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Smart and Sustainable Energy Solutions- for Smart Cities in India

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Abstract: India, being the first most populated country in the world, contributes to 6.1% of the world's primary energy consumption. India has been ranked third largest primary energy consumer in the world. Due to rapid urbanization and the growing urban population, there will be serious implications on energy consumption and subsequent carbon emissions. In the context of smart cities, sustainability is an essential dimension. Cities face a series of complex interlinked challenges across different sectors (built environment, mobility, water & waste management, and public services) and it is critical to review these challenges by integrating the principles of smart energy management for achieving sustainable and low-carbon urban development. Managing the energy footprint of cities is one of the most challenging goals, and with the evolution and transformation of existing cities into smart cities, smart energy management thus becomes an integral component of this urban transformation.

Key words: *Smart city, Smart energy management, Hybrid system, Smart grids*

1. Introduction-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. Smart city is a concept that brings the use of development of city and smart technology together. 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. 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

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. The integrated Smart Energy Management (SEM) as shown in Fig 1 will ensure the optimal utilization of available resources and reduce reliance on unsustainable energy sources.

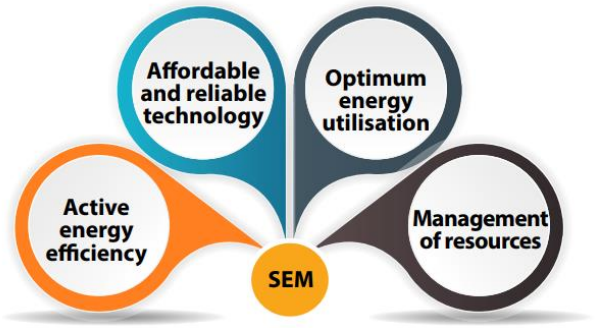


Fig1: Features of Smart Energy Management

Smart Energy management can be defined as the science involved in planning, directing, controlling energy supply and consumption to maximize productivity and comfort, and to minimize energy costs and pollution through conscious, judicious and efficient use of energy. In terms of energy savings, energy management entails the process of monitoring, controlling, and conserving energy in any given

context. It involves optimized energy utilization, management of energy resources, and active energy efficiency.

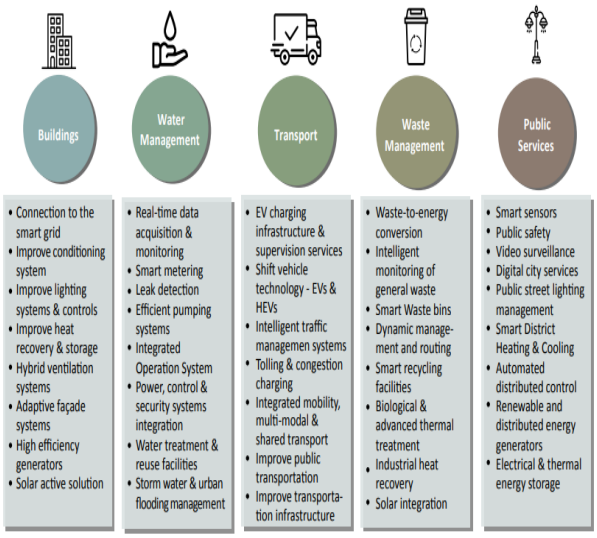


Fig2: Smart Energy Management in different sectors

In order to meet the energy needs of citizens and reduce carbon emissions, the Indian government has adopted a two-pronged approach, i.e., focusing on supply and demand. On the generation side, greater use of renewable energy, mainly solar and wind is being promoted. On the demand side, efforts are being made to improve energy efficiency through a variety of innovative policy measures that fall within the umbrella of the 2001 Energy Conservation Law.

The demand for affordable and reliable electrical energy requires different energy sources, where the cost of production often outweighs the environmental factor. One of the ways to achieve sustainability and reduce the emission of greenhouse gases in smart cities is through the promotion of sustainable energy. Cities influence climate change since they consume large amounts of energy leading to higher carbon dioxide (CO_2) emissions and environmental degradation. The penetration of Renewable Energy (RE) in cities is low. The potential and strategies to harness more RE in cities is to be studied and to be tapped effectively.

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. Here are some important aspects of sustainable energy solutions are stated-

2. Future possibilities of renewable energy sources in cities:

India's total installed renewable energy capacity touched 168.96 GW mark by February 2023-end. Out of the total 168.96 GW, 64.38 GW is solar power capacity, 51.79 GW hydro, 42.02 GW wind and 10.77 GW bio power. Government has announced its aim of achieving 500 GW installed capacity from non-fossil fuel based capacity (Hydro, Nuclear, Solar PV, Wind, Biomass etc.) by 2030

A. Solar Energy

To generate energy using solar energy, there are two types of conversion technologies: photovoltaic (PV) and solar panels. PV is used to generate electricity; solar panels are used to generate heat energy.

Technical solutions include *PV solar systems.* These are usually installed or integrated on roofs or building facades. Proximity to the consumer is the most important technical advantage of systems for residential buildings. Transport fees and energy losses are avoided in this way. However, there are also many social and environmental benefits, such as increased resilience to extreme weather events, as well as the effects of climate change.

But there are also some disadvantages. On the one hand, the restriction of the land. Cities often lack the right land to install PV systems, or the cost to the land is too high. On the other hand, the integration of VRE sources can have an impact on grid operation and impair the urban power grid and grid stability.

B. Wind Power

Wind energy has evolved in recent years. However, it has not yet penetrated the built environment. Their size, the inability to detect turbulent flows and low wind speeds, noise and controversial aesthetic, as well as an insufficient understanding of the aerodynamics of the wind, is among the biggest problems. The performance of urban wind turbines also needs to be improved. The use of wind turbines in urban areas is mainly in the research and development phase.

C. Bio-energy and Waste-To-Energy

In bio-energy, locally available raw materials are preferred from a logistical and ecological point of view. Local biomass, which is needed for energy production, can come from agricultural and forestry areas near the city, as well as from urban waste streams. The recycling of waste has another advantage – the protection of the environment through littering. Bioenergy has some advantages. On the one hand, it offers a constant and reliable energy supply, on the other hand, it is an attractive solution for the waste management of a city. In this way, the emission of greenhouse gases, as well as other environmental pollution is reduced.

However, the sustainable supply of raw materials is not always guaranteed. The supply depends on a partly limited collection radius for forestry and agricultural waste, as well as on the waste management system. In addition, it is questionable how the public feels about bioenergy because waste incineration plants can affect air quality and therefore also the health of the public. A coupling of waste management and the energy sector is needed to be able to ensure appropriate measures.

D. Geothermal Energy

Geothermal energy plays an important role in the electricity and heating network. Geothermal energy can provide cold, heat, and electricity. For intelligent energy systems, near-surface geothermal energy is an important source of energy. Intelligent heat and power grids are connected via underground heat storage systems. In this way, an affordable and reliable heating and cooling supply can be ensured for both urban and rural areas.

Geothermal energy is used in particular for space heating and room cooling, as well as for hot water in cities. How? By using the energy obtained, which is stored in the soil or the rock below the earth.

There are 2 technologies:

- *Geothermal heat water pumps:* used for individual and tertiary buildings. The heat water pumps can be used in systems of different sizes and offer water heating, low-temperature cooling, and low-temperature heating. This technology is a particularly attractive solution for new near-zero energy (NZEB) buildings and for existing buildings that are being renovated.
- *Borehole Thermal Energy Storage (BTES) or Aquifer Thermal Energy Storage (ATES):* used for the seasonal recovery and storage of thermal energy. The energy is stored as soon as it is available and can be used when needed.

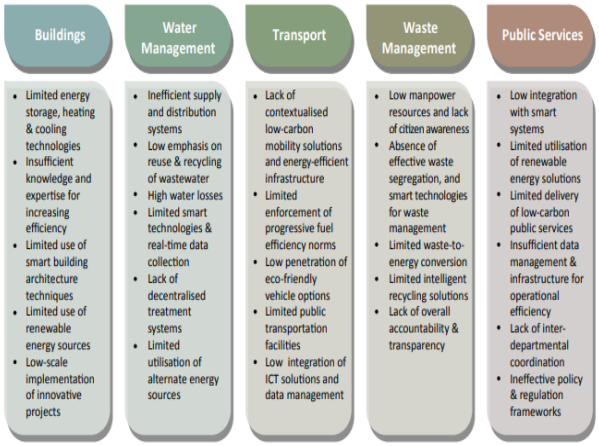
E. Smart Grids

Smart grids combine generation, storage, and consumption. A central control system optimally coordinates them with each other and thus compensates for power fluctuations in the grid – particularly due to fluctuating renewable energies. A smart grid is equipped with information and communication technology (ICT). This enables real-time communication between utilities and consumers. In this way, a more dynamic interaction in the flow of energy is created, which in turn can contribute to a more sustainable and efficient power supply.

What are the benefits of smart grids?

- More efficient transmission of electricity
- Quicker restoration of electricity after power disturbances

- Reduced operations and management costs for utilities, and ultimately lower power costs for consumers
- Reduced peak demand, which will also help lower electricity rates
- Increased integration of large-scale renewable energy systems
- Better integration of customer-owner power generation systems, including renewable energy systems
- Improved security



Limitations in adoption of SEM

Conclusion: Smart cities have a variety of possibilities to use renewable energy sources, saving costs and minimizing greenhouse gas emissions. However, despite having many options available, there is no one-size-fits-all solution for our cities. A combination of these innovative measures and a strong commitment to the Nations Sustainability Goals is essential if our cities are going to be strong and resilient in the future.

The first step is to save energy, then energy conversion programs, which are gradually transitioning from fossil fuels to renewable energy sources, minimize energy consumption and energy waste.

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Topics of Interest:
Green & Sustainable Energy, IoT and Automation, Image Processing