SOLAR ENERGY APPLICATIONS IN SMART CITIES

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ABSTRACT

The Internet of Things has a vision in which the internet extends into the real world embracing everyday objects. This technology has many applications like solar cities, smart villages, and solar street lights and so on. As renewable energy grew at a rate faster than any other time in history during this period. Using the IOT technology for supervising solar photovoltaic power generation can greatly enhance the performance, monitoring, and maintenance of the plant. with the advancement of technologies, the cost of renewable energy types of equipment is going down globally encouraging large scale solar photovoltaic installation. Energy harvesting is a promising option to mitigate battery replacement. Extensive simulations and measurements from our prototype demonstrate that the proposed method harvests 8% more energy and extends the operation time of the device 60% more during a day. The experimental results of this study demonstrate that the proposed platform can not only improve the interconnectivity of the entities in the industrial energy management system but also reduce the energy costs of industrial facilities.

KEYWORDS: GIS, ICT, Remote sensing, solar radiation

I. INTRODUCTION

Solar energy is energy that comes from the sun. Every day the sun radiates or sends out, an enormous amount of energy. The sun radiates more energy in one second than people have used since the beginning of time. It takes millions of years for the energy in the sun's core to make its way to the solar surface, and then just a little over eight minutes to travel the 93 million miles to earth. The solar energy travels to the earth at a speed of 186,000 miles per second, the speed of Light. It has covered many current areas of research and development such as cooking, drying, desalination, and power generation. Wellington E. Web-former Mayor of Denver, Colorado said that “The 19th century was a century of empires; the 20thcentury was a century of the nation-state; the 21st century is a century of cities”. Cities play a key role throughout the world. Cities are driving the economy.

It is an important source of renewable energy and its technologies are broadly characterized as either passive solar or active solar depending on how they capture and distribute solar energy or convert it into solar power. The developing countries have started to focus on making smart cities. India being a fast-growing economy has the vision to build ten smart cities in the near future. A smart city is an urban development vision to integrate multiple information and communication technology (ICT) and Internet of Things (IoT), solutions in schools, libraries, transportation systems, hospitals, power plants, and other community services. ICT is used to enhance quality & performance by improving contacts between the government and citizens. Smart city technology includes government services like transport, traffic management, energy, health care, water, innovative urban agriculture, and waste management. The motive behind building a smart city is to improve the quality of life by tackling inefficiency

Using technology.

II. SOLAR SMART CITIES

II.1 Aims and objectives of solar smart city

- Improving the governance in the city — Making governance citizen-friendly and cost effective - increasingly rely on online services to bring about accountability and transparency, especially using mobiles to reduce cost of services and providing services without visiting offices
- Solar Cities aim to assist urban local bodies in evaluating their present energy consumption, future demand and preparing master Plans for energy savings.
- Generation through RE installations & energy efficiency measures.
- Reduce congestion on roads, air pollution and resource depletion, boost local economy, promote interactions and ensure security
- In solar cities, Municipal Corporations have also come forward to implement the scheme and setup RE Projects.
- Promoting a variety of transport options - Transit Oriented Development (TOD), public transport and last mile para-transport connectivity

II.2 Proposed solar cities

Initially 8 big cities have been selected for making smart cities. These are Amritsar, Delhi, Mumbai, Bangalore, Chennai, Vizag, Kolkata and Myanmar. The location of smart cities in the map of India. 34 solar cities falling in the list of smart cities in stage 2 are Guwahati, Raipur, Bilaspur, Panaji, Gandhinagar, Surat, Rajkot, Faridabad, Hubbali- Dhardwad, Kochi, Bhopal, Indore, Gwalior, Thane, Nagpur, Kalyan-Dombivilli, Aurangabad, Imphal, Aizwal, Kohima, Bhubaneswar New Town Kolkata and Chandigarh.

III. DEATIALS OF SMART CITIES

Four smart cities are discussed in detail viz. Lavasa, GIFT, Kochi and Bangalore with their objectives and estimated time period for completion of the project.

III.1 Lavasa (India)

Lavasa is a private, planned city being built near pune. It is stylistically based on the Italian town Portofino, with a street and several buildings bearing the name of that town. A 25,000 acres (100 km^2) or 8,000 acres (32 km^2) project being developed by HCC, this as-yet-incomplete city has been controversial for multiple reasons including procurement of land, harm to the environment, and loans acquired through political corruption.

III.2 GIFT (Gujarat International Finance Tech city)

Gujarat International Finance Tec-City (GIFT City) is a business district promoted by the Government of Gujarat through a joint venture company. GIFT City is India's first operational smart city in the Ahmedabad and international financial services centre.

GIFT is an operational smart city developed in the Ahmedabad metropolitan region as a greenfield development. The project includes features like a district cooling system, underground utility tunnel, and automated vacuum waste collection. The city is designed for walkability and includes commercial and residential complexes.

The project is located on the bank of the Sabarmati River and is around 12 km (7.5 mi) from Gandhinagar international airport. GIFT is easily accessible from all directions through 4-6 lane State and National Highways. A double corridor metro system is planned to connect GIFT City to the Airport and various parts of Ahmedabad and Gandhinagar.

III.3 Kochi

The Government of Kerala headquartered at Thiruvananthapuram is a democratically elected body that governs the Indian State of Kerala. The state government is headed by the Governor of Kerala as the nominal head of state, with a democratically elected Chief Minister as real head of the executive. The state government maintains its capital at Thiruvananthapuram (Trivandrum) and is seated at the Kerala Government Secretariat or the Hajur Kutcheri.

III.4 Karnataka

Smart Cities Mission, sometimes referred to as Smart City Mission, is an urban renewal and retrofitting program by the Government of India with the mission to develop 100 cities across the country making them citizen friendly and sustainable. The Union Ministry of Urban Development is responsible for implementing the mission in collaboration with the state governments of the respective cities.

IV. SOLAR CITIES PROGRAMME

IV.1 Roadmap for Solar Power by 2022

India is poised to achieve a growth rate which is projected to trigger a major rise in energy demand due to demographic expansion, increasing urbanization and rising demands for mobility. By 2022, India targets solar power installation of 100GW, which is an ambitious target and requires a quantum four-fold growth in the sector. India's total installed solar power capacity reached 15611MW (13951MW utility scale and 1660 MW rooftop solar) on June 30, 2017.

IV.2 Solar Power installation Capacities of the selected states of India

The solar power installation capacity of 10 highly potential states of India. The maximum installation capacity is of Rajasthan which is 1199.7 MW. Gujarat stands at second rank with 1000.65MW.

V. STATEWISE SOLAR RADIATION IN INDIA

Solar radiation is the radiation, or energy we get from the sun. It is also known as short-wave radiation. Solar radiation comes in many forms, such as visible light, radio waves, heat (infrared), x-rays, and ultraviolet rays. Measurements for solar radiation are higher on clear, sunny day and usually low on cloudy days. When the sun is down, or there are heavy clouds blocking the sun, solar radiation is measured at zero.

V.1 Solar radiation in Rajasthan:

Rajasthan, one of the largest states in India receives maximum solar radiation intensity in India. According to United States Department of Energy, Rajasthan receives the second largest amount of solar radiation in the world. Jodhpur in Rajasthan is receiving maximum solar radiation which is known as Sun City of India. Rajasthan is also blessed with abundant land so it would be ideal for solar PV [6].

V.2 Solar Radiation in Gujarat:

Gujarat receives second largest amount of solar radiation in India. Gujarat receives 5.5 to 6 kWh/m2/day with 300 sunny days/year. Most locations in Gujarat receive an annual Direct Normal Incidence (DNI) in between 1,800 - 2,000 kWh/m2. Waste land of about 14.40 million acres is receiving largest amount of solar radiation. Northern part of Gujarat is receiving more solar radiation. The locations connected by the desert of Kutch region of Gujarat receive the maximum DNI in the state.

V.3 Solar radiation in Maharashtra*:*

Dhulia and Jalgaon from north Maharashtra, Osmanabad and Aurangabad from Marathwada and Chandrapur and Wardha districts of Vidarbha have the highest exposure to solar rays.

V.4 Solar radiation in Tamilnadu:

After Rajasthan and Gujarat, Tamil Nadu receives the third largest amount of solar radiation in India. Tamil Nadu receives about 5.35kWh/m2/day.

VI. APPLICATIONS OF SOLAR ENERGY

- Solar energy is harnessed to pump water in remote areas
- Solar cookers
- Solar cars, solar trams, solar buses and even satel- lites are also seen to operate with the help of solar energy.
- Solar energy can be used to heat residential homes
- Many people use solar energy to heat their water supply and their swimming pools as well Recreational vehicles and some boats may also run on solar energy.
- Small gadgets that involve little energy, such as calculators and watches, often use solar energy (Beerbaum, 2000).

VII. SMALL SCALE SOLAR POWER GENERATION:

About 40% energy is consumed by buildings in a city, therefore energy efficient green buildings on solar passive design should be promoted. A passive solar designed house can be low-tech and no more expensive than standard construction. The aim of the system is to achieve best output on small scale solar power house. Focussing load as fan, mobile charger, lighting, refrigerator, television etc. Home lighting systems are powered by solar energy using solar modules. The generated electricity is stored in batteries and used for the purpose of lighting whenever required. These systems are can be most widely used in non-electrified rural areas and as reliable emergency lighting system for important domestic, commercial and industrial applications.

VII.1 Solar Domestic Applications:

A **solar cooker** is a device which uses the energy of direct sunlight to heat, cook or pasteurize drink and other food materials. Many solar cookers currently in use are relatively inexpensive, low-tech devices, although some are as powerful or as expensive as traditional stoves,[1]and advanced, large-scale solar cookers can cook for hundreds of people.[2] Because they use no fuel and cost nothing to operate, many nonprofit organizations are promoting their use worldwide in order to help reduce fuel costs (especially where monetary reciprocity is low) and air pollution, and to slow down the deforestation and desertificationcause by gathering firewood for cooking.

Solar cooking developed by Mooni Ashram at Goraj, Gujarat by which meals for 200 students of Shardamandir Baxi Punch School is prepared.Solar water heating system of capacity 31,000liters of water is being designed and developed for Ashram's kitchens, guest houses and hospitals.

VII.2 Solar Vehicles:

A solar vehicle is an electric vehicle powered completely or significantly by direct solar energy. Usually, photovoltaic (PV) cells contained in solar panels convert the sun's energy directly into electric energy. The term "solar vehicle" usually implies that solar energy is used to power all or part of a vehicle's propulsion. Solar power may be also used to provide power for communications or controls or other auxiliary functions.

Solar vehicles are not sold as practical day-to-day transportation devices at present, but are primarily demonstration vehicles and engineering exercises, often sponsored by government agencies. However, indirectly solar-charged vehicles are widespread and solar boats are available commercially.

VII.2.1 Solar Car:

solar car is a solar vehicle used for land transport. Solar cars usually run on only power from the sun, although some models will supplement that power using a battery, or use solar panels to recharge batteries or run auxiliary systems for a car that mainly uses battery power.

Solar cars combine technology typically used in the aerospace, bicycle, alternative energy and automotive industries. The design of a solar vehicle is severely limited by the amount of energy input into the car. Most solar cars have been built for the purpose of solar car races. Some prototypes have been designed for public use, although no cars primarily powered by the sun are available commercially.

VII.2.2 Solar Impulse:

Solar Impulse is a Swiss long-range experiment solar-power aircraft project, and also the name of the project's two operational aircraft. The privately financed project is led by Swiss engineer and businessman André Borschberg and Swiss psychiatrist and balloonist Bertrand Piccard, who co-piloted Breitling Orbiter *3*, the first balloon to circle the world non-stop. The Solar Impulse project's goals were to make the first circumnavigation of the Earth by a piloted fixed-wing aircraft using only solar power and to bring attention to clean technologies.

The aircraft is a single-seated monoplane powered by photovoltaic cells; it is capable of taking off under its own power. The prototype, often referred to as Solar Impulse 1, was designed to remain airborne up to 36 hours. It conducted its first test flight in December 2009. In July 2010, it flew an entire diurnal solar cycle, including nearly nine hours of night flying, in a 26-hour flight. Piccard and Borschberg completed successful solar-powered flights from Switzerland to Spain and then Morocco in 2012, and conducted a multi-stage flight across the US in 2013.

VIII. SOLAR POWER PLANTS

VIII.1 Issues and Challenges for solar power plants:

- Initial high capital cost. Solar parks are capital intensive to setup.
- Lack of cheap financing. Innovative financial solutions required. E.g. Indian government launched green bonds to finance renewable energy projects. What are green bonds?
- Require large area. Lack of adequate land is problem. Solution: rooftop solar energy, offshore solar energy plants, vertical solar plants. Japan Building World's Largest Floating Solar Power Plant, Dr. Harsh Vardhan launches the 'Solar Power Tree'
- Intermittent nature of electricity. Works in daytime and varies with solar insolation.

- Grid stability. When solar energy becomes significant proportion of total electricity mix then grid stability is a concern because of its intermittent nature. Investments in new technological solutions to maintain grid stability required. Germany's Green Energy Destabilizing Electric Grids - IER
- Lack of trained manpower. Shortage of skilled manpower in R&D, manufacturing, construction and maintenance sector of solar energy. Lack of skilled workforce for India's rapidly growing solar sector

VIII.2 Solutions to overcome challenges:

- Scientists and Engineers need to discover more efficient semiconductors or some alternative inorganic materials to increase the efficiency of the solar cell. Doubling the efficiency of solar panel will reduce the size of the array which in turn requires less space and so can shorten the payback time. Mass production of solar panels with high efficiency will bring down the costs and make them cheaper.

- New transmission technology is needed to bring the clean energy market. Low cost high efficient Energy storage systems can attract the users for utilization of solar energy.

- Awareness programs are required to change the mind set of people.

IX. CONCLUSION

Initial high capital cost. Solar parks are capital intensive to setup. Lack of cheap financing. Innovative financial solutions required. E.g. Indian government launched green bonds to finance renewable energy projects. What are green bonds? Require large area. Lack of adequate land is problem. Solution: rooftop solar energy, offshore solar energy plants, vertical solar plants. Japan Building World's Largest Floating Solar Power Plant, Dr. Harsh Vardhan launches the 'Solar Power Tree 'The solar smart cities can be efficiently developed with utilization of solar energy. Abundant solar radiation is available in states like Rajasthan, Gujarat, Maharashtra, Tamilnadu and few others states as mentioned above. Intermittent nature of electricity**.** Works in daytime and varies with solar insolation.Grid stability. When solar energy becomes significant proportion of total electricity mix then grid stability is a concern because of its intermittent nature.

Investments in new technological solutions to maintain grid stability required. Germany's Green Energy Destabilizing Electric Grids - IER Solar systems installed on rooftops of residential, commercial, institutional & industrial buildings premises can solve the energy crisis as well can become a source of income as it can be -fed into the grid at regulated feed-in tariffs or -used for self-consumption with net-metering approach. Solar energy has multiple applications like Cooking, Drying, Desalination, Sterilization, refrigeration, transportation, Water heating, space heating and cooling etc. If these vehicles utilize solar energy instead of conventional fuel petrol the nation will progress at faster rate as these conventional fuels are inadequate and are exported from other countries. Optimum utilization of solar energy will be proven to be a boon to the society by its sustainable development. India can become a developed nation by making smart cities and smart villages. Lack of trained manpower. Shortage of skilled manpower in R&D, manufacturing, construction and maintenance sector of solar energy. Lack of skilled workforce for India's rapidly growing solar sector

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