

Energy Conservation Using AI

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Abstract—The use of artificial intelligence in energy management has already attracted attention since it offers the possibility of revolutionising the ways in which we consume, produce and distribute energy. This article examines the impact of artificial intelligence on energy management and the broader changes it is bringing about in the power sector. The study shines a light on artificial intelligence to guide the way towards a sustainable future. Its objective is to evaluate the capabilities and potential of artificial intelligence and machine learning in transforming the energy industry. When energy management systems adopt artificial intelligence, energy consumption increases, waste is reduced and efficiency improves. The research describes the fundamental changes that artificial intelligence is bringing to the energy sector and what this means for businesses and consumers. By looking at new applications of AI-driven energy management, it reveals some interesting insights into the opportunities and challenges involved. The paper highlights the advantages of AI in energy consumption, in terms of optimised costs, and with regard to sustainable uses for everyday needs, and offers some new ideas to industrial field workers and civil governments so that they can take the lead.

Index Terms—HVAC system, PMV sensor, multi-agent systems (MASs)

I. INTRODUCTION

In today's changing world, saving energy has become one of the most important aims when it comes to reducing energy consumption and the harmful effects on the environment. The Ministry of Energy and Mineral Resources (2018) reported that in 2015 the industry's final energy consumption amounted to 229 million oil equivalents (BOE), making it the second biggest consumer of energy after the transport sector (260 million BOE) [1]. The same ministry also stated that by 2021 energy consumption in Indonesia had

reached 909.24 million BOE, with the transport sector coming out on top at 388.42 million BOE and the industrial sector at 317.57 million BOE [2]. This shows that energy use has increased over a period of six years. In this context, the entertainment industry is also the main contributor to energy consumption and has a negative impact on the environment. One solution to these problems is the application of artificial intelligence in various sectors, including the entertainment industry. Energy efficient design does not only help in lowering energy consumption but also leads to a cleaner and more environmentally friendly use of natural resources. The use of AI in the entertainment industry brings about various innovations in the management of energy and in reducing environmental impacts. By means of AI algorithms and green technologies, the entertainment industry will be able to optimize energy use. Greenhouse gas emissions will be reduced and production efficiency will be improved. As Shi et al (2020) argue, this technology aims to improve the efficiency of electricity generation, transmission, and distribution, as well as other advantages, in order to cut energy costs and promote the use of renewable energy sources [3]. Through the use of artificial intelligence, an environmentally friendly design in the entertainment industry results in the implementation of energy-saving and excellence concepts when it comes to products and services for consumers in a continuously globalized environment; energy saving in the entertainment industry is therefore one of the most important priorities if sustainable environmental goals are to be achieved. The case study for this research is Jalan Sutomo in Medan city. It is one of the main roads with heavy traffic and a variety of industrial and entertainment activities. The potential for applying AI technology in the optimization of

energy use is considerable. The aim of this case study is to investigate how the use of artificial intelligence can improve the efficiency of energy use within the entertainment industry's design setting, specifically in the case of Jalan Sutomo.

II. THE PROBLEM STATEMENT

Generally, achieving a high level of occupant well-being—this including thermal comfort, visual comfort and indoor air quality—means that a large amount of energy has to be used; it is therefore necessary to aim at an optimized balance between well-being and energy saving in order to achieve sustainable buildings. The issue of energy conservation and well-being in buildings is complex; optimizing the performance of the entire building is both computationally intensive and very difficult to put into practice in real buildings. This difficulty arises from the need to have information concerning the performance and condition of all the systems and equipment in a building and from the challenges associated with handling HVAC systems which turn on and off, systems that change their operating states, systems that have multiple modes of operation, and so on. For instance, the HVAC system is a classic multi-input/multi-output and non-linear time varying system which is subject to disturbances and uncertainties. As a result, it is very hard to develop a mathematical model that can accurately describe the process in different operating states and modes. It should also be noted that there are other types of limitations in practice. For example, the user's activity level and the thermal resistance of their clothing, factors which appear in the predictive mean vote (PMV) equation, cannot be measured by sensors. There would be great potential for reducing the cost of PMV sensors in terms of HVAC applications (Liang and Du, 2005).

III. A FEASIBLE APPROACH

Modern AI and the fields of intelligent agents (IAs) and multi-agent systems (MASs) provide a possible answer to the problem mentioned above. These IAs and MASs operate on a distributed basis and are thus able to manage the computational load effectively. Since standard communication protocols (such as Ethernet, BACnet, ARCNET, ModBus, LonWorks, KNX and the Internet) are available, the IAs can

exchange information and work together in order to attain the main objectives, including energy efficiency, comfort, health and productivity in living spaces. Digital environments that make use of AI methods and techniques and that are capable of detecting the presence of users and adapting to their needs are known as ambient intelligence (AmI). The rest of the chapter is structured as follows: in the second section we give the classification and the purpose of the BAS; in the third section we provide an overview of AI technologies; the fourth section offers a brief introduction along with some important applications of energy conservation in buildings using conventional AI techniques, the key component of which is expert systems (ESs); the fifth section deals with the CI methodologies that are mainly used for an energy consumption predictor and for comfort; the sixth section describes the architecture and the basic algorithms of IAs; in the sixth section we design an IA for the purpose of energy conservation, this IA making use of a 3-D fuzzy comfort set (FCS) and a grey energy predictor; the eighth section is concerned with the methodology for the development of MASs and with related work in this area; in the ninth section we present AmI in a building environment, which represents a new viewpoint of AI; in the tenth section we conclude the chapter and outline future perspectives.

IV. ENERGY CONSERVATION

In order to conserve domestic energy resources and use them more efficiently, efforts should be made to promote energy savings, expand the number of people who consume and use energy sources, reduce the threshold for energy consumption, and regulate the way in which energy is used. Government Regulation No. 33 of 2023 on Energy Saving comes into force with regard to energy savings at the regional and provincial levels as well as in the case of energy savings in service companies. Energy saving is defined as a systematic, planned and extensive attempt to conserve domestic energy resources and to make their use more efficient.

Energy conservation is carried out at all stages of energy management, this including upstream management, whose objective is to conserve energy resources, and downstream management, whose objective is to improve energy efficiency [4].

As stated in Article 6, energy saving is carried out via energy saving programmes carried out by energy providers, energy source users and/or energy consumers at least through:

1. Energy Economy
2. Energy saving financing
3. The development of a business aimed at saving energy
4. Raising awareness regarding energy conservation
5. Increase in personnel
6. Research and innovation and/or
7. Energy saving cooperation.

When it comes to energy conservation, one of the measures that can be taken is energy conversion. This involves changing one form of energy into another form which is more useful [5]. In the industrial sector, energy conversion can be used to improve system efficiency and decrease energy waste. For example, in the Jalan Sutomo area of Medan, which receives a great deal of sunlight, using solar panels to produce electrical energy from the heat is a certain way of carrying out energy conservation efforts. It is also one of the measures aimed at conserving energy to make use of rainwater harvesting systems and greywater treatment so that the water can be reused.

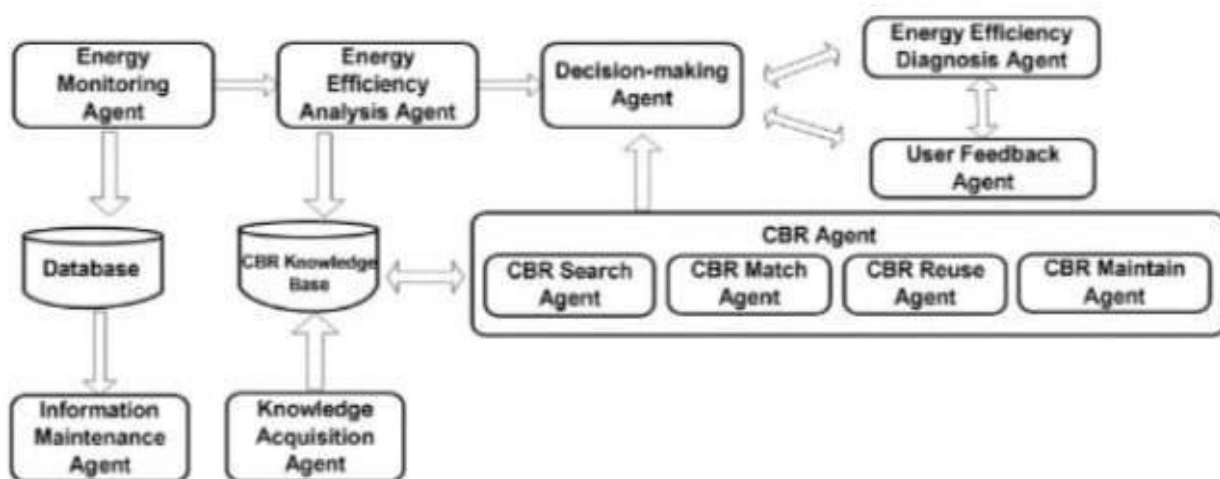
V. METHODOLOGY

The study employs qualitative methods involving the gathering of data by means of a review of the

literature, that is, by comparing a number of studies which have the same subject and function, particularly in the field of the entertainment industry. The information obtained from this literature review, together with any relevant theories, expert knowledge and government regulations and policies, will serve as input for the planning process.

VI. ARCHITECTURE OF EEMS

Decision-making is the kernel of EEMS, due to the diversity of users' requirements and uncertainties in using electricity, it's usually difficult to find fixed rules or algorithms to support decision-making. Since CBR can use the old experience to solve new problems, providing flexible solutions, and compared with the algorithms of quantitative, qualitative analysis of experience is easier for us to acquire, CBR is suitable in the decision-making link. But in fact, there is not much experience or similar cases in EEMS, it is hard for us to get a variety of models in processing problems, so we present MAS in this paper to integrate different processing modes in various industries and systems. The method of MAS can enrich knowledge base of CBR, offering plenty of source cases. To sum up, this paper adopts the approach of the combination of CBR and MAS technology in EEMS, providing more diverse solutions in decision-making procedures. Systematic design is shown in figure 1.



Energy Monitoring Agent:

This part is responsible for monitoring the usage of electricity. Energy monitoring agent compares current

energy usage with historical information, records the results and reports an emergency when abnormal data appears.

Energy Efficiency Analysis Agent:

This agent is in charge of data analyzing. energy efficiency analysis agent will classify the characteristics of different users, and finally find out the principle of energy utilization, which is helpful to making effective decisions.

Decision-making Agent:

This agent considers the results of energy efficiency analysis agent and the present strategy completely, and makes correct decisions when required. At the same time, it will take the CBR output as an important reference. Finally, the agent generates new and reasonable electricity scheme to guide users.

Energy Efficiency Diagnosis Agent:

Analyzes energy-using equipment from the system side, estimates current energy consumption and gives supplementary references to decision-making agent, helping to improve energy efficiency.

User Feedback Agent:

Uses the service condition to estimate the effectiveness of the system, evaluate the efficiency of the model from the user side, and output auxiliary suggestions to make real-time adjustments, improving decision-making plan continuously.

Information Maintenance Agent:

This agent is in charge of all the system information's maintenance and classification in a regular time, including user profile, energy-using equipment information, energy utilization data and data from measuring points. CBR Agent and CBR Knowledge Acquisition Agent cooperate with each other to work for decision-making agent. Some details will be introduced in the following passage.

VII. HOW AI IS REVOLUTIONIZING ENERGY MANAGEMENT

The Need for AI in Energy Management

The demand for energy is increasing rapidly, and traditional methods of energy management are no longer sufficient to meet this demand. As a result, there is a growing need for more efficient and effective energy management solutions. This is where AI comes in. By leveraging the power of machine learning and data analytics, AI can help energy companies and

businesses optimize their energy usage, reduce costs, and improve sustainability. AI techniques can be used to model load and demand forecasting as demand and supply forecasting are helpful in many other smart grid decisions [8]. The types of energy management systems in the smart grid with supporting technologies are shown in Figure 1, where RES refers to renewable energy sources.

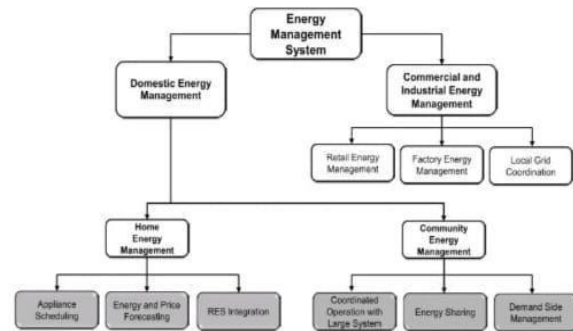


Figure. Energy Management System in the Smart Grid System

Smart Grids and Energy Optimization

Smart grids are intelligent energy network that uses sensors, smart meters, and other advanced technologies to monitor and manage energy consumption in real time. AI algorithms can analyze the data gathered from these systems and make predictions about future usage patterns. This allows energy companies to optimize their energy production, storage, and distribution, thereby reducing costs and improving efficiency.

VIII. DATA ANALYTICS AND PREDICTIVE MAINTENANCE

AI systems can use data analytics to monitor equipment and predict when maintenance is required. This helps energy companies to reduce downtime, improve reliability, and extend the lifespan of their equipment. For example, AI-powered algorithms can identify potential faults in wind turbines, which allows maintenance teams to address the issue before it causes a problem.

Improving Energy Efficiency through AI

Energy storage is a critical component of the renewable energy landscape. AI systems can optimize energy storage systems by predicting energy demand and adjusting energy storage levels accordingly.

Demand response is another area of energy management where AI can help. AI algorithms can analyze energy demand patterns and adjust energy production accordingly, reducing energy waste and improving efficiency. One of the most significant benefits of AI in energy management is the ability to improve energy efficiency. Here are two ways in which AI is driving improvements in energy efficiency:

Smart Building Management and Automation

AI-powered smart building management systems can optimize energy usage by automating tasks such as lighting, heating, and cooling. By monitoring occupancy patterns and adjusting these systems accordingly, smart building management systems can reduce energy consumption and costs.

AI-Driven Energy Analysis and Optimization

AI can be utilized to analyze energy usage patterns and identify energy-wasting areas. By analyzing data from sensors and other sources using machine learning algorithms, AI can identify patterns that indicate inefficient energy usage. This data can then be utilized to optimize energy consumption and reduce waste.

IX. CONCLUSION

In the face of energy conservation challenges, the entertainment industry has great potential to integrate artificial intelligence (AI) technology and green design principles to improve energy efficiency and reduce environmental impact. The utilization of artificial intelligence (AI) in the design of the entertainment industry, with a case study conducted in Jalan Sutomo, Medan, promises to be an effective solution in energy conservation and reducing environmental impact. Through the use of AI technology, the entertainment industry can optimize energy use efficiently, reduce excess energy consumption, and minimize greenhouse gas emissions. The study results show that the implementation of AI in the entertainment industry can create a more economically and environmentally sustainable environment. However, challenges such as initial investment costs and complex system integration need to be overcome to achieve wider applicability. In conclusion, the utilization of artificial intelligence in the design of the entertainment industry

in Jalan Sutomo, Medan, has great potential to support the goals of energy conservation and environmental sustainability globally.

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