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EDITORIAL

Artificial intelligence could revolutionise the education and training of the next generation of power and energy engineers and researchers

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1. Introduction

Modern power grids currently face several challenges, including aging infrastructure, increasing integration of variable renewable energy sources, the inability to cope with extreme weather events and cyberattacks, and grid congestion and rising costs. These challenges will impact energy security, economic development, and the clean energy transition (Voropai, 2020). It is well known that in many countries (in particular developing countries), the transmission lines, distribution systems, and substations are decades old and outdated and unable to meet the demands of 21st-century energy consumption. This is true, for instance, for South Africa, which has been plagued in recent years by interminable load shedding due to inadequate power generation and aging transmission and distribution infrastructure (Folly, 2021). The integration ofmore renewable energy sources (RESs) in the grid could alleviate some of the challenges that the grid is facing. Integrating RESs into the electric grid presents both significant opportunities and substantial challenges. Opportunities include reducing carbon emissions, improving energy security, and driving innovation in energy technology. Challenges include managing the intermittency and variability of renewable sources, ensuring grid stability and reliability, and addressing infrastructural needs (Ang, et al., 2022). The integration of RESs requires advanced grid management systems and potentially increased energy storage capacity.

Another challenge that the electricity grid has faced is related to grid resilience and cybersecurity. In recent years, there has been an increasing frequency and intensity of extreme weather events and various terrorist activities. These pose a threat to the physical integrity of the grid. Furthermore, the grid is becoming increasingly digital, making it more vulnerable to cyberattacks. Addressing these challenges requires a multi-faceted approach, including investments in grid modernisation, cybersecurity, and energy storage solutions, as well as regulatory reforms to facilitate innovation and investment (Omogoye, et al., 2021).

The increasing complexity and dynamism of power and energy systems increases the need to develop new, advanced solutions that can deal with the novel characteristics of the system. Artificial intelligence (AI), therefore, emerges as a natural resource to provide solutions to the challenges (Pito, 2022). Given the increasing importance of AI in the power and energy sector, it is crucial that the next generation of engineers and researchers acquire expertise in AI methodologies and applications (Rozite, et al, 2023).

AI has the potential to significantly impact the education and research endeavours of future power and energy engineers and researchers. By leveraging AI, educators can create personalised learning pathways, automate administrative tasks, and use advanced analytics to monitor student progress. In research settings, AI can accelerate discovery and

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innovation by automating complex data analysis, predictive modelling, and synthesizing large volumes of literature. By harnessing the power of AI, educators and researchers can work more efficiently, effectively, and collaboratively (Mishra, 2024).

It should be mentioned that Meta AI on WhatsApp was used to generate an outline for this opinion paper.

2. Current challenges in power and energy education

Power and energy education faces a range of challenges that impede its effective delivery. These challenges include the misalignment of curricula with industry needs, inadequate resources, limited opportunities for practical experience, and constraints in accessing funding for infrastructure development and equipment acquisition. These challenges are especially acute in developing countries, where they can have far-reaching consequences for both educational institutions and the development of the energy sector.

Power and energy systems are becoming increasingly complex, with the integration of renewable energy sources, energy storage, electric vehicles, and smart grid technologies. Addressing the complexity of power and energy system necessitates a paradigm shift in traditional planning, operation, management, and transactional approaches that have been employed for decades.

The existing education system, designed to meet the needs of the industrial era, is no longer aligned with the demands of the modern workforce. Traditional pedagogical approaches, characterised by passive learning and standardised curricula, is often not adequate to engage students or equip them with the skills and competencies required to succeed in today's rapidly evolving job market.

Our education system, which was conceived in the industrial era to produce workers for mass production, is outdated and in need of transformation. Furthermore, the absence of sufficient hands-on experience and real-world exposure to power and energy systems can create a gap between theoretical knowledge and practical application, making it challenging for students to develop the skills and expertise needed to effectively contribute to the industry. The availability of modern equipment, software, and expertise is essential for providing students with a comprehensive and industry-relevant education. However, educational institutions (particularly in developing countries) may face limitations in accessing these resources, and this can impact the quality of education and students' preparedness for the workforce.

3. Artificial intelligence: Its benefits and applications in power and energy education

The strategic integration of AI in power and energy education could redefine the boundaries of teaching and learning. AI can offer numerous applications in power and energy education, primarily focusing on improving teaching and learning experiences, enhancing curriculum content, and preparing students for the future of the energy sector. These applications range from more effective, personalised and efficient learning platforms to AI-powered simulation tools and data analytics. Integrating AI could offer several benefits, including increased student engagement and motivation, greater efficiency, enhanced practical skills, and better student outcomes.

AI should not replace human teachers, but should, rather, augment their capabilities, providing valuable insights, support, and resources to enhance student learning outcomes. As AI technologies continue to advance, they will play an increasingly important role in shaping the future of education, driving innovation, and improving the quality of education.

The integration of AI in power and energy education can help address several key challenges, including the following (Meta AI, 2025):

- AI-powered adaptive learning systems can create tailored learning experiences that cater to individual students' needs, abilities, and learning styles, promoting more effective knowledge acquisition.
- AI-driven simulation tools can model complex power systems, allowing students to analyse and optimise system performance under various scenarios. This will allow students to apply theoretical knowledge in a safe and controlled environment and develop practical skills.
- AI-driven forecasting tools can help students understand the variability of renewable energy sources and develop strategies for integrating them into the grid.
- AI-driven smart grid simulations can help students understand the complexities of grid management, including demand response, energy storage, and grid resilience.
- AI-powered energy management systems can optimise energy consumption and generation, providing students with real-time data and insights to inform their decision-making.
- AI-powered tutoring systems offer one-on-one support to students, providing real-time feedback, guidance, and assessment, and helping to bridge knowledge gaps.
- AI-driven predictive analytics can enable educators to identify at-risk students, predict stu-

dent outcomes, and optimise educational interventions, ultimately improving student success and retention.

4. Conclusion and recommendations

The future of power and energy education is being shaped by AI, offering innovative solutions to enhance the learning experience, improve student outcomes, and address industry challenges. As the power and energy sector continues to evolve, it is essential that educators and industry professionals work together to develop and implement AI-powered educational solutions that prepare the next generation of professionals for the challenges and opportunities of the future.

The integration of AI in power and energy education is poised to revolutionise the way students learn. By leveraging AI-powered solutions, educators can create more engaging, effective, and industry-relevant learning experiences that drive student success and address pressing industry challenges. As the power and energy sector continues to evolve, the development and implementation of AI-powered educational solutions will require close collaboration between educators and industry professionals to ensure that the next generation of engineers is equipped with the knowledge, skills, and expertise necessary to thrive in a rapidly changing industry. Educational institutions should invest in AI-powered simulations, virtual labs, and intelligent tutoring systems and partner with industry professionals to develop and implement AI-powered educational solutions and continuously evaluate and improve AI-powered educational solutions to ensure they remain effective and relevant. Moreover, educators and students should develop a basic understanding of AI concepts and applications. By embracing AI in power and energy education, we will be able to create a more engaging, effective, and efficient learning experience that prepares students.

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