

# An Investigation Of The Latest Trends In Commercial And Industrial Rooftop Solar Systems.

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## ARTICLE INFO

## ABSTRACT

Considering the global emphasis on renewable energy sources to tackle climate change and meet energy demands, rooftop solar power generation is emerging as a viable option. This qualitative study offers a thorough analysis of rooftop solar power generation, looking at its advantages, disadvantages, potential, and features. This study attempts to provide insights into the present situation and future possibilities of rooftop solar adoption by reviewing the literature, case studies, and expert comments. The fundamentals of photovoltaic technology, rooftop solar system components, power generation methods, installation kinds, and the advantages to the economy, environment, and society are some of the important subjects covered. Adoption obstacles and challenges, including large upfront expenditures, legal restrictions, and technological constraints, are also covered. The study identifies opportunities for enhancing rooftop solar uptake.

**Keywords:** Rooftop Solar, Renewable Energy, Sustainability

## I. Introduction:

To address the world's energy concerns and fight climate change, the use of renewable energy sources, like solar electricity, is becoming more and more important. Rooftop solar power generation is one of the most promising and widely available renewable energy technologies for decentralizing energy production and lowering dependency on fossil fuels. The goal of this qualitative study is to present a thorough review of rooftop solar power generation by examining its main features, benefits, drawbacks, and prospects for broad use. Installing photovoltaic (PV) panels on the rooftops of residential, commercial, and industrial buildings allows rooftop solar power generation to capture solar energy and turn it into electrical power. For people seeking to produce clean energy and lessen their carbon footprint, rooftop solar has become a desirable alternative because of its straightforward design, growing PV technology, and falling costs.

In this study, the researcher examines several elements that affect rooftop solar adoption, such as financial incentives, regulatory frameworks, innovations in technology, and environmental concerns. Using a qualitative examination of extant literature, case studies, and expert viewpoints, our objective is to furnish discernment regarding the present condition of rooftop solar adoption and its prospects for further expansion. This qualitative study intends to contribute to a fuller understanding of rooftop solar power generation's position in the shift towards a more sustainable energy future by investigating both the opportunities and constraints surrounding it. We seek to offer insightful information to researchers, industry stakeholders, and policymakers who are interested in encouraging rooftop solar adoption as a crucial part of the renewable energy landscape through thorough analysis and discussion.

## II. Objectives of the study

1. To provide an understanding of rooftop solar power generation
2. To evaluate the economic, environmental, and social benefits associated with rooftop solar power generation.
3. To identify and analyze the challenges and barriers hindering the widespread adoption of rooftop solar.
4. To explore opportunities for enhancing the uptake of rooftop solar power generation

### III. Understanding Rooftop Solar Power Generation:

#### A. Principles of Photovoltaic Technology:

The photovoltaic effect, which occurs when specific materials are exposed to sunlight and produce an electric current, is the fundamental component of rooftop solar power generation. Solar panels are composed of semiconductors based on silicon, which are used as their building components. Photons from sunlight cause electrons in the solar cells to move, which results in the creation of an electric current. Inverters are used to change the direct current (DC) electricity into alternating current (AC), which is then compatible with conventional electrical systems.

#### B. Components of Rooftop Solar Systems:

A rooftop solar system usually consists of a few essential parts. Photovoltaic modules, sometimes referred to as solar panels, are the main components that turn sunlight into electricity.

An essential function of inverters is to transform the DC electricity produced by the panels into AC electricity that may be exported to the grid or used in buildings.

In addition, electrical cable links the system to the building's electrical infrastructure, while racking and mounting methods firmly fasten the panels to rooftops.

#### C. Mechanisms of Electricity Generation:

Through the conversion of solar irradiance into electrical energy, solar panels provide electricity. Photons from the sun's rays excite the electrons in the solar cells, producing an electric potential in the PV panels. Electrons begin to flow as a result, producing DC power.

This DC electricity is then transformed into AC electricity via inverters, guaranteeing that it is compatible with either the building's electrical system or the grid.

### IV. Types of Rooftop Solar Installations:

- On-Grid Rooftop Solar Systems: Rooftop solar systems that are linked to the main electrical grid are referred to as on-grid systems. Through net metering, excess electricity generated can be recycled back into the grid to gain credits or revenue. Excellent locations with dependable grid infrastructure.
- Off-Grid Rooftop Solar Systems: These systems are not linked to the main electrical grid. Batteries and other energy storage devices are needed by them to store extra electricity for usage in the absence of sunlight. frequently utilized in isolated areas or places where grid connectivity is impractical.
- Hybrid Rooftop Solar Systems: Rooftop solar systems that combine solar energy with additional energy sources, such as wind or diesel generators, are called hybrid systems. Batteries are utilized in battery storage systems to store extra electricity and offer backup power. offer more efficiency and dependability than stand-alone solar systems.
- Building-Integrated Photovoltaics (BIPV): These systems replace traditional building materials with solar panels that are integrated into the framework of the building. Solar windows, solar facades, and solar roof tiles are a few examples. Because they may be used to generate electricity and serve as building materials, they offer dual functionality.
- Solar PV systems that float are mounted over bodies of water like ponds, lakes, and reservoirs. They can be erected in locations with limited land, lower water evaporation, and cool solar panels. Many nations have successfully used floating solar farms.
- Community solar projects: These enable several people or companies to contribute to a common solar installation. Participants get credits or discounts on their power bills depending on how much solar output they contribute. Give people who are unable to install solar panels on their property access to solar energy.

### V. Economic, Environmental, and Social Benefits of Commercial & Industrial Rooftop Solar:

#### 1. Economic Benefits:

- (i) Cost Savings: By producing their solar power, commercial and industrial establishments can drastically lower their electricity bills, which will result in long-term cost savings.
- (ii) Return on Investment (ROI): Depending on the region, incentives, and electricity rates, rooftop solar installations can have an enticing ROI with payback durations of three to seven years.
- (iii) Income Generation: Through feed-in tariffs or net metering programs, surplus electricity produced by rooftop solar systems can be sold back to the grid, generating additional income.
- (iv) Employment Creation: The solar business boosts local economies and employment prospects by generating jobs in production, installation, and maintenance.

### **Environmental Benefits:**

- (i) **Lower Carbon Dioxide Emissions:** Rooftop solar power contributes to a reduction in the need for fossil fuels to generate electricity, which lowers carbon dioxide emissions and helps to mitigate climate change.
- (ii) **Air Pollution Reduction:** Rooftop solar energy helps reduce air pollutants including sulfur dioxide, nitrogen oxides, and particulate matter, improving air quality. It does this by dispensing with electricity produced from coal or natural gas.
- (iii) **Resource Conservation:** Long-term sustainability and conservation efforts are aided by solar energy's renewable nature, which does not degrade finite resources like fossil fuels do.

### **2. Social Benefits:**

- (i) **Energy Independence:** Installing rooftop solar panels can help achieve some energy independence by lowering dependency on outside electricity sources and boosting resistance to blackouts.
- (ii) **Community Development:** By supplying sustainable energy, generating jobs locally, and fostering economic expansion, commercial and industrial rooftop solar systems can aid in the development of their communities.
- (iii) **Education and Awareness:** By increasing public knowledge of sustainability and renewable energy, rooftop solar systems can motivate people and companies to embrace greener practices.

Commercial and industrial rooftop solar is an attractive option for companies aiming to lower their carbon footprint, cut energy expenses, and contribute to a more sustainable future since it offers a variety of social, economic, and environmental benefits.

## **VI. Challenges and Barriers to Adoption in Commercial & Industrial Rooftop Solar:**

- **High Upfront Costs:** The high upfront costs of buying and installing solar panels and accompanying equipment are one of the main obstacles to the adoption of rooftop solar for commercial and industrial buildings. For certain businesses, the initial expenditure may be unaffordable even with the long-term cost savings.
- **Finance Options:** The adoption of rooftop solar may be hampered by limited access to finance options including loans, leases, or power purchase agreements (PPAs). Finding inexpensive finance solutions that work with their budgetary limits may be difficult for businesses.
- **Regulatory obstacles:** Companies wishing to install rooftop solar systems may face difficulties due to the complexity of the regulatory procedures, which include interconnection, building code and zoning compliance, permitting, and installation. These laws differ depending on the area and may increase the installation procedure's duration and expense.
- **Technical Restrictions:** Installing rooftop solar power can be difficult or less effective in certain commercial and industrial buildings due to structural constraints or shading problems. Furthermore, integrating solar panels with current electrical systems can be difficult and needs specific knowledge.
- **Problems with Grid Connection:** It can be difficult to connect rooftop solar systems to the grid, particularly in places with old or insufficient grid capacity. Rooftop solar installation viability and dependability may be impacted by grid connection problems.
- **Public Perception and Awareness:** Misconceptions regarding the affordability and dependability of solar energy, along with a lack of knowledge about its advantages, can discourage companies from exploring solar power. Increasing acceptance and adoption can be achieved through educating the public and busting myths.
- **Maintenance and Reliability:** Businesses may find it difficult to guarantee the correct maintenance and dependability of rooftop solar systems, particularly if they lack the knowledge or resources necessary to properly monitor and maintain the systems.
- **Uncertainty in Policies and Incentives:** Businesses thinking about rooftop solar may experience uncertainty due to changes in government policies, tax credits, and incentives for solar energy. Businesses may find it challenging to make well-informed decisions on solar energy investments due to this uncertainty.

Policymakers, regulators, industry stakeholders, and financial institutions must work together to address these obstacles and hurdles to provide solutions that increase rooftop solar's appeal and accessibility for commercial and industrial buildings.

## **VII. Opportunities for Enhancement:**

### **A. Innovative Financing Models:**

- **Solar Leasing:** Provide solar leasing so that businesses can purchase solar energy with monthly lease payments and avoid the upfront expenditures associated with solar installations.

- Power Purchase Agreements (PPAs): Allow companies to buy solar power at a fixed price, frequently less than utility rates, from a third-party supplier.
- Green Bonds: By issuing bonds to fund eco-friendly projects, such as rooftop solar systems, you can raise money for solar projects.

#### **B. Policy Incentives and Support Mechanisms:**

- Tax Credits: Lower the total cost of rooftop solar installations by offering financial incentives to companies who invest in solar energy.
- Feed-in Tariffs: Encourage businesses to invest in solar energy by guaranteeing a certain amount for each kilowatt-hour of electricity produced by rooftop solar systems.
- Regulatory Reforms: Simplify the interconnection and permitting procedures to facilitate rooftop solar system installation for companies more quickly and easily.

#### **C. Technological Innovations:**

- Energy Storage Solutions: To store extra energy for use in times of low sunlight or high demand, combine battery storage systems with rooftop solar arrays.
- Smart Grid Technologies: To maximize rooftop solar system performance and enhance grid integration, use cutting-edge monitoring, and control technologies.
- The goal of thin-film solar panels is to create flexible, lightweight panels that are simple to install on a range of commercial and industrial rooftops.

#### **D. Community Engagement Strategies:**

- Community solar programs: These let companies get solar energy without having to put panels on their roofs by allowing them to buy shares in an off-site solar project.
- Workshops for Education: Arrange lectures and workshops to inform companies about the advantages of rooftop solar energy and how to get past typical adoption obstacles.
- Partnerships with Neighborhood Organizations: To promote rooftop solar and interact with the neighborhood, work with neighborhood nonprofits, schools, and community centers.

### **VIII. Case Studies and Best Practices:**

- Walmart: With solar panels mounted on numerous of its retail locations and distribution hubs, Walmart has been a pioneer in rooftop solar installation. Walmart has reduced its dependency on fossil fuels and its carbon footprint by producing substantial amounts of solar energy by utilizing its expansive rooftop areas.
- Apple Inc.: The company has pledged to use only renewable energy sources to power all its facilities globally. The business has shown its dedication to sustainability and environmental care by investing in rooftop solar installations at its data centres, offices, and retail locations.
- IKEA: Throughout the world, IKEA has put rooftop solar panels in several of its retail locations and distribution hubs. IKEA has significantly reduced its environmental footprint by implementing energy efficiency techniques in its facilities in addition to producing sustainable energy.
- Kohl's: To assist offset its energy expenses and lessen its carbon imprint, Kohl's has installed rooftop solar panels at some of its retail locations. To spread knowledge about the advantages of solar energy, Kohl's has also interacted with both its staff and customers.
- General Motors: The Detroit-Hamtramck Assembly Plant is one of the manufacturing plants where General Motors has installed rooftop solar panels. In addition to lowering energy expenses and the company's dependency on fossil fuels, these solar systems show the business's dedication to sustainability.

#### **• Best Practices:**

- Site Selection: When installing solar panels, pick rooftops with the best possible solar exposure and structural soundness.
- Energy Efficiency: Before installing rooftop solar, lower overall energy use by putting energy efficiency measures into place.
- Financial study: To fully comprehend the advantages and disadvantages of installing rooftop solar power, do a comprehensive financial study.
- Maintenance and Monitoring: To guarantee maximum performance and longevity, maintain and keep an eye on rooftop solar systems regularly.
- Community Involvement: Talk to stakeholders and the local community to increase support for rooftop solar projects and to spread the word about the advantages of solar energy.

### **IX. Future Trends & Outlook:**

It is anticipated that improvements in solar panel technologies, such as perovskite and bifacial solar cells, would boost efficiency while lowering costs, increasing the competitiveness of rooftop solar. Better battery

technology and grid-scale storage systems are two examples of innovations in energy storage solutions that will improve rooftop solar integration and boost energy reliability. By integrating advanced metering infrastructure (AMI) and demand response systems with other smart grid technologies, rooftop solar energy can be used more effectively, leading to increased grid stability. By optimizing energy production and consumption, IoT-enabled gadgets and sensors can raise rooftop solar systems' total efficiency.

The commercial and industrial sectors are anticipated to adopt rooftop solar power in greater numbers because of growing awareness of climate change and the advantages of renewable energy. In the face of disruptions caused by climate change, businesses are realizing the importance of rooftop solar in boosting energy resilience and lowering reliance on conventional energy sources. A lot of companies are establishing challenging sustainability objectives, such as using a certain percentage of renewable energy, which may increase demand for rooftop solar installations. The popularity of EaaS models, in which companies lease the energy infrastructure but pay for the energy services, may lead to a growth in rooftop solar adoption.

The adoption of rooftop solar power will be greatly aided by the continuation of government incentives like tax credits, rebates, and feed-in tariffs. The development of rooftop solar will be aided by the simplification of the interconnection and permitting procedures, as well as the use of standards for energy storage and grid integration. To encourage policy support for rooftop solar and other renewable energy sources, numerous governments and municipalities are establishing renewable energy targets.

### **X. Conclusion:**

In summary, several technological, commercial, and policy advancements are anticipated to spur more use and integration of rooftop solar in the commercial and industrial sectors, indicating a good future for the technology. The advantages of rooftop solar, which include cost savings, environmental sustainability, and energy independence, make it a compelling option for businesses looking to reduce their carbon footprint and lower their energy expenses, even in the face of obstacles like high upfront costs, regulatory hurdles, and technological limitations.

Innovative finance structures, supportive regulations, cutting-edge technology, and community involvement tactics are essential to increasing rooftop solar adoption. Businesses may optimize rooftop Solar's economic, environmental, and social benefits by taking advantage of these options, helping to ensure a more sustainable energy future. All things considered, rooftop solar has a great deal of potential to contribute to the shift to a clean energy economy. Businesses may position themselves as leaders in sustainability and benefit from clean, renewable energy by tackling obstacles and seizing possibilities.

### **XI. References:**

1. Alstone, P., & Engel-Cox, J. (2019). Financing Renewable Energy in Developing Countries: Drivers and Barriers for Private Finance in Sub-Saharan Africa. *International Journal of Climate Change Strategies and Management*, 11(3), 358-378.
2. Breyer, C., & Ueckerdt, F. (2018). Global Energy System Based on 100% Renewable Energy-Power Sector. Lappeenranta University of Technology.
3. Chen, M., et al. (2019). Recent developments and key barriers to distributed energy resources in industrial parks in China. *Applied Energy*, 253, 113570.
4. Climate Policy Initiative. (2017). The landscape of infrastructure finance. Climate Policy Initiative.
5. Dzombak, R., et al. (2017). Commercial and Industrial Solar in New Jersey: The Decision-Making Process. Solar Energy Research Institute for India and the United States (SERIUS).
6. International Renewable Energy Agency (IRENA). (2019). Renewable Energy Market Analysis: GCC 2019.
7. Khadka, A., et al. (2020). Assessment of the potential for rooftop solar photovoltaic in Bangladesh. *Sustainable Cities and Society*, 57, 102156.
8. Koirala, B., et al. (2020). A review on renewable energy development in Nepal: Status, potential, policies, and institutions. *Renewable and Sustainable Energy Reviews*, 118, 109514.
9. Lu, Y., et al. (2019). Rooftop solar photovoltaic development in China: Status, barriers, and strategies. *Energy Policy*, 135, 111055.
10. Ministry of New and Renewable Energy, Government of India. (2020). National Solar Mission: Targets and Achievements.
11. Ministry of Power, Government of India. (2020). Ujwal DISCOM Assurance Yojana (UDAY).
12. National Renewable Energy Laboratory (NREL). (2017). Solar Powering Your Community: A Guide for Local Governments.
13. Ogawa, T., et al. (2018). Comparative analysis of solar PV policies and deployment in Japan and Germany: Lessons for China. *Renewable and Sustainable Energy Reviews*, 81, 2819-2832.



14. Poudel, R., & Subedi, S. (2020). Review on energy consumption scenarios in Nepal: Status, potential, and policy implications. *Energy Strategy Reviews*, 27, 100423.
15. Renewable Energy Policy Network for the 21st Century (REN21). (2020). *Renewables 2020 Global Status Report*.
16. Solar Energy Corporation of India (SECI). (2019). Tender Document for 500 MW Grid Connected Roof Top Solar PV System Scheme under CAPEX & RESCO Model.
17. Solar Energy Industries Association (SEIA). (2020). *Solar Market Insight Report 2020 Q3*.
18. Singh, N. K., & Kumar, R. (2019). An analysis of rooftop solar PV power projects in India: Review and challenges. *Renewable and Sustainable Energy Reviews*, 115, 109370.
19. Solar Energy Corporation of India. (2020). *Indian Solar Sector: A Decadal Journey (2010-2020)*.
20. Ekhande, Kirtikumar. (2011). *Changing Scenario of World Trade Export-Import & Indian Contribution in Export Of World Trade*.
21. United Nations. (2020). *Sustainable Development Goals*.