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Life Cycle Assessment of a Floating LiDAR System for Offshore Wind Energy

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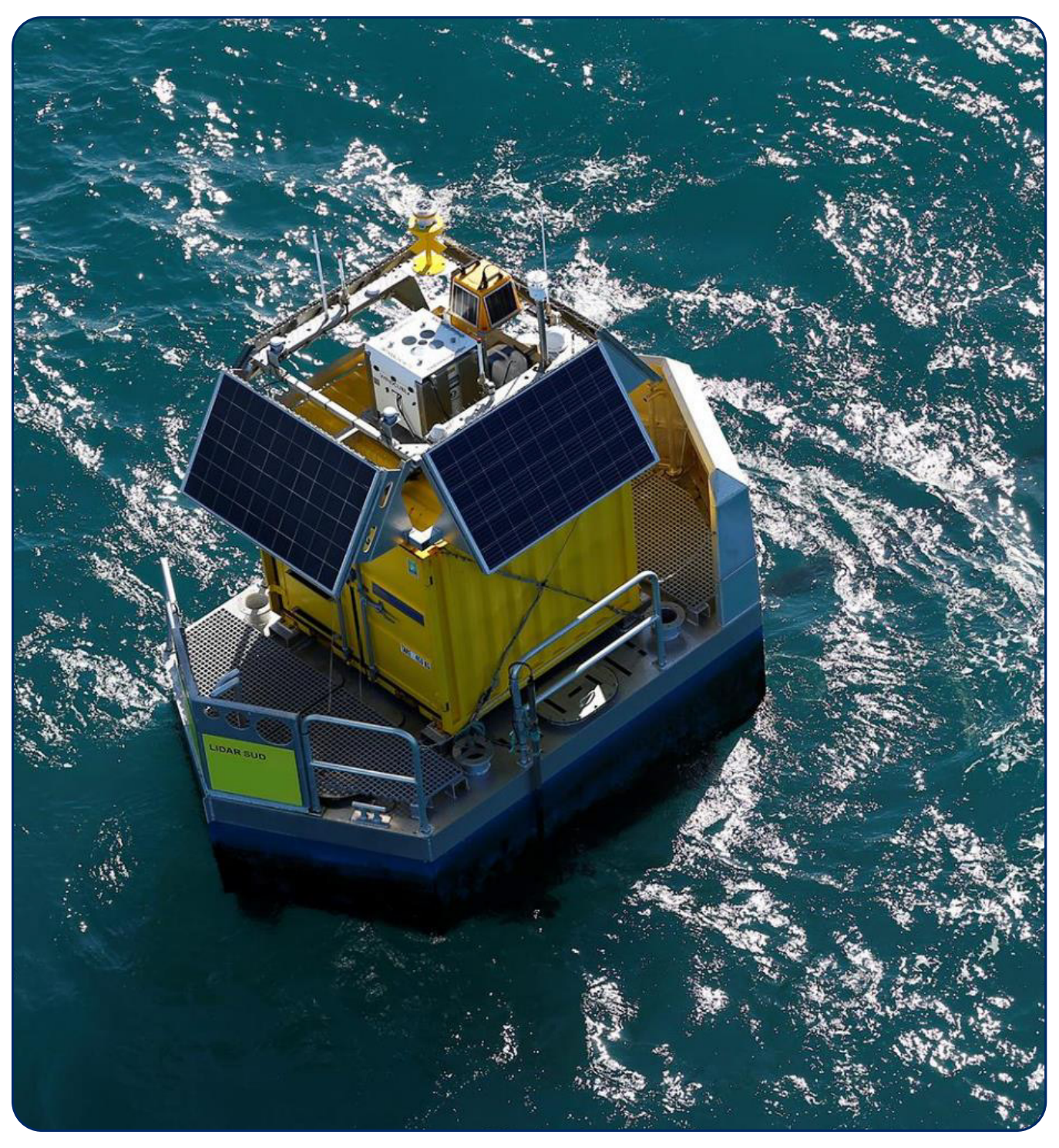
SUMMARY

The increasing demand for renewable energy has driven notable advancements in offshore wind energy technologies, where accurate wind resource assessment is critical for optimizing wind farm performance and reducing costs.

Floating LiDAR Systems (FLS) have emerged as a promising solution for offshore wind measurement, offering a more flexible and cost-effective alternative to fixed meteorological masts.

This study presents the Life Cycle Assessment (LCA) of the WINDSEA, AKROCEAN FLS, evaluating its environmental impact across its full life cycle from manufacturing to decommissioning.
Assuming that the subloop "Pre-verification campaign ➝ Commercial campaign ➝ Refurbishment" is being repeated five times in one life cycle of the Floating LiDAR, it was identified that the most significant contributors to the system's carbon footprint are buoy commissioning and decommissioning to/from the measurement site.

The optimisation of this impact is proposed in this analysis.

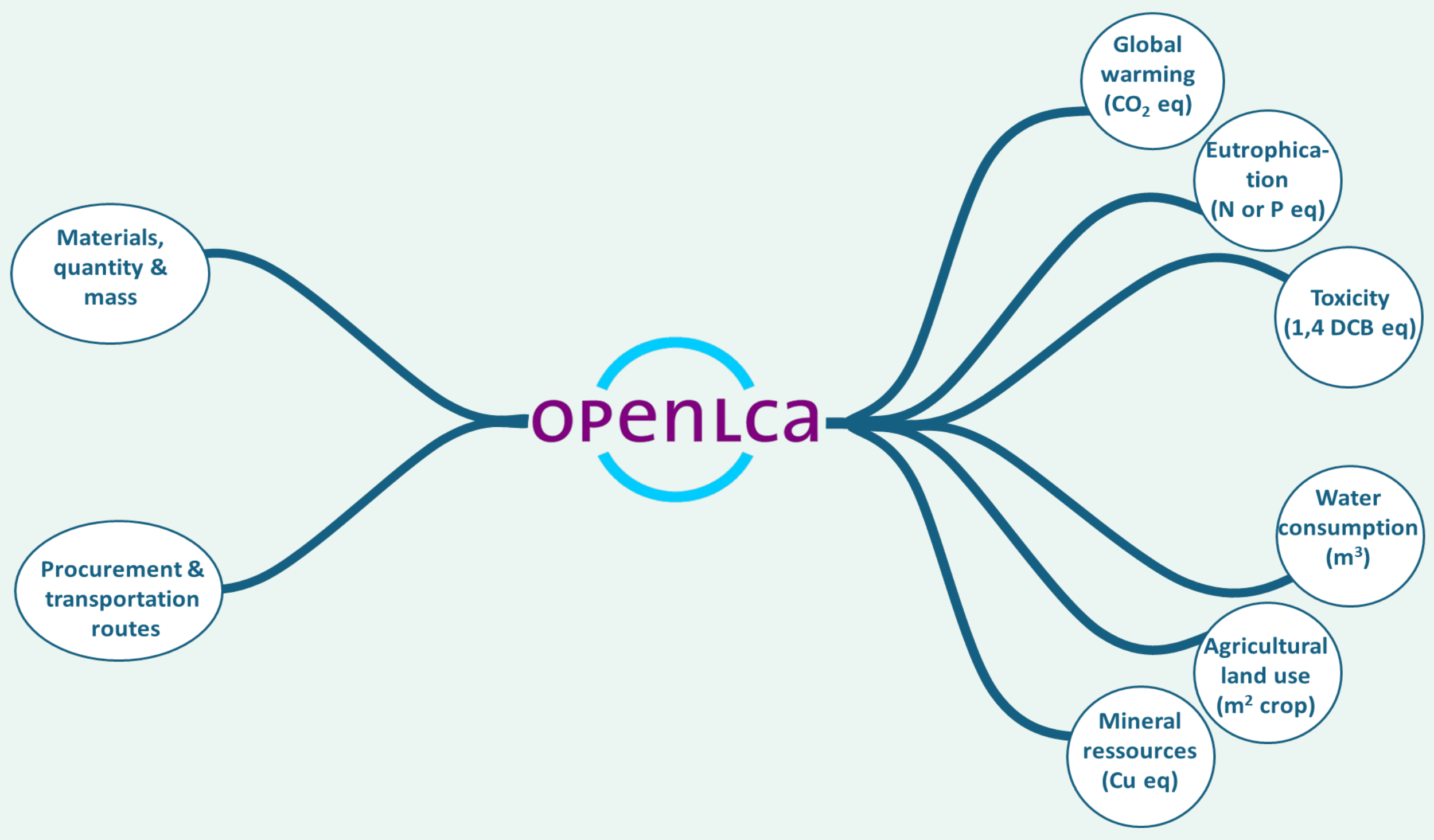


METHODS

Tools

The openLCA software was used to conduct the Life Cycle Assessment (LCA) of the FLS, focusing on its environmental impact. The methodology involves the development of a detailed nomenclature for materials and their respective mass, as well as the creation of a logistic chain that accounts for procurement and transportation routes. Data was collected to build a robust database, allowing for accurate modelling of the system's life cycle and its associated environmental impacts.

The analysis covers various environmental indicators, with a particular focus on Global Warming Potential (GWP), expressed in Carbon dioxide (CO_2) equivalent (CO_2eq) emissions.



Optimisation of maritime operations impact

It was identified that maritime operations (commissioning and decommissioning) are the most significant contributor to the FLS carbon footprint. Following this analysis, a custom computation tool was developped to refine the GWP of the maritime operations.

The characteristics of typical vessels used in these maritime operations, workboats or tugboats, were analysed, with specific attention to fuel consumption and subsequent calculation of CO_2 emissions.

For the sake of the analysis, the workboats used in Northern and Western Europe were considered. Thus, three carbon footprint scenarios — standard, low and high carbon — were analysed to compare the impact of different vessel operation strategies on CO_2 emissions.

Parameters such as vessel speed and distance were used to compute fuel consumption.

Carbon footprint case	Vessel type LLWW[1]	Mobilisation distance [NM]	Distance to port [NM]	Towing speed [kt]	Cruising[2] speed [kt]
Low	Workboat 2711	20	20	4	6
Standard	Workboat 2711	20	20	5	8
High	Workboat 3544	20	20	5	8

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[1] LLWW vessel length and width

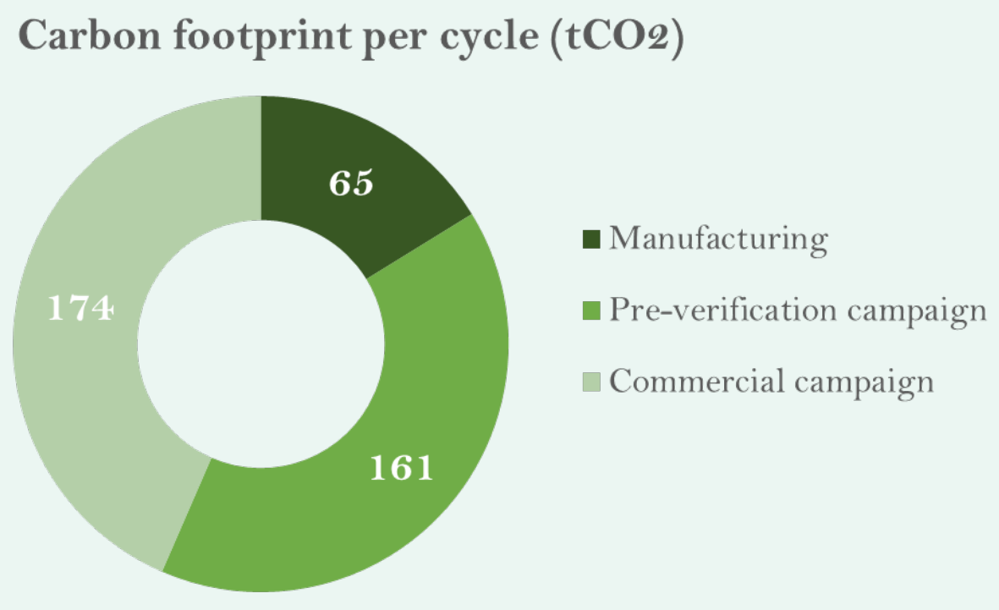
[2] Vessel speed without towing

RESULTS

Environmental impact - GWP

The manufacturing phase of the FLS, covering components like the floater, electronics, structure, and mooring, was evaluated for its carbon footprint.

The analysis extended through the entire life cycle of the system, including the pre-verification campaign, refurbishment and eventual End-Of-Life (EOL) management.



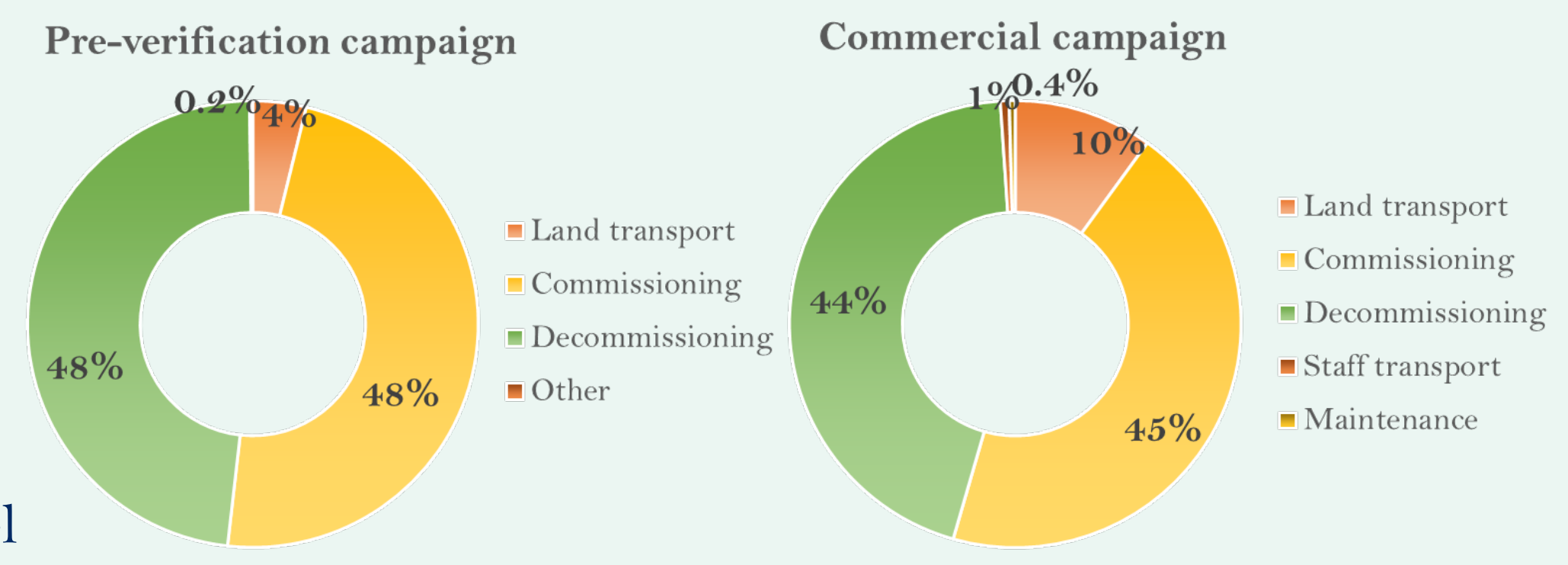
The manufacturing impact (65 tCO_2) is equivalent to

298,713 km by thermal vehicle	251,373 km by short-haul flight	757 smartphones

Source - Impact CO_2 by ADEME

The study identifies that maritime operations are responsible for 77% (309 tCO_2) of the total CO_2 emissions.

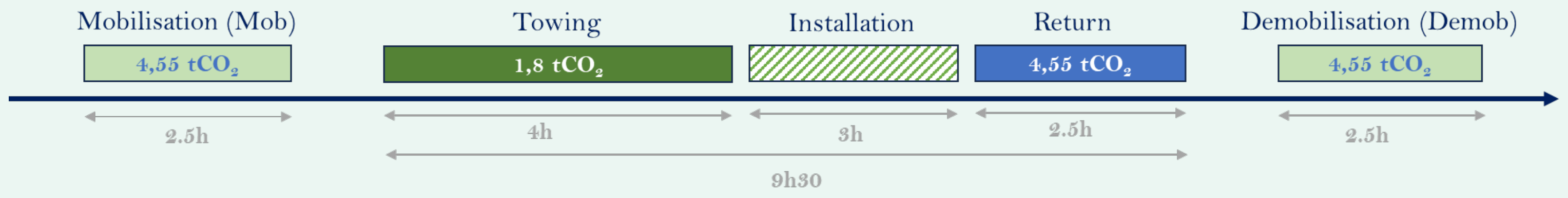
This includes operations related to vessel mobilisation and demobilisation, FLS towing and deployment/recovery as well as vessel return. These operations represent either the commissioning or the decommissioning of the FLS.



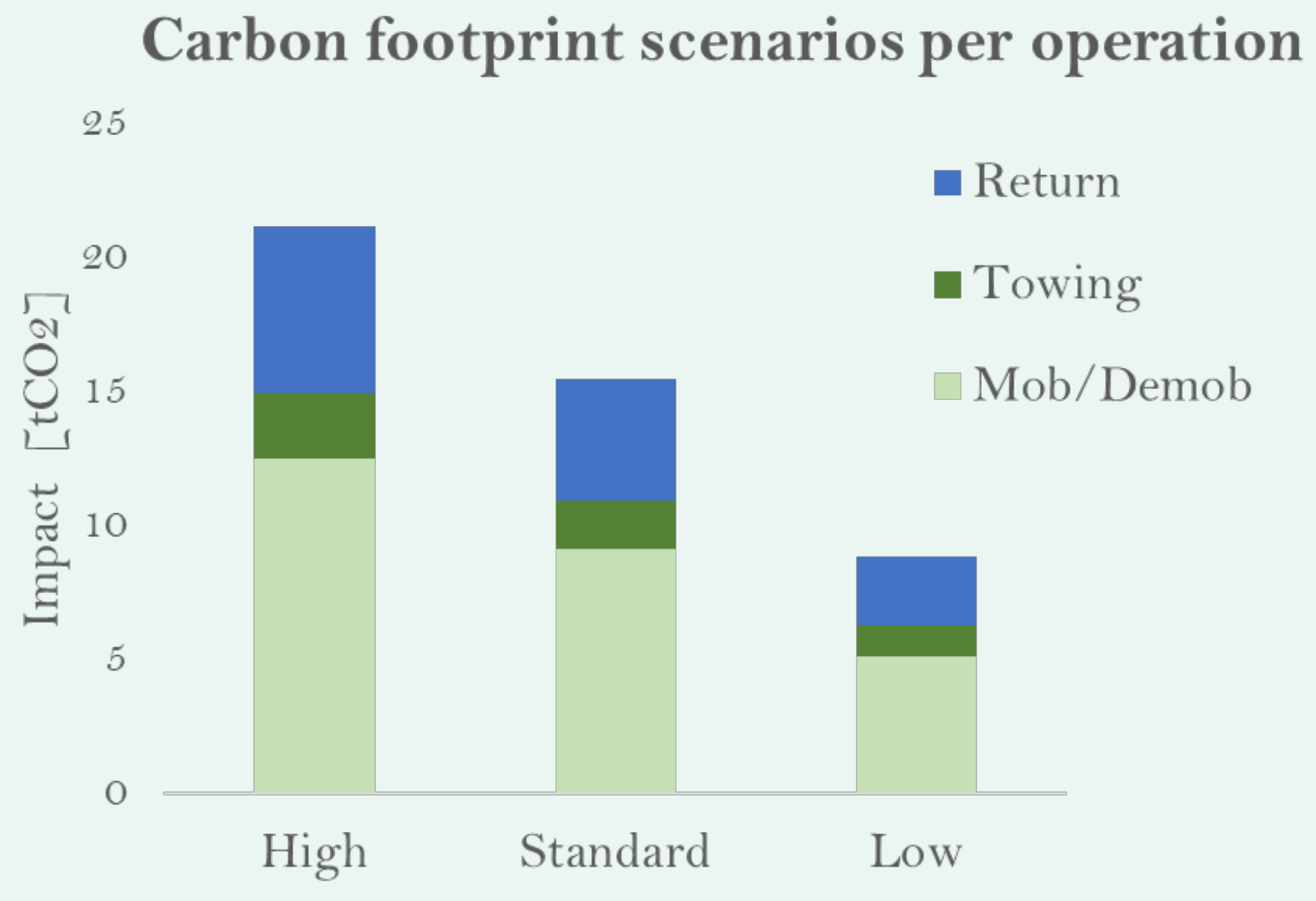
Optimisation of maritime operations impact

The impact was evaluated for each stage of the operations consisting of vessel mobilisation and demobilisation as well as buoy towing, installation/recovery and vessel return.
The assessment was carried out for the three carbon case scenarios as illustrated on the timeline (example of a standard case and commissioning).

The analysis showed that the impact of the installation/recovery is insignificant.



A key finding of the study is that significant carbon footprint reductions can be achieved by optimizing vessel operations, for instance reducing vessel speed during towing and cruising. Moreover, fuel consumption is not directly related to vessel length or displacement, but mostly depends on engine characteristics and speed.



CONCLUSIONS

This study provides a comprehensive LCA of a Floating LiDAR System, identifying maritime operations as the largest contributor to the system's carbon footprint.

Moreover, the development of a scenario-based calculation methodology offers valuable insight into optimizing maritime logistics to minimize environmental impacts.

Finally, a relatively small reduction of vessel speed (1 to 2 knots) allows to decrease CO_2 emissions by 33% which corresponds to 132 tCO_2eq across the system's life cycle.

PERSPECTIVES

Manufacturing

The current LCA highlights the most impacting components of the production process. Evolutions of the buoy manufacturing will aim to mitigate the environmental impact by either changing the design, materials, or the building process.

GWP reduction and model validation

A tool to compute vessel fuel consumption and CO_2 emissions of maritime operations has been developed and is used by AKROCEAN to design and monitor these operations.

For each operation, vessel and timeline data are logged in the tool then the output is compared to real consumption data. One year of this comparative analysis will allow to:

- Confirm the accuracy of the model
- Validate the impact of the speed reduction on the global CO2 footprint

Once validated, the tool will serve prior to the operations to assess and adjust the impact of each operation. CO_2 footprint being directly linked to fuel consumption, a reduction in fuel consumption has direct environmental as well as economical benefits.