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A Novel Methodology of IoT Implementation in Energy Management

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Abstract

The work throws light on the need for energy management and the method adopted to efficiently utilize the available green energy sources abundantly available in nature. The controlling and supervision is proposed to be done by adopting a novel technique called the Internet of Things (IoT) which is the most emerging section in the technological society. The key to the solution is to remove any manual hindrance to the system and make the execution completely automated and entirely safe by protecting it with necessary measures. The hybrid energy system is used to compile the accessible energy sources and use the most relevant energy to produce power which will be supplied to the load. The poor management will be completely eradicated by the introduction of IoT. An additional advantage is that both the consumers and the controllers will have complete transparency in the entire process. The controller will have the access to manipulate the progress and the consumer will be able to monitor all the changes and the consumption done by him. Awareness to save energy will also be awoken which is very necessary for the current generation.

Keywords: Energy Management, Hybrid System, Safety, Transparency, IoT

1. Introduction

The use of non-conventional energy is an effective way to protect our environment and it is simultaneously very efficient. The real problem that we face after the implementation of such a system is the poor management and lack of monitoring. Though the use of green energy also known as environment-friendly resources is abundantly available in nature and their management is not necessary, but wasting these energies that are being produced by the system is a huge setback. We have to come up with a solution to completely consume the energy obtained. This can be done by deploying a system which would monitor the production, consumption, faults and the load requirements in an area allotted to the system. In a country like India which lies near the equator which aids it to be a tropical country, this adds up to the fact that most of the renewable sources can be obtained within our boundaries itself. Utilizing sources of energies naturally available to us is a gift that we gave to ourselves. The mammoth chore is to develop a structure that will allow us to effectively explore and consume every watt of power produced within the border. One such solution is creating a management system using the Internet of Things (IoT) which is the most trending technology in the current world. A novel idea to manage all these energy sources and to improve the efficiency of power production is proposed through in this work. Use of different resources to produce more power is already in progress and that system is known as a hybrid energy system. Our country has such a system installed in Haryana which is a big step forward. Resource utilization is already done, but resource management is yet to be done. The first step has already been taken for the harnessing of different kinds of energy and the second step is taken by us in the form of a management system.

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2. Hybrid Energy System

As the spread of renewable energy generation continues and countries expand to allocate more resources to increase the overall percentage of renewable energy generation capacity, more stability will be required to ensure that such technologies like wind and solar aren't as reliant upon specific weather conditions[1]. In line with this thinking, matching different forms of renewable energy and introducing more efficient storage technologies will be the best option for increased reliance on renewable energy resources.

Renewable energy has often been dismissed by opponents as being too variable for very high penetrations due to its reliance upon the sun shining or the wind blowing. These variability issues are especially troublesome when combined with old energy grids, unable to cope with such fluctuations.

Much of the weather-reliant issues could be done away with by introducing enhanced energy storage technology and by developing what are called "hybrid" energy systems- energy systems which, in tandem with a smart grid, combine two or more forms of energy generation so that anyone is able to cover the other at any point in time[2].

The system is an integration of Photo-Voltaic (PV), Wind Energy (WE), thermal energy systems for a sustained electrical generation to cover the electrical power demand during adequate insolation, or/and adequate deposit of energy. Figure 1 shows a basic block diagram of a Hybrid energy system. The system combines the advantages of each generation system and provides electrical power to meet the required load. The current trend of research and development are focused in Hybrid Renewable Energy Systems (HRES) that allow hybridization and optimization of the electrical generation.

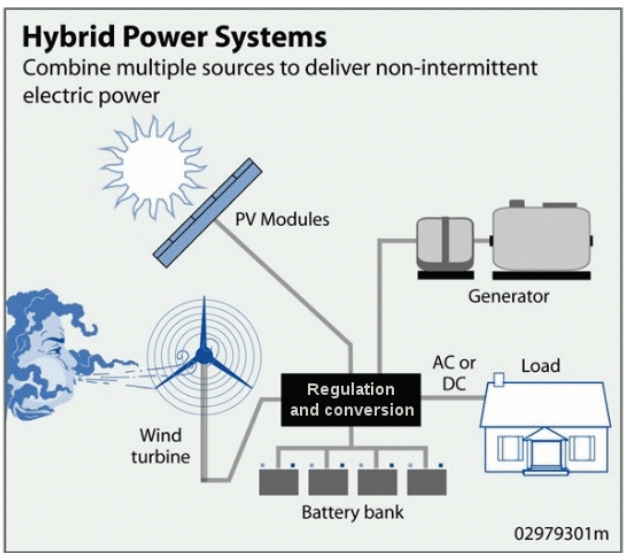

Figure 1. Basic block diagram of a hybrid power system.

3. Internet of Things (IOT)

The Internet of Things (IoT) is the network of physical devices, vehicles, home appliances and other items embedded with electronics, software, sensors, actuators and connectivity which enables these objects to connect and exchange data. Each thing is uniquely identifiable through the embedded computing system but is able to inter-operate within the existing internet infrastructure. IoT allows many daily things to be tracked, monitored, and connected, and a lot of information can be collected automatically.

The IoT allows the objects to be sensed or controlled remotely across existing network infrastructure, creating opportunities for more direct integration of physical world into computer-based systems and thus results in improved efficiency, accuracy and economic benefit in addition to reduced human intervention.

Rising energy prices, increasing ecological awareness, and changing consumer behaviors toward greener products are driving decision makers to put green manufacturing and energy efficient production processes at the top of their priorities and the Internet of Things (IoT) being the current emerging technology promises an effective solution for all these demands.

Application of IoT in power system could make wonders in the power sector unit by efficiently managing the distribution of produced power with minimal wastage. The automated monitoring, control, management, maintenance and transparency can effectively overcome the limitation of poor monitoring in our country and can result in a smart saving of energy and non-renewable resources like fossil fuel.

3.1 Applications of IOT

IoT applications are still in its early stage. However, the use of IoT is rapidly evolving and growing. Quite a few IoT applications are being developed and/or deployed in various industries including environmental monitoring, health-care service, inventory and production management, Food Supply Chain (FSC), transportation, workplace and home support, security and surveillance. Below are some IoT applications in industries.

3.1.1 Using IoT in the Health-Care Industry and Renewable Energy Management system

IoT provides new opportunities to improve health care. Powered by IoT's ubiquitous identification, sensing, and communication capacities, all objects in the health-care systems (people, equipment, medicine, etc.) can be tracked and monitored constantly[4]. Enabled by its global connectivity, all the healthcare-related information (logistics, diagnosis, therapy, recovery, medication, management, finance, and even daily activity) can be collected, managed, and shared efficiently.

An Integrated Community-Scale Energy Model (ICEM) was developed for supporting Renewable Energy Management (REM) systems planning with the consideration of changing climatic conditions. Through quantitatively reflecting interactive relationships among various renewable energy resources under climate change, not only the impacts of climate change on each individual renewable energy but also the combined effects on power-generation sector from renewable energy resources could be incorporated within a general modeling framework[3].

3.1.2 Using IoT in FSC (Food Supply Chain)

IoT technologies offer promising potentials to address the trace ability, visibility, and controllability challenges. It can cover the FSC in the so-called farm-to-plate manner, from precise agriculture to food production, processing, storage, distribution, and consuming. Safer, more efficient, and sustainable FSCs are expectable in the future.

3.1.3 Using IoT for Safer Mining Production

Mine safety is a big concern for many countries due to the working condition in the underground mines. To prevent and reduce accidents in the mining, there is a need to use IoT technologies to sense mine disaster signals in order to make an early warning, disaster forecasting, and safety improvement of underground production possible.

3.1.4 Using IoT in Transportation and Logistics

IoT will play an increasingly important role in the transportation and logistics industries; IoT is expected to offer promising solutions to transform transportation systems and automobile services[5]. As vehicles have increasingly powerful sensing, networking, communication, and data processing.

3.1.5 Using IoT in Fire Fighting

IoT has been used in the fire-fighting safety field to detect potential fire and provide early warning for possible fire disasters. IoT is also implemented in urban smart transport intelligent system and it is helpful mainly in smart cities[6].

4. Implementation of Internet of Things in Hybrid System

A new idea of implementing the IoT technology to effectively manage the power produced by the hybrid energy power system is introduced in this work. The layout of the proposed hybrid system using IoT is portrayed in Figure 2. As it is evident from the given diagram, the hybrid cabinet system is connected to various components which generate power, such as a solar panel, a wind turbine and a diesel generator. As a backup, a battery bank is also provided in the setup. The battery is proposed to be a lithium-ion battery which has proved its efficiency in the past with many applications.

The software in which the IoT plays its role will detect the environmental conditions, compare it with the ideal conditions which would be already fed into the system by the controller as initial data and then decide the best generator to be put to work so that the maximum output is generated in that specified area.

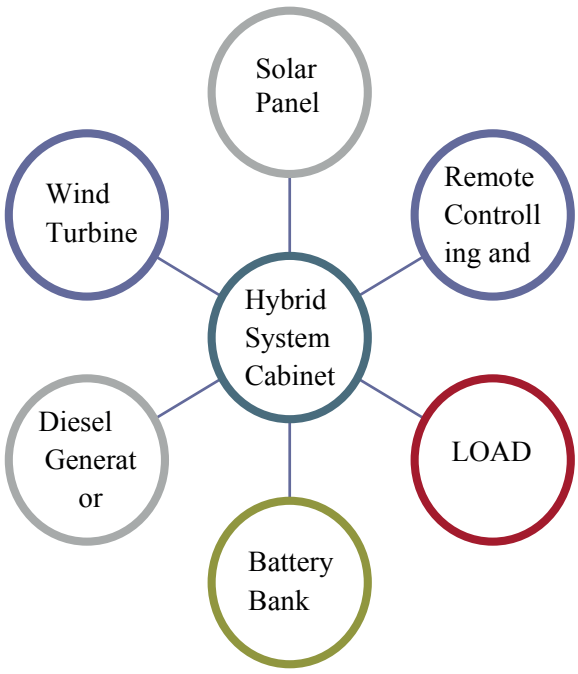

Figure 2. Layout of the hybrid system using IoT.

It is evident from the figure that the system is also connected to a load which will have a specific demand. The code for the software will be written in such a way that when the load demand is fulfilled, the remaining energy will be utilized to charge the battery bank, and when all the energy is sufficiently provided to the load, the remaining energy will be distributed to the nearby grid which will be a pathway for the other consumers to use the energy produced by our prototype, and we can also ensure that there is no wastage of energy in this process.

The data that is being manipulated in the system is very sensitive, so only a partial portion will be visible to the consumers, which ensures the security and credibility of the system, but at the same time, the transparency between the controller and the consumer is maintained.

A real-time implementation is proposed which will soon be a reality. A thorough survey of our college premises has been done by us and the consumption details have been procured, a small-scale prototype in a particular area with full knowledge of the load is being made which will manage the energy purchase and consumption inside our college premises. The coding for this prototype will be done on an Arduino board and the data fed into it will suffice enough for the system to learn the technical conditions and variations on its own.

5. Results

Consider a situation at which the generating station has to supply a load of 3MW through the energy generated from solar, wind and diesel engine generators. Assume that the maximum capacity of solar and wind generators be 2MW each and that of the diesel generator be 1MW. If all the three generators attain their maximum potential then the overall capacity generated exceeds the load capacity and attains a value of 5MW and hence additional 2MW generated is not utilized properly. Hence, Flowchart and algorithm are constructed for the cases at which the overall capacity exceeds the load capacity and to utilize the energy generated properly.

5.1 Algorithm

Step 1: Start.

Step 2: Obtain the value of solar and wind generated at that particular time.

Step 3: Compare the generated capacity with the load capacity if it is less or equal then go to Step 8 or else go to the next step.

Step 4: There are three possible cases to utilize the additional energy generated.

Step 5: Consider the 1st case at which the energy generated via solar=1MW and wind=2MW or solar=2MW and wind=1MW. In such case, the additional energy which would have been through the diesel engine is saved and thus the additional cost is reduced.

Step 6: Consider the 2nd case at which the energy generated via solar=1MW, wind=2MW and diesel=1MW or solar=2MW, wind=1MW and diesel=1MW. In such case, the additional energy of 1MW generated is shared with the nearby load center where there is an energy demand. Thus, the additional energy which would have been wasted is utilized properly.

Step 7: Consider the 3rd case at which the energy generated via solar=2MW and wind=2MW. In such case, the additional energy generated via solar is used to charge DC battery from which the energy can be obtained at times of shut down.

Step 8: Stop.

5.2 Program

```
#include<stdio.h>
int main ()
{
int a,b,c=1,d,choice,option;
printf ("Enter the value for power
generated through solar:");
scanf ("%d",&a);
printf ("\nEnter the value for power
generated through wind:");
scanf ("%d",&b);
d=a+b+c;
if (d>3)
{
if (a==1 && b==2 || a==2 && b==1)
{
option=1;
}
else if (a==2 && b==2)
{
```

```
option=2;
}
switch (option)
{
case 1: printf("1.Need the power generated through diesel to be saved.\n 2.Need the power generated through diesel to be shared.");
printf("\nEnter your choice:");
scanf("%d",&choice);
if(choice==1)
{
printf("Power generated by diesel is saved");break;
}
else
{
printf ("Additional power is shared to the nearby load center");break;
}
case 2:printf("Additional 1MW is used to charge a DC battery. Also, the power generated through diesel is saved");break;
default:printf("The power generated itself is not sufficient");break;
}
}
else if(d==3)
{
printf("The power generated is sufficient and no additional power is generated");
}
else
{
printf("The power generated itself is not sufficient");
}
}
```

Output

1. Enter the value for power generated through solar:1
   Enter the value for power generated through wind: 0
   The power generated itself is not sufficient
2. Enter the value for power generated through solar:1
   Enter the value for power generated through wind:1
   The power generated is sufficient and no additional power is generated
3. Enter the value for power generated through solar:1
   Enter the value for power generated through wind:2
   1. Need the power generated through diesel to be saved.
   2. Need the power generated through diesel to be shared.

   Enter your choice: 1
   Power generated by diesel is saved
4. Enter the value for power generated through solar:2
   Enter the value for power generated through wind:1
   1. Need the power generated through diesel to be saved.
   2. Need the power generated through diesel to be shared.

   Enter your choice: 2
   Additional power is shared to the nearby load center
5. Enter the value for power generated through solar:2
   Enter the value for power generated through wind:2

Additional 1MW is used to charge a DC battery. Also, the power generated through diesel is saved.

6. Latest Developments

In the modern times, IoT will become one of the day's today essential devices, as the usage of IoT is comparatively increasing in many ways. One such use of IoT is power management system field as shown in Figure 3. Many researchers are doing research in the IoT based power system[7]. The researchers and industrialists are

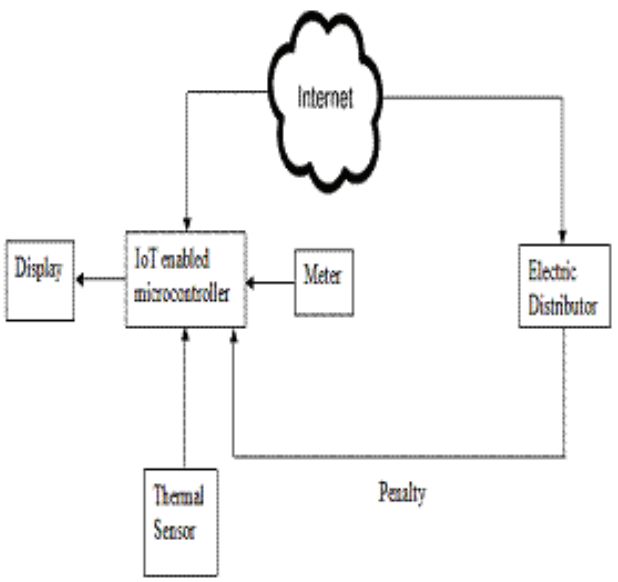

Figure 3. Schematic sktech of power management system field.

forced to design low power consuming system as there is an increase in power requirements. The wastage of energy will occur which is a very serious concern. To avoid wastage of energy, power management scheme came up with a solution. This system consists of thermal sensing and IoT enabled micro-controllers for the working method.

In the Gulf countries such as Saudi Arabia IoT is used for Desalination of the water which is one of the most important sources of water. For the Gulf countries, it is most important to start integrating renewable technologies to be the conventional grid for powering desalination plants. In this work, the new technology is implemented by using IoT. These IoT will monitor renewable based desalination plants[8]. The system studied is a hybrid wind-solar energy driven desalination plant that is implemented from an IoT perspective using the network simulation tool Packet Tracer. The plant is powered using renewable sources which operate the pumping station. In addition, the motors are automatically controlled according to the water level and demand whereas the boiler is also controlled automatically by a thermostat. Network Address Translation (NAT) and Access Control List (ACL) are used to implement network security and aid in access control. There is also a web-accessible monitoring station housed on a server to which employees are given different levels of access according to their position. In this research, they had implemented a hybrid wind-solar energy-based desalination plant using Packet Tracer simulator. The schematic of the power station and water level control are portrayed in Figure 4.

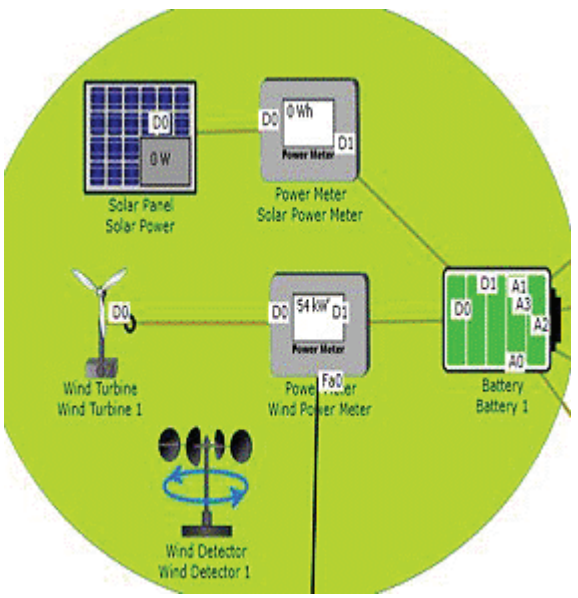

Figure 4. Power Station.

This work says about their proposed technique for the energy management of thermal dissipation to increase the efficiency of solar cells. The energy from solar will be stored as the alternate energy whereas the energy from the Peltier plate[9]. The Peltier plate enables to capture the heat from surroundings and convert into electrical energy. This hybrid technology increases the efficiency of the solar power system which helps us to increase the efficiency of the solar power system. This technology is used to feed the data into the cloud and it can be accessed at any point of time during generation. This technology is used to generate with and without the use of sunlight which uses the green energy.

7. Future Prospects of the Idea

The proposed prototype is a small scale model which will comply the needs of the college campus and will effectively manage the resources inside the campus. Though it is a small model, it can be expanded up to great extent. Many ways are possible, like the installation of hubs or switches to implement the same on a wide scale such as for an entire city.

The Indian government is an ardent believer of digital India and has taken up a ₹ 2, 01, 979 crores project which aims to make 99 cites of India completely automated. The name of the project is a Smart city project. Our idea is not only along the lines of this project but also gives an innovative outlook on a problem that is very essential. The large-scale project will be a management system which will manage the consumption, saving, maximum utilization and minimum wastage of the energy that is being purchased by any sector.

The proposed idea will be a solution for the problems in the power sector side. It will pave way for effective energy management by utilizing the available green energy sources like wind and solar. This will prevent the use of conventional energy resources, saving the cost of fuel will also contribute to the improvement in economic value.

8. Conclusion

As a complex cyber-physical system, IoT integrates various devices equipped with sensing, identification, processing, communication, and networking capabilities. In particular, sensors and actuators are getting increas-

ingly powerful, less expensive and smaller, which makes their use ubiquitous. Industries have a strong interest in deploying IoT devices to develop an industrial application such as automated monitoring, control, management, and maintenance and we have utilized it in the management of hybrid energy system in order to improve the performance of all the generating devices present in it. Due to the rapid advances in technology and industrial infrastructure, IoT is expected to be widely applied to large industries.

This work will clearly explain the importance of IoT in energy management. The deployment of various green energy resources with the aid of IoT is clearly highlighted. The functional process of load shedding and the importance of the IoT technology along with the algorithm is explained as shown in section 5. Latest developments associated with the proposed work are also elucidated. This work will be quite beneficial for power energy sector.

9. Acknowledgment

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