

# Introducing Smart Energy Conservation Systems in Smart Cities

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**Abstract:-** Energy conservation has become a hot topic at the present time as the rate of energy consumption is continuously increasing. The energy sources are depleting at a very fast rate and soon there is going to be a shortage of energy sources. The smart cities need to understand the importance of energy conservation and this research work is focused on introducing the energy conservation systems in the smart cities. The smart cities need to adopt some of the systems managing and controlling the energy consumption. People can contribute to the environment by conserving energy.

**Keywords:-** Energy conservation, Smart cities, Solar panel system, Energy Management Systems, Environment.

## I. INTRODUCTION

Energy saving has become a hot topic mainly due to the proliferation of energy challenges and climate change globally. People's perception towards the use of smart technologies for energy conservation could be stated in the concept stage. People want to contribute to the environment but they still end up paying electricity bills. Electricity is mainly generated through fossil fuels, renewable energy sources and nuclear energy. The energy sources are depleting at a much faster rate than generation rate and this is going to become a serious concern for the world. Electricity is widely available and this modulates people's attitude towards energy saving [1].

The smart energy system could be defined as an approach to reduce the need of energy services which eventually allows improving the environmental quality, personal financial security, national security and higher savings. The main advantage of smart energy systems is that it allows lowering the energy costs as well as prevents depletion of energy sources. Smart home devices and systems could assist in saving energy by allowing people to control and monitor energy usage in different ways. Intelligent house control and smart cities could save up to 40 percent of energy consumption. The smart energy conservation system has numerous benefits apart from energy saving. The government is taking initiatives to improve the environment's quality of life in a friendly manner. The Smart City initiatives could decrease or minimize the carbon footprint in mega cities. The smart cities using the energy conservation systems could provide better living conditions to the population [2].

In order to execute the initiatives, the cities need to adopt different types of renewable energy technologies and conservation techniques. The study is going to highlight the technologies that could be adopted by the smart cities to build a clean environment. The technologies needs to be adopted by the manufacturing sectors and urban spaces in the smart cities as most of the energy is consumed in those sectors. According to a report released by Schneider electric firm, the global need for energy is going to increase 40 percent by the year 2030 [3].

The drastic increase in energy consumption is going to bring competition for resources, climate change and pressure on prices and impact on the economic growth. The cities must try to focus on making their energy more efficient, green, reliable and smarter. The increment rate could be reduced in cities starts adopting smart energy conservation systems and technologies.

## II. LITERATURE SURVEY

### A. Energy Conservation in Built Environment

The Energy Conservation Act came into action in the year 2001 where the Bureau of Energy Efficiency was established in the year 2002. The BEE has revised the Energy Conservation Building Code in the year 2017 and this allowed accomplishing energy neutrality mainly in commercial buildings. The BEE established a minimum performance standard for commercial buildings. The BEE stated some measures and technologies that could allow the cities to conserve energy. The BEE came up with a typical break up of Power demand and it was mainly meant for building a green environment composing commercial complexes and residential complexes [4]. The breakup of power demand has been listed below.

Description	Break up in %
Lighting & all socket loads	60%
HVAC	30%
Others	10%

Fig 1:- Breakup of Power Demand  
(Source: Martínez-Molina *et al.* 2016)

The BEE developed a HVAC system which stated the major reasons for high power consumptions. The reasons are:

- Aged and inefficient system
- Variable load
- Oversized equipment
- Inefficient preventive maintenance
- Manually operated system

Some technologies that could be used to lower the energy consumption have been discussed in this study.

➤ *Variable Speed Chillers*

The air conditioning that is being used in most of the buildings in the cities are of air cooled type which generally consumers near about 1.3kW per ton refrigeration. The power consumption of air conditioning could be lowered up to 0.5kW per TW. This is possible through the use of Variable Speed Chillers and also through the automation, humidity and real time sensing of temperature [6].

➤ *Sustainable Planning for buildings*

The buildings need to be constructed in such a way that it consumes less energy and sustainable planning is needed for building. Sustainable planning mainly comprises carrying out thermal modelling of a specific site as well as of the built environment so that the path of sunlight could be analysed and optimised. The orientation and shape of the building should be in such a way that there could be major difference between inside and outside the building. The overall temperature of the building could be drastically minimized through the building structure. [8]

*B. Renewable Energy Integration in Smart Cities*

The renewable energy sources share in the country’s installed generation capacity is near about 20 percent. The government of India has set some goals for renewable energy sources; the government wants to accomplish 37% shared by the year 2022. The Ministry of Power has stated that the cities 10 percent of power demand must be met from renewable energy sources. The Ministry of Power has also stated some measures for increasing renewable energy sources. The measures are mainly the systems that need to be installed in the smart cities. The systems are:

- Cogeneration in sewage treatment plants
- Rooftop solar units
- Power generation from the municipal waste

➤ *Rooftop Solar Plants*

The rooftop solar plant concept is basically based on grid connected solar panels which gets installed on the rooftop and terraces of numerous buildings in the smart cities. The rooftop solar plants generate enough power for basic usage of electronic devices and systems in homes. Nearly 1kW power generation through solar panels could require an area up to 12 m<sup>2</sup>. The cities need to encourage their citizens to install this rooftop solar plant on their terrace

so that they could conserve energy for the future and contribute to the environment. The states must implement a net metering policy as well as conventional energy meters for installing the solar system. The power authorities also need to install net meter at the user’s end [16].

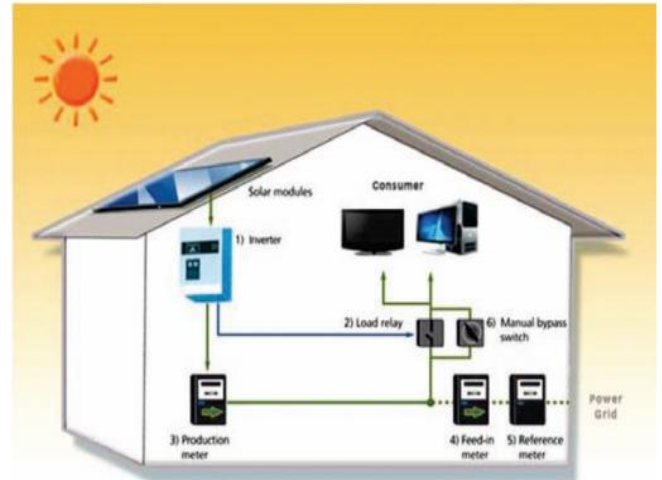


Fig 2:- Concept diagram for rooftop solar unit (Source: Martínez-Molina *et al.* 2016)

The spaces where the solar units could be installed are:

- Top of canals
- Solar trees in gardens and open areas
- Terrace areas of the government buildings
- Bus stops
- e-Vehicle charging stations
- Open spaces near the water treatment plants, pumping stations and sewage treatment plants

A user can export power grid ranging from 10 percent to 100 percent of the contract demand. The export also depends on the states norms so the cities with high demand have low export. Some of the smart cities in the country have pre-installed solar systems in numerous areas just for energy conservation. The government is taking every possible step to conserve energy and to protect the non-renewable energy sources [9].

➤ *Power Generation from Municipal Waste*

Solid waste management has been a major concern for most of the developed countries as the waste generation is continuously increasing. The solid wastes had to be processed after collecting. A large amount of energy is consumed for managing the solid waste, energy resources are required to protect the environment. A waste management plant basically requires near about 300 TPD solid wastes as an intake and near about 1MW energy is needed for managing that amount of waste. There are mainly two types of waste processing technologies which are; biological process and thermal process [11].

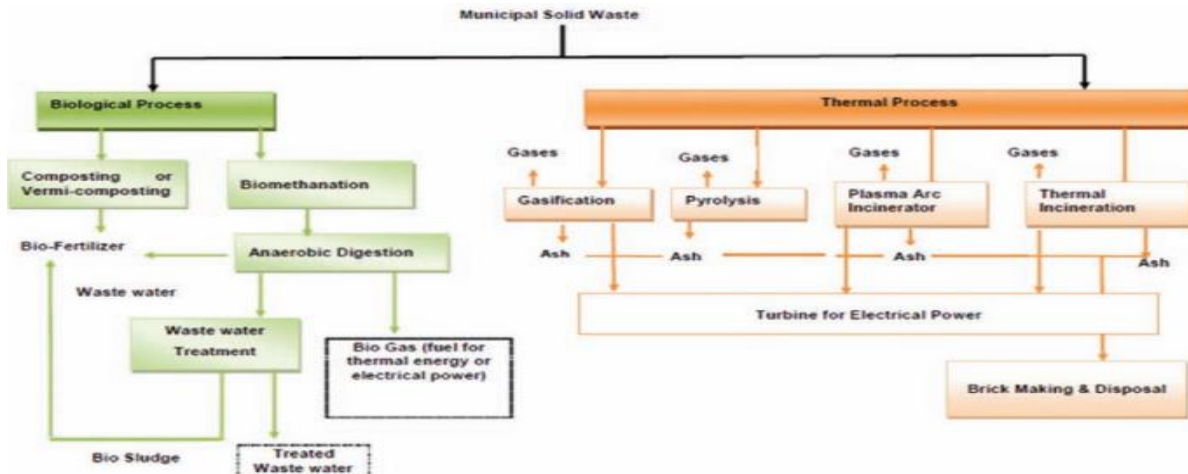


Fig 3:- Waste to Energy Technologies  
(Source: Calvillo, 2016)

The figure above depicts different types of waste management technologies that could be adopted by the smart cities. This technology could allow the cities to consume less amount of energy as well as they could process the waste efficiently.

➤ *Cogeneration in Sewage Treatment Plants*

The sewage treatment plants consume very high power as the plants compose the process that requires high energy. There are technologies that could be adopted by the cities to lower the power consumption in STP. The options are:

**Option 1:** The process of methane gas generation through methane. This system is mainly based on the BOD content of ambient and sewage temperature and this system could generate near about 10 kW. This system is capable of recovering between 30 to 40 percent of sewage treatment plants power demand [17].

**Option 2:** Installation of solar panels on the roof-tops and open spaces of treatment plants. As the power consumption of STP is very high so they need to use renewable energy sources in order to conserve some amount of energy. As discussed earlier, solar panel system requires up to 12 meter square per kilowatt. Numerous solar panel systems could be combined to generate high energy and the energy could be used by the STP plant [12].

**III. PROPOSED METHODOLOGY AND DISCUSSION**

Research methodology is considered to be the most crucial part of the study as it allows following a systematic pattern for information gathering. The study focuses on introducing smart energy conservation in the smart cities. A student and researcher need to follow the research onion for completing the work successfully. There are different layers

in the research onion which eventually depicts the steps involved in the methodology. The study is going to follow the positivist philosophy as it allows gathering information that is factual and valid. Positivism philosophy also allows studying the truth and facts that are already in existence. The study is not going to use realism philosophy as it allows gathering information from what is visible to the eyes. This process is quite complicated and it is mostly followed by experienced researchers. The study is also not going to follow the interpretivism philosophy as the work gets based on social outlook and people’s perceptions [7].

The research is going to follow the deductive approach as it is going to assist in reducing the information from the sources that are available. The study has skipped the inductive approach as it requires formation of new theories and concepts from the information that is available. This is a complicated process and requires great experience to follow the approach. The explanatory research design is going to be followed in this study as it allows connecting the variables in the research work. The explanatory design also allows finding out the actual cause and effect of the observed phenomenon. This design is going to assist in explaining the reason why the issue occurred and how the issue could be solved. The descriptive design is not going to be followed in this study as this design is mainly preferred in primary method. The descriptive design allows finding the answers to the problems relating to the research topic [10].

The study is going to follow the secondary data gathering method rather than the primary method. The secondary method allows students and researchers to gather information indirectly from the sources like journals, internet, books and newspapers. While the primary method allows gathering information directly from the sources, the methods involved in primary method are interview and survey. In the primary method, numerous participants and respondents are needed as they could provide answers to the research

questions. It is better to use the existing literature for finding answers for the research. The study is going to follow the qualitative data type as a thematic analysis needs to be conducted in the study. The data type for this study is going to be secondary qualitative. The quantitative data types involve the use of mathematical formulas, measurements and statistics. This approach makes the research work more authentic and valid. While the qualitative approach allow to explain a specific phenomenon. The qualitative approach allows analysing a theme or a topic with the help of existing literature [18].

The study is going to conduct thematic analysis smart energy conservation systems in smart cities. The thematic analysis allows gathering information from the existing

literature but the journals or articles that are going to be used in the study should not be old. The study is going to gather information from three published journals. Some themes needs to be defined in the thematic analysis and must be relevant to the research topic. The themes need to be relevant to the research topic [7].

**IV. EXPERIMENTAL RESULTS**

The study is going to conduct a thematic analysis for gathering essential information for the research topic. The thematic analysis is going to be comprised of three journals.

➤ *Thematic analysis*

Source	Theme 1 (Energy Management Technologies)	Theme 2 (Smart cities)	Theme 3 (Environment)
Zhou, Bin, Wentao Li, Ka Wing Chan, Yijia Cao, Yonghong Kuang, Xi Liu, and Xiong Wang. "Smart home energy management systems: Concept, configurations, and scheduling strategies." <i>Renewable and Sustainable Energy Reviews</i> 61 (2016): 30-40.	The electricity consumption has drastically increased and the consumption rate is going to continuously grow. The study focuses on the use of renewable sources of energy for power generation as the non-renewable sources are depleting at a fast rate.	The cities need to adopt the technologies and systems that could conserve energy. Homes and complexes must focus on installing solar panel system as it generates enough energy for daily device and gadget usage. The grid based solar panels could be installed on the rooftop of the building or terrace.	The home energy management system not only saves money but it also allows contributing to the environment. The energy needs to be preserved at any cost because the energy generation sources are getting depleted and this is going to be a major concern for the world.
Shahzad, Gul, Heekwon Yang, Arbab Waheed Ahmad, and Chankil Lee. "Energy-efficient intelligent street lighting system using traffic-adaptive control." <i>IEEE Sensors Journal</i> 16, no. 13 (2016): 5397-5405.	The states and power management authorities need to focus on installing light-emitting-diode street lights for monitoring the usage and adaptive lighting. The study discusses the use of traffic-flow based smart led street lighting technology.	The indoor and outdoor lighting consume an ample amount of energy, so it is better to conserve energy through the street lights. The street lights used in the cities starts operating during the dusk time and the lights continue to glow for the entire night.	Smart cities must be equipped with street lights that automatically turn off when there are no vehicles. The process is going to save energy as well as save the environment.
Sharma, Sumedha, Amit Dua, Mukesh Singh, Neeraj Kumar, and Surya Prakash. "Fuzzy rough set based energy management system for self-sustainable smart city." <i>Renewable and Sustainable Energy Reviews</i> 82 (2018): 3633-3644.	The smart cities are equipped with smart building and information technology. The smart cities gets uninterrupted power connection, the smart cities must focus on implementing some energy management systems in the city so they could lower their electricity bills and also to conserve energy.	The smart cities could install the thermal energy storage system as this system allows storing thermal energy. The smart cities also need to focus on adopting the solar panel system for conserving energy.	The energy conservation systems allow the cities to lower the energy consumption. The energy consumption rate is going to grow and the world needs to be prepared for that phase. Cities need to adopt the systems that could conserve energy.

Table 1:- Thematic Analysis  
(Source: Created by author)



### ➤ Analysis

The cities need to adopt the grid technologies and systems to generate energy. The government and cities must focus on the home energy management system. By energy management, people could save the environment as well as non-renewable sources. The energy consumption from the street lights is very high and traffic-flow based smart led street lighting technology can lower the energy consumption rate. The solar panel system is the most effective and reliable system which could be easily installed. Some of the smart cities are already installed with the solar panel system; most of the cities need to focus on installing energy management systems to conserve energy. The energy is mainly generated through renewable sources and non-renewable sources. The smart cities need to focus on using renewable sources for energy generation. The cities could aim for increasing the energy generation through renewable sources. The building architect also plays a major role in energy management. The government could take steps to encourage the cities and citizens to conserve energy through energy management systems and technologies.

## V. CONCLUSION

The energy consumption is going to become a major concern for the world as the rate of energy consumption is continuously increasing. Energy is mainly generated through renewable sources and non-renewable sources. The non-renewable sources are getting depleted at a very high rate and this is going to affect the future. The government and other authorities are taking major steps to preserve the natural resources through effective energy conservation. The smart cities need to be equipped with energy conservation systems for reducing the energy usage. The study has thoroughly discussed about the systems that could be beneficial for the smart cities. The study involves a thematic analysis for gathering essential and valid information for the research work. The thematic analysis has allowed summarising three journals related to the research topic. The journals used in the study were all focused on conserving the energy through the implementation of energy conservation systems. The research work has followed the research for conducting the research successfully.

The solar panel system could be stated as one of the most effective and successful energy conservation systems that could be installed on the rooftops and terrace. The solar panel system uses renewable energy sources so it is very beneficial for the environment. People could contribute to the environment by conserving energy. The energy resources are depleting at a very fast rate so the prices for the energy are going to increase. The sewage treatment plants consume a huge amount of energy so they need to install solar panels to conserve energy. The government needs to take initiatives as well as implement policies for increasing energy conservation. The government needs to guide smart cities about the systems that they need to install for reducing the

use of energy. Street light could be one of the examples, the government needs to use street that turns off automatically when there are no vehicles running on the road. This type practices are going to allow the smart cities to conserve energy and to protect the environment.

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