Eco-designing heat pumps: Tackling efficiency, refrigerants, and the embodied impact of components

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"Design is an art, and as such, it can be neither imposed nor truly taught."

Prof. V. Nunziata





What can be modeled with LCA?





What can be modeled with LCA?

Based on technical, scientific, and economic knowledge:

- A technological system
- Environmental cause-and-effect relationships
- Market relations

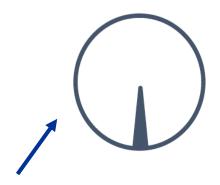






We need to be market experts (for market relationships)

Attributional LCA



Two types of LCA to respond to two different questions

Consequential LCA



What are the consequences of purchasing a product?

What part of the environmental burdens should be assigned to the product?



Weidema B.P., 2003. Geographical, technological and temporal delimitation in LCA. Technical guidelines for product life cycle assessment no. 3 (final draft). Project: "LCA-metodeforbedring/metodeudvikling og konsensusskabelse; Delprojekt 2: Systemafgrænsning." Danish Environ Prot Agency, Copenhagen, Denmark 2003:1–58. https://lca-center.dk/wp-content/uploads/2015/08/Geographical-technological-and-temporal-delimitation-in-LCA.pdf





We need to be market experts (for market relationships)



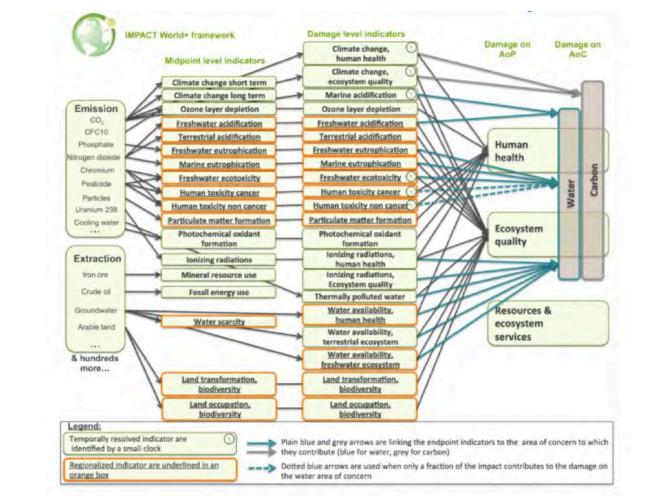
 We need to be environmental scientist (for cause-effect relations)







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 We absolutely need to be HVAC engineers (technological system)





By its nature, LCA requires a multidisciplinary approach, so networking is not only an opportunity but a necessity.



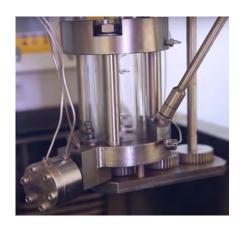




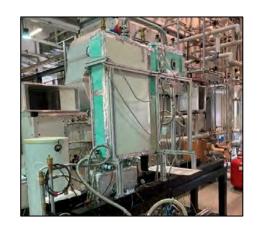
TWO DOUBLE CLIMATIC CHAMBERS



ANECHOIC
CHAMBER FOR
ACOUSTIC TESTS



MEASURES OF FLUID MIXTURES PROPERTIES



ADSORPTION SYSTEM LAB

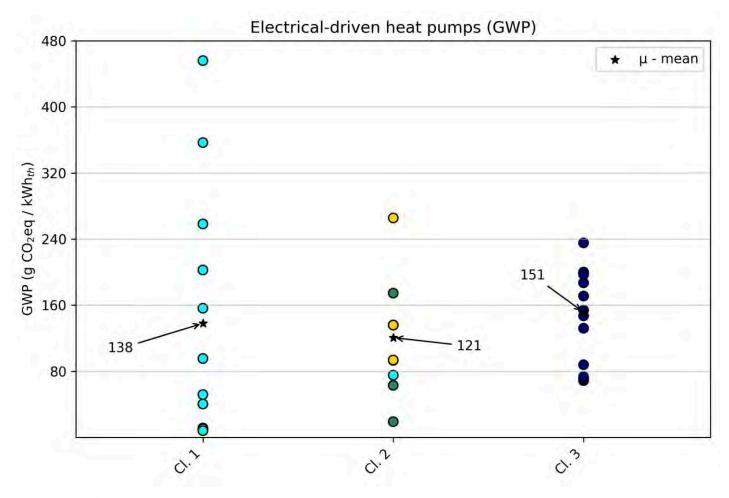




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www.relab.polimi.it





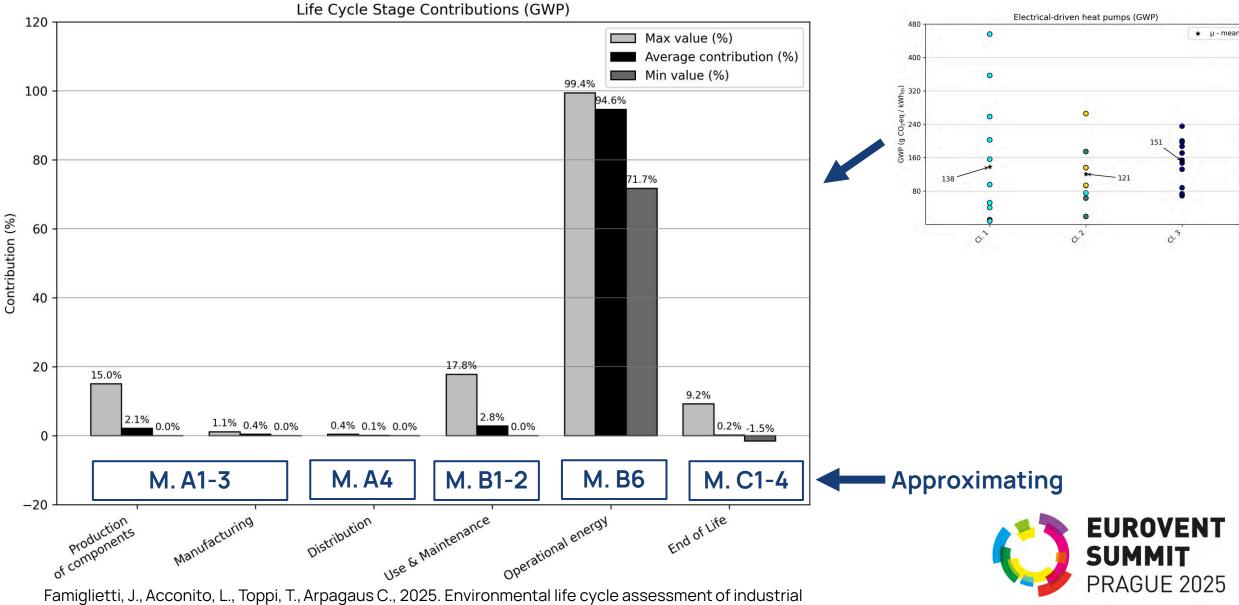
- Cluster 1: industrial heat pumps.
- Cluster 2: heat pumps in district heating networks.
- Cluster 3: heat pumps for civil application.

Famiglietti, J., Acconito, L., Toppi, T., Arpagaus C., 2025. Environmental life cycle assessment of industrial high-temperature to residential small-size heat pumps: A critical review. https://doi.org/10.1016/j.ecmx.2025.100947

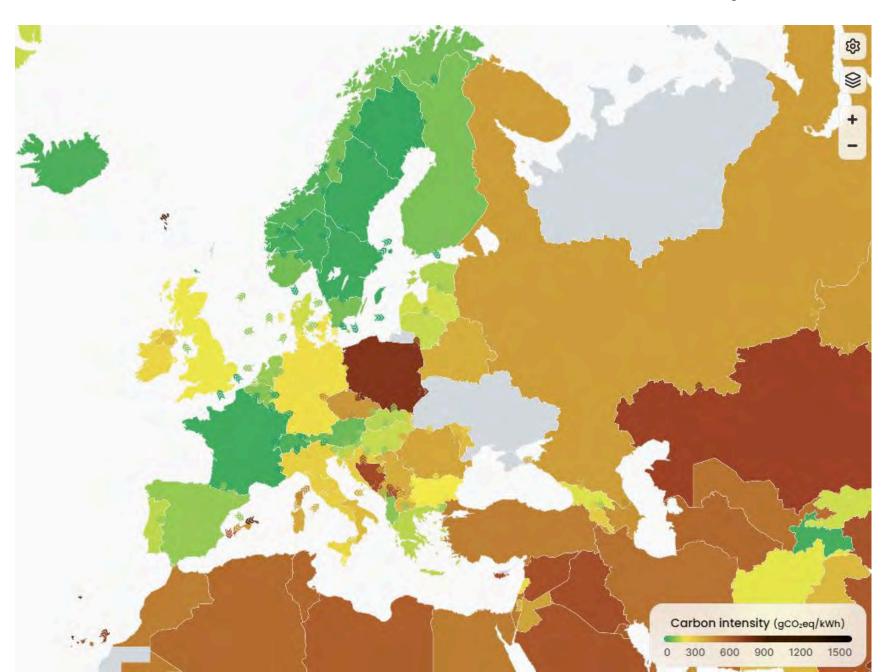




#ManufacturingForTomorrow



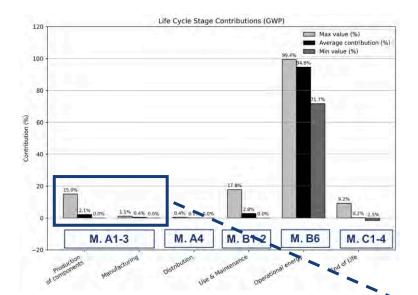
Famiglietti, J., Acconito, L., Toppi, T., Arpagaus C., 2025. Environmental life cycle assessment of industria high-temperature to residential small-size heat pumps: A critical review. https://doi.org/10.1016/j.ecmx.2025.100947



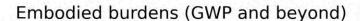


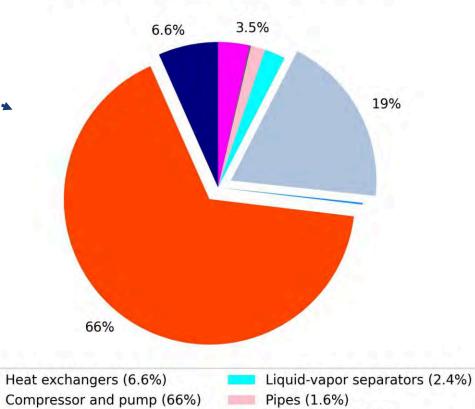
Source: https://app.electricitymaps.com/map /72h/hourly





Embodied burdens





Refrigerant (0.1%)

Frame and Welding (3.5%)

Lubricating oil (0.2%)

Inverter (19%)



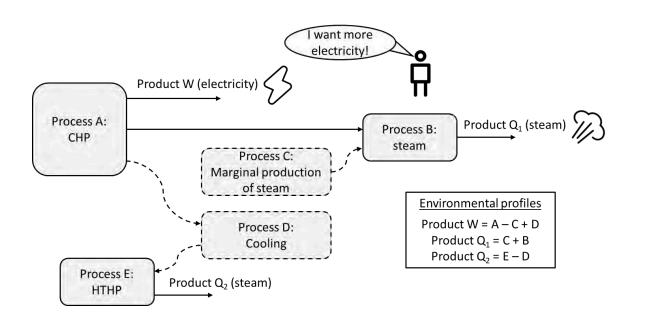
DIPARTIMENTO DI ENERGIA

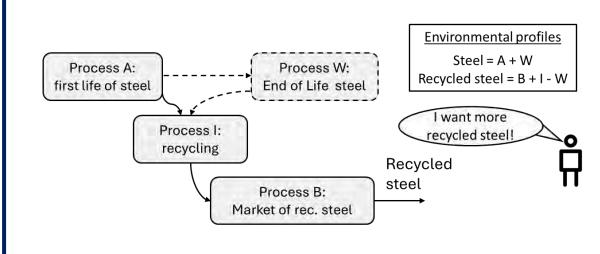






Who are the marginal suppliers?











"Understanding a product's life cycle isn't bureaucracy — it's the foundation of better design."

THANK YOU FOR THE ATTENTION!

Contatti

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