

Application of Artificial Intelligence Techniques in Geothermal Energy Management Systems for Improved Performance: A Review

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Abstract

Geothermal energy holds significant potential as a renewable energy source, aligning with sustainable development goals to reduce carbon emissions. This study explores the potential impact of geothermal energy in reducing environmental harm caused by fossil fuels. The African continent, particularly the East African Rift System (EARS), offers vast geothermal potential. Tanzania, for instance, has an estimated theoretical geothermal capacity of over 5000MWe, presenting a reliable and sustainable energy option. In line with this the Tanzania Geothermal Development Company (TGDC) has so far identified more than 52 potential areas where geothermal resources can be found and has taken steps into further exploration. To optimize geothermal energy generation, studies emphasize the

importance of understanding system architectures and design principles. AI plays a crucial role in this optimization, offering advanced technologies to analyze energy system patterns and generate meaningful insights. Machine learning algorithms and deep learning methods analyze industrial records and geological data to improve system efficiency and predict future sustainability. Digital twin an AI-based smart technology emerges as a transformative tool, allowing real-world modelling of geothermal plants for optimal operational efficiency. By dynamically changing system variables and observing real-time effects, digital twins enable continuous improvement and integration with AI ecosystems for ongoing optimization. Despite these advancements, challenges remain, including model accuracy and data quality. Ongoing research is needed to refine AI models, address uncertainties, and explore additional applications to optimize geothermal energy production. There is need to further perform computational based simulation modelling in establishing the required optimization parameters.

Keywords

Geothermal Energy, Artificial Intelligence (AI), Digital Twin Technology, Machine Learning (ML), East African Rift System (EARS).

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Biographies

Jared Kelvin Nganyi is an Emerging Technologies Researcher and Industrial Automation, Controls & Instrumentation Engineer with vast years of experience in manufacturing industry in programmable logic controllers (PLC), supervisory control and data acquisition (SCADA), BMS, and AutoCAD Electrical engineered designs, and drawings. Conducted site installation, supervision, and commissioning of the said projects systems. Project management, a key strength that I have gained over time in the industry while working with vast teams; partners, system integrators, contractors, and suppliers to deliver complex time bound projects. Specific areas of expertise include, data modelling and management, DBMS, UX and UI, user centered design, ISO/IEC/ IEEE standardization best practices, robotics, industrial automation, industrial control systems design, product development, building management systems (BMS), energy management and analytics, Industrial Internet of Things (IIoT), and embedded systems design.

Prof. Shubi Felix Kaijage is an Associate Professor of Electronics Engineering and Information Systems in the School of Computational and Communication Science and Engineering (CoCSE), at the Nelson Mandela African Institution of Science and Technology (NM-AIST), Arusha, Tanzania. He obtained Doctor of Engineering (Dr. Eng) degree from the University of Ryukyus, Japan, attained in 2011. His two-year post-doc research fellowship was carried out in 2011- 2013 at the Research Center of Terahertz Technology, Shenzhen University, Shenzhen, P. R. China. Furthermore, Shubi has vast experience in management, whereby since 2017, for over 5 years (March 2017 to August 2022); has been serving in the capacity of a Dean of the School of Computational and Communication Science and Engineering (CoCSE). During his tenure, as Dean, successfully made three (3) ICT-based demand-driven curricula/programs which are now offered in the school of CoCSE. Moreover, for two (2) years, from 2015, he worked as a Head of the Department of Communication Science and Engineering, before being appointed as Dean of the school.

Joel Nadebu Ouma is an Electrical Engineer with a solid record of accomplishment of over 9 years of experience in design and construction of Electrical, Telecommunications and Energy projects both in Public and Private sectors in Kenya. Eng. Nadebu is currently working at State Department for Public Works as a Senior Superintending Engineer and is responsible for design, documentation, supervision and management of government projects in the Built environment. He's interested in Building Automation, Artificial Intelligence, Energy Management and Telecommunications. Eng. Nadebu is a registered and licensed professional Engineer by Engineers Board of Kenya (EBK) and a corporate member of Institution of Engineers of Kenya (IEK).Tech.

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