LIFE CYCLE ASSESSMENT OF PORTABLE POWER SUPPLIES

White paper

Instagrid

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Life Cycle Assessment – A Quantitative Approach to Sustainability

Companies are increasingly adopting more sustainable practices. Simultaneously, the global regulatory environment drives companies to reconsider their business activities, including emission reductions. As most emissions are related to products, focusing on the product life cycle and moving beyond vague sustainability claims is crucial: we must take a quantitative approach.

Quantifying Impact

A Life Cycle Assessment (LCA) serves as the foundation for a credible and transparent approach to product sustainability. It's a widely recognised method for assessing the environmental impacts of a product throughout its life cycle—from raw materials and production to distribution, use, and final disposal. The LCA provides valuable visibility, allowing us to prioritise actions with the biggest impact on each life cycle phase. Additionally, it helps us derive impact-based recommendations and offers technical guidance for sustainable product design, green manufacturing, and full life cycle management.

Why share our approach?

To effectively fight climate change, we need more data—and more LCAs. However, knowing where to start and what to concentrate on may not be easy. We want to share our quantitative approach to sustainability as we trust in the power of shared knowledge and genuine dialogue. We hope it lights a spark in you, too!

LET'S TALK?

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Scope and Methodology

Our comparative LCA started as part of the European Union co-financed EU LIFE project (June 2019–June 2022) focused on clean air. By early 2023, this LCA study received certification according to ISO 14040 and ISO 14044 by TÜV Nord.

The primary goal was to evaluate the environmental impact of the entire life cycle of **Instagrid's portable power supplies (Instagrid ONE)** compared to **small combustion generators with a power output of up to 5.7 kVa**.

The system boundaries consider all activities from extraction of raw materials trough processing, manufacturing, districution and end-of-life (cradle-to-grave). The product life cycle is divided in four main phases:

- production
- transport
- use-phase
- end-of-life.

The **product scope** included:

- our battery-based portable power supply, Instagrid ONE
- diesel powered small combustion generator,
- gasoline powered small combustion generator.

The functional unit was defined as 1 kWh of the total energy delivered over the whole service life.

Emission measurements on equivalent load profiles of the product scope above were conducted with an external partner, HLNUG (Hessisches Landesamt für Naturschutz, Umwelt und Geologie).

The FIT Umwelttechnik GmbH conducted **a product recycling and dismantling study**, and its findings were incorporated into the LCA model.

Life Cycle Inventory

For a Life Cycle Inventory (LCI), we collected data on all inputs and outputs across various stages of the product's life cycle. The LCI included a Dismantling Analysis and a Composition Analysis. We analysed the data using SimaPro LCA software and the Ecoinvent database, supplemented by primary data from measurements.

Our **primary data** sources:

- **Dismantling Analysis**: We dismantled a battery-based portable power supply into sub-assemblies, which were further disassembled and analysed into base materials.
- **Composition Analysis**: We assessed a battery cell LCI dataset by gathering information from product material safety data sheets obtained from suppliers and similar product LCAs.
- **Product IoT Data:** We collected field measurements from 12 European customers (mainly construction companies) to analyse user behaviour.

Examples of our **secondary data** sources:

- We tracked all materials back to **resource extraction**, mainly using the Ecoinvent database.
- We analysed the environmental impact of **product disposal** using Ecoinvent waste treatment data.
- For **lithium-ion batteries**, we adopted a 50:50 mix of hydrometallurgical and pyrometallurgical methods based on consultations with battery recycling experts.

Material distribution of Instagrid ONE.[1]

46.1% Battery cells	2.6% Electronics	0.9% Copper
18.8% Plastics	2.7% Steel & Iron	0.1% Ceramics
8% Paper	20.8% Aluminium	

[1] Based on product recycling and dismantling study by FIT Insitute

Impact Analysis

For Impact Analysis, we calculated and reported eight widely accepted impact categories according to the EPD (Environmental Product Declaration) methodology.

1

GHG (kg CO_2e)

Sum of all greenhouse gas emissions, using the most recent global warming potentials (GWP) for all non-CO_2 gases, in mass of CO_2 equivalents

2

$PM_{2.5}$ (kg $PM_{2.5}e$)

Fine particulate matter formation potential in mass of $PM_{2.5}$ equivalents

3

NO_x (kg NO_xe)

Ozone formation potential in mass of NO_x equivalents

4

SO_2 (kg SO_2e)

Acidification potential in mass of SO_2 equivalents

5

PO_4 (kg PO_4e)

Eutrophication potential in mass of PO_4 equivalents

6

NMVOC (kg NMVOC)

Photochemical oxidant creation potential in mass of non-methane volatile organic compounds

7

OZONE (kg CFC-11e)

Ozone-depleting potential in a mass of CFC-11 equivalents

8

WATER (m_3)

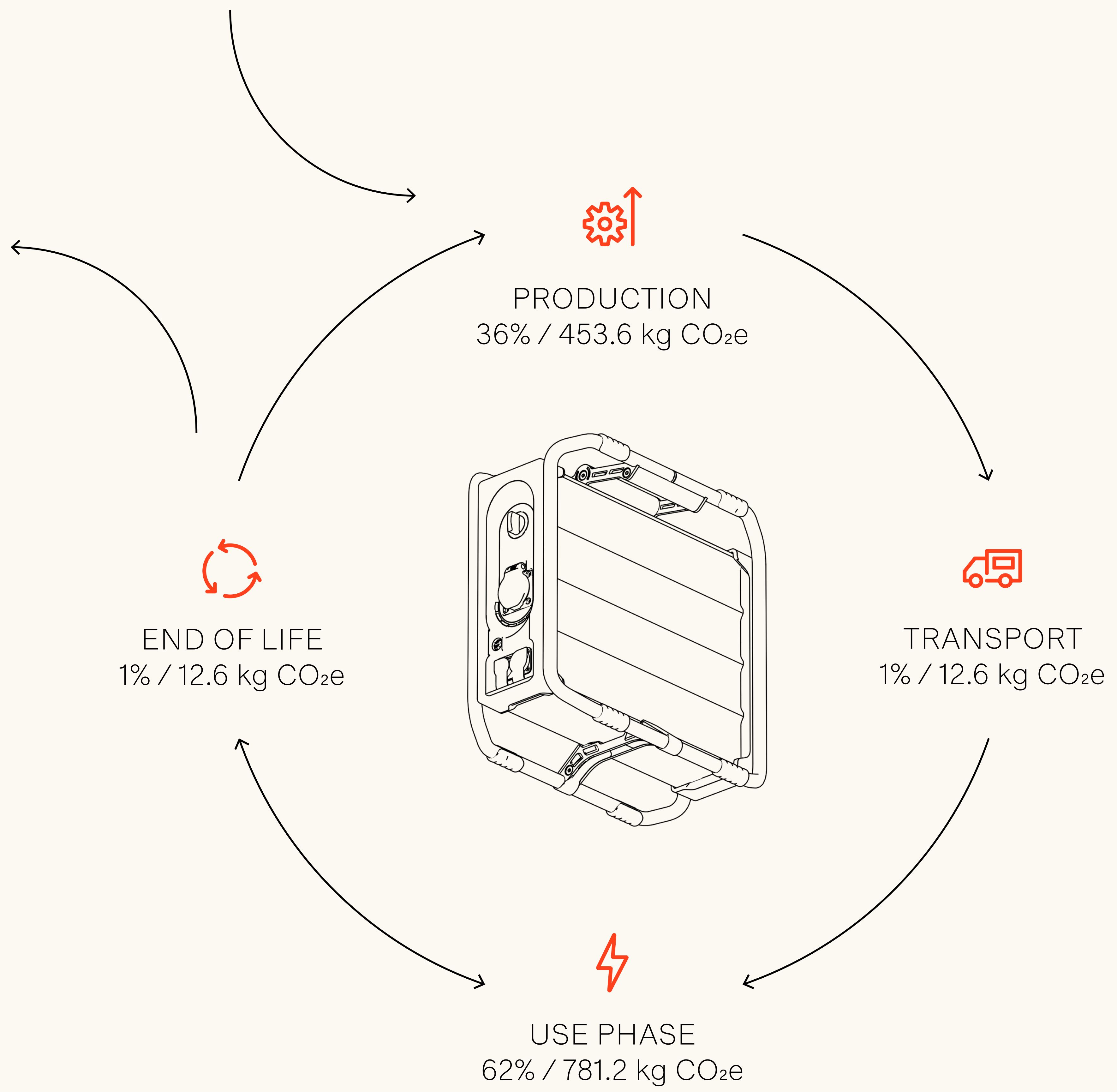
Water scarcity footprint

Instagrid ONE

Our LCA yielded the following results: Over its product life cycle, Instagrid ONE emits **1,260 kg CO_2e[2]**, of which the **use phase contributes 62%**.

The use phase describes the typical use of the product after it is purchased. In our study, we examined its typical use case by twelve different construction companies across seven European countries.

Instagrid ONE's CO_2e emissions divided into life cycle phases.

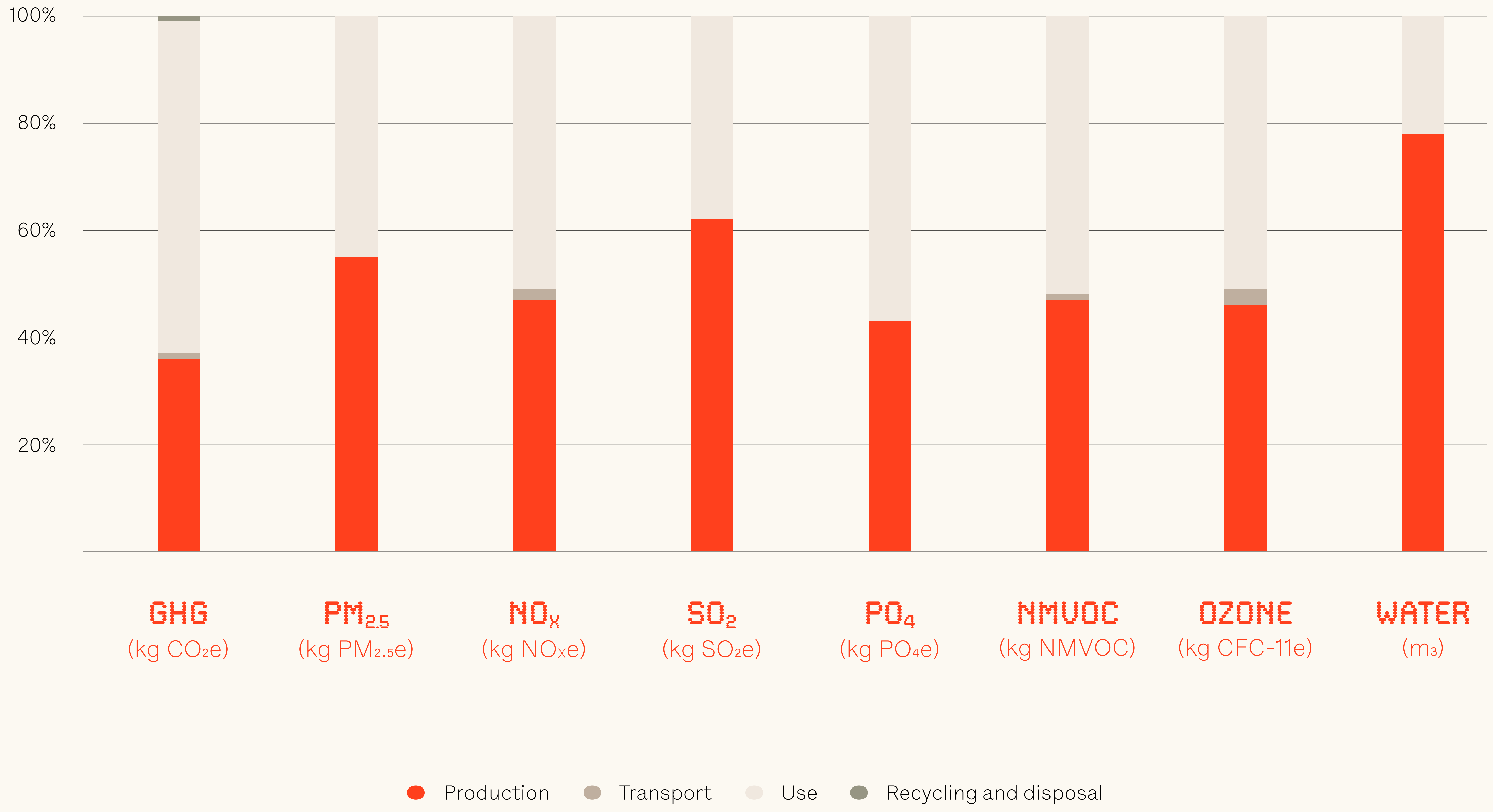


[2] Total life cycle emissions and emissions per life cycle phase are rounded.

Instagrid ONE

By shifting our focus from the CO_2e emissions to selected impact categories, we gained a holistic understanding of the environmental burden related to the life cycle of an Instagrid ONE. We see that the life cycle emissions are primarily driven by production and use phases.

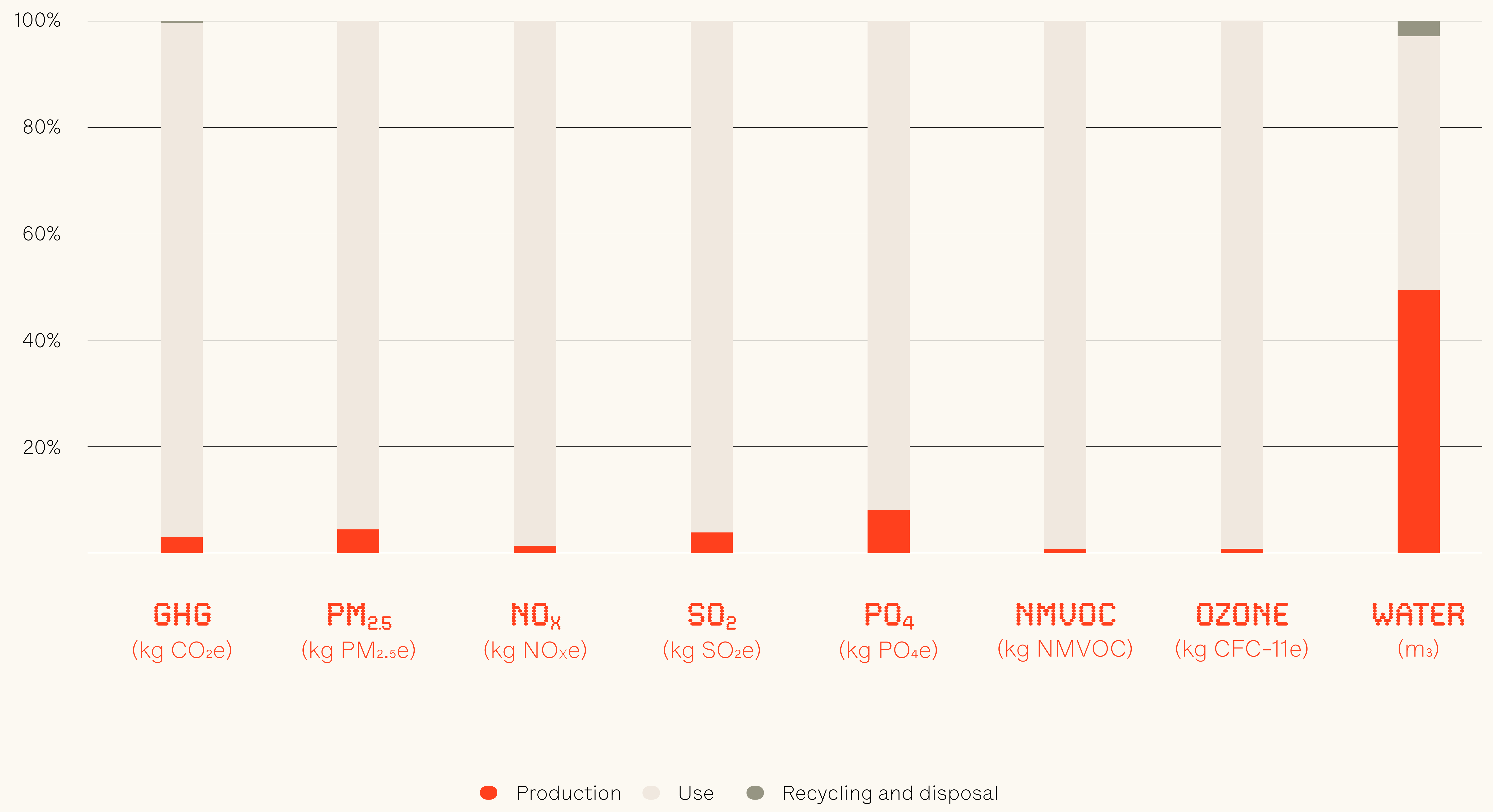
The modelled life cycle phases of Instagrid ONE on all impact categories.



Gasoline Generators

Using the same approach, we modelled the contribution of gasoline and diesel generators' different life cycle phases (production, use, recycling, and disposal) to the eight selected environmental impact categories. The use phase was found to dominate all impact categories.[3] The life cycle emissions are primarily driven by use phase.

The modelled life cycle phases of gasoline generators on all impact categories.



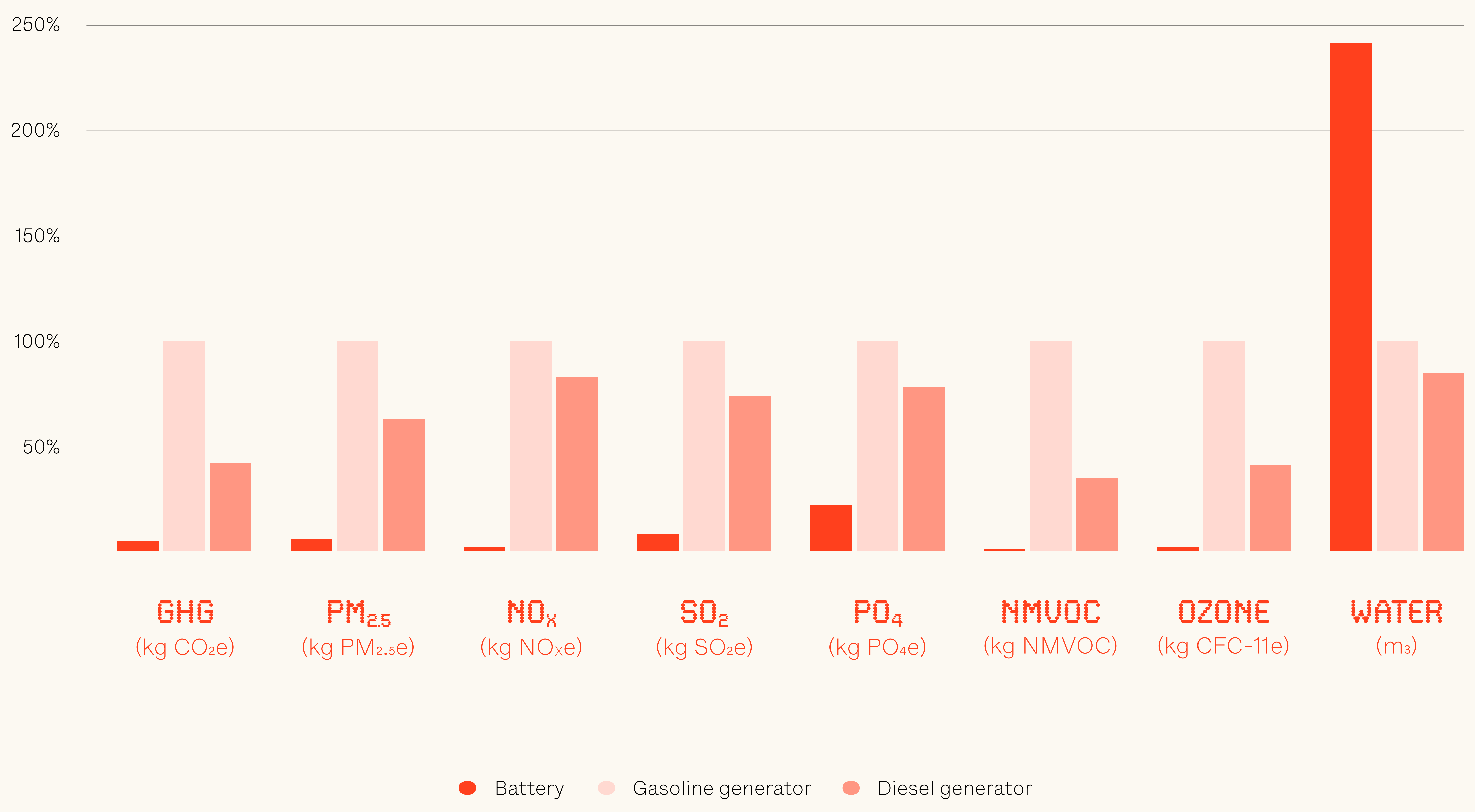
[3] The transport phase was not included in the generators' LCA due to the lack of data. Since the battery-based portable power supplies' impact on this phase is negligible, a similar non-significant result can be expected for the generators.

Comparative Analysis: Instagrid ONE vs Diesel and Gasoline Generators

After investigating Instagrid ONE's life cycle and the individual CO_2e emissions of generators, we were ready to begin comparisons. To accurately reflect the lifespan difference between each product, we normalised the values by kWh delivered for comparison purposes.

According to the LCA model, Instagrid ONE achieves a remarkable 97% reduction in total GHG emissions.[4] Battery-based portable power supplies generally have a far lower impact in almost all impact categories.[5]

The overall results on all impact categories across the life cycle of the product scope.

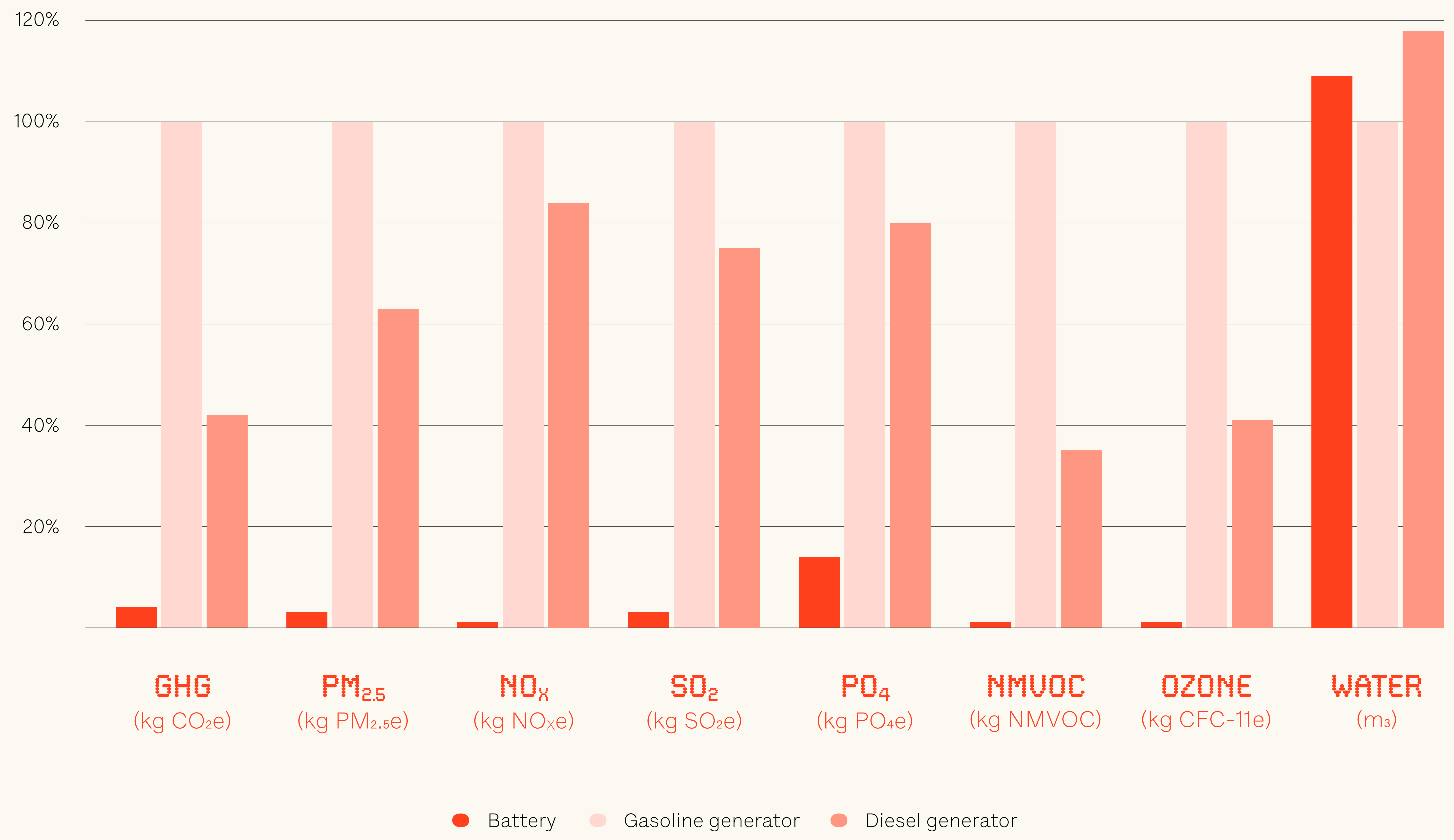


[4] Relative environmental impact across the lifecycle of battery-based portable power supplies compared to gasoline and diesel generators when values are normalized by kWh under the assumption of high profile users.
[5] Water usage is a regional topic and impacts areas with scarcity challenges. For the LCA study, there was no primary data available to get a clear picture. Instagrid's supply chain choices aim to minimize this impact and we continue to further investigate it.

Comparative Analysis: Instagrid ONE vs Diesel and Gasoline Generators

As the use phase significantly impacts the life cycle emissions of both Instagrid ONE and generators, our next step was to compare their environmental burden per kWh during this phase. Generally, Instagrid ONE shows less impact on all impact categories as compared to gasoline and diesel generators.

The results of comparing the environmental impact per kWh during the use phase.



Sensitivity Analysis

To ensure the reliability of our results, we conducted a sensitivity analysis, systematically varying charging scenarios including user profiles (high vs. average profile users), battery cycle numbers (500 vs 1000), and charging scenarios. This allowed us to evaluate their different effect on the outcomes.

Recent innovations have extended the estimated lifetime of a battery-based portable power supplies to 1000 cycles, compared to the previous 500 cycles. Our study reveals that this increase in battery lifetime reduces the global warming potential by 27% and decreases the water scarcity footprint by 44%.

Further interviews with our customers indicated that they mainly charge overnight or during lunch breaks. Therefore, our LCA model included the EU electricity mix grid data for the use phase. However, our analysis also reveals that charging the battery-based portable power supply with renewable energy, such as solar power, reduces the life cycle impacts in six out of the eight investigated categories, as shown to the right.

Environmental impact of Instagrid ONE considering different sources of energy, for example the EU standard electricity mix vs PV solar energy vs coal-based energy.

Limitations and Challenges

Understanding the limitations and challenges of the LCA tool is crucial due to its data-intensive nature and the complexity of life cycles. For us, the following aspects required careful consideration.

- **Primary data:** Gathering primary data involves specific measurements or surveys from various sources, such as suppliers and customers, and monitoring equipment in manufacturing facilities. While primary data is context-specific, collecting requires time and resources.

- **Secondary data:** The success of the entire assessment depends on choosing appropriate data from the database, requiring a deep dive into material composition and processes.

- **Impact categories in practice:** Water scarcity is a regional concern. While essential for strategy analysis, addressing it directly in primary data is challenging. The impact depends highly on the country of sourcing.

- **Feedback effect and lack of comparability:** Specific recycling methods might increase CO_2 intensity but contribute positively to circularity. Therefore, it's hard to compare the impacts of different recycling methods solely based on CO_2 intensity, but differentiated indicators are needed.

What we have learned: Prioritising high-impact initiatives

Based on the LCA findings, here are our key takeaways for the near future.

As we continue to grow, we will expand our LCAs to cover new products like Instagrid LINK and adapt the methodology to the requirements set out in the EU Battery Regulation. Additionally, we will implement IoT on a larger scale to extend our primary data collection.

BIGGEST IMPACT PROJECTS

We prioritise high-impact initiatives over easier tasks. The LCA is a tool that helps to identify high impact tasks and prioritise them over others.

EMISSION SAVING MODEL

We have implemented an Emission Saving Model to highlight the positive impact of switching to portable batteries for our customers. The model is built on key findings from our LCA, including lifetime CO_2e savings and behaviour data from the use phase. It provides concrete data for our customers, revealing the significant influence of charging behaviour on emission savings.

SUSTAINABLE PRODUCT DEVELOPMENT PLAN

We have developed a Sustainable Product Development Plan to review designs with product owners, engineers, and designers. Through the plan, we assess the environmental impact of materials and search for alternatives. For example, using recycled aluminium for the housing of Instagrid ONE reduces its carbon footprint by 48% compared with using virgin aluminium.

SECOND LIFE STRATEGY

We focus on making our products last longer, as indicated by our sensitivity analysis, which demonstrated a notable reduction in life cycle emissions. Accordingly, we are actively developing a reuse strategy for our batteries to maximise lifespan.

SUPPLIER DATA

We partner with critical suppliers to collect CO_2 production data and implement measures to reduce the production phase environmental impact.

ITERATIVE IMPROVEMENT

We will continuously improve our modelling process. By developing our data collection methods, we aim to provide even more accurate representation of our products' impacts across their life cycles.

Want to know more? Download our latest impact report or send us a message.
We like to answer all your questions – including the tough ones! sustainability@instagrid.co

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