

Assessment of a Solar Cookstove Using Heat Storage Technology

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1. Background, Challenge & Objectives

Background / Context

In Madagascar, almost 99% of the population relies on wood as their primary source of energy for cooking (EnDev, 2021). ADES Solaire, a Swiss-Madagascan NGO, developed energy saving cookstoves to reduce the fuel amount. The next goal is, to switch to solar energy in the form of solar cookstoves. Due to their closeness to the equator, early sunsets hinders the population in adapting to solar energy because they cannot cook dinner with it. Additionally, cloudy weather complicates solar cooking even more. Therefore, a solar cookstove should be developed with integrated energy storage to allow them to utilize solar energy 1 hour later than possible before.

Research Questions

What is the ecological footprint and economic impact of a solar cooker with heat storage compared to energy saving cookers or classic wood fired cooking?

Objectives

1. Research on existing solutions and technologies related to the topic
2. Discuss and specify technological requirements with NGO
3. Economic and sustainability assessment
4. Evaluation of a functional model

2. Methodology / Materials

Methodology

The following graph shows the applied methodologies to conduct this research.

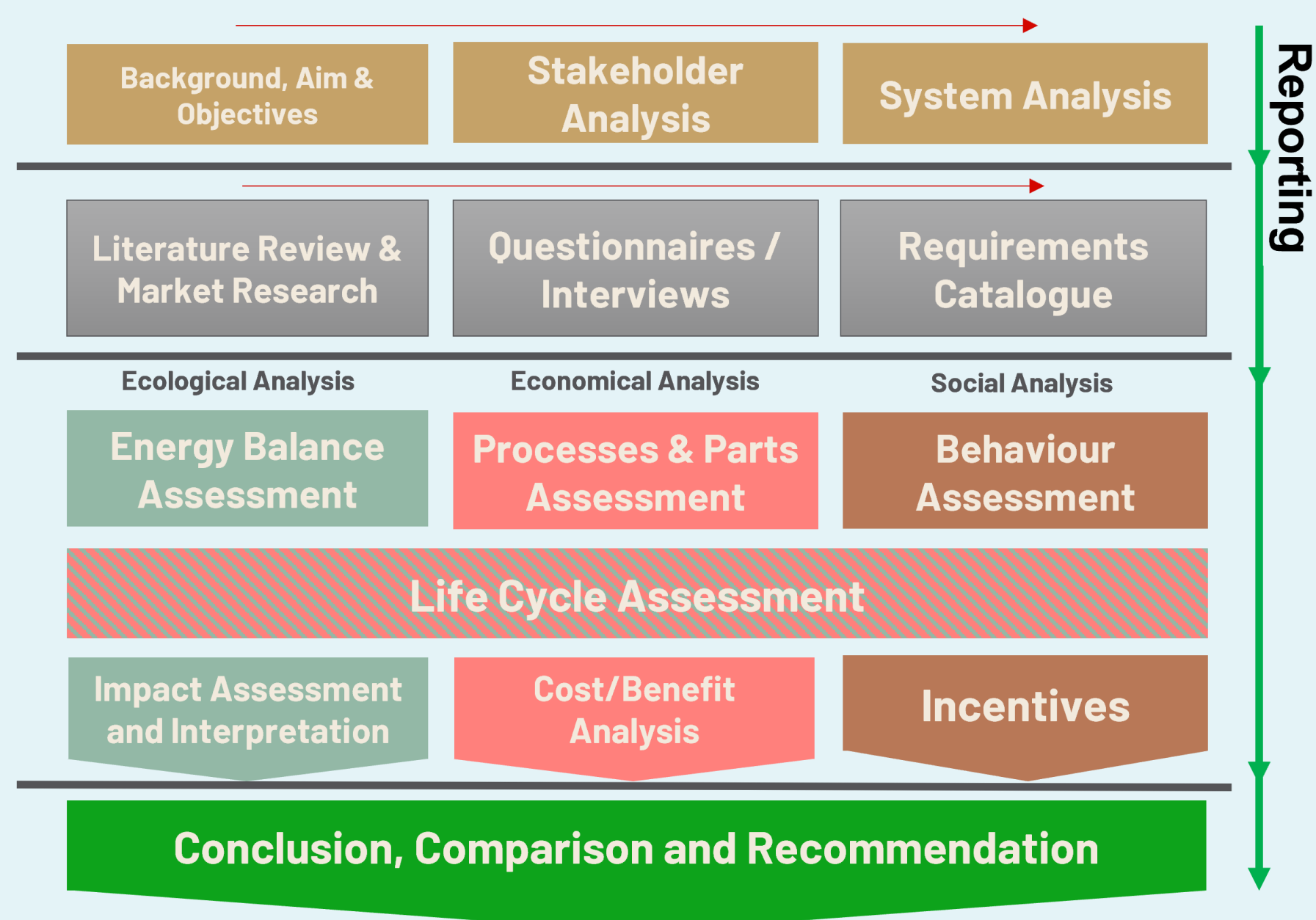


Figure 1: Methodology overview and work-flow

Data and Tools

- Data for the LCA was used from the Ecoinvent Database 3.9.1
- The LCA was performed in SimaPro 9.5

3. Results / Solution / Recommendations

Functional Model

In his parallel bachelor thesis, Patrick Estermann developed a functional model of a solar cooker with latent heat storage in form phase change material (PCM). It was able to store energy for 1h and cook for a duration of 1.5h. On the basis of his results, economic and ecological analysis was performed as well as optimisation developed.



Figure 2: Functional model using PCM as latent storage (Estermann, 2023)

Reduction of Energy use and GHG Emissions

Through the performed LCA it is conceivable, that by using the SC with wood during rain season, the energy usage is **14 times** lower when switching from coal and **4 times** lower when from wood. The wood savings are up to 93 % when switching from wood and 85 % when switching from charcoal to an ideal setup. The GHG reduction is **65 times** and **3.2 times** lower for charcoal and wood respectively.

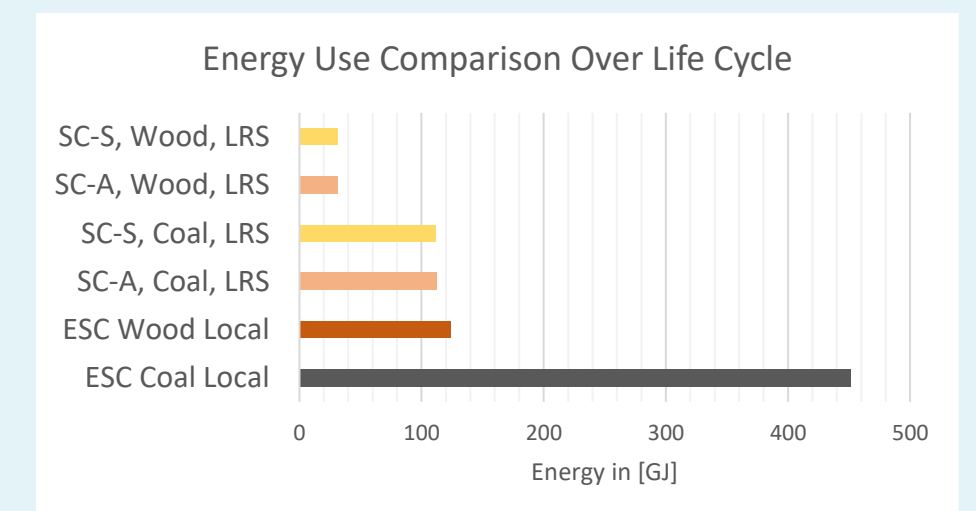


Figure 3: Energy use over life cycle of different scenarios

Cost Benefit Analysis Different Scenarios

The analysis shows, that the local population can maximise savings after **5 years** of usage significantly compared to baseline scenarios. They could save up to **191 CHF** in 5 years, which is almost **5 monthly** incomes (WorldData.info, 2022).

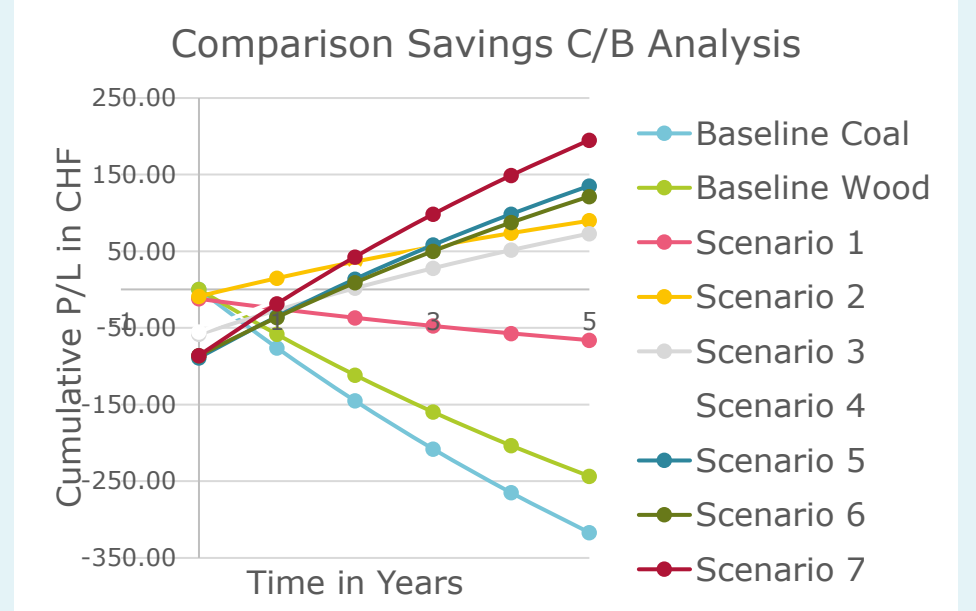


Figure 4: Cost savings through employment of SC and ESC for optimal use

The expensive, but efficient setup can be amortised after **13 to 15 months**.

4. Discussion, Conclusions & Outlook

Discussion

The research shows that the use of coal is especially problematic for the environment and wasteful in terms of energy. Switching from coal to wood and employing solar cookers can significantly help to reduce the usage of wood as an energy source.

Conclusions

Such research is beneficial to conduct along the development of a product to optimise the ecological and economical impact. Additionally, it helps to understand the needs of the prospective users and argue for the deployment of efficient solutions successfully.

Outlook

For improved SC designs, similar research as this must be conducted to prove economic and ecological viability. Especially, when constructed from aluminium with other PCMs.

Literature

- EnDev, (2021), Portfolio on Madagascar and how energy saving cookers help change. Retrieved March 2023, <https://endev.info/countries/madagascar/>
- Patrick Estermann, (2023), Bachelor Thesis, Entwicklung eines Solarkochherdes mit Latentwärmespeicher
- WorldData.info. (2022). Economics in Madagascar compared to the EU. <https://www.worlddata.info/africa/madagascar/economy.php>