A generic GHG-LCA model of a smart mini grid for decision making using the example of the Don Bosco mini grid in Tema, Ghana

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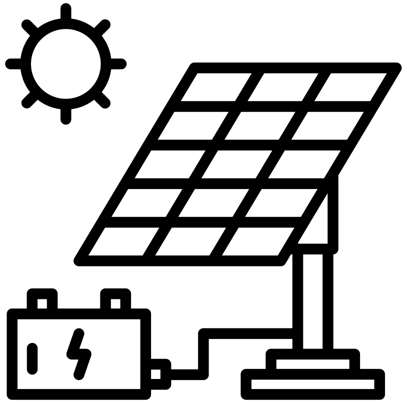
Agenda

- Introduction: Potential and challenges of Mini-Grids for sustainable energy supply
- Methodology: Generic GHG-LCA model of a mini-grid
- Results: Case Study of the Don Bosco Mini-Grid
- Conclusion and Outlook

Potential and challenges of Mini-Grids

- **Sustainable Development Goals (SDG) 7**: Access to affordable, reliable and clean energy for all by 2030
- **Sub-Saharan Africa**: energy supply is neither clean nor reliable
  → mostly based on oil, natural gas (grid) or stand-alone diesel generators
  → Energy access of 83%/ 67% in rural areas [1]

- **Mini-Grids** are a reliable, environmentally friendly option for power supply [2,3]
- However, optimization is necessary:
  - Storage is a key component to level production & demand [4,5]
  - Storage and PV are often over-dimensioned
  - Storage and PV are expensive and have high environmental impacts



Aim: a generic and practic-oriented LCA tool to previously optimize the design of stand-alone Mini-Grids to minimize its GHG emissions.

Approach for the generic LCA model

Literature review

- Design of Mini-Grid
- Common storage systems
- Lifetime of components

Mini-Grid components

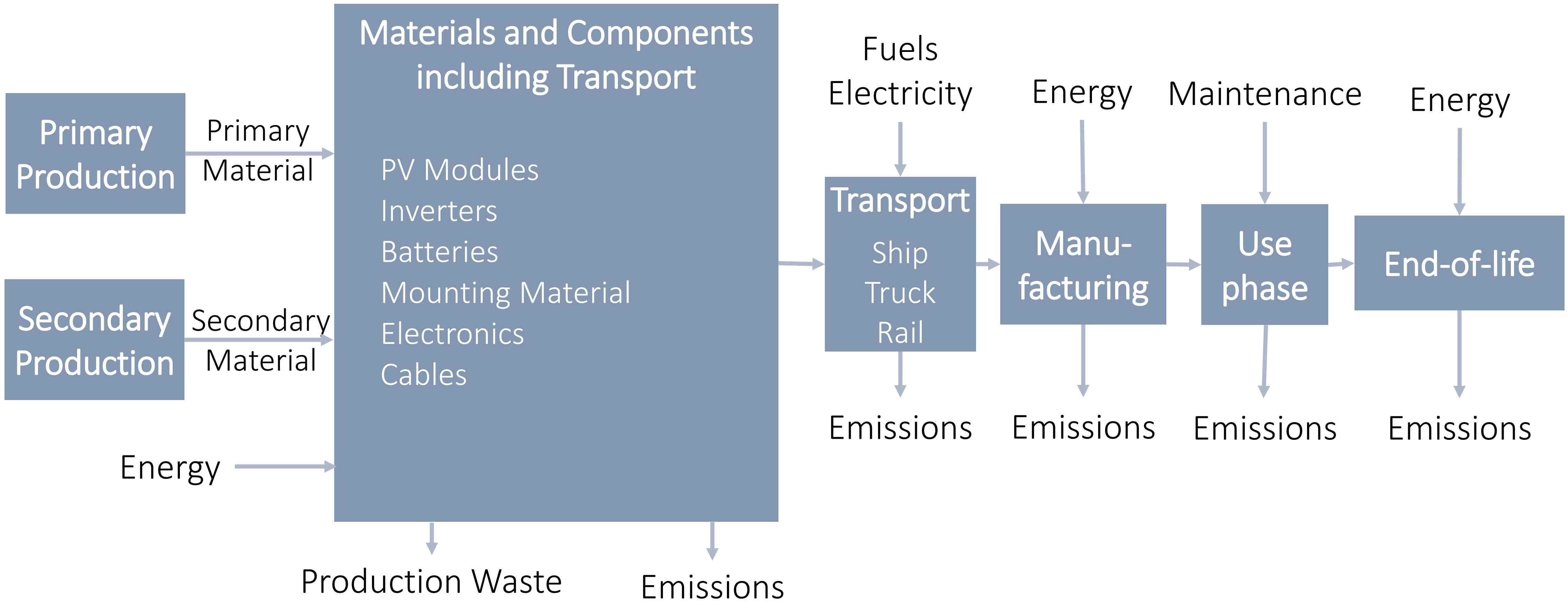
- Batteries
- Inverters
- Photovoltaic moduls
- Mounting material
- Cables
- Electronics / Controllers

Generic LCA model

- Excel file based on GaBi LCIA data
- Global warming potential (GWP 100)
- Functional unit: consumed kilowatt hour (kWh)

Aim: a generic and practic-oriented LCA tool to previously optimize the design of stand-alone Mini-Grids to minimize its GHG emissions.

System boundaries and life cycle inventory



Impact category: Global Warming Potential, 100 years (GWP100) in CO_2-equivalents (CO_2eq.)

Functional unit: 1 kWh electricity consumed

Approach for the generic LCA model

Lifetime modelling

Free Parameters	Dependent Parameters		
Main assumptions	**Lifetime**		**Units over Lifetime**
Lifetime of the Mini-Grid	25	Years	1,0
Lifetime of PV Modules	25	Years	1,0
Lifetime of Copper Cables	25	Years	1,0
Lifetime of Aluminium Cables	25	Years	1,0
Lifetime of Electronic Components	7	Years	3,6
Lifetime of Li-ion Battery	10	Years	2,5
Lifetime of Lead Acid Battery	6	Years	4,2
Lifetime of Mounting	25	Years	1,0
Lifetime of Solar Charger	7	Years	3,6
Lifetime of Inverter	7	Years	3,6

Assumptions in the Generic LCA model. Own illustration. Image: Microsoft Office

Approach for the generic LCA model

Lifetime Bill of Material

Free Parameters			Dependent Parameters		
BOM Mini-Grid	**Amount**	**Unit**	**Lifetime BOM**	**Amount**	**Unit**
PV Modules	103,290	W	PV Modules	103,290	W
PV Modules	5,947	kg	PV Modules	5,947	kg
Copper Cables	665	kg	Copper Cables	665	kg
Aluminium Cables	7	kg	Aluminium Cables	7	kg
Electronic Components	36	kg	Electronic Components	129	kg
Li-ion Battery	-	kg	Li-ion Battery	-	kg
Lead Acid Battery	5,863	kg	Lead Acid Battery	24,430	kg
Mounting Material Alu	698	kg	Mounting Material Alu	698	kg
Solar Charger	36	kg	Solar Charger	129	kg
Inverter	619	kg	Inverter	2,211	kg
Sum	**13,871**	**kg**	**Sum**	**34,215**	**kg**

BOM of the Generic LCA model. Own illustration. Image: Microsoft Office

Case study application

The Don Bosco Mini-Grid in Tema, Ghana

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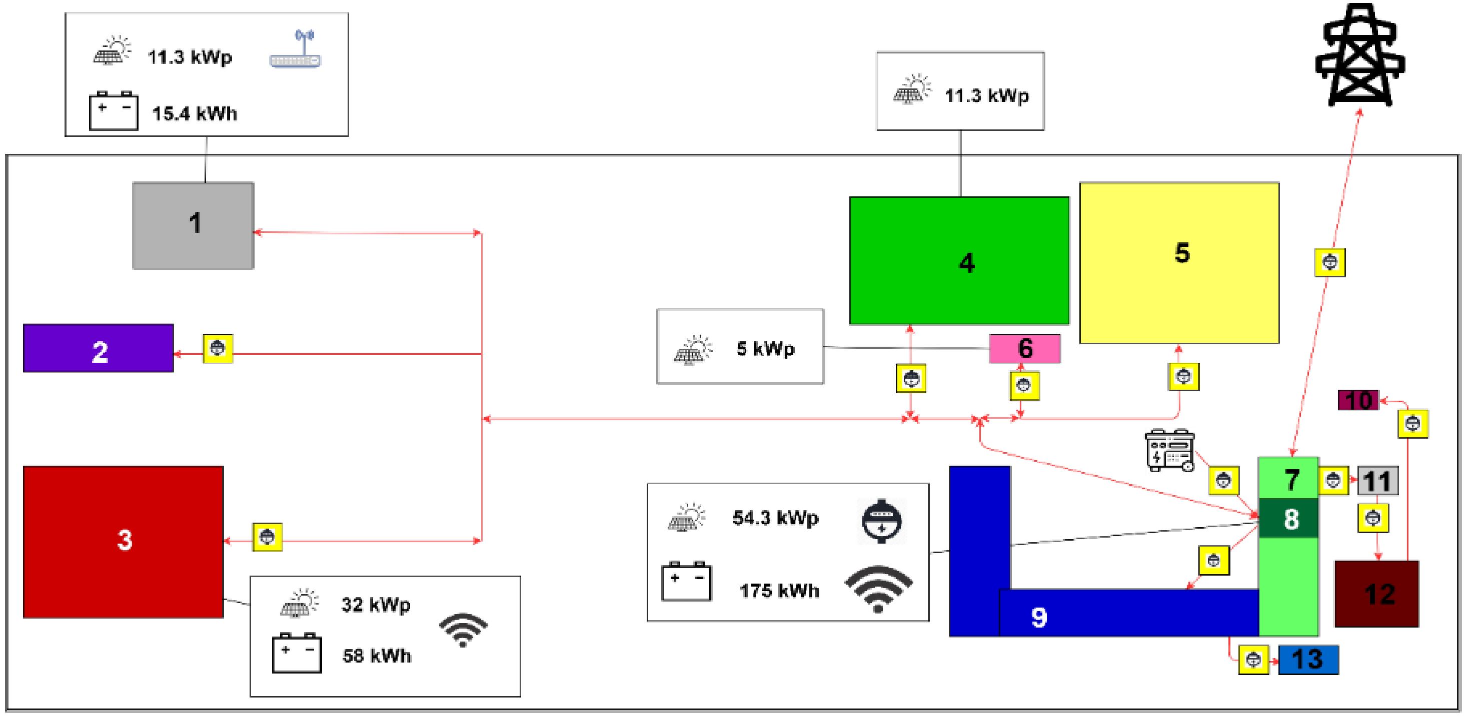


Smart Meter recommended

List of devices enter the link

10 m

Total Area: 250m*150m

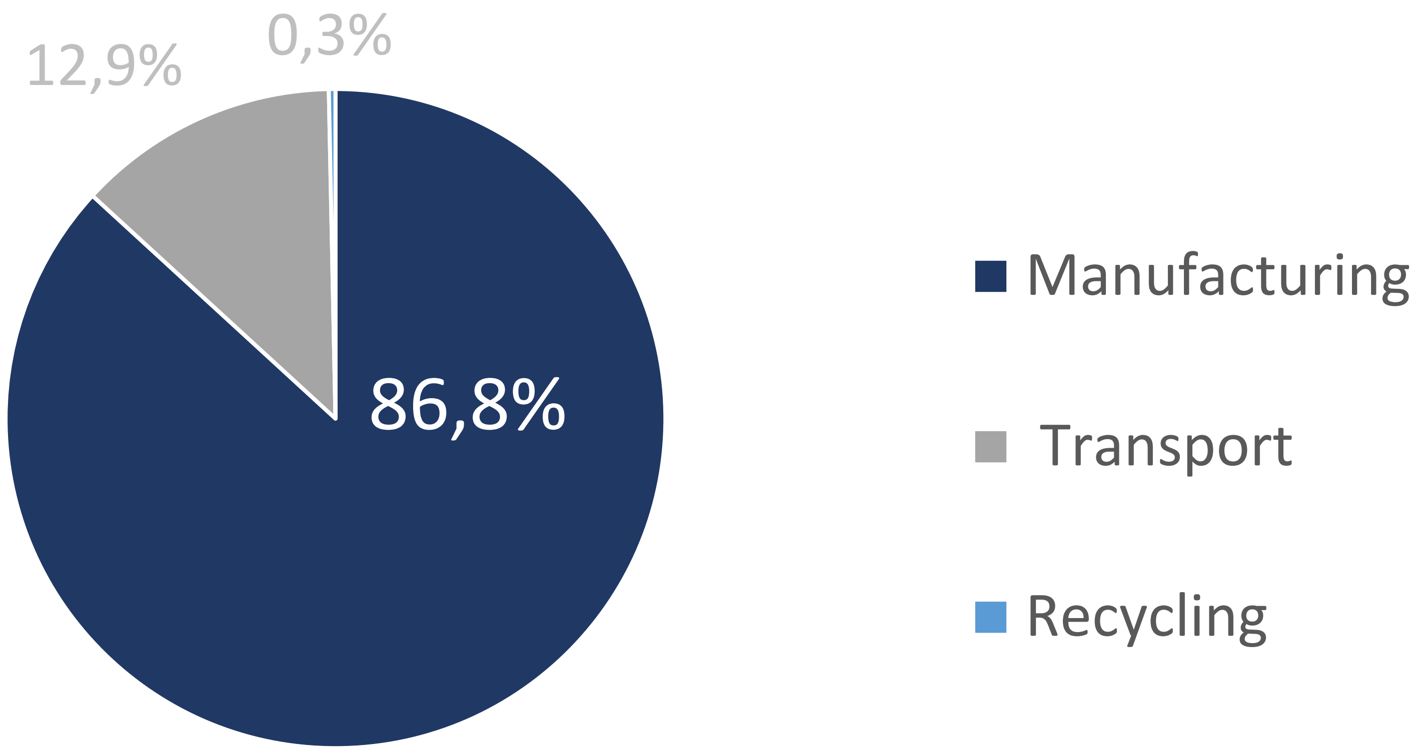
Buildings:
1 Church
2 Guesthouse
3 Provincial House
4 Hostel
5 Car repair shop & Driving school
6 Container
7 Solar Training Center
8 Power Room
9 TVET
10 Security
11 Waterpump
12 Canteen
13 Watertower

installed PV- Moduls
installed Battery
WiFi access
installed smart Meter
recommended smart Meter

Energy with Flow direction (Consumer)
Energy with Flow direction (Prosumer)
GSM Modem
Diesel Generator
Ghana national Grid

GWP 100 of the Don Bosco Mini-Grid

Life cycle perspective



The GWP is 235 tCO_2eq. with more than 86% coming from manufacturing

GWP 100 of the Don Bosco Mini-Grid

Life cycle vs. Manufacturing phase

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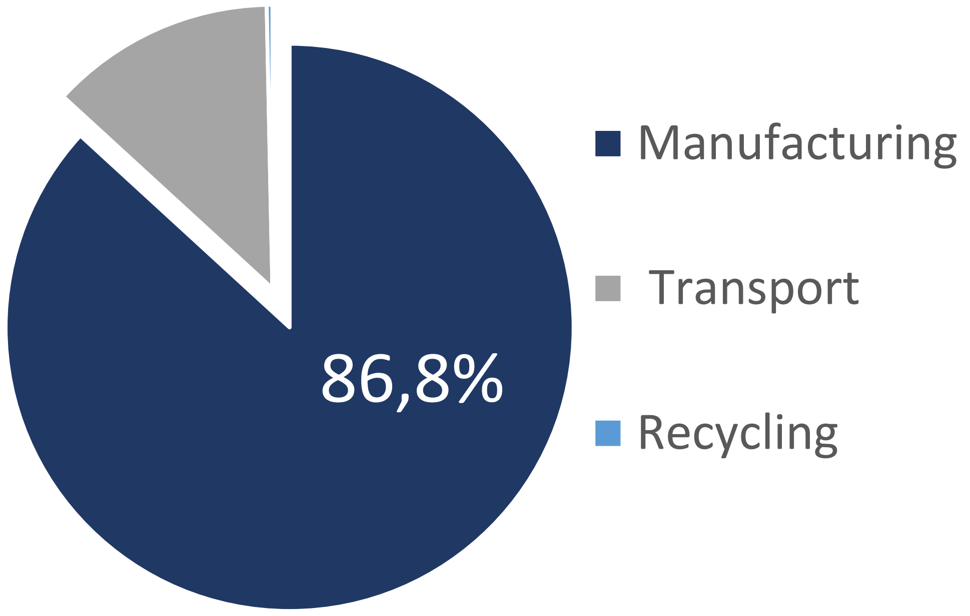
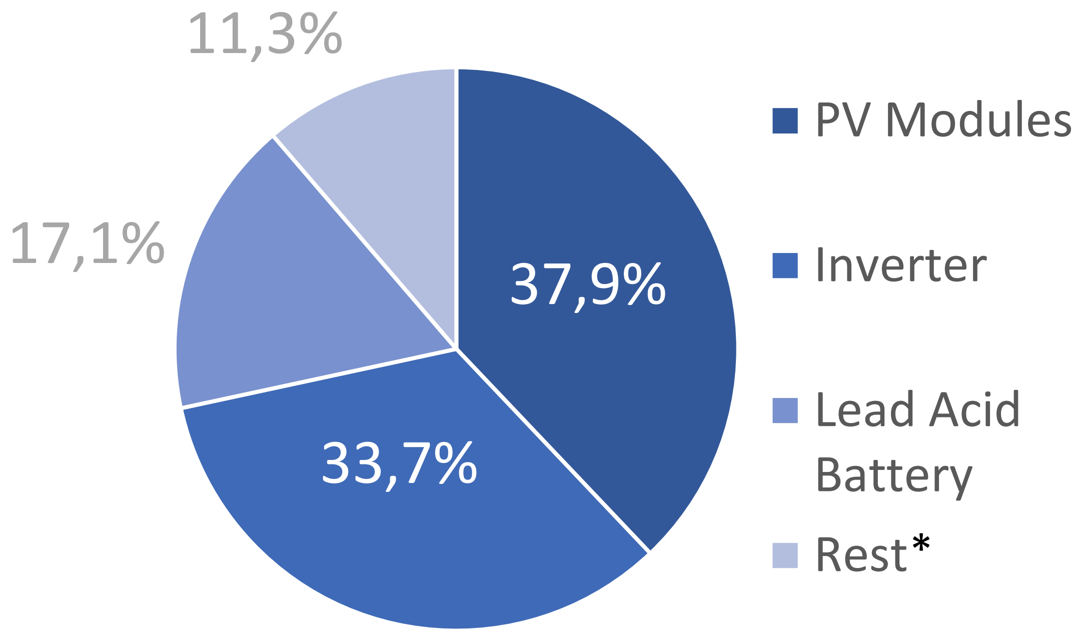
Life Cycle



Manufacturing

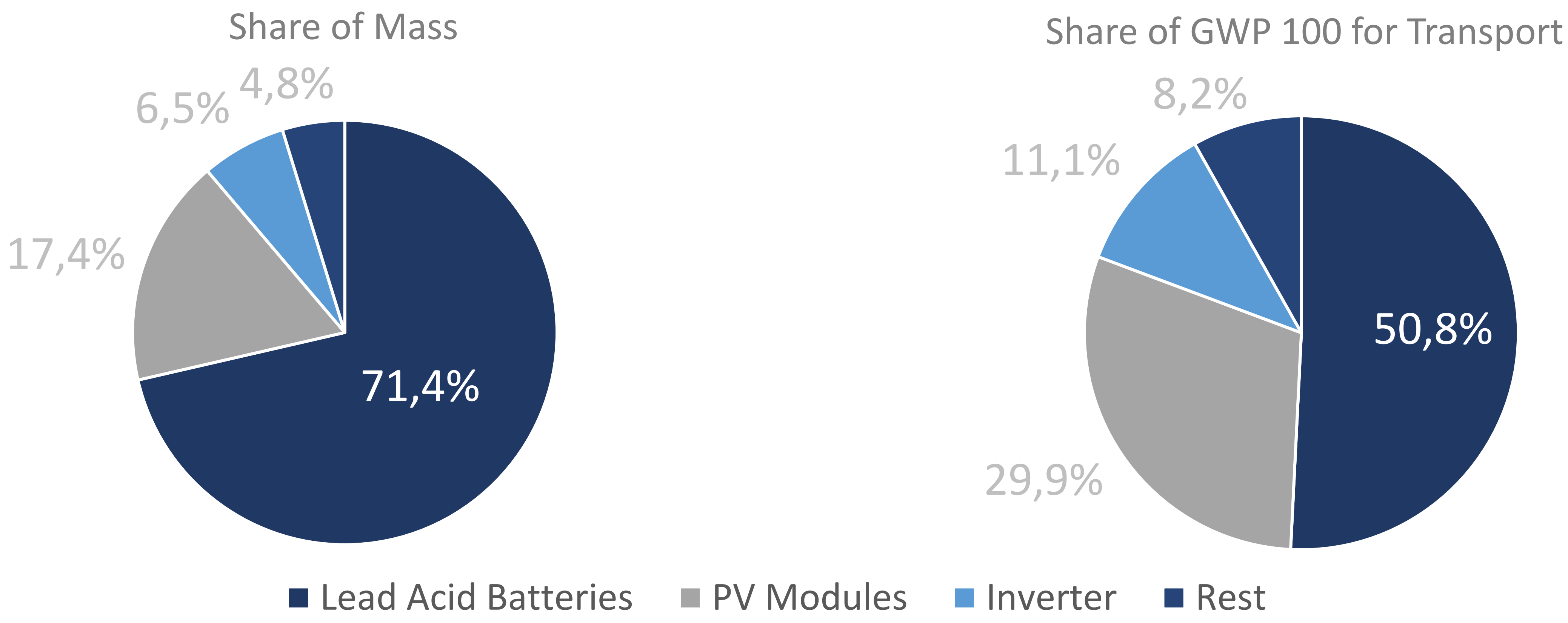


PV modules and Inverter are the components with the highest impact

*including cables, electronic components, Li-ion batteries, mounting materials and the solar charger

GWP 100 of the Don Bosco Mini-Grid

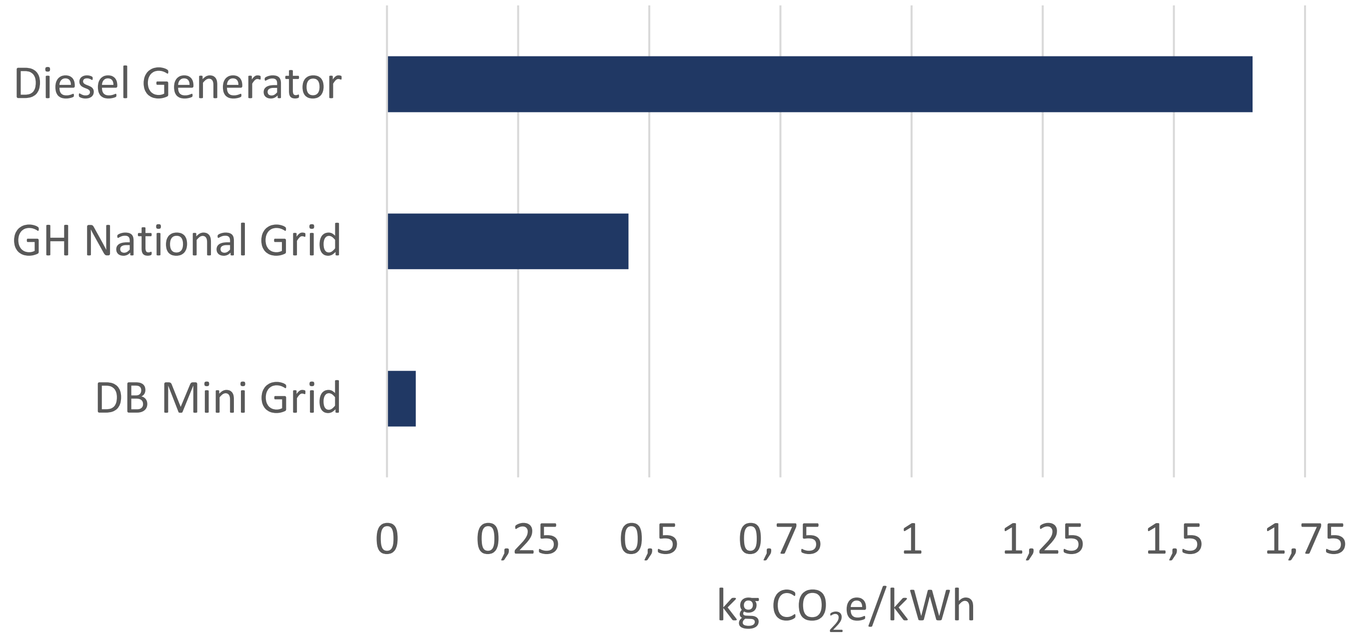
Share of components in transport emissions



Lead acid batteries have the highest impact on the emissions during transport

GWP 100 of the Don Bosco Mini-Grid

Comparison with other electricity sources



Savings of **1,713 tCO_2e** vs. GH national grid

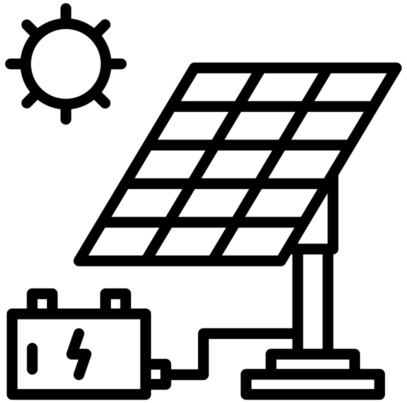
Savings of **6,769 tCO_2e** vs. diesel generator

The DB Mini Grid can save up to 6,800 tCO_2e, equiv. to almost 50Mkm by car

Conclusion and outlook

- Using the generic GHG-LCA model any **Mini-Grid constellation can be modelled and optimized to reduce the carbon footprint**.
- The case study shows **Mini-Grids have the potential to reduce emissions**
- The **Hot-spot** for emissions are **PV modules** and **lead-acid-batteries** (during transport

- In **further research** it is important…
  - to consider other technologies e.g. lithium-ion batteries.
  - to quantify the impact of different consumption scenarios and demand side management.
  - to use the LCA model in conjunction with a Mini-Grid modelling tools such as Homer.
  - To extend the generic model should with additional environmental impact categories and economic criteria.



Thank you for your attention!

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