DC Number	DC5
Title of the PhD Project	Fault detection and diagnostics in large-scale heat pump systems
Keywords	Fault detection and diagnostics, learning-based condition monitoring, large-scale heat pumps, data-driven methods
Recruitment organisation	Fraunhofer Research Institution for Energy Infrastructures and Geothermal Systems IEG
Supervisors names and contacts	Shahin Jamali (FhIEG) – Shahin.jamali@ieg.fraunhofer.de
Scientific context and objectives	The transition towards a sustainable energy future is critically dependent on the integration of efficient technologies such as large-scale heat pumps into district heating networks to meet the growing EU energy demands and climate targets. However, successful integration of such technologies face various challenges including supply security, system reliability, and process resilience which pose significant technical obstacles that limits the widespread adoption of these sustainable energy system (SES) components at an industrial scale. Traditional fault detection and diagnostics (FDD) tools, primarily designed for primary applications within smart buildings, fail in addressing the unique complexities and reliability requirements of large-scale heat pump systems. To overcome the latter challenges, the project mainly aims to develop smart FDD methodologies focused on condition monitoring framework for large-scale heat pumps. This framework will be mainly based on data-driven fault detection and diagnosis (FDD) tools[1,2] that will utilize virtual sensors created through imitation learning. These tools will model and characterize the health and performance degradation process by framing it as a credit assignment problem. To address this, a health indicator function will be developed using deep reinforcement learning, designed to learn from and adapt to the multi-parameterized system dynamics of large-scale heat pumps. Additionally, experimental validation will be conducted for the developed FDD and condition monitoring and maintenance tools. Fraunhofer IEG is taking a leading role in the development of AI-based technologies for energy sector. The DC will join the Competence Center «Monitoring and Artificial Intelligence» and work in close collaboration with several colleagues at Fraunhofer IEG, who are engaged in AI and monitoring-related projects, such as GFK-Monitor[3] and OptiDrill[4]
Required skills	- A degree in engineering, computer science, or a related discipline, with a focus on control systems, data science, or energy systems is particularly advantageous - Sound knowledge of Data science methods, fault detection and diagnostics, control engineering or energy technology - Proficiency in data-driven modelling techniques and programming languages such as Python, MATLAB, or similar - Ability to conduct independent research, flexibility, along with strong analytical and problem-solving skills - Effective communication skills for working in interdisciplinary and international research teams - Desire for professional and personal development, possibly for a doctorate - Very good knowledge of English
References	[1] Outa, R. , Jamali, S. , Reinsch, T. , Bracke, R. , 'AI-Based Failure Detection and Prediction for Electrical Submersible Pump in Geothermal Wells using fibre optic distributed sensing'. The EGPD, April 2023. [2] Outa, R. , Jamali, S. , Reinsch, T. , Bracke, R. , 'Machine Learning-Based Failure Detection and Prediction for Electrical Submersible Pump in Geothermal Well'. Der Geothermiekongress 2023. [3] GFK-monitor.de/en [4] www.optidrill.eu