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DECARBONISATION OF DISTRICT HEATING – REVIEW OF CURRENT SYSTEM DYNAMICS MODELLING APPROACHES

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Abstract – Decarbonization of the heating sector, with an emphasis on expanding and decarbonizing District Heating (DH), is critical for achieving national and EU-level decarbonization goals. However, decarbonization of DH presents a set of conflicting goals, also referred to as the "energy trilemma" – ensuring sustainability, system security and reliability, and economic viability. To achieve successful decarbonization of DH, all three goals need to be optimally balanced. System Dynamics (SD) modelling allows the observation of complex system behaviour over time by observing feedback loops and dependencies within a given system. Thus, given the complexity of DH systems and their interdependence with other energy systems, an SD modelling approach is widely used to model different aspects of the future development of DH, as well as to observe the dynamic effects and feedback loops emerging from technology integration and policy interventions. This paper develops a systemic literature review approach to analyse and review existing studies that employ SD modelling of DH systems. It identifies the scope and aim of the models and summarizes the main feedback loops identified and key takeaways, evaluating to what extent the energy trilemma is currently explored in existing literature. It is found that existing studies predominantly focus on modelling the integration of specific technologies into DH systems, thus covering technological aspects of DH decarbonization. However, studies covering systemic analysis of economic viability, system security, and environmental impacts of DH decarbonization remain fragmented, as the aspects are mostly explored separately. As a result, current research offers only a partial understanding of how the conflicting goals of the energy trilemma interact through feedback loops and create interdependencies within DH systems.

Keywords – Decarbonisation; district heating; energy trilemma; system dynamics