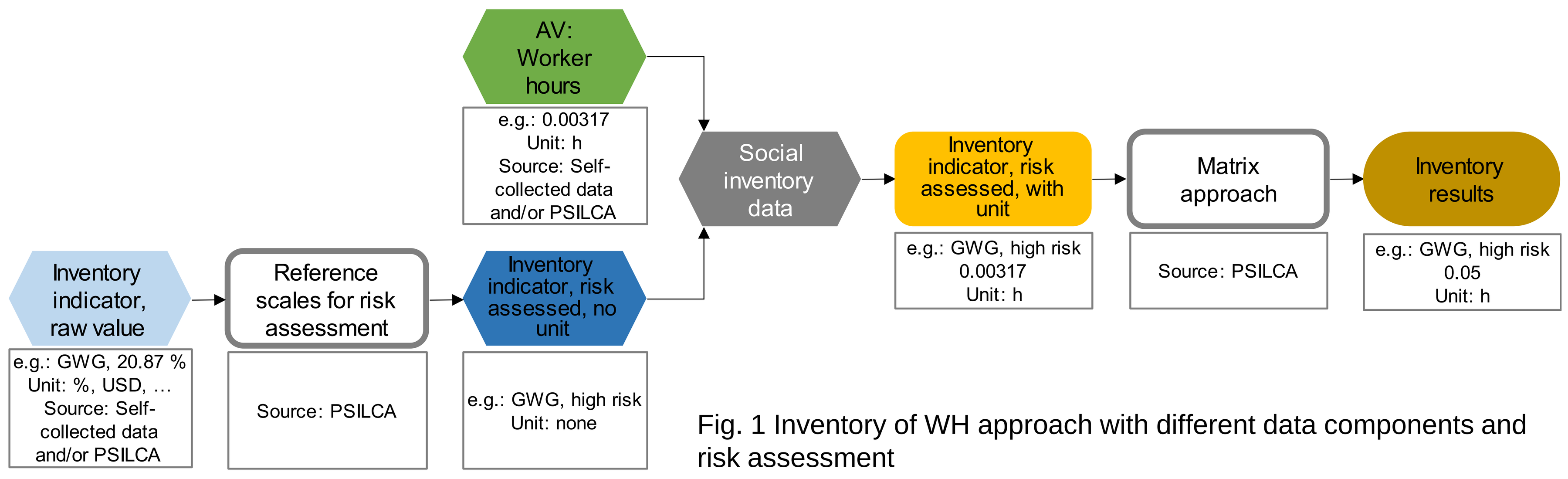


Fig. 1 Inventory of WH approach with different data components and risk assessment

The reference flow on the output side of an unit process can have any amount and unit. Figure 1 shows the quantitative raw values of inventory indicators that can have also any unit and are translated into qualitative risk levels with the help of reference scales defined by GreenDelta. The activity variable (AV) h is used for the amount and is the same within one unit process [1]. The risk assessed inventory indicators enter a matrix calculation which is the same as in the RV approach. The inventory results are risk assessed and displayed in the unit h.

Raw values (RV) approach

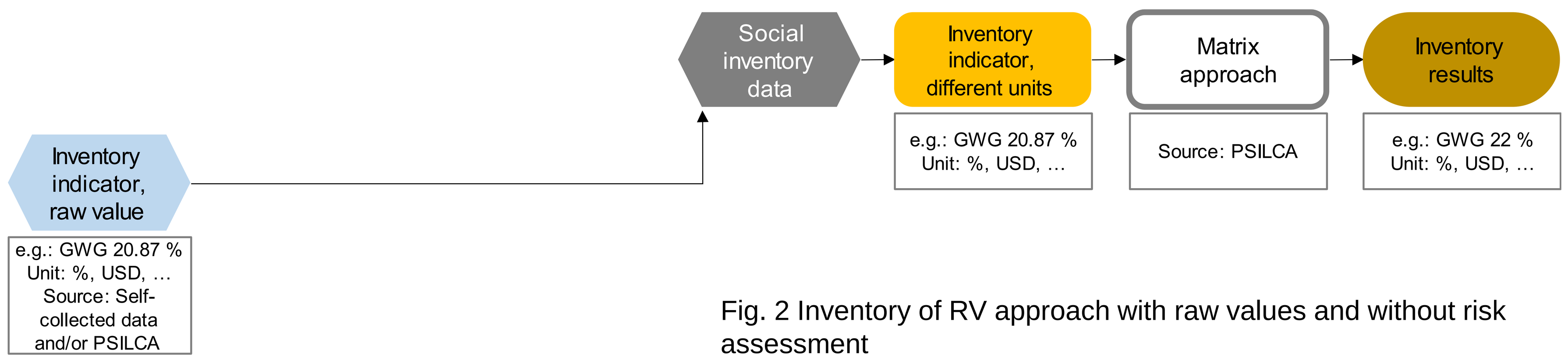


Fig. 2 Inventory of RV approach with raw values and without risk assessment

The reference flow on the output side of an unit process equals 1 USD. Figure 2 shows the quantitative raw values of inventory indicators that are directly used and keep their amount and underlying unit. No activity variable is used [1]. The inventory indicators enter a matrix calculation which is the same as in the WH approach. The inventory results are displayed in different units.

Impact assessment

Worker hours (WH) approach

Social Impacts Weighting Method

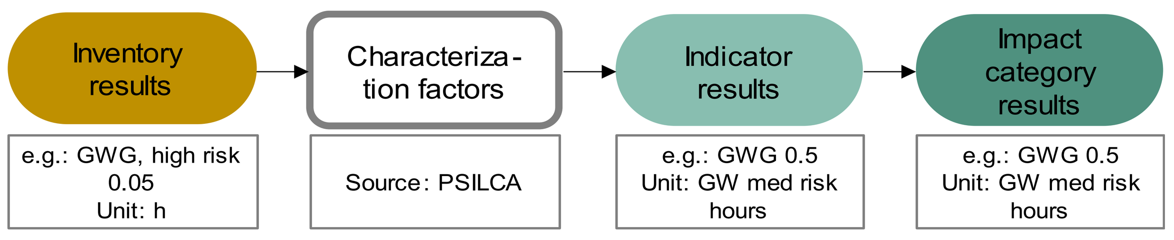


Fig. 3 Three PSILCA results of WH approach

(1) $$SI\,[IC\ med\ risk\ hours] = g_{kP}\,[h] * CF\left[\frac{IC\ med\ risk\ h}{h}\right]$$

(2) $$IC = \sum SI\,[IC\ med\ risk\ h]$$

SI: Indicator result
g_{kP}: Inventory result of indicator k for unit process P
CF: Characterization factor
IC: Impact category result

Indicator level
Inventory indicators for each risk level
- With risk assessment
- With matrix approach
- No impact assessment

Exponential characterization factors (CFs), used to quantify qualitative risk levels, calc. with equation (1)

Indicator level
Impact indicators for each risk level
- With risk assessment
- With matrix approach
- With impact assessment

Impact category level
Impact categories, calc. with equation (2)
- With risk assessment
- With matrix approach
- With impact assessment

Raw values (RV) approach

Not an impact assessment corresponding to UNEP guidelines [2] but a foundation for an impact assessment.

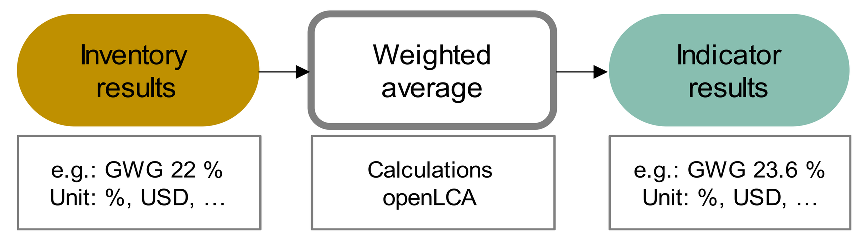


Fig. 4 Two PSILCA results of RV approach

(3) $$r_k = \frac{g_k}{\sum_{i=1}^{n} a_{ii} * s_i}$$

(4) $$s_i = (A^{-1} * f)_i$$
$$s = (A^{-1} * f)$$

r_k: Indicator result of indicator k
g_k: Inventory result of indicator k
a_{ii}: Output of process i
s_i: Scaling factor for each individual process i
s: Scaling factor for the entire vector s
A^{-1}: Inverted technical matrix
f: Demand vector

[1]

Indicator level
Inventory indicators (not shown in openLCA results)
- No risk assessment
- With matrix approach
- No impact assessment

Normalization: Equation (3) and (4) calc. weighted average of the inventory indicator. Economic outputs of unit processes used as weights [1]

Indicator level
Impact indicators
- No risk assessment
- With matrix approach
- No impact assessment
- With normalization

Modeling aspects

Worker hours (WH) approach

Reference flow in output can have any amount and unit	Scaled according to product system
Adding inventory indicators to unit processes optional	Inventory indicators with 0 worker hours result in no direct impacts caused within that unit process
Number of unit processes does not necessarily influence results	Scaled according to product system

Raw values (RV) approach

Reference flow in output always has to equal “1 USD”	Requirement: For all inventory indicators which do not scale with the output, a reference flow for which they are true is defined by GreenDelta as 1 USD
Adding (the same) inventory indicators to every unit process mandatory	Requirement: Inventory indicators with 0 become subject to an evaluation e.g., a *gender wage gap* of 0 % would be the optimum, and a *sector average wage* of 0 USD would be the worst possible option
Number of unit processes has influence on results	Consequence: Reference flow of 1 USD for every unit process causes economic output a_{ii} which has an influence on indicator results r_k. Every unit process has inventory indicators and adds to social impacts and therefore to inventory results g_k

Overview of advantages and shortcomings

Worker hours (WH) approach

\+ All data characteristics (quantitative, qualitative or semi-quantitative) [3]
\+ Comparable, summable [2]
\+ Prioritization [4]
\+ Modifiable risk levels and CFs [1]

\- Data for worker hours not available, uncertain [5]
\- Transparency loss [2]
\- Reference scales, risk levels, CF´s subjective
\- Unit of results: IC specific med risk hours
\- Reflection of relative significance ambiguous [2]
\- Focus stakeholder workers [1]

Raw values (RV) approach

\+ Safes time
\+ No predefined subject risk assessment
\+ Unit of results: initial units
\+ Interpretation easier [3]
\+ Higher transparency
\+ All stakeholders

\- Averaged [3]
\- Transparency loss [3]
\- Only life cycle stages with same inventory indicators can be integrated

Future prospects

Could the inclusion of a risk assessment in the RV approach be beneficial? How can it be conducted? Is an integration after the weighted average feasible? Is it possible to combine the two approaches? Are the hotspot results of the two approaches different? Is it the same across all stakeholder groups?

Member of the Helmholtz Association

[1] Loubert M, Maister K, Di Noi C, Radwan L, Ciroth A, Srocka M (2023) PSILCA v. 3.1. A Product Social Impact Life Cycle Assessment database. Documentation, Berlin, Germany, [2] UNEP (2020) Guidelines for Social Life Cycle Assessment of Products and Organizations 2020, Paris, France, [3] Ciroth A, Di Noi C, Srocka M (2020) Revisiting the activity variable in Social LCA beyond worker hours, LCA XIX. GreenDelta GmbH, Tucson, Arizona, USA, [4] Benoît Norris C (2014) Data for social LCA. Int J Life Cycle Assess 19, 261-265. [5] Karlewski H, Lehmann A, Ruhland K, Finkbeiner M (2019) A Practical Approach for Social Life Cycle Assessment in the Automotive Industry. Resources 8, 146.

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

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

1 Dignity Private Company, 30-32 Leoforos Alexandrou Papagou, Zografou 15771, Athens, Greece.
2 Teagasc, Agriculture And Food Development Authority, Oak Park, Carlow, R93 XE12, Ireland.
E-mail:apetridi@dignity.com.gr

Abstract

Beverage production is going to increase substantially in the coming years. While numerous studies have assessed the environmental impacts of beverage production, there is a scarcity regarding its social aspects. Additionally, consumer preference for plant protein based products is steadily rising, leading to a notable increase in their production. In this analysis the social risks associated to a plant protein based beverage, produced in Ireland, in pilot scale, are examined. The findings revealed that there are certain social indicators highly affected from the beverage production, mainly those related to value chain actors. The risks derive mostly from the electricity consumption, required mainly in the protein isolate phase. Thus, an alternative approach was proposed, focusing on reducing the energy consumption of the primary contributor, the freeze drying process. Implementing this modification substantially mitigated social risks, but further studies are required for a more sustainable beverage production process.

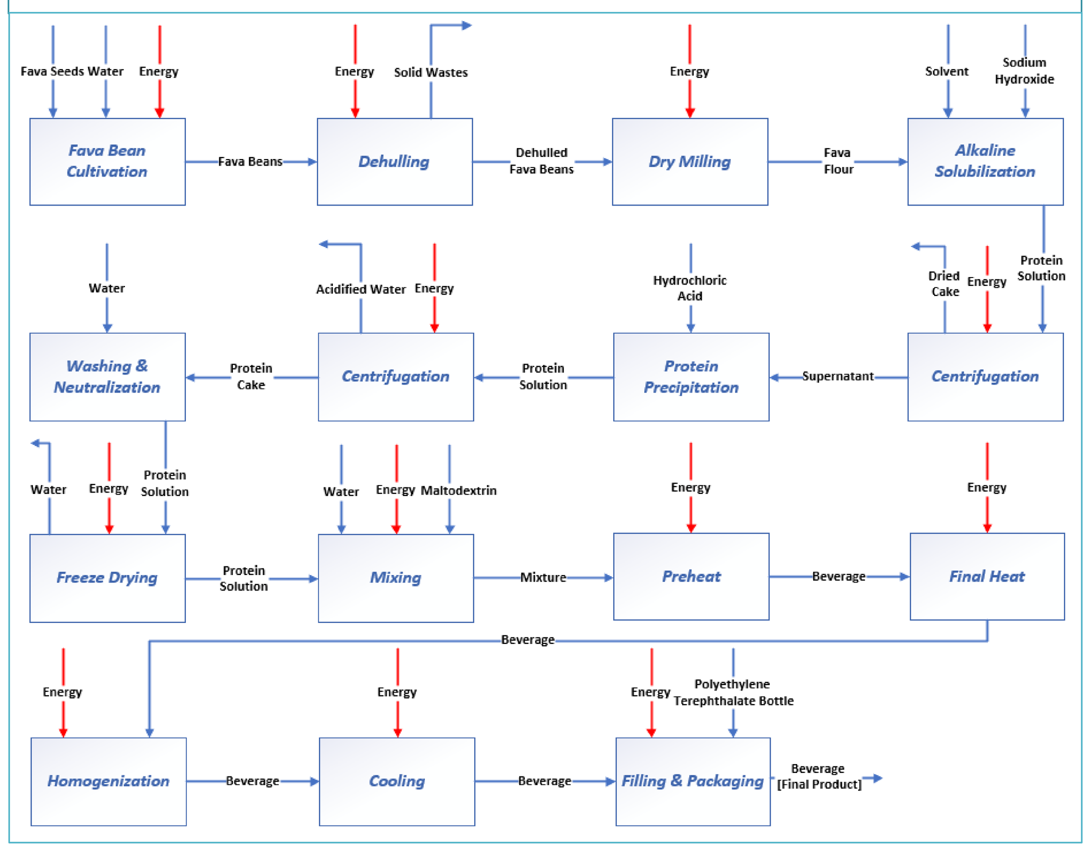
Introduction

The beverage industry stands as a vital economic sector with a profound impact on local and global economies. According to Statista, in 2023, the sales from non-alcoholic beverage industry globally reached 1.45 trillion USD, while in 2027, it is expected to reach 1.74 trillion USD [1].

Simultaneously, the growing preference for plant-based protein indicates a significant shift in dietary habits and consumer choices. The global plant-based protein supplements market is projected to grow from $5.40 billion in 2021 to $7.84 billion in 2028 at a CAGR of 5.5% in forecast period [2]. This movement is driven by a combination of factors, including health consciousness, environmental concerns, and ethical considerations.

Within this context, VALPRO Path Project aims to combine these two aspects, by developing a plant protein based beverage, in pilot scale, in Ireland. However, both the cultivation phase and the pilot production process have raised concerns over their social impacts on workers, value chain actors, local communities and society.

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 process and suggest strategies for their mitigation. The process line of the beverage production, in pilot scale, is presented in Flowchart 1.



Flowchart 1. Plant protein based beverage production process

Methods and Materials

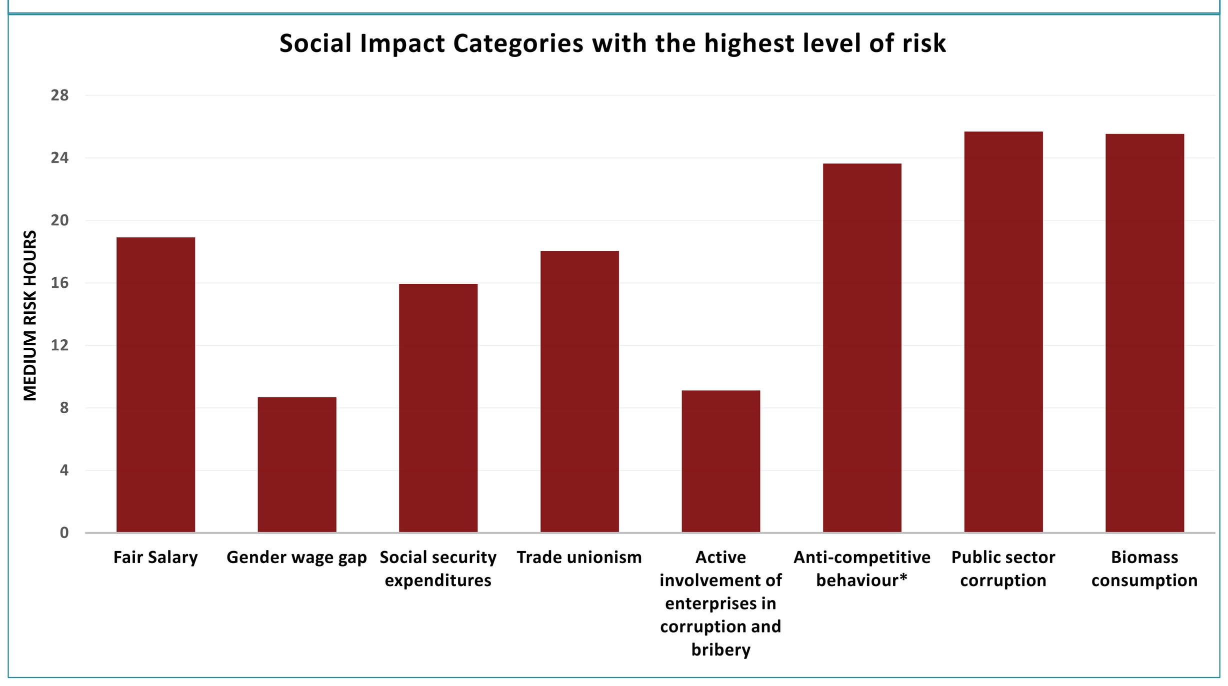
The Social Life Cycle Assessment was implemented in OpenLCA v1.11.0. The boundaries of the system were cradle to gate and the functional unit 1 kg of beverage produced. The data for the inventory was collected through:

- National Databases
- Site-specific data
- Soca v2 database

As an impact assessment method 'Social Impacts Weighting Method' was applied, which uses different risk levels as characterization factors and the results are expressed in medium risk hours. The analysis covers 55 impact indicators focusing on the four stakeholders. Worker hours was the activity variable used, which illustrate the time workers spend to produce a certain amount of product, equivalent to 1 USD output in the given process or sector .

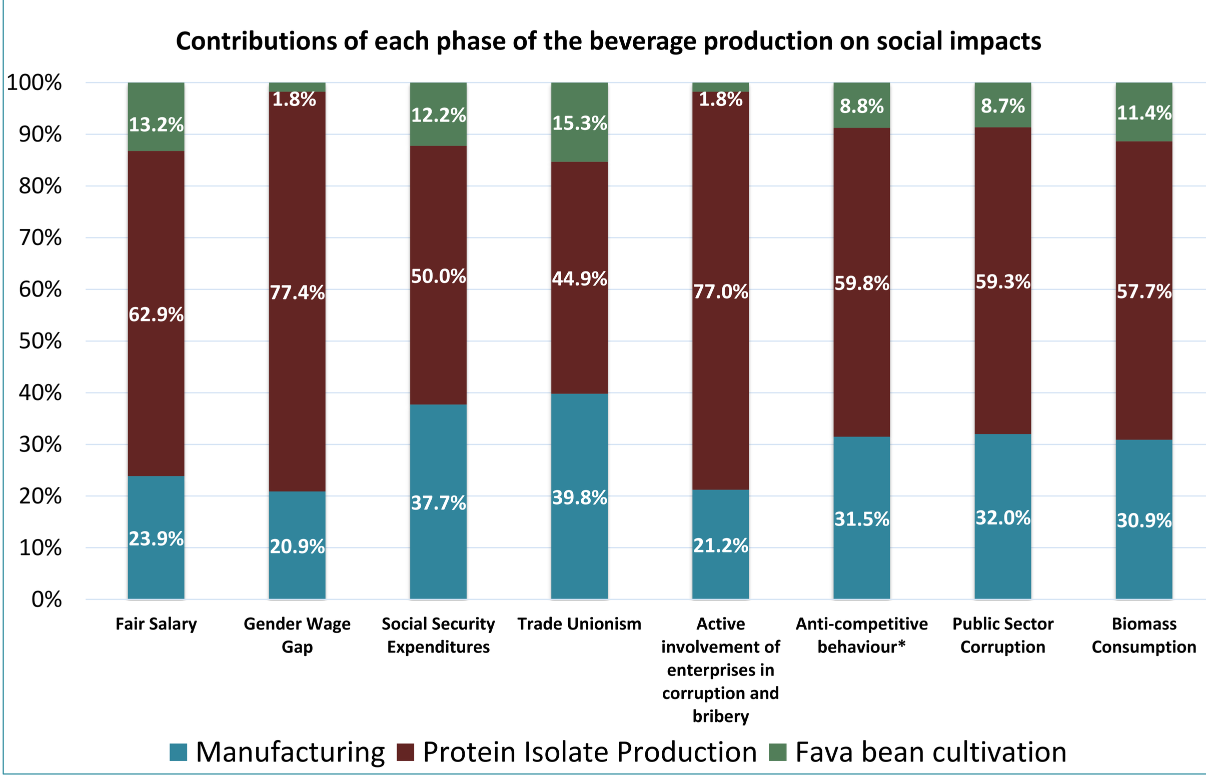
Results & Discussion

The social indicators that scored the highest risks, on the beverage production process, are illustrated in Flowchart 2.



Flowchart 2. Selected Social Impact Categories with the highest level of risk

Three out of the four indicators of stakeholder value chain actors belong to the impacts with the highest risk, demonstrating that it is the most affected. Flowchart 3 depicts the percentages of highest risked social impact indicators attributed to each production stage.



Flowchart 3. Contributions of the beverage production phases on social impacts

The majority of the high social risks are associated to the electricity consumption. As electricity flow in the analysis 'High voltage electricity production mix in Ireland' was chosen, which utilizes electricity characteristics of 2017. That year, Ireland generated 5808 GWh electricity from coal, with South Africa ranking as the 4th largest exporter of coal briquettes to Ireland, significantly accelerating the social risks of electricity consumption [4,5]. According to Human Rights Watch, South Africa suffers from inequality, unemployment, corruption, unhealthy conditions and environmental degradation, leading to severe social threats [6].

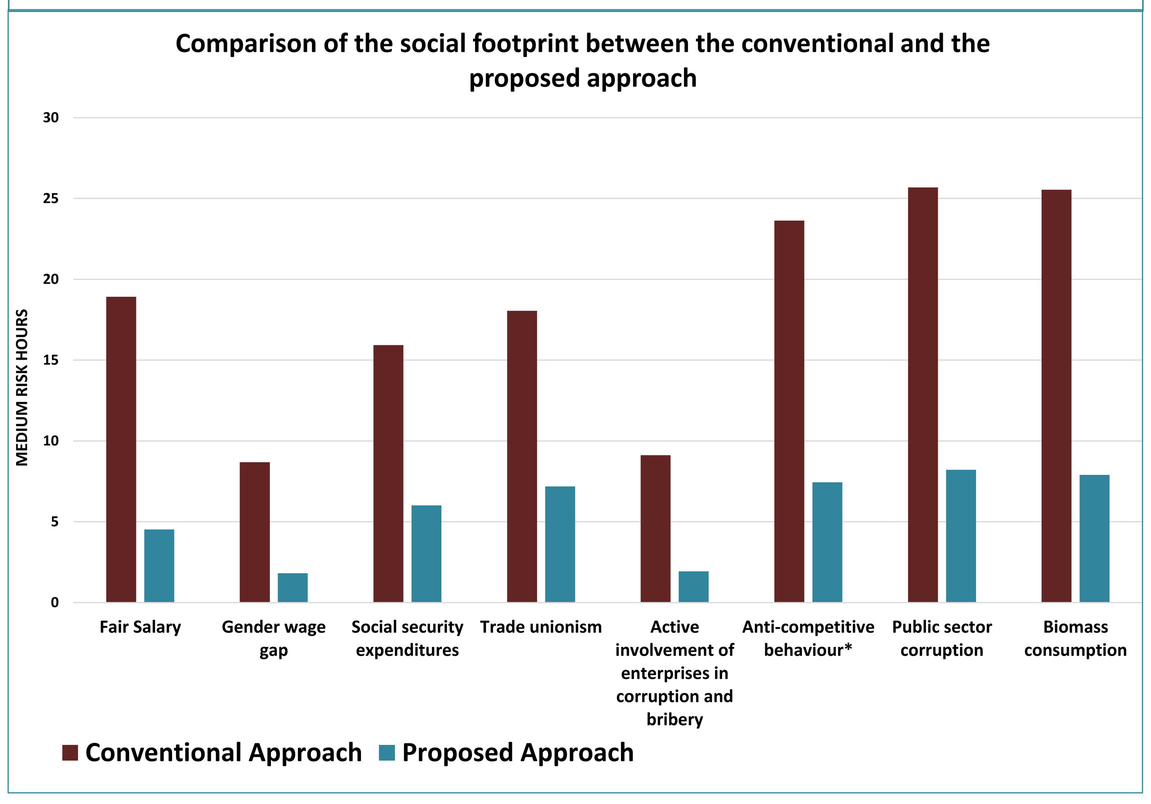
Results & Discussion

Protein isolate is the production phase most impacting to the social indicators scored the highest risks, as depicted in Flowchart 3. This process phase consumes elevated amounts of electricity, especially in the freeze dying process, and requires sodium hydroxide in the alkaline solubilization phase, both contributing substantially to the social impacts.

Given that electricity consumption stands out as the primary contributor, an alternative scenario, focusing on reducing electricity, is proposed. Freeze drying has the highest electricity demands of the process, due to absence of a liquid phase removal process after washing and neutralization.

Implementing an ultrafiltration process prior to freeze drying would lead to a more concentrated solution entering the freeze drying process, and thus mitigating the total electricity demands.

The comparative results of the two analysis are presented in Flowchart 4.



Flowchart 4. Comparative results of the highest risked social indicators between the base and the proposed approach

The most significant social risks are substantially decreased with the proposed approach, concluding that electricity demands decline, would contribute to a more socially sustainable plant protein based beverage.

Conclusions

The Social Life Cycle Assessment of plant protein based beverage produced in Ireland revealed that there are some critical social indicators, with substantial risks. These social risks affected all of the stakeholders, with an emphasis on value chain actors.

The primary contributor to the social risks was the electricity consumption. Given that protein isolate production is the highest electricity-intensive phase, a specific change in the process line of this phase was proposed to achieve mitigation of the energy demands.

The alternative approach yielded that by reducing electricity consumption, the social impacts are substantially moderated, highlighting the pivotal role of electricity generation blend in industries.

It's important to note that the analysis was performed on a pilot scale process [7]. This suggests potential variations in the results when applied on industrial scale. Additional studies should be conducted to the field in order to promote a more holistic approach considering all the three pillars of sustainability: environment, economy, and society.

*Anti-competitive behaviour or violation of anti-trust and monopoly legislation

Contact

Angeliki Petridi
DIGNITY PRIVATE
Email: apetridi@dignity.com.gr

UK Research and Innovation
Co-funded by the European Union

This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No. 101059824 and co-funded by UK Research and Innovation (UKRI) under the UK government's Horizon Europe funding guarantee.

References

1. M. Ridder. (2024). Worldwide non-alcoholic beverage market revenue from 2016 to 2027. STATISTA.
2. Plant Based Protein Supplements Market Size, Share & COVID-19 Impact Analysis, By Type (Soy Protein, Pea Protein, and Wheat Protein), Distribution Channel (Mass Merchandisers, Pharmacies/Drugstores, Specialty Stores, Online Retail, and Others), and Regional Forecast, 2021-2028. (2021). Fortune Business Insights.
3. Kirill Maister, Claudia Di Noi, Andreas Ciroth, & Michael Srocka. (2020). PSILCA v.3: A Product Social Impact Life Cycle Assessment database
4. International Energy Agency, Ireland, Coal supply
5. AJG Simoes, CA Hidalgo. The Economic Complexity Observatory: An Analytical Tool for Understanding the Dynamics of Economic Development. Workshops at the Twenty-Fifth AAAI Conference on Artificial Intelligence (Coal Briquettes in Ireland). (2011)
6. South Africa: Events of 2022, Human Rights Watch
7. Kamani, M. H., Liu, J., Fitzsimons, S. M., Fenelon, M. A., & Murphy, E. G. (2024). Determining the influence of fava bean pre-processing on extractability and functional quality of protein isolates. *Food Chemistry: X, 21*, 101200

Please complete the Consumer acceptance questionnaire of plant protein based products here:

Life Cycle Assessment of 600-W Onshore Wind Turbine in Egypt

Ghaidaa N. Abdelkader[1]

[1] Environmental Engineering Program, Zewail City of Science, Technology, and Innovation

INTRODUCTION

Wind energy contributes to 14% of Egypt's electricity, with no direct emissions during operation compared to fossil fuel. However, the production process of wind turbines has an environmental impact. This study analyzes the environmenetal impact of a small 600-W onshore wind turbine in Egypt over a 20-year lifespan. The future mass production of the wind turbine is targeted for farms, agricultural lands, eco-friendly villas, and signal towers in Egypt

RESEARCH METHODOLGY

1 Goal and scope

The assessment aims to identify the primary emission sources for a 600-W wind turbine's production from cradle to grave approach (figure 1), focusing on its main components (hub, nacelle, blades and tower) and stages. In addition to investigating the emissions behind the production of 1 kilowatt-hour of electricity from wind turbine

2 Data collection tools and data sets

Solidworks software was used to gather the primary data for wind turbine material and masses. figure 2 shows the material breakdown. The data are shared with suppliers for manufacturing. The LCA software used is openLCA using Ecoinvent v.3.7.1 cut-off database.

3 Life cycle impact assessment

The environmental potential impacts categories (climate change, Water consumption, Terrestrial acidification, Land use, Freshwater ecotoxicity, Human carcinogenic toxicity and Human non-carcinogenic toxicity

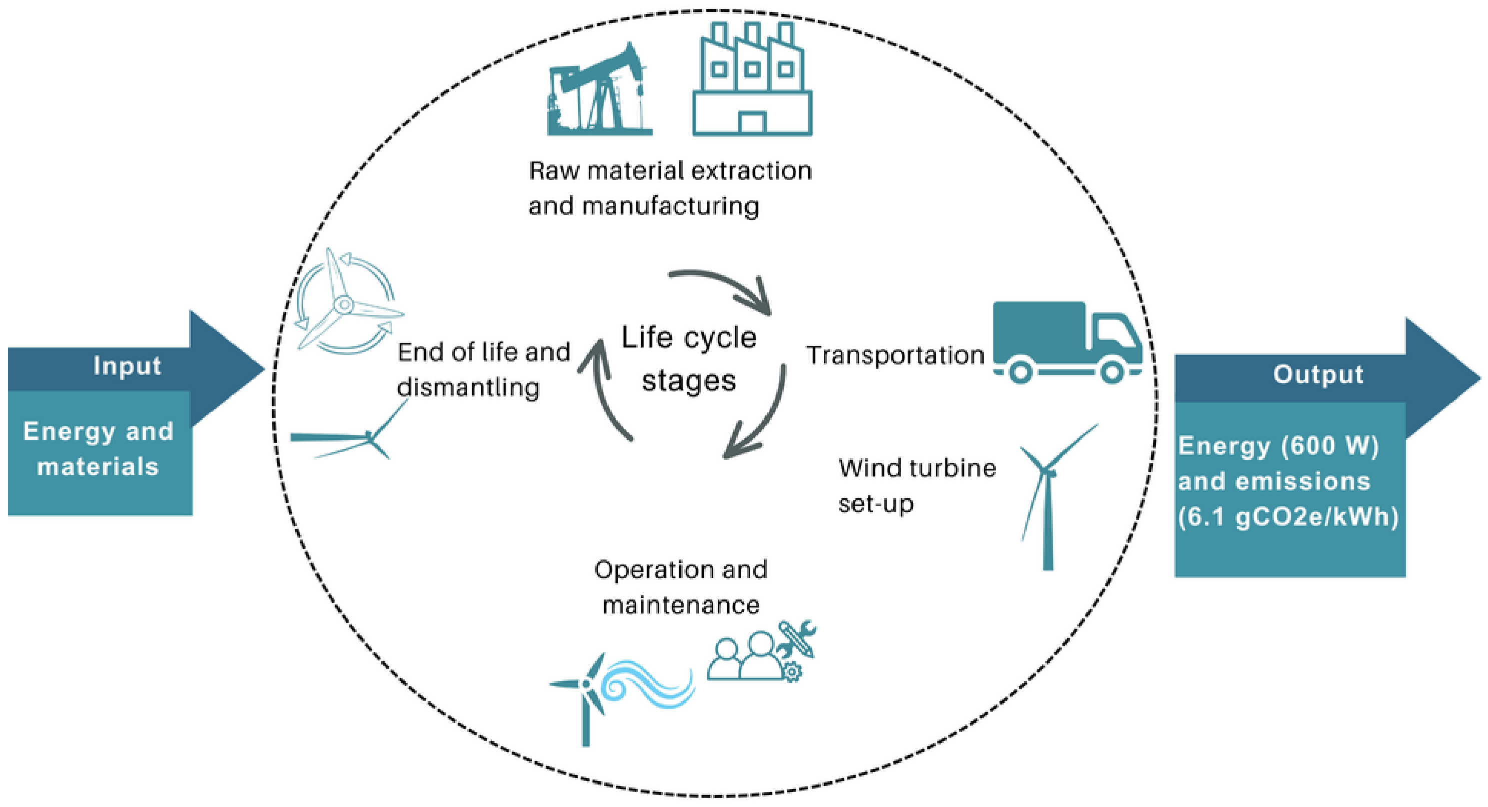


Figure 1: System boundary and life cycle stages

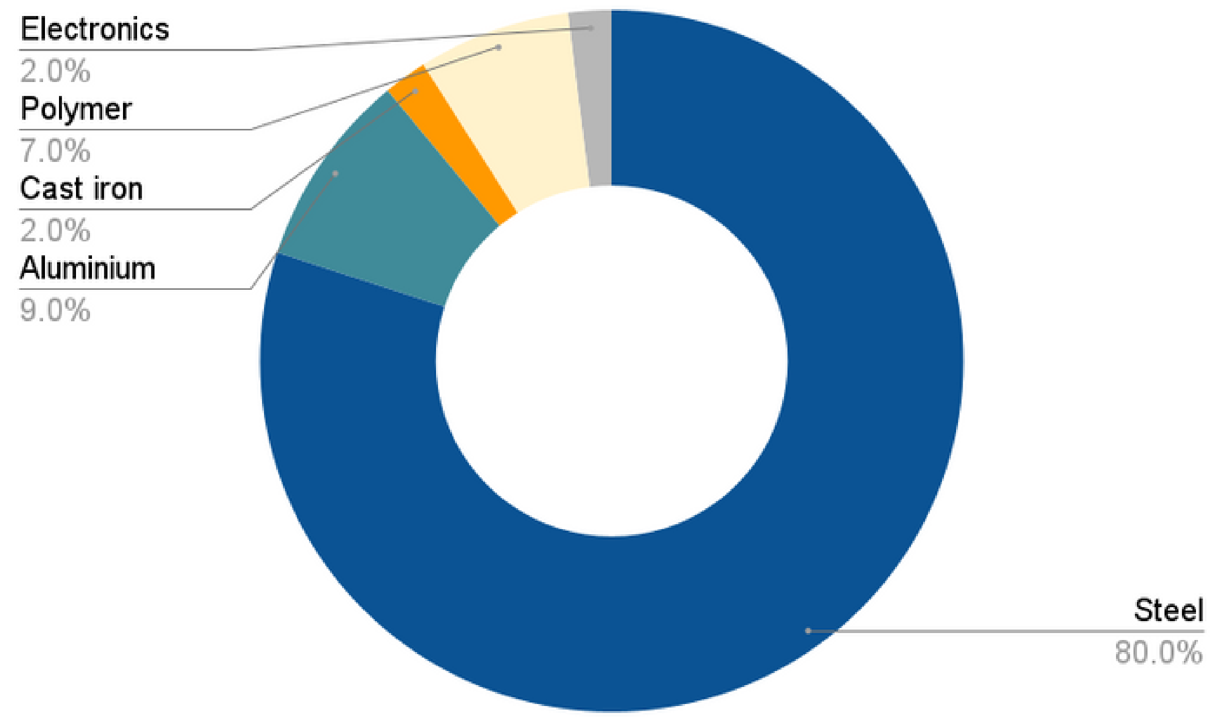


Figure 2: Material breakdown of 600 W wind turbine

RESULTS AND INTERPRETATION

A share of over 95% of the emissions resulted from the raw material extraction and manufacturing stage resulting in 77.5 kgCO2eq for a 600 W wind turbine. The total amount of CO2 emitted per kWh is estimated at 6.1 gCO2/kWh. Figure 3 shows the percentage of each stage. The nacelle is the most contributing component to the environmental impact categories compared with other components due to the many components included in the nacelle.

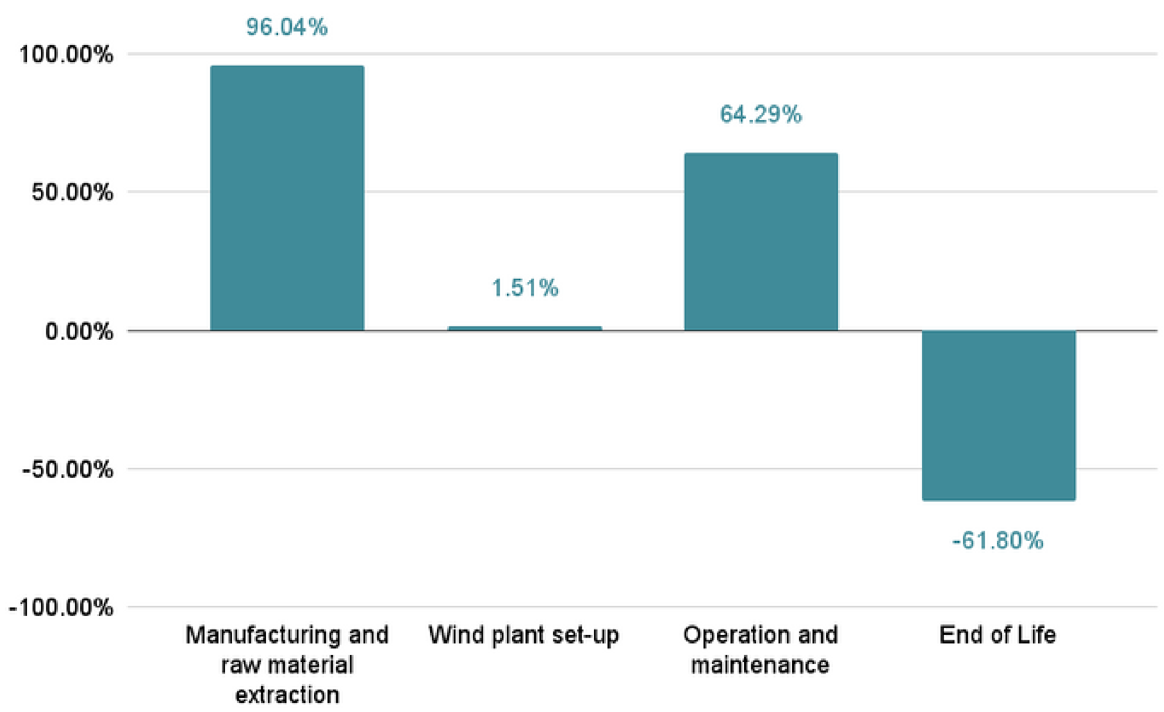


Figure 3: Percentage of global warming contribution from each life cycle (gCO2eq/kWh)

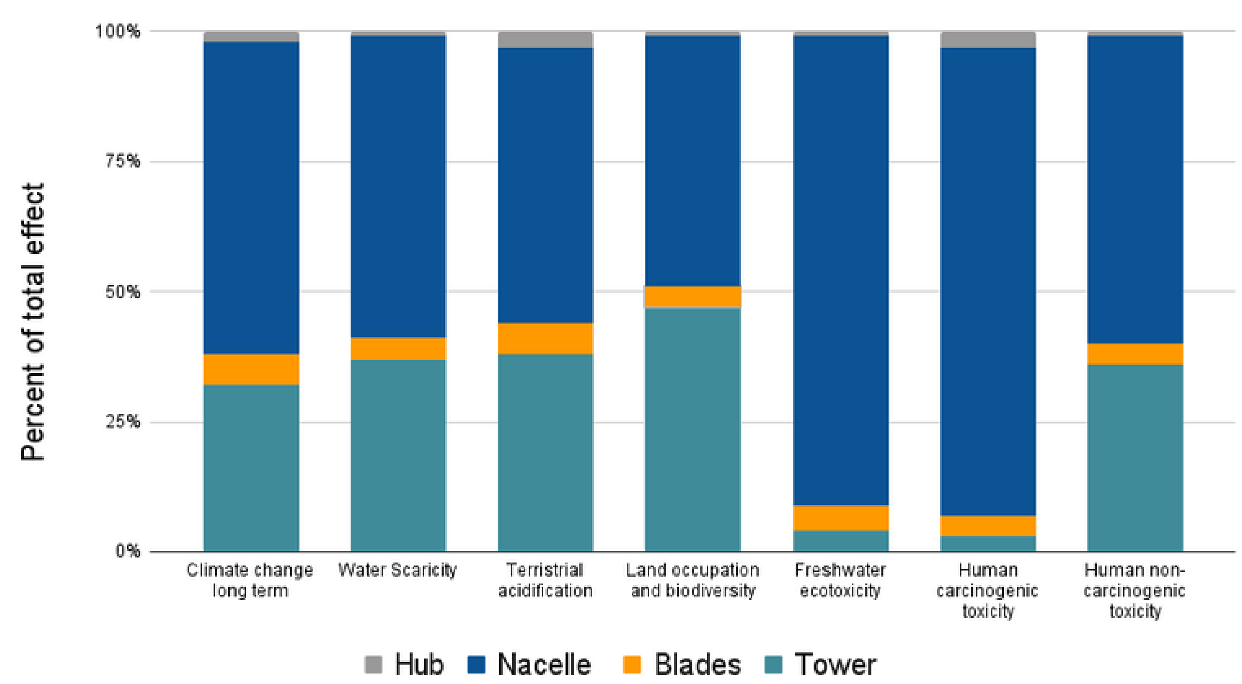


Figure 4: contribution of turbine components to the selected impact categories

CONCLUSION

The study highlighted that each kilowatt-hour of wind turbine operation emits 6.1 grams of CO2, primarily due to raw material extraction and manufacturing. To address this, further research is needed to reduce the environmental impact of these phases, possibly by exploring greener material alternatives.

STOANE LIGHTING

EQUIPMENT DESIGN + MANUFACTURE

Innovate UK

Edinburgh Napier UNIVERSITY

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

Irene Mazzei[1]

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

irene@mikestoanelighting.com

Due to the urgency of the environmental crisis, policymakers are progressively introducing more 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, and to 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 between the manufacturer and a UK-based academic institution, through the Knowledge Transfer Partnership (KTP) program.

Background System

- Identification of materials and processes involved in production.
- Collection of data on in-house manufacturing operations.
- Collection of data from the supply chain.

Internal Database + XLS

Automatic calculation of flows associated to product, for each life cycle stage.

Practical Application

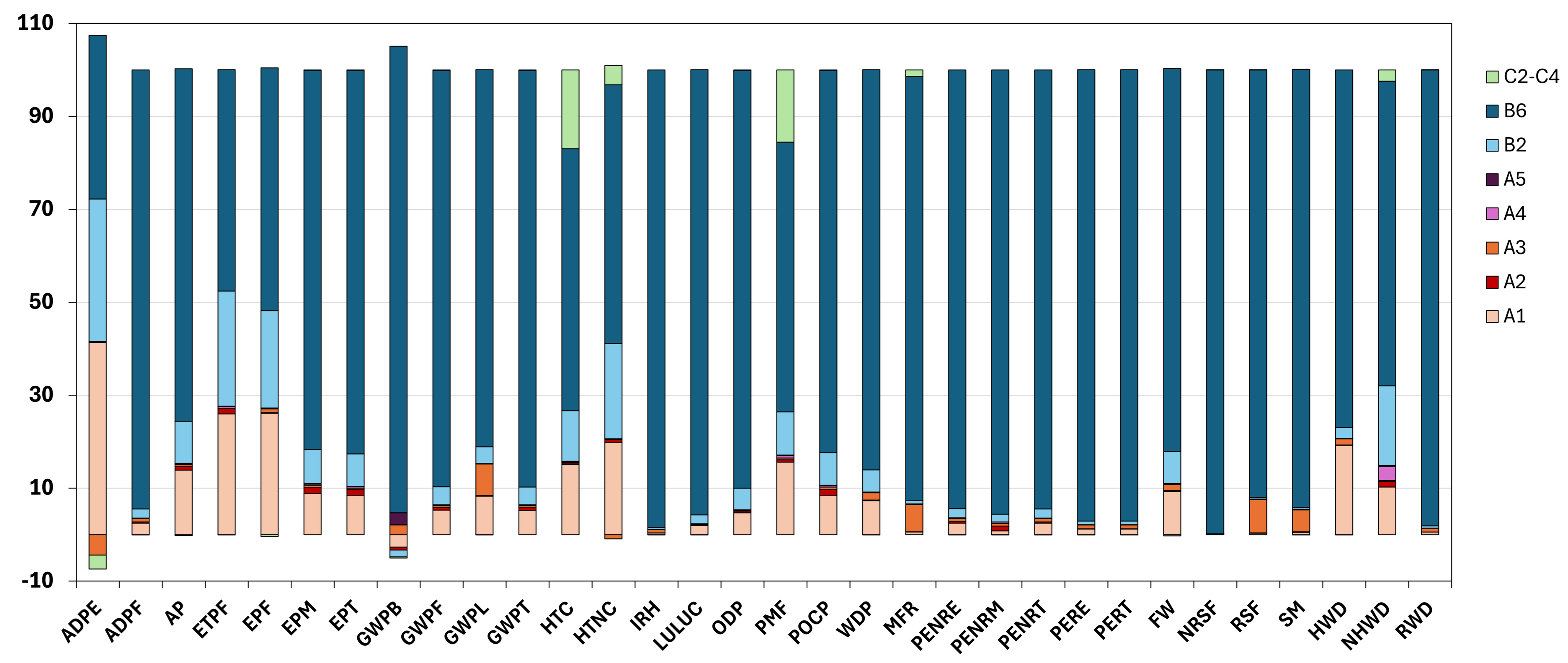
Primary Data → XLS → ecoinvent / openLCA ← Secondary Data

LCA Results + LCA Report

External Verifier + PEP ecoPASSPORT

EPD

Example of Results



- Standardised process and results.
- Accessible and compatible with regulatory requirements.
- Streamlined report creation adapted to EPD format.

Further use of LCA tool

openLCA.conf

15 – 16 April 2024, Berlin

The LCA process created allows the company to easily produce LCA results, not only with the purpose of creating EPD and other reports, but also to (i) base design and manufacturing decisions on scientific data, (ii) track their progress on environmental impacts of products and (iii) gain knowledge on environmental impact assessment topics applied to lighting. The user-friendly interface offered by OpenLCA was key to create a system with the potential to return streamlined results, enabling the lighting manufacturer to break the accessibility barrier often associated with LCA tools.

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

Maryam Mehri[1], Simone Pauling[1]

Background and Aims

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 and layers, dual breed chicken performance in feed conversion rate, especially in the cut-ups, is lower 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 studied so 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 software.

AIMS

Exploring the environmental impacts such as eutrophication, acidification and climate change of conventional and dual-purpose chicken breed under similar housing conditions using;

(a) feed parameters

(b) non-feed parameters

Results

Table 1: Feed borne CO2eq per kg feed, feed intake and CO2eq (kg/kg Breast Meat (BM)) of dual and conventional broilers

Feed	CO2eq (kg/kg feed)	Feed intake (kg/kg BM) Dual	CO2eq (kg) Dual	Feed intake (kg/kg BM) Conventional	CO2eq (kg) Conventional
Starter	0.718	4.7	3.374	2	1.43
Fattening I	0.700	7	4.9	3	2.1
Fattening II	0.722	19.5	15.01	3.1	2.23
Total (kg/kg BM)		31.2	23.284	8.1	5.76

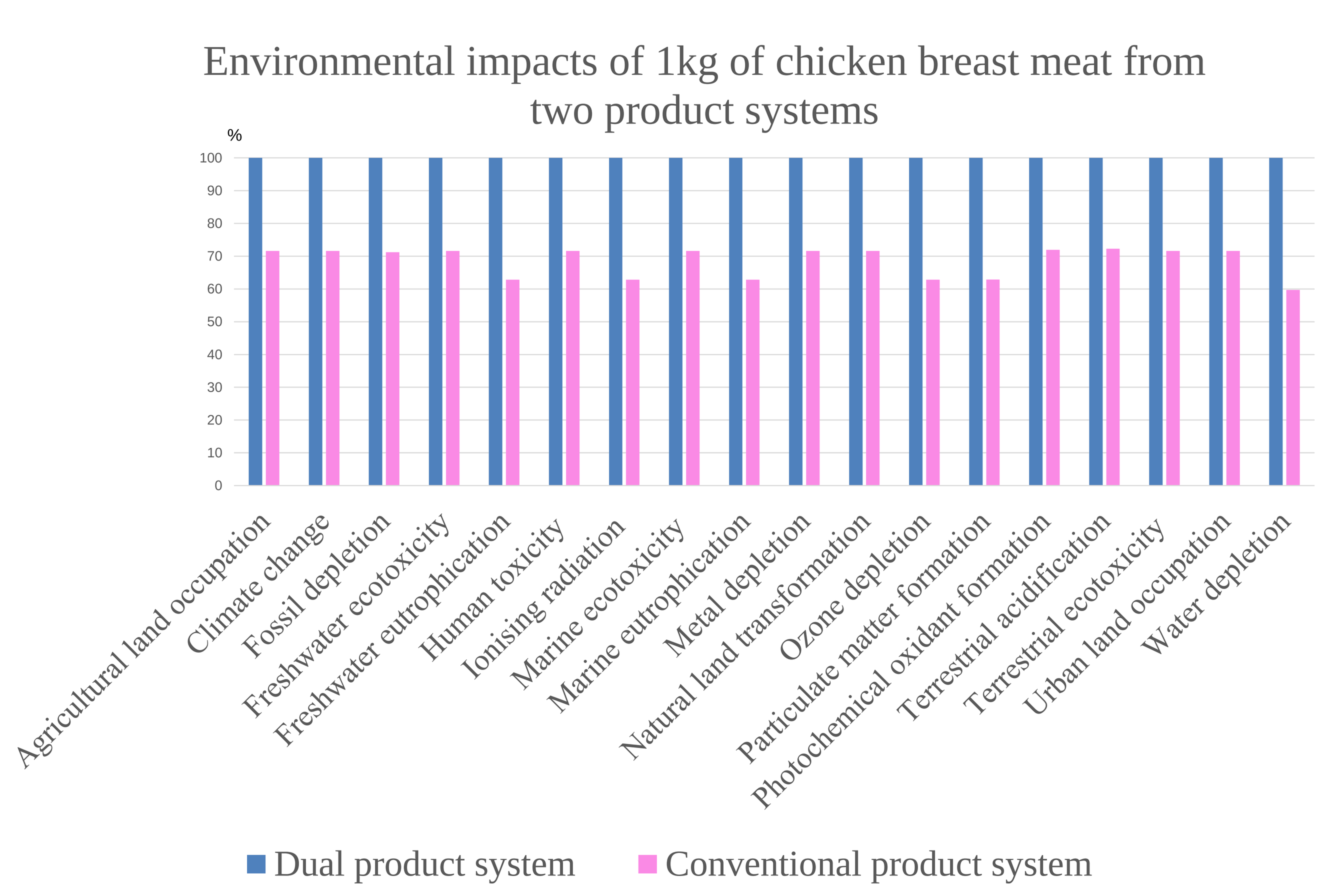


Fig. 1: Comparison of the environmental impacts of 1kg of chicken breast meat produced from two product systems of conventional and dual purpose breeds considering both feed and non feed parameters

Table 2: Contribution of the feed and non feed parameters on selected environmental impact factors in two product system of conventional and dual broilers

Indicators	Non feed parameter Dual (%)	Feed parameters Dual (%)	Non feed parameters Conventional (%)	Feed parameters Conventional (%)
Fossil depletion	95.645	4.355	96.158	3.842
Freshwater eutrophication	0.007	99.993	0.009	99.991
Marine eutrophication	0.005	99.995	0.006	99.994
Ozone depletion	0.049	99.951	0.056	99.944
Water depletion	0.005	99.995	0.005	99.995

1. Producing 1kg of breast meat in dual chickens requires nearly four times the amount of feed compared to conventionals (table 1).
2. Due to the higher feed intake in dual broilers, the CO2 eq of their feed is almost four times **higher** relative to the conventionals (table 1).
3. Dual layers´s feed intake per kg egg is **higher** as of their feed´s CO2 eq in comparison with the conventional layers (table 3).
4. Environmental impact factors of dual purpose chickens in both meat and egg production system is greater than the conventionals (fig. 1 & 2).
5. Contribution analysis of feed and non feed parametrs in both broilers and layers shows the dominant influence of feed production on environmental impact factors (except for fossil depletion factor) (table 2 & 4).

Table 3: Feed borne CO2eq per kg feed, feed intake and CO2eq (kg/kg egg) of dual and conventional layers

Feed	CO2eq (kg/kg feed)	Feed intake (kg/kg egg) Dual	CO2eq (kg) Dual	Feed intake (kg/kg egg) Conventional	CO2eq (kg) Conventional
Pre-Layer	0.666	0.064	0.043	0.049	0.033
Layer I	0.706	2.676	1.889	2.091	1.476
Total (kg/kg egg)		2.740	1.932	2.140	1.509

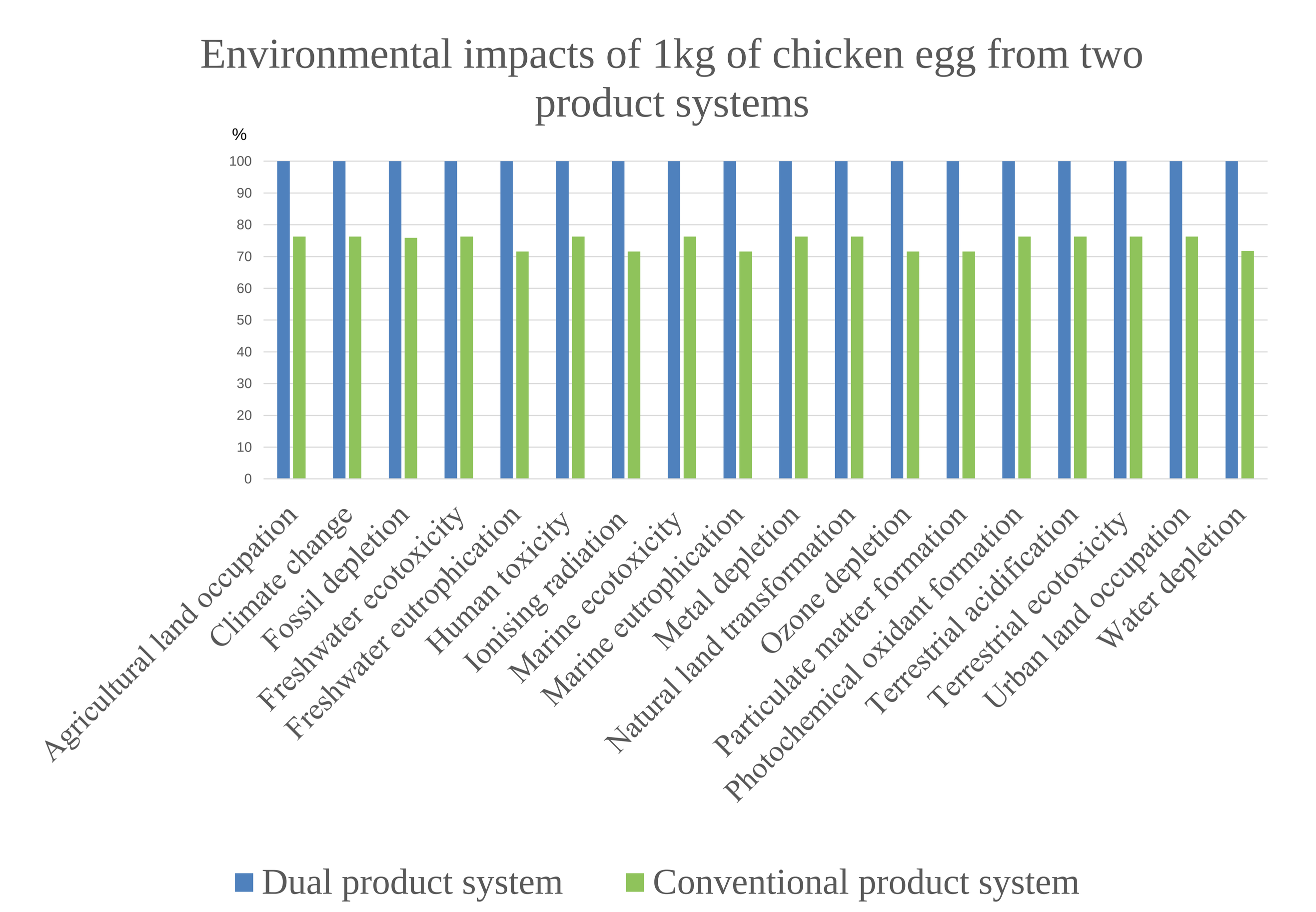


Fig. 2: Comparison of the environmental impacts of 1kg of chicken egg produced from two product systems of conventional and dual purpose breeds considering both feed and non feed parameters

Table 4: Contribution of the feed and non feed parameters on selected environmental impact factors in two product system of conventional and dual layers

Indicators	Non feed parameter Dual (%)	Feed parameters Dual (%)	Non feed parameters Conventional (%)	Feed parameters Conventional (%)
Fossil depletion	91.350	8.650	91.837	8.163
Freshwater eutrophication	0.004	99.996	0.005	99.995
Marine eutrophication	0.002	99.998	0.002	99.998
Ozone depletion	0.025	99.975	0.027	99.973
Water depletion	3.512	96.488	3.733	96.267

Conclusion & Discussion

Lower performance in dual broiler leads to higher amount of feed intake, CO2eq and greater environmental impact factors

Lower performance a swell in dual layer leads to higher amount of feed intake, CO2eq and greater environmental impact factors

Feed parameters exerts a more substantial influence on the environmental impact factors than the non feed parameters

Materials and Methods

The study has been carried out using OpenSourceLCA software and ecoinvent database, using Lohmann Dual (layer and broiler), Lohmann Brown, and Ross 308 data of performance, feed & resources use, and waste products for a cradle-to-farm-gate life cycle assessment. Additionally, FeedprintInt 2020 provided feed production emission information in various supply chain stages. In both software, "ReCiPe midpoint (H)" impact assessment method has been applied. The functional unit for layer and broiler lines are considered as Egg Mass per starting hen (EM) and kg Breast Meat (BM), respectively.

For broilers, production data of the growing period and live weight of Ross 308 has been adopted from Bessei (2022) and for Lohmann Dual broiler from Damme, Urselmans & Schmidt (2015). The data on the breast yield of both broilers has been adopted from Siekmann et al. 2018. The data in the study of Damme, Urselmans & Schmidt (2015) has been also used for laying period and Egg mass per starting hen of both Lohmann brown and dual.

The data of total energy and water consumption for both broiler (kWh/kg breast meat) and layer (kWh/kg egg) has been derived from KTBL print (2018).

The amount of manure produced per kg breast meat and kg egg has been adopted from the Feedprint NL 2022. Data regarding the feed composition and diets for both broiler and layer has been provided by one of the contacts in feed production industry. The geographical centre of Germany has been considered as the feed mill location, Hamburg as the Main Landing port for feed materials and 100Km as the distance from the feed mill to the farms.

Contact:

[1]Faculty of Life Sciences, Rhine-Waal University of Applied Sciences, Marie-Curie-Straße 1, 47533 Kleve, Germany

[maryam.mehri@hochschule-rhein-waal.de]

References:

1. *Bessei, W. (2022). Comparison of the environmental impact of growing males of a brown layer line and a fast growing broiler line – greenhouse gases, acidification, eutrophication, land and water use. Verlag Eugen Ulmer. https://doi.org/10.1399/eps.2022.357*
2. *Busse, M., Kernecker, M. L., Zscheischler, J., Zoll, F., & Siebert, R. (2019). Ethical Concerns in Poultry Production: A German Consumer Survey About Dual Purpose Chickens. In Journal of Agricultural and Environmental Ethics (Vol. 32, Issues 5–6, pp. 905–925). Springer Science and Business Media LLC. https://doi.org/10.1007/s10806-019-09806-y*
3. *FeedPrint NL (2022). http://webapplicaties.wur.nl/software/feedprintNL/index.asp*
4. *KTBL (2018),Faustzahlen für die Landwirtschaft. 15th edition.*
5. *Openlca 1.11, https://www.openlca.org/*
6. *Siekmann, L.; Janisch, S.; Wigger, R.; Urban, J.; Zentek, J.; Krischek, C. (2018): Lohmann Dual: A dual-purpose chicken as an alternative to commercial broiler chicken? Aspects of meat quality, lipid oxidation, shear force and muscle structure. In Europ.Poult.Sci. 82. DOI: 10.1399/eps.2018.254.*

OpenLCA Conference for the Life Cycle Assessment and Sustainability

15th-16th April 2024, Berlin, Germany

The open openLCA LCA conference for life cycle assessments and sustainability: cases, methods, data, developments, community. Berlin 2024

Life Cycle Assessment of Tap Water of Annaba City - Algeria

Mehdi Belhani[1] and Hamouda Boutaghane[2]

[1]*National Higher School of Technology and Engineering (ENSTI), Department of Mining Metallurgy and Materials, L3M, Annaba, 23005, Algeria.*

[2]*Laboratory of Soils and Hydraulic, Badji Mokhtar Annaba University, PoBox 12, Annaba, 23000, Algeria.*

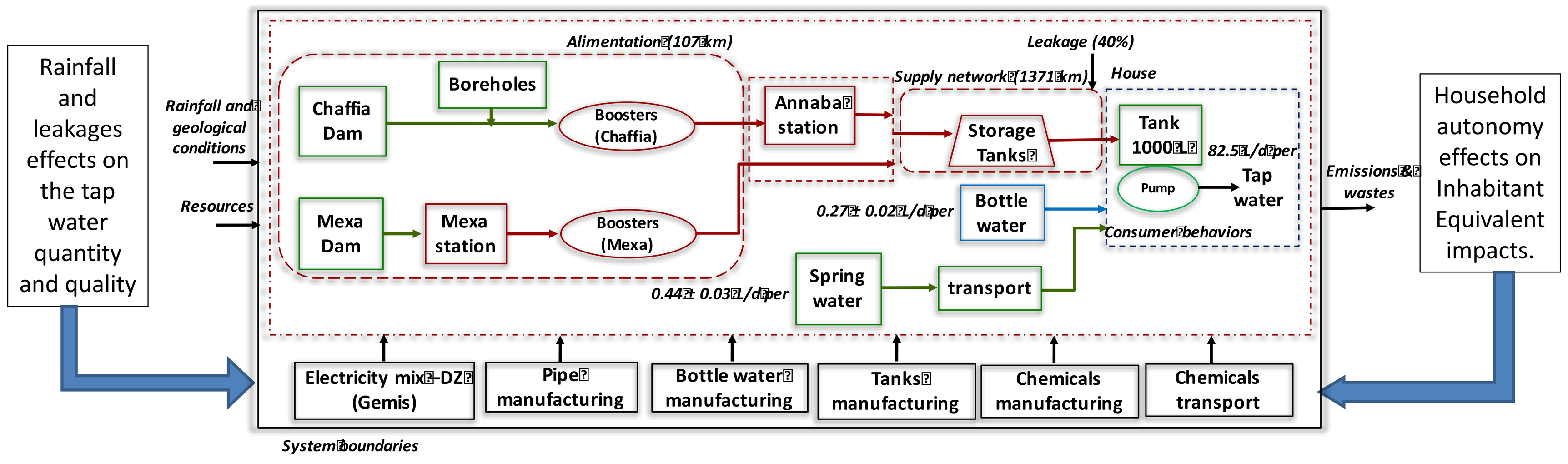
[1]*m.belhani@ensti-annaba.dz;* [2]*hamouda.boutaghane@univ-annaba.dz*

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 study was conducted using OpenLCA software and the ecoinvent v3.5 databases with the attributional form. 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 (82,5 L/Person day). The Inhabitant Equivalent consumed 18.12 g Oil-eq of fossil resources and generated 43.75 g CO_2-eq in the optimal conditions (150 L/Person day).

BACKGROUND & CONTEXT

- The urban water system in Annaba supplied to a population of 700,000 inhabitants in addition to various industrial and agricultural operations.



- Because constraints, the population turned to household tank-pump systems for water storage and bottled and spring water for their drinking needs.
- Plans were underway for the rehabilitation of the system assuming that the HDPE substitute 20% of the deteriorated supply network.

PROBLEM STATEMENT

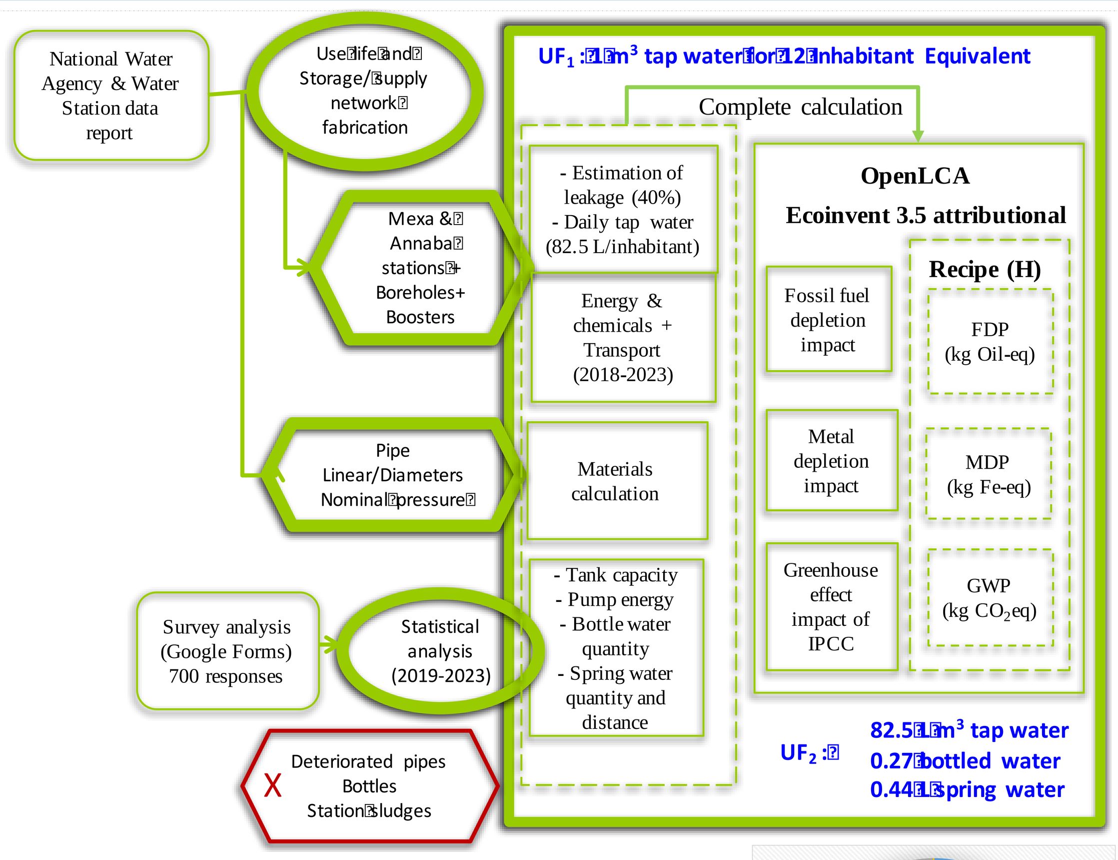
- How to effectively address the impacts of the tap water within causality of the urban water system limits (leakage and water stress) and consumer behaviors ?
- The concept of Inhabitant Equivalent was not solely tied to the definition of tap water.
- Previous urban water Life Cycle Assessment studies had not integrated the impact contributions of spring water mobilization.
- The application of Life Cycle Assessment remained lacking in Algeria, especially in the fields of water, energy, and transportation.

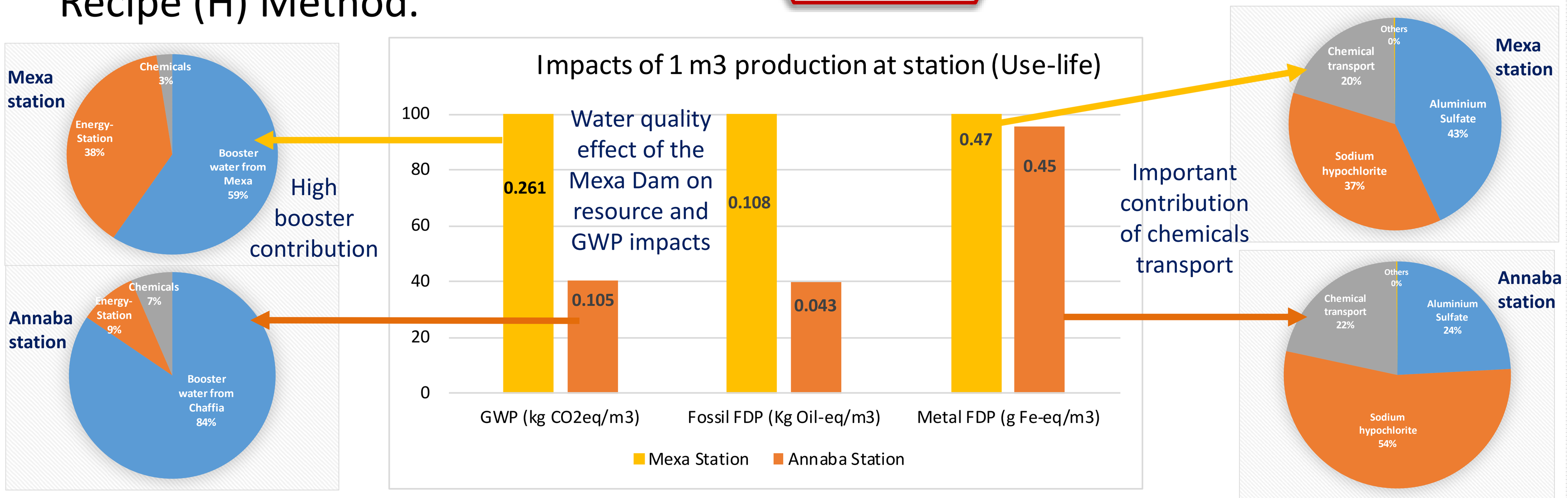
OBJECTIVES

- 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 after network rehabilitation (150 L/person day).
- The environmental impacts of the Inhabitant Equivalent were analyzed in relation of the tap water system constraints and the consumer behaviors.
- The contribution impacts of each part of the system were identified.

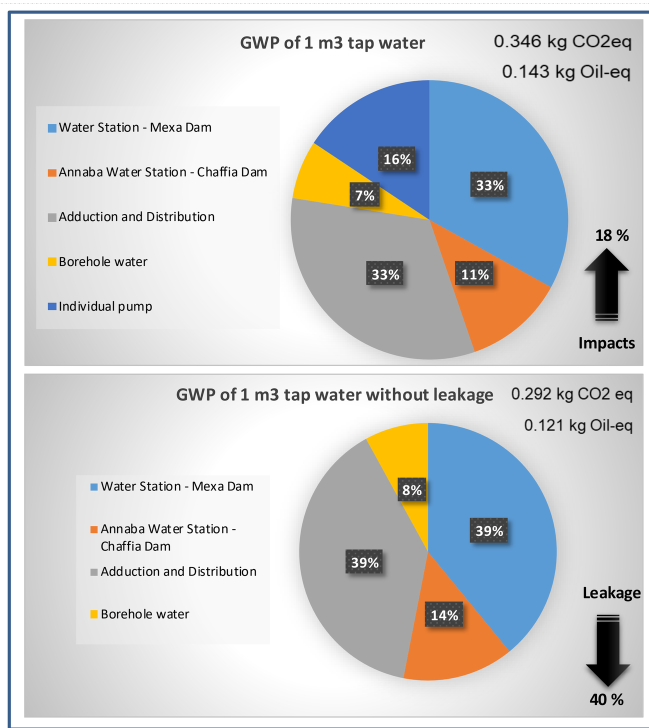
SYSTEM MODELLING & INVENTORY ANALYSIS

- Collection of data from public reports.
- Modelling of consumer behaviors form Survey analysis.
- Complete modelling and calculation using OpenLCA and Ecoinvent 3.5 on the basis of two functional units (UF$_1$ for tap water and UF$_2$ for consumer behaviors).
- Impact evaluation using Recipe (H) Method.

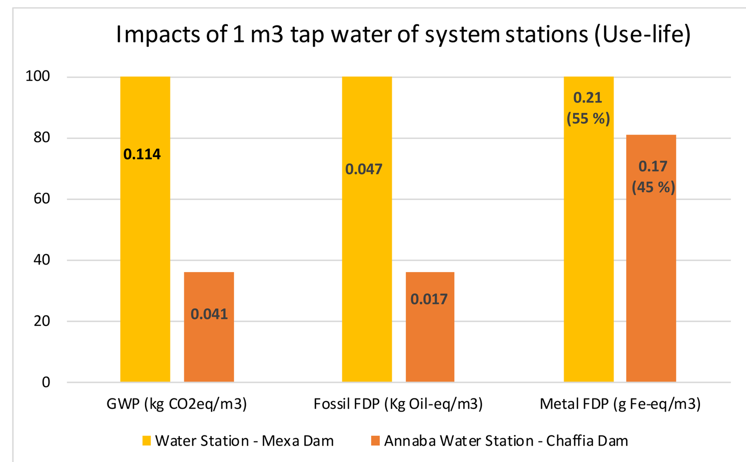




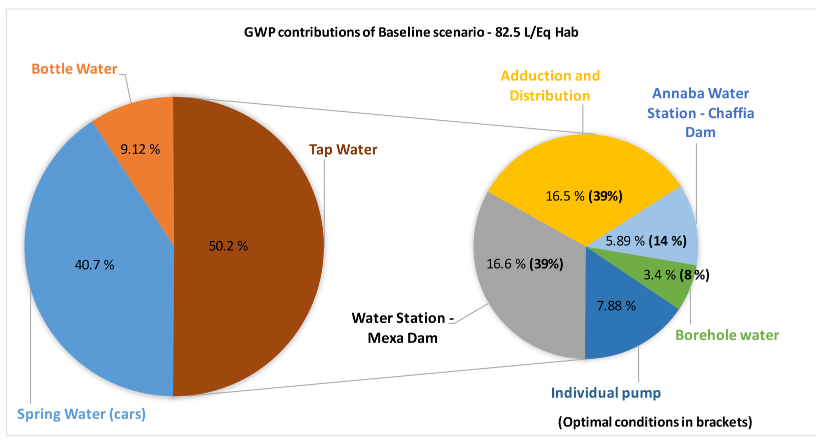
RESULTS AND DISCUSSION



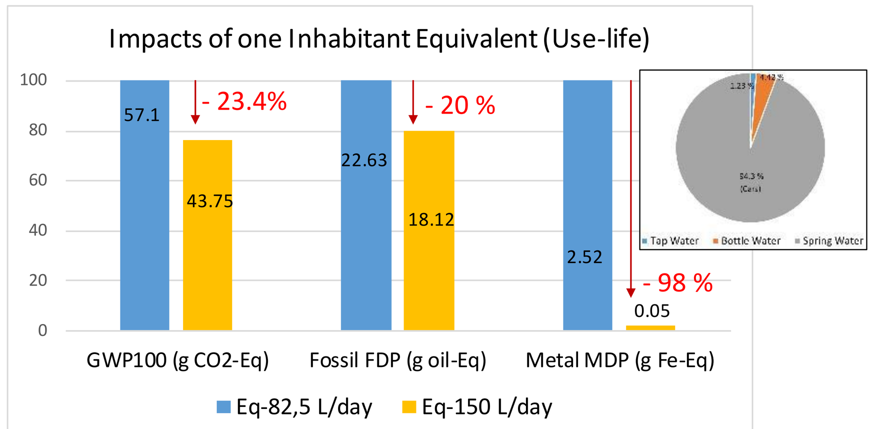
- The GWP impact of household pumps contributed half (16%) of that of the adduction and distribution (33%).
- The borehole contributions were not significant.
- The rehabilitation made it possible to reduce the GWP impact of the leakage by 18%.



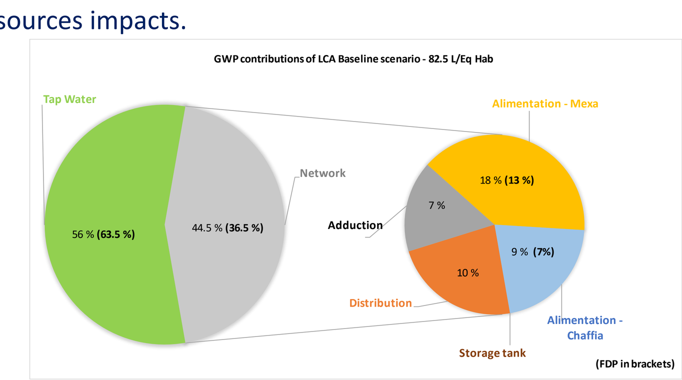
- The consumer behaviors contributed to half of the GWP and fossil resource impacts.



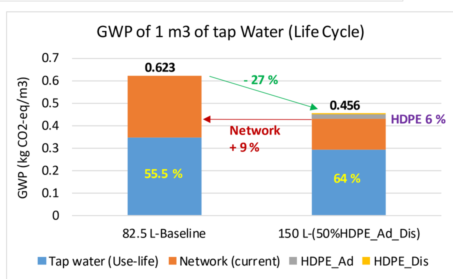
- The consumer behaviors impacts could be reduced by 20% by eliminating leakage and improving the quality of drinking water.



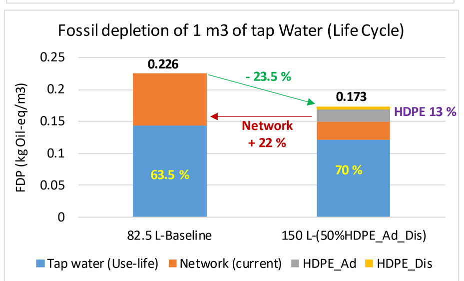
- Network infrastructure contributed almost half of GWP and fossil resources impacts.



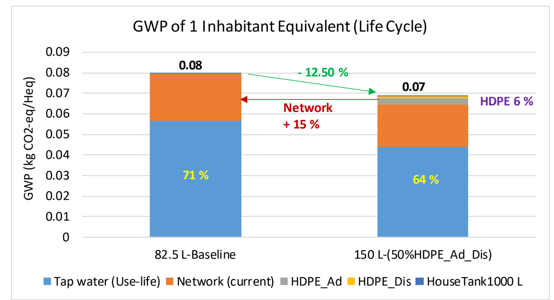
- The rehabilitation reduced the GWP impacts of the tap water life cycle by 27% but introduced 9% to the infrastructure impacts.



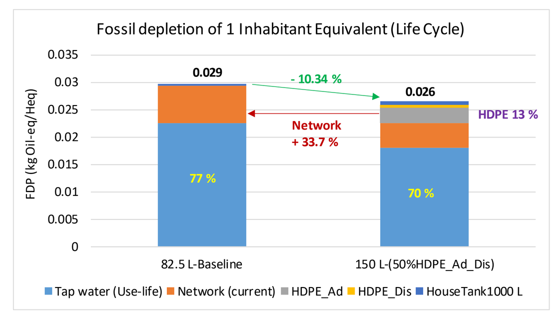
- The rehabilitation reduced the fossil resources impacts of the tap water life cycle by 23.5 % but introduced 22 % to the infrastructure impacts.



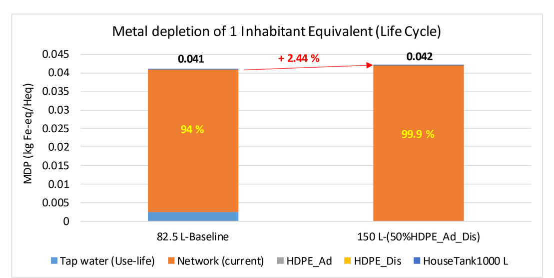
- The rehabilitation reduced the GWP impacts by 12.5 % but introduced 15 % to the infrastructure impacts.



- The rehabilitation reduced the fossil resources impacts by 10.34 % but introduced 33.7 % to the infrastructure impacts.



- The contribution of the infrastructure increased in the GWP and resources impacts of the Inhabitant Equivalent unlike that of the tap water.



CONCLUSION

- ➢ The environmental impacts of the urban water system were influenced by the geological characteristics and water quality of the dams, along with the presence of leakages in the supply network.
- ➢ The utilization of HDPE decreased the environmental impacts during the operational phase and throughout the entire life cycle.
- ➢ 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.
- ➢ The study scope should be expanded to incorporate renewable energy and to encompass the end-of-life of the sludge and bottles.

REFERENCES

1. *ISO, Environmental management – life cycle assessment – principles and frame-work, International Standard ISO 14040, Second Edition 2006-07-01, 2006.*
2. *J. Stokes, A. Horvath, Life Cycle energy assessment of alternative water supply systems, Int J Life Cycle Ass 11 (2006) 335-343.*
3. *OpenLCA software, 2023.*

The open openLCA LCA conference for life cycle assessments and sustainability: cases, methods, data, developments, community. Berlin 2024

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

Susie Ruqun Wu [1], Changliang Shao [2]

1 SusDatability Ltd., Shenzhen, China; 2 National Hulunber Grassland Ecosystem Observation and Research Station, Institute of Agricultural Resources and Regional Planning, Chinese Academy of Agricultural Sciences, Beijing, China

1. Context

The lack of standardized protocols for implementing life cycle impact assessment (LCIA) methods in various LCA software (i.e. software-LCIA method combination) has become a known issue, mainly due to differences in the software implementation of LCIA methods, e.g., a difference in the characterization factors (CFs) (Lopes Silva et al., 2019; Speck et al., 2016). Here we conducted a consistency analysis focusing on two widely-used LCIA methods (ReCiPe 2016 and CML-IA baseline) by comparing their implementation in three software tools (SimaPro [Demo Analyst version 9.3.0.2], openLCA [LCIA data from openLCA GitHub (accessed June 2022)], and Brightway2 [v2.3, with the older CML 2001 implemented in the software, and the python package "bw-recipe-2016" v0.3], in addition to the raw data sources from the LCIA developers' official documentation.

2. Methods

2.1 Elementary Flows (EFs)

The consistency analysis of EFs' nomenclature and their mapping to environmental compartments was carried out using descriptive statistics, counting the total number of original EFs as well as unique EFs (because one EF appears in multiple compartments) used in each impact category (IC) of the LCIA implemented in the four LCIA sources

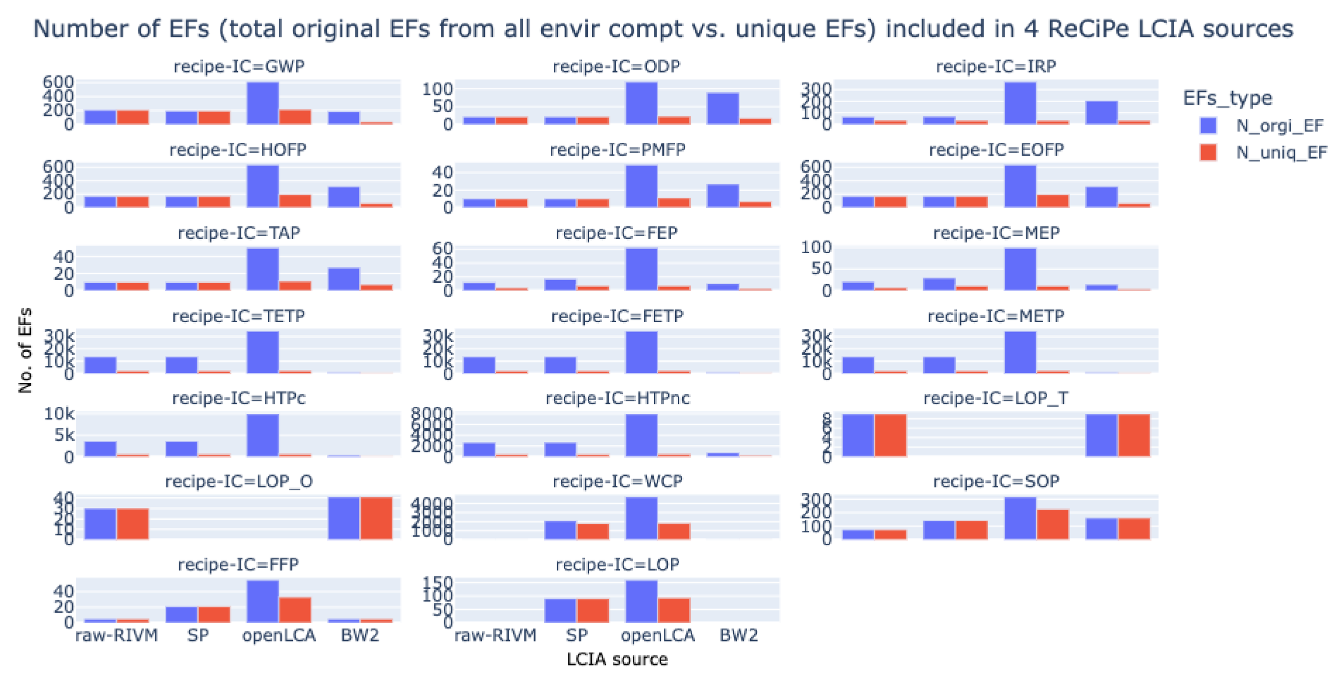
2.2 Consistency checks on CFs – pairwise comparison and identification of outlier EFs

A list of common EFs to be compared pairwisely between two LCIA sources was extracted, to ensure that only CFs of the same EF to the same compartment would be compared. Outlier EFs are those with a comparison ratio of CFs obtained from the two paired LCIA sources either ≤ 0.95 or ≥ 1.05 for all ICs, except for toxicity-ICs of ReCiPe, in which hundreds of EFs would become outliers by using this threshold. A comparison ratio of ≤ 0.65 or ≥ 1.5 was chosen to identify outlier EFs for toxicity-ICs of ReCiPe.

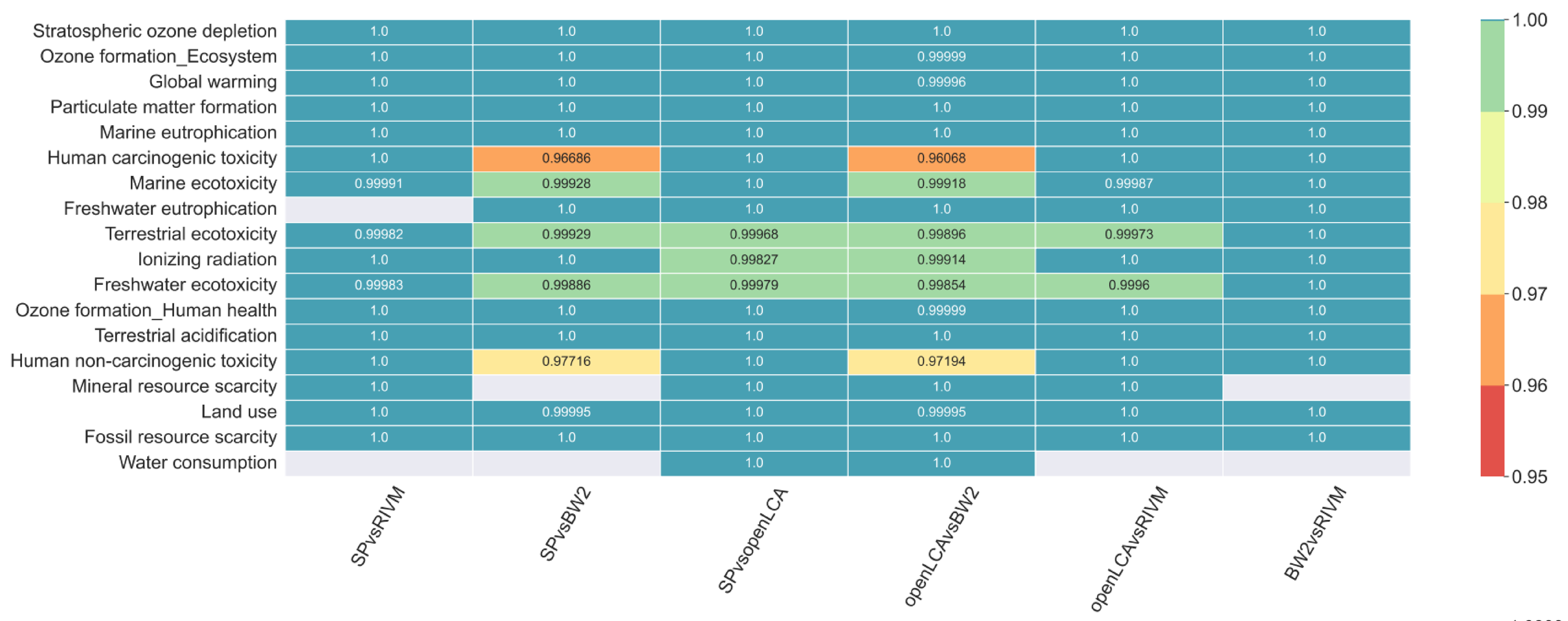
All data, analysis scripts and results are available at: https://github.com/susierwu/LCIA_comp/

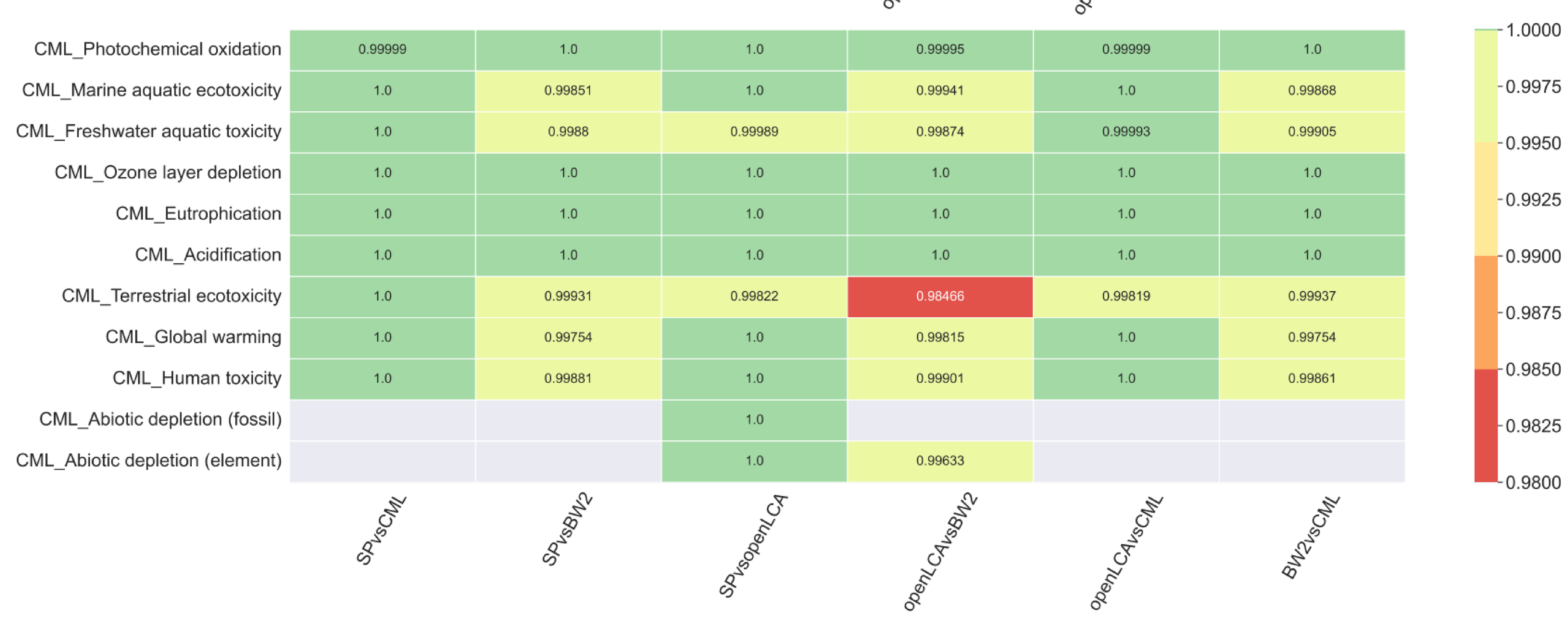
3. Results

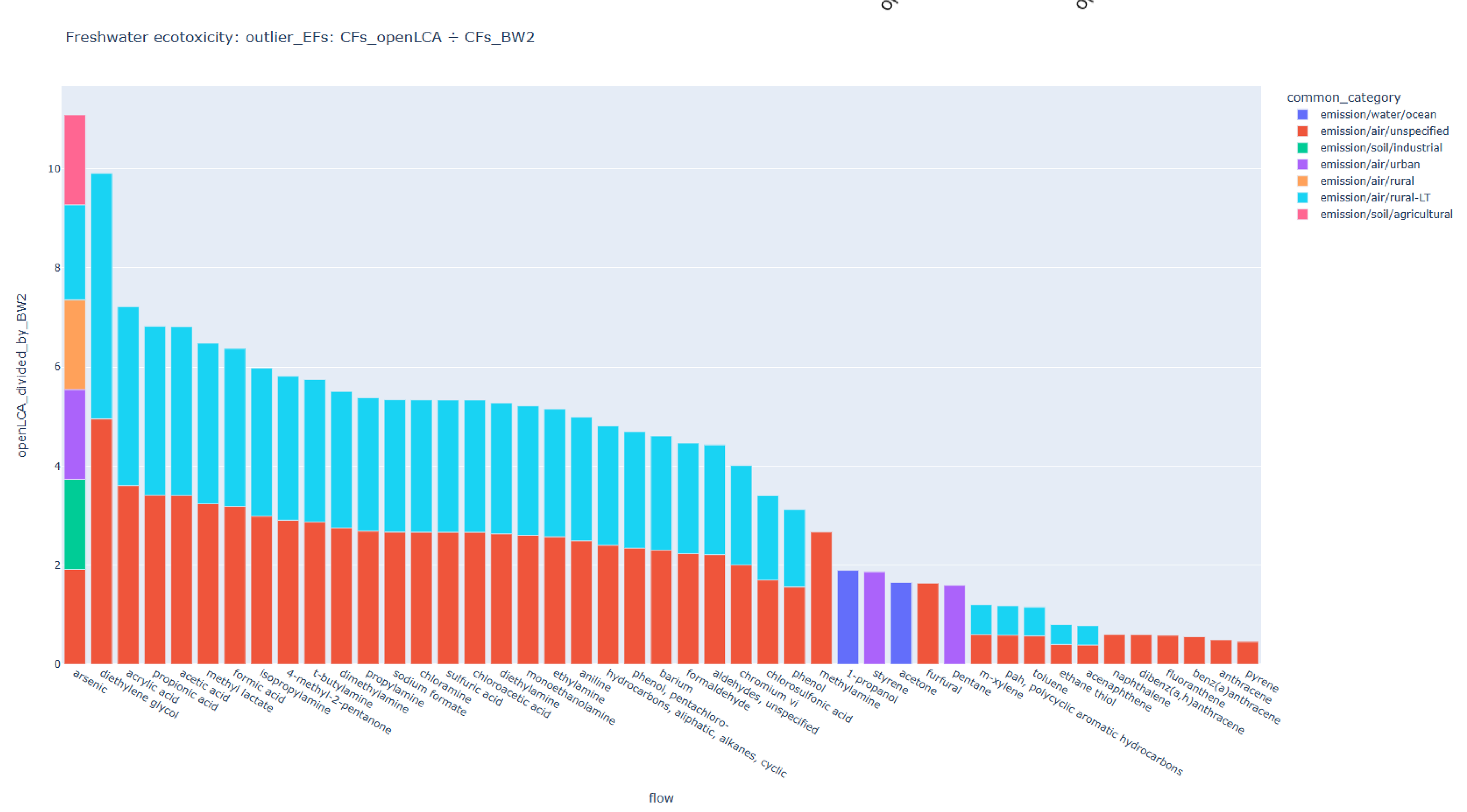
There is a lack of consistent EF nomenclature and absence of a common list of environmental compartments.



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.







1. Limitations and Discussion

The study was conducted almost two years ago, the results were only valid for the specific tool/LCIA method version. As the two major open-source LCA tools available in the market, openLCA and BW2 share some common characteristics, such as data openness and transparency. However, their pairwise comparison yielded the lowest correlation among all, with multiple outlier EFs identified. Two of the most widely used LCA tools, openLCA and SimaPro, had a satisfactorily high correlation of 1.0 in almost all ICs. We hope to encourage LCA software and data developers to pay more attention to cross-validation of data, even though they continue to manage data independently.

Recommendations to instruct the public to understand the environmental information of EPDs with less efforts on the behalf of EPD Programme Operator and why declared indicators are important?

Zeng, Yuzhi
EPD China. Lane 320, Tianping Road, Xuhui District, Shanghai, China. E-mail: prc@epdchina.cn

Background information of sponsored organization

EPD refers to Environmental Product Declaration, which is the Type III environmental declaration providing quantified environmental data using predetermined parameters and, where relevant, additional environmental information.

According to ISO14025, EPD Programme Operator is an independent body that conducts Type III environmental declaration programme.

The EPD Promotion Center is the Programme Operator of EPD China Programme , which the first registered and qualified EPD Programme Operator in China. EPD China actively respond to international and national policies and build the its competency to assure the quality, reliability, and consistency of the published EPDs.

Background information of conference topic

Relatively high amount of feedback from EPD owners and the public audience that they don't know how to use declared results which include 13 main environmental indicators, additional indicators relating to recourse usage, waste categories, and outflows, and optional indicators such as human toxicity.

How to help the EPD owner and public audience to digest these complex information in published EPDs is becoming a question worth to ponder for. In order to find the answers for the proposed question, the informal short discussion among representatives from the public and the interested companies are conducted.

Discussed questions at glance

- *Does the organization you work for conduct EPD project?*
- *Where do you know the concept of EPD?*
- *Do you think the published EPDs at EPD China is readable for you?*
- *Which part of EPD report you and your stakeholders are most interested in?*
- *Is there any difficulties for you to understand declared indicators in the EPDs, if yes, please specify?*
- *Which kind of resource you need if you feel hardto understand declared indicators in the EPDs?*

Methodlologies

Qualitative method of a short informal discussion with participants on given questions have been used.

Response from five participant from product department of the companies have been collected. Eighty percent of them have published their EPDs on their products and one of them have not started the EPD project yet.

Content analysis has been used for examining the participants' oral answers of qualitative questions.

Limitations
Relatively small number of participants was joined this discussion
The discussion could not been recorded and raw data was been collected through note-taking process.
There is no follow-up discussion to the deep category analysis after the first discussion.

Overview of participants' response

Here are overview of 5 participants' replies to the questions

Does the organization you work for conduct EPD project?
YES (80%)   NOT YET (20%)

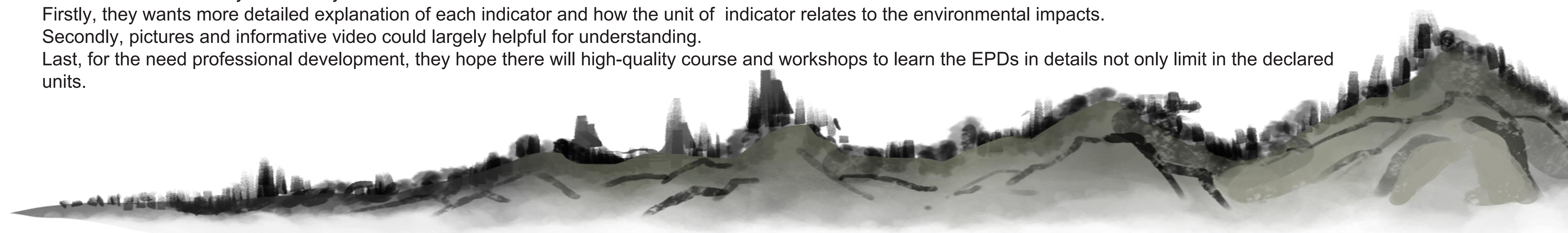
Where do you know the concept of EPD?
Answers to this question varies, one of them mentioned it is from their clients from Europe, some mentioned they knew it from the biding guidelines and LEED programme, others mentioned it was from the senior manager in the company and colleague from certification department respectively.

Do you think the published EPDs at EPD China is readable for you?
YES (20%) NO(80%)

Which part of EPD report you and your stakeholders are most interested in?
Most participants agrees the environmental impacts in the EPD report are highly valued, especially on the global warming potential indicators. To compare this result with competitors is common even EPDs within same category of product in different programme operator are not suggested to be compared.

Is there any difficulties for you to understand declared indicators in the EPDs, if yes, please specify?
Most participants mentioned they know the meaning of the words but did not clear how these words are relate to specif environmental impacts. In addition, they said they wanted to know average results of same products even they had been told the aims of EPDs is not for setting the benchmark but providing reliable environmental information.

Which kind of resource you need if you feel hard to understand declared indicators in the EPDs?
Firstly, they wants more detailed explanation of each indicator and how the unit of indicator relates to the environmental impacts.
Secondly, pictures and informative video could largely helpful for understanding.
Last, for the need professional development, they hope there will high-quality course and workshops to learn the EPDs in details not only limit in the declared units.



Importance of declared indicators

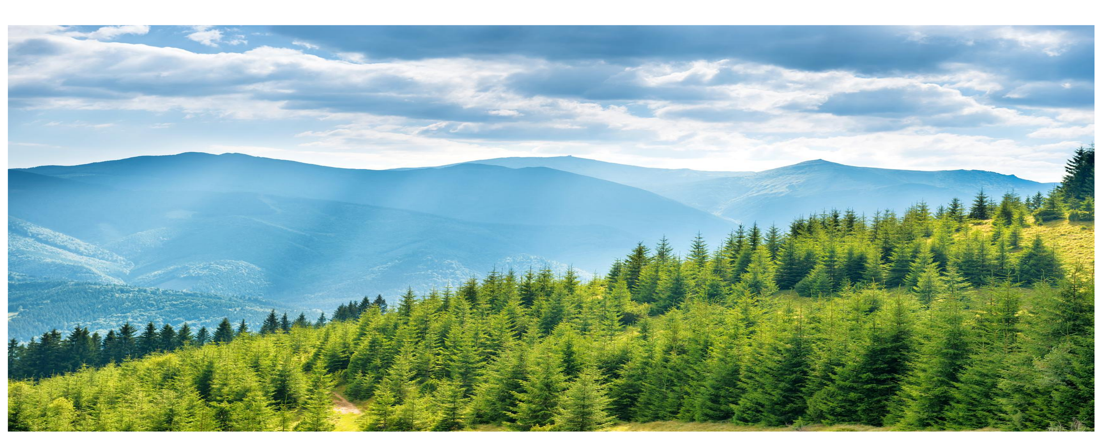
Relatively complete environmental impacts from global warming potential to eutrophication, and to water deprivation etc, are listed through indicators with consistent analysis method.

The results of declared indicators can support companies in relevant sectors understand the environmental impacts of their products or services.

Enhance collaboration and jointly serve the interests of consumers, the market, and relevant stakeholders with open and transparent information.

At heart of the sustainable development, indicators of resource usage at energy level can support the EPD owner realize the demand of clean energy transition.

The practical action such as proper waste management, recycling, and reuse is highlighted with compulsory indicator.



Declared indicators according to EN 15804

RESULTS OF THE LCA - ENVIRONMENTAL IMPACT per functional ordeclared unit

Core indicator	Unit	A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
Global Warming Potential total (GWP-total)	[kg CO2 eq.]																	
Global Warming Potential fossil fuels (GWP-fossil)	[kg CO2 eq.]																	
Global Warming Potential biogenic (GWP-biogenic)	[kg CO2 eq.]																	
Global Warming Potential land use and land use change(GWP-luluc)	[kg CO2 eq.]																	
Depletion potential of the stratospheric ozone layer(ODP)	[kgCFC 11 eq.]																	
Acidification potential, Accumulated Exceedance (AP)	[mol H+ eq.]																	
Eutrophication potential, fraction of nutrientsreaching freshwater end compartment (EP-freshwater)	[kg Peq.]																	
Eutrophication potential, fraction of nutrients reachingmarine end compartment(EP-marine)	[kg N eq.]																	
Eutrophication potential, Accumulated Exceedance(EP-terrestrial)	[mol N eq.]																	
Formation potential of tropospheric ozone (POCP)	[kg NMVOC eq.]																	
Abiotic depletion potential for non-fossil resources (ADP-minerals&metals)	[kg Sb eq.]																	
Abiotic depletion potential for fossil resources (ADP-fossil)	MJ, netcalorific value																	
Water (user) deprivation potential, deprivation-weightedwater consumption (WDP)	[m3 world eq.Deprived]																	

RESULTS OF THE LCA - Resource use and waste categoriesper functional or declared unit

Core indicator	Unit	A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
Use of renewable primary energy excluding renewable primary energy resources used as raw materials(PERE)	MJ																	
Use of renewable primary energy resources used as raw materials(PERM)	MJ																	
Total use of renewable primary energy resources(PERT)(primary energy and primary energy resources used as raw materials)	MJ																	
Use of non-renewable primary energy excluding non- renewable primary energy resources used as raw materials(PENRE)	MJ																	
Use of non-renewable primary energy resources used as raw materials(PENRM)	MJ																	
Total use of non-renewable primary energy resources(PENRT)(primary energy and primary energy resources used as raw materials)	MJ																	
Use of secondary material(SM)	kg																	
Use of renewable secondary fuels(RSF)	MJ																	
Use of non-renewable secondary fuels(NRSF)	MJ																	
Net use of fresh water(FW)	m3																	

RESULTS OF THE LCA - Resource use and waste categoriesper functional or declared unit

Core indicator	Unit
Hazardous waste disposed(HWD)	kg
Non-hazardous waste disposed(NHWD)	kg
Radioactive waste disposed(RWD)	kg
Components for re-use(CRU)	kg
Materials for recycling(MR)	kg
Materials for energy recovery(MER)	kg
Exported energy(EE)	MJ

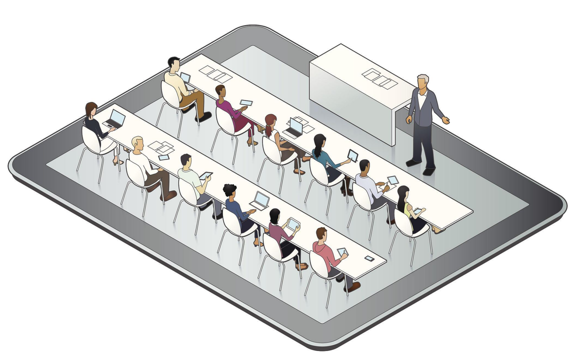
The EPD China Template is open to all for downloading. Well illustrating from the template, the included indicators are accordance with EN 15804 showing in the tables at left.

Possible solutions

Additional explanation of indicator

Illustrative diagrams （eg. Eutrophication ）

Informative videos



Course, training or workshops

Conclusion

To sum up, verifiable, accurate, non-misleading environmental information for product or service through the third party verification process help companies understand their products' environmental information communicate those with customers. A the core of the EPD, group of indicators indicates the complex of EPD project process from data collection, to LCI analysis, and to interpretation. Available informative resources supporting the EPD owner and the public to understand the main content of the EPD report are needed.

Acknowledgments

I would like to thanks the volunteering participation of companies representatives to answer questions.
I would like to thanks all staff at EPD China to review the poster and give sincere feedback.
I would like to thanks OpenLCA to hold this annual conference make communication on LCA topics being widely heard.
I would like to thanks the readers for reading this relatively rough study compared to academic research work.

Recommended resource:
EPD China website: www.epdchina.cn
EPD China Programme Leaflet: http://www.epdchina.cn/resources
EPD China General Programme Instructions: http://www.epdchina.cn/resources
EPD China Programme Template: http://www.epdchina.cn/resources

References

EN 15804, Sustainability of construction works – Environmental product declarations –Core rules for the product category of construction products.
ISO 14020, Environmental labels and declarations – General principles.
ISO 14025, Environmental labels and declarations – Type III environmental declarations – Principles and procedures.
ISO 14040, Environmental management – Life cycle assessment – Principles and framework.
ISO 14044, Environmental management – Life cycle assessment – Requirements and guidelines.
ISO/TS 14067, Greenhouse gases – Carbon footprint of products – Requirements and guidelines for quantification and communication.
ISO 21930, Sustainability in buildings and civil engineering works – Core rules for environmental product declarations of construction products and service