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RFID TECHNOLOGY HIDDEN LOOP TO OPTIMIZE ENERGY INTELLIGENT BUILDING PRODUCTIVE AND NON-PRODUCTIVE

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ABSTRACT

The development of modern technologies has provided powerful devices in order to increase benefit and decrease costs. Building management systems (BMS) use these kinds of technologies especially information technologies for the purpose of energy optimization, costs reduction, and biological resources preservation. Intelligence technologies based on radio frequency identification (RFID) which transfers the information through RFID intelligence tags and readers are among modern technologies in this field which can be applied in the identification and inspection of people and objects, and in controlling environmental conditions and traffic control. The present article attempts to consider the effect of applying RFID on building energy management by looking over the results of current researches about modern technologies, BMS, and RFID and thus, work wonders on the optimization of building energy, the reduction costs, and the preservation of environmental resources.

Keywords: Radio Frequency Identification (RFID), Building Management System (BMS), Energy Management

INTRODUCTION

Many energy resources we use are not renewable, and will come to an end one day. On the other hand, a great number of these resources cause irretrievable damages in the environment. For instance, using fossil fuels results in long-term greenhouse effects and global warming.

In addition, these resources are very expensive and have deep effects on economy. Therefore, energy management and using it with economy are among the most important purposes of societies and governments. Energy management is an issue which has been of importance since oil crisis (shortage) in 1970s (Sivill, 2011).

This phrase has a lot of meaning which includes energy manufacture and production management, energy services, and energy preservation or protection (Turner, 1993). Also, it means "the correct and useful use of energy in order to maximize profits and increase competitive position (Capehart *et al.,* 2003)", and sometimes has been described as a way of the arrangement and optimization of energy, by using system and techniques in order to reduce required energy in each production unit while freezing or decreasing the total expenses of production.

By the development of technologies like it and information systems in all fields, energy has referred to information systems to improve management. Among these systems, energy information system (EIS) (Motegi *et al.,* 2003) and energy management information system (EMIS) have been proposed. Using these technologies in buildings which has contributed to decreased costs and optimized energy, has resulted in the appearance of BMS. RFID is one of the most common technologies in these two systems (Cong *et al.,* 2012). This technology is one of the best ways of identifying objects automatically, and can be considered as the complement of "bar code" (Hai-lin *et al.,* 2008); it operates based on wireless frequencies, and does not need to contact between information receiver and transmitter; also reaching light from data carrier by means of receiver is not necessary; this in turn leads to the lack of the interference of manpower, save time and energy, durability of tag, and increased security (Ferrer *et al.,* 2010). In this technology, some data can be read or written on data carrier mark.

The tags include chip and antenna, and have a very simple function. The chip transfers data through antenna, and the sensors around receive them (Journal and RFID, 2011).

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RFID has led to the appearance of BMS. Monitoring and controlling these buildings in the areas of "warming up, cooling, ventilation, smoke, recognizing fire place" has led to energy optimization and decreased costs. Automatic control and recording of data are other advantages of RFID which are useful in identifying, inspecting, and monitoring people and objects status, controlling environmental conditions, and traffic. Using tags and sensors in certain places allows to control physical conditions in the environment such as temperature, the kind of the inside gases, dampness, light, air, and to increase security (Alibabaie *et al.,* 2014).

The present article is to consider RFID effect on the optimization of generator and non-generator (domestic and commercial) building management systems (BMS) by reviewing previous and current researches. First, a brief summary of RFID technology, its applications, advantages, and disadvantages will be presented. Then, the explanations about generator and non- generator sections, and the way of enabling BMS by means of "RFID" in order to increase profitability and optimize energy will be introduced. Then, the effect of this technology on energy management and the advantages of this use, and also the factors having effect on the development of this technology in "building management system" will be presented.

Finally, the use of this technology, the reduction of costs, and the protection of environmental resources in future will be considered. New opportunities of applying RFID technology in the context of energy optimization of generator and non-generator BMSs, useful performing and replacement in the management of energy optimization and benefit increase confirm the necessity of doing this research.

The Appearance of RFID Technology

This phenomenon appeared in 1964, when leon theremin invented an instrument for the united states of Russia (Crispo and Tanenbaum, 2006). This tool was able to send radio caused by different events to the specified place; this was a device for spying, and transmitted vocal data by means of radio waves. These vocal waves, translated the reflection of radio waves into an understandable language. This device in spit of lacking good abilities was recorded as the first device which operates with RFID technology (Crispo and Tanenbaum, 2006).

It's necessary to point that according some references, RFID technology has appeared since 1920, and has been completed in 1960s (Crispo and Tanenbaum, 2006). Then, an American researcher, Harry Stokman had published an article about RFID as "communication through reflection" in 1948, and had predicted that radio waves can be used for identifying different objects and devices and even humans, which this claim required more research.

The Components of RFID Technology

RFID which is the abbreviation of "radio frequency identification", has been applied by large chain stores like "Wall Marth" and "MC. Donald", and important organizations such as "U.S Defense Ministry", and has been successful (Miles *et al.,* 2008). RFID is composed of: tag, reader, printer, antenna which reinforces the signal, information management software, data bank, and internet (Bhattacharyya and Floerkemeier, 2010).

RFID Applications

Nowadays, RFID is used in cases like controlling the comings and goings of the staff in allowed and not allowed places, the electronic protection of products against robbery, controlling balance, recording the time and place of comings and goings. For example, this technology is applied for the automatic record of the time and place of patrol for some certain jobs, automobile identification, traffic control, tracing the drivers who infringe and the automatic record of infringement, controlling passengers' equipment, finding livestock and fowls, libraries management, and in medicine like recording and storing patients' information such as name, address, reception data, the kind of illness, the consultant, the type of operation etc (Miles *et al.,* 2008).

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Table 1: Comparing the types of RFID tags

Type	Disadvantages	Advantages
Inactive	Short Distances (About 4 Meters), Poor Performance Near Liquids And Metals, Only Have Readable Memory.	Long Lifetime, Low Costs, Widespread Application, High Flexibility, Short Dimensions
Semi-Inactive		Communication In Average Distances (About 4-To 50m),Ability To Connect With Sensors And Send Their Data, More Memory Suitable For Big Objects
Semi-Active	Expensive, Don't Have Public Application. Because Of Using Battery (Chemicals)	
Active	Less Durability, Long Dimensions	Communication In Far Distances (More Than 1000m) TABLE I. Ability To Connect With Sensors And Send Their Data, More Memory TABLE II.

According to the reference (office government U.S., 2005), RFID technology advantages are as follows:
- Decreased Expenses (Decreased Manual Activities And Increased Speed)
- Non-Stop Automation
- Decrease In Error
- Invisible Processes Control
- Updating The Tags Without Manual Interference
- Security
- Unity

Building Management System (BMS)
BMS allows to manage lightings, security and audio-visual systems, surveillance cameras, electrical locks, and heating and cooling systems, and conditions can be changed based on time or sensor's data or by manual interference through software (in intelligence phone, tablet, touch board, pc, phone call). Also, various sensors of smoke, CO_2, CO, gas leak, window breakage etc. Can be added to this system, and then security, preventive, and communication commands to contact with police, fire station, or to send SMS can be transferred automatically based on their information (Cong, Stack, Kai, & Menze, 2012).
The basic matter of BMS technology which has been based on the centralization of the user and his/her needs, indulges present and future needs and is able to adapt to future technologies.
In BMS we can adjust the temperature of rooms separately. Also, the system function can be conditional on the presence of inhabitants in building, and can be scheduled based on working hours or day and night; hence, the consumption of energy will decrease.
Now, a half of buildings more than 10000 square meters in area in America which use various kinds of BMS systems, save more than 10% of total energy consumption in buildings more than 10000 square meters in area. By observing international standards in all the processes of measuring requirements, designing, monitoring, and instructing the users during the exploitation of the system, the expected decrease in energy consumption will be obtained (Guidance, 2008).
*Intelligence Building Management System (IBMS)*
The rate of consuming energy around the world is inexplicable. Therefore, many governments have durable development policies and the intelligence use of energy resources. Their goal is to reduce energy wastes. Their ultimate purpose is not the reduction of consumption of energy, but is to optimize energy consumption together with an acceptable amount of comfort for the users. According to examinations made, the basic part of energy consumption is in residential areas, business, governmental, and industrial buildings. Therefore, there have been begun improvements in IBMS in view of ambient intelligence (AMI). The properties of IBMS are as follows:

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- Monitoring energy consumption
- Installing sensor
- The infrastructure of interaction with the users
- Data processor in order to process sense data and perform the strategies of saving energy.

It's necessary to point that AMI success depends on applied sense technologies (sensors and the software used for deciding) (De Paola *et al.,* 2013). Figure 2 illustrates the model of an IBMS.
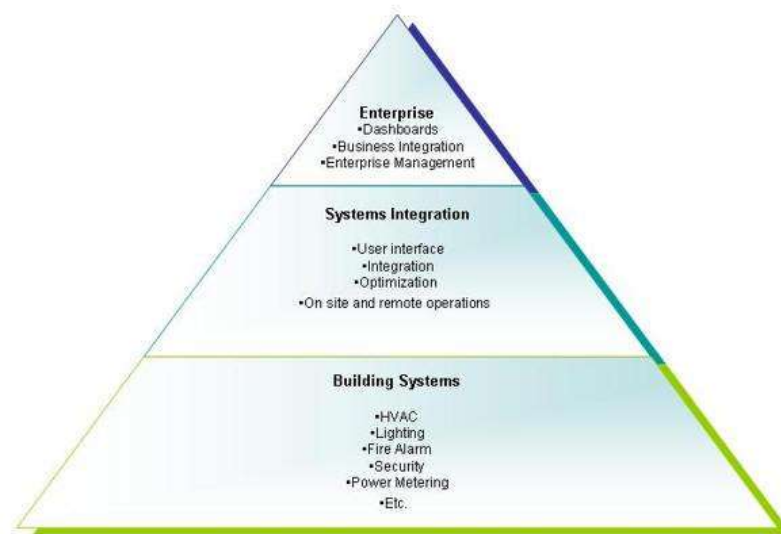
Intelligent Building Model
Figure 2: BMS Model

The Development of BMS System
Because of change in needs in the current world, the buildings in future would confront with challenges such as having a secure, healthy, and enjoyable to do individual and team works. In addition, energy consumption should be economical and optimized in a building in the stages of designing, constructing, and living in it.

BMS systems without need to control are adjusted automatically. For instance, the lighting system of a BMS is adjusted automatically and by the environment light. Also, robots are parts of BMS. One of the ways of directing moving robot for a long time is to provide equipped sensors which are so expensive.

By using RFID in the systems which guide, the robot position and direction can be determined carefully, and in this way, costs will decrease.

The beneath surface of the floor of this leading system is a net full of several tags, and works like traffic lights to determine robots track. In addition, robots are equipped with a reader and a plan loaded in controller in order to determine the position of the tags in the floor. Robots determine and control their position and direction by means of these equipment.

Intelligence technologies like monitoring lighting system, air-conditioning, and electronic doors are among the ways of energy management in building. The purpose of these technologies is to save energy and users comfort (Rycroft, 2014). The standard ISO50001: involves enabling the building to start, perform, maintain, and improve the management of energy consumption. Its goal is to achieve a systematic policy in order to improve energy consumption. The main parts of this standard are:
- Energy consumption
- Measuring, certifying, and reporting the use of energy
- Designing, selecting, and buying equipment to decrease energy consumption
- Controlling the whole variables which affect energy consumption; such as the staff.

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This standard is combined with other management systems. Achieving the maximum use of energy is possible through these two ways:

1. The efficient designing of the building for purposes of energy consumption
2. The dynamic management of the building for purposes of energy consumption.

In the first way, there are standards which are not about the people in the building, and depend on building materials, using sunlight, air-conditioning optimization etc.

In the second way, energy consumption is based on the changes of the internal and external conditions of building space. In this way better use of space can increase the optimization of energy consumption. By using BMS and it systems a convenient and pleasant place will be created for the staff. Unoccupied spaces result in wasting energy and increasing costs (Cong *et al.,* 2012).

One of the buildings involving BMS system is the tower "Majunga" in Paris, and is 194 meters in height, includes 45 floors, and is the third skyscraper in France. This tower includes equipment such as electricity, laying cable, heating and ventilation control, lighting control, security systems, alarm system management, space management etc. Which are parts of BMS requirements? The following lines present the examples of using BMS in the tower "Majunga" (Rycroft, 2014).

3. The staff can control the conditions of work environment by using pc or intelligence phones; for example lighting control, switching on/off the light, changing curtain angles to use sunlight, and changing temperature.

4. The system applied in "Majunga" adjusts lighting, heating, and air-conditioning automatically in order to provide maximum convenience for employees and save energy. All the equipment applied in the system, measure proper light and amount of temperature or co_2 sensors measure the amount of fresh air entered the system.

5. Data collection about the amount of energy consumption by each employee. BMS determines the amount of energy consumption by each employee. Each employee can compare this information with other employees' information and lead to save energy by means of encouragement.

6. Using solar systems in order to reduce needed energy and using renewable energy resources (Rycroft, 2014).

IBMS Applications

Temperature Control

When a person goes on a long journey, can start building installation system, adjust the temperature, and start heating and cooling systems in certain times by means of phone or mobile phone or internet in order to create a convenient environment and prevent energy waste (Ho, 2008).

Lighting Control

The intelligence control of lighting not also controls the amount of lighting up, but also is so effective in energy consumption. In fact, desirable light will be provided both from sunlight and light resources, and this process is done automatically. Generally these systems can perform a desirable process by using sensors which determine movement and the amount of environment's brightness, and the switches set up in every internal space. It's obvious that in automatic state, light resources light up the building based on sensors of light amount and defined desirable point.

Audio-Visual Systems

When BMS is equipped with audio systems, then the following facilities will be provided:

- Independent internal radio with the ability to save available stations for every part of BMS.
- The possibility of receiving audio signal through sound indexes available in central unit.
- The possibility of two-way audio or/and audio-visual communication (inter come system) for every part of BMS.
- To sound audio alarms and warnings.

Fire Alarm Systems

One of the features of BMS is the system of alarming and putting out the fire which is used in BMS and residential and industrial areas to minimize damage caused by the fire and also warn building's residents in order to prevent casualties. Three signs of smoke, warmth, and flame are used to identify the fire.

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Remote Control
BMS allows being aware of current situation and control the building by means of SMS, call center and/or internet.

BMS Advantages
The main purpose of using BMS in buildings is to make good use of economic advantages, decrease energy consumption, and create a secure and quiet environment. All the advantages of using BMS are:
1. Energy consumption is economical and will decrease.
2. Increase of the durability of equipment and remote control
3. Optimized use of equipment and increase of their durability
4. To present a control system with the ability to plan performance
5. Significant decrease in the costs related to maintenance and repairs
6. Optimizing and saving energy
7. There's no need to a building contractor.
8. The possibility of monitoring and controlling all the spaces under control by means of a pc, mobile phone or internet
9. Because the management of different systems and installations in building is associated, all the equipment operates with coordination and the possibility of interference and problems caused by lack of coordination disappears.
10. The possibility of collecting statistical reports on all the equipment and their performance in order to optimize consumption and operation (De Paola *et al.,* 2013).

General Attitude to Saving Energy in Buildings
- To aware people about energy consumption, to present proper feedback to users about consuming energy, and encouraging them to have behaviors compatible to the environment. Although this method is the base of saving energy, is not effective in a long period of time.
- The deletion or decrease of stand by state in system; because energy consumption in this state is more than in active state. Standby should be identified by an economical system monitoring energy consumption, and be change into inactive state.
- To schedule the operation: in this method, intelligence technologies are used for the operation of electrical devices, for example consumption limitation at the peak of consuming energy which results in optimizing energy consumption.
- Comparative control: in this method, the presence or absence of people in environment is identification and the environment shows suitable reaction.

The Necessity of Optimizing Energy Consumption
Optimizing energy consumption is to choose patterns and adopt and apply methods and policies in consuming energy appropriately. In this frame, determining the share of various kinds of energy in the total energy consumption of every society considering its long-term facilities, and also applying the most efficient way of using them is considered. This way of consuming energy not also assures life permanence and the durable development of society, but also results in energy conservation for all people and posterity, and is a prevention of raising and developing environmental pollutions caused by the inappropriate consumption of energy.

The expense of constructing power station for producing and distributing electricity is 800 dollars in each. In addition to expenses, the time required to construct power station' is 3 to 8 years. Also, sometimes power stations annual expenses are more than 20‰ of initial investments. Considering the current potentials of saving in industry, 670 billion dollars can be saved annually. In non-generator part, we can prevent the wasting of national investments by the appropriate use of electrical devices. It's necessary to point that in commercial buildings in Iran, annually about 200 million petroleum barrels are used for heating and cooling. While, if only 10‰ of the use of heating and cooling devices in a year decreases, about 20 million petroleum barrels will be economized.

In addition to economic factors, there are other factors which conform the necessity of energy consumption optimization:

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1. The excessive use of fossil energies which result in increasing environment pollution.
2. The excessive increase in the population and more demands for energy.
3. The limitation of energy of energy resources because they aren't renewable.
4. The increase in energy consumption because of the inappropriate pattern of using it.
5. Lack of a system for recycling energy
6. The presence of worn-out industries and factories.
7. The dependence of national economy on oil earnings.
8. The increase in greenhouse gases and acid rains.

RFID Applications in Conducting the Infrastructures of BMS
The improvement of information and communication technologies leads to intelligence products able to communicate in different places, directions, and conditions. RFID chips present initial communicational devices which are inexpensive and application in every product. The decrease in the price of communication and data processing makes construction environment more intelligence and more efficient (Ho, 2008).
Some requirements in construction which illustrate the need for using RFID are as follows:
- To trail and locate :pieces, vehicles, equipment etc. -
- The efficiency increase in the management of provision cycle, especially for the material and pieces which are produced outside the workshop.
- Identification number for products, which leads to use appropriate tools and instruments.
- Service systems maintenance
- Recording tools' track
- Therefore, some of current applications of RFID in construction

Workshops are:
- Production: locating the product from production to use in workshop in different positions.
- Quality control: during the production ,distribution, and the construction process
- Operation control: the optimization of construction processes
- Availability control: placing RFID equipment entrances and storehouse control
- Maintenance management: the facility of periodic inspections of machinery and control tools.
- Measurement: in rent machineries and equipment performance and recording workshop equipment services.
- Safety : the immunity of operations
- Security: the control of worthy products, the prevention of robbery, and the identification of fake tools.
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- Safety: the immunity of operations
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- Current systems management: locating the equipment.

In construction workshop or places which some of them are in experimental state, some other are aimed for certain cases, some are optimized, and some have been carried out (Ho, 2008).

Movement Manifestation and RFID Tags: Efficient Methods in Generator Organization
Some of RFID tags are put in the staff's seal to measure the space occupied. Then by using the data received from tags and analyzing them, the whole efficiency of building increases (De Paola *et al.,* 2013). The method d5X by using the systems manifesting the movements decreases energy consumption. In this method, if an employee goes out of his/her offices, the systems manifesting the presences turn off the light, air –conditioning system, and temperature controllers automatically (Rycroft, 2014).
RFID tags save these important information (Manzoor *et al.,* 2009):
1. Using the system's properties
2. The amount of using work spaces
3. System management(BMS decision by means of the data provided by tags)

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4. Security management (adjusting alarm in the case of a person entering forbidden areas ,the illegal exit of a computer from a certain place)

5. Developing a data base including the information in tags (the equipment' serial number, prices, types, etc.) (Manzoor *et al.,* 2009).

RFID the Decrease in the Fuel Consumption of Iran Oil Company's Automobiles

For the first time in the areas of the south which contain a lot of oil (petroleum), RFID system has been installed on this company's automobiles in order to save energy, monitor the automobiles, and decrease the waste of energy. By this way the possibility of monitoring the provision and allocation of fuel and the optimized use of it in the transportation fleet, factories' needs, and equipment and machineries which need to fuel has been provided. An RFID chip has been considered separately for this company's automobile's, and through installing this chip on the automobiles, the calculation and illustration of the amount of consumption in kilometer, the amount of automobiles fuel consumption, and the monthly fuel consumption of that organizational unit will be stored in the server.

Conclusion

Considering the necessity of energy consumption and optimization management to support the development of practical researches, technology, and non-renewable resources in energy, and also to plan for the correction of energy consumption pattern, and section, applying RFID technical facilities in energy section, applying RFID management.

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