EMERGENCY PREPAREDNESS FOR SMR WASTE MANAGEMENT IN EU DISTRICT HEATING

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The district heating sector in Europe currently meets about 15% of the overall demand for low-temperature heating, with the majority, approximately 60%, still relying on fossil fuels. While biomass is presently as the only widely adopted renewable alternative, its availability is constrained, underscoring the necessity of nuclear energy to achieve full decarbonization of heat production by the middle of the century. Projections from the Heat Roadmap Europe suggest that nuclear-generated heat will grow from just over 10% to nearly 50% of district heating capacity within this period. Instead of modifying existing nuclear power plants to support cogeneration, a more adaptable and scalable strategy involves the deployment of Small Modular Reactors (SMRs), which provide a tailored solution for integrating nuclear heat into district heating networks. The integration of SMRs for district heating requires robust emergency preparedness strategies to address safety challenges during transient conditions such as refueling, startup and shutdown sequences, power fluctuations, and maintenance. These operational phases pose specific risks that necessitate structured response measures to ensure public safety, regulatory compliance, and confidence in nuclear district heating. This study examines emergency preparedness for SMRs, highlighting accident scenarios, risk mitigation strategies, and response planning. Elements of probabilistic risk assessments examine the likelihood of core damage considering passive safety mechanisms of modular designs, while tailored emergency response frameworks remain crucial. Site-specific emergency planning is taken into account, involving urban deployments that incorporate enhanced shielding, automated safety responses, and rapid evacuation protocols, while remote sites are supported by self-sufficient emergency response infrastructure. Transparent risk communication and stakeholder engagement play a pivotal role in reinforcing emergency preparedness. Independent safety audits, real-time radiation monitoring, and standardised emergency response protocols are essential to ensuring preparedness and effective crisis management. This study supports policy recommendations advocating for harmonised regulatory frameworks, integrated emergency planning, and risk-informed safety measures. Strengthening emergency preparedness will facilitate the safe and sustainable deployment of SMRs in district heating networks across Europe.

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