SETAC Europe 26th LCA Symposium: Session 4.07 - Better Data and Modelling for Sustainable Transport

Life Cycle Inventories for Aviation: Background Data, Shortcomings, and Improvements

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DLR

Agenda

- Motivation
- Shortcomings and challenges
- Foreground and background data
- Improvements: Maintenance use-case
- Take-Aways

Motivation
Why Life Cycle Assessment (LCA) in aviation?

Aviation is **responsible for 3.6 %** of the human-induced greenhouse gases (GHGs) emissions

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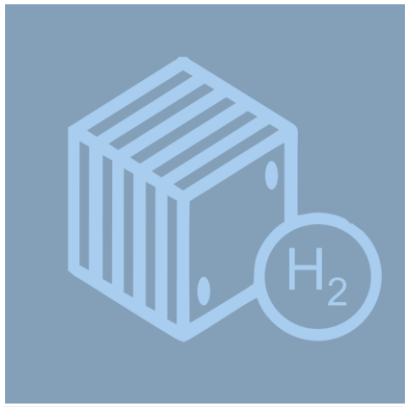

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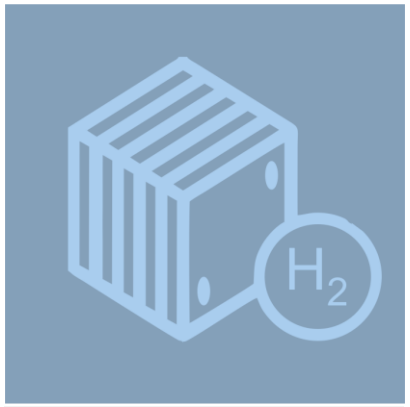

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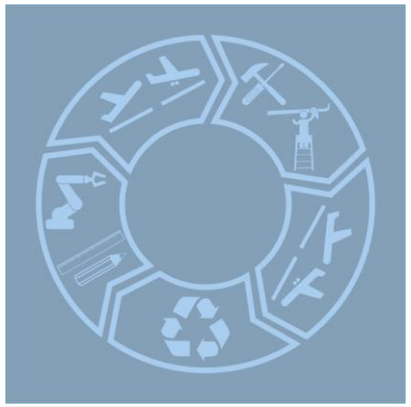

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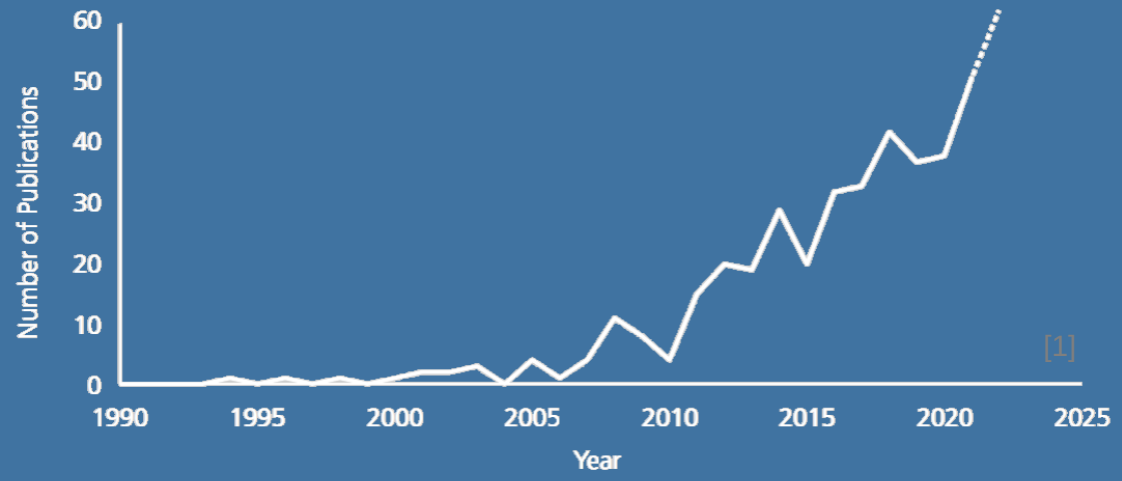

CORSIA
Carbon Offsetting and Reduction Scheme for International Aviation

Federal Ministry for Economic Affairs and Climate Action

[1] Source: Rahn, Antonia (2021) Life Cycle Assessment Methodologies for Aircraft Maintenance. DLR-Internal.

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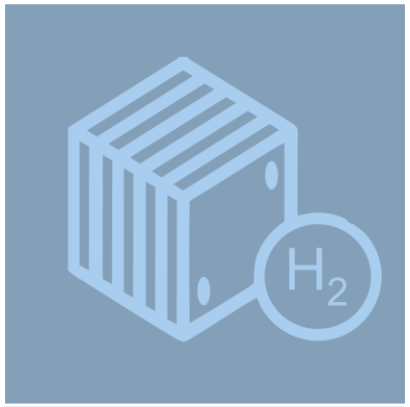

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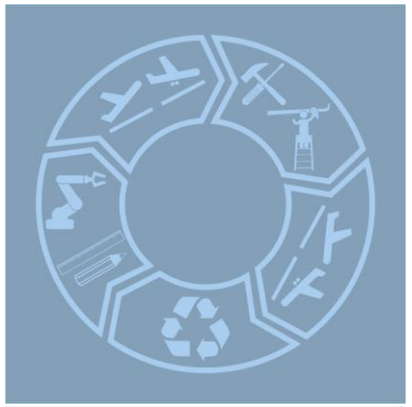

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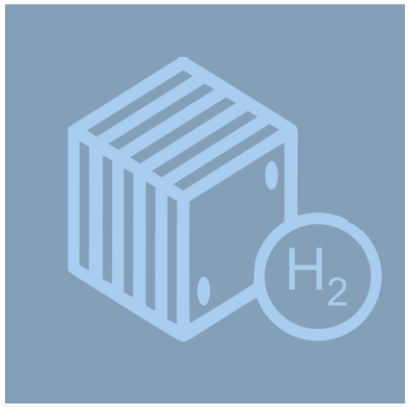

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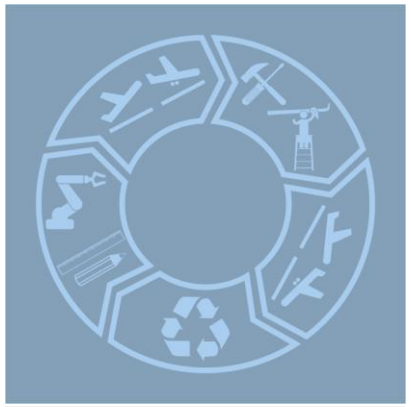

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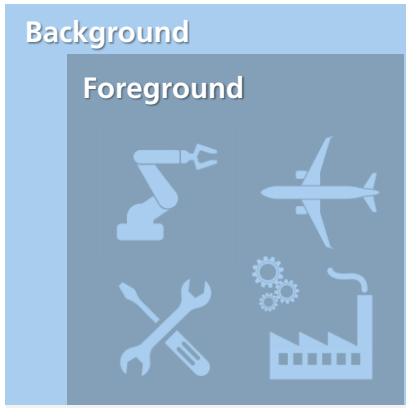

Sector-specific **LCI data are often lacking**, which hinders LCA conduction

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Shortcomings and challenges
LCI data gaps

"The inventory data for carbon fiber manufacturing [for aircraft] are not well defined in any LCI database." (Calado et al., 2019)

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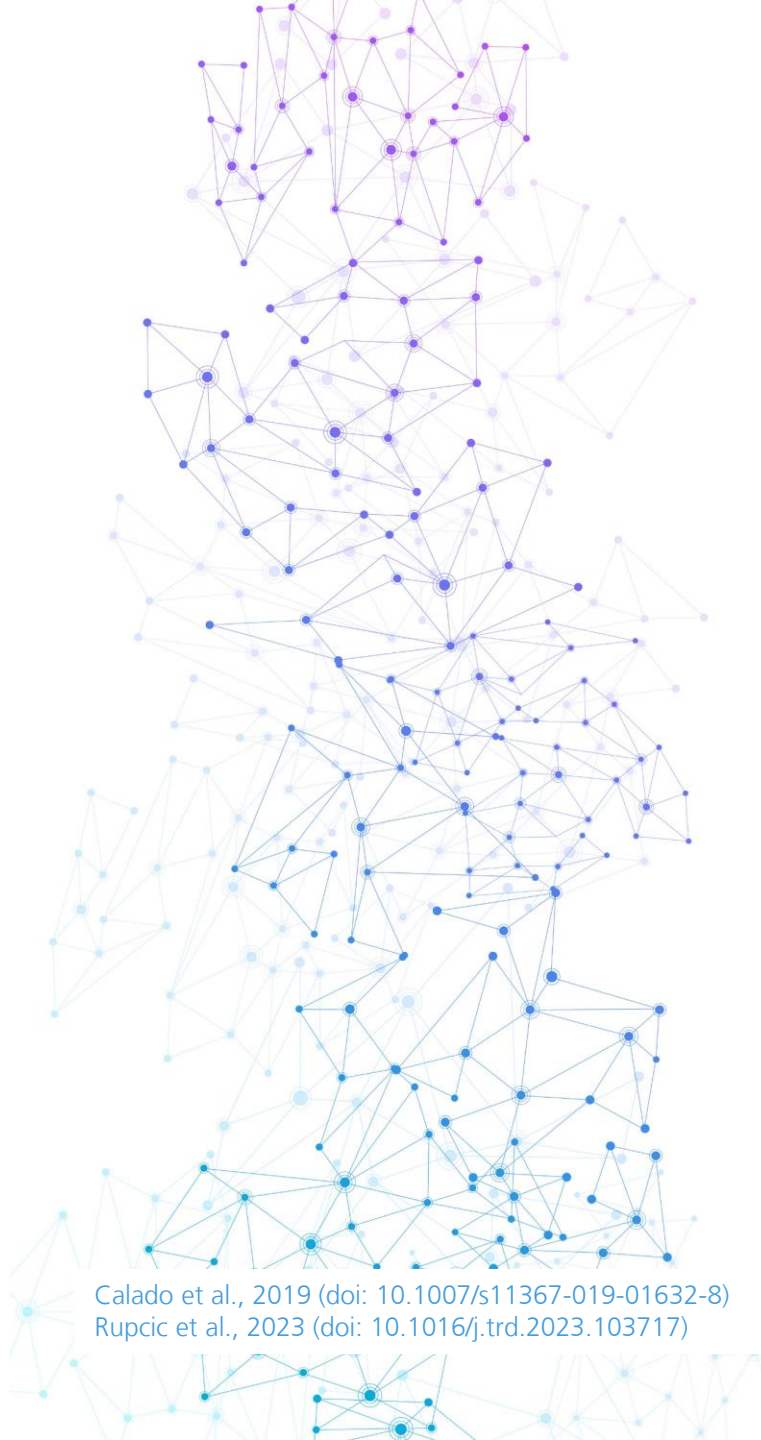

Calado et al., 2019 (doi: 10.1007/s11367-019-01632-8)
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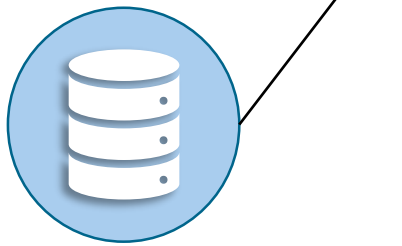

Emerging environmental awareness

- LCA is a new discipline in aviation
- Initial stage compared to sectors such as energy production

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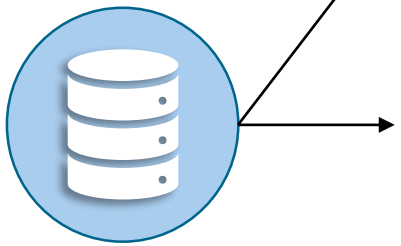

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Extensive data collection

- Not clear for suppliers what data is necessary
- Economic KPIs* differ from ecologically-driven parameters

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[*] Key Performance Indicators

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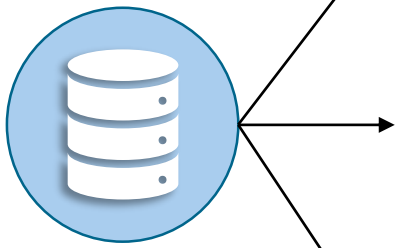

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Primary, granular data

- Digital Product Passport (DPP): enables data traceability in highly complex supply chains

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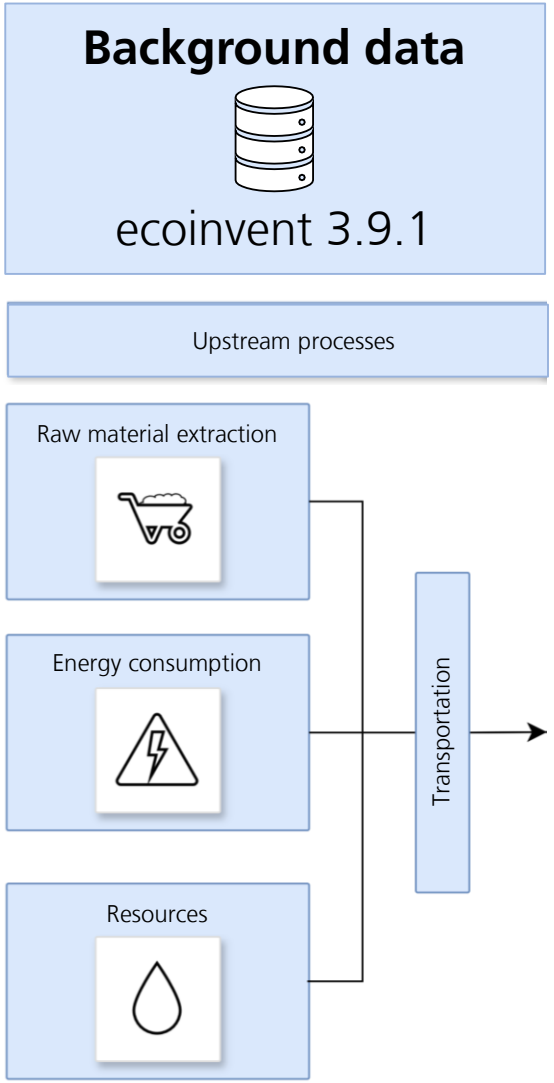

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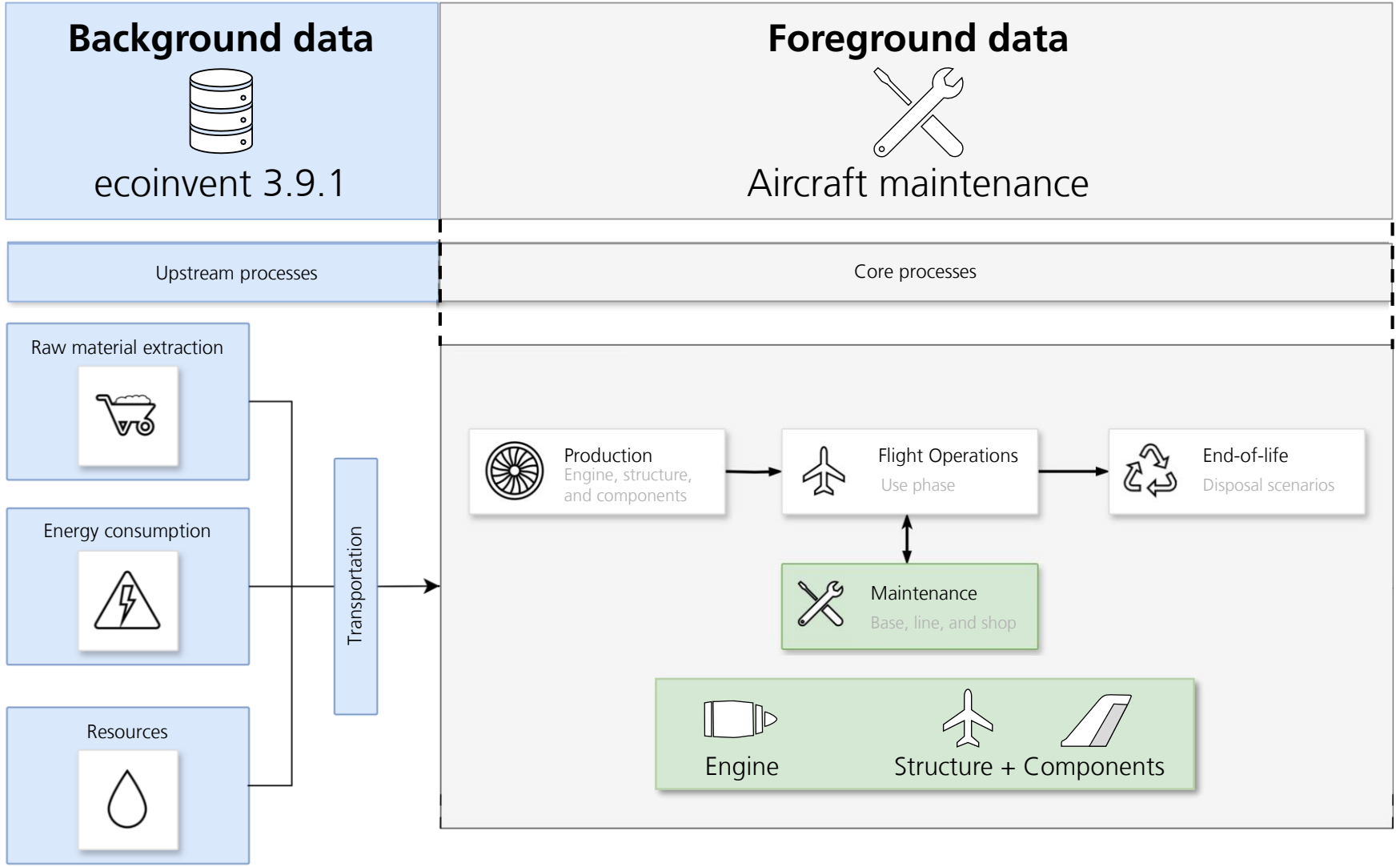

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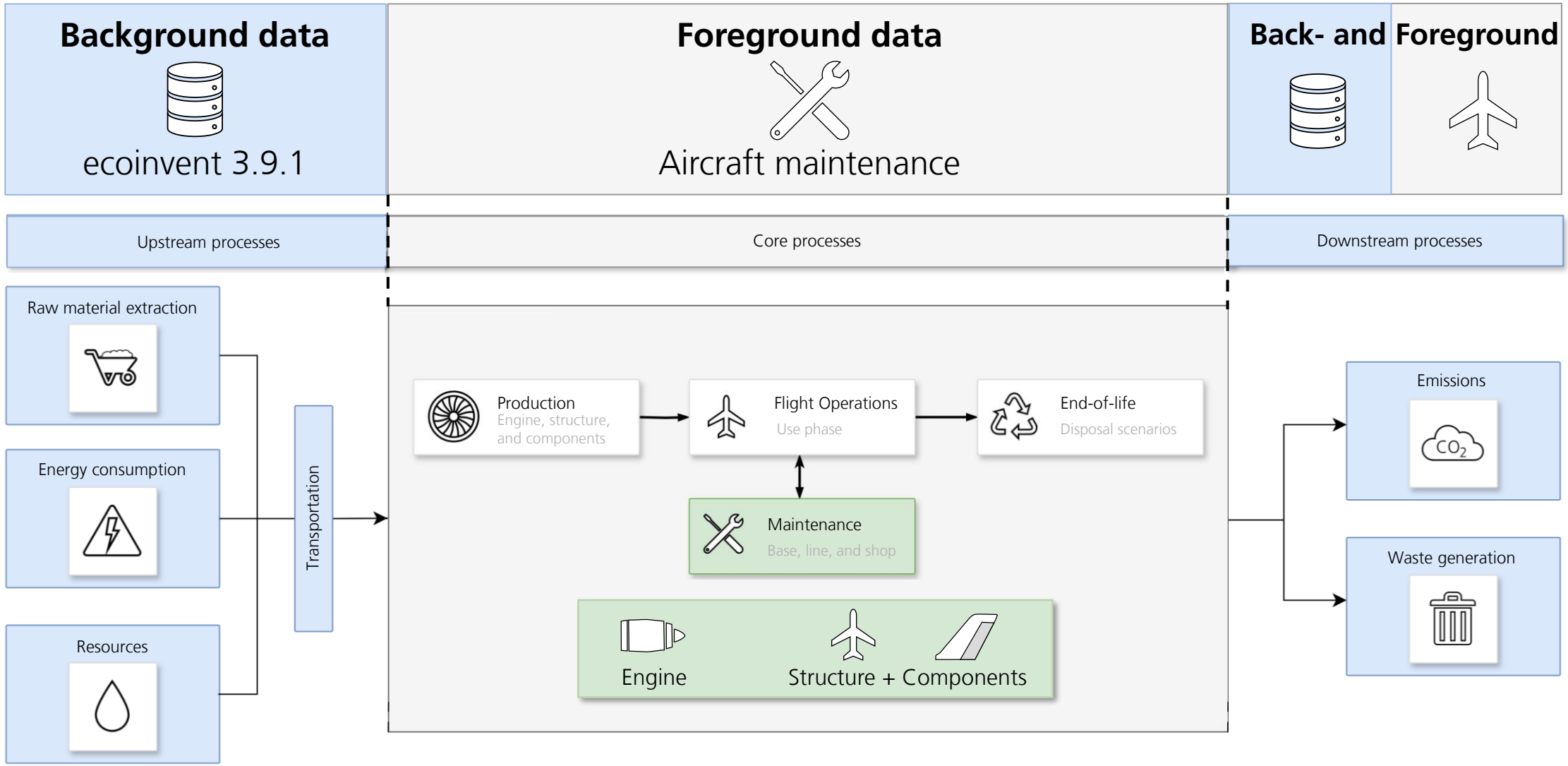

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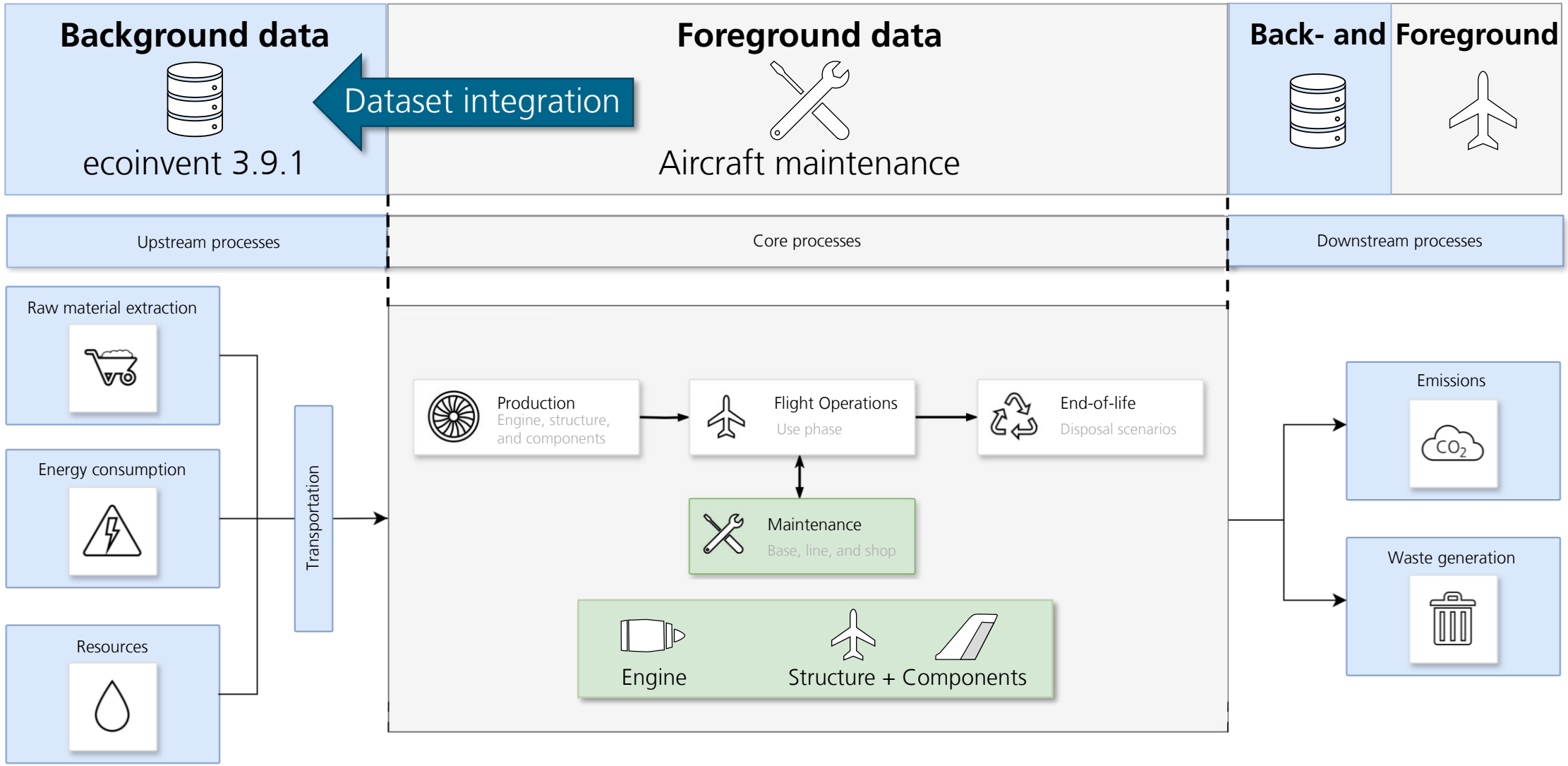

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Improvements: Maintenance use-case

Translating foreground to background data

Background data

ecoinvent 3.9.1

Foreground data

Aircraft maintenance

Germany

Europe

Structure + Components

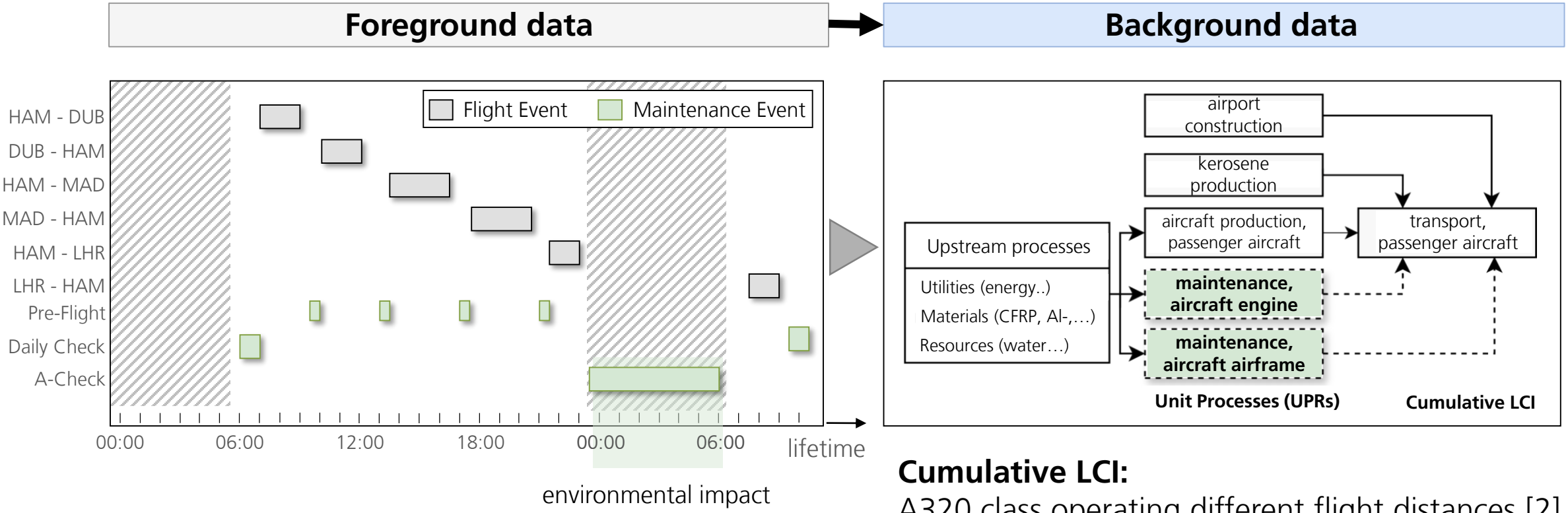
Line		A-Check: 450 FH
Base		C-Check: 5000 FH
		D-Check: 6 years
Shop		APU shop: 7000 FH
		Landing gear shop: 10 years

Engine

Shop		Engine shop visit: 9000 FH
Life Limited Part (LLP)	1 FC	Fan: 30000 FC Compressor: 20000 FC Turbine: 20000-25000 FC

FH: Flight Hour, FC: Flight Cycle

Improvements: Maintenance use-case
LCI dataset for aircraft maintenance



Aircraft life cycle:

- DLR's discrete-event simulation tool LYFE [1]
- based on flight schedules and maintenance intervals

Cumulative LCI:

A320 class operating different flight distances [2]

LCIA Method:
EF 3.0

Background database:
ecoinvent 3.9.1

[1] Pohya, A.A., Wehrspohn, J., Meissner, R., Wicke, K., 2021. A modular framework for the life cycle based evaluation of aircraft technologies, maintenance strategies, and operational decision making using discrete event simulation. Aerospace 8. doi.org/10.3390/aerospace8070187.

[2] Rahn, A., Schuch, M., Wicke, K., Sprecher, B., Dransfeld, C., Wende, G., 2024. Beyond flight operations: assessing the environmental impact of aircraft maintenance through life cycle assessment. J. Clean. Prod. 453, 142195. https://doi.org/10.1016/j.jclepro.2024.142195.

Improvements: Maintenance use-case
LCI dataset for aircraft maintenance

Functional Unit

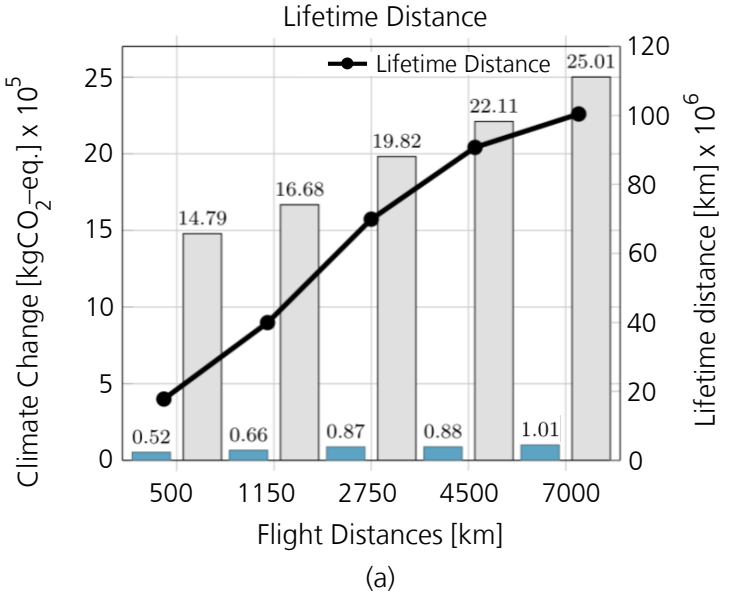
Lifetime distance:
- product of average flight distances and total flight cycles during entire aircraft operation phase
- accumulated impact rises with the average flight distance

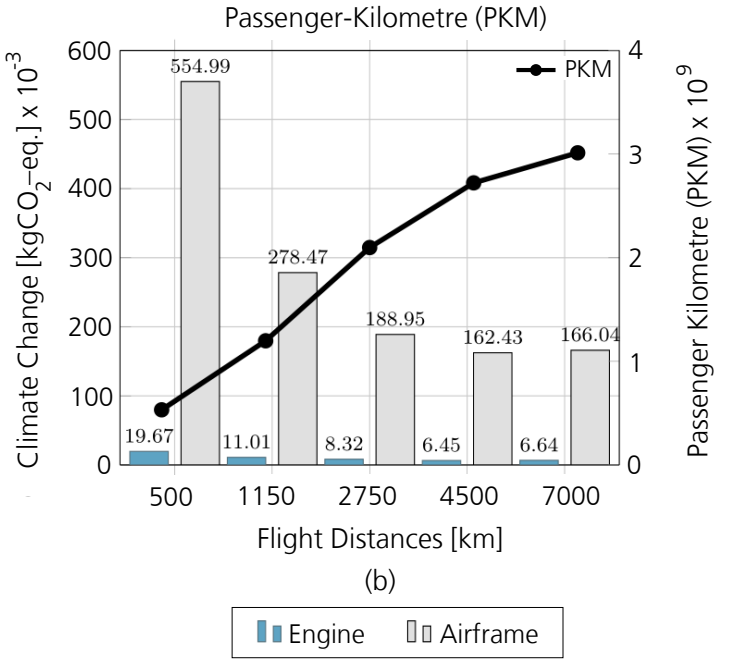
Passenger-Kilometre (PKM):
- higher impact per PKM for shorter flight distances
- connection to UPRs as aircraft and kerosene production

Aggregation Level

Background database:
- maintenance dataset for aircraft operating medium-range flights in Germany
- gate-to-gate UPRs represent average technology description

Sector-specific:
- dataset split for different flight distances for more granular, in-depth inventories
- distinct maintenance demands for each flight distance





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Life cycle inventories for aviation

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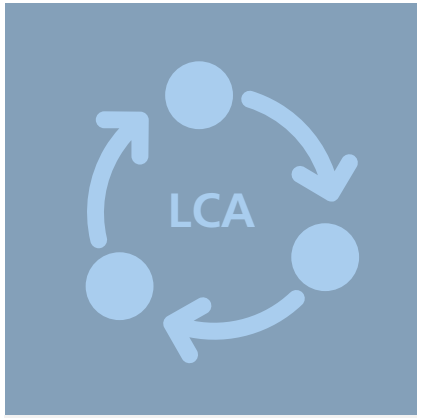

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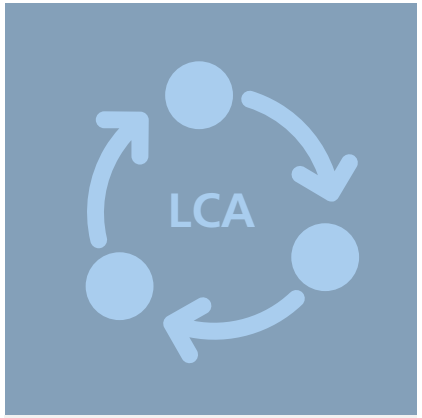

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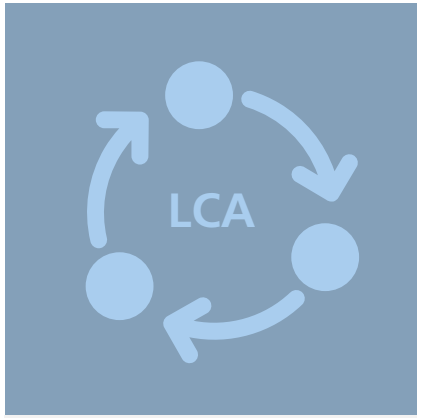

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Aircraft maintenance dataset available in next release: **ecoinvent v3.11** (November 2024)

Thank you for your attention!

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For further details, please refer to our publication in Journal of Cleaner Engineering and Technology: