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Fundamentals CPD

Artificial Intelligence & Energy Management

By Andrew Cooper, managing director of EDGE APM

The purpose of this CPD article is to introduce the subject of Artificial Intelligence (AI) to readers. The article will explore what AI is, examine its current applications, and discuss its future potential, particularly in relation to supporting energy managers. The article considers the impact of AI on different sectors where energy managers might be engaged, and while it seeks to provide practical examples, it does so at a high-level. The examples provided, and AI categories and technologies covered, are not exhaustive.

An introduction to Artificial Intelligence (AI)

AI is a branch of computer science that aims to create systems capable of performing tasks that would normally require human intelligence. These tasks include learning and adapting to new information, understanding human language, recognising patterns, solving problems, and making decisions.

There are different categories of AI, and this article considers those categories that could be most relevant to energy managers now and in the future. This includes:

- Narrow AI, which is designed to perform a specific task such as voice recognition.
- Generative AI, which can create new content that is similar to human-generated content. This includes images, sounds, or text, and predictive patterns. It's often used in creative fields like music, art, and design.
- General AI or Artificial General Intelligence (AGI), which can perform, and potentially exceed, any intellectual task that a human being can do. However, this currently remains a theoretical concept within the field of AI research. According to UK government, a number of AI companies have publicly stated their aim to build AGI and believe it may be achievable within the next twenty years. Other experts believe we may not build AGI for many decades, if ever[1].

An example of a technology that uses Narrow AI is Amazon's 'Alexa' and Apple's Siri which amongst other things can control household appliances, including building services, when connected (i.e., "Alexa/Siri change my heating temperature setpoint" etc.), but Narrow AI is also used in building services controls, and building management systems, including building energy management systems.

The most well-known example of Generative AI is ChatGPT – which generates new text. But it also has a use in energy management. For example, Generative AI algorithms can help automate maintenance tasks and identify potential problems before they develop into expensive repairs and/or interfere with operations.

Generative AI can scrutinise sensor data, historical maintenance records, and property or industrial features to recognise patterns and forecast maintenance needs. This anticipatory approach assists you in prioritising maintenance tasks, optimising resource distribution, and reducing operational costs. And generative AI has a key role to play when creating the interface(s) between smart grids and buildings, which is clearly explained in the case study 'Artificial Intelligence for Building Energy Management Systems'[2].

AI and regulations

AI is a rapidly evolving technology, and its growth carries risk. These risks are referenced in a short video prepared by the International Energy Agency (IEA)[3]. However, the regulation of AI is not uniform across the world.

In some countries, AI is subject to specific regulations. For instance, in the European Union (EU), the General Data Protection Regulation (GDPR) has provisions that apply to AI. The GDPR requires that individuals have the right to explanation when they are subject to automated decisions, which includes decisions made by AI systems.

In March 2024 the EU adopted new regulations[4] specifically for AI that would create legal requirements for high-risk AI systems, including those used in critical infrastructures, education, employment, and public administration.

In other countries there is a more laissez-faire approach to AI regulation. For example, in the United States, there are currently no federal laws specifically regulating AI. Instead, existing laws and regulations that apply to privacy, discrimination, and safety are used to govern AI systems. However, in October 2023 the White House issued an Executive Order on the Safe, Secure, and Trustworthy Development and Use of Artificial Intelligence[5].

Outside of national and international regulatory frameworks the international standard for AI Management System is ISO/IEC 42001 Information technology - Artificial Intelligence - Management System. The standard outlines internal governance and risk management, with the aim of supporting AI development, building business confidence internally and externally, and providing a route for regulatory compliance. In February 2024 Australia announced that it had adopted the standard[6].

As part of this CPD readers should watch a short video prepared by the IEA.



https://www.youtube.com/watch?v=oxD4Wv74G4Q

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AI and the Fourth Industrial Revolution

AI is part of a wider digital revolution encompassing a range of digital technologies, concepts and trends. For example, alongside AI sits the Internet of Things (IoT). Some have named this the 'Fourth Industrial Revolution'. According to the World Economic Forum: "We stand on the brink of a technological revolution that will fundamentally alter the way we live, work, and relate to one another. In its scale, scope, and complexity, the transformation will be unlike anything humankind has experienced before."[7]

2019 research by PwC UK, commissioned by Microsoft[8], estimated that using AI for environmental applications could contribute up to $5.2 trillion USD to the global economy in 2030 and reduce GHG emissions by 4%. This is/was an amount equivalent to 2.4 GT CO2e – equivalent to the 2030 annual emissions of Australia, Canada and Japan combined.

The International Energy Agency (IEA) recognises the significant role of AI in improving energy efficiency and reducing greenhouse gas emissions. In its 2017 report 'Digitalisation and Energy'[9], the IEA estimated digital technologies such as AI could cut total energy use in residential and commercial buildings by around 10% by 2040. It stated: "These efficiency gains are largest in heating and cooling, particularly through the use of smart thermostats and sensors. Smart lighting allows for potentially substantial cuts in lighting electricity demand."

Similarly, the Energy Institute reports that if scaled across industry, digital technologies could deliver up to 20% of the 2050 reduction needed to hit the IEA's net zero trajectories in the energy, materials and mobility industries[10].

These kinds of figures have led the UK government to predict the UK AI market will grow to over $1 trillion (USD) by 2035 [11].

AI in energy management

AI can be used in energy management in several ways. Firstly, it can be used to optimise energy consumption. AI algorithms can analyse data from various sources such as weather forecasts, historical energy usage patterns, and real-time data from sensors. This analysis can assist in forecasting future energy requirements and modifying control strategies in building services, industrial processes, transportation and energy infrastructure systems alike.

Secondly, AI can be used to manage renewable energy sources more effectively. For instance, AI can predict the output of solar panels or wind turbines based on weather forecasts and adjust the operation of these systems to maximise their efficiency. This helps to reduce reliance on fossil fuels and lowers greenhouse gas emissions.

Thirdly, AI can be used to detect faults and anomalies in energy systems. By continuously monitoring the performance of these systems, AI can identify any deviations from normal operation(s) and alert maintenance staff before a major breakdown occurs. This not only prevents costly repairs and potential downtime to critical infrastructure but also ensures that energy systems are always operating at their peak efficiency.

AI in buildings

In the UK 80% of the buildings that will be standing in 2050 have already been built[12]. At the same time, it is widely understood that there is a significant performance gap between 'as designed' new buildings and the reality of their operations. If we are to deliver a zero-carbon estate, we must get better at predicting energy consumption and managing that consumption throughout the lifecycle of a building, and AI has a significant role to play in this.

AI algorithms can analyse historical data on energy usage and environmental conditions to predict future energy needs. This allows building managers to adjust heating, ventilation, and air conditioning (HVAC) systems in advance to meet anticipated demand, reducing energy waste and saving money.

Smart thermostats can learn from occupant behaviour and adjust temperature settings accordingly to optimise comfort and energy efficiency. Similarly, AI-powered lighting systems can automatically control and adjust brightness levels based on natural light availability and occupancy patterns. These systems, which are already available, can also be operated through wireless controls systems using open protocols such as DALI. With the removal of additional cabling requirements, networks can be expanded with minimal disruption - extra spaces or even separate buildings can be integrated into the same system.

Forming part of an IoT, these lighting systems can 'track occupants' as they move around the building, while also allowing connection to the BMS for HVAC controls and optimisation strategies. They could potentially be used to identify if and where occupants are in a building in the event of an emergency such as a fire.

By continuously monitoring system performance and analysing data from sensors installed throughout the building, AI can detect anomalies that may indicate a malfunctioning piece of equipment or an area of the building that is not being heated, cooled or ventilated efficiently. This allows for proactive maintenance and repairs, preventing energy waste and reducing operational costs. This approach to maintenance is often referred to as predictive maintenance.

AI can also play a crucial role in predicting peak demand periods and adjusting building systems accordingly. An example might be using AI to ensure buildings reduce their energy consumption during the times when electricity prices are highest. This not only saves money but also helps stabilise the grid.

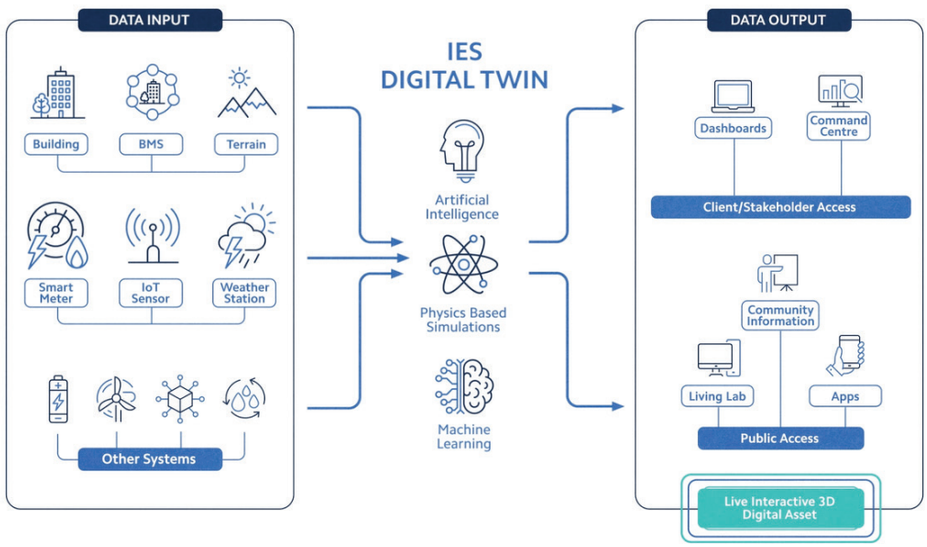
Advanced analytics also enable the creation of digital replicas of physical assets ("digital twins") that can be used to simulate and optimise design and operation. Rather like BIM, which allows for integrated coordinated space planning in a virtual environment before, during and after construction, an AI enabled digital twin allows organisations to stress test multiple design and/or operational scenarios in a virtual environment using self-learned and predictive generative algorithms.

IES has prepared a 3.5 minute video[13] on how it uses AI in its digital twinning solutions. Readers should watch the video as part of this CPD.

AI in industrial processes

AI can learn from past performance data

Figure 1: How AI and machine learning can bring life to physics-based simulations to create Generative AI digital twinning.



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and continuously adjust operational parameters to maximise efficiency. For instance, in a manufacturing plant, AI could control machinery and equipment, adjusting their operation based on real-time data to minimise energy consumption. This level of automation not only reduces energy waste but also frees up human resources for more strategic tasks.

An example of AI being used in industry is BMW and its use of Car2X and AIQX AI technologies[14]. The BMW Group is using AI to transform the models in production into communicative aids that, for instance, offer continuous information about their assembly status or independently identify and report assembly mistakes.

As with buildings, AI can also facilitate proactive predictive maintenance strategy in industrial settings. This is particularly important in the industrial sector where some industries are business critical to the wider economy and national infrastructure. And again, as with buildings, AI makes digital twinning possible even in the most of complex industrial settings.

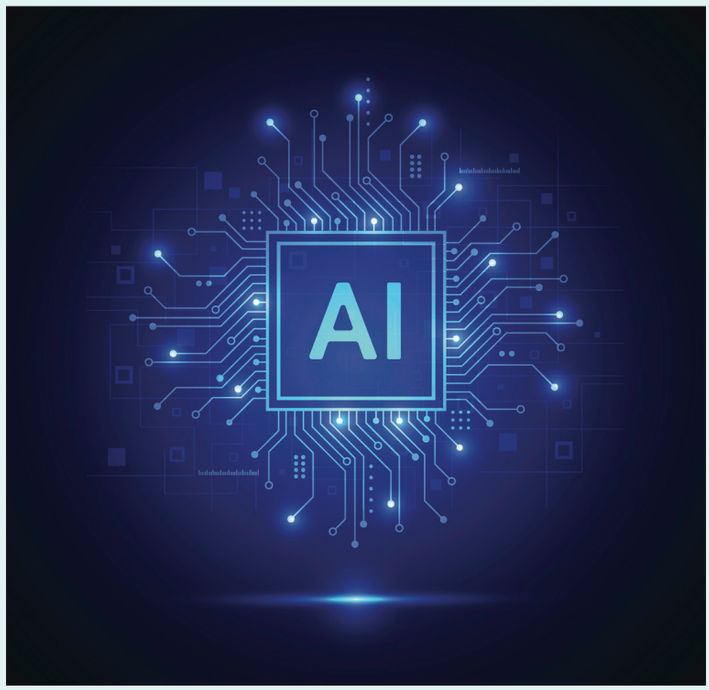
AI and transportation

The transport sector is one of the largest consumers of energy and accounts for around one-fifth of global carbon dioxide (CO_2) emissions[15].

AI can optimise route planning for transport vehicles. By analysing traffic patterns, weather conditions, and other factors, and it can suggest the most efficient routes for drivers. This not only saves time but also reduces fuel consumption. AI can help manage fleets by determining the optimal number of vehicles needed for a particular route or time, thereby avoiding unnecessary energy use.

In electric vehicles (EVs), AI can enhance energy management by optimising battery usage. It can predict the energy consumption based on driving patterns and route information, allowing for more efficient use of battery power. Furthermore, AI can assist in smart charging strategies for EVs. It can determine the best times to charge based on factors like electricity rates and grid load, helping to balance the demand on the power grid and save costs.

AI can also facilitate energy-efficient driving behaviours. For example, it can provide real-time feedback to drivers on their driving habits, suggesting improvements that could lead to lower fuel consumption. Many EV cars (and some modern ICE cars) have integrated speed and distance control. When this is used, the AI systems within the car maximise efficiency and range-saving energy. The 'sat nav' can continuously compute the most energy efficient journey based on real time data. Brought together, EVs and AI combined have enormous potential to save energy and decarbonise fleet vehicles.



AI in energy systems

Possibly more than any other sector, AI has the potential to revolutionise our energy systems and many of the capabilities and opportunities already discussed throughout this article are applicable to the energy sector.

The decarbonisation of energy systems, including electrical infrastructure and heat networks, is critical for the world to meet international agreements on limiting the worst impacts of climate change. AI can be used to facilitate and enhance the operation of smart grids, heat networks and heat and power networks.

Smart grids are electricity networks that use digital technology to monitor and manage the flow of electricity from all generation sources to meet the varying electricity demands of end users. AI can be used to analyse data from sensors and smart meters to detect anomalies, predict failures, and optimise the flow of electricity. This can improve the reliability and resilience of the grid. AI can be used to manage distributed energy resources, such as rooftop solar panels and battery storage systems. AI algorithms can determine when to store electricity in batteries for later use or when to feed it back into the grid.

AI is key to maximising the financial worth of renewable energy and facilitating its easier integration into the grid. An example of this type of approach is Google and its AI subsidiary DeepMind which developed a neural network in 2019 to enhance the accuracy of forecasts for 700 MW of wind power capacity. Based on historical data, the network developed a model to predict future output up to 36 hours ahead with significantly greater precision than was previously achievable[16].

AI can also help to efficiently 'manage out' or optimise older fossil fuel power stations as we transition to low carbon fuel sources. Australian technology company Synengco has utilised its AI-enabled technology, SentientSystem[17], to optimise operations in complex industrial and power station infrastructure systems for over twenty years.

Finally, UK Power Networks has been able to speed up its electricity connection upgrade services through a partnership with Google involving digitalisation of its electricity cable maps[18]. Google's DeepMind engineers have partnered with the distribution network operator (DNO) to create the digital versions of its electricity cable maps, which span over 180,000km of electricity cables. Digital maps mean UKPN can provide better, faster services to customers who apply for upgraded electricity connections when, for example, they need to connect renewable energy sites or electric vehicle (EV) charging hubs.

In keeping with the theme of this article, the co-author is ChatGPT.

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Please mark your answers below by placing a cross in the box. Don't forget that some questions might have more than one correct answer. You may find it helpful to mark the answers in pencil first before filling in the final answers in ink. Once you have completed the answer sheet, return it to the address below. Photocopies are acceptable.

Questions

Question 1: What type of AI does Alexa and Siri use?
- ☐ Artificial General Intelligence
- ☐ Generative AI
- ☐ Narrow AI
- ☐ Reactive Machines AI

Question 2: Which type of currently available AI can assist with predictive behaviour?
- ☐ Artificial General Intelligence
- ☐ Generative AI
- ☐ Narrow AI
- ☐ Reactive Machines AI

Question 3: In the IES case study / video on digital twinning, what was the value of potential energy savings identified for NTU Singapore by the digital twin?
- ☐ S$4.75million
- ☐ S$5.75 million
- ☐ S$6.75million
- ☐ S$7.75 million

Question 4: Under the European Union the General Data Protection Regulations, which of the following statements is correct?
- ☐ Individuals have no right to explanation when they are subject to automated decisions made by AI systems, and that introduces systemic risk
- ☐ Individuals have the right to explanation when they are subject to automated decisions made by AI systems
- ☐ The regulations are silent on AI, which is why the EU has passed new regulations
- ☐ The regulations prohibit the use of AI

Question 5: Which of the following International Standards applies to the management of AI systems?
- ☐ ISO/IEC 42001
- ☐ ISO/WD 19011
- ☐ ISO/IES 27000
- ☐ ISO 50001

Question 6: How many industrial revolutions have there been?
- ☐ Three
- ☐ Four
- ☐ Five
- ☐ Six

Question 7: What percentage of UK buildings in 2050 are estimated to have already been built?
- ☐ 50%
- ☐ 60%
- ☐ 70%
- ☐ 80%

Question 8: In the short video by the International Energy Agency on digitalisation and energy, what is the main risk it highlights from digitalisation?
- ☐ Systemic failure due to unprecedented levels of data and internet traffic
- ☐ The threat of cyber-attacks
- ☐ Alienation and exclusion of large segments of the global population who cannot access or use a computer
- ☐ All of the above

Question 9: DeepMind developed a neural network in 2019 to enhance the accuracy of forecasting future generation of wind power. But by how many hours ahead could it predict future output?
- ☐ 35 hours
- ☐ 39 hours
- ☐ 33 hours
- ☐ 36 hours

Question 10: One of the benefits of AI enabled lighting systems is:
- ☐ No additional cabling requirements when extending networks
- ☐ Integration into other systems such as BMS or even fire alarm/control systems
- ☐ Cheaper to install
- ☐ They look great, helping to find new occupiers for buildings

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