Chapter

Impact of IoT on Renewable Energy

Sivagami Ponnalagarsamy, V. Geetha, M. Pushpavalli and P. Abirami

Abstract

The emerging computing technology in this era is the Internet of Things. The network of intelligence that bridges various devices, systems located in remote locations together by means of cloud portal. IoT maybe equipped with millions or billions of devices. IoT handles large volume of data, process the huge data and performs useful control actions to make our life safe and simple. IoT evolves Human-human communication with thing-thing communication. IoT applications are not confined to a particular sector. In the fields such as health care, smart homes, industries, transportation, etc., the technology which is more influential is IoT. Energy sectors are now undergoing transformation. The transformation is driven by IOT. Green energy without IoT cannot be imagined in this energy sector. Renewable energy sources will be the major power producers among all the other sources due to the depletion of conventional energy sources. Among the renewable energy sources, Solar and Wind contributes more when compared to geothermal, biomass, etc. Renewable energy power production depends on environmental factors such as temperature, wind speed, light intensity etc. These factors affect the performance of energy conversion in renewable energy sources. Since our future generation will depend only on renewable energy, it becomes necessary for the researchers to integrate IOT to provide reliable and affordable energy. Renewable power generation helps in reducing the toxic level of gases which may be produced by thermal power stations during power generation. IoT brings about changes from generation to transmission to distribution. For example, let us compare the traditional grid with that of the smart grid. In the case of traditional one-way communication exists that is power produced from the power station is transmitted to the customer. The customer has to pay for the energy consumed. But smart grid has two-way communication. The customer has the capability to pay for the energy consumed only and if excess power produced can be transmitted to the grid. IoT helps in analyzing the demand as well the wastage of energy, helps in scheduling the load in order to reduce the cost. The sensors and data sciences with IOT helps in achieving the automation and intelligent operation of renewable energy farms, increases the efficiency and reliability of the farms to meet our future power demand.

Keywords: IoT-Internet of Things, PV-Photovoltaic, Smart grid, Wind

1. Introduction

Renewable energy picks up new pace due to depletion of fuel level at accelerating speed. Energy good for the people as well as the planet is Green resources.

The energy derived from sources which are natural, furnish or renew themselves without depleting the resources of the planet is Renewable Energy. These green re-sources are such as sunlight, wind, rain, wave, tide etc. It can be stated that Renewable Energy is virtually inexhaustible.

Energy sources whether renewable or non- renewable have its own impact on the environment fossil fuel. World still depending on fossil fuel cause climate change by emitting greenhouse gases, also leaves endangered particles that affect the health of the people. Compared to non- renewable the advantages of renewable are it reduces the use of land and water, it also reduces the air and water pollution, no or lower greenhouse gas emissions.

Greenhouse gas of significant are expelled during combustion of fossil fuels but renewable energy emits less or no green-house gases. No or less emission consequence is good climate. Fuel based transport, increase in industrial activities, power generation worldwide increases level of air pollution. Air pollutants make the people to suffocate. World health organization studies confirm that air pollution above urban skies cause premature death. Fossil fuel level apart from getting depleted it also pollutes the environment where as renewable energy meets the objectives that is replaces end of life concept and is seed for social and economic development. Power generation using nonrenewable is influenced more by geo political strife when compared to that of green resources.

Renewable energy cost low and energy prices are affordable. In order to build and maintain facilities more investment is spent for material and workmanship. Renewable energy creates jobs to fuel the economy of the local people because the investment is made within same continents, frequently the same country and usually the same town itself. Renewable energy has lowest cost source for power production and also available to expand. The way available to expand energy access to all areas namely, urban, suburban and per urban. The green resources accessible to all are good signs for development. It is secured and is of good quality.

Renewable energy companies have tremendous global growth last few years. This scaling should maintain profit and productivity. Reports confirm that renewable energy share expected to increase about 22.5% of the global power mix [1]. Use of IoT for renewable energy helps in saving electrical energy. IoT finds out the methods to optimize the capacities of expanding grids across remote locations. Thus, by keeping IoT at the forefront green source companies gain a lot.

Over a last few decade, a drastic change is seen in the energy sector because of upcoming renewable energy and depletion of exhaustible resources. According to International Energy Agency by the year 2022 renewable energy source and IoT economy is expected to reach 43% gain. IoT play a key role in evolving energy sector. It is difficult to envision the future of inexhaustible resource without IoT. Thus, let us look into the possibilities how IoT integrated renewable energy sector meet the growing power requirement as well as how it enhances the efficiency.

2. IoT architecture for renewable energy

The layers involved in monitoring and controlling renewable energy sources are perception layer or bottom most layer, network layer, middleware layer, application layer or top most layer. Layer responsible for collecting data is perception layer. It collects detailed information about physical factors for monitoring and managing the environment. The layer is equipped with various sensor devices or other components to meet the configuration to full fill the requirement of user. Next to

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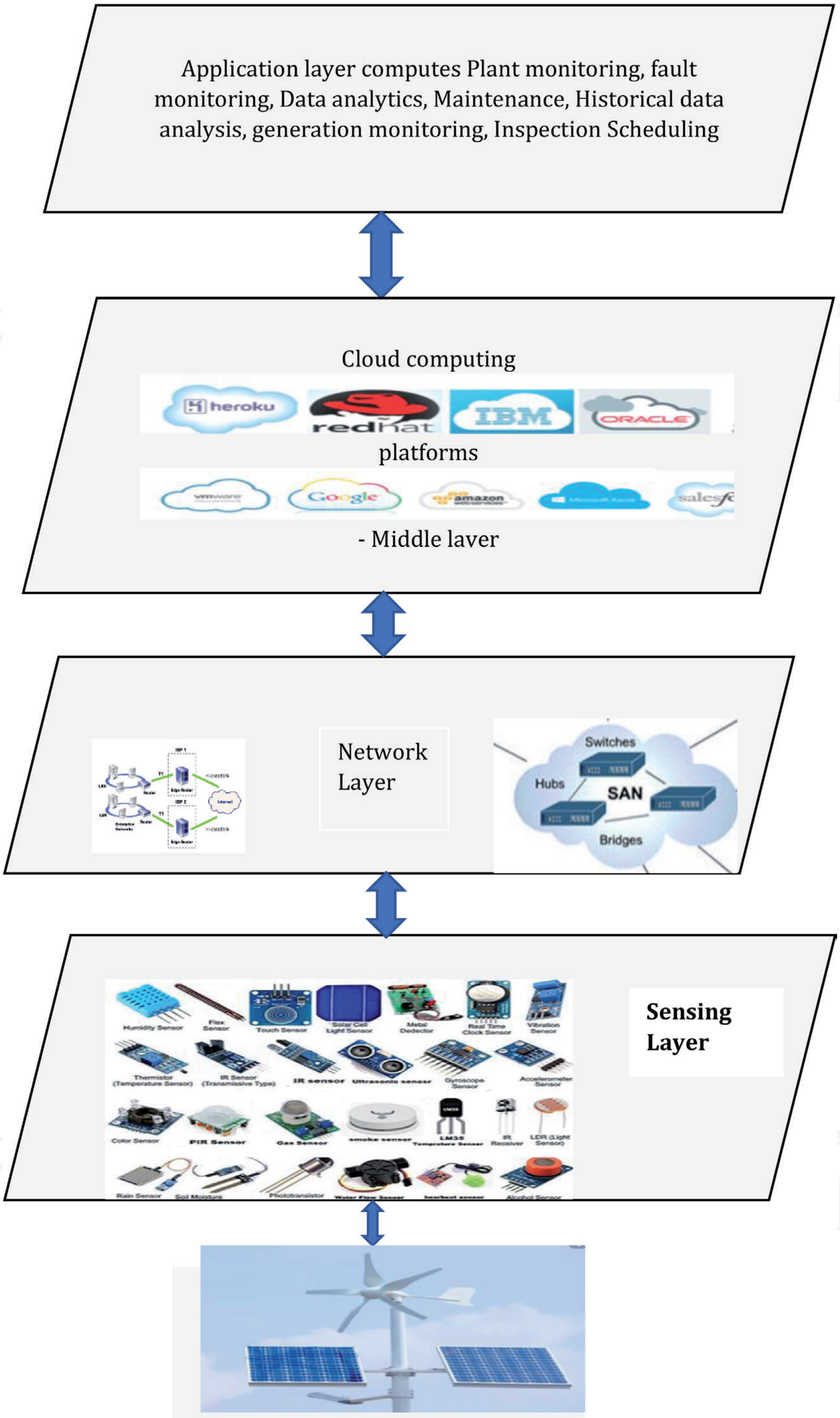

Figure 1.
IoT layers for renewable energy.

the perception layer is the network layer. It transfers information and data through access and transport network. Access network are short range wireless network like Wifi, ZigBee, sensor area network. Transport network access includes wired or wireless area network. Some of the technologies for transport network access are Internet protocol version 4 and 6, user datagram protocol.

The interfacing of network layer with that of the application layer is carried out by the middleware. This layer extracts the information and convert into required format. Middleware decomposes complex system into simpler one. It follows Service Oriented Approach. Application layer includes cloud computing platform, application platform. The application layer stores the data received from the perception layer via gateway and organizes the data received and computes the data and predict decisions. Thus, application layer delivers gathered information about the monitored parameters to from the web server to the user. The data can be accessed by the user in the form of reports or visual graphs. The layers involved in performing various functions are shown in **Figure 1**.

3. IoT for renewable energy

The maximum PV yield is determined by mainly two factors namely unalterable and alterable factors. Unalterable factors are the environmental factors such as solar insolation, wind movement, rainfall, dust properties, ambient temperature and humidity. It has to be accepted by default. Alterable factors allow design flexibility and by varying their design values its response also varies. The alterable factors are orientation of the panel, tilt angle, sun tracking devices, solar reflectors to produce optimum yield.

Physical monitoring of farms such as solar, wind, hydropower etc. becomes difficult and involves human intervention. IoT sensors help in monitoring and managing generation, transmission and distribution across remote locations without involving human interventions. PV set up consists of converter with or without MPPT tracking, controller to feed the grid. Standalone PV system consists of converter with or without peak power tracker, controller, battery storage and inverter Some of the ventures proffered for monitoring the parameters of PV are as follows. The **Figure 1** sketches up the general set up of renewable energy integrated with IoT.

Installation of solar photovoltaic system has seen a rapid growth in recent years because of advancement in technology and reduction in cost of the PV panels. Since PV systems are located at impassable locations it becomes necessary to continuously monitor the performance. IoT based solar PV monitoring uses GPRS module, low cost microcontroller. These components equipped with PV allows the user to access data about the productivity of PV from anywhere. It identifies the fault from the recorded data, informs about the maintenance requirement as well whether yield of PV satisfies the demand or not [2]. A low-cost monitoring system developed using.

Raspberry Pi, microcontroller to provide real time system data in graphical form instead of numerical. Substantial parameters such as voltage, current, environmental temperature are monitored. Based on monitored data decision can be determined whether PV system can be expanded or not [3].

IoT technology supervising solar PV plant helps in evaluating the performance of PV farm in remote location. In this proffered method PV voltage and battery voltage is determined by voltage divider circuit, PV current and battery current is determined by differential amplifier. Grid voltage determined from potential transformer and grid current determined using current transformer. PIC18F46K22 microcontroller as heart of the data logging unit, SIM900 as communication module are interfaced with single core processor AMR926EJ-S. It determines the fault, reminds about the maintenance schedule. Real time data of the plant will make the concerned authority to enhance the decision-making process. Real time data is made available in web server. The remote monitoring becomes essential now a days as the solar farms are interweaved to the utility grid. The energy efficiency of PV farm is improved by IoT based remote monitoring [4].

Agriculture has two major issues namely water scarcity, labor cost. Agribot developed for agriculture purpose is powered by PV. The PV is equipped with boost converter to power the Arduino. Agribot employs YL69 to determine the moisture content of the soil and LM3569 to measure the temperature. The monitored moisture content of the soil and temperature are transmitted to the cloud portal via wireless network. It processes the data and performs control action. The control unit is activated to pump the water to the field when the measured values of moisture content and temperature are below the threshold values. If the measured values are above the threshold limits Agribot just passes that area without irrigating the field. The DC motor is used to drive the Agribot. IoT not only enhances the efficiency of PV but also improves the irrigation of the farm to increase the yield of the farm field [5].

IoT implemented to harness maximum power from PV. PV voltage and current are made available to the cloud portal. The cloud portal processes the voltage and current to determine the actual power. The actual power is compared with that of the set value. If it is equal to zero then the duty cycle for switching device of the converter remains the same. If it is not equal to zero then it compares the value of PV voltage with that of the threshold value. If it is less or greater accordingly the duty cycle of the switching device is varied in order to track maximum power. IoT performance compared with that of different algorithm technique for tracking maximum power and found that IoT converges fast and the implementation complexity is also not high and the parameters considered by IoT are voltage, current and irradiation [6]. IoT replaces the hardware-based stations for measuring the global horizontal irradiance as well as cell temperature and ambient temperature. IoT based module captured the data similar to hardware- based station. It does at a lower cost. Thus, this system provides solar statistics without the intervention of humans and determine in which location sun strike is more and calculates the amount of energy that can be obtained in that area [7].

In Electrical Computer Engineering laboratory at Memorial University 260 watts Solar panel monitored using opensource SCADA system based on IoT. IoT includes the parameters PV voltage and current. The sensors measure the voltage and current of PV. It is made available to the Arduino microcontroller. The values are communicated through Node Red Programming tool. The server platform for storing data, as well as for monitoring and performing control actions is EmonCMS. The experimental setup validated and the outcome of the system proffered holds good not only for monitoring and performing control actions but also for data receiving, transmission and presentation also. The proffered system is suggested for applications such as in generation, transmission and distribution of power, industries etc. [8]. For marine applications Solar photovoltaic system is implemented for generating power and is known as auto generators. In order to determine the energy harnessed by PV it is equipped with infrared camera with 8 megapixel, GPS, transceiver, Raspberry pi, GPS. The images of PV panels are modulated and sent through internet gateway. The modulated images are received using Software Desired Radio and transmitted via ethernet cable for retrieving the actual images at the user end. In order identify the fault from remote location and also to determine whether fault occurred can be recovered or it requires a service. Thus, the energy monitoring device using IoT cutdown the cost and aims at continuous monitoring to harness maximum yield without any interruption [9].

IoT for solar monitoring system proffered uses Amazon Web Services to have a live control over peak power. The performance of the monitoring system is carried out on two IoT platforms Beagle Bone Green and ESP8266. Maximum Power Point Tracker (MPPT) software loaded on these two platforms for buck converter topology. The internet connection performance is determined by two parameters namely perturbation period and its magnitude. The time taken to receive the data of temperature and irradiance, convert analog data to digital data execute the algorithm to determine the output and change the value of duty cycle accordingly must be less than that of the perturbation time period. Both wireless profiles were programmed using python and CPP to determine the runtime of MPPT. The outcome of the proffered system is that MPPT frequency of operation depends on how fast data is transmitted and received. Cloud portal- based methodology for tracking maximum power is feasible [10].

In solar array reliability is one of the crucial factors deciding power generation efficiency. Some of the occurrence which reduce power production is shading which may be permanent or temporary. Temporary is of less severity when compared to permanent which has high severity. The other factors which interrupting the power production are line to line fault, single or double ground fault, open circuit fault, short circuit fault. The way in which IoT identifies the fault is that it executes algorithm technique and predict the reason for occurrence of decrease in yield. Soiling – the aggravation of dust on the surface of the solar panels. It reduces the conversion efficiency. Many cleaning techniques are available. Using IoT the cleaning actions are performed at remote locations without human intervention to increase the conversion efficiency. Moreover, reducing soiling effect increases the life span of the panel otherwise it creates hotspot on the surface of the panel making it faulty. Unmanned vehicle with thermal camera is made to fly over the PV farm. The images are processed using IoT cloud portal to determine the exact location of hotspot on the panel [11–14].

Solar energy harvested fed directly to microgrid to facilitate lighting, battery charging. The computing and control technique provided using IoT. Control technique implemented enhances optimal tracking. This dependable control technique using IoT not only improves the reliability but also the self- recovery of the system [15]. When solar panels are placed on the rooftop it becomes difficult to monitor and study the stability of the system. The sensor units monitoring PV parameters are connected to the Zigbee devices to make the data available to the web. Web server presents the data to the user using Ajax and Html technology. The platform implemented for Zigbee is opensource Linux operating system. Zigbee performance is found feasible for distributed solar cells [16].

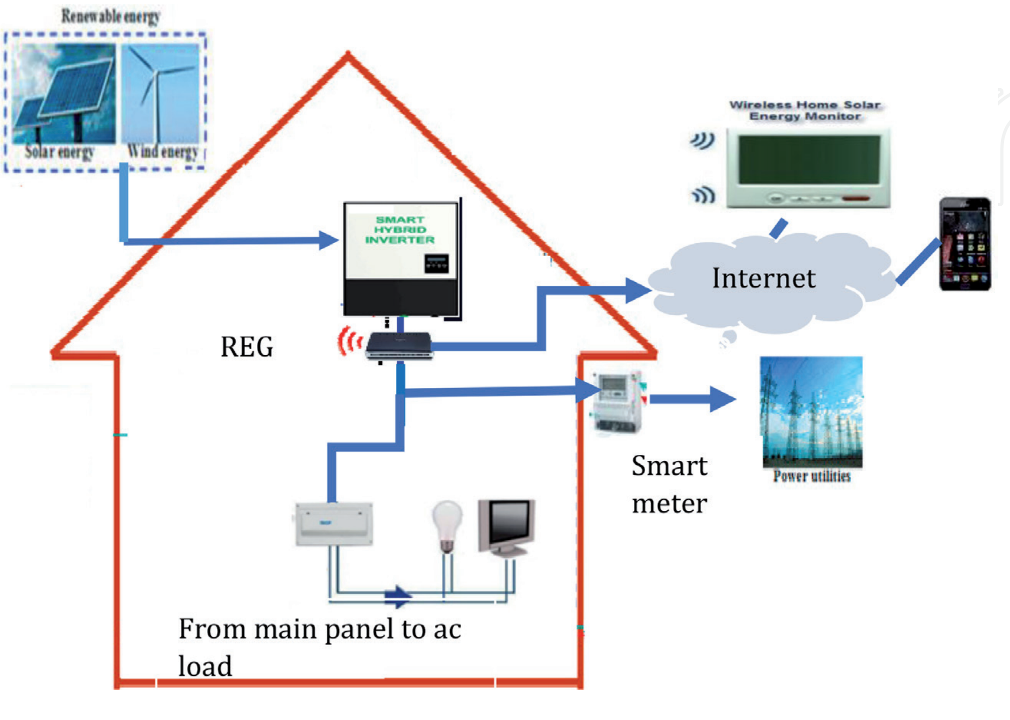

Figure 2.
Remote monitoring for smart home.

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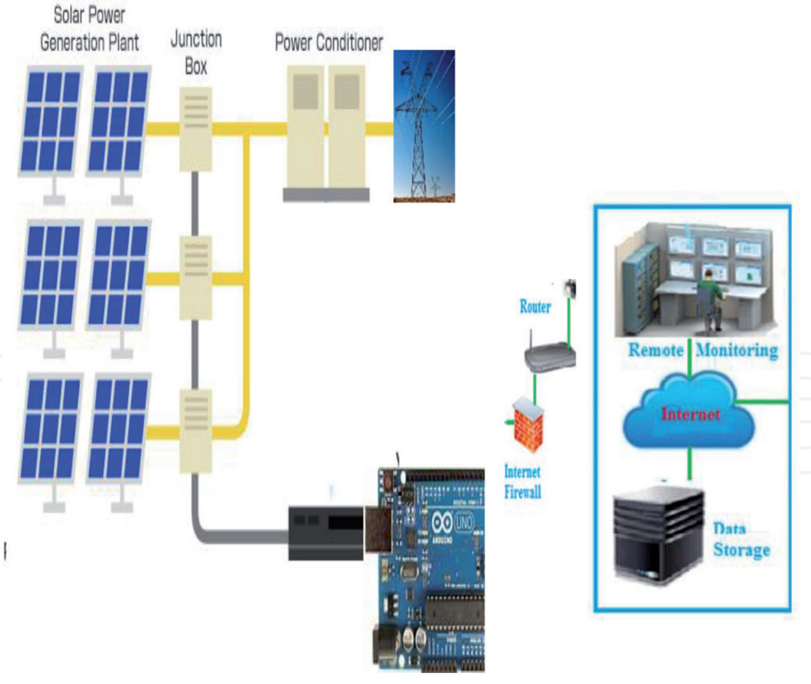

Figure 3.
Remote monitoring for PV grid.

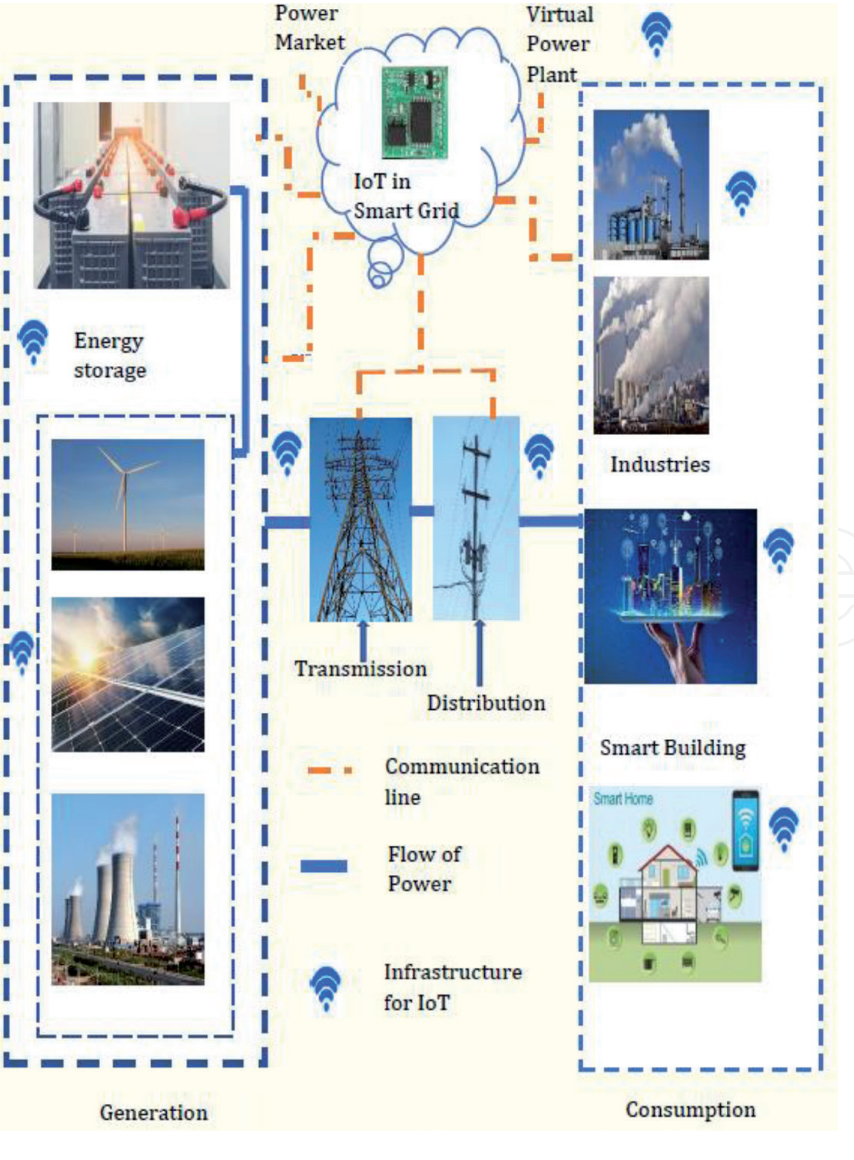

Figure 4.
IoT technology for generation and consumption community.

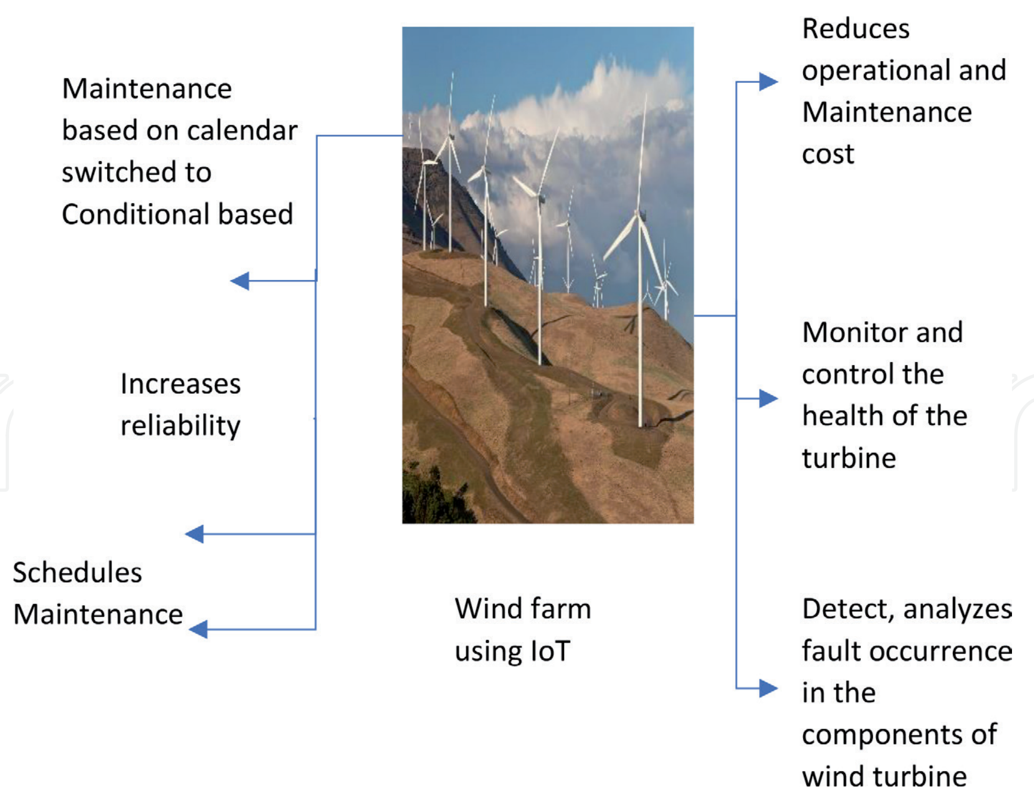

Figure 5.
IoT technology for wind farm.

Software developed to monitor the parameters PV voltage and current, temperature of the panel, operating time. The proffered system identifies the occurrence of fault automatically and allows remote monitoring using GSM embedded module. With stored data analysis carried out to determine the performance of PV system. Specialist and operators are allowed to monitor the performance. Software developed can be altered or updated according to the requirement by specialist. Operators can just monitor only [17]. The **Figures 2** and **3** delineates the remote monitoring for smart home and PV grid.

The **Figure 5** sketches IoT for wind farm which monitor the parameters of wind turbine such as velocity of wind using anemometer, voltage, current, vibration, humidity, power using respective sensors. The measured real time parameters are made available to the users in remote location via Internet. IoT integrated cloud portal helps to store, analyze the data of measured real time parameters with that of actual data determined using machine learning algorithms. These techniques not only determine the fault but also helps in decision making [18, 19].

4. Conclusion

Thus, from the above references in order to enhance the efficiency of renewable energy continuous monitoring becomes necessary which is carried out using various sensor devices. Everything is made simple and easy using evolving technology IoT is shown in **Figure 4**. If renewable energy sources keep IoT at its forefront the benefits it presents are.

Physical monitoring of farms such as solar, wind, hydropower etc. becomes impossible. IoT sensors help in monitoring and man-aging generation, transmission and distribution across remote locations. Continuous monitoring ensures that all equipment work efficiently thus helps in improving reliability.

Renewable energy equipment has complex constructions. They require an adjustment according to environmental change. IoT implemented wind, solar have better control and also helps in reducing operational cost. The advanced monitoring using IoT improves safety on the premises to avoid disaster by providing timely alerts, automatic shutdown etc.

IoT powered smart grid have the ability to detect changes in the demand supply of electricity and is able to react to these changes automatically and provide needed information to manage demand. Thus, improves the energy efficiency.

Energy equipment housed IoT sensors constantly monitor, analyze and predict the energy requirement. The building analyzed da-ta helps in managing infrastructure or to modify the existing infra-structure based on demand. Sensors help in isolating affected area and automatically reroute power as soon as the problem is solved.

Based on accurate measurement using sensors IoT can predict the precise energy generation thus optimizes production and control. The energy consumed reports can be sent to the users so that they can identify the energy wasted and can save energy bills.

Though IoT becomes part of consumers and industries, the problem that revolves around IoT is lack of security. For example, on 23rd December 2015 at Ukraine first power grid cyber-attack took place. The malware disrupted three energy distribution companies. It switched off 30 substations. It left 230000 people without electricity for a period of six hours. Since, IoT devices share information over the internet. Thus, the data hacked affects the privacy of consumers and industries to an extreme level. In order to overcome the issues IoT devices must develop top notch encryption for sharing information over the internet. Apart from this it creates unemployment in developing countries since it replaces human intervention with thing to thing communication. Moreover, people look out to do their task easier with less effort. IoT makes their work simpler and easier at the same time it makes the people lazy and dependent on technology.

In forth coming years IoT with renewable energy transform the energy sector by continuous monitoring, performing control actions to improve the efficiency as well as to distribute the energy harnessed efficiently. IoT implemented with renewable energy saves consumer time as well as money. It reduces the carbon foot print. In future the renewable energy sector will become smarter, efficient and more reliable. Though IoT has many advantages it must put effort to determine the ways in which it can combats its demerits.

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