INNTERESTING

ENVIRONMENTAL, SOCIAL AND ECONOMIC ASSESSMENT OF THE THREE CASE STUDIES

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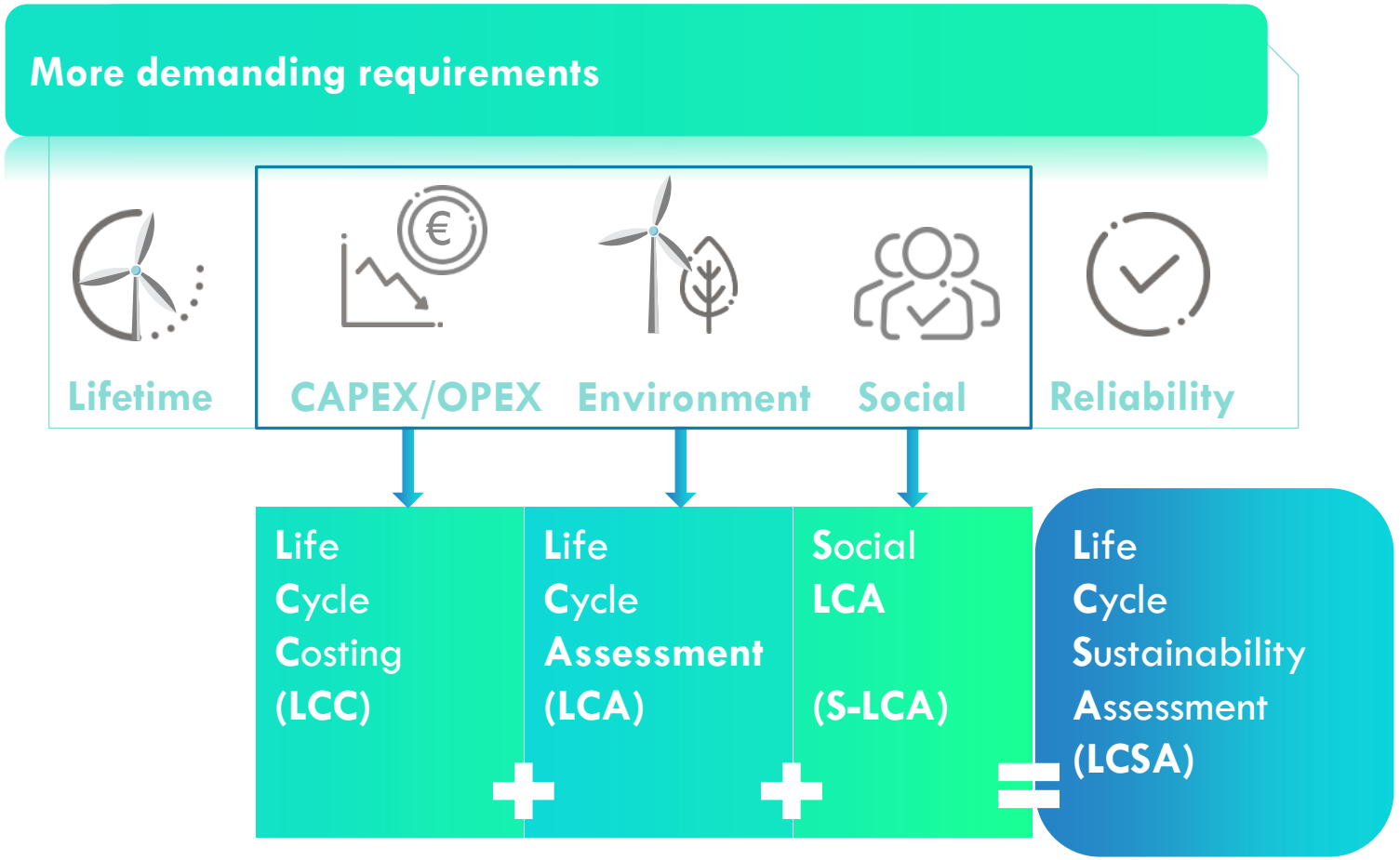
REASON BEHIND AND OBJECTIVE OF THE LIFE CYCLE SUSTAINABILITY ASSESSMENT



- Identify improvement options regarding economic, environmental and social performance of the INNTERESTING case studies and testing methods
- **To reduce environmental and economic impact and to improve social acceptance of the newly developed designs, concepts and testing methods**

METHODOLOGICAL FRAMEWORK LCSA

General main framework

- ISO 14040:2006
- ISO 14044:2006

Environmental LCA

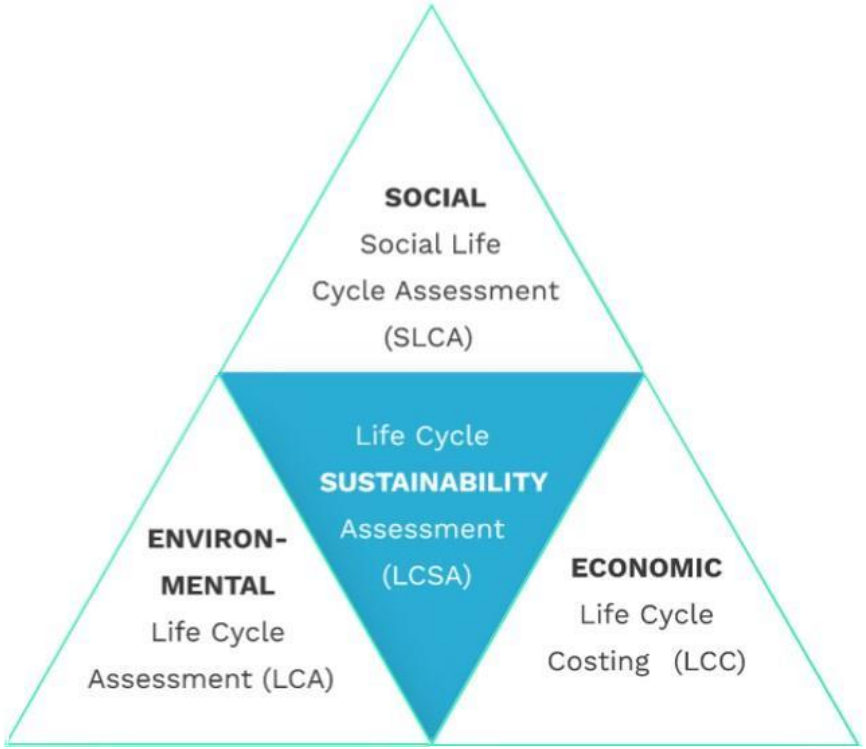
- EN 15804:2012+A2:2019

Socio-economic S-LCA

- UNEP/SETAC Life Cycle Initiative (2009) Guidelines for Social Life Cycle Assessment of Products
  edited by Catherine Benoît and Bernard Mazijn
- UNEP/SETAC Life Cycle Initiative (2020) *Guidelines for Social Life Cycle Assessment of Products and Organizations*
  edited by Catherine Benoît et al.

Economic LCC

- SETAC (2011) *Environmental life-cycle costing: a code of practice*
  by Thomas E. Swarr, David Hunkeler, Walter Klöpffer, Hanna-Leena Pesonen, Andreas Ciroth, Alan C. Brent, Robert Pagan

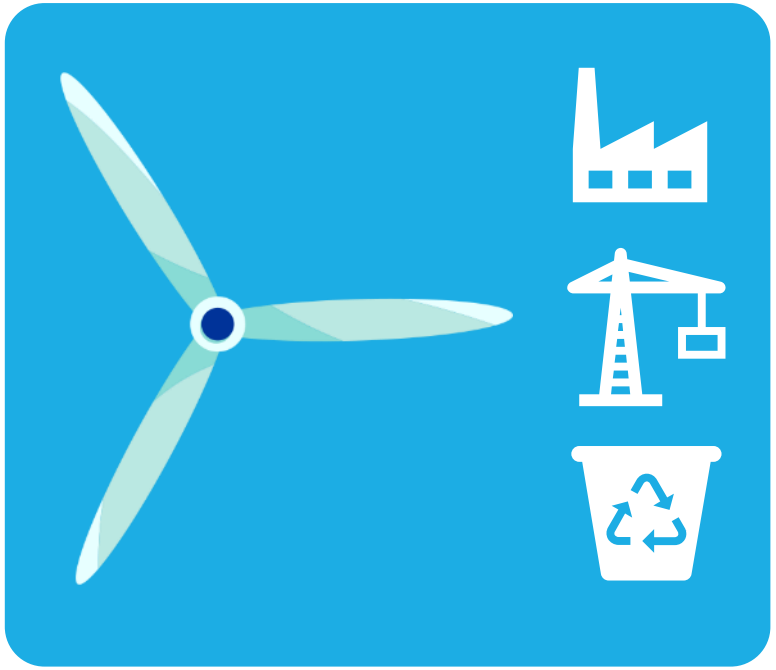


LCSA PERFORMED ITERATIVELY THROUGHOUT THE PROJECT

Assessment steps and resulting indicators

Life Cycle Inventory Analysis

Data collection



LCIA models

Life Cycle Impact Assessment (LCIA)

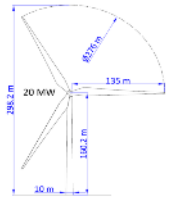
Environmental indicators

Economic indicator €

Social/socio-economic indicators

ASSESSED THREE BUSINESS-AS-USUAL REFERENCE SCENARIOS

One specific reference scenario (RS) per case study



RS1 - 20 MW offshore wind turbine with a service life of 25 years

source generic LCI data: 20 MW common research wind turbine model by T. Ashuri et al. (2016)

RS2 - 10 MW onshore wind turbine with a service life of 20 years

source generic LCI data: DTU 10-MW Reference Wind Turbine by Bak et al. (2013) & 10MW RWT Costs Models v1.02 by Chaviaropoulos (2016)

RS3 - 3.4 MW onshore wind turbine with a service life of 20 years

source generic LCI data: IEA Wind Task 37 3.4-MW Land-Based Wind Turbine by Bortolotti et al. (2019)

Report available online www.innterestingproject.eu/downloads/d6-1-report-on-sustainability-assessment-of-bau-reference-situation.pdf

Remark a revision of the BAU scenarios will be included in the final LCSA report in which the testing methods will be included

SCENARIO COMPARATIVE ASSESSMENT RS3 - CS3

2020: start operation of 3.4 MW onshore wind turbine in Burgos (Spain)

2024: one pitch bearing fails due to crack

Business-as-usual
replacement after redesign
6 months downtime
3 replaced bearings

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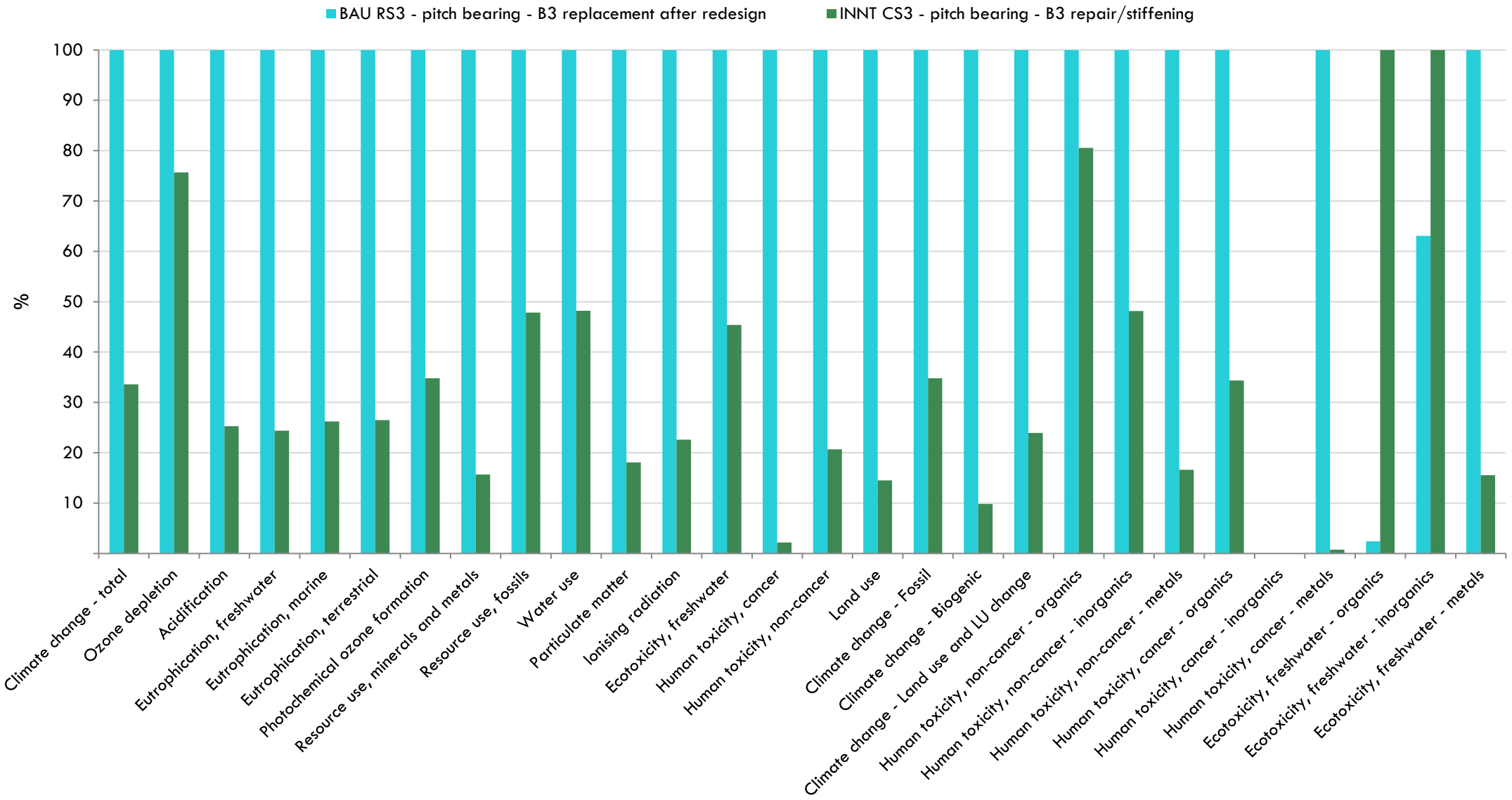
repair & stiffening solution
1.5 months downtime
1 repaired + 2 stiffened bearings

End of 2029: decommissioning of wind turbine

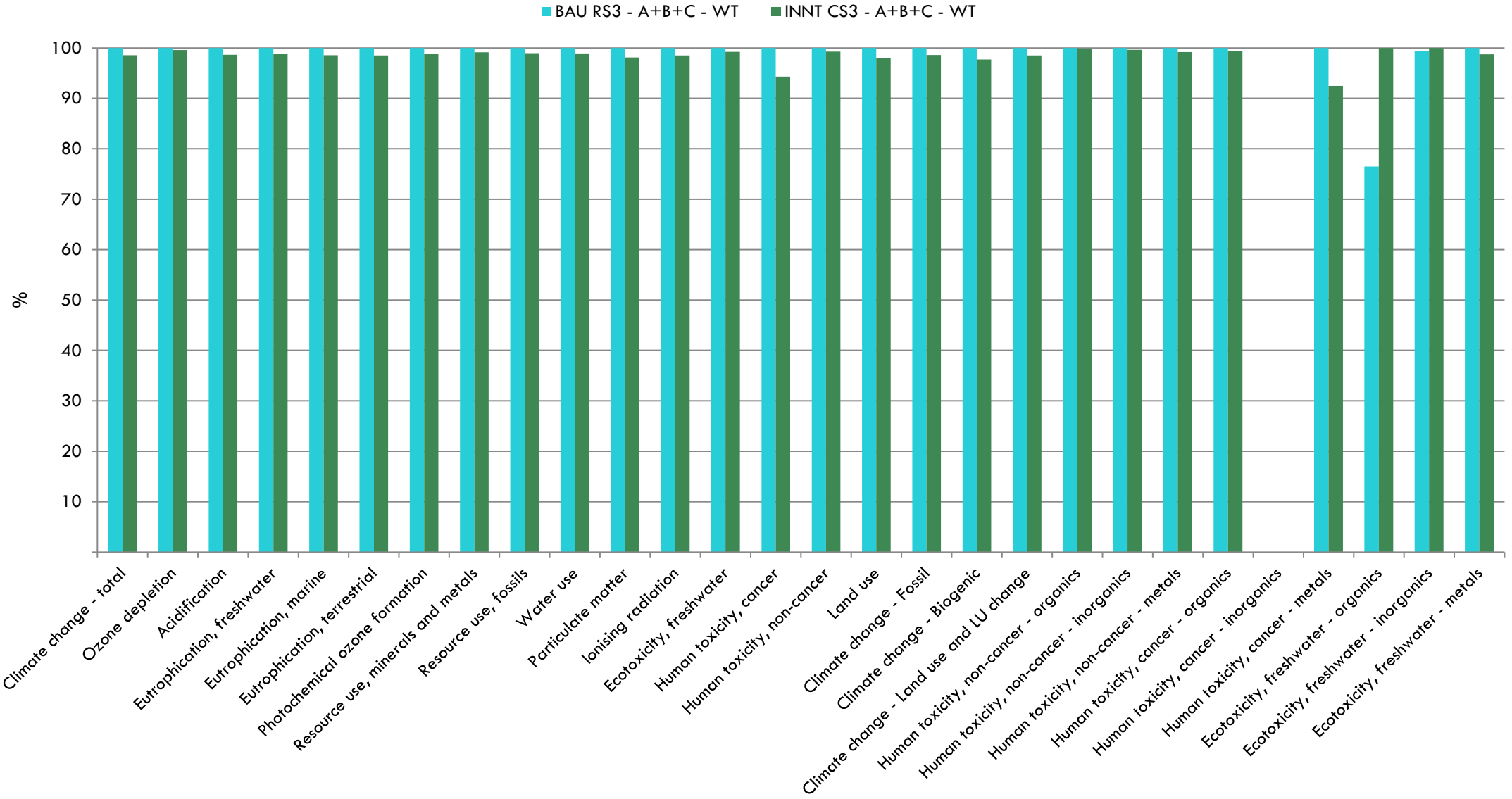
ENVIRONMENTAL LIFE CYCLE ASSESSMENT - RS3 vs CS3 RESULTS

Impacts BAU replacement vs INNTERESTING repair + stiffening



ENVIRONMENTAL LIFE CYCLE ASSESSMENT - RS3 vs CS3 RESULTS 3.4 MW ONSHORE WT

Impacts BAU RS3 vs INNTERESTING CS3 complete WT and over complete lifetime



SOCIAL LIFE CYCLE ASSESSMENT - BACKGROUND

Screening life cycle assessment

- Aim to identify social and socio-economic hotspots in the life cycle of the reference turbines and INNTERESTING solutions
- Method considers 49 social indicators structured in 5 stakeholder groups

Selection of most important social indicators

- Based on materiality assessment and sustainability reports of three main European wind turbine manufacturers and PSILCA (very) high risk levels
  - ➢ focus on Health & Safety (workers) and Fair salary

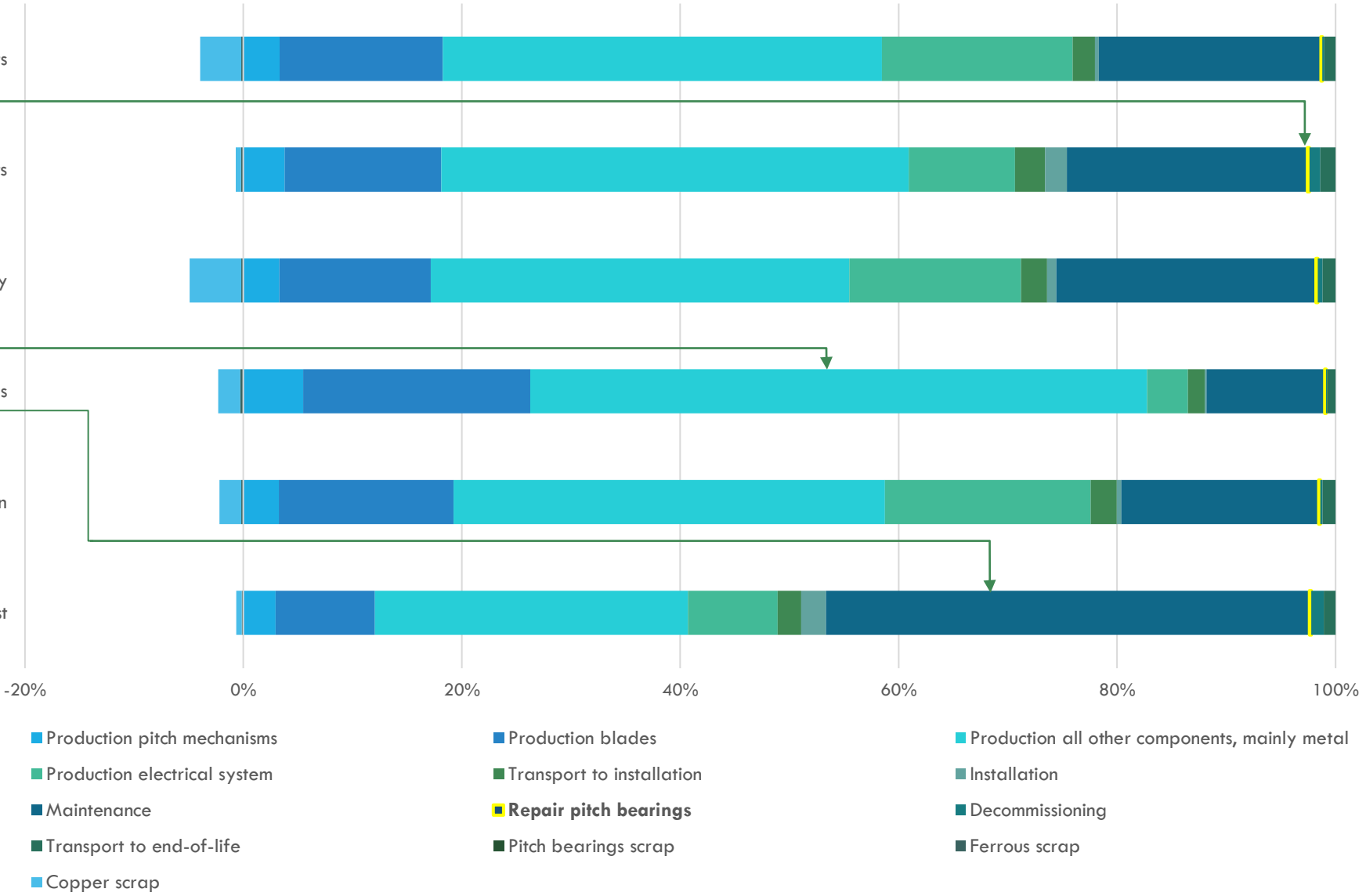
SOCIAL LIFE CYCLE ASSESSMENT - CS3 RESULTS 3.4 MW ONSHORE WT

Impacts over complete lifetime

Repair pitch bearings

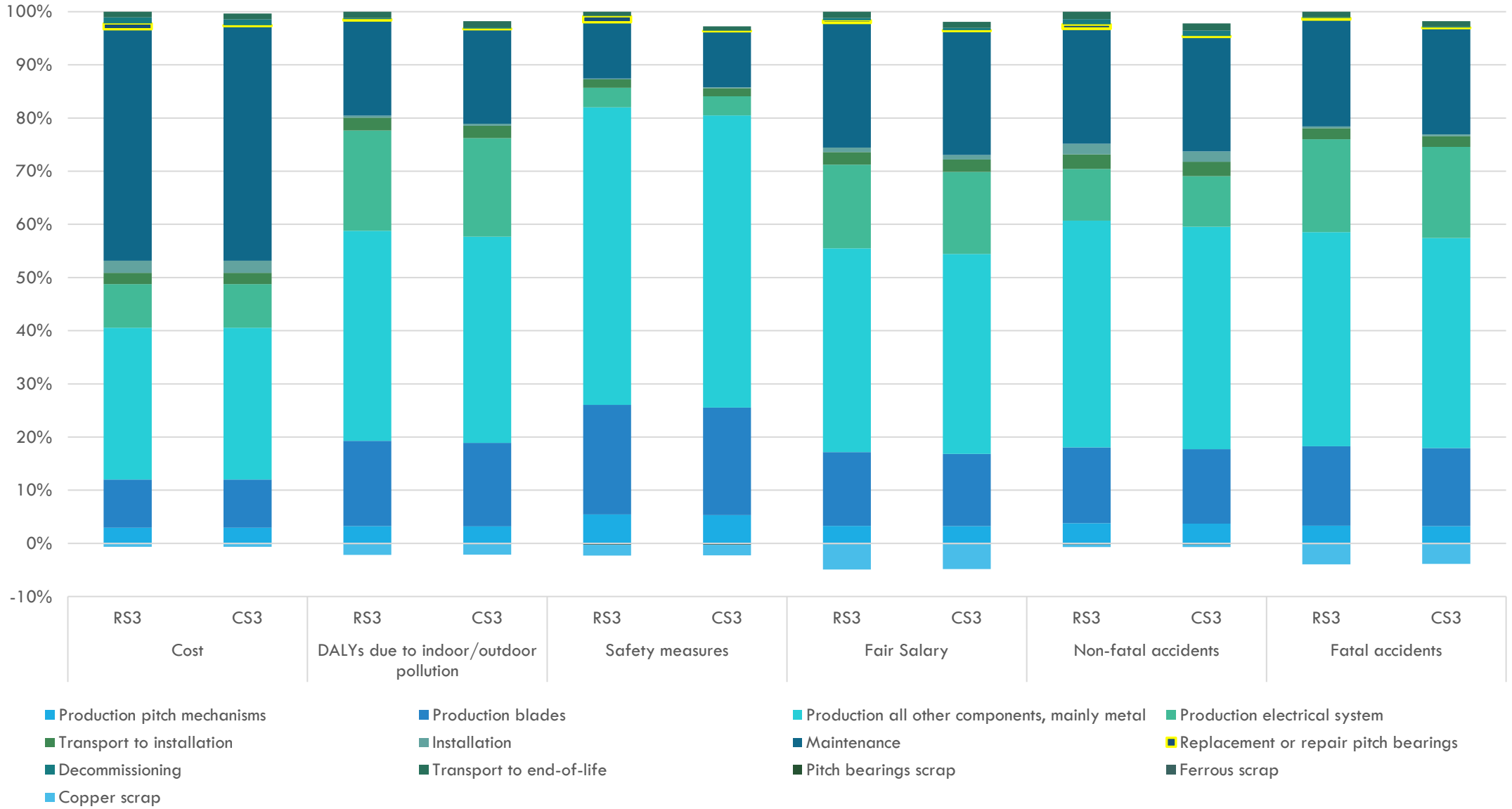
Hot spots:

- All other components
- Maintenance



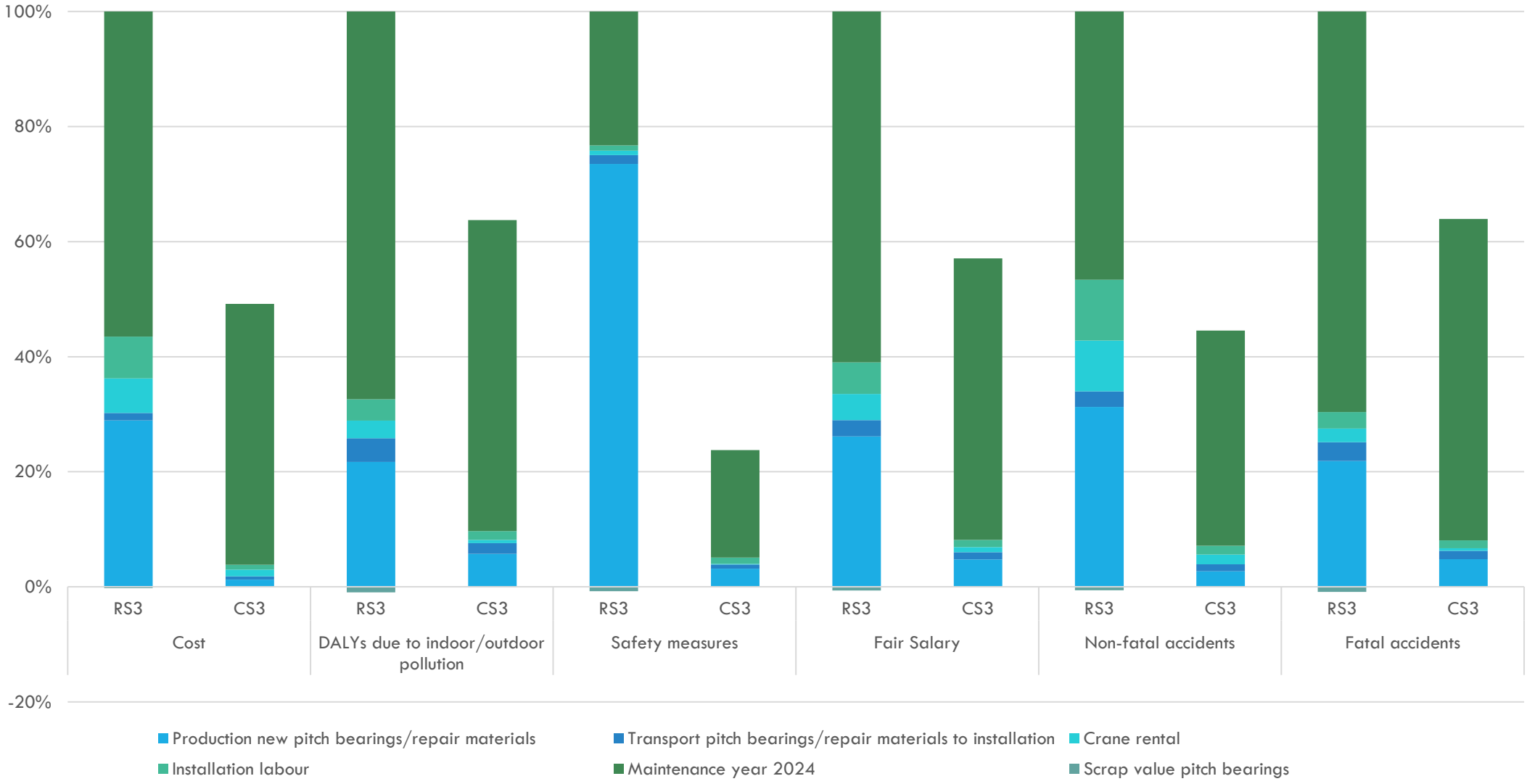
SOCIAL LIFE CYCLE ASSESSMENT - RS3 vs CS3 RESULTS 3.4 MW ONSHORE WT

Impacts over complete lifetime



SOCIAL LIFE CYCLE ASSESSMENT - RS3 vs CS3 RESULTS 3.4 MW ONSHORE WT

Impacts in year 2024 (occurrence of pitch bearing failure)



SOCIAL LIFE CYCLE ASSESSMENT - CONCLUSIONS

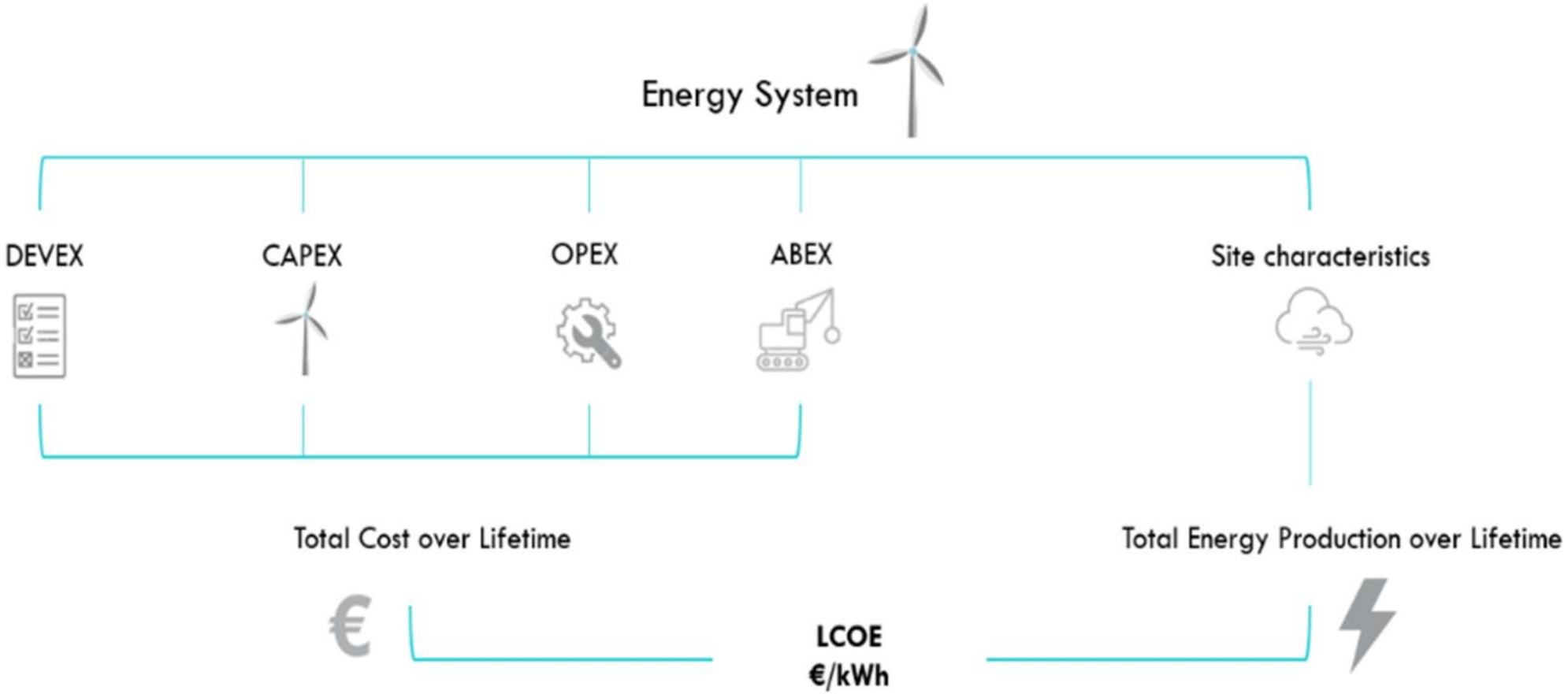
Conclusions CS3

- Hotspots: the production of tower, nacelle, drivetrain and hub (all other components) and maintenance
  - Pitch bearings have only a marginal contribution
- Regarding health and safety, in general, higher risks occur in the metal sector (used as a proxy for tower, nacelle, drivetrain and hub production) compared to the maintenance sector in Spain
- Regarding fair salary, the risk is equal in the metal sector and maintenance sector in Spain

Qualitative assessment CS3

- Repair and stiffening solution imposes less requirements on transport
- Noise pollution is expected to be lower
- Although the solution will reduce the need to produce entirely new pitch bearings, no negative impact on employment is expected

LIFE CYCLE COSTING - LEVELIZED COST OF ENERGY



DEVEX - Development Expenditures
CAPEX - Capital Expenditures
OPEX - Operational Expenditures
ABEX - Abandonment Expenditures

LIFE CYCLE COSTING - POTENTIAL OF INNTERESTING SOLUTIONS

INNTERESTING solutions have an important potential in reducing the LCOE driven by a decrease in

- production losses (due to reduction in downtime)
- investment costs (initial material costs & replacements)
- operational costs (maintenance & repair)
- transport & logistics costs

LIFE CYCLE COSTING - CS3 RESULTS 3.4 MW ONSHORE WT

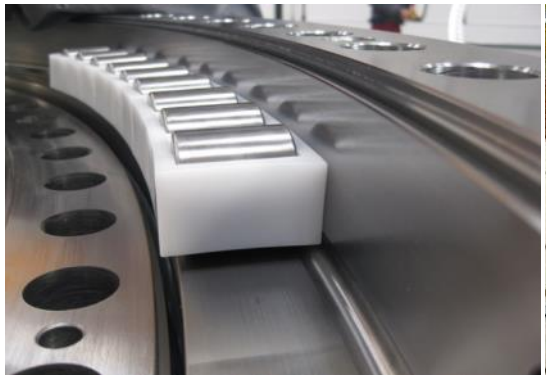
Estimated impacts in year 2024 (occurrence of pitch bearing failure) compared to RS3

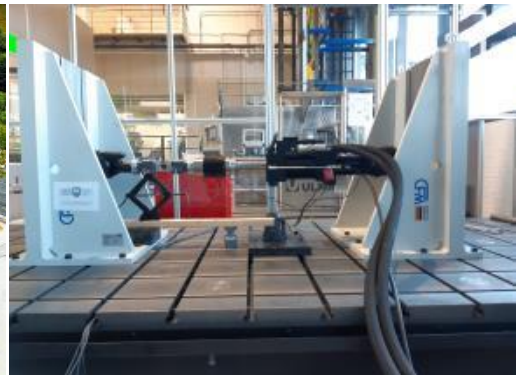
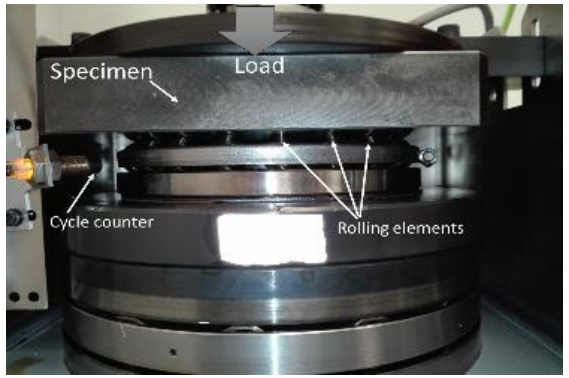
- increase in energy production + 2 680 MWh
- decrease in material & (dis)assembly costs - 60 kEUR
- decreased engineering costs < -1 kEUR
- vs. higher variable O&M (due to lower down-time) + 36 kEUR
- vs. revenues of scrap steel for RS3 < +1kEUR

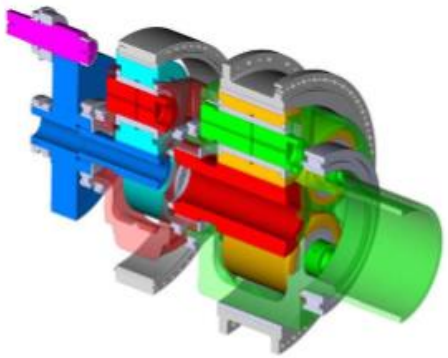
- On the long run: potential lifetime extension, lower risks of failure, and more knowledge

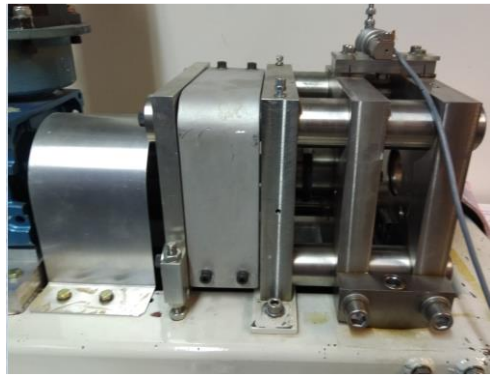
NEXT STEPS LCSA

Complete LCIA of CS1, CS2 and the testing methods



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THANK YOU!

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