Sustainable Development in the energy Sector using Artificial Intelligence

Naresh Chhabra [1]

Abstract

Technological advancements in the field of Artificial intelligence (AI) are being adopted by society at large since it has the potential to change the way we transact. Conventional methods are being disrupted, and it has an enabling impact in most cases. In the Energy sector, the Digitisation model is being adopted, driven by AI technology. From Generation to Transmission, from demand to supply, all are now managed automatically with the help of smart algorithms that are almost human-like. These software applications optimise operations and aid decision-making. However, AI is yet to sit in the chair to make decisions because AI is still a utopian concept that may conflict with the co-existence of man and machine. This path could lead to economic downfall and have an adverse impact on sustainability.

This study aims to examine recent advances in AI technology and its use in energy supply and demand management, especially in the context of SDG 7. This transition from a conventional system to newer technological advanced management will impact leadership, necessitating a certain kind of training and education. Thus, the business and energy industry need to focus on adopting AI technologies, while public policies should be in place to regulate developments and their implementation to protect customer privacy, information security, and customer safety. This article combines perspectives from the energy industry and public policy to analyse the impacts of AI on Sustainable Development in the Energy sector. In conclusion, the paper draws some inferences for management/leadership amid state-of-the-art technological and social change in the Energy sector.

Keywords: Artificial Intelligence (AI), Sustainable Development Goals (SDG), Internet of Things (IoT), energy supply and demand, big data, energy digitisation

[1] Commodore, Indian Navy

1.Introduction

In 2017, Warren Buffet, a very successful stock market investor, was asked about the impact of AI. He said, "AI is here to disrupt." Now, Warren Buffet knows a lot about investing, but he's not an AI expert. So, should we be concerned about what he said? The answer is yes, because AI is indeed changing the way we live. We have things like Siri, Alexa, self-driving cars, and smart technology that suggests things to us. Companies like Yahoo, Twitter, Amazon, and Google also use AI to provide us with helpful tools. For example, Google saved a lot of money using AI to manage its devices better (Kaplan and Haenlein, 2019). So, AI is already here and is changing our society. It's up to us to think about what we need to do. And policymakers need to make plans for a future where AI plays a big role. Right now, the world is on the edge of a big change with technologies like AI, Quantum Computing, and 5G. These technologies will affect how we communicate, live, work, and more.

Advancements in AI are important, but they need rules to make sure they help sustainable development. If we don't have rules, AI might not be transparent or ethical, which could be unsafe. AI has gotten really good at things like recognizing images, understanding speech, and making decisions, often doing better than people. Using AI and automation costs a lot of money, and this is connected to how well it works. Money is becoming the most important thing for making things happen, which could mean less need for human work and productivity. This might make inequality worse and cause big changes in society and the economy, unlike anything we've seen in a long time. All of this can have serious effects on how people live and on global goals for equality and development.

Machine Intelligence vs. Human Intelligence

Artificial Intelligence (AI) is like making machines smart with technology, so they can do things that seem like human thinking (Marr, 2018). But AI and natural human intelligence (NI) are different. AI is faster and usually works without breaks, while NI can be more impartial but sometimes makes biased decisions. NI can handle really tricky tasks better than AI and is better at doing many things at once. NI can also move around better, but AI can adapt quicker because it doesn't take thousands of years to change like NI. AI used to be expensive, but it's getting cheaper fast. It's becoming so good that it's replacing some human jobs, but not all at once.

In the future, humans might merge with AI, and robots might become a part of us (Harari, 2017).

2.Growth of AI

AI had its beginnings in 1950 when Alan Turing came up with a test called the Imitation Game. This test helped tell if a response came from a human or a machine. Then, in 1956, John McCarthy organized a workshop called the Dartmouth workshop. This is where the term "Artificial Intelligence" was first used, and people who were interested in AI discussed the problems they wanted to solve. In the 1970s and 80s, computers became much more powerful, but AI was mostly a thing in research labs. In 1996, IBM's computer program Deep Blue did something big – it beat the world chess champion, Gary Kasparov. This made many people think that AI had become so smart that it could outthink humans, at least in a game that was considered very hard for a machine.

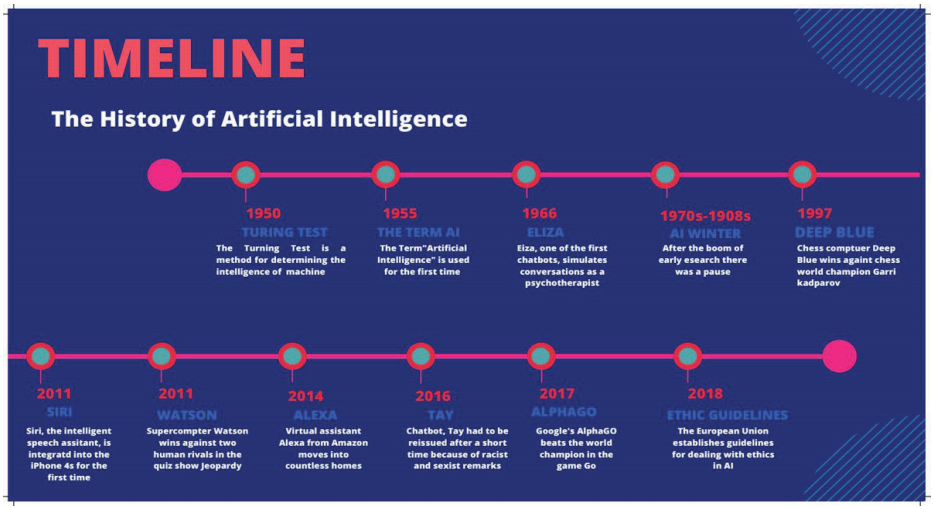

Figure 1: Growth of AI

The advent and subsequent rapid spread of the internet convinced computer scientists and researchers that computing and applications could be done in a distributed manner. In addition, advances in the field of big data, cloud computing, and neural networks have shaped AI into what it is today.

While AI can be categorised as Narrow, Strong, and Artificial General Intelligence (AGI), any machine capable of displaying or equipped with at least one human-like ability can be called artificially intelligent. In other words, humans are striving to make machines mimic natural intelligence. Thus, AI can be defined as the science that focuses on the development of functions similar to human intelligence, including cognition, reasoning, speech recognition, language skills, problem-solving, and the ability to respond to emergency situations. This multidisciplinary science calls for collaboration between various departments such as computer science, biology, psychology, linguistics, mathematics, and engineering, making AI unique and distinct from other technologies.

3.AI and Sustainable Development

Jeffery Sachs, Senior Advisor to the UN on SDGs and also the director of the UN Sustainable Development Solutions Network (USDSN), stated that the world is at an age where nations must collaborate and contribute to the eradication of poverty, social inclusion, economic justice, and environmental protection (Sachs, 2015).

He proposed a framework at the 2002 UN World Summit on Sustainable Development (WSSD) in Johannesburg, suggesting the four pillars of economic development, social development, environmental protection, and good governance as four components for analysing sustainable development (World Summit of Sustainable Development [WSSD], 2002, p. 2). However, Sachs did not take cognisance of newer technologies like AI. Thus, the impact of dynamic and evolving AI on Sustainable Development, which is emerging now, needs to be studied and utilised to its full potential.

Artificial General Intelligence (AGI), still a theoretical concept, has Human-Level Machine Intelligence (HLMI) (Artificial Intelligence, 2018), causing concerns that AGI will not only take away jobs but also replace humans as the superior species. Though the timelines are anyone's guess, jobs are being replaced through improved efficiencies in both production and supply chains. Such developments directly impact SDG #9 pertaining to Industry, Innovation, and Infrastructure and SDG #8 for Decent Work and Economic Growth favourably but have an adverse effect on SDG #10 and #1 because they do not reduce inequalities; rather, they bring in inequalities and poverty.

Some people believe that AI can help reduce inequality by sharing the benefits of increased production and efficiency, which aligns with SDG #10 (Reduced Inequalities). However, in the past, this hasn't happened because of a lack of awareness, people's efforts, and fair justice systems. While the future might be different, it's not realistic to think that those who create and own the next AI technology will give it away for free to everyone. Instead, they are more likely to use it to make themselves richer, which could widen the gap between those who have the technology and those who don't. This unequal distribution of wealth, knowledge, and power won't just be at the individual level but could also be concentrated in specific countries and cities. This would make global inequalities even worse and make it harder to achieve SDG #10 (Reduced Inequalities).

Instead, if nations rise above the goal of amassing wealth and keeping knowledge as their domain, as propounded by Jeffrey Sachs, AI can be harnessed in a wide range of economic sectors and situations to contribute to managing environmental impacts and climate change, which is humanly impossible. Some examples of applications include AI-infused clean distributed energy grids, precision agriculture, sustainable supply chains, environmental monitoring and enforcement, and enhanced weather and disaster prediction and response. Research by PwC UK, commissioned by Microsoft, models the economic impact of AI's application to manage the environment across four sectors—agriculture, water, energy, and transport. It estimates that using AI for environmental applications could contribute up to $5.2 trillion USD to the global economy in 2030, a 4.4% increase relative to business as usual. In parallel, the application of AI levers could reduce worldwide greenhouse gas (GHG) emissions by 4% in 2030, an amount equivalent to 2.4 Gt CO2e—equivalent to the 2030 annual emissions of Australia, Canada, and Japan combined.

At the same time as productivity improvements, AI could create 38.2 million net new jobs across the global economy, offering more skilled occupations as part of this transition. Recently, Stanford University launched an institute for Human-Centered Artificial Intelligence (HAI) that will bring together experts from various fields like economics, philosophy, ethics, psychology, and others (Marconi, 2019).

4.AI and Energy Management

The global economy is highly dependent on energy production and distribution (Jha et al., 2017). However, the current infrastructure in the energy sector, mainly the power grid infrastructure, is too old, inefficient, obsolete, prone to faults, and lacks inherent safety or protections under fault conditions. Furthermore, the conventional power grid infrastructure was not designed to accommodate the integration of Renewable Energy Sources (RES). The challenge to be addressed is the supply characteristics of RES in relation to the variable loads handled by the grid, and AI technology is seen as an effective and efficient solution. Since SDG #7 is about ensuring clean and affordable energy, it is imperative to adopt and deploy AI alongside traditional energy infrastructure because it is key to the development of agriculture, communications, healthcare, transportation, and, in other words, overall economic development. The lack of access to energy will hinder economic and human development.

The UN has established certain targets under SDG #7, which include ensuring universal access to affordable, reliable, and modern energy services, substantially increasing the share of renewable energy in the global energy mix, and doubling the global rate of improvement in energy efficiency by 2030. Sub-targets 7A and 7B also aim to enhance international cooperation to facilitate access to clean energy, research, and technology, and promote investment in energy infrastructure. This is intended to expand infrastructure and upgrade technology to provide modern and sustainable energy services for all in developing countries.

This is important because the United Nations' Sustainability Development Goals Report for 2022 shows that progress is being made towards sustainable energy goals. However, the rate of progress right now is not enough to reach Goal #7 by 2030. There are still significant differences in access to clean and sustainable energy. While the global access to electricity improved from 83% in 2010 to 91% in 2020, the number of people without electricity decreased from 1.2 billion to 733 million during that time.

From 2018 to 2020, the rate of electricity access increased by an average of 0.5% each year, which is slower compared to the 0.8% yearly increase from 2010 to 2018. At this current pace, only 92% of the world's population will have access to electricity by 2030, leaving 670 million people without it. The proportion of people using clean cooking fuels and

technologies went up from 57% to 69% between 2010 and 2020. However, in 2020, 4 billion people still had to rely on inefficient and polluting cooking methods.

The share of renewables in total final energy consumption reached 17.7 per cent in 2019, which was 1.6 percentage points higher than in 2010. Lastly, the goals aim to address energy efficiency, where global primary energy intensity (energy efficiency) improved from 5.6 Mega Joules per US dollar in 2010 to 4.7 in 2019, with an average annual improvement rate of 1.9 per cent. To meet the energy efficiency target, the annual rate of improvement until 2030 will need to average 3.2 per cent a year. To achieve all the above-stated targets under SDG #7, it is essential for the global community to adopt AI technology to revolutionize the energy sector. From generation to control, forecasting, and efficient demand management, AI can handle these tasks with minimal human intervention. AI can manage efficient device control, such as transformers and inverters, and monitor power points. The role of AI in planning and forecasting load demand (Kong et al., 2018), forecasting solar energy (Rodríguez et al., 2018), forecasting wind energy (Ren et al., 2015), and forecasting hydro and geothermal energy (Debnath and Mourshed, 2018) has been well-established.

With the substantial increase in AI deployment and IoT in the energy industry and smart grid infrastructure control, cyberattacks have been studied, and solutions to prevent these attacks are increasing rapidly (Sani et al., 2019). These attacks can destroy infrastructure and exacerbate climate concerns (for example, if a cyber-attack destroys a nuclear power plant, it can be very harmful to the environment) and lead to significant economic losses. Can AI eliminate the possibility of cyberattacks? AI can help trace the suspects of attacks and determine what additional evidence is required to conclude automated investigative AI algorithms. The adoption and concept of AI and IoT will notably enhance the smart grid's security against cyberattacks (Sani et al., 2019). References (Minoli et al., 2017) and (Yang et al., 2017) provide solutions to prevent cyberattacks on smart grid infrastructure. AI's ability to handle large volumes of data is a significant benefit for power system protection. This is achieved by automating the development of security threat algorithms.

AI's digital technologies will enable the renewable energy industry in several ways, including the maintenance and operation of renewable energy sources, improved monitoring of power infrastructure, more secure

system operations, and new market designs (International Energy Agency, 2017). Key innovations and dimensions in AI applications can be categorised into key components, including energy market design, business models, system operations, and enabling technologies (International Energy Agency, 2017).

Countries worldwide began outlining their AI strategies from 2017 onwards. The timelines are outlined by Dutton and are shown in the figure.

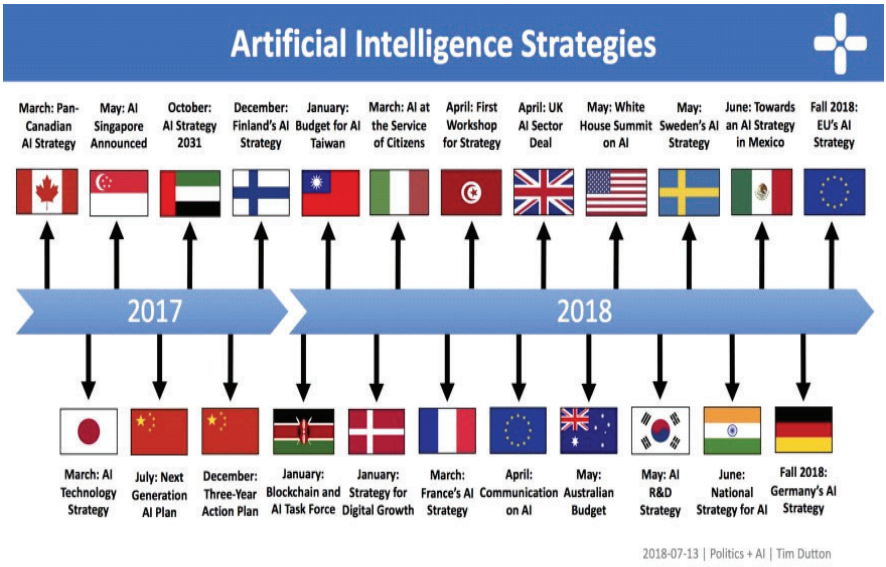

Figure 2: Timelines of AI Strategy by Dutton

Enunciation of AI strategies has made neural networks, expert systems, pattern recognition, and fuzzy logic models the focus of energy research (Demirci et al., 2019). During the research, it became evident that there are bottlenecks for adopting AI in the energy sector. The quality and, in some cases, the lack of data itself are the biggest bottlenecks. While Quantum computing works in favour of AI, it also increases the probability of hacking. While AI and sustainability go hand-in-hand, an AI algorithm currently produces an enormous carbon footprint, which has a reverse effect on other SDGs (Nishant et al., 2020).

Another challenge is the lack of AI skills and domain knowledge among decision-makers in the energy sector. While there are professionals with

significant technical depth, there are few who possess both AI knowledge and the requisite experience in the energy sector to develop AI-powered applications for the energy sector. The existing power system infrastructure is definitely outdated and is not compatible with the requirements of AI-enabled systems. This necessitates a significant amount of capital investment and leads to the development of economic pressure, which developing countries are not capable of absorbing (Fickling, 2019). AI, being a black box concept for an ordinary consumer, fails to earn trust and is therefore one of the biggest hurdles to its acceptance

5.AI Technology and Management Leadership

Accepting AI is not just a technical matter; it's a social and technical issue because it depends on various factors, and the most important group involved is society, meaning all of us. There are challenges when it comes to accepting AI as a helpful tool, including cultural differences, trust problems, judgments, and especially ethical concerns. AI isn't perfect and can have biases in its algorithms, which can lead to harmful outcomes (Barocas et al., 2017). While people are still studying these biases, AI has the potential to help with things like energy and achieving the Sustainable Development Goals.

However, it will only work well if future managers and business leaders are ready to deal with the opportunities and challenges that come with this new technology. Deciding whether to use a certain technology can make or break an organization. Sometimes, using new tech can give a big advantage and lead to success, while other times, it's necessary just to survive. There are cases where companies failed because they couldn't adapt to technological changes. AI is one of those technologies in today's rapidly changing world during the Fourth Industrial Revolution.

However, AI's promise of increased efficiency and production comes with some drawbacks. To achieve their production goals, organisations must not only find but also retain competent talent. At the same time, businesses must be cautious about putting safeguards in place to reduce the hazards associated with AI. According to the AI Index report 2021, the hiring rate in all sample nations increased in 2020. From 2016 to 2020, the countries with the highest increase in AI hiring include Brazil, India, Canada, Singapore, and South Africa. India has a hiring Index of 2.8, the USA 2.1, and Singapore 2.5.

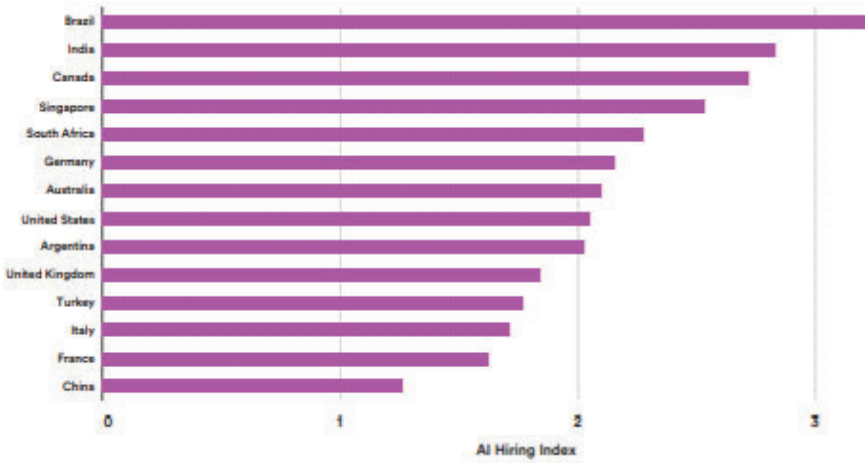

Figure 3: AI Hiring Index by Country, 2020 (Source: LinkedIn, 2020| Chart: 2021 AI Index Report)

The disparity among countries in the adoption of AI is evident in various reports, and thus there will be a divide between nations in capturing the potential benefits. To reduce this gap, it is considered essential that future leaders be taught the micro and macro levels associated with AI technology. At the micro level, Science, Technology, Engineering, and Mathematics (STEM) will play a vital role, as emphasized by Galperin, 2010; Ogunsola & Okusaga, 2006; Schwab, 2018.

At the macro level, the adoption of AI applications can reap great benefits. This can involve studying and analysing a problem, arriving at probable solutions, finding the optimal solution, which can be evaluated for its effectiveness. If found suitable, the knowledge can be shared worldwide.

Deep learning techniques can be used to train the network or the AI application about the problem, which can learn, store, compare, and recommend at a much higher pace than humans can even think of. This very ability is suggested by this paper to be utilised for solving the problems identified by the SDGs. This new model can facilitate remote data collection at the individual level and aggregate the results, which is otherwise not possible. The application can be made open-source, where anybody can add to the pool of knowledge. This can make it an educational and learning tool that learns with time and a changing environment. Thus, the education system must innovate to teach today's students, who will be tomorrow's leaders, about AI and the tools available

in various sectors for economic growth and sustainable development of the nation.

The fact that future leaders will encounter niche technologies like AI in their work environments demands that the government take steps now to change the curriculum in a way that introduces the concept of data science and emphasises that data is the future fuel on which economies will run. More accurate input data will lead to reliable output recommendations. Nations that want to take the lead, including India, have started conducting hackathons, collaborative computer programming, etc., to solve global problems.

Due to AI being a capital-intensive technology, it is essential to be financially prudent and consider the availability of funds when making decisions regarding the implementation of AI in the respective systems. If managed well, AI could lead to a virtuous cycle of higher productivity, income growth, and more socially inclusive and environmentally responsible practices. When mishandled, even well-intended AI applications can result in unintended consequences and a backlash against the new technology.

AI is mainly used for the Sustainable Development Goals (SDGs) in countries that are good at AI. To help less advanced countries, they need to understand their specific problems and get help with education, startups, entrepreneurship, and governance to catch up in AI. Governments should work with companies and communities to use AI for goals like Industry, Innovation, Infrastructure (SDG #9), Sustainable Cities and Communities (SDG #11), and Partnerships for the Goals (SDG #17).

As far as SDG #7 is concerned, AI will be a star performer and will be able to harness advances in AI techniques to improve the integration of renewable energy, optimise load and its distribution, create a balance between accuracy and reliability of power supply, and defend against and detect cyber-attacks, among other things. In this regard, management education that helps future leaders understand and embrace this new world of AI intervention in everyday life will be key to individual success as well as a nation's future growth trajectory.

6. Conclusion

AI is a very important technology in the energy sector, and it's helping make the world more sustainable. Many people and groups are involved in

this. The energy industry is changing, moving towards cleaner and more efficient ways of doing things, and AI is helping a lot with that. Countries using AI are doing better in terms of efficiency, saving important resources, and sharing knowledge for the benefit of the planet. But not all countries are using AI yet, and that can be a problem. Some countries need to overcome issues like not caring enough, not wanting to change, not knowing about AI, or not having enough resources. Governments also play a big role in this. Countries should think more about the long-term benefits for their own country and the whole world when it comes to AI and sustainability.

AI brings new technology and skills that can help us achieve the Sustainable Development Goals (SDGs). It can provide data to help us reduce waste and improve how we make, use, and recycle things. In the energy industry, this means collecting data about how energy systems work and how we measure it. AI can make these systems work better and cost less. But, since AI is still new, there are some risks to watch out for. We need to be careful and minimize any bad things that might happen because of AI. In the energy sector, AI can help operators manage everything from routine tasks to fixing problems with equipment. It can even predict when things need maintenance.

Thus, when used wisely for projects that promote sustainability, AI will open up enormous opportunities across geographies, enable more effective and efficient public policy for sustainability, and, more specifically, improve access, connectivity, and efficiency in industries like that of Energy.

References

1. Agrawal, A., Gans, J., & Goldfarb, A. (2018). Prediction machines: The simple economics of artificial intelligence. Boston MA: Harvard Business Review Press.
2. Artificial Intelligence (2018). Opposing viewpoints online collection, Gale, 2017. Opposing viewpoints in context. Retrieved from http://link.galegroup.com/apps/doc/PC301099927/OVIC?u=a13qu&sid=OVIC&xid=a6804b12.
3. Artificial intelligence technology could help protect water supplies (2018, July 18). PhysOrg. Retrieved from https://phys.org/news/2018-07-artificial-intelligencetechnology.html.
4. Barocas, S., Crawford, K., Shapiro, A., Wallach, H., 2017. The problem with bias: from allocative to representational harms in machine learning,

in: Special Interest Group for Computing, Information and Society. Philadelphia.

5. Barnett, V. (2002). Which was the "real" Kondratiev: 1925 or 1928? Journal of the History of Economic Thought, 24(4), 475–478.
6. Cosgrove, W. J., & Loucks, D. P. (2015). Water management: Current and future challenges and research directions. Commentary in Water Resources Research. Retrieved from

   https://agupubs.onlinelibrary.wiley.com/doi/epdf/10.1002/2014WR016869.
7. Cousteau, J. M. Quote on the architects of peace website (n.d.) Retrieved from http://www.architectsofpeace.org/architects-of-peace/jean-michel-cousteau?page=2. Digging Deeper: Plant Village. (2018, December 27). WPSU Penn state video. Retrieved from

   https://news.psu.edu/video/426943/2016/09/20/wpsu-penn-statesdigging-deeper-plantvillage.
8. Debnath, K.B., Mourshed, M., 2018. Forecasting methods in energy planning models.
9. Renew. Sustain. Energy Rev. 88, 297e325.

   https://doi.org/10.1016/j.rser.2018.02.002.
10. Demirci, M., Unes, F., & Korlu, S. (2019). Modeling of groundwater level using artificial intelligence techniques: A case study of reyhanli region in Turkey. Applied Ecology and Environmental Research, 17(2), 2651–2663.
11. Fickling, B.D., 2019. Cyberattacks Make Smart Grids Look Pretty Dumb. Bloomberg
12. Bloomberg

    https://www.bloomberg.com/opinion/articles/2019-06-17/

    argentina-blaming-hackers-for-outage-makes-smart-grids-look-dumb.
13. Galperin, H. (2010). Goodbye digital divide, hello digital confusion? A critical embrace of the emerging ICT4D consensus. Information Technologies and International Development, 6, 53–55 Special Edition.
14. Garimella, K., & Fingar, P. (2018). AI & blockchain. Tampa, FL: Meghan-Kiffer Press.
15. Goralski, M. A., & Górniak-Kocikowska, K. (2018, April). Permissionless evolution of ethics – artificial intelligence. In J. Mark Munoz, & Al Naqvi (Eds.). Business strategy in an artificial intelligence economy (pp. 69–78). New York, NY: Business Expert Press.