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solar photovoltaics: transforming energy landscape

building integrated solar technologies

impact on energy systems

future trends

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Mrs. Sara Kunnath is the Former Deputy Director at Mahatma Gandhi Institute of Rural Energy and Development Bangalore. She has vast experience in renewable energy training an development and was instrumental in conducting bilateral programs for Ministry of New and Renewable Energy in collaboration with USAID for utility engineers and entrepreneurs pan India. Her core expertizes lie in renewable energy for rural development, rainwater harvesting, lake rejuvenation, skill development of rural youth for renewable energy projects.

India is a rapidly growing economy with a large population. The demand for electricity in the country is rising and is outpacing the supply. There is a need for access to clean, affordable and reliable source of energy. Availability of energy determines the quality of the lifestyle of individuals and that of the total economy. Per capita consumption of energy is considered as one of the important indices of economic development across the world.

The Eleventh Plan produced an average GDP growth rate of 8 per cent, whereas the twelfth plan which ended in 2017, had set a target of 9 per cent average growth of GDP over the plan period. The proposed growth rate would not be possible if there is no backup plan to generate the energy source to build the required infrastructure.

Coal forms the major share in the energy mix of India. The Coal Vision Report commissioned by Coal India Limited (CIL) observed that with the increasing threat of climate change impacting the global community and with the global funding focus on renewables, it is just a matter of time that the alternate clean energy would replaced coal. Solar Energy is considered as the key substitute for coal in India.

A strong government policy is driving the renewable energy penetration in the country. For the first time in India, more solar capacity was installed than coal in 2017. India is in the high solar insolation region and is endowed with large solar energy potential with most of the country having around 300days of sunshine per year with annual mean daily global solar radiation in the range of 4- 6 kWh/m^2/day. The Government has set an ambitious target for renewable sources to reach 175 GW by Financial Year 2022. The target aims at achieving 100GW through solar energy, 60 GW from wind energy, 10GW from Biomass and 5GW from small hydropower. The 100 GW of solar energy, will comprise of 40 GW Rooftop and 60 GW through Large and Medium Scale Grid Connected Solar Power Projects. With this target, India will become one of the largest Green Energy producers in the world.

The momentum has started with the incorporation of grid-connected large-scale solar parks and rooftop solutions and off-grid Solar Photovoltaic solutions. The grid connected Rooftop Solar PV is ideal for industries, commercial buildings and educational institutions. Educational institutions stand to gain as it creates interest for students in science, technology, engineering and mathematics (STEM) which are core components of a solid educational foundation. Further the activities of the educational institution coincide with the sun window or the solar energy generation time. With innovative methods, the government is paving the way to usher in the green energy revolution.

SOLAR CITY- Several Indian cities and towns are experiencing a rapid increase in the peak electricity demand. The local governments and the electric utilities are finding it difficult to cope with this rapid rise in demand and the resulting shortage of power. The "Development of Solar Cities" programme is encouraged to support the Urban Local Bodies to prepare a road map to guide their cities in becoming renewable energy cities or solar cities to promote energy security and green energy. A total of 60 cities and towns are proposed to be supported for development.

...continued in page 53

Electricity systems are changing on a worldwide scale. Dependence on, and global demand for, electricity are increasing and, as environmental concerns become more pressing, focus on reduction of greenhouse gas emissions becomes more pertinent. This forces us to move towards a decarbonised electricity system based on a large array of variable renewable generation, predominantly delivered by wind and solar photovoltaic (PV). Solar PV technology is one of the renewable technologies which has the potential to shape a clean, reliable, scalable and affordable electricity system for the future. Considering this fact, governments are encouraging the development and deployment of solar PV technology all over the world.

Converting solar energy into electrical energy by PV installations is the most recognized way of using solar energy. Since solar PV cells are semiconductor devices, they have a lot in common with processing and production techniques of other semiconductor devices such as computers and memory chips. Efficiency of a typical PV cell is around 15%, which means it can convert one-sixth of solar energy into electricity. Taking into account the energy consumed in the production of photovoltaic cells, they emit several tens of times less carbon dioxide per unit in relation to the energy produced from fossil fuel technologies. Photovoltaic cell has a lifetime of more than thirty years and is one of the most reliable semiconductor products. They also require minimal maintenance. At the end of the life cycle, photovoltaic modules can be recycled almost completely. Photovoltaic modules bring electricity to rural areas where there is no electric power grid, and thus increase the life value of these areas.

Solar systems have become very competitive solutions for residential, commercial and industrial applications for both standalone and grid connected operations. Photovoltaic systems will continue to develop in a direction to become a key factor in the production of electricity for households and buildings in general. The PV systems are generally installed on roofs and/or integrated into facades. These systems contribute to reducing energy consumption in buildings. Also, photovoltaic technology, as a renewable energy source, contributes to diversification of energy sources and security of electricity supply.

The European Union has carried out a series of legislative acts in the field of renewable energy and energy efficiency, particularly promoting photovoltaic technology for achieving the objectives of energy savings and CO_2 reduction in public, private and commercial buildings. Having taken leadership in photovoltaics manufacturing and deployment, China too is moving its policy positions forward, cashing in on the uncertainty that surrounds the current US energy and climate policy. And, Germany is closing down all its nuclear power plants. So there needs to be substantial global investments in renewable, clean energy sources, with PV as the most natural choice, to replace non-renewable energy sources and to keep promises made in Paris. As soon as politicians start to take actions on their policy commitments, PV will once again need capacity expansion. Also the global transportation fleet is turning electric faster than anyone could have imagined only a year ago.

Incentives for the energy produced by renewable sources in all developed countries have made photovoltaic systems very affordable, and return on investment in photovoltaic systems has become shorter and keeps decreasing. In recent years, this industry has been growing at a rate of 40% per year and the photovoltaic technology also creates thousands of jobs at the local level.

In this issue of energy manager, our first article takes you through a case study on Building Integrated Solar Technologies. In the second cover feature, Darshan Goswami explains in detail the significance of solar fuels. Further ahead, ADEME describes the future of French solar photovoltaics. Articles on futuristic trends and impact on energy systems are also included.

We hope our readers find this issue enlightening and informative and would love to receive your comments and suggestions.

building integrated solar technologies (BIST) for a city's best

Komali Yenneti and Saikiran Kasamsetty

Buildings currently account for a staggering 40 percent of the global energy consumption and one third of the world's greenhouse gas emissions. This is just the beginning - as more of the world's population call cities 'home', these trends are expected to change in a way that cities have never conceived or imagined.

The good news is that cities are embracing ambitious ideas and innovative solutions to decrease energy costs and clean up the atmosphere. The solar passive design and simple roof top water heating solutions of the 20th century are being replaced by 'Carbon Zero' or 'Carbon Positive' buildings, 'Smart Energy' buildings, and 'Energy Living Laboratories' that use open innovative ecosystems to reduce energy consumption and GHG emissions, and support the development of renewable energy in our urban environments. This article focuses on this new way of visualising the design and planning of future cities which has resulted in the advancement of novel methods for building energy generation and management through promising energy technologies such as Building Integrated Solar Technologies (BIST).

Buildings currently account for a staggering 40 percent of the global energy consumption and one third of the world's greenhouse gas emissions (GHGs) (UNEP-DTIE, 2013). This is just the beginning and as more of the world's population call cities 'home', these trends are expected to change in a way that cities have never conceived or imagined. There may be no vehicle tail-pipe exhaust fumes or belching smoke stacks to be seen, but every time we insensitively make a poorly designed building or choose energy-intensive and fossil-fuel pathways to light, cool, and heat our buildings, we are pumping up GHG emissions and the built environment's contribution to the 'carbon debt' (Prasad, 2012). But the entire story is not gloomy.

The good news is that cities are embracing ambitious ideas and innovative solutions to decrease energy costs and clean up the atmosphere. We are re-envisioning the ways buildings are conceived and constructed. We are integrating new and innovative ways into our lives, so that our buildings become greener, self-sufficient and high-performing. The solar passive design and simple roof top water heating

solutions of the 20th century are being replaced by 'Carbon Zero' or 'Carbon Positive' buildings, 'Smart Energy' buildings, and 'Energy Living Laboratories' that use open innovative ecosystems to reduce energy consumption and GHG emissions, and support the development of renewable energy in our urban environments. This new way of visualising the design and planning of future cities has resulted in the advancement of novel methods for building energy generation and management through promising energy technologies such as Building Integrated Solar Technologies (BIST) which are today amongst the rapidly expanding segments of solar photovoltaic (PV) systems, with an assumed capacity growth of 50 percent just between 2009 and 2015 (Azadian and Radzi, 2013).

BIST include technologies for space heating and cooling, water heating, Building Integrated Photovoltaic (BIPV) and Hybrid Photovoltaic Thermal (BIPVT). A BIPV serves the dual function of replacing conventional building materials and as a power generator, while a BIPVT produces both electrical and thermal energy.

What is BIST?

BIST is exactly what the name indicates: a solar energy collection system in which PV modules are integrated into a variety of building parts such as roofs, façades, walls, skylights, balconies or window glasses to produce electrical/thermal energy. BIST include technologies for space heating and cooling, water heating, Building Integrated Photovoltaic (BIPV), Hybrid Photovoltaic Thermal (BIPVT). A BIPV serves the dual function of replacing conventional building materials and as a power generator, while a BIPVT produces both electrical and thermal energy.

A BIST differs from the conventional roof-mounted or rack-mounted PV systems that are retrofitted onto buildings to produce electricity/thermal energy for domestic consumption or electricity to be fed into the electricity grid. These 'out-of-the box' but eminently sensible technologies can be seamlessly integrated into the entire building envelope and can easily replace conventional roof materials, claddings, and window overhangs unlike the conventional solar panels that are bulky and require special mounting brackets and expertise (figure 1).

A BIST can support multiple functions of a building, for example, water heating, electricity, shading, and visual aesthetics, as well serve as weather protection, thermal insulation, and noise protection building components. The electricity/thermal energy generated from a BIST can satisfy approximately 20-75 percent of the building's electricity and thermal energy requirements (Debbarma et al., 2016). So, the next question is, what are the BIST technologies and in what ways integration can happen?

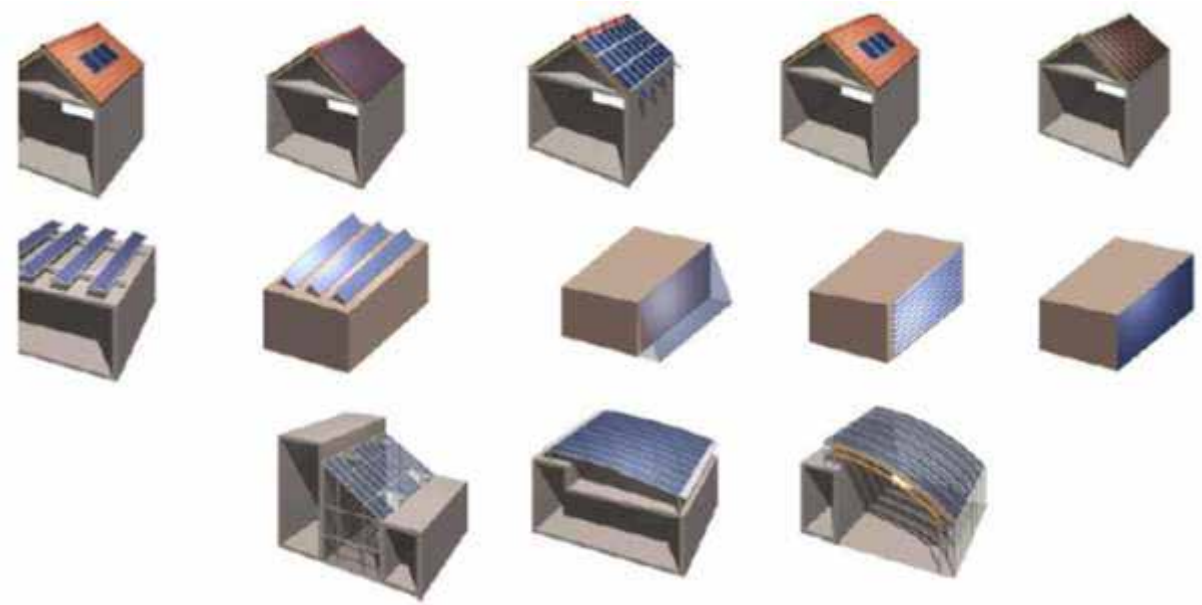

Figure 1: Typical building applications of BIST (Vashishtha and Sharma, 2013)

करने में कारक है। जबकि परिसंपत्ति प्रबंधन कार्यक्रमों पर उनके प्रभाव को अधिकतम व्यापक ऊर्जा और कार्बन बचत को प्राप्त करने की संभावना के लिए एक व्यापक और सक्रिय ऊर्जा और परिसंपत्ति प्रबंधन रणनीति पर नतीजा होगा। इसके अलावा, यह भी सभी परिसंपत्तियों भर ROIs की निगरानी के लिए सक्षम होगा, साथ ही सुविधाओ के कमर्चारियों और वरिष्ठ प्रबंधन की अनुमति पूरी तरह से उच्च प्रभाव समाधान के विकास पर ध्यान केंद्रित करने के लिए।

ऊपर रणनीतियों और समाधान के प्रत्येक हर विशेष रूप से उद्योग के लिए विचार करने की आवश्यकता होगी। उदाहरण के लिए, चिकित्सा और दवा कपनियों के परिसंपत्ति संवेदनशील जा रहा है, जबकि दूरसंचार व्यवसायों ऊर्जा गहन माना जाता है। एक सुसंगत ऊर्जा और परिसंपत्ति प्रबंधन रणनीति है कि एक आदेश कभी बदलते बाजार के लिए सबसे अच्छा तरीका संभव में अनुकूलन करने में कारक है।

प्रमुख प्रोत्साहन सुविधा प्रबंधकों को एक व्यापक सुविधा अनुकूलन कार्यक्रम में अपनी ऊर्जा प्रबंधन रणनीति को एकीकृत करने के लिए, जबकि एक ही समय में परिसंपत्ति प्रबंधन कार्यक्रमों पर उनके प्रभाव को अधिकतम व्यापक ऊर्जा और कार्बन बचत को प्राप्त करने की संभावना है। यह केवल एक व्यापक और सक्रिय ऊर्जा और परिसंपत्ति प्रबंधन रणनीति में परिणाम नहीं होगा, लेकिन सबसे महत्वपूर्ण बात, सभी परिसंपत्तियों भर ROIs की निगरानी के लिए सक्षम होगा, साथ ही सुविधाओ के कमर्चारियों और वरिष्ठ प्रबंधन की अनुमति पूरी तरह से उच्च प्रभाव समाधान के विकास पर ध्यान केंद्रित करने के लिए।

लेखक -

श्री गब्रियल हरटडो गोंजालेज
वर्तमान में विसी फैसिलिटिज में ऊर्जा प्रबंधक के रूप में कार्यरत

हिन्दी अनुवाद -

श्री प्रदीप गुप्ता
अपर महाप्रबंधक
तथा उपाध्यक्ष, सीम्