Journal of Population Therapeutics & Clinical Pharmacology

RESEARCH ARTICLE
DOI: 10.53555/jptcp.v30i19.3767

EMPOWERING AGRICULTURE: A GREEN REVOLUTION WITH INTERNET OF ENERGY-DRIVEN FARM ENERGY MANAGEMENT FOR SUSTAINABLE AND ECO-FRIENDLY PRACTICES

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Abstract: This research provides an acute analysis of the possibilities of an IoE-based FEMS to improve the efficiency and efficacy of future Farms buildings' energy use. According to the problematic evaluation, modern controllers combined with IoE-based tools for using renewable building energy for Farms are needed. The research emphasized information and sources could more work on creating future applications for FEMS. The primary objective of this research is to draw attention to a few problems and duties associated with traditional controllers and IoE applications for poultry Farms building energy management systems and almost net ZEB. Developing a poultry farm building management system requires a systematic approach to ensure its effectiveness and alignment with the Farm's specific needs. Implementing IoE-based farm energy management systems can create a more sustainable and environmentally friendly poultry production industry. It combines the benefits of energy optimization, renewable energy integration, waste management, environmental monitoring, and data-driven decision-making, contributing to a greener and more efficient farming operation. Automated poultry farms can provide higher efficacy and efficiency due to the implementation of advanced technologies and systems. These include automated feeding, watering, environmental control, and monitoring systems. With proper implementation, efficacy can be significantly increased, reaching 90 per. As a result, investigating and creating an advanced optimized controller and IoE for future FEMS. Implementing a poultry farm building management system can yield beneficial results for the farm and its operations, like Enhanced Production Efficiency, Improved Animal Welfare, Enhanced Feeding Management Energy Efficiency, and Cost Savings.

Keywords: Internet of Energy (IoE), Farm energy management system, nearly or net zero energy building, sustainable energy.

INTRODUCTION

Nowadays, energy security is a global barrier to long-term economic growth [1]. The Universal Energy Agency predicts that by 2035, the world's demand for electricity will increase by more than two-thirds [2] additionally, researchers observed that Earth's Climate is warming significantly [3]-[5]. The" Energy Trilemma," shown in Fig 1 which focuses on the economy, environment, and energy security, has become an important in the modern era [6]. Power quality issues and network degradation are a result of the increasing electricity demand. In addition, the wide use of fossil fuels has a direct influence on the ecosystem.

As a result, it has been suggested that renewable energy sources take the place of fossil fuels [7] It is expected that renewable energy sources would supply 80 per of the world's energy in 2100. Renewable energy sources lowered world demand by 22 % in 2013, claim the authors of [8]. By 2020, this percentage will probably increase to about 26 % as energy usage becomes better known. However, there are issues with instrument control and storage when integrating renewable energy sources into utility networks [9], [10]. Therefore, the growth of the economy depends on the effective utilization of generated power. In order to evaluate bidirectional information and power transfer, an (IoE) based solution has been put out as an intelligent grid delay [11]. The Concept of smart grid and (IoT) are combined in IoE [12]. An Internet-based architecture called the Internet of Things (IoT) enables billions of smart objects to exchange resources, knowledge, and data. Examples of areas where (IoTs) might be used include power supply, military/Forces applications, weather forecasting and telemetric services. While monitoring and controlling energy-generating units an intelligent grid may provide two-way messages between the grid and the (FEMS).

However, the IoE is significantly used in the local and industrial sectors, as well as electric vehicles and distributed energy sources, in increasing numbers. The main source, the Internet, may be used to monitor and manage energy sources. When energy is required, it is transferred from one source to another source.

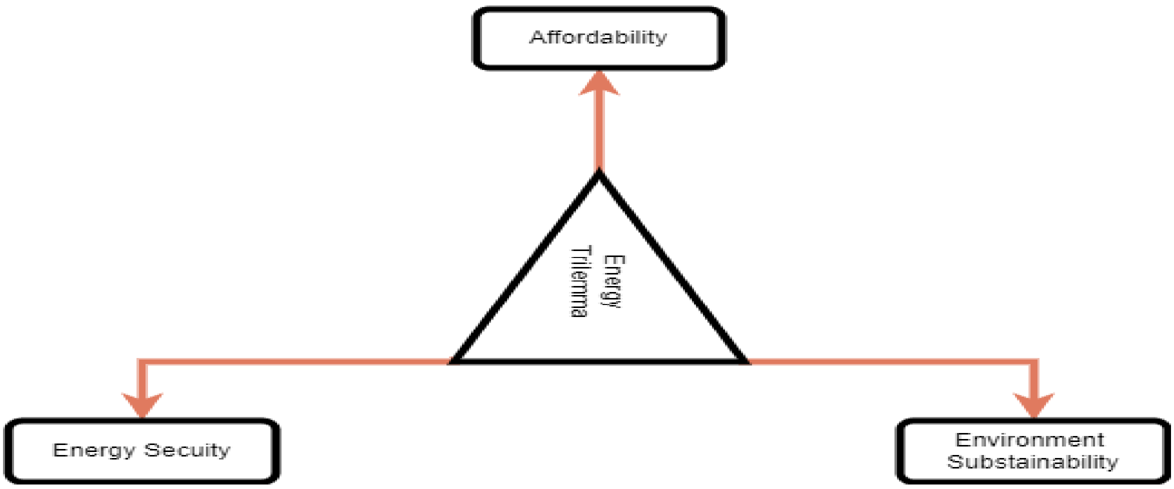

Fig. 1 Energy Trilemma

Right now, the sector with the highest energy use is the buildings sector [13]-[15]. So, efficient energy building has emerged as a worldwide objective for modern technology [16]. Buildings are responsible for one-third of all Greenhouse gas (GHG) emissions and use around 40 per of the world's energy, according to research [1],[17]-[20], estimated 49 per energy consumption in 2014, which include 60 per of the energy going toward heating and cooling [15]. Therefore, the most challenging and difficult issues in the building sector are energy intake and its effect on temperature change [21]-[24] as shown in Fig 2 [8], and Net Electricity Consumption Worldwide shown in Fig 3. The demand for poultry meat and chicken eggs is projected to double by 2050.

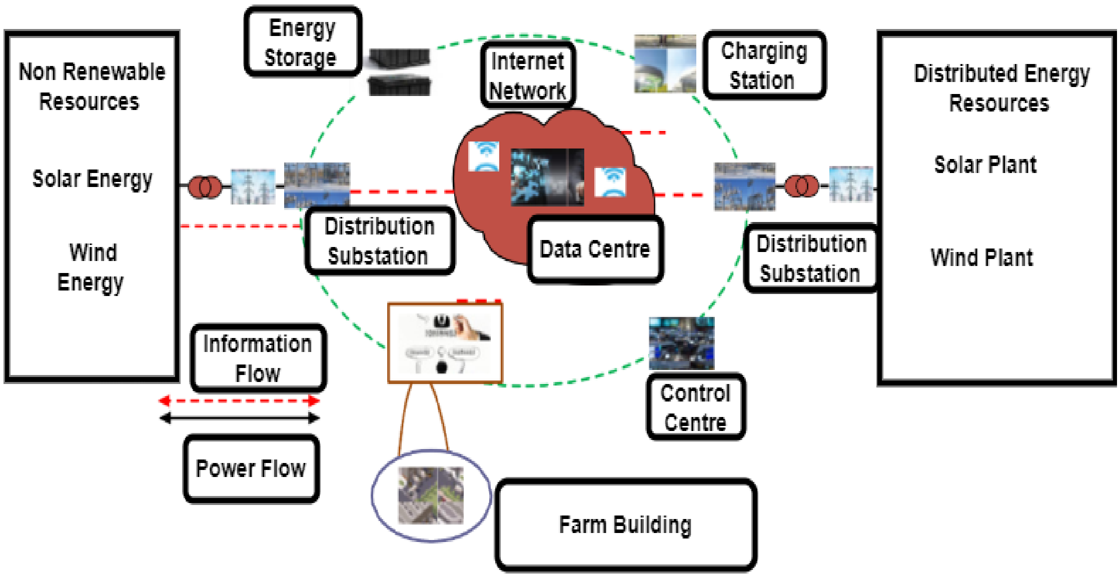

Fig. 2 Overall architecture of the IoE-based FEMS

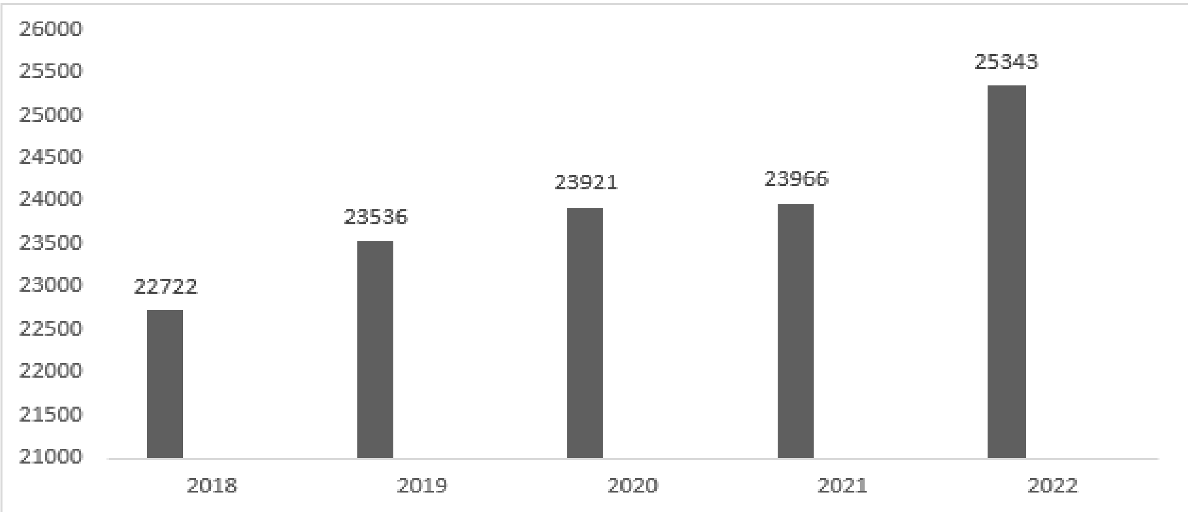

Fig. 3 Net Electricity Consumption Worldwide

which could impact the cost-effectiveness of poultry production due to increased global competition for agricultural resources. However, by implementing intelligent management technology and adopting new Farming tactics, these challenges can be overcome. Technologies like the IoE-based Poultry Farms Energy Management System (FEMS) optimize energy consumption, while innovative tactics such as precision agriculture and data-driven decision-making improve operational efficiency. By embracing these solutions, the poultry industry can meet the rising demand sustainably and cost-effectively. Together with other techniques for the gathering and use of data produced by Farms, they include methods for precision livestock Farming (PLF). PLF is a Farming method that aims to monitor animals/birds in real-time, preferably resulting in single monitoring of animals and at the lowest unit that can be controlled, to maximize the attention and care that Farmed animals receive. Poultry houses having smart sensors that can monitor a variety of production-related factors in real-time can start PLF systems. Very huge amounts of data will need to be stored and made easily available because of monitoring chicken production with new sensory technologies. So, Decisions should be made quickly or in real-time based on the outcomes as data are generated and made available. However, Using PLF technique needs the establishment of critical data analysis systems that enable consistent data-driven decision-making. This paper aims to highlight the areas where modern PLF sensor techniques improve systems of poultry production, such as the environmental optimization of the poultry house/shelter, the improvement of bird care, and precision feeding systems. Furthermore, discuss and implement challenges and potential drawbacks for each area where technology can make a difference. A variety of methods that can help with this are also crucially discussed in the context of avian influenza virus, and sensor technologies have a great deal of potential to help with faster detection and diagnosis of poultry disease. Additionally, Systems for the access storage and analysis of sensor-generated data are also discussed, along with data governance, a topic that will play a significant role in future systems to produce poultry. IoE and big data analytics techniques are studied regarding their connection to new sensor techniques and data. Furthermore, to the potential advantages they offer for poultry production methods [25].

1.1 Problem Statement

The agricultural sector plays a pivotal role in our economy, yet conventional practices often contribute to environmental degradation and operational inefficiencies due to a heavy reliance on non-renewable energy sources. To tackle these challenges, there is a pressing need to establish an innovative and efficient eco-friendly environment within agriculture. Integrating the Internet of Energy (IoE) into Farm Energy Management Systems (FEMS) presents a promising solution. However, several challenges persist, including energy inefficiency, a lack of sustainability, suboptimal resource management, and the existence of data silos within farming systems. This research endeavors to develop an IoE-based FEMS to address these challenges and establish a sustainable and eco-friendly agricultural environment. The primary objectives encompass optimizing energy usage, integrating sustainable practices, enhancing resource efficiency, establishing data integration, implementing real-time monitoring, and ensuring scalability. The anticipated outcomes involve substantial energy and cost savings, a reduction in environmental impact, improved resource management, and data-driven decision-making capabilities for farmers. The research methodology encompasses literature reviews, case studies, algorithm development, and practical implementations, with a focus on real-world applicability and scalability. Ultimately, the research aims to contribute to the broader goal of fostering sustainable and eco-friendly farming practices, ushering in a new era of resilience and efficiency in agriculture.

1.2 ZEB

The FEMS has been investigated by several researchers as a potential tool for IoE. Due to this, the primary goal of defensible energy development in poultry Farms is to increase energy efficiency while minimizing waste and adverse effects on the environment [26]. Fig 4 [27] shows a theoretical framework of the smart FEMS. Due to the requirement that this architecture, be monitored for the balance between generation Consumption, the FEMS previously mentioned can alternatively be referred to as a Zero energy building (ZEB) [28] or nZEB [29]. The definition of a ZEB is based on several criteria, including energy use, access to renewable sources of supply, utility grid connections and regulations. Therefore, for future growth, several developed nations are already implementing the zero-energy building architecture [1], [27] - [33] reported on potential research into energy retrofits for characteristic of ZEBs, where the standard structure of energy intake production has changed to a (nZEB) balance between the import and export.

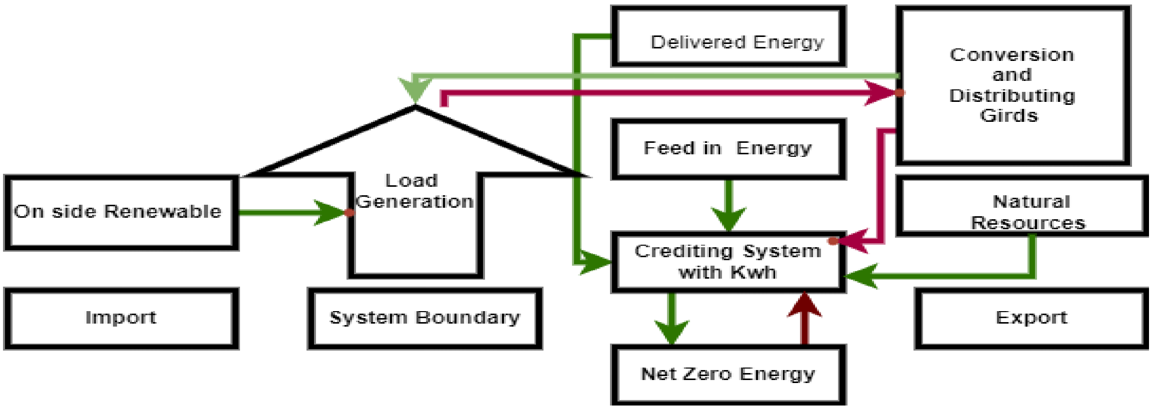

Fig. 4 Schematic of a typical nZEB

1.3 Farm Energy Management System

A FEMS is a classic method for keeping track of and managing buildings' energy usage. Production in Pakistan [34]. The quantity of energy wasted in a Farm building's energy economy may drastically rise due to poorly maintained and badly controlled equipment. It is challenging to find comprehensive information on the energy usage of various construction equipment. For FEMSs, a conceptual framework has been put out shown in fig 5 [35] Where the effect of the occupants and weather-responsive control were seen as the two main factors. A building information model (BIM) is used to store the physical properties, components and geometric information that can be used to calculate the thermal efficiency and lighting intensity of a Farm building. Setting up set points for the reference energy model allows one to gauge the structure's energy efficiency.

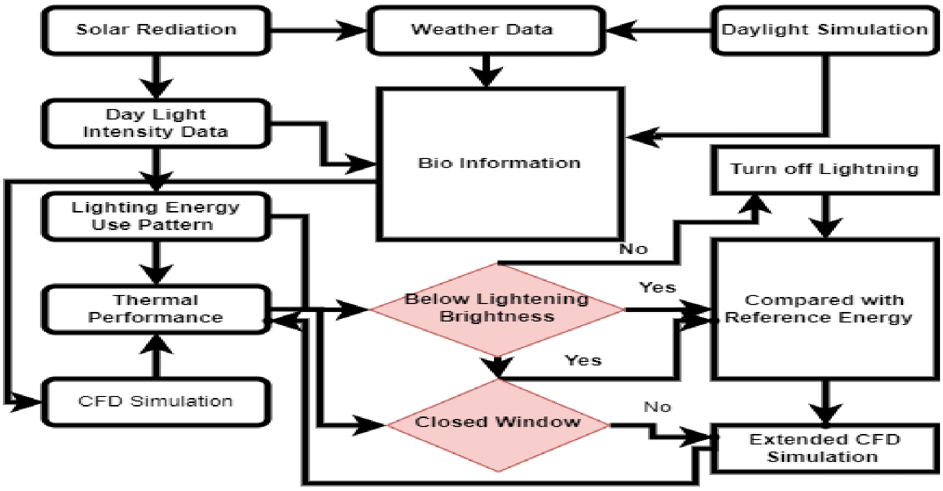

Fig. 5 Conceptual framework of the smart FEMS

1.4 Energy Consumption Management

The primary objective of an IoE-based FEMS is energy savings. The implementation of such systems relies on two main techniques: renovating existing buildings and developing new buildings. When comparing these two approaches, refurbishing old buildings emerges as the ideal method for FEMS due to its potential to save energy, reduce waste and emissions, and conserve materials. Refurbishing old buildings not only achieves energy efficiency but also contributes to climate change mitigation and environmental development [36]. By focusing on refurbishment, FEMSs can harness the existing infrastructure and optimize its energy performance. This approach minimizes the environmental impact associated with constructing entirely new buildings and promotes sustainability by reducing resource consumption. Through energy-efficient renovations, FEMSs not only address the energy-saving objective but also lead to various additional benefits. These may include improved indoor air quality, enhanced occupant comfort, reduced operational costs, extended building lifespan, and increased property value.

1.5 Trending and Benchmarking

Trending analyses energy costs and usage to determine a building's performance. Energy meters can be used to collect this data. The best settings can then be changed in accordance with weather and maintenance information after identifying instances of extreme usage. It can show whether a piece of equipment needs to be improved or replaced. The anticipated simple can return refers to the number of years taken for the cost savings generated by a system to equal the initial investment cost of the entire system [37]. This metric helps evaluate the financial viability of implementing an IoE-based FEMS. Benchmarking a building's energy usage and performance can assess its potential for improvement in terms of energy efficiency. The effectiveness of benchmarking relies on the accuracy of the scope, goals, and metrics defined for the process. Therefore, benchmarking encounters challenges due to the increasing number of data centers and the complexity of data management [13] and categorizes the significant steps and benefits of benchmarking [38]. These steps involve defining the benchmarking scope, setting clear goals, collecting, and analyzing data, identifying improvement opportunities, implementing changes, and continuously monitoring and evaluating performance. By following these benchmarking steps, stakeholders can gain valuable insights into the energy usage and efficiency of their buildings. This information supports the implementation of an effective FEMS, enabling data-driven decision-making and continuous improvement in energy performance.

1.6 Fault Detection and Diagnosis

Fault detection and diagnosis (FDD) is a crucial process in FEMS that involves identifying and detecting errors to protect the system from additional losses and damage. While FDD can be complex, it offers numerous opportunities for system improvement and optimization. Several applications of FDD in FEMS have been examined, particularly focusing on the relationships between high temperature, pressure, and Thermodynamics for error diagnosis and detection. In the 1990s, the US Department of Energy developed a comprehensive investigative tool for whole Farm buildings to detect and reduce energy consumption. Subsequently, many researchers have concentrated their efforts on FDD in FEMS. A notable study by [39] explored a general application of FDD, consisting of four steps: monitoring, identification, error evaluation, fault decision, and diagnostic making. The FDD process encompasses error diagnosis and fault detection. Fig 6 [39] illustrates a complete examination of FDD application in a planned system. Different types of models, such as fuzzy models, neural network-based FDD methods, and physical models [40], have been recognized for FDD implementation. These models aid in detecting and diagnosing faults within the FEMS, providing valuable insights for system optimization and maintenance. By utilizing FDD techniques, potential issues can be identified and resolved promptly, minimizing energy waste, and ensuring optimal performance of the system. Fault detection and diagnosis (FDD) methods can be classified into different categories based on the measuring process used. These categories include model-based FDD, signal-based FDD, active FDD, knowledge-based FDD, and the last one is hybrid FDD. Among these, model-based FDD stands out as a highly useful and accurate method. It involves repeatedly observing the system's output and comparing it with expected data to detect errors. Model-based FDD relies on the first principles technique of physics, making it a precise approach. It can be fully determined by models such as the Black Cox model, enhancing its effectiveness and reliability [41]. By employing model-based FDD, faults in the system can be identified and diagnosed based on the expected behavior, ensuring efficient operation, and minimizing energy waste. In signal-based FDD, frequency and time domain techniques are used. So, if a fault is detected in a system, then they easily measure the output signal of the faulty system differs from the output of the original system.

1.7 Measurement and Verification

A building data management system's primary goals are to find ways to save energy and assess a building's energy efficiency [42]. (M and V) of data estimates energy efficacy and depletion of different building equipment and considers the energy demand. Measurement can be made by considering the entire system or a specific system component. The following elements make up an operational and successful M and V plan. Like as Operating hours, HVAC effects, brightness light level and existing controls site selection [43]. In [44] M and V in several nations have been debated.

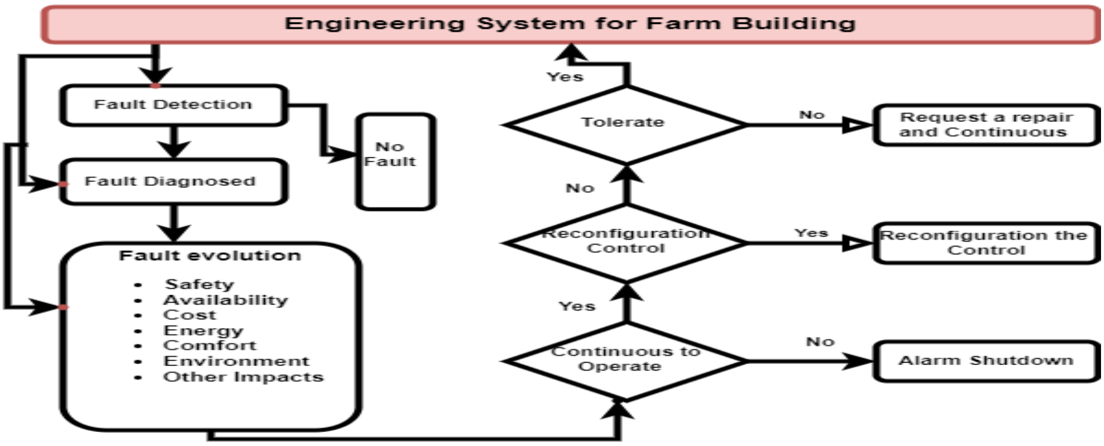

Fig. 6 Generic application of FDD in an engineered system

In United States and China, the (M and V) process has been applied for the last 30 years. The method has only freshly been adopted in India and is still in its early stages of development. The toughness, superiority, and toughness of energy efficiency (M and V) may differ by region. The International Performance Measurement and Verification Protocol (IPMVP) offers many ways to demonstrate the success of renewable energy projects and other forms of energy efficiency.

2 EFFICIENT AND ECO-FRIENDLY ENVIRONMENT BY OPTIMIZING THE USE OF ENERGY

An IoE-based FEMS can help optimize the use of energy in poultry Farm buildings by collecting data from sensors and other IoE devices, analyzing, and interpreting the data to identify opportunities for energy conservation and efficiency, and automating tasks and processes to improve energy efficiency. Using energy-effective appliances and tools like replacing old, ineffective appliances with newer models that have earned the Energy Star label can help decrease energy depletion and lower energy bills. Implementing energy-saving strategies on turning off lights and electronics when they are not in use, using natural light whenever possible and setting thermostats to energy-efficient temperatures can all help reduce energy consumption. Investing in renewable energy sources and setting up wind turbines, solar panels or other renewable energy sources can help decrease the dependence on fossil fuels and lower greenhouse gas discharges. This proposal means Upgrading building insulation and windows improving the insulation and sealing of a building can help reduce energy losses through the walls and roof while upgrading to energy-resourceful windows can help heat increase in the summer and reduce heat loss in the winter. The flow chart of operating Energy of poultry production facilities is shown in Fig 7.

2.1 Use an energy management system.

An IoE-based poultry Farm energy management system can help optimize the use of energy in poultry buildings by collecting data from sensors and other IoT devices, analyzing and interpreting the data to identify opportunities for energy conservation and efficiency or automating tasks and processes to improve energy efficiency.

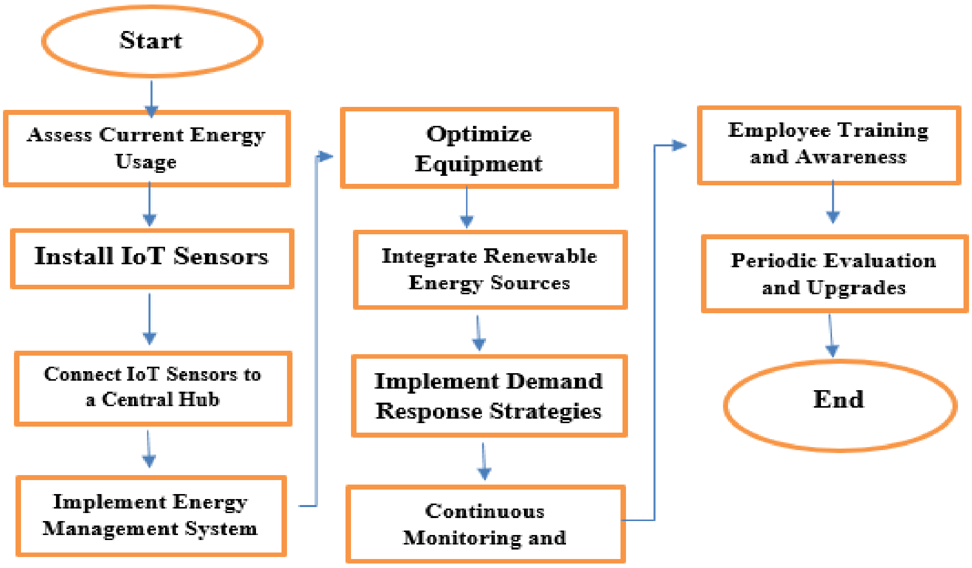

Fig. 7 Operating Energy of Poultry Production Facilities

2.2 Temperature Sensor

A temperature sensor is a device that is used to measure temperature, usually in degrees Celsius (°C) or Fahrenheit (°F). It can detect changes in temperature and convert them into an electrical signal that can be read by a controller or computer. There are many different types of temperature sensors, together with thermistors, thermocouples, and resistance temperature detectors (RTDs). Thermocouples are used to measure the voltage produced by two different metals that are coupled together. Thermistors can be used to change the resistance of a semiconductor material as per the temperature changes. RTDs work by calculating the variation in resistance of a metal wire as temperature changes. Temperature sensors have many uses, including in the locomotive industry, in home appliances like air conditioners and refrigerators, in industrial methods, and in scientific research. They are essential in preserving the correctness and dependability of temperature-sensitive systems and procedures.

2.3 Use an energy management system

A humidity sensor is a device that measures the amount of humidity and water vapor in the air or other gases. It is also known as a hygrometer or humidity sensor. Humidity sensors work by sensing changes in electrical capacitance or resistance produced by the presence of water vapor in the air. There are two main types of humidity sensors capacitive and resistive. Capacitive humidity sensors work by measuring the change in capacitance between two electrodes as the amount of water vapor in the air changes. The Resistive humidity sensors are used to measure the change in resistance of a material as it absorbs or loses humidity. Humidity sensors are used in many applications, such as in weather monitoring, heating, ventilation, and air conditioning (HVAC) systems, food processing, and storage, and industrial processes. They are essential for maintaining optimal humidity levels to prevent mould growth, corrosion, and other issues caused by high or low humidity levels. Fig 8 Shows the Humidity level of the Farmhouse some time Digital meter and sometimes no digital meter. Both sensors are working but on digital meter shows accurate readings.

Fig. 8 Digital and Manual Humidity Sensor

2.4 Water meter (hydrometer)

A water meter, also called a hydrometer, is a device which is used to measure the volume of water flowing through a pipe. It is commonly used by water utilities to measure the amount of water consumed by households, Poultry Farms, and other customers. Water meters work by measuring the velocity of water flowing through the pipe and converting it into volume readings. There are several types of water meters, including displacement, velocity, and electromagnetic meters. Displacement water meters measure the amount of water flowing through the pipe by counting the number of times a chamber or piston is filled and emptied by the flowing water. Velocity water meters use the principle of fluid mechanics to measure the velocity of water flowing through the pipe and convert it into volume readings. Electromagnetic water meters use the principle of electromagnetic induction to measure the velocity of water flowing through the pipe. Water meters are important in helping water utilities accurately bill their customers for the water they use. They also help to detect leaks and monitor water usage patterns, which can help identify areas of high water consumption or potential problems with the water distribution system.

2.5 Static Pressure Sensor

A static pressure sensor is a device used to measure the static pressure of a fluid, which is the pressure exerted by the fluid when it is not moving or flowing. This type of sensor is commonly used in industrial and HVAC (heating, ventilation, and air conditioning) systems to monitor and control pressure levels. Static pressure sensors. work by using a diaphragm or other sensitive element to measure the pressure of the fluid. They can be designed to measure pressure in either absolute or gauge (relative to atmospheric pressure) terms. They typically produce an electrical signal that can be read by a controller or computer. Static pressure sensors are used in a variety of applications, such as monitoring air pressure in HVAC systems to ensure proper airflow and ventilation, measuring liquid pressure in pipelines to prevent leaks and detect blockages, and monitoring the pressure of gases in industrial processes. They are essential for maintaining optimal pressure levels and ensuring the safe and efficient operation of systems and equipment. With the help of the Static Pressure Sensor how gets accurate results, the working of static pressure sensor is shown in Fig 9.

Fig. 9 Static Pressure and Ammonia (NH3) Sensor

2.6 Ammonia (NH3) Sensor

An ammonia (NH3) sensor is a device used to detect and measure the concentration of ammonia gas in the air. It is commonly used in industrial and agricultural applications to monitor and control the levels of ammonia gas, which can be harmful to human health and the environment. There are two types of Ammonia Sensors used in Poultry Farmhouses, working of Ammonia sensors Shown in Fig

10. Digital Meter provides efficient reading and non-digital provides manual reading. Ammonia sensors work by using a sensing element, such as an electronic or optical sensor, to detect the presence of Ammonia gas in the air. The sensing element produces an electrical signal that is relative to the awareness of ammonia gas, which can be read by a controller or computer. Ammonia devices are used in a variety of applications, such as in refrigeration systems, food treatment, and animal Farming. In refrigeration systems, ammonia sensors are used to sense leaks of ammonia gas, which can be toxic and flammable. In food processing, Ammonia sensors are used to monitor the levels of ammonia gas produced during fermentation and other processes. In animal husbandry, Ammonia sensors are used to monitor the levels of ammonia gas in animal housing facilities, which can cause respiratory problems for animals and workers. Overall, ammonia sensors are essential for maintaining safe and healthy environments in various industrial and agricultural settings.

2.7 CO2 Sensor

A CO2 sensor is a device used to detect and measure the amount of carbon dioxide (CO2) gas in the air. It's commonly used in indoor air quality monitoring systems, as well as in industrial and scientific applications.CO2 sensors work by using a sensing element, such as an infrared or electronic sensor, to detect the presence of CO2 gas in the air. The sensing element produces an electrical signal that is proportional to the concentration of CO2 gas, which can be read by a controller or computer. CO2 sensors are used in a variety of applications, such as in HVAC systems to monitor and control indoor air quality, in greenhouses to monitor and optimize plant growth, and in scientific research to monitor the concentration of CO2 in the atmosphere. In indoor air quality monitoring systems, CO2 sensors are used to detect and control the levels of CO2 in indoor spaces to prevent the buildup of stale air and maintain comfortable and healthy environments. CO2 sensors can also be used in combination with other sensors, such as temperature and humidity sensors, to provide a comprehensive picture of indoor air quality. Overall, CO2 sensors are essential for maintaining safe and healthy environments in various indoor and outdoor settings.

2.8 Precision livestock Farming and Implementing of new sensors and technologies to enhance poultry production.

Decision-making, analysis and sensing, and monitoring and interference are the three main functions of livestock management systems. By reducing the need for human decision-making or physical observations [45]. These processes can be automated with PLF systems, significantly reducing the amount of time and effort required to handle many animals. The majority of PLF systems enable the achievement and observation of livestock in real-time, as well as the management of the smallest and individual unit, frequently employing a single-animal method. This method makes it possible to raise and manage a larger number of animals while maintaining the level of care that could only be provided by using fewer animals defined in [46]. Single creature care and the executives are unimaginable on enormous poultry tasks that contain hundreds/a huge number of the birds, subsequently, the level of birds is checked utilizing PLF instruments, and other these information sources can be applied thus to evaluate herd wellbeing. PLF systems are used to monitor many poultry because sensors are used to measure a variety of parameters. The accompanying segment considers three regions wherein sensors and various abilities can advantage poultry creation frameworks, specifically.

3 SUSTAINABILITY OF THE FARM BY REDUCING GREENHOUSE GAS EMISSIONS

Consider using alternative housing systems like Traditional poultry housing systems, such as battery cages, can be less sustainable and have a higher environmental impact compared to alternative systems, such as enriched colonies or free-range systems. Switching to a more sustainable housing system can help reduce greenhouse gas emissions and improve overall sustainability. However, Manure can be a significant source of greenhouse gas emissions on a poultry Farm. Implementing good manure management practices, such as composting or anaerobic digestion, can help reduce these emissions. Moreover, use environmentally friendly feed ingredients Choose feed ingredients that are sustainably produced and have a lower environmental impact. For example, using plant-based protein sources, such as peas and lentils, instead of soy or corn can reduce greenhouse gas emissions associated with feed production.

3.1 Implement a water conservation program

Water is a vital resource for poultry Farms and using it efficiently can help reduce greenhouse gas emissions associated with its treatment and transport. Implementing a water conservation program, such as using drip irrigation or installing low-flow fixtures, can help reduce water consumption and associated greenhouse gas emissions. Implementing a water conservation program within the poultry farm management system involves the integration of various strategies to minimize water usage while maintaining the health and productivity of the flock. The system can be enhanced with automated watering systems, equipped with sensors and timers to regulate water distribution based on poultry needs. Real-time monitoring and analytics features track water consumption patterns, promptly identifying leaks or irregularities. Rainwater harvesting systems can be incorporated to collect and store rainwater for non-potable uses, reducing reliance on external water sources. Water recycling and filtration systems treat wastewater for reuse in cleaning and cooling. Educational modules within the system can train farm personnel on water conservation practices, fostering a culture of awareness. Weather data integration adjusts water distribution based on environmental conditions, optimizing water usage. Drip irrigation for vegetation areas minimizes water runoff, and regular maintenance checks identify and address leaks promptly. The system can track regulatory compliance with water conservation regulations and set benchmarks for reduction goals. Collaboration with water suppliers and incentive programs for personnel contribute to the success of the program. By integrating these features, the poultry farm management system ensures efficient water usage, environmental sustainability, and continuous improvement in water conservation efforts.

3.2 Use alternative transportation methods.

Transportation is the most significant source of greenhouse gas releases, and switching to alternative modes of transportation, such as electric vehicles or biodiesel, can help reduce these emissions. Several alternative transportation methods can be used in poultry Farms. Here are some suggestions. The integration of alternative transportation methods within the poultry farm management system is essential for enhancing operational efficiency, reducing environmental impact, and optimizing logistics. This can be achieved by incorporating electric vehicles (EVs) into the farm's fleet, reducing emissions and operating costs. Autonomous vehicles can be explored for specific tasks, promoting efficiency and cost-effectiveness. Establishing bicycle and pedestrian paths within the farm premises encourages human-powered transportation, promoting a healthy lifestyle and reducing reliance on motorized vehicles for short distances. Providing electric bicycles or scooters further enhances on-farm mobility with minimal environmental impact. Efficient route planning algorithms integrated into the farm management system optimize transportation routes, reducing fuel consumption and travel time. Car-sharing programs contribute to resource-sharing and lower carbon footprints. Monitoring and reporting features in the system track fuel consumption, emissions, and transportation costs, providing valuable data for informed decision-making. Maintenance tracking ensures the reliability of alternative vehicles, minimizing downtime and extending their lifespan. Employee training programs familiarize staff with alternative transportation methods, fostering eco-friendly practices. Regular cost-benefit analyses help assess economic and environmental impacts, ensuring the ongoing sustainability of transportation practices. Through the implementation of these strategies, the poultry farm management system can contribute to environmental sustainability while promoting efficiency in transportation operations.

3.3 Plant trees or other vegetation

Planting trees or other vegetation on the Farm can help absorb carbon dioxide, a greenhouse gas, from the atmosphere. This can help offset the Farm's greenhouse gas emissions and improve overall sustainability. Planting trees or other vegetation in poultry Farms can have several benefits, including. Incorporating tree planting and other vegetation within the poultry farm environment is a multifaceted strategy that yields numerous benefits for both the flock and the overall sustainability of farm operations. Strategically planting trees offers natural shade, aiding in temperature regulation and preventing heat stress among poultry during periods of high temperatures. Additionally, these trees can act as windbreaks, contributing to optimal ventilation within poultry houses. The presence of dense vegetation, such as shrubs or grass, helps mitigate dust levels and reduce ammonia emissions, enhancing air quality and respiratory health for the birds. Beyond environmental considerations, incorporating vegetation areas within poultry enclosures provides a more natural foraging environment, supporting mental stimulation and overall well-being among the flock. Furthermore, planting a variety of trees and vegetation fosters biodiversity, attracting beneficial insects and organisms that contribute to a balanced ecosystem. Vegetation can also serve as a visual barriers, minimizing disturbances and creating a tranquil environment that reduces stress among the poultry. Practically, tree planting contributes to erosion control when strategically placed along farm perimeters, and the organic matter from pruning and fallen leaves can be integrated into composting areas, supporting nutrient cycling and creating natural fertilizers for the farm. However, it is crucial to consider biosecurity measures to prevent the introduction of potential contaminants with the chosen vegetation.

In addition to the functional benefits, thoughtful landscaping and tree planting enhances the aesthetic appeal of the farm, which can be particularly important for farms open to the public or engaged in agritourism. Moreover, selecting drought-resistant tree and vegetation species, and exploring partnerships with environmental organizations or government initiatives, ensures a sustainable approach to tree planting that aligns with water conservation efforts and broader environmental goals. Overall, integrating tree planting and vegetation within the poultry farm environment represents a holistic approach that not only enhances the farming environment but also contributes positively to ecological sustainability.

3.4 Implement a composting program

Composting organic materials, such as manure and food waste, can help reduce greenhouse gas emissions by greenhouse gas, a potent, capturing methane and converting it into a less harmful form of carbon. Implementing a composting program in poultry Farms can be an effective way to manage poultry waste and produce nutrient-rich compost that can be used to improve soil health and support crop growth. Implementing a composting program within a poultry farm management system involves a systematic integration of various processes and features to efficiently manage and utilize organic waste generated on the farm. Firstly, the system should incorporate a waste segregation feature to identify and separate different types of organic waste, such as poultry litter, manure, and plant residues. Specific collection points for organic waste should be mapped within the system, facilitating efficient waste collection with the aid of GPS or location tracking features. Designating composting areas and integrating monitoring sensors for temperature and moisture levels are essential steps. These sensors should be connected to the farm management system for real-time monitoring. Managing composting bins and equipment is crucial, and the system should include an inventory management feature to track availability and condition.

To streamline composting activities, the system should incorporate a scheduling feature, and planning tasks like turning and aeration. Record-keeping is vital for tracking input materials and activities, contributing to historical data that can optimize composting processes. Quality control measures, including testing and analysis features, ensure that the compost meets regulatory standards and farm requirements.

Automated alerts and notifications keep farm personnel informed about critical composting activities. A dedicated training module within the system educates personnel about composting best practices, fostering understanding and adherence to the program. Regulatory compliance tracking features document adherence to environmental and agricultural guidelines.

Integration with overall farm planning ensures that composting plans align with crop nutrient needs and soil health. A dashboard or reporting tools visualize key composting metrics, providing a comprehensive overview of the program's performance. Establishing a feedback loop within the system encourages farm personnel to contribute insights and suggestions for continuous improvement in the composting program.

3.5 Methods of Data Collection and Storage

Data collection and storage are crucial components of Precision Livestock Farming (PLF) systems. The data collected from various sensors and devices is used to generate insights and inform decisions regarding animal welfare, health, and productivity. To ensure accurate and reliable data, PLF systems must be designed to collect data in a consistent and standardized way and store it securely and reliably. In the realm of poultry farm management systems, a diverse array of methods is employed for effective data collection and storage, catering to the dynamic needs of poultry farming operations. Automated sensor technologies play a pivotal role by continuously monitoring environmental variables like temperature, humidity, and ventilation, with the collected real-time data seamlessly stored in centralized databases or cloud systems accessible through the farm management interface. RFID tagging offers a personalized touch, enabling individual bird tracking by gathering data on health, growth rates, and movement, all of which find their storage haven in the interconnected databases of the management system. Manual data entry, carried out by farm personnel, supplements the automated approaches, providing valuable insights into daily activities such as feeding schedules, health assessments, and egg production. The advent of mobile applications further streamlines data collection, allowing staff to input information directly from smartphones or tablets, enhancing the efficiency of on-the-go tasks. GPS and location tracking technologies prove instrumental in monitoring the farm's logistics, tracking the movement of equipment, vehicles, and personnel, with the recorded data seamlessly integrated into the overarching farm management system. Barcode scanning facilitates efficient inventory management, tracking feed usage, restocking, and overall inventory levels. Camera systems capture visual data within poultry houses, offering insights into bird behaviour, health conditions, and overall flock dynamics, all of which contribute to a visual repository linked to the farm management system. Weather stations provide external weather data crucial for decisions related to poultry house climate control, with this data integrated into the system for comprehensive environmental analysis.

Cloud-based storage solutions ensure the secure and scalable storage of vast datasets, fostering accessibility and data integrity. Automated feed systems, recording feed consumption data for individual birds or flocks, further enrich the system with nutritional insights and feeding optimization. Collectively, these data collection and storage methods empower poultry farm managers with a robust information ecosystem, enabling data-driven decision-making for enhanced efficiency, productivity, and overall farm performance.

4 Applications of the IoE in FEMS to used find out results.

There are several features of the IoE and the Internet that are similar and different. The similarities may be divided into two groups: structural similarities and functional similarities. The Internet and the Internet of Everything both have three structurally related components transmission, generation, and distribution. The functional commonalities of the Internet and IoE refer to these similarities [48]. Point-to-point information transfer between the two nodes on the Internet is possible. In Addition, here, information is continuously produced, copied, and stored. So, the IoE is unable to reproduce energy. Moreover, the energy demand must balance the supply of energy. The Internet situation may be handled using a widely used secure method. As a result of the difficulty in implementing network-based or security-based solutions in the IoE, several forms of security are required.

4.1 Find out results using Plug-and-Play and Appliance Integration

The IoE's plug-and-play interface makes it easier to connect storage and renewable energy sources. Many plug-and-play interfaces are used to interface techniques like AC and DC. The AC and DC Microgrid can connect via its interface. The combination of home appliances is very important to balance the demand and supply in the capable operation of IoE. So, the Eco-Friendly environmental impact of different appliances such as vacuum cleaners [13] refrigerators [48]-[50] cooker hoods [51] and televisions has been presented in this research. Finally, the use of Plug- and-Play and Appliance Integration can reduce the demand for GHG emissions and electricity. How to connect Farm buildings, houses and Factories with Other Sources like utility, Wind power etc. Find results with the help of Plug-and-Play and Appliance Integration Shown in Table 1.

Table 1 Key Technologies for the IoE

Use Plug and play Appliance	Description	Results (%)
Improved Operational Efficiency	Increased efficiency	25
	Reduced labor requirements	30
	Enhanced overall productivity	20
Enhanced Data Accuracy and Monitoring	Achieved data accuracy rate	95
	Real-time monitoring	99
	Data collection and analysis efficiency	40
Optimal Resource Management	Reduced feed waste	35
	Reduction in water consumption	25
	cost savings	15
Increased Animal Welfare and Health	Reduced mortality rates by	20
	Decrease in diseases	15
Streamlined Data Analysis and Reporting	Reduced data analysis time	50
	Improved decision-making	30

4.2 Using PLF Technologies Data and find out the results.

PLF concerns the use of advanced technologies and data analytics to manage livestock production more efficiently and accurately [52]. PLF technologies are designed to provide real-time monitoring and control of livestock production systems to improve animal welfare, health, and productivity. The data generated by PLF technologies can be used to optimize feed and nutrient management, prevent disease outbreaks, and reduce the environmental impact of livestock production.

4.3 Discussion

Efficient Eco-friendly environments can be achieved through the implementation of Internet of Energy (IoE) based Farm energy management systems. These systems combine advanced technologies and intelligent algorithms to optimize energy usage, reduce waste, and promote sustainability in agricultural practices. An IoE-based farm energy management system integrates various components and devices such as sensors, meters, actuators, and control systems, which are connected through a network infrastructure. These devices collect real-time data on energy consumption, weather conditions, crop growth, and other relevant parameters. The data is then analyzed and processed using advanced algorithms and machine learning techniques. By leveraging the power of IoE, farm energy management systems enable farmers to make informed decisions regarding energy usage and conservation. They provide real-time insights into energy demand, allowing farmers to adjust their operations accordingly. For example, by analyzing weather patterns, the system can predict the optimal irrigation schedule, reducing water and energy waste. Moreover, IoE-based farm energy management systems facilitate the integration of renewable energy sources into agricultural practices.

Solar panels, wind turbines, and other renewable energy generators can be connected to the system, enabling farmers to generate their own clean energy. Excess energy can be stored in batteries or fed back into the grid, contributing to overall energy sustainability. Another crucial aspect of these systems is their ability to automate and optimize energy-consuming processes. By controlling equipment, such as pumps, lighting systems, and ventilation, based on real-time data and predefined algorithms, energy consumption can be reduced significantly. This results in cost savings for farmers and a lower environmental impact. Furthermore, IoE-based farm energy management systems support remote monitoring and control, enabling farmers to manage their operations from anywhere, using web or mobile interfaces. This flexibility enhances operational efficiency and saves time and resources. Additionally, the system can send alerts and notifications to farmers in case of any deviations or abnormalities, allowing for quick response and preventive actions.

In summary, an efficient and eco-friendly environment in farming can be achieved through the implementation of IoE-based farm energy management systems. These systems provide real-time insights, optimize energy usage, promote renewable energy integration, automate processes, and enable remote monitoring and control. By leveraging advanced technologies, farmers can reduce waste, conserve resources, and contribute to a sustainable future. Results show that Continuous monitoring enables early detection of health issues, disease prevention, and targeted interventions. Data-driven decisions optimize feed formulations, resource allocation, and environmental control for better results. Real-time data enables prompt identification of disease outbreaks, reducing the spread and minimizing economic losses. Analyzing data provides valuable insights for informed decisions on flock management, resource allocation, and operations. Efficient resource management reduces waste and minimizes the environmental impact of poultry farming.

5 Conclusion

This research discussed a FEMS that is focused on the usage of different IoE techniques to reduce energy consumption and GHG radiation. According to the study, challenges including energy usage and security have grown in importance for sustainable economic growth. The primary challenge in FEMS is to enhance energy efficiency by reducing losses, energy consumption, and the overall impact of climate change. To address these issues, the concept of the Internet of Energy (IoE) is explored, enabling the management and monitoring of a building’s energy usage through bidirectional communication between the smart grid and FEMS. Various criteria, such as energy use, retrofit options, renewable supply facilities, utility grid connections, and specific requirements, are considered in the exploration of nearly or net zero energy buildings. The IoE, with its ability to exchange power and optimize energy usage, offers sustainable energy development across different generations and energy efficiency needs. However, several challenges need to be overcome, including building depreciation, boundary conditions, architectural heritage preservation, real-time data optimization and carbon reduction, collection, and cost-benefit analysis models. Based on a review of the literature, this assessment highlights the potential uses of IoE-based FEMS and its core technologies to help implement advanced FEMS in the future. The authors emphasize the need for an enhanced methodological foundation for future FEMS plans. The core technologies of IoE-based FEMS, including energy routers, energy storage devices, renewable energy source integration, and plug-and-play interfaces, are examined, each offering unique features and benefits. As a result, problems with farm building energy efficiency and optimization, unique climatic circumstances, energy storage materials, nonlinear electronic interface, and power quality make it difficult to adopt the available IoE-based FEMS technologies. The application of IoE-based FEMS in nearly Zero Energy Buildings (nZEB), Zero Energy Buildings (ZEB), and mobile smart services aims to minimize building energy consumption and CO2 emissions by facilitating the exchange of information on energy demand and supply. By employing IoE-based FEMS, significant energy savings and reductions in greenhouse gas (GHG) emissions can be achieved. This article addresses several challenges and issues to ensure energy security, efficiency, and sustainable solutions amidst economic and environmental constraints. The discussed issues encompass various aspects related to energy management, including optimizing energy usage, ensuring energy security, addressing economic viability, enhancing environmental sustainability, and leveraging advanced technologies. By addressing these challenges, IoE-based FEMS can contribute to a more efficient, sustainable, and intelligently built environment. In order to guarantee energy security and efficiency while addressing economic and environmental difficulties, this research concluded as follows.

CONFLICTS OF INTEREST

The authors declare that there are no conflicts of interest.

FUNDING

The author received no financial support for the research.

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