PROGRESS TO SUCCESS

Powerized

Digitalization of Power Electronic Applications within Key Technology Value Chains

CDT 5.1: Sustainability

Aalto University
School of Electrical Engineering

Partners: ABB Infineon KEMPOWER

Objectives:

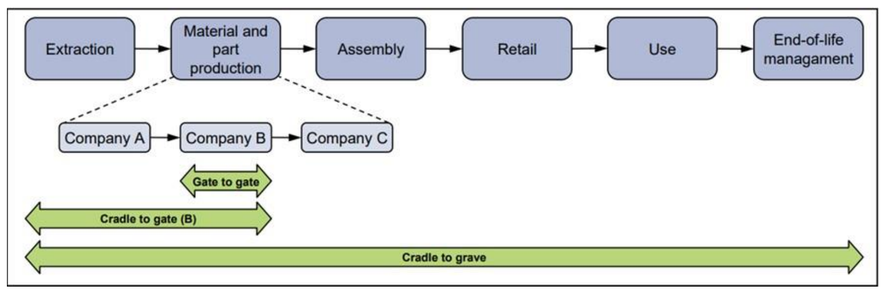
To provide comprehensive environmental assessments for Si IGBT and SiC MOSFET power modules, highlighting the most eco-friendly options throughout their entire life cycles. The assessment identifies major areas of environmental burden, aiming to establish a foundation for ecodesign guidelines through these evaluations.

Motivation & Relevance:

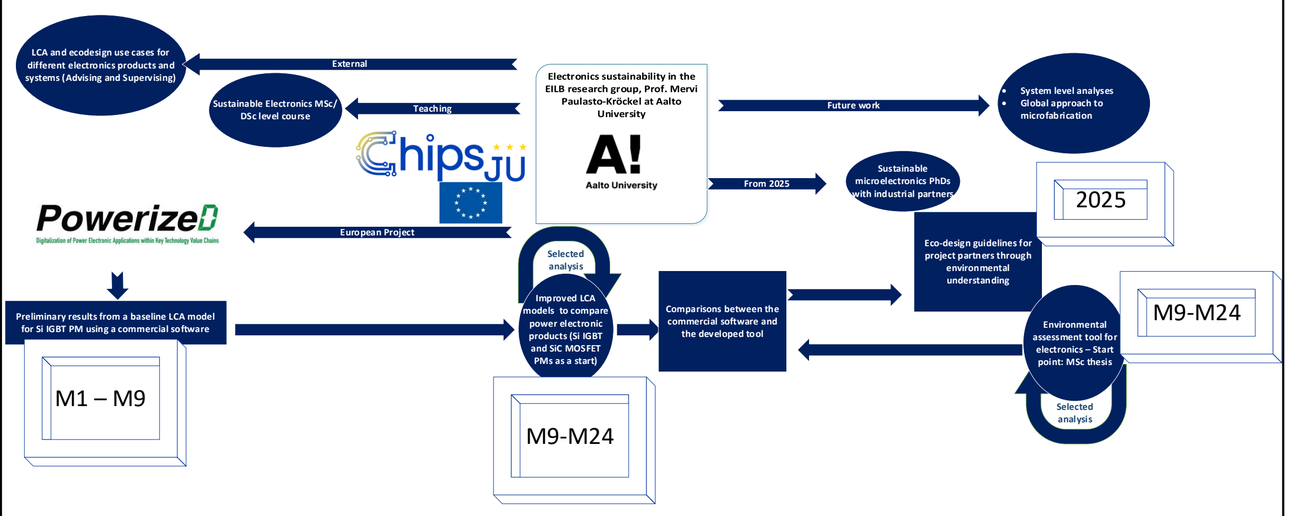
According to the UN's e-waste monitor, e-waste is expected to rise to 74 million metric tons by 2030 from a recorded figure of 53.6 million metric tons in 2019. With global energy demand projected to increase by 28% between 2014 and 2040, the shift toward renewable energy systems will intensify. This growth will drive a corresponding increase in demand for Power Electronic Converters (PECs), critical for converting energy from renewable sources.

Recent efforts have aimed at assessing the environmental performance of these devices, both individually and when integrated into converters. However, progress has been limited by the lack of sufficient LCA-useful data. Furthermore, a comprehensive, transparent method for quantitatively comparing their full life cycles is still missing. Given the rising energy demand, evaluating the environmental impact of Si IGBTs and SiC MOSFETs is becoming increasingly important.

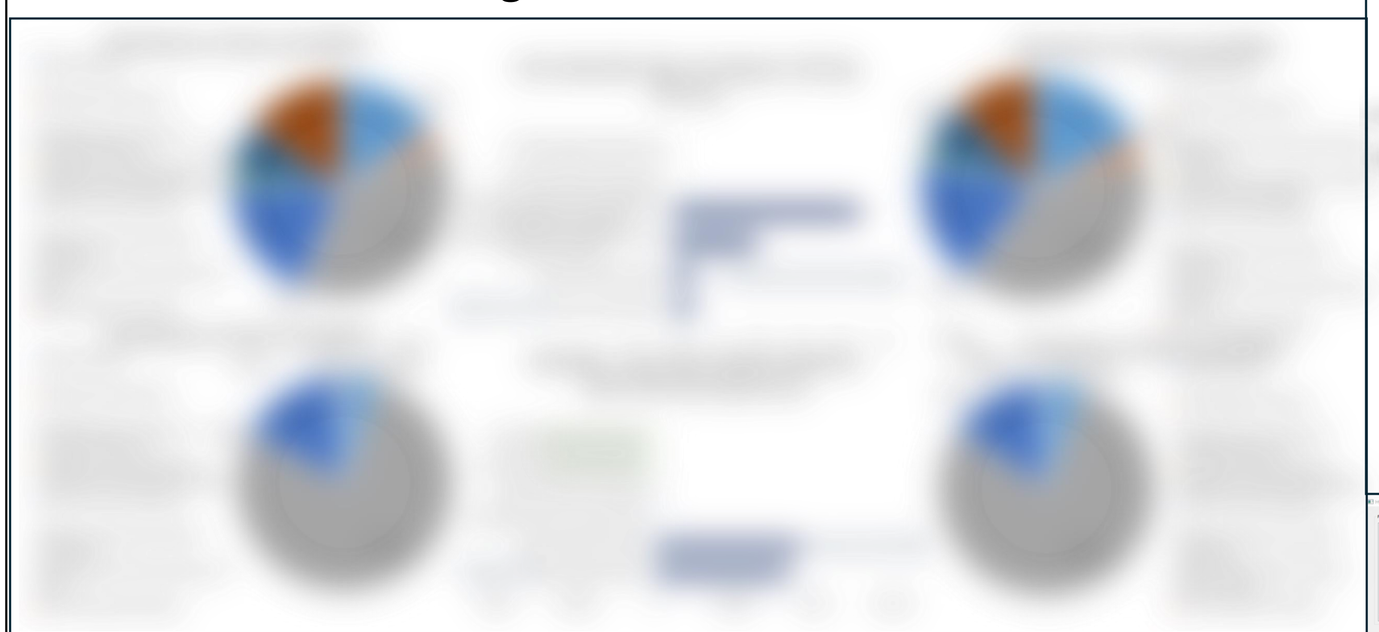
Methods:



Ref: International Reference Life Cycle Data System (ILCD) Handbook, 2010

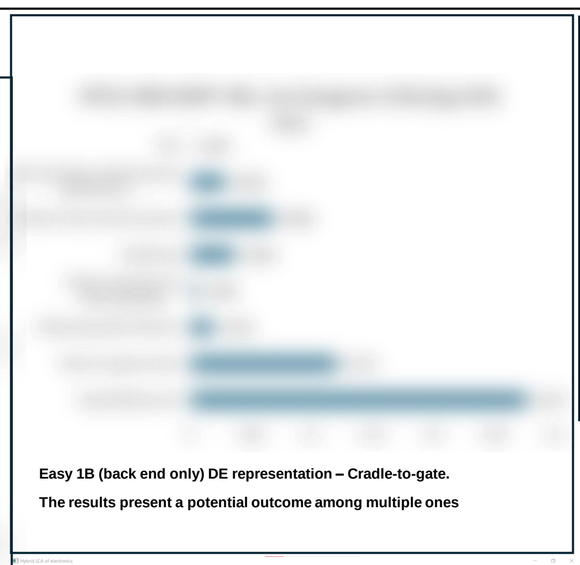


Aalto Results & Challenges: M9-Current:



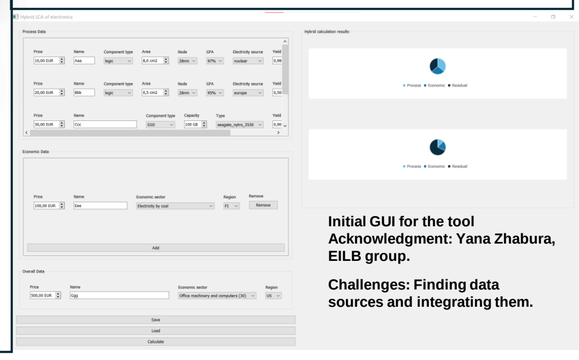
EconoDUAL3 Si IGBT 1.2kV 450A vs 62mm SiC MOSFET 1.2kV 420A GLO representation - Cradle-to-grave results excluding the use phase and insignificant subphases

- **Represents a potential outcome among multiple ones. Parameters include yield, technology, geographical representations, type of energy used, assumptions etc.**
- **The front-end represents high production facilities where SiC energy demand is 3X that of Si**
- **The results consider that the module is fully recycled**



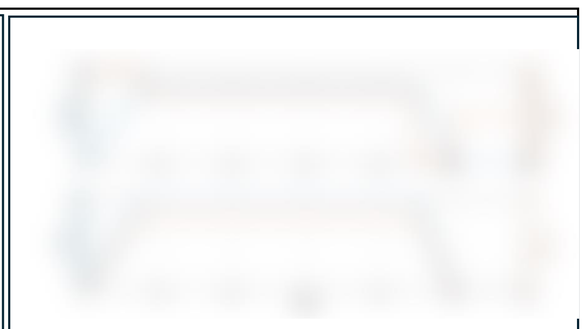
Easy 1B (back end only) DE representation – Cradle-to-gate.

The results present a potential outcome among multiple ones



Initial GUI for the tool
Acknowledgment: Yana Zhabura, EILB group.

Challenges: Finding data sources and integrating them.



Reconstructed cycle profile

Cycle profile provided by Joonas Leppänen, ABB (FI)

Mosfet				IGBT			
43.41 W				130.05 W			
Conduction Loss (W)		Switching Loss (W)		Conduction Loss (W)		Switching Loss (W)	
23.72		19.69		57.28		72.77	
Mosfet	Diode	On	Off	IGBT	Diode	On	Off
4.81 (w)	18.91 (w)	14.17 (w)	5.52 (w)	9.50 (w)	47.79 (w)	26.47 (w)	46.30 (w)

One cycle losses per switch comparison of Si IGBT vs SiC MOSFET, to be then amplified to represent the use phase losses of the power modules

Challenge: Realistic application within the project scope.

Acknowledgement:

Hossein Sadeghlafmejani, Prof. Marko Hinkkanen group, Aalto University

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