

Space Cooling: recovery, reuse, recycling and supply chain impacts

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Topics:

Building A Circular Economy for Products and Materials
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Abstract:

The global cooling sector has undergone tremendous growth in recent years, and cooling demand is projected to double or triple by 2050. Surging air conditioning demand will continue to be driven by increased populations, incomes and occurrences of extreme heat events. Cooling equipment growth has important pollution and material implications as they are made up of critical metals and precious raw materials - including ferrous metals, copper, aluminum and printed circuit boards composed of copper, silver, gold and palladium - that generate significant electronic waste at end-of-life. Air conditioning equipment also contains fluorinated gas (F-gas) refrigerants, which are potent gases that are thousands of times more heat-trapping than carbon dioxide (CO₂). While recovery, reuse, and recycling strategies have been assessed for cold chain and refrigeration, there is currently limited analysis on how these strategies could be adopted for the global space cooling industry and potential supply chain implications.

This paper aims to address this research gap by qualitatively evaluating product and material recovery, reuse and recycling frameworks from both demand and supply-side perspectives and with the support of cooling-specific case studies. It also focuses on quantitatively assessing potential energy, emissions and resource benefits of such strategies for space cooling equipment. This paper first analyzes how existing recovery, reuse and recycling frameworks can be applied to space cooling, with emphasis on the demand-side enablers (e.g., innovative business models, supporting policies and regulations) and changes in supply-side production network throughout the supply chain (e.g., design, production and distribution, end-of-life recovery) needed to overcome existing barriers. It will present case studies of circular business models for space cooling technologies, including reuse and recycling, and how effective refrigerant reclamation and recovery programs have been operationalized. Lastly, the paper will highlight global modeling results of energy, emissions and material recovery from scenario analysis of selected strategies for air conditioners.

The findings of this paper are intended to inform the development of product and material recovery, reuse and recycling strategies for a rapidly growing stock of space conditioning equipment by addressing existing organizational, economic and regulatory barriers and potential supply-chain bottlenecks such as limited workforce development. Quantification of energy consumption, emissions, and material recovery potential through modeling help highlight the scale and urgency for coordinated public-private actions needed to increase recovery, reuse and recycling while improving and securing supply chains for the cooling sector.