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A STRUCTURED LCA METHODOLOGY FOR COMPARATIVE ENVIRONMENTAL ASSESSMENT OF DISTRICT HEATING PIPE MATERIALS

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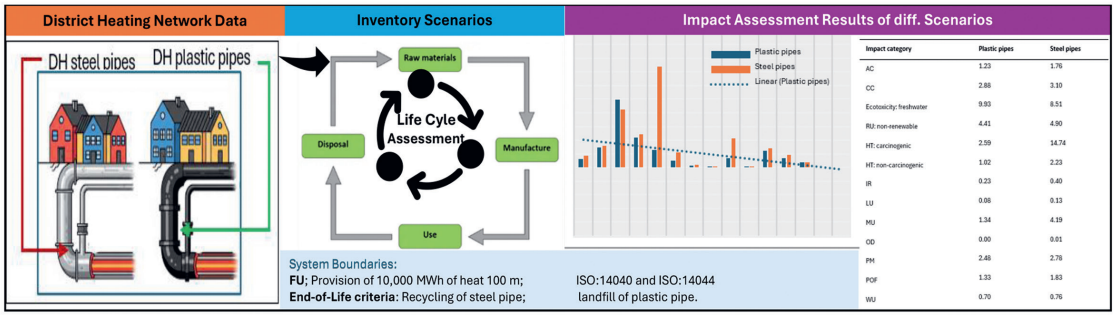
Abstract – The environmental assessment of district heating and energy distribution systems is widely focused on carbon equivalent emissions related to energy generation units, while the environmental impacts associated with distribution materials are seldom addressed. In particular, the selection of pipe materials is often excluded from system-level assessments, despite their long service life and material intensity. This study presents a structured methodological approach for the comparative life cycle assessment of district heating pipe materials, focusing on steel and plastic pipes under identical functional conditions. The assessment is based on a functional unit defined as the transport of the same amount of thermal energy over a fixed distribution distance, ensuring functional equivalence between the compared systems. Different end-of-life scenarios were evaluated in order to assess their influence on comparative results, including recycling allocation for steel pipes and landfill disposal assumptions for plastic pipes. The results demonstrate that material choice and end-of-life modeling have a noticeable effect on the environmental performance of district heating pipe systems across several impact categories. Steel pipes generally show higher impacts related to resource use and toxicity, while plastic pipes exhibit lower impacts in most categories, including greenhouse gas emissions, but are more sensitive to disposal assumptions. The proposed approach provides a transparent basis for material assessment in energy distribution systems and supports more informed decision-making in sustainable district heating design.

Keywords – Comparative analysis; district heating infrastructure; end-of-life modeling; environmental impact assessment; functional unit definition; recycling allocation



Methodological framework for the comparative assessment of district heating pipe materials

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