

# Air-conditioning Life Cycle Assessment Research: A review of the methodology, environmental impacts, and areas of future improvement

## PROBLEM

Despite the **rapid expansion of air-conditioning** (AC) systems and their significant contribution to global energy use and emissions, most environmental assessments focus narrowly on **operational efficiency**. Current **Life Cycle Assessment** (LCA) studies **lack methodological consistency** and often **exclude key life cycle stages**, limiting their effectiveness in evaluating the true sustainability of AC technologies.

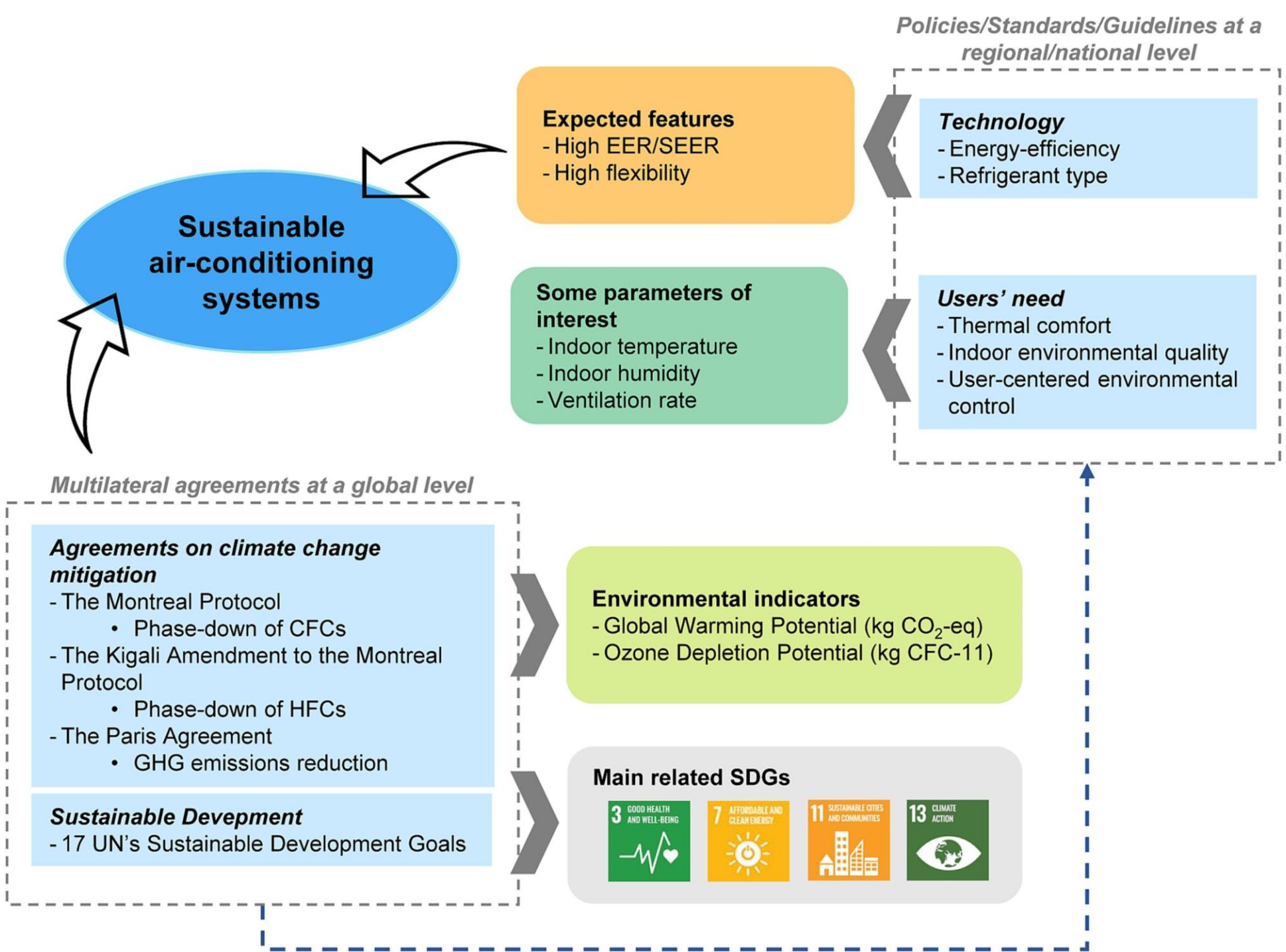
## MAIN OBJECTIVE

To conduct a **systematic review** of existing LCA studies on **air-conditioning systems** and answer:

- What are the **methodologies and assumptions** used in AC-related LCA studies?
- Which **life cycle stage** contributes most to environmental impacts?
- Can LCA results effectively determine whether an AC system is **sustainable**?

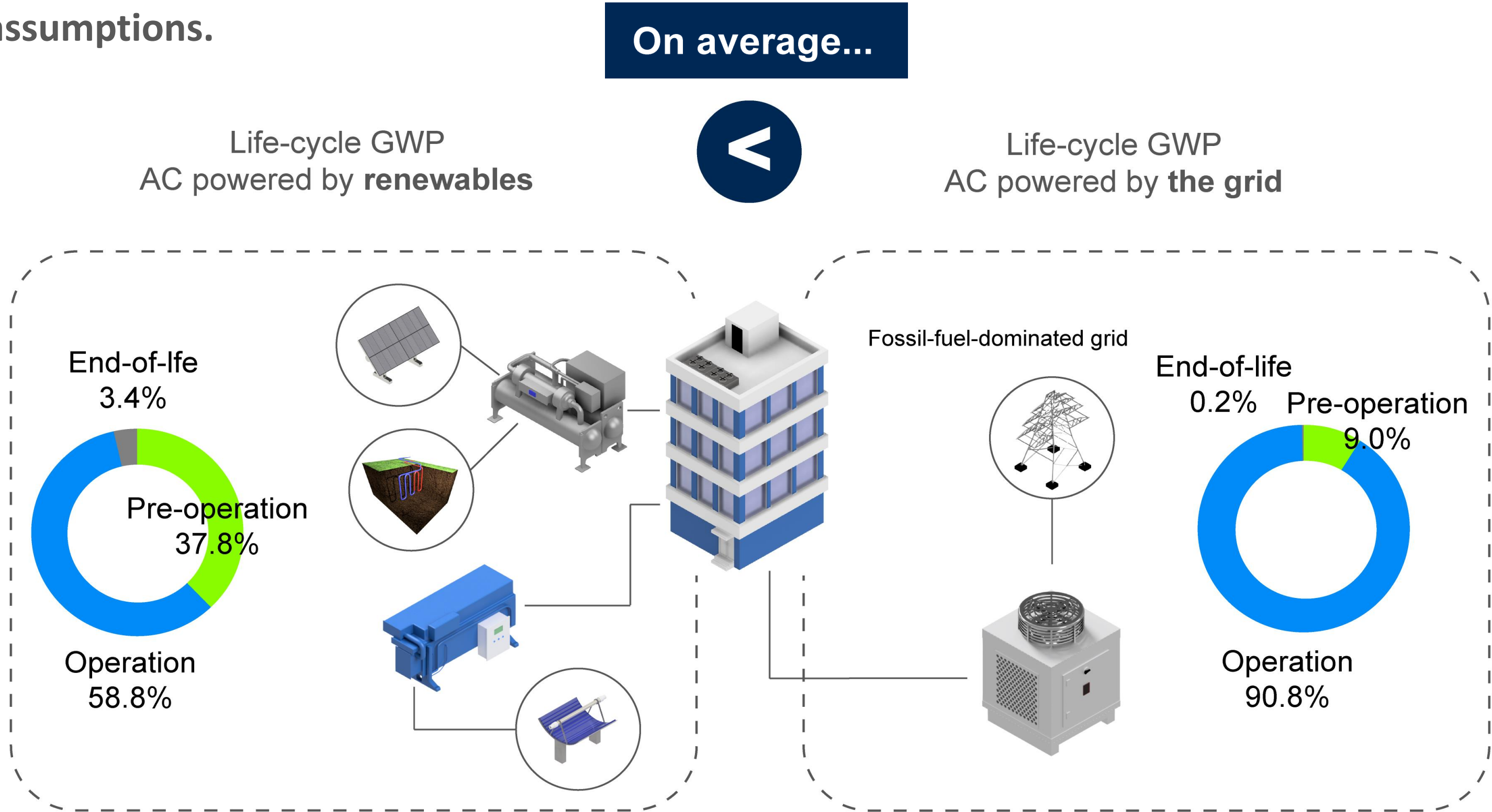
## PROPOSAL

- Reviewed **41 peer-reviewed articles** published between 2000 and 2023.
- Selected studies focused on **active cooling systems**, excluding whole-building or combined energy systems.
- Key aspects analyzed:
  - ❖ **Goals and functional units.**
  - ❖ **System boundaries and lifespan.**
  - ❖ **Impact assessment methods.**
  - ❖ **Distribution of Global Warming Potential (GWP).**



## RESULTS

- Grid-powered AC systems** showed the **highest GWP during the operation phase**, mainly due to electricity consumption from carbon-intensive grids.
- Pre-operation phase** dominates in **renewable-based systems** (due to PV panels, batteries, and others).
- The **variation in GWP results** is highly influenced by:
  - ❖ **System layout.**
  - ❖ **Energy source mix.**
  - ❖ **Lifespan assumptions.**



## CONCLUSIONS

- Standardized guidelines** are needed for defining LCA scope, especially for AC systems.
- Renewable-powered systems** may lower GWP but can shift burdens to other environmental categories.
- Transitioning to a **clean electricity grid** has greater potential impact than only focusing on system design.
- Future research should:
  - ❖ **Expand studies to tropical and developing regions.**
  - ❖ **Address maintenance and refrigerant leakage.**
  - ❖ **Improve data availability in LCI databases for AC systems.**