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Impact of sustainable design on India's smart cities development

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ABSTRACT

Smart city is an idea that helps people to use technology for the development of city. Smart cities are developing fast and they present new services which extremely influences planning and policy making, although they take place with urban services. Energy schemes for smart cities development need the higher part of renewable energy sources i.e. solar and wind for electricity and high standard of integration of utilities and industry providing business and households. It is more important to know the renewable energy contribution in the overall smart city's development and planning. This paper highlights and measures the impact of energy planning and smart city interrelation and recognizes the meeting ideas. The energy planning scopes are drawn from the Indian government policy and they are related with smart city's planning environment.

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1. Introduction

Smart city is a concept that brings the use of development of city and smart technology together. This will immensely advance the infrastructure by giving more public places and facilities to the population. But, smart technology and development are the vital feature of Smart Cities rather. The public will be getting benefits from the dynamic development and assessment of the different information in the smart way. The smart city idea integrates information and communication technology and numerous smart instruments connected to the system to enhance the city operations services and link to the people. This technology permits the official to touch directly with the city structure and public and to observe the city conditions. The Smart city task planned by the Indian government has many offers and has a big budget which will influence the more Indian population. The government of India has a vision of making more than 100 of smart cities with renewable energy generation, smart meters, secure electricity supply, smart treatment of waste material, smart building and sustainable environment. The smart cities development polices insist of using more energy from renewable energy system [1–4]. The carbon footprints increase with the uses of crude oil, coal and gas so this can be decreased by using renewable energy system. The integration of renewable energy with the existing grid in a big solution for all smart cities, this will decrease the unit's generation from the thermal plant. The renewable energy in the smart cities can be used in water heaters, electricity generation, street lightning, pumps, cooking, traffic signals, green building etc. The renewable energy based buildings integrated with the main gird can save the conventional energy in a big amount. Whereas, many countries like USA, Japan, Italy are adopting the grid connected renewable energy system to assist the urban bodies in evaluating the present energy demand and future consumption [5–8]. Among the different energy sources available, solar energy system is widely used and adapted because of its accessibility and advantages [9–14]. They are preparing the policies for power savings through the hybrid energy system installation. In this paper, development of the hybrid energy system based smart cities in Section 2. In Section 3, economics of hybrid energy system- analysis is presented. Net metering approach for smart cities is discussed in section 4. Further, Hybrid energy system based smart cities project actions in Section 5. Finally, concluding statements are presented in Section 6.

2. Development of the hybrid energy system based smart cities

The solar energy system is becoming the leading power generation system globally, and is positively well matched to city atmo-

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spheres. Whereas, the wind energy system is also suited to city environments because the vertical axis turbine based wind energy system can be easily installed in urban areas than the horizontal axis turbine based system. But, urban area has low wind speeds problem this can be overcome by installing many rotors or with gearbox which can turn by different values of wind speed.

Further smart cities environments can offer wind harvesting chances as tall buildings can generate funnel effects for producing stronger wind speed. So, smart system will be needed for the smart cities development with smart features to properly track the power generation, consumption, storage and managing the demand. The smart storage system can provide the energy when it is needed and stored during off peak demands. Hence, the main smart modernization is the smart grid to track the demand, control all sources, and properly matching the supply and demand. In India, there are many cities are falling in the list of smart cities like, Raipur, Agartala, Dehradun, Nagpur, Chandigarh, Ludhiana etc. The Government of India provides the money per city for making the master plan, installing the hybrid energy system and capacity buildings.

The solar energy system can be installed on the rooftop of the commercial, residential and industrial buildings. The power generation from the solar energy system can be fed to the main grid with the use of net metering scheme. This helps in saving in transmission losses, and there is no need of extra land for installation. This can also reduce the electricity bills by providing the electricity to the local supplier, besides battery less system makes the installation easy and cost effective.

Whereas, the wind energy system requires land but by using vertical turbine system, this requirement can be reduced. The power generated from the wind energy system can be given to the grid by the use of net metering approach this can reduce the carbon footprints because these generated units do not need to buy the from the grid. The hybrid energy system is the cost effective system because during off peak hours the extra units can be sold out to the utility. Fig. 1 shows the hybrid energy system based smart cities development scheme. Smart cities need proper controlling of hybrid energy system to increase the reliability of the scheme.

3. Economics of hybrid energy system- analysis

In order to find a cost-effective smart solution for smart cities, the overall combined cost of a grid-connected solar and wind energy system for residential, industrial and commercial buildings is estimated. For analysis reason, it is assumed that for smart city growth, there is a need of 2400 kW solar energy system and 800 kW wind energy system for residential, industrial and commercial type buildings.

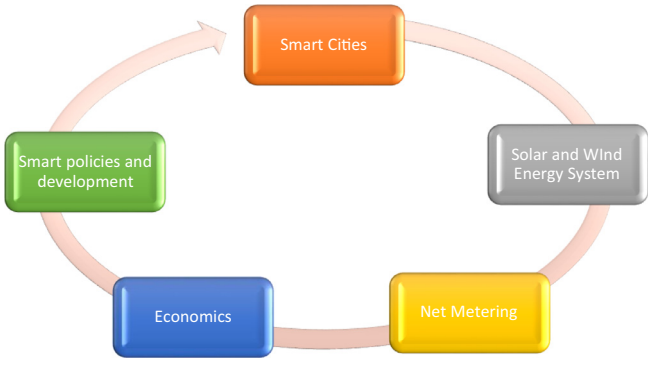

Fig. 1. Hybrid energy system based smart cities development scheme.

The 3200 kW grid-connected hybrid energy system will provide the 10,400 units per day. Buildings covering all sectors, especially smart cities, are deemed to consume 6800 units per day. As shown in Table 1, the overall cost of the grid-connected hybrid energy scheme for residential, industrial and commercial buildings in 2019 is approximately 315,253,536 INR. The hybrid energy system's lifetime is 25 years, so it is possible to measure the annual and monthly costs of the units produced by this system. Tariff rates for the Chennai, India area are taken into account for analysis purposes.

Complete cost of 10,400 units used by the grid per month = 2,692,800 INR

The hybrid energy system needs a cost of 10,400 units per month = 1,050,844 INR

Saving = 2,692,800–1,050,844

=1,641,956 INR/Month

=19,703,472 INR/Year

4. Net metering approach for smart cities

Many facilities are permitting to hybrid energy systems to be integrated to the main grid by put on the net metering scheme. The Net metering scheme allows the owner of the particular system to sell the extra power generated from the hybrid energy system to the utility at the exact price at which the electricity is brought from the main grid. Fig. 2 shows the net metering scheme benefits related to the smart cities. The United States has been using this approach for a long time whereas in Japan, incentives providing as a capital funding for this purpose. India is a superior country where solar and wind power are accessible easily for a longer time. Further, the Government of India has waived off the regional transmission losses and charges on the power generated by renewable energy sources to increase the use of renewable energy system. The net metering scheme is used to get the cost effective solution, if the net metering scheme is not used then the surplus power generated from the hybrid energy system will be wasted.

The net metering scheme gives the great potential to purchaser related welfares, electric utility allied welfares, financial viability and environmental benefits. The development capacity under net metering scheme can be permitted to equivalent to appropriate percentage the utility gives the intra state losses and financial feasibility.

5. Hybrid energy system based smart cities project actions

Once the idea of hybrid energy based smart city and the key challenges are known, then an organized method to the action possibilities of the project has been established. The smart cities idea are changed from the actions made for execution to the implemen-

Table 1
Total cost of grid-connected hybrid energy system for residential, industrial and commercial type buildings. (2400 kW solar energy system and 800 kW wind energy system).

Particular	Quantity	Investment (INR)
PV modules, Inverter	10160(315 W), 640	215,099,936
MPPT controller with DC/DC converter	–	8,320,000
Vertical axis wind turbines	–	29,920,000
Electrical structure, installation	–	31,280,000
Planning and development	–	6,800,000
O and M, other misc.	–	23,833,600
Total		315,253,536

Fig. 2. Net metering scheme benefits.

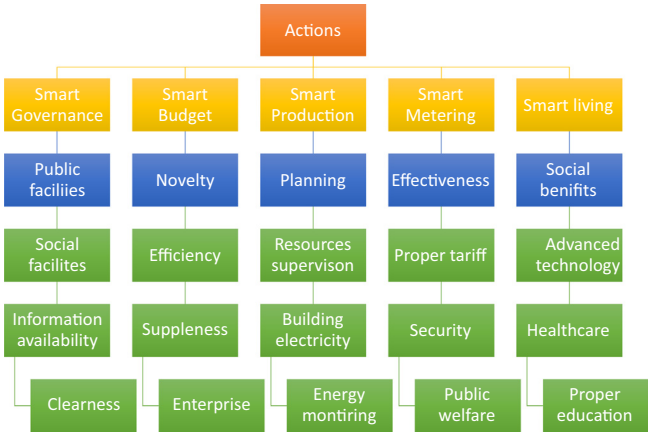

Fig. 3. Hybrid energy system based project actions.

tation of the method to handle the challenges. Therefore, it is essential to know a complete overview of options and to relate with the challenges. The main factor for hybrid energy based smart cities projects has been known to be use of technology. According to standards, smart city project actions are defined as shown in Fig. 3. The various actions are defined and put into relation with the smart city challenges identification. After that, these projects are being established in smart cities with sub actions executions. The main aim of project actions planning is the effectively implementation of the project.

The progression of the concept of smart cities leads from particular system to global city methods over which it is probable to overcome the associated challenges at different stages. Therefore, it can be noticed that it is essential to develop the effective method within the city project for achieving the complete vision.

6. Conclusion

This paper highlights the different aspects of sustainable urban development with hybrid energy system. Smart cities are emerging fast and they provide the new services which tremendously effect the planning and policy making. The hybrid energy system is integrated to the main grid with the smart metering approach and the net metering scheme permits the owner of the system to sell the extra power generated from the hybrid energy system to the utility at the exact price at which the electricity is brought from the main grid, this would give the economic saving. In this work, solar and wind energy system for electricity and high standard of integration of utilities and industry providing business and households is considered. Further, the economic feasibility of grid-connected hybrid energy system for economical and efficient operation of the system to electrify the different residential, commercial and industrial buildings in smart city in India is presented. Also, hybrid energy system based smart city project actions are discussed.

CRediT authorship contribution statement

Iram Akhtar: Conceptualization, Methodology, Software, Writing - original draft. **Sheeraz Kirmani:** Supervision, Writing - review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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