Life Cycle Assessment (LCA) of Electrocoating for Aerospace Applications

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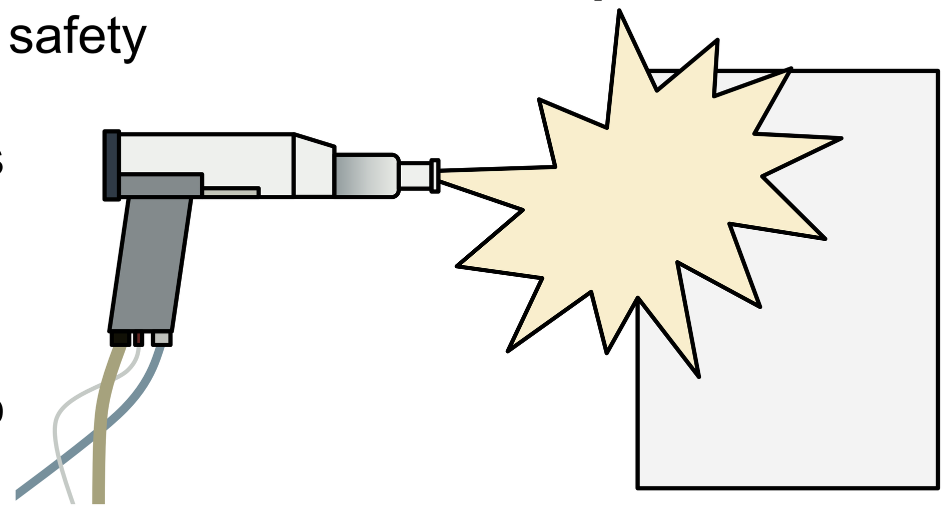
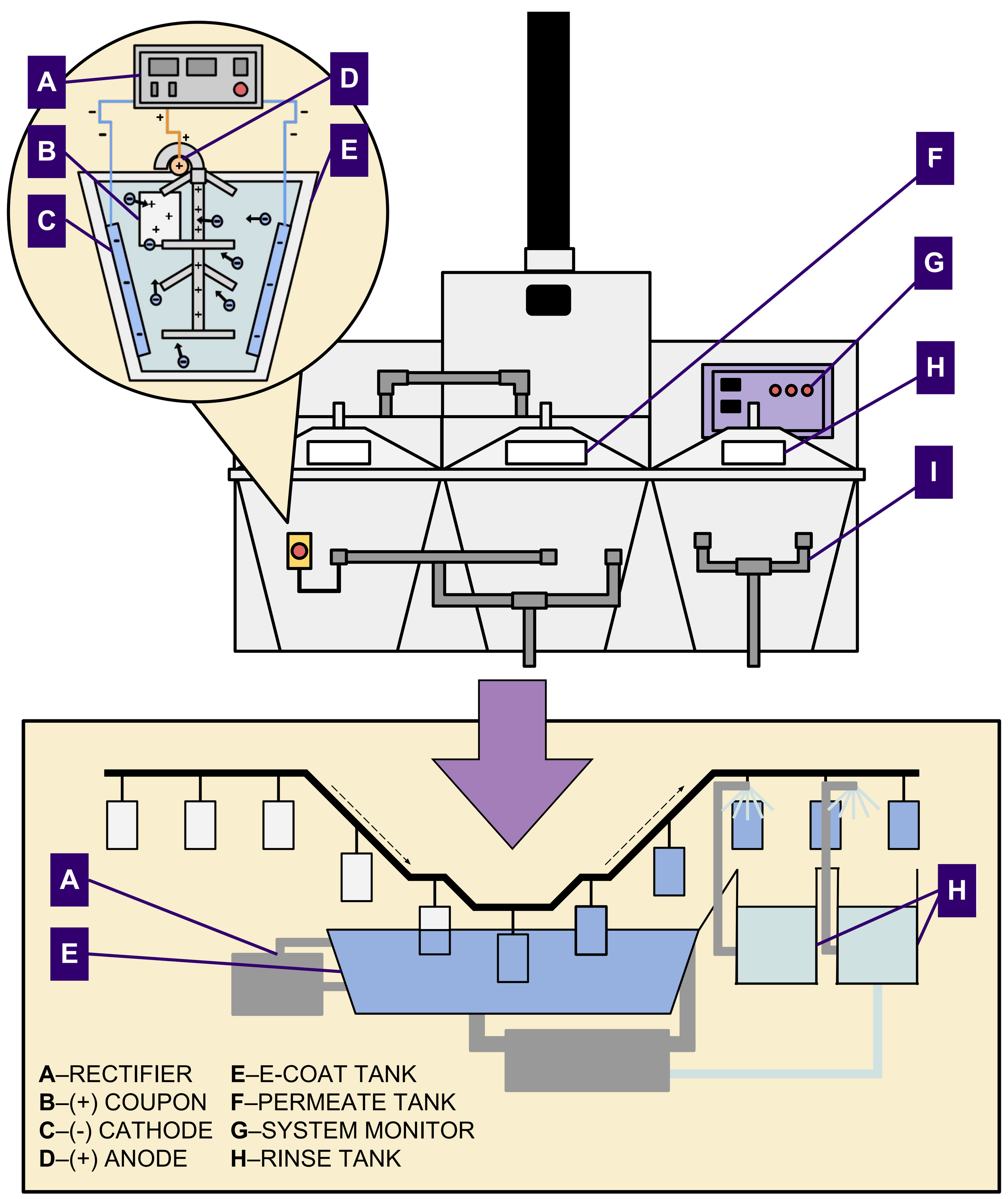
BACKGROUND

➔Aerospace parts require **corrosion-resistant primers** to ensure durability and safety

➔**Traditional spray primers** use solvents that emit volatile organic compounds (VOCs) and produce material waste due to overspray



➔**Electrocoating** uses an electric field to apply primer evenly, reducing material waste



➔**Life cycle assessment (LCA)** helps assess if process scale-up is environmentally justifiable[1]

➔Our LCA used the **ISO 14040** framework:

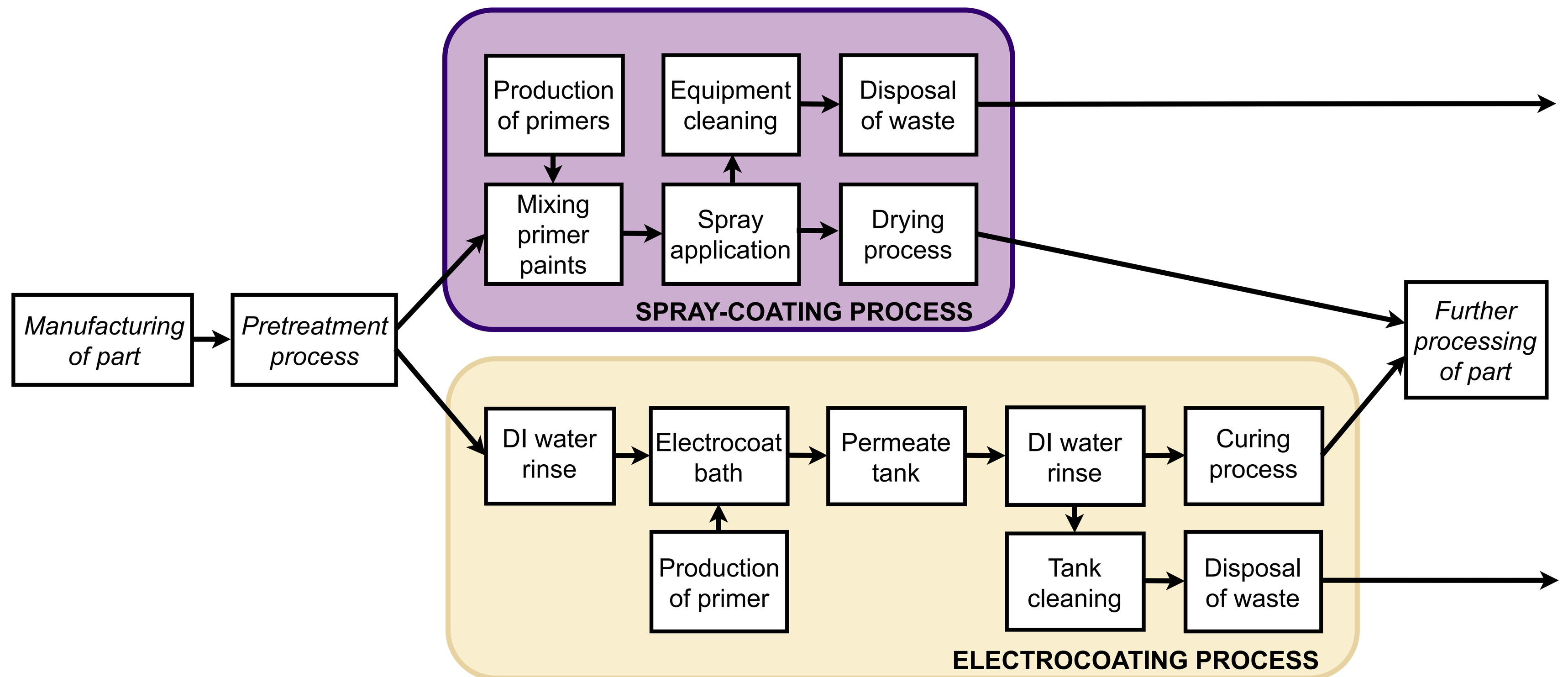
1. **Goal & Scope:** define functional unit and system
2. **Inventory (LCI):** gather input/output data
3. **Impact Assessment (LCIA):** evaluate emissions and resource use
4. **Interpretation:** analyze results, identify major contributors, assess uncertainty

GOAL AND SCOPE DEFINITION

➔**Goal:** Compare the environmental impacts of electrocoating and traditional spray coating for priming aerospace parts

➔**Functional unit:** 1 m^2 of coated aluminum aerospace component

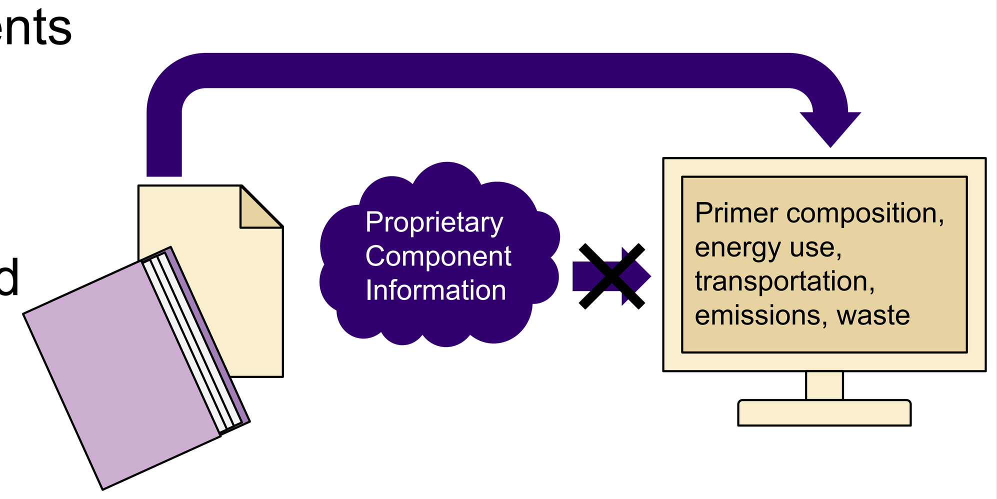
➔**System boundary:** After pretreatment process, before part is processed further



LIFE CYCLE INVENTORY (LCI)

➔Key input data were taken from safety and technical data sheets, industry literature, and patents

➔**Major assumptions:** average values taken for component data, older datasets used due to limited database access, only included components with data for both methods



➔Focused on energy use, material inputs, and emissions directly associated with coating steps; excluded upstream/downstream processes common to both methods

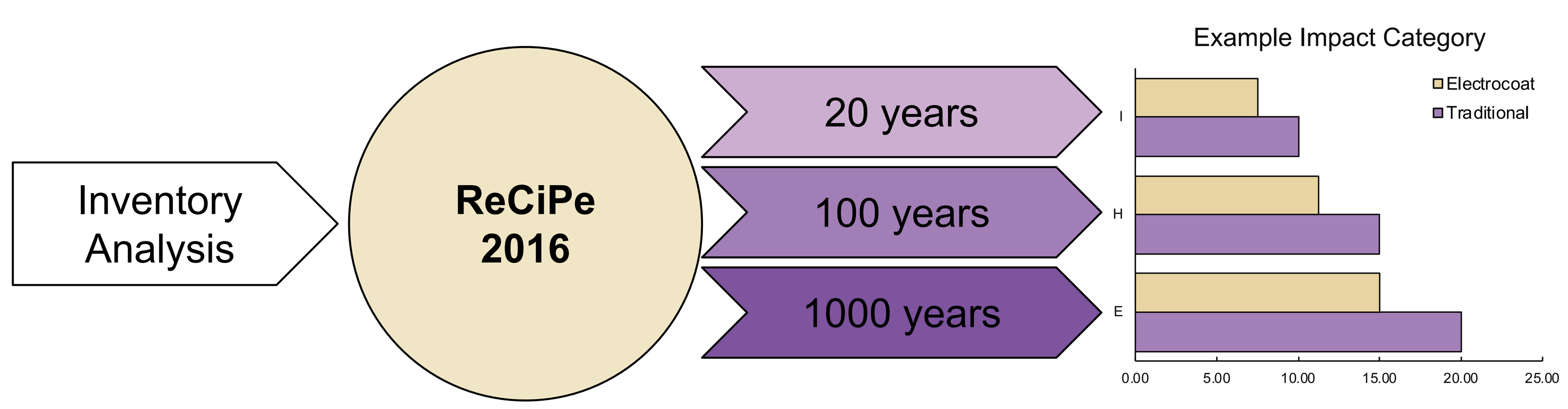
IMPACT ASSESSMENT (LCIA)

➔Modeled in **openLCA** according to defined system boundary:[2]

- ◆ Uses dummy processes for components from inventory data

➔Results evaluated with **ReCiPe 2016** midpoint indicators using **three perspectives**:

- ◆ **Individualist (I):** short-term, optimistic view
- ◆ **Hierarchical (H):** consensus-based, policy-relevant view
- ◆ **Egalitarian (E):** long-term, precautionary view



INTERPRETATION

➔Initial findings suggest **electrocoating** has **lower environmental impacts** in human non-carcinogenic toxicity, marine ecotoxicity, and global warming.

- ◆ More conclusive results can be derived using our framework with a complete database

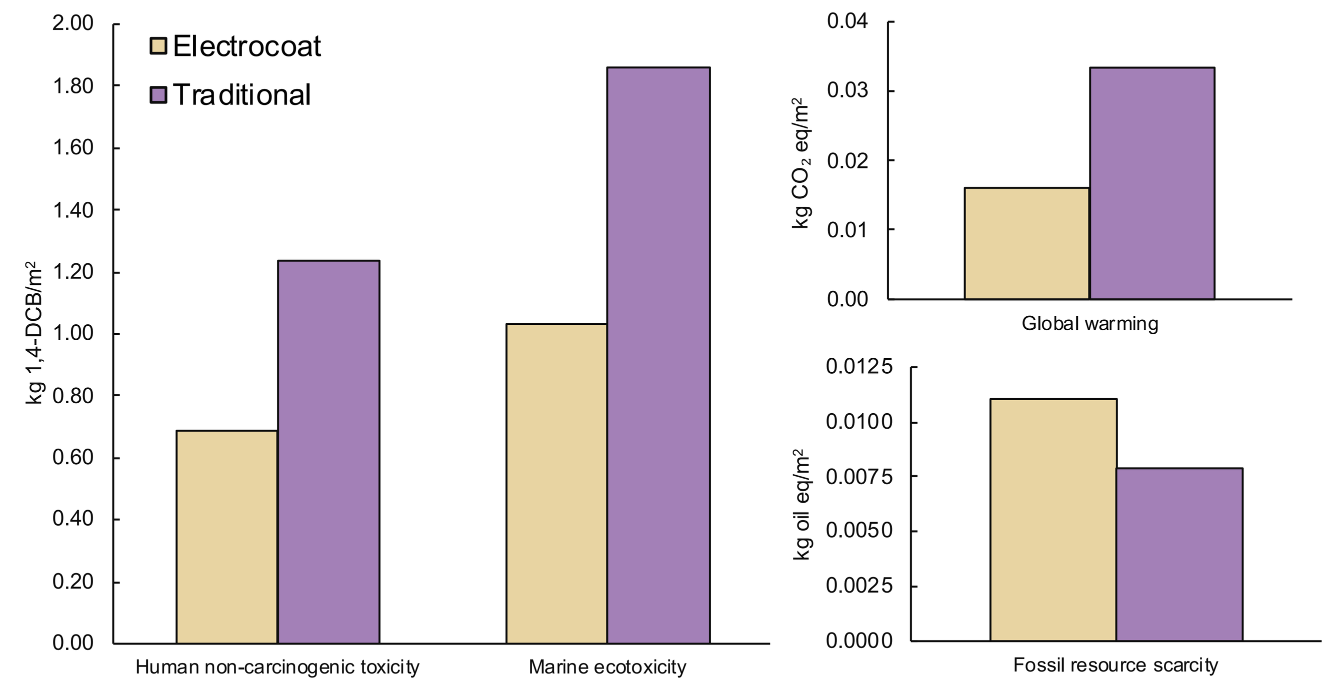


Fig. 1. Comparison of processes across four influential impact categories. Differences likely due to decreased VOC production and transportation requirements as well as increased energy usage for electrocoating.

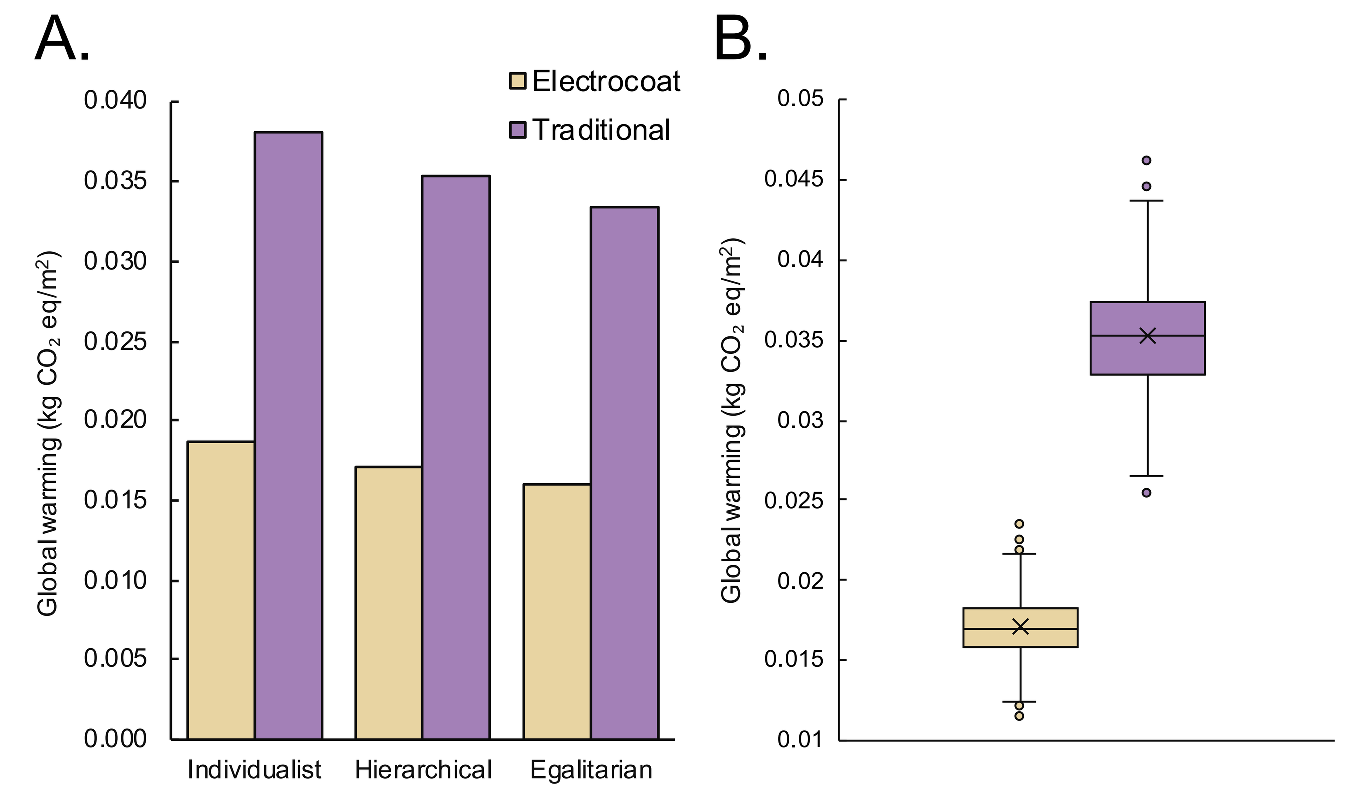


Fig. 2. Preliminary uncertainty analysis calculated using ReCiPe 2016 method in openLCA.[2] **(A)** Global warming potential results across cultural perspectives, showing relatively consistent values. **(B)** Distribution of 1,000 global warming potential values generated from Monte Carlo simulations reflecting input uncertainty. Traditional coating indicates statistically significant increase in global warming potential.

ACKNOWLEDGMENTS & REFERENCES

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1. M. Finkbeiner, A. Inaba, R. Tan, K. Christiansen, and H.-J. Klüppel, "The New International Standards for Life Cycle Assessment: ISO 14040 and ISO 14044," *Int. J. Life Cycle Assess.*, vol. 11, pp. 80–85, 2006.
2. A. Ciroth, M. Srocka, and J. Hildenbrand, openLCA. (2024). *GreenDelta*, Berlin, Germany.

Full list of citations available upon request