

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

Jacopo Famiglietti
Researcher
Politecnico di Milano



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

Prof. V. Nunziata



POLITECNICO
MILANO 1863

DIPARTIMENTO DI ENERGIA



**EUROVENT
SUMMIT**
PRAGUE 2025

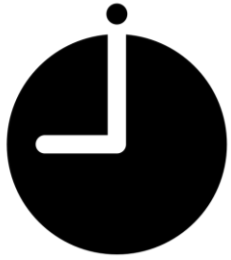
#ManufacturingForTomorrow

- 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



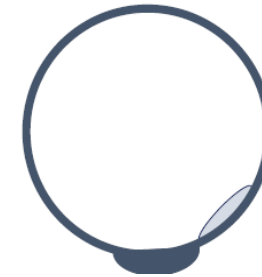
- We need to be market experts (for market relationships)

Attributional LCA



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

Consequential LCA



What are the consequences of purchasing a product?

Two types of LCA to respond to two different questions



**POLITECNICO
MILANO 1863**

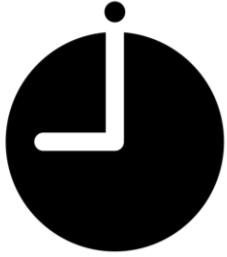
DIPARTIMENTO DI ENERGIA

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 konsensususkabelse; 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>



**EUROVENT
SUMMIT
PRAGUE 2025**

#ManufacturingForTomorrow



- We need to be market experts (for market relationships)



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



POLITECNICO
MILANO 1863

DIPARTIMENTO DI ENERGIA

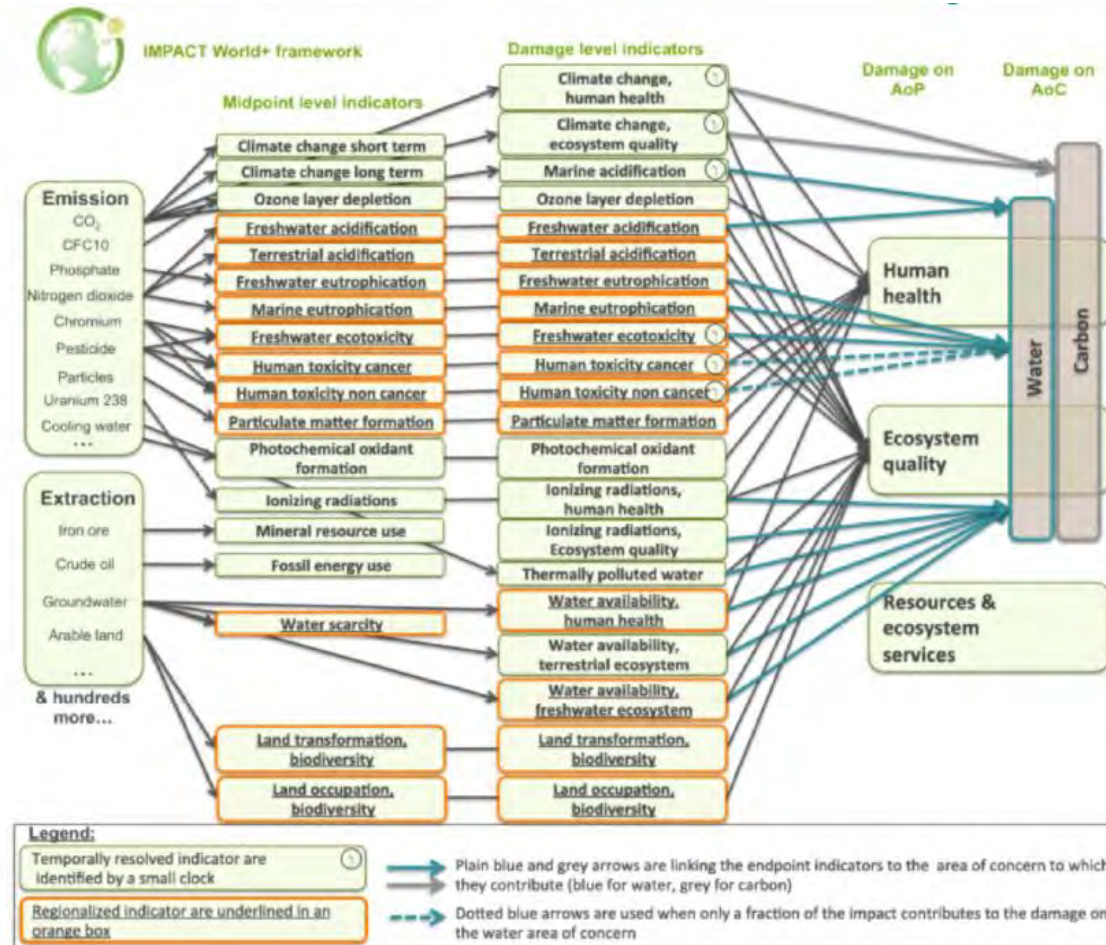


**EUROVENT
SUMMIT**
PRAGUE 2025

#ManufacturingForTomorrow



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



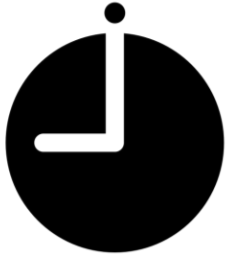
**POLITECNICO
MILANO 1863**

DIPARTIMENTO DI ENERGIA



**EUROVENT
SUMMIT
PRAGUE 2025**

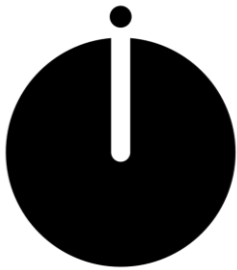
#ManufacturingForTomorrow



- We need to be market experts (for market relationships)



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



- We absolutely need to be HVAC engineers (technological system)



POLITECNICO
MILANO 1863

DIPARTIMENTO DI ENERGIA



**EUROVENT
SUMMIT**
PRAGUE 2025

#ManufacturingForTomorrow

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



POLITECNICO
MILANO 1863

DIPARTIMENTO DI ENERGIA



**EUROVENT
SUMMIT**
PRAGUE 2025

#ManufacturingForTomorrow



TWO DOUBLE
CLIMATIC
CHAMBERS



ANECHOIC
CHAMBER FOR
ACOUSTIC TESTS



MEASURES OF
FLUID MIXTURES
PROPERTIES



ADSORPTION
SYSTEM LAB



**POLITECNICO
MILANO 1863**

DIPARTIMENTO DI ENERGIA



R E L A B

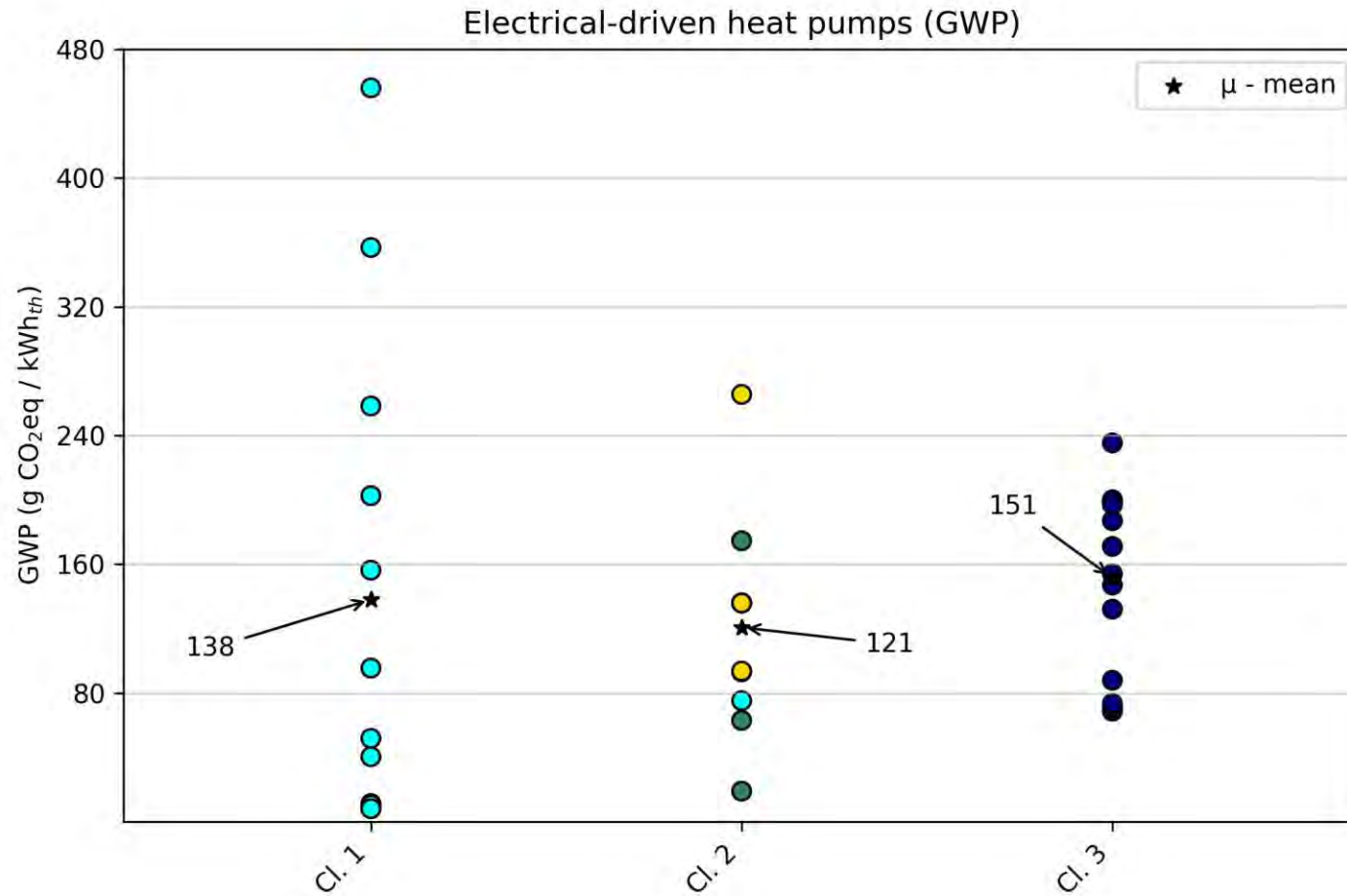
RENEWABLE HEATING AND COOLING LAB

www.relab.polimi.it



**EUROVENT
SUMMIT**
PRAGUE 2025

#ManufacturingForTomorrow



- 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>



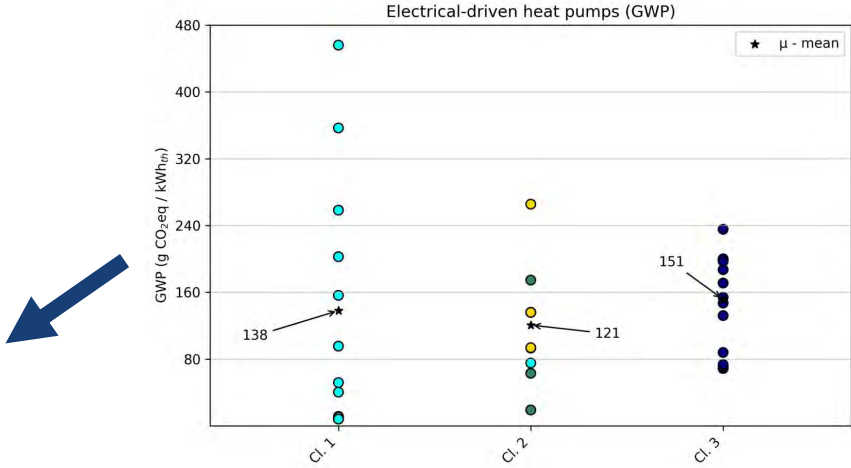
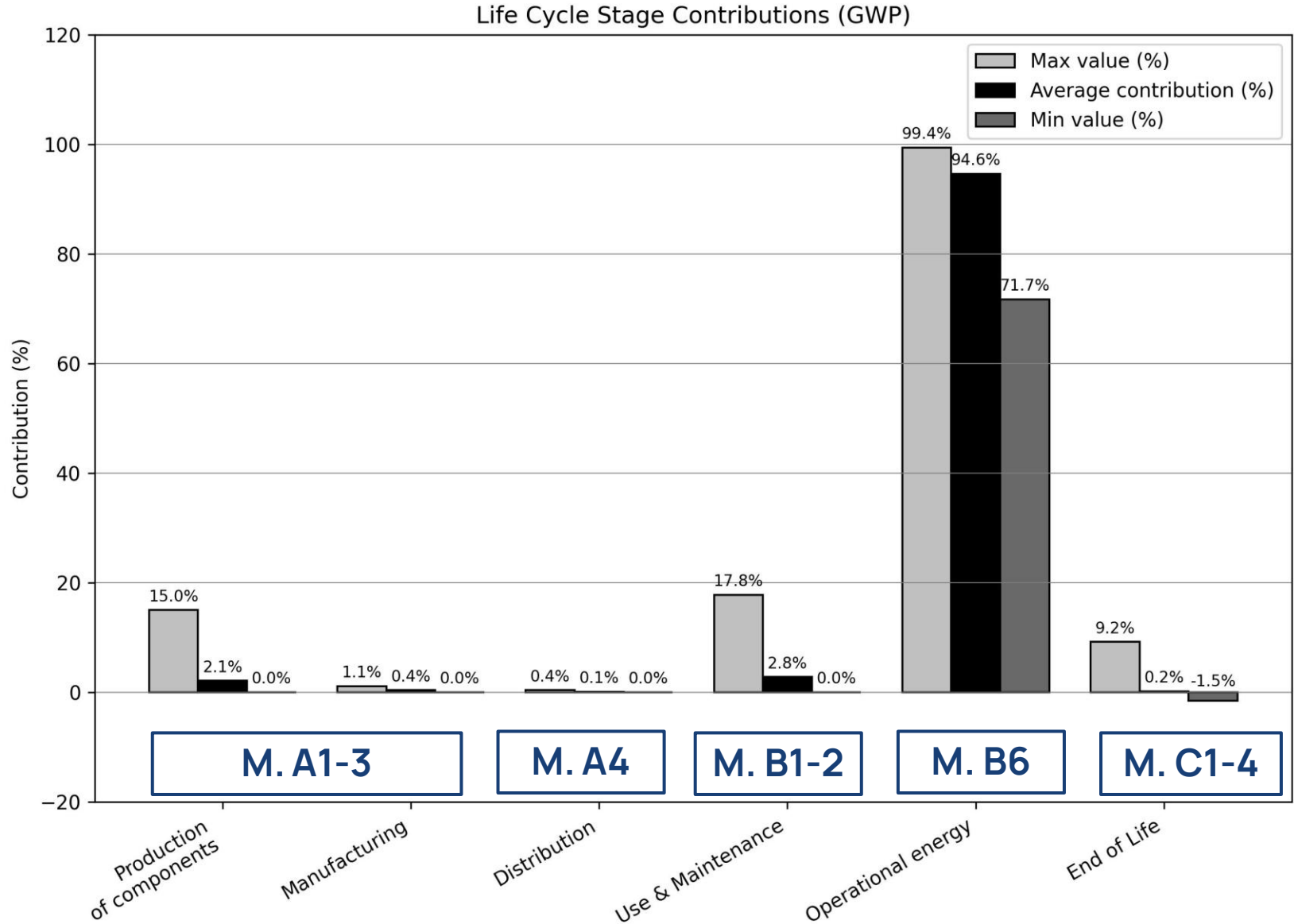
**POLITECNICO
MILANO 1863**

DIPARTIMENTO DI ENERGIA



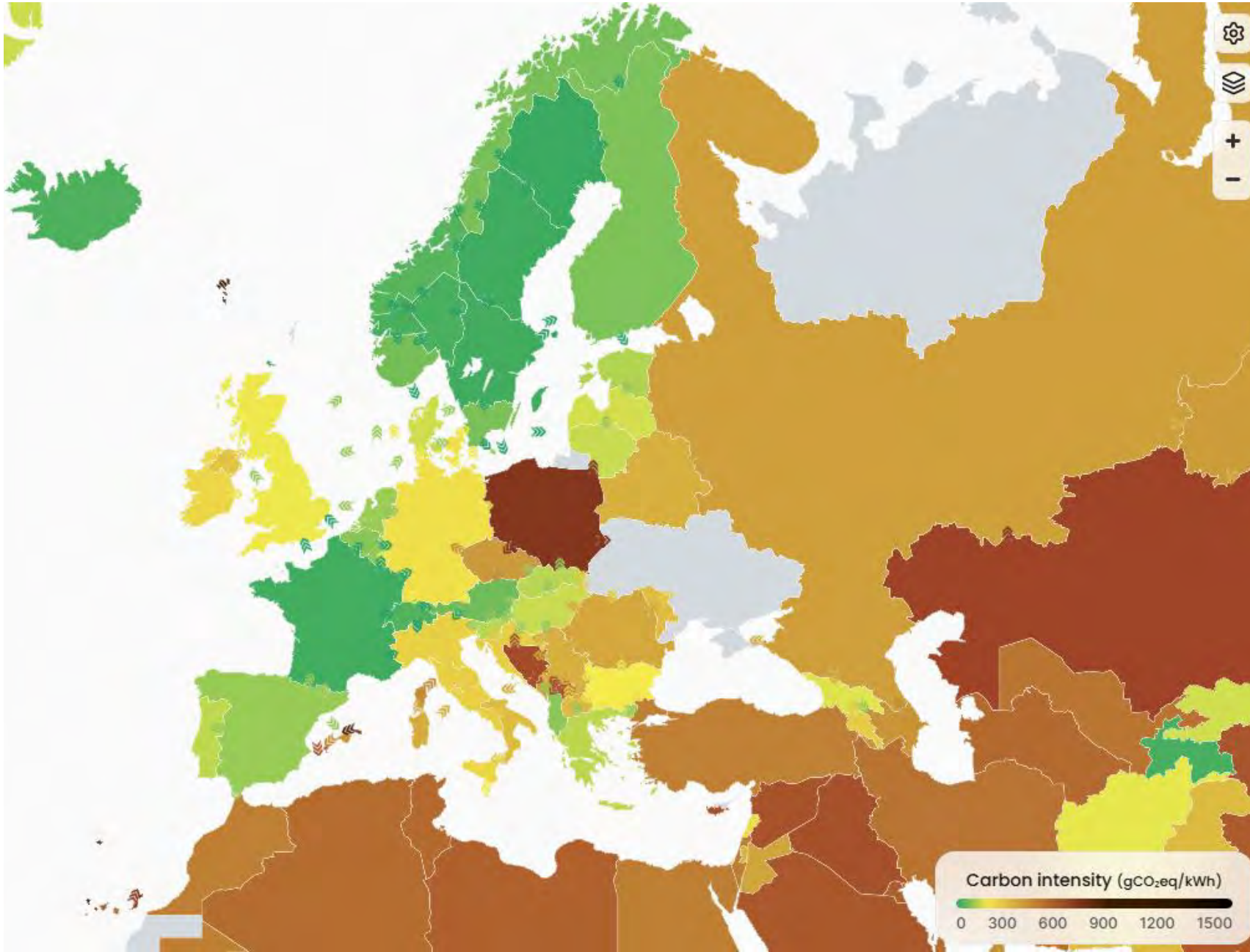
**EUROVENT
SUMMIT
PRAGUE 2025**

#ManufacturingForTomorrow



Approximating

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>



**POLITECNICO
MILANO 1863**

DIPARTIMENTO DI ENERGIA

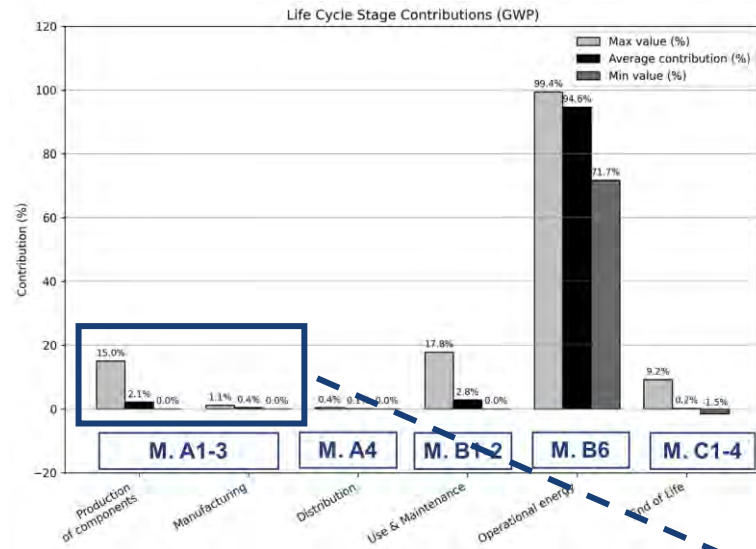
Source:
<https://app.electricitymaps.com/map/72h/hourly>



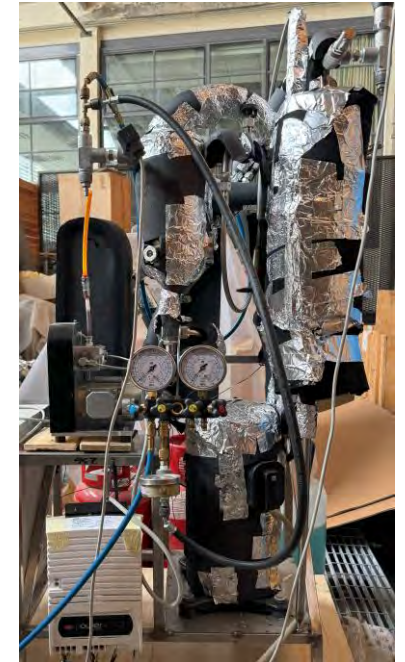
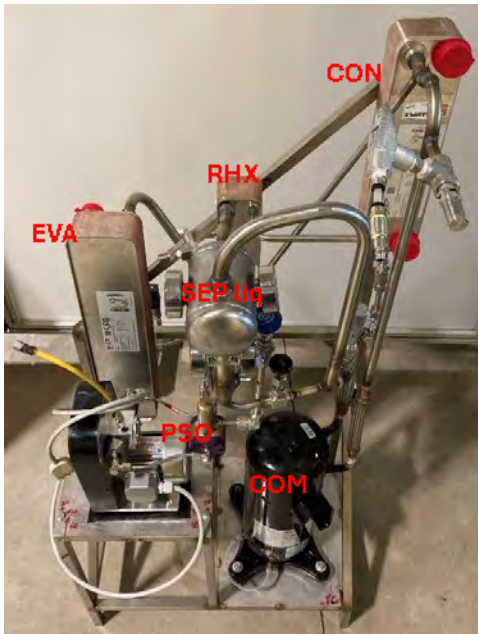
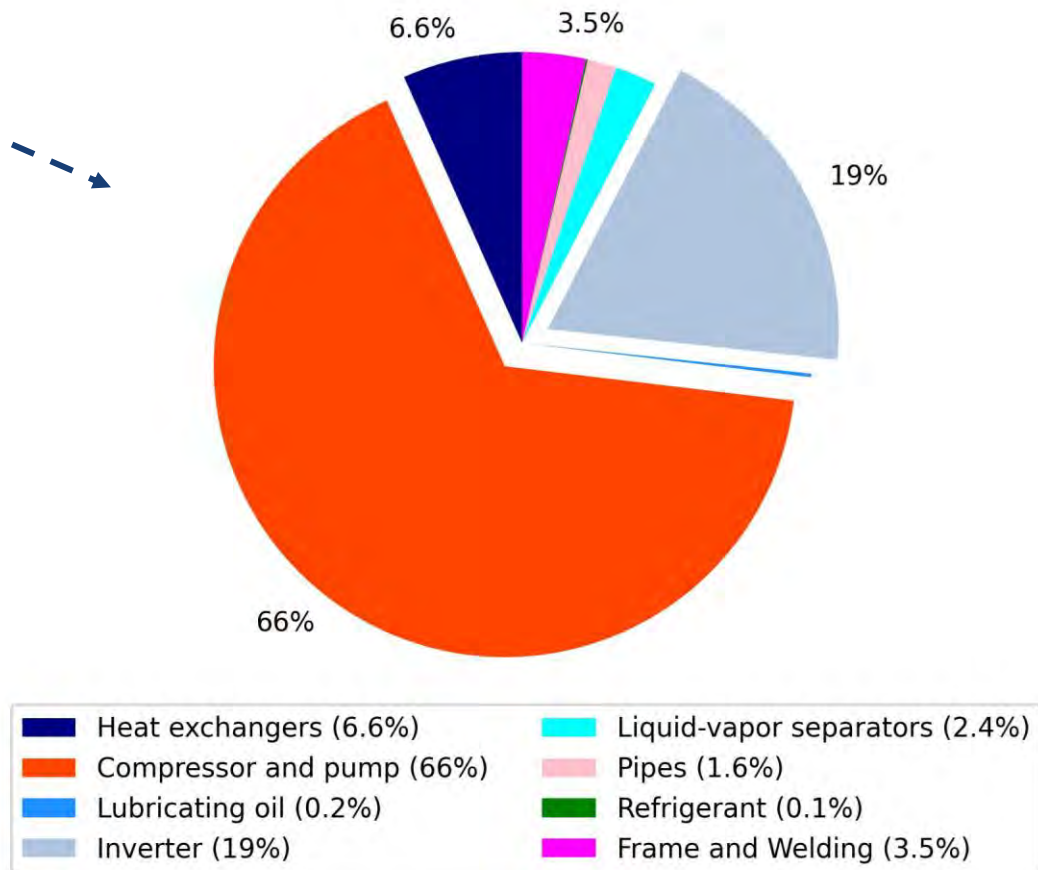
**EUROVENT
SUMMIT
PRAGUE 2025**

#ManufacturingForTomorrow

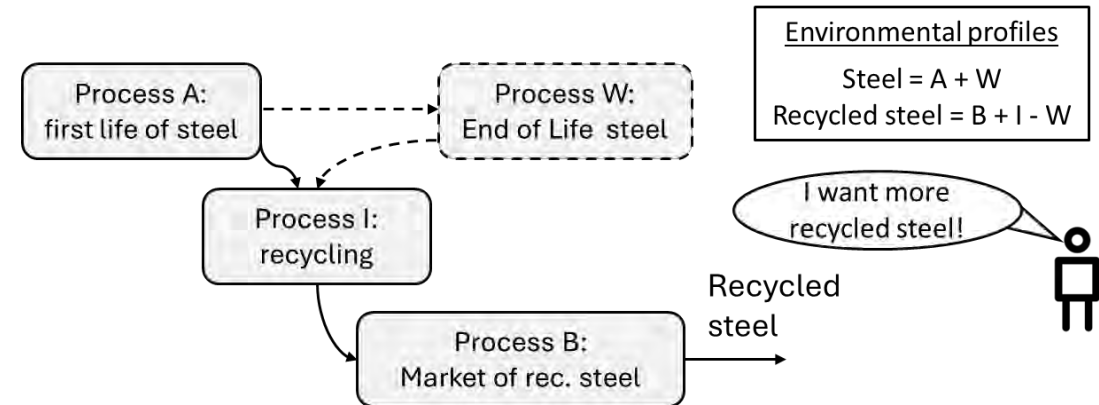
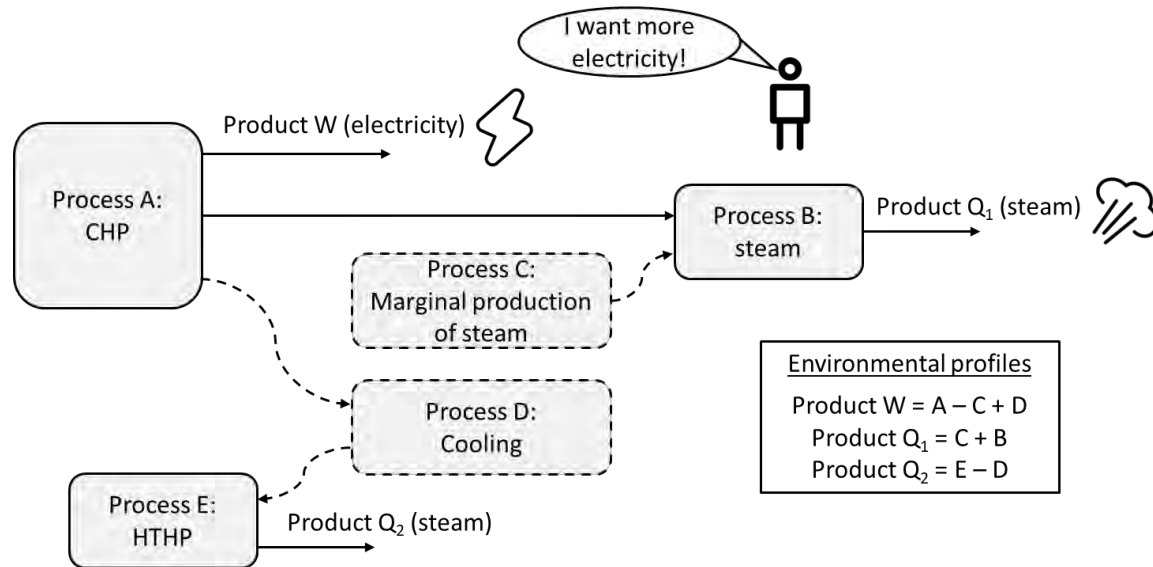
Embodied burdens



Embodied burdens (GWP and beyond)



Who are the marginal suppliers?





POLITECNICO | DIPARTIMENTO
MILANO 1863 | DI ENERGIA

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

THANK YOU FOR THE ATTENTION!

Contatti

jacopo.famiglietti@polimi.it
www.energia.polimi.it

