Chapter 55
A Critical Analysis on the Application of Next-Generation Internet of Things (Iot) for Building Efficient Energy Systems for Improved Temperature Control and Better Energy Consumption

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Abstract This research article is focused on analyzing the application of next-generation Internet of Things (IoT) in creating energy-efficient systems so as to improvise the temperature and manage the energy consumption effectively. The term IoT is a new concept that has been growing imminently due to growing needs and requirements of government, individuals, corporations, etc. The IoT is mainly stated as a critical system of computing machines that possess better and enhanced connection so as to automate various aspects of the routine needs of the individuals, it also assists in creating better information approach for evaluation and implementation of different approaches for sustainable living. The IoT system connects the different smart devices and senses through cloud-based controllers, the sensors in the building can enable in collecting and transmitting the real-time data on the environment, this information is then used by the controller's team to offer quick responses on the temperature control ana management. The systems enable in applying predictive

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and adaptive algorithms which will enable in executing the real-time operational responses, like turning on or switching off the lights based on the signals from in-room occupancy and turning on the air conditioning based on the level of occupancy in the building, this enables in optimizing the heating, ventilation and air-conditioning system so as to enhance better energy consumption. This article presents a critical analysis of the usage of IoT in enhancing the energy-efficient system in the building for improved temperature control and enhanced energy consumption.

55.1 Introduction

Based on the available sources it is noted that the conventional host of videos, images, etc. the worldwide web is now enhancing and offering better services to all stake-holders. The IoT system connects different types of sensors and other smart devices to the local or cloud-based. These sensors are mainly responsible for transmitting the real-time information related to the building, environment, etc. so that appropriate controls can be implemented. The emergence of IoT systems enables the government, organizations, and individuals in reacting to energy-efficient systems which will adjust the temperature control in the building thereby supporting efficient usage of power and energy [1]. The application of IoT has enabled in implementation of smart energy systems which have been used to control and automate the energy usage in residential and commercial buildings. The usage of IoT prototypes has significantly supported in preserving the energy consumption and thereby maintains better temperature control in the environment.

It is noted that the overall communication between the command centers and the consumers has enabled in creation of smart energy meters. These aspects have ensured that the overall exchange of messages regarding the consumption of energy and the usage has ensured in creating energy-efficient systems for sustainable growth in the future. The application of IoT on gas meters has enabled in creating and transmitting of real-time data related to the temperature in the building and thereby adjusting the temperature of air condition system for better energy usage.

The IoT possesses smart choice head which received the operational data and is then moved to local nodes stated as smart fusion, this information is monitored and controlled based on the collation and exchange of information from IoT network. It is widely regarded that IoT is considered to be an effective measure in monitoring and controlling the energy usage in the building [2]. The system can be set up so as to measure the overall energy usage, analyze the nature of energy type to be applied like solar energy, natural gas, etc. and also look to meet the energy needs in an effective manner (Table 55.1).

The primary aspect is that it will identify the devices which are responsible for energy usage and make the process more efficient. This enables in understanding the creative actions which enable ineffective usage, analyze the potential in application where the IoT system by monitoring and controlling the usage of power. This is mainly achieved by allowing the IoT to connect the devices grid so as to remove the

Table 55.1 Drivers and challenges of implementing IoT in energy sector

Categories	Features of IoT in energy efficiency
External drivers	Normative pressure Government regulations Need to protect climate change
Internal drivers	Support from the stakeholders Investment allocation Maintenance and cost savings
External challenges	Relative advantage Continuous change in technology Technology compatibility Adoption cost
Internal challenges	Increased operational cost Quality of maintenance Support from employees

Source Saleem et al. [2]

standby power consumption. Lastly, the IoT system can enable accessing the power by limiting the overall consumption which is not critical. If the option tends to exist, the IoT can select the times of the lower grid to power the devices [3]. This enables in more cost-effective and maintains spread the power demand in effective manner. The smart buildings are stated as the creative aspect which enables in application of different sensors which are connected to the different subsystems like lighting, elevators, surveillance cameras, common heating, HVAC, and others.

The IoT implements adaptive and predictive controllers which will help in reducing the consumption of energy, remove wastage and enhance experiences for the tenants and occupants. Moreover, there are enhanced complexities in building the energy environments which are arising due to large variety of datasets and implementation of control mechanisms.

55.2 Literature Review

In the era of globalization, communities around the world are focused on integrating through the application of technologies, this enables in serving different purposes across industries. As stated by the IoT is considered as the overall convergence of virtual, real, and digital aspects with are focused on making smarter cities by applying and using intelligent devices. Which will enhance efficient usage of the energy in the buildings and thereby manage temperature control?

It this been stated that IPV6 is considered as the critical protocol for the concept, this allows the developers in using various physical devices while connected to them and also control them at any point in time [4]. The application of IoT has moved from the traditional virtual and theoretical concept into reality, many experts tend to state the IoT application is highly effective in industrial areas, consumer-related IoT,

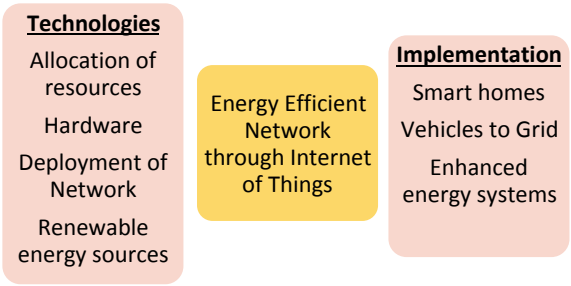

Fig. 55.1 IoT architecture in energy

etc. The usage of smart wearables, smart appliances at home, phones, etc. has made IoT more popular and effective.

Furthermore, the author has stated that the IoT is stated as an effective tool in monitoring and controlling the building energy and its overall usage. The IoT can be set up so as to measure the source power, this focused on isolating each equipment, moreover, IoT can enable in analyzing the power demand for various equipments in different rooms or floors and enable in managing its power consumption in a better manner [5] (Fig. 55.1).

The application of IoT is more focused on collaring the critical data which are highly helpful in different aspects related to application in creating energy-efficient systems for enhanced temperature control and better consumption. The first aspect is that the system will enable in creating for high energy usage and also focus on creating energy-efficient systems. The IoT also supports in understanding the data which are available in each room and equipments in the building forecast the energy usage and also study the results in different energy reduction methods. The next aspect is that the IoT system not only enables monitoring of the temperature but also controls and manages the usage of power based upon occupancy levels and other criteria [6]. This is mainly achieved by allowing the IoT system to disconnect the devices from the grid so that the consumption can be minimized when there is no usage.

Also, the IoT enables in selecting when the devices can access power, for example, need for hot water in the morning and night whereas it is not required during the day, this will limit the consumption of power source, moreover, when the option exists, the IoT can select time of low grid demand to power devices, which will allow more cost-effective for the users, enable in enhancing the power optimization in the communication and use less power, which will reduce the energy bills.

IoT solutions often have limitations and challenges, in many cases, there are solutions and solutions. Common problems can occur due to the network of different types of sensors and devices, each of which performs different functions. This is problematic due to the many problems that arise. In addition, IoT systems need to communicate with each other and wired solutions are not always possible. Connection problems due to structural disruption or an unstable internet connection are common. Another limitation of IoT systems is that they can produce extremely large amounts of data that require efficient handling and storage.

55.3 Methodology

The main aim of the study is to analyze and apprehend the implementation of next-generation IoT in creating energy-efficient systems for enhancing temperature control and energy consumption. This paper is a conceptual analysis of the subject area which stated the role of IoT in creating better energy-efficient systems. The researchers intend to apply the descriptive research so as to understand the role of technology in the energy consumption and effective usage. The researchers have applied secondary data sources in order to analyze the different types of IoT systems that have been implemented in the communities and buildings, the various data sources used are Google scholar, EBSCO, etc. Qualitative analysis is applied in the study so as to provide comprehensive understanding of the research area.

55.4 Implementation of IoT in Building Efficient Energy Systems

Many studies have been explored in analyzing the overall reaction and development of the IoT system related to power-driven appliances recognition. There is an opportunity that the electric appliances detection and monitoring tend to provide greater importance based on the focus on using energy-efficient systems. Furthermore, researchers have supported in application of a monitoring system called Raspberry Pi, which is a low-cost and high reliable IoT system. This enables in using eh Node programming to collate the data from the energy meters and save them for effective analysis. These data can be easily accessible through personal computers or smartphones using various applications [7]. The IoT-enabled energy monitoring system tends to facilitate in analyzing the energy usage and also take adequate steps in conservation measures. The IoT-based system tends to consist of the energy meters, implementation of Raspberry Pi system, cloud-based services, and control devices. It is also noted that there exist other IoT devices apart from Raspberry Pi, which are Arduino, NVIDIA, Nano, etc. (Table 55.2).

Furthermore, the implementation of FX5U IoT enables the device t to possess better communication with the inverter through 3C frames. The implementation of communication devices can enable communicating through 4G/5G networks, Bluetooth devices or Wi-Fi, etc. In another study, it is noted that the IoT system enables in implementation of microcontroller in the temperature sensors which are then connected to modules, this enables in controlling the indoor climate based on the outdoor environment. The system which is used is based on three key aspects, the first is categorized as sensors, the second is the main gateway, and the last part is involved in cloud networking [8]. The overall system flow enables in using the IoT position in the central devices, enable enhanced data flow, the IoT sensor is then situated in the terminal and is linked to the cloud servers. The sensor data are then measured and

Table 55.2 Application of IoT

Categories	Critical description	Intended benefits
Energy regulation	Access to the smart grid for all users	Enhancing the supply chain management system in energy sector, harness the pricing mechanism
Predictive analytics	Analyzing the energy usage	Forecast the energy requirements in the usage, maintain the internal temperature based on the outdoor environment
Smart grids	Operating the grid using IoT	Enhancing energy efficiency and integration of distribution
Microgrids	Operating the smaller grids	Enhancing security of energy supply

Source Rinaldi et al. [7]

stored in the cloud server for effective analysis, this will enable enhanced application of the energy-saving systems.

In order to enhance the critical transfer of data through network various encryption procedures are applied and maintained, this is more powerful and enables better storage of the data and information. The system tends to be found to enhance the cooling capacity by nearly 15% and the performance is optimized by 45% which allows better microclimate control inside the buildings.

The productive temperature control is highly helpful in optimizing the energy usage and overall consumption. The IoT infrastructure is considered to be an effective manner so as to accomplish them, the HVAC system is mainly controlled through the effecting reactive systems. The predictive controller tends to process the data based on patterns relate to heating and cooling based on various factors including weather conditions, operations aspects, occupancy, and related factors [9]. The HVAC system tends to know about the heating of the building and occupancy aspects related to heating process. Moreover, such system tends to detect the overall performance of the HVAC system in enhancing performance. The system is designed to sense the moisture and react in controlling the doors and ventilation aspects to the specified portion of the buildings.

Moreover, IoT data collection system enables in combination with reinforcement to enhance energy usage in the building. The application of IoT systems tends to collect the data, analyze the information and infer energy usage so as to create better HVAC scheduling methods [10]. The IoT system tends to analyze the energy usage, forecast the requirements, and establish the energy-saving policy. The IoT-based architecture enables predictive control of HVAC systems in enhanced situations, the closed-loop control mode tends to control the thermal comfort on the associated energy utilization in the single zone aspects. The IoT system enables connecting the sensors and actuators which are remote database services and actuated in the HVAC system.

55.5 Conclusion

IoT-based solution for predicting indoor temperature. Forecast-based technology such as demand response and demand control is used to reduce energy waste. The solution uses an advanced, non-linear, self-aggressive neural network to make predictions based on data collected by IoT. The forecasts proved to be accurate and reliable. Efficient management of energy consumption of HVAC systems in smart grids with variable energy prices. An energy planning plan was proposed that minimizes the cost of energy consumption over a certain period of time, taking into account the energy price and overall comfort constraints, i.e., temperatures determined by the decisions of the user of a particular living room. The HVAC system took into account user preferences for certain rooms and certain temperatures for maximum comfort. In addition, HVAC system controllers can be remotely monitored and adjusted for "dynamic" changes to maintain the efficiency of the HVAC system. The system used a Thermal Comfort Validator web application that predicted average voice comfort theory based on feedback from passengers in real-time. The system is ready to achieve energy savings based on data collection and processing while offering a high level of convenience.

IoT has an intelligent sampling head that receives operational data and forwards it to the local nodes declared as intelligent fusion, this information is verified and verified based on the collection and exchange of information from the IoT network. It is generally accepted that IoT can be seen as an effective measure to monitor and regulate a building's energy consumption. The system can be configured to measure the total energy consumption, the type of energy used, such as solar, natural gas, etc. To analyze its nature. The IoT system provides access to energy and can also limit its total consumption so that it is not critical. If the option is generally available, IoT can select the shortest network time to operate the devices. This helps to reduce costs and effectively maintain the distribution of energy needs. Smart buildings are presented as a creative aspect that allows the use of different sensors for different subsystems such as lighting, elevators, surveillance cameras, shared heating, HVAC, and more.

IoT implements adaptive and predictable controls that help reduce energy consumption, eliminate waste, and improve tenant and tenant experiences. In addition, the design of energy environments is becoming increasingly complex due to the diversity of data sets and the application of control mechanisms.

Control IoT with cloud computing and intelligence as opposed to controlling smartphones or web apps. A variety of appliances that can be controlled by actuators have been introduced, such as lamps, fans, appliances, and home security. A configuration with three objects was described to create an effective method for an advanced smart home idea and application. a typical IoT application of an intelligent standalone lighting and ventilation system. The system was able to monitor temperature, humidity, CO_2 concentration and from there control an autonomous lighting and ventilation system in energy. The HTTP system stores data on cloud-based servers and can be managed via a smartphone or computer. In addition, the system could

record real-time data on the cloud server, where the consumer could also view it, in real-time, anywhere in the world.

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