Life Cycle Assessment of Composites Additive Manufacturing using Recycled Materials

Konstantina-Roxani Chatzipanagiotou[1], Despoina Antypa[1], Panagiotis Zouboulis[2], Anna Karatza[2], Krzysztof Pikoń[3], Magdalena Bogacka[3], Szymon Sobek[3], Sebastian Werle[3], Eleftherios Amanatides[4], Dimitrios Mataras[4], Elias P. Koumoulos[1]

1 Innovation in Research & Engineering Solutions (IRES), 1780 Wemmel, Belgium
2 BioG3D P.C., Technological & Cultural Park of Lavrion, GR19500 Lavrion, Greece
3 Faculty of Energy and Environmental Engineering, Silesian University of Technology, 44-100, Gliwice, Poland
4 Plasma Technology Laboratory, Department of Chemical Engineering, University of Patras, GR26504 Patra, Greece

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Additive Manufacturing (AM): Environmental Perspective

Less input material required; less waste material generated

Interesting applications for aircraft, naval and automotive components

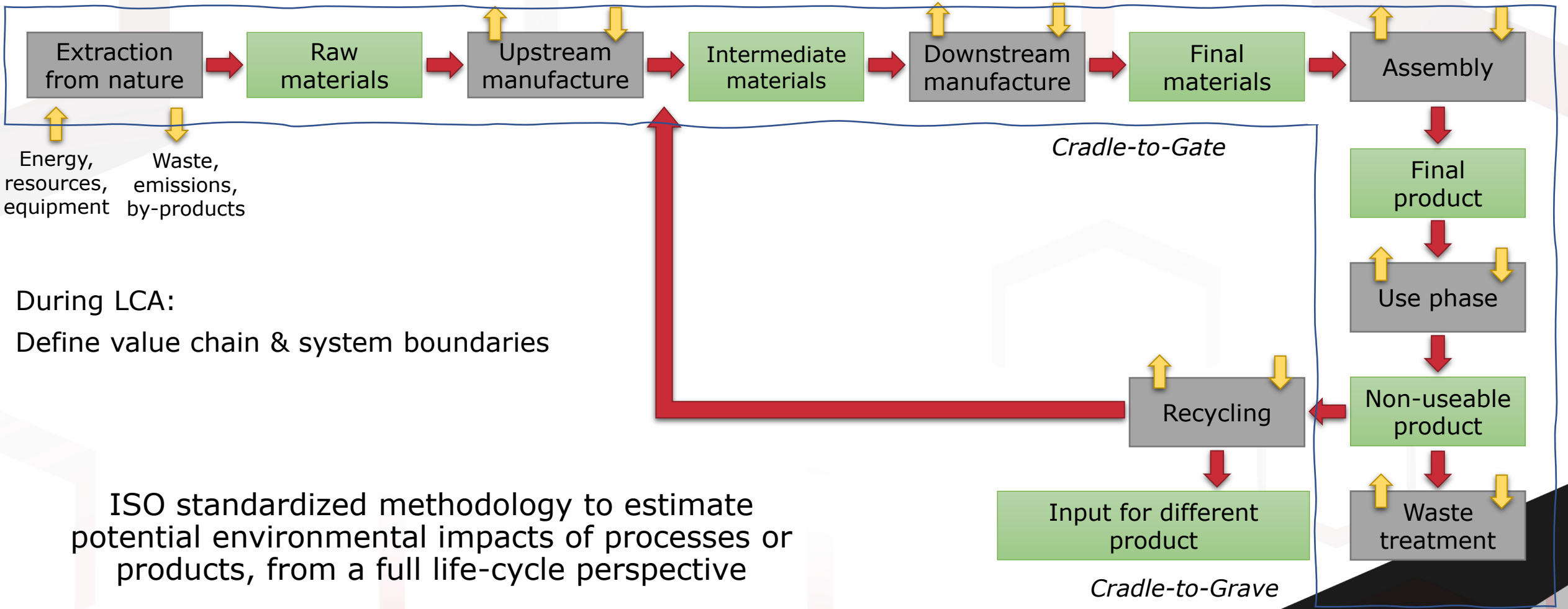
This presentation: AM of carbon fiber-reinforced thermoplastic composites

Technology: fused filament fabrication (FFF) 3D printing

Source of carbon fibers: virgin and recycled

Objective: analyze the environmental impacts of composites, using different composition scenarios, and different product functionality scenarios

Life Cycle Analysis (LCA)

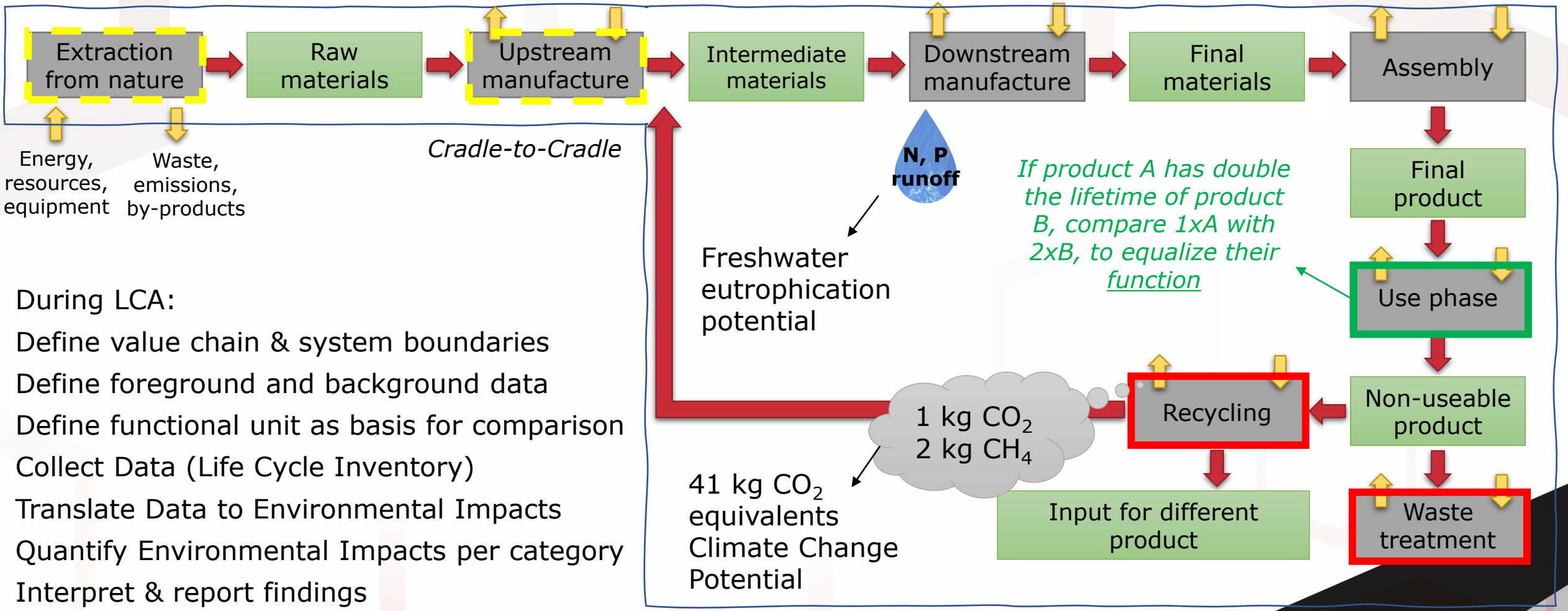


During LCA:

Define value chain & system boundaries

ISO standardized methodology to estimate potential environmental impacts of processes or products, from a full life-cycle perspective

Life Cycle Analysis (LCA)



During LCA:

Define value chain & system boundaries

Define foreground and background data

Define functional unit as basis for comparison

Collect Data (Life Cycle Inventory)

Translate Data to Environmental Impacts

Quantify Environmental Impacts per category

Interpret & report findings

Case Study & Methodology

- Wider context: EuReComp (*GA 101058089*)

R6 strategy (**R**euse, **R**epair, **R**efurbish, **R**emanufacture, **R**epurpose and **R**ecycle)
Various sources of composites (aerospace, aeronautics, automotive, wind energy)
Interdisciplinary approach (market, logistics, technology, advanced modelling, sustainability, cost, risk)
Multiple scales (lab, pilot, demonstrator)
Open and Closed-Loop Recycling

- Today's presentation: Closed-loop recycling of chopped carbon fibers via solvolysis, compare virgin and recycled fibers for AM with 15% wt. carbon fiber content, not considering polymer re-use or dismantling process

- Composition of products: 3 scenarios

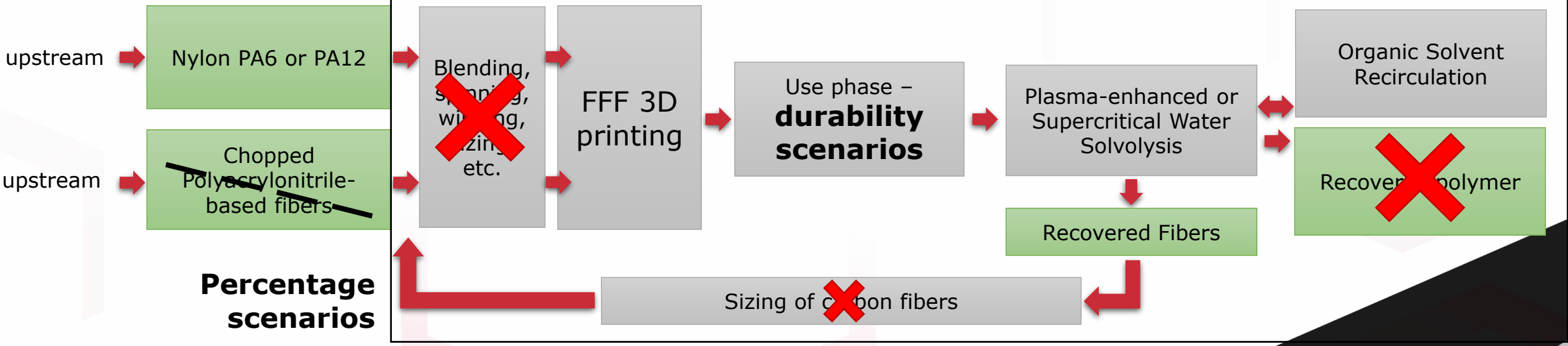
100% virgin fibers; 50% virgin fibers; 25% virgin fibers

- Product functionality/durability: 3 scenarios

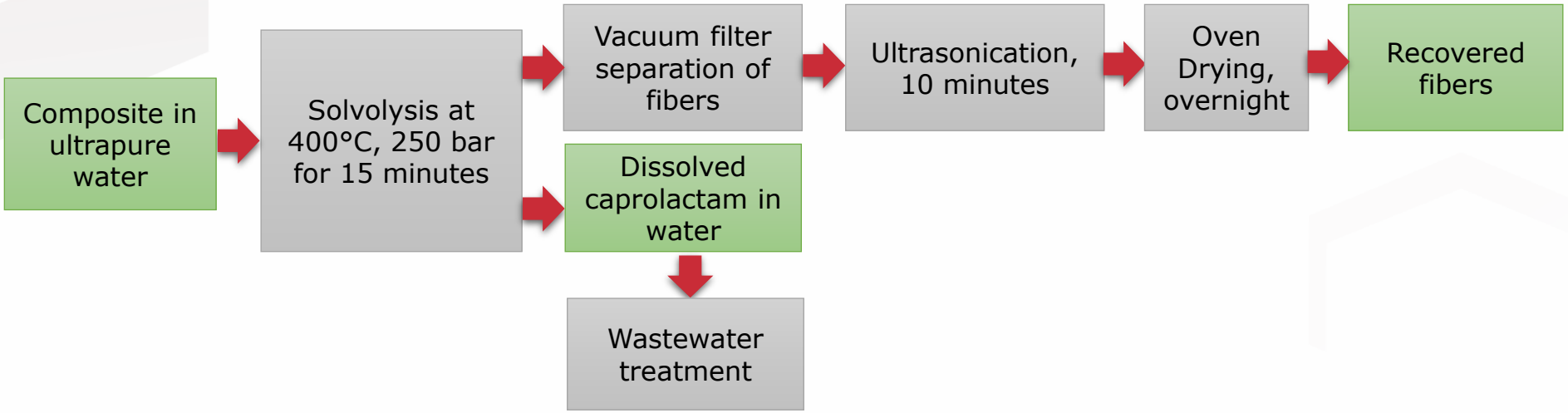
same performance virgin and recycled fibers; 25% loss of functionality after recycling;
50% loss of functionality after recycling

System Boundaries

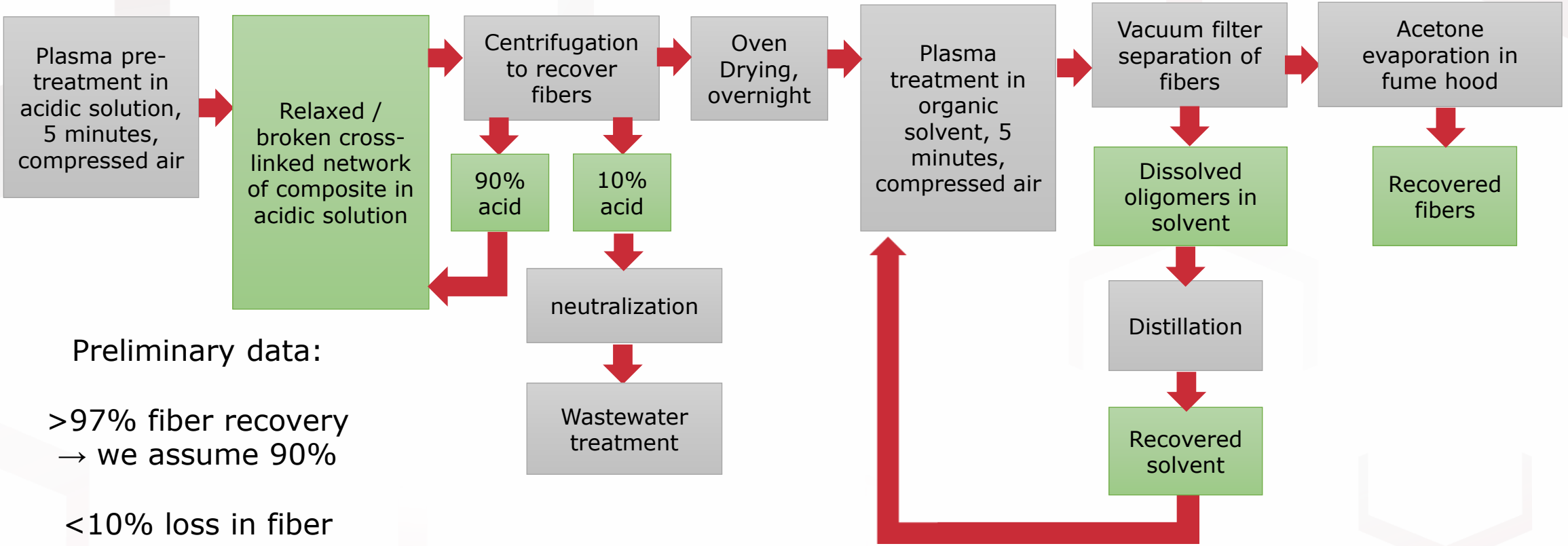
Repeat process multiple times to simulate durability scenarios



Supercritical Water Solvolysis



Plasma-enhanced Solvolysis

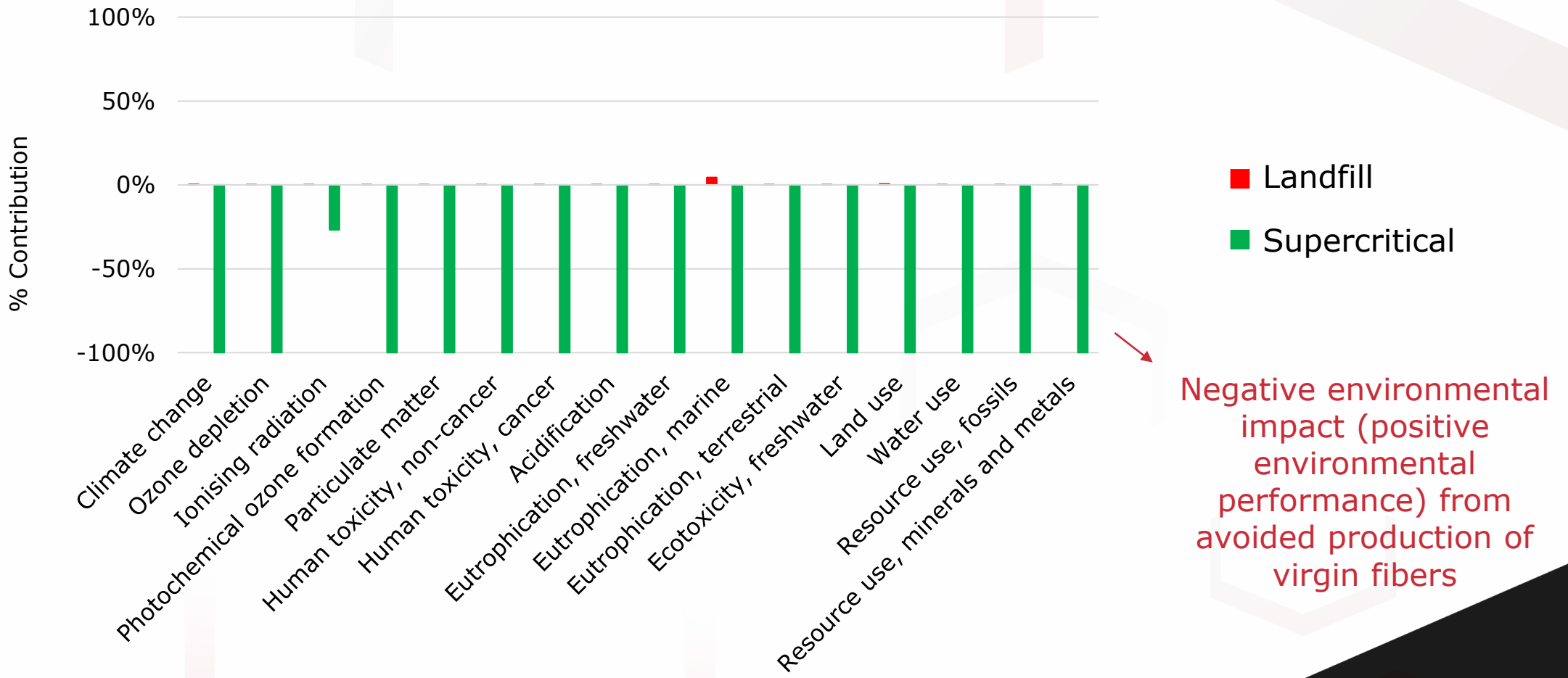


Preliminary data:

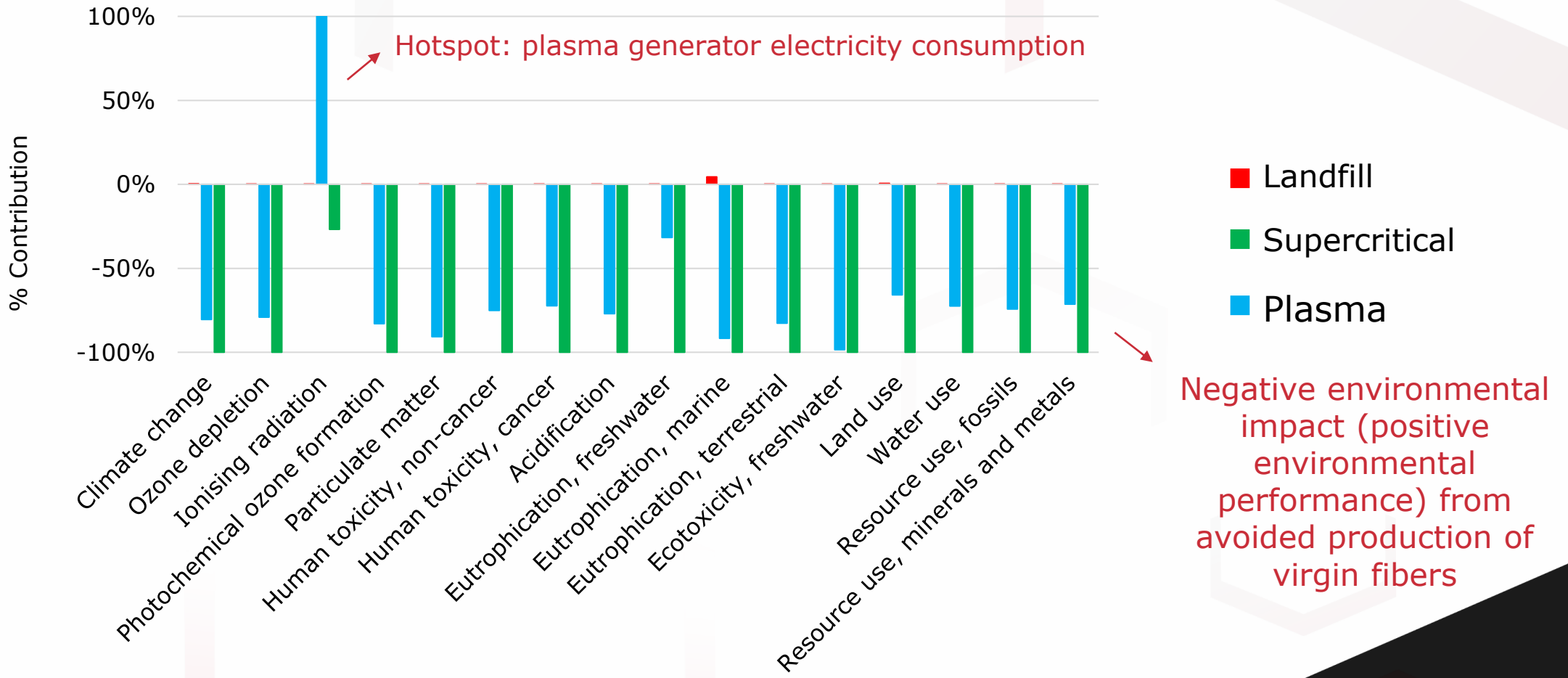
>97% fiber recovery
→ we assume 90%

<10% loss in fiber mechanical properties
→ we model 3 scenarios

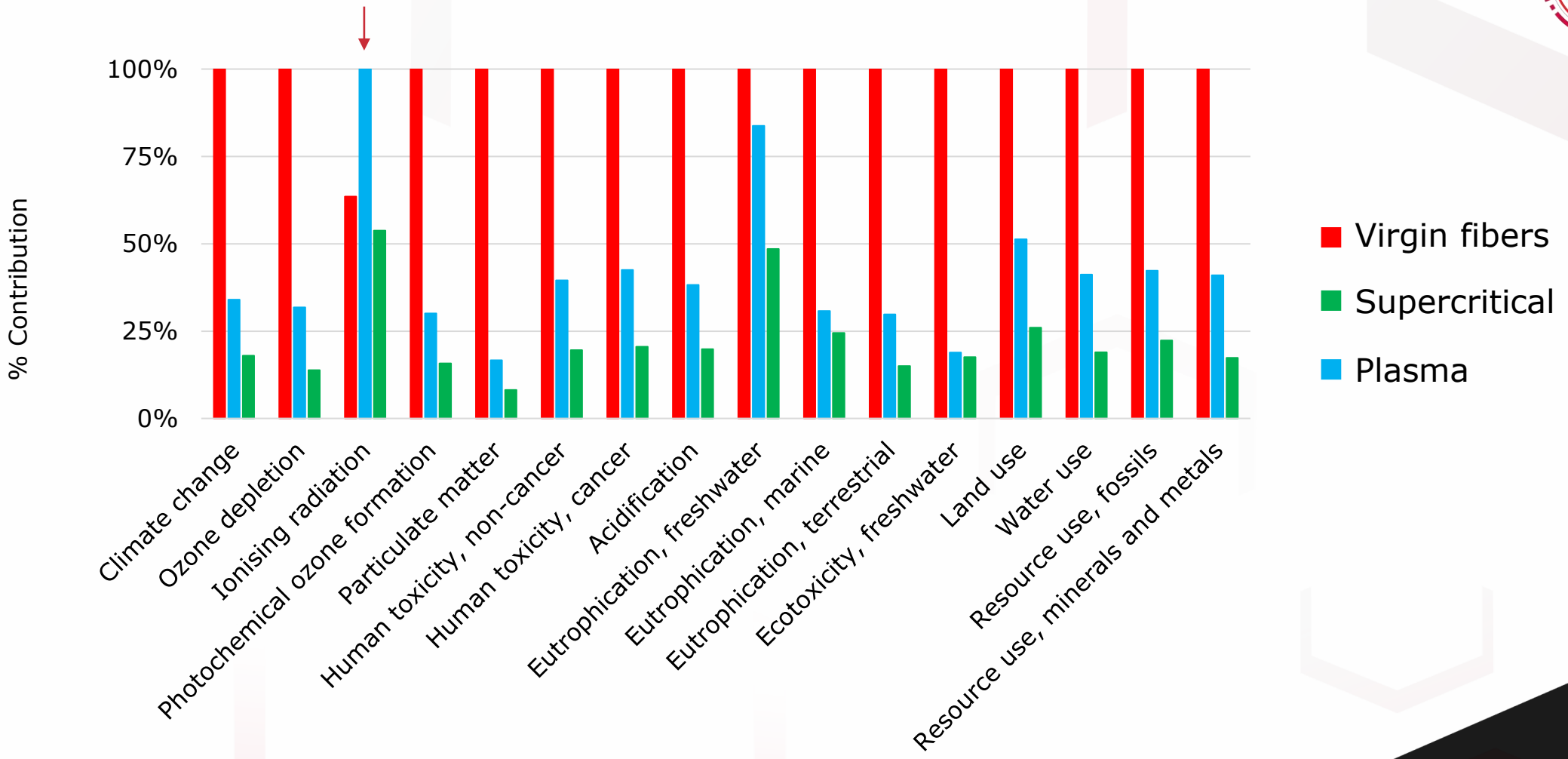
Results: Solvolysis Vs. Landfilling



Results: Solvolysis Vs. Landfilling

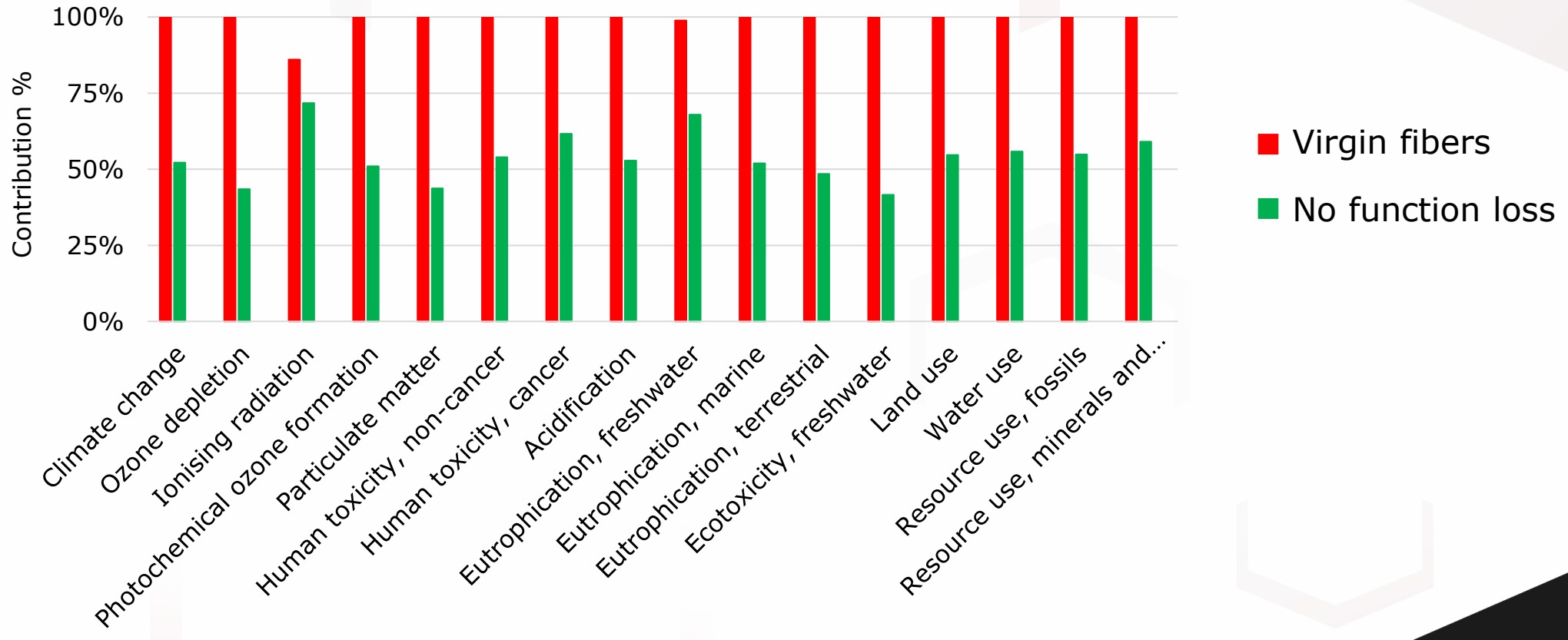


Results: Solvolysis Vs. Fiber Production



Both solvolysis processes have lower impact than virgin fiber manufacture and landfilling

Results: Performance over Life Cycle



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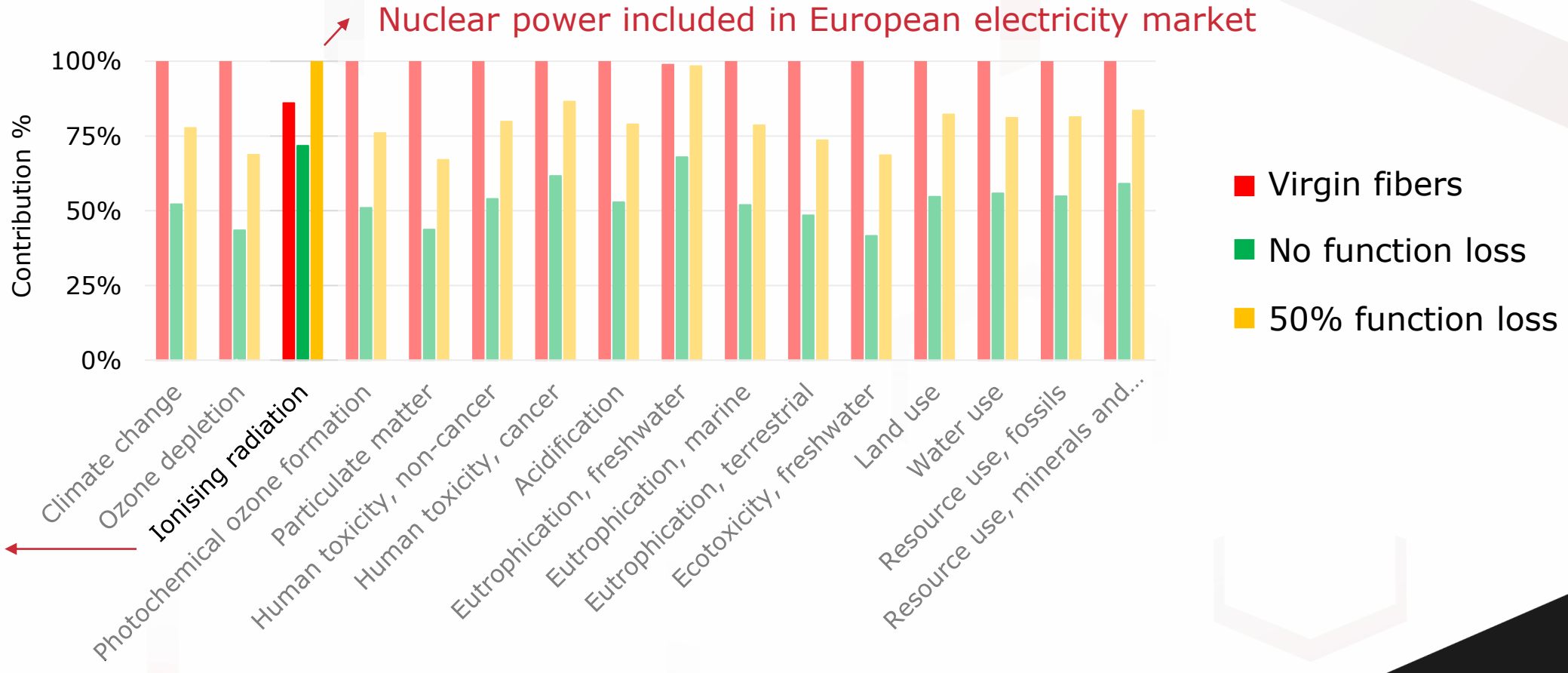
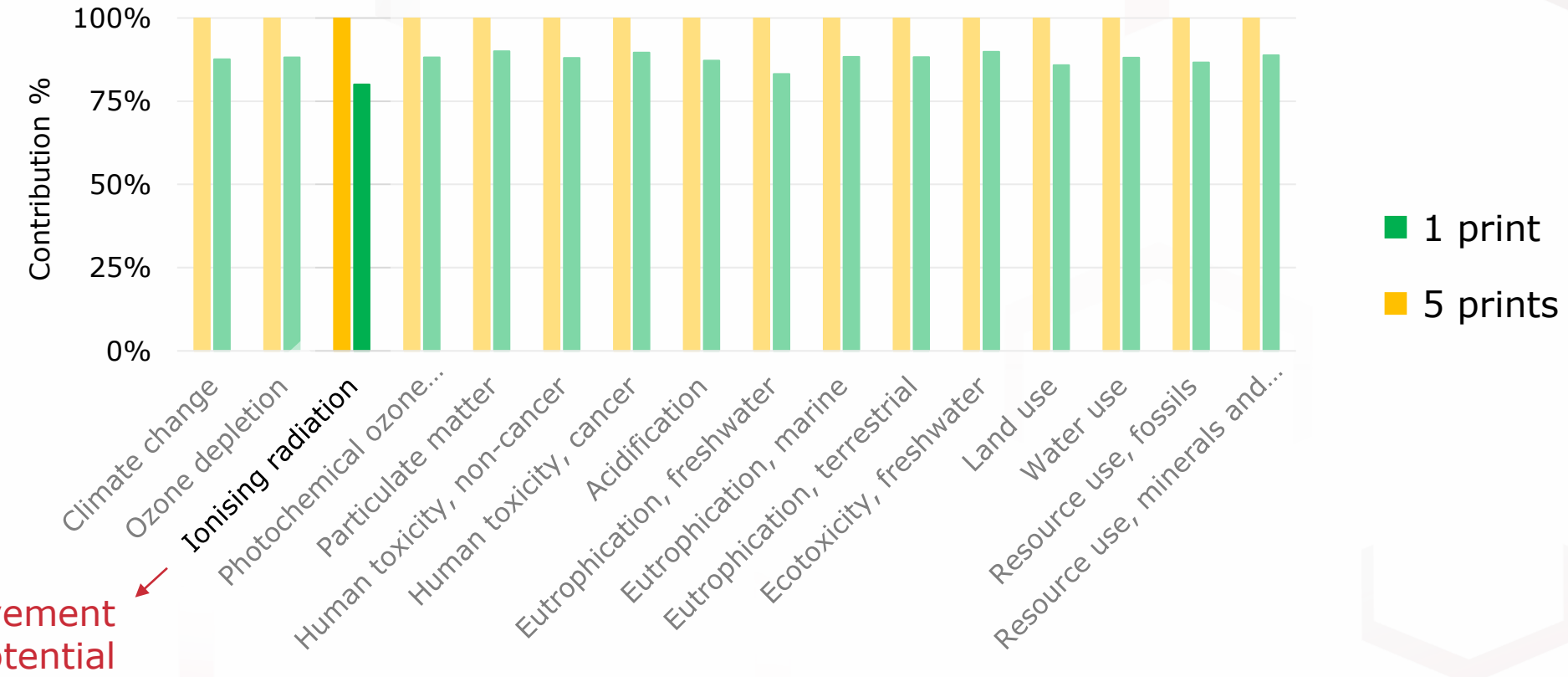


Electricity consumption for additional 3D printing

Lower impact than conventional product, even after functionality loss for fibers

Results: Optimizing equipment use in FFF



High improvement potential

Opportunities to further improve environmental performance

Conclusion

- Solvolysis is a promising recycling method for composite materials
- Up to 48% decrease in global warming potential over entire lifecycle
- Electricity consumption main contributor to environmental impacts
- Opportunities to further improve performance by optimizing the use of equipment

Thank you

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Rue Koningin Astridlaan 59B, 1780, Wemmel, Belgium
info@innovation-res.eu
innovation-res.eu/
innovationreseu
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