

2020

Critical Review Statement:

Life Cycle Assessment of Midsummer:s Lightweight CIGS Solar Panels

Dr. Niels Jungbluth (ESU-services Ltd.)



Life Cycle Assessment
Of Midsummer:s Lightweight CIGS Solar Panels

Title: Life Cycle Assessment of CIGS thin film solar panels produced by Midsummer AB
Date: 2020-04-28
Report number: 703a
Ordered by: Midsummer AB
Issued by: Miljøgiraff AB



Schaffhausen, 13. May 2020

Midsummer AB

Imprint

Title	Critical Review: Life Cycle Assessment of Midsummer:s Lightweight CIGS Solar Panels
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Publications	Each reference to this review statement is only allowed if the same publication shows also the full review statement without alterations.
About us	ESU-services Ltd. has been founded in 1998. Its core objectives are consulting, coaching, training and research in the fields of life cycle assessment (LCA), carbon footprints, water footprint in the sectors energy, civil engineering, basic minerals, chemicals, packaging, telecommunication, food and lifestyles. Fairness, independence and transparency are substantial characteristics of our consulting philosophy. We work issue-related and accomplish our analyses without prejudice. We document our studies and work transparency and comprehensibly. We offer a fair and competent consultation, which makes it for the clients possible to control and continuously improve their environmental performance. The company worked and works for various national and international companies, associations and authorities. In some areas, team members of ESU-services performed pioneering work such as development and operation of web based LCA databases or quantifying environmental impacts of food and lifestyles.
Version	13.05.20 08:43 https://esuserVICES-my.sharepoint.com/personal/mitarbeiter1_esuserVICES_onmicrosoft_com/Documents/627 CR LCA solar cell Miljö/Jungbluth-2020-Critical Review-statement-LCA-Midsummer-v1.0.docx

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1 Background and Objectives

The consultancy Miljögiraff has an LCA for solar cells produced by Midsummer AB. The consultant was asked by Midsummer AB to organize this review and to clarify the framework conditions in advance:

The LCA is carried out according to the standards ISO 14040-44, 67. In this context, the customer would like to launch an external critical review according to the standard ISO 14040 of this work. This critical review shall turn around points defined by the standard ISO (objectives and scope, analysis of the inventory, the evaluation of the impacts and the interpretation). For this LCA a review panel of three persons should review the LCA model (for compliance to ISO14044).

The International Organization for Standardization (ISO) (2006a:6.3) states the following concerning the procedure for the review of a comparative study planned to be published:

“A critical review may be carried out as a review by interested parties. In such a case, an external independent expert should be selected by the original study commissioner to act as chairperson of a review panel of at least three members. Based on the goal and scope of the study, the chairperson should select other independent qualified reviewers. This panel may include other interested parties affected by the conclusions drawn from the LCA, such as government agencies, non-governmental groups, competitors and affected industries.”

This is a public study which does allow comparative assertions. Therefore, a review panel would be recommended according to ISO 14040 if it should be published. For the moment it is agreed that the review is conducted only by one person.

The commissioner asked Dr. Niels Jungbluth for a critical peer review. Key characteristics for this review are summarized in the following Tab. 1.1.

Tab. 1.1 Key characteristics of the critical review

Title	Life Cycle Assessment of Midsummer:s Lightweight CIGS Solar Panels
Commissioner	Midsummer AB
Main study author	Pär Lindman & Marcus Wendin Miljögiraff - Life Cycle Assessment and Design For Environment www.miljogiraff.se Marcus@miljogiraff.se , par@miljogiraff.se
Products and variants investigated	CIGS thin film solar panels
Scope	Cradle to grave
Functional unit	kWh of electricity produced in different locations at panel wit 22 V (without power conversion and distribution)
Standard to be applied	International Organization for Standardization (ISO) 2006a, b, 2011
Product category rules	None
Comparative study	Yes, comparison to other means of electricity generation
Publication foreseen	Yes. The study should be provided to customers
Size of documentation provided for review	About 50 pages full LCA report.
Software for background calculations	SimaPro 9.0
Background database	Ecoinvent v3.5, Cut-Off (ecoinvent Centre 2018)
Foreground data	Production of input materials and processing to product, mounting, use phase, disposal
Provision of LCI data for review	Documented in report and SimaPro software model
Life cycle impact assessment	Carbon footprint and other LCIA indicators (Frischknecht et al. 2007; Huijbregts et al. 2017; IPCC 2013)
Timetable	Submission of study 31.3.2020
Stages of the review	One stage for review of the full LCA
Meetings in person	None
Review Panel	Only one reviewer

2 Standards and review criteria

The critical review was carried out according to the International Standards ISO 14040 and 14044 (International Organization for Standardization (ISO) 2006a, b).

The study was reviewed according to the following five aspects outlined in ISO 14040. It is assessed whether

- *"the methods used to carry out the study are consistent with this International Standard,*
- *the methods used to carry out the study are scientifically and technically valid,*
- *the data used are appropriate and reasonable in relation to the goal of the study,*
- *the interpretations reflect the limitations identified and the goal of the study, and*
- *the study report is transparent and consistent."*

3 Review process

The task of the reviewer is to review the documentation provided according to Tab. 1.1 including the four phases, namely

- Goal and scope definition,
- Inventory analysis,
- Impact assessment, and
- Interpretation

The goal of the study as such is not reviewed as this lies in the responsibility of the commissioner. However, it was reviewed whether the goal is stated explicitly and transparently. The definition of the scope is part of the critical review, the definition of the functional unit, the system definition and its boundaries, the allocation approaches and the impact category indicators chosen.

The authors of the study provide access to all data necessary for an informed critical review. This holds also true for data provided by third parties and for confidential data. The review of the inventory analysis includes the inventory raw data (input data), the modelling approaches and selected inventory results.

The review of the impact assessment should include the impact and characterization factors applied, the impact indicator results and, eventually, the normalized results.

Within the interpretation phase, the consistency of the modelling, the data used, and the conclusions is reviewed and checked whether it is in line with the goal and scope definition. Data quality aspects, significance, and sensitivity analyses as well as completeness checks are subject to the critical review too.

The following interactions between the commissioner, the practitioner and the reviewer took place:

- Provision of draft report dated 31.3.2020, 50 pages in PDF-format, including a full description of the study and SimaPro Model of the LCI.
- Submission of first round of review comments (6.4.2020)
- Further discussions by Skype and Email
- Provision of revised pre-final report dated 28.4.2020, 51 pages in PDF-format
- Provision of revised final report dated 12.5.2020, 53 pages in PDF-format and updated SimaPro model

The process of the review can be summarized as follows:

- Most questions of the reviewer were answered sufficiently. Upon reviewer's request considerable revisions were made concerning documentation in the report, LCI models and description of results. The critical review process took place in an open and constructive atmosphere. The final study report includes almost all the comments of the reviewer given in the earlier stages of the review process.
- The present definitive version of the review report considers the revisions made by the practitioner after submitting the feedback on the pre-final report.
- The goal of the study as such was not reviewed as this lies in the responsibility of the commissioner. However, it was reviewed whether the goal is stated explicitly and transparently.
- The definition of the scope was part of the critical review, the definition of the functional unit, the system definition and its boundaries and the allocation approaches.

- The review of the inventory analysis includes the modelling in SimaPro .
- The review of the impact assessment includes only the impact indicator results.
- Within the interpretation phase, the consistency of the modelling, was reviewed and checked whether they are in line with the goal and scope definition.
- It was not in the responsibility of the reviewer to check the report for formatting, layout, grammar, and spelling issues.
- This critical review statement is only valid for the full report and the full results as it was provided for final review. Summaries, marketing statements or later modifications have not been reviewed.

4 Critical review report according to ISO 14040ff

4.1 Consistency of the methods with the ISO standards

The functional unit and reference flow are considered appropriate for the goal and scope of this study.

4.2 Scientific and technical validity of the methods applied

In general, the inventory models established are scientifically and technically valid.

4.3 Appropriateness of data

The report includes a detailed description of the production process and the foreground data. The underlying model of life cycle inventory data was provided in SimaPro. This facilitated the review considerably and is highly acknowledged.

The data used in the foreground and in the background can be justified in view of the goal and scope of the study.

For the reviewer, it is not possible to fully ensure the correctness and validity of all calculations within such a review process.

4.4 Assessment of the interpretation in view of limitations and goal and scope

As such the results presented in the report are well justified.

The interpretation considers the limitations due to the goal and scope of this study. Furthermore some scenarios e.g. on the electricity mix during production or the location of installation help to understand the influencing factors for the final results.

4.5 Transparency and consistency of study report

All relevant information could be found in the report (or the electronic data). The report is clearly structured and well-readable. With the information, the report is acknowledged as transparent and consistent.

4.6 Self-declaration of reviewer independence & competencies

(According to ISO/PDTS 14071, Annex B)

I (Niels Jungbluth), hereby declare that:

- I am not a full- or part-time employee of the study's commissioner or practitioner.
- I have not been involved in scoping or carrying out any of the work to conduct the study at hand, i.e. I have not been part of the commissioner's or practitioner's project team(s).
- I do not have vested financial, political, or other interests in the outcome of the study.

My competencies relevant to the Critical Review at hand include knowledge of and proficiency in:

- ISO 14040 and ISO 14044.
- LCA methodology and practice, particularly in the context of LCI, (including data set generation and data set review, if applicable).
- Critical Review practice.
- The scientific disciplines relevant to the important impact categories of the study.
- Environmental, technical, and other relevant performance aspects of the product system(s) assessed.
- Language used for the study.

A short CV and a list of relevant references are part of the review report.

I assure that the above statements are truthful and complete.

4.7 Conclusions

The reviewed carbon footprint study as outlined in Tab. 1.1 complies with the requirements of the ISO standards 14040 and 14044.

The goal and scope are appropriately defined. The methods used are scientifically and technically valid. The data used are appropriate and reasonable in view of the goal and scope of the study. The report is complete, clearly structured, and well-readable. Conclusions and recommendations are based on the results of the analyses, respecting the limitations described in the report.

I recommend submitting the entire report including this review report to the commissioner.



Dr. sc. tech. ETH, Niels Jungbluth

Chief Executive Officer ESU-services Ltd.

Schaffhausen, Wednesday, 13 May 2020

5 References

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- SimaPro 9.0 SimaPro (9.0) SimaPro 9.0 (2019) LCA software package. PRé Consultants, Amersfoort, NL, retrieved from: www.simapro.ch.

6 The reviewers experience and company

6.1 Dr. Niels Jungbluth, Chief Executive Officer (CEO)

6.1.1 Philosophy of [ESU-services Ltd.](#)

ESU-services Ltd. was founded in 1998. Its core business is research, consulting, review, and training in the field of Life Cycle Assessment (LCA). This methodology aims to investigate environmental aspects of products and services from cradle to grave, from resource extraction to manufacture, use and end of life treatment.

Fairness, independence, and transparency are the main characteristics of our consulting philosophy. We work issue-related and accomplish our analyses without prejudice. We document our studies and our work in a transparent and comprehensible manner. We offer a fair and competent consultation, which enables our clients to control and continuously improve their environmental performance.

ESU-services covers several economic sectors such as energy, basic minerals, metals, and chemicals, biomass, transportation, waste management, information technology, food and lifestyles. ESU-services also contributes to the development of impact assessment methods such as ecological scarcity 2013. Since 2007, ESU-services runs the Regional SimaPro Competence Centre of Switzerland, Germany, Liechtenstein and Austria.

6.1.2 CV

Dr. Niels Jungbluth studied Environmental Engineering at the Technical University of Berlin. He made his diploma thesis during a six month stay at the TATA Energy Research Institute in New Delhi, where he prepared a life cycle inventory for cooking fuels in India. Between 1996 and 2000 he worked on a Ph.D. Project at the Swiss Federal Institute of Technology (ETH) in Zurich at the chair of Natural and Social Science Interface. His Ph. D. thesis on the environmental consequences of food consumption has been awarded with the Greenhirm Price 2000 by the German Öko-Institut. In this thesis he investigated food consumption patterns by means of life cycle assessment.



He started working with ESU-service in 2000. Between 2006-2012 he was managing partner together with Rolf Frischknecht. Since 2012 he acts as a managing director. His main working areas are food, biomass, energy systems, input-output-analysis and sustainable consumption. He is responsible for the SimaPro centre and the data-on-demand service of ESU.

Dr. Niels Jungbluth is in the editorial board of the “Int. Journal of LCA” and works as reviewer for several other scientific journals. He works as a special expert for several organisations as e.g. Deutsche Bundesstiftung Umwelt, United Nations Framework Convention on Climate Change UN-FCCC, CEN TC 383 standard (GHG accounting on biofuels), UNEP-SETAC life cycle initiative, Swiss law on tax exemption for biofuels.

6.1.3 References (selection)

ESU-services has conducted more than 300 projects related to LCA in the past 25 years. See below for a brief list of the most recent and relevant projects involving a review. A full description of the company including a list of several hundred project references can be found on the Internet (www.esu-services.ch/projects/fulllist/). The full list of papers peer-reviewed by Niels Jungbluth can be found on publons.com/author/488732/niels-jungbluth#profile.

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Year	Project title	Commissioned by
Since 1999	Peer Reviews of papers	www.publons.com/researcher/488732/niels-jungbluth
Since 2001	Subject Editor "LCA for Energy Systems and Food Products"	The International Journal of LCA
Since 2011	Editorial Board ecoinvent for the themes: 06 Extraction of crude petroleum and natural gas, 19 Coke and refined petroleum products, 27 Electrical equipment and several other themes	ecoinvent Centre
Since 2014	Individual verifier for the international EPD® System	On request
2020	Critical Review: Life Cycle Assessment of CIGS thin film solar panels	Miljøgiraff
2020	Calculation of CO2 intensities and validation for the "Greenhouse gas balance of the rental and leasing platform Sharely.ch: Determination of the amount of CO2-eq saved per rental transaction	Sharely AG
2019	Verification: EPD of the Stadler double-decker train KISS	Stadler Bussnang AG
2019	Critical Review: Comparative carbon footprint of transport services	Denkstatt, AT
2019	Verification: EPD of a thin film solar cell	Miljøgiraff & MälarEnergi
2019	Verification: EPD of a glass-glass PV module	Fachhochschule Nordwestschweiz
2019	Critical Review: LCA of meat trays made from different materials	Fraunhofer-Institut für Umwelt-, Sicherheits- und Energietechnik, DE
2019	Verification: EPD model for lightweight concrete drainage channels	BG-Graspointer GmbH & Co KG, AT
2019	Evaluation of the Bioeconomic Research Programme Baden-Württemberg	Ministerium für Wissenschaft, Forschung und Kunst Baden-Württemberg
2018-19	Critical Review life cycle inventory of bitumen products	Eurobitume, BE
2018-19	Expert panel for the revision of "Product Category Rules (PCR) for preparing an Environmental Product Declaration (EPD) for Electricity, Town Gas, Steam, and Hot and Cold Water Generation and Distribution"	ESU-services
2018	Critical Review: Life cycle assessment of concrete drainage channels of BG-Graspointer GmbH & Co KG	BG-Graspointer GmbH & Co KG, AT
2018	Update Critical review of an LCA study on transport packages for vegetables and fruits	Fraunhofer-Institut für Umwelt-, Sicherheits- und Energietechnik, DE
2017-18	Critical Review: Comparative LCA between bio-isobutene (produced from sugar beet) and fossil propane/butane for gas cooker application	Butagaz, FR
2017-18	Critical Review: LCA of mono propylene glycol	Oleon, FR
2017	Validation of company specific LCA guidelines	Nestec Ltd. Nestlé Research Center
2016-17	Critical Review of developments for the Product Biodiversity Footprint	i care & consult
2016	Critical review of an LCA study on transport packages for vegetables and fruits	Fraunhofer-Institut für Umwelt-, Sicherheits- und Energietechnik, DE
2015	Critical review of an LCA study on cotton recycling	H & M
2014	Critical review of an LCA study on coffee	Luigi Lavazza S.p.A
2014	Critical review of the GreenCALC web tool	NEFAB
2014	Critical review of an LCA for bread baking	FP7 Low Energy Ovens (LEO) project
2014	Critical review of an LCA and ILCD dataset for global organic cotton production	TEXTILEEXCHANGE
2013	Critical Review of an LCA of a water consumption device	Itron
2013	Review of research proposals	The European Commission, 7th Framework Programme
2012, 2013	Review of project proposals FNR	Fonds National de la Recherche, Luxembourg
2012	Critical Review "Life Cycle Assessment of Toray Film Europe's PET and OPP films"	Toray Film Europe
2012	Critical Review of a study on the carbon footprint and energy use for unconventional natural gas from fractionating	International Institute for Sustainability Analysis and Strategy (IINAS)
2011	Critical Review life cycle inventory of bitumen products	Eurobitume, BE
2010	Critical review of an EPD for agricultural biogas	AXPO AG
2010	Critical Review of an LCA study of bio-ethylene vs. ethylene	The Procter and Gamble Co., US
2010	Review of the ecological footprint calculator	WWF Switzerland
2009	Review of project proposals for the French Food Research Programme ALIA	INRA support Unit of ANR, FR
2009	Review study "sustainable construction with steel"	Stahlbau Zentrum Schweiz
2008	Review of primary energy factors	Amt für Hochbauten der Stadt Zürich
2008	Background review of consumer information	Coop
2008	Critical review of an LCA of green waste disposal and utilization in Basel	ERZ Entsorgung und Recycling Zürich
2008	Review of LCA studies	Geberit International AG
2008	Review openLCA data converter	GreenDeltaTC GmbH
2007	Review building products database by Empa	Amt für Hochbauten der Stadt Zürich
2007	Review of CO2-intensities used by EnvImpact	Centre Info
2007	Critical Review of an LCA for hand drying systems	HTS Suisse SA
2006	Review New CHP Energy Systems	Swiss Federal Office of Energy (SFOE)
2004	Critical Review according to ISO 14040ff of different LCA studies for biofuel production and use	Various
2004 - 2007	Project leader "Life cycle assessment of bioenergy products". Coordination of project partners, validation of data for ecoinvent v2.0. Review of project reports.	Bundesamt für Energie, Bundesamt für Landwirtschaft and Bundesamt für Umwelt, Wald und Landschaft
2004 - 2008	RENEW: Renewable fuels for advanced powertrains. LCA of BtL-fuel (Biomass-to-Liquid) production including critical review according to ISO 14040, 44	FP7, The European Commission, Bundesamt für Energie and Bundesamt für Bildung und Wissenschaft
2003	ecoinvent 2000: validation of ecoinvent reports for waste management and transport systems	Federal Office for the Environment (FOEN)