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Artificial Intelligence (AI) in Human Resource Management (HRM): A Conceptual Review of Applications, Challenges and Future Prospects

Artificial Intelligence in Finance: Innovative Economic Strategies for Financial Inclusion

Artificial Intelligence in e-Commerce: Designing Marketing Strategies

EMBRACING AI for HUMANITY

AI & Energy: Problems and Prospects

# AI & Energy: Challanges and Prospects

***Dr. Soumen Guha***

*Managing Director, Sustech Engineering Pty Ltd., Perth, WA*

**Introduction**

The demand of energy has grown simultaneously with the growth of civilisation and prosperity of humankind. This search for energy to enhance the quality of life in a finite world has been an eternal challenge. On the one hand is there is increasing demand, and on the other side there is a dearth of supply. This has led to discovery of new sources of energy, innovation of new technologies and development of efficient machines. Attaining efficiency at every stage of the energy value chain, from production to transmission to distribution and consumption, has been a continuously developing story. In the modern era, with a goal to deliver energy to all, it is a challenge to do so while being carbon neutral. This journey to scale new heights of optimised and efficient use of energy, achieving increased energy consumption while reaching carbon neutrality, will be aided by artificial intelligence (AI) in the coming decades.[1]

**Evolution of AI**

The beginning of AI, as in the form we understand today, dates back a few centuries, when the pursuit of reason and logic were practiced by philosophers and mathematicians in a systematic and documented way. The first automation occurred in physical mechanical systems. At the beginning these were simple mechanical devices meant for specific set of tasks. Later, these machines evolved to perform more complex tasks.

Then the mechanical computers were invented, which carried out difficult and complex calculations and tasks. But these huge machines had their limitations due to space constraints and manufacturing cycles. The need to overcome these hurdles gave rise to the electronic computers. These electronic computers were fundamentally diffierent and opened up new horizons of virtuality, evolving much faster than their mechanical predecessors. Iterative calculations and testing of ideas became much easier. Storing huge data became increasingly within the reach. Soon people understood the key benefit of the new technology – the ability to identify patterns for predictive analysis. For the first time a machine could replicate a part of the pattern of human reasoning and problem-solving. This is the advent of machine learning and AI.

From this point we could see early machines performing human actions, like robots. Albeit these early robots were preprogrammed. But as we have seen in recent developments, virtual assistants like Siri and Alexa are fed with human intelligence. Technology is now approaching the stage where it could credibly be called AI. Algorithms have become the buzzword. Increasingly we are transforming more subjective tasks like decision-making, personality assessment, product targeting, into computer aided decisions. AI is truly on the march.

Parallelly, data storage and computing technology is scaling new peaks. Hence large data pools can now be captured, leading to advances of machine learning to deep learning.

[1]There are serious and valid concerns that AI can be a powerful tool in the hands of unethical people. But our focus for the purpose of this article is on AI's socially legitimate use for the energy world.

Complex human neuron dependent capabilities like image and voice recognition have now become reality.

The algorithms now collect data, analyse and establish patterns, and also aberrations of those patterns, to establish derivative algorithms. We see these manifestations of AI today in everyday applications like self-driving cars on the city roads. The web-based translations are getting refined by the day. Bots are becoming more efficient in recognising moods and responding appropriately.

Today AI takes as inputs, observations from the desired problem space based on complex or less complex sensors like cameras, vibration sensors, videos etc. It then and applies advanced techniques of recognizing patterns, classifying patterns, predicting future behaviour.

If AI could achieve such progresses in extremely subjective individual behaviour and expression related applications, imagine what it can do in the fields of energy, where data is well structured and documented historically.


*Image 1: AI - picture of self-driven car*

## Energy Industry and Data

The energy industry has always generated and accumulated a lot of historical data about generation, transmission and consumption, because of their basic business needs of calculating profitability. For example, all the centralised energy exploration and production companies like oil and gas explorers and coal miners keep the production and sale data. The power companies maintain data on how much fuel they burn and how much energy they produce. The distribution companies' meter and generate data of their receipt and sale of energy and power.

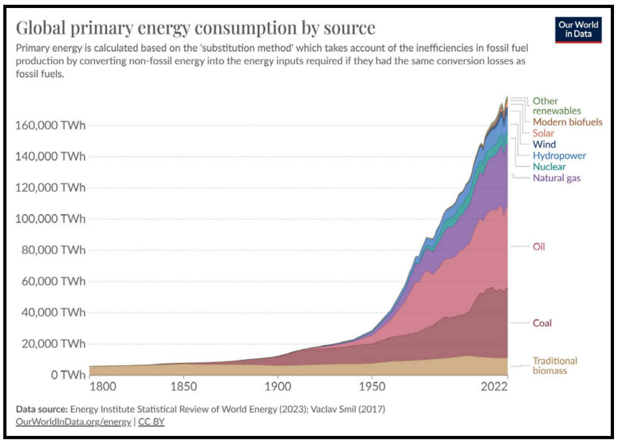


*Image 2: Energy Production and Consumption - Our World in Data*

Besides increasing profitability, the other driver for making the power industry efficient was regulation that kept a control on price. This continuous improvement of processes and machines was possible because of measurable data.

For example, based on the collected data, the energy distributors communicate with consumers through simple communication platforms like the energy bills, providing consumers with the option to choose between diffierent energy plans. This kind of planned consumption commitment gave the advantage of optimising the grid.

In the present age of big data and enormous computing power, further scope of optimised use of energy and management of complex grids including consumer generated energy (e.g. solar cells), becomes even more possible. Predictions about needs and supply of energy is made based on historical data. The famous duck curve (see Image 3) is an example of how the energy business planners and engineers use such data for forward planning. All these are possible because of the data rich energy industry.

The data collected over a very long period in the energy industry when statistically analysed, shows some patterns. These patterns can be processed and presented through conventional computer programming to assist data-driven decision making. This is what has been practised for many decades now by business analysts and decision makers. One can imagine how much data can be co- related and compiled from these well-structured datasets, increasing the ease of well-informed decision-making. This data can be the bedrock of machine learning. With enough data available for machine learning, simulating human cognitive and analytic explanations of the data, the AI will evolve, and its capabilities will grow.

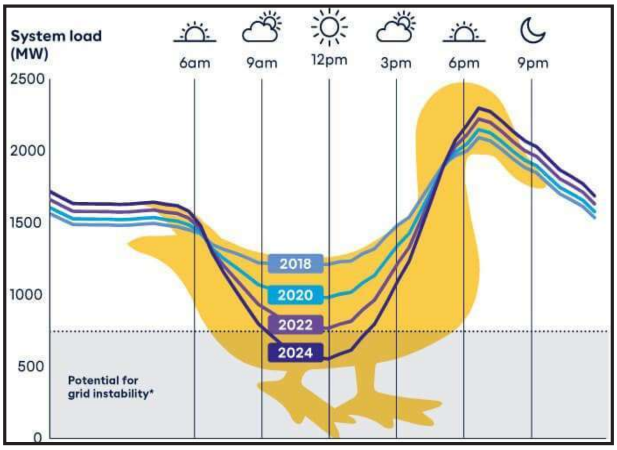


*Image 3: Solar Duck Curve Explained: What it Means in Western Australia (synergy.net.au)*

Traditional Energy and AI

Below here are some real-life examples of how AI can be applied to the Energy Industry and make it efficient. In the process, both energy costs and carbon emission may be reduced.

**Case Study**

**Problem**

A power corporation is being plagued by high cost of maintenance of electric poles. These poles have to be checked on a regular basis for pilferage, for damage, for wear and tear. And these are high tension line poles that are tremendous safety hazards if they break down.

A team of 4 or 5 people, daily or twice a day, take photographs of each of the poles from diffierent angles and save the images in long-term storage. They send it to a control room. The expert engineer identifies the defects from the pictures and sends back a request to the observation team for either retaking the pictures from a nearby view or sends a request to the maintenance team to fix the identified defects. This method is time consuming, error prone, therefore expensive.

**Solution**

Imagine a drone circling those poles from a measurable distance, with high optical zoom cameras installed. Live feeds of the poles from diffierent angles could be streamed to the control centre. Then the data can be processed by machine learning algorithms and defects will be identified within few minutes of the image being captured. Thus, the cycle time and processing-analysis cost goes down drastically. The state of the art in machine learning is such that the defects which need to be identified can be determined by standard machine learning techniques within a very high degree of accuracy.

AI finds further application in this scenario where the drone's flight path is being controlled by an automatic control system, and the streaming video is being processed in real time to give a classification of the defects, if any. After that, some traditional software steps can be taken, like notifying, mailing, calling relevant support levels.

**Methodology and Principles followed for the solution**

- Images and videos are used as the sensory medium.
- These are captured on a near real time basis by drones.
- The flight path of drones is controlled by an automated system.

- Images and videos are transmitted via the internet to the servers doing the analysis.
- The servers doing the analysis apply advanced machine learning techniques to classify the defect into categories, which they infer from the images.
- On finding a defect classification in any image, the servers transmit the control signal to the drone to capture images or videos of the relevant pole at the proper angle.
- The servers then communicate to the relevant maintenance and support centres.

**Energy Audits**

Modern-day automation techniques mean that we now have energy audit sensors placed at all of the relevant consumption points, which constantly stream power and energy data in real time. Instead of periodic energy audits, now it is continuous. The accumulated audit data help identify the anomalies in the consumption pattern, irregularities in the machinery maintenance, aberration of regular patterns in the utility billing. Also, the data allows real time alerts regarding impending high billing errors. However, this is state of the art analytics rather than machine learning or AI.

AI involves the prediction of the consumption patterns and altering the schedule of the consumption, to bring down energy consumption. For example, all air conditioners in a large office complex are switched on simultaneously at the beginning of the day. This causes a sudden spurt in energy demand. Once this is identified using the continuous energy audit, a simple step of staggering the start of the machines can avoid the demand spurt.

Based on the audit data, AI can show the energy consumption patterns of machines and the identification of peak and trough periods during the week. This can even out demand by scheduling and loading the machines over the entire day.

**Macro and Micro Scale Energy Production**

In the macro sphere, entities responsible for energy production, both government and private, are resorting to prediction of consumer demand in the near future and taking necessary action to meet it. Daily changes in energy production and in energy consumption patterns can be studied very easily from a one-year historical data record of energy production and consumption at diffierent points in the grid. Diffierences in demand during the day, during the week, during the month and during certain months can be identified. Accordingly, many proactive measures can be adopted to even out the supply and demand to accommodate or address the patterns. Storing the excess energy in periods of low demand and pumping it back to the grid during high demand periods has been practised for quite some time now. Parallels of this solution can be found in the telecommunication operators' industry, where bandwidth is utilised during low demand periods by downloading data based on the user's preferences, and served from cache during high demand periods, to reduce the load on the network. All of these solutions are facilitated by machine learning systems with appropriate algorithms and a good analytics system.

In the micro scale energy production, solar energy is now a reality. A household with a significant solar energy generation capacity has a utility energy source, solar energy source, battery storage capacity and devices which consume energy. Now hardware is available which has AI built into the firmware which balances the power consumed from the utility energy source based on how much solar energy and stored energy is available at an instant. Rules are being set in the firmware, which can be configured by the energy consumer. Based on consumption patterns and time of day and the real time balance of energy sources, whether to increase or decrease the power drawn from utility, when to divert utility power for immediate consumption or battery storage etc. is being decided by the machines. The machines have AI and internet of things built-in to enable this. This results in a drastic reduction in unnecessary power consumption in peak demand periods and wasted utility energy in low demand periods.

On a macro scale, the same strategy is being employed by the power utility companies, through the concept of the smart grid. Energy demand in a particular grid or area at a particular time is being mapped. Areas with more demand at any point of time are being allowed to draw the energy from areas in the grid that have less demand at that moment.

The smart grid concept is thus minimising waste and enabling the efficient utilisation of energy. While still new, with the progress of machine learning and AI based optimisation techniques and strategies, and improvement in electrical and electronic hardware, the smart grid system will be far improved and matured.

A step further is for the smart grid projections to be integrated for the entire nation and beyond. This would approach an almost real time management of energy generation, making the whole energy production and distribution more capital efficient. This would also help in predictive pricing of energy and assisting policy makers with forward planning and resource allocation.

## Renewable Energy and AI

Renewable energy sources, including solar, wind, hydroelectric, and biomass, made up approximately 30% of the total electricity generated globally. As of 2022, hydroelectric power is the most common source of renewable energy globally, with an installed capacity greater than 1,200 GW. In comparison, there are more than 600,000 wind turbines are operating globally, with a combined capacity greater than 600 GW. Wind energy was the fastest-growing source of electricity globally, with a growth rate of 15%, while solar energy was the fastest-growing source of electricity in the United States, with a growth rate of 27%. China is the world's largest producer of solar energy, followed by the United States and India.

The horizon of AI in energy will be beyond the bounds of generation and consumption of conventional energy fields. It will expand to renewables and other forms of explorations of renewable energy.

As a simple example, predictions of renewable energy generation can be made based on weather modelling. This data can be used to configure and schedule the consumption points and activate the storage units downstream. In our journey of net zero and to restrict the global warming to 1.5°C, AI has a big role to play.[2]

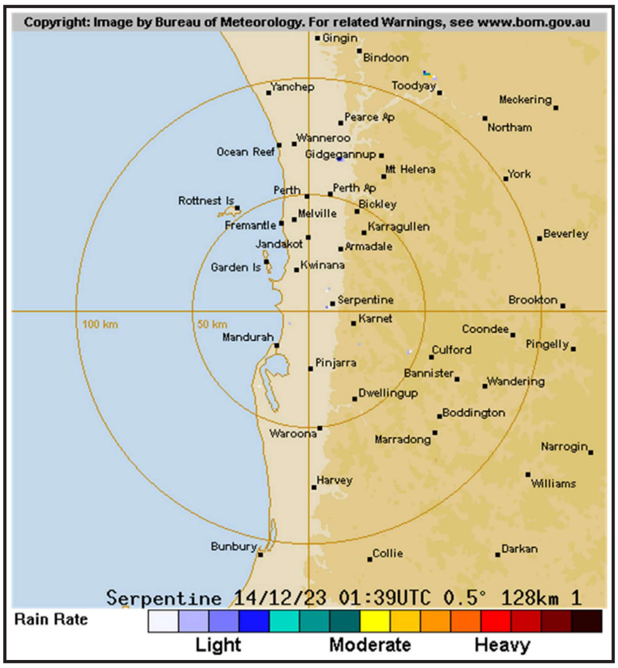


*Image 4: Weather Forecast maps, Bureau of Meteorology (bom.gov.au)*

[2]This Society of Petroleum Engineers article discusses the status of renewable and clean energy in the Global energy map, and how is AI being used there: https://jpt.spe.org/ai-paves-the-way-for-a-sustainable-energy- future

The use of AI in the renewable energy sector can reduce the project capital costs and operating costs and increase the availability and reliability of the energy. With the efficient management of energy supported by AI, renewables can eventually become more commercially viable than explored and mined energy. This journey has started.

**Exploration and Planning**

AI improves the efficiency and project economics of exploring and converting naturally occurring renewable energy forms to usable renewable energy. AI can be used to analyse large datasets from satellite imagery, sensor networks, and other sources to identify the optimised locations for renewable energy projects such as solar farms, wind farms, geothermal plants, and hydroelectric dams. AI can also predict the viability of renewable energy projects based on factors such as weather conditions, land use, and the availability of resources, for more informed decision-making about where to invest. AI can help create detailed hydroelectric and geothermal reservoir models, which are typically used for identifying the most efficient site locations and for designing the operational infrastructure for the most effiective generation of renewable power. AI can also be for installation and operation of renewable energy plants by helping fine tune the placement and orientation of solar panels and wind turbines, maximising energy production and increase plant efficiency.

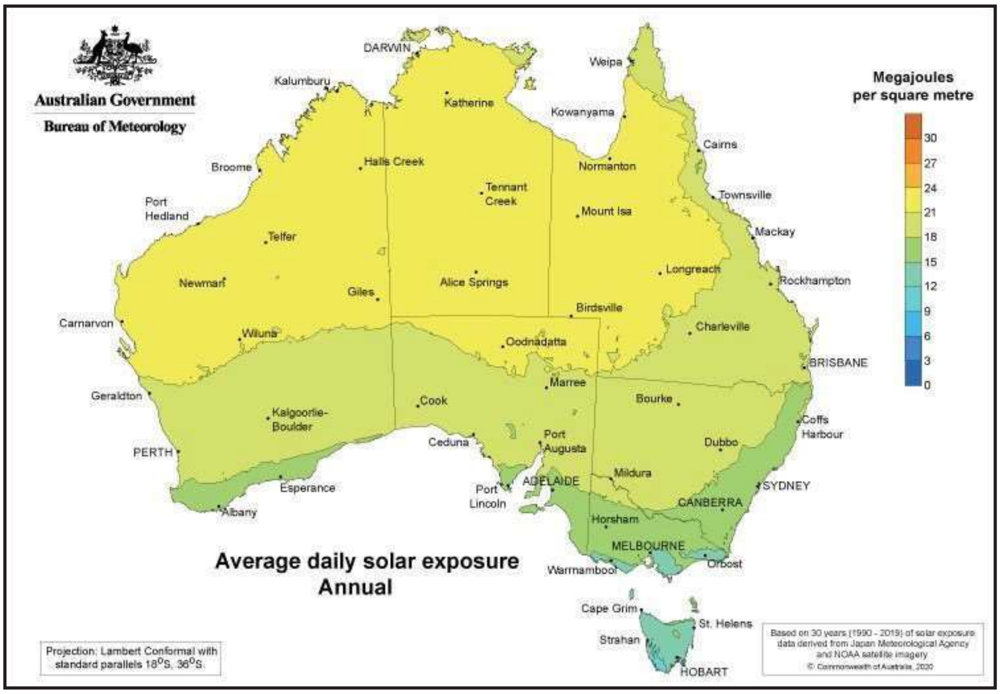


*Image 5: Average daily solar exposure maps, Bureau of Meteorology (bom.gov.au)*

**Performance Optimization**

Environmental impacts of excessive energy use can be reduced significantly through performance optimisation of the renewable-energy systems. AI can be used to optimise the energy usage of electric vehicles (EVs) by predicting the most efficient route to a destination. Using the data on traffic and weather conditions, AI can reduce a vehicle's energy consumption. Furthermore, AI can optimise battery charging in EVs by predicting the best times to charge based on factors such as electricity prices and availability.

In the case of solar panels and wind turbines, AI can improve performance by predicting when to adjust the angle of the panels and turbines, to maximise the amount of sunlight and wind they receive. Similar performance enhancements have been demonstrated in geothermal energy where AI tunes the performance of geothermal power plants by adjusting the flow rate of the geothermal reservoir to maximise energy production while ensuring sustainable heat extraction with minimal environmental footprint.

**Energy Production Forecasting**

The use of AI in renewable energy industry can improve the accuracy and reliability of energy production forecasts, allowing energy companies to make more informed decisions about their energy transition strategies. Energy companies can then plan for the future by predicting how much renewable energy will be available and what their energy mix and infrastructure investments should be. AI-backed renewable-energy production forecasting can help energy companies reduce costs and downtime by avoiding overproduction or underproduction of renewable energy. AI can help analyse data from a variety of sources, including weather forecasts, satellite imagery, sensor networks and other state of the art technologies to predict the likely performance of renewable energy plants. AI will become crucial for real-time data collection and remote-controlled operation, predictive as well as pre-emptive maintenance needs, improving the reliability and predictability of renewable energy sources and its power generation. AI can help ensure that renewable energy sources are operating at their maximum capacity, thereby giving the best return of the capital invested.

**Safety**

AI is needed in the renewable energy sector to improve safety. AI has already been used in real-time monitoring of structural integrity of wind turbines and the temperature of solar panels to identify potential problems before they cause damage or failure. AI can facilitate the on-time maintenance and repairing of renewable energy systems, reducing the risk of accidents and downtime.

AI can also be deployed for predicting the likelihood of natural disasters such as earthquakes and hurricanes and to optimise the response to these events to minimise the damage to renewable energy systems, by prompting the emergency response protocol of operating plants, a major part of which can also be AI-driven. AI can predict when EV batteries and other components will need maintenance or repair, allowing for proactive rather than reactive maintenance before the car becomes un-roadworthy and creates a safety hazard for the public.

**Waste Management and Recycling**

AI is routinely used to predict the likely lifespan of renewable energy systems and optimise the timing of their decommissioning and recycling. AI can be further used to optimise the recycling of materials used in renewable energy systems, such as solar panels, wind turbines, and hydroelectric dams, by identifying the most valuable materials in these systems and then determining the most efficient recycling processes.

**Conclusion**

AI is the frontier of our generation. It has the capacity to drive all aspects of life, including energy production-transmission, distribution and consumption, making the industry highly efficient and interactive. This is because of the enormous amount of historical data that the energy industry has collected over the years. In the new age, with application of AI, more renewable sources of energy can be discovered. The energy value chain can be mapped out and accounted for. AI can help us in our journey to achieve net zero. Waste can be minimised, and a quantum leap of societal efficiency can be achieved. There is a world of opportunity for AI in energy.

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**Globsyn Knowledge Campus**
Mouza Chandi, PS - Bishnupur, J. L. No. - 101, District - 24 Parganas (South),
Kolkata - 743 503 Phone: +91-33-6600-3600

gbsjournal@globsyn.edu.in

www.globsyn.edu.in