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Electric vehicles in reducing burden on fossil-fueled generation by renewable energy transition in commercial buildings in India

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Abstract

Commercial buildings account for a major contribution to carbon emissions. The combination of Electric Vehicles (EVs) and renewable energy offers many advantages in reducing carbon emissions and improving energy resource allocation for power generation. There are ambitious targets laid out by local governments in India to ensure there is high penetration of EVs. The goals in increasing the renewable energy penetration up to 500GW by year 2030 is not just a dream but a realized fact as many major private sector companies have a wide scale deployment of level 2 and fast chargers. Traditionally commercial buildings rely on utility power to meet their energy needs. However, this paper aims to derive benefits from EVs for commercial buildings by decarbonizing the market with renewable energy resources allocation for the major buildings in metropolitan cities. EVs are emergent in India's transition towards renewable energy both solar and wind power, particularly in commercial buildings. In the commercial sector, for reducing the burden on fossil-fueled electricity generation, the synergy between EVs and renewable energy plays a crucial role.

Keywords: Decarbonization; Electric Vehicles; Renewable Energy

1. Introduction

India’s transition towards sustainable future in the energy demands for power generation during decarbonization is evolving at much rapid pace than expected because of the continued support from the government and improved policies [1] [2] [3]. The renewable energy from solar and wind are potent in major areas along the northern to southern areas. Northern to Southern regions receive sunlight throughout the year. Southern areas and other coastal regions receive significant wind speeds to derive power from wind farms. Some of the major wind’s farms such as Jaisalmer Wind Park have installed capacities of more than 1000 MW [4] [5]. Supportive policies have led to accelerated growth in clean energy technologies. This remarkable progress is substantiated from the facts and figures in total solar generation being at 90.76GW and wind at 47.36GW [6] [7]. The major portion of this renewable energy generation comes from four states namely- Rajasthan, Gujarat, Tamil Nadu, and Karnataka.

Sustainable development gives growth and progress that confines the boundaries for the current generation to not exploit the resources in a manner that it compromises the need of the generations to come. The tri-pillars of the sustainable development [8] focusses on optimizing the resource usage, promoting responsible production and manufacturing, and encourages the recycling. The focus is to combine all tri-pillars together therefore EVs may offer an improved sustainable development from their reduced carbon emissions. There are some scholars who recognize the essence of cultural pillar to the sustainable development. This is evident from fact that many cultural differences limits the EV penetration in certain areas around the world [2] [9]. While the concept has gained widespread acceptance, there are possible opposition to this concept as it may lead to compromised usage of resources for current generation.

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Nevertheless, sustainable development in developing India becomes an uncompromised area when commercial buildings were proposed to use renewable energy for reducing energy demand on fossil-fueled generation stations.

Major cities in Bengaluru, Delhi, Ahmedabad, Mumbai, Kolkata, and Chennai are experiencing a rising number of office spaces to support the booming commercial market. This requires increased commercial building occupancy and construction of required infrastructure to both house the people and meet the energy demand. Usually for an office building space the major power requirement is lighting, HVAC, and data connectivity. Given the fossil fueled generation increases greenhouse gas emissions many building designers offer solar package along with their designs. Growing EVs require the addition of charging infrastructure in surrounding areas of the buildings to reduce the burden on the power grid for energy demand and improve the tenant experience from ease in accessibility of the charging stations [10]. Moreover, the evolving technology in the electric vehicles and their charging stations requires experts to delve deeper into understanding the difference in the type of the chargers, suitability [10], and battery power optimization [11]. The energy efficiency from improved motor designs as explored by author in [12] derives strengths in decarbonization technological advancements. As the government policies in mandating requirements of renewable energy generation requirements for the utility companies grow the responsibility of the customers at commercial buildings become highly important given the all the stakeholders have equal responsibility in meeting the sustainability goals.

EV charging is rapidly expanding with Tata Power's significant role in addition of both slow and fast chargers. The authors own research in [13] established the potential of the development of EV chargers for rural and urban areas. A recent development of EV chargers of both slow and fast charging capabilites in the rural area at Akbarpur, India becomes a validation of the research by authors in [9] [11]. India's total energy generation for electricity comes from fossil fuels at 54.5% share in the overall 446,190MW. Coal is the major share of fossil fuels whereas natural gas, lignite, and diesel are other forms of fossil fuel in widespread use. Even though renewable energy generation is of great significance, the use of fossil fuels continues to be the first choice of the generation needs. Figure 1 shows the energy profile of the India as of 2018. The balance between renewable energy and fossil-fueled generation drives the objectives of this research paper. This paper is divided into sections that describe the review of current research, analysis approach, modeling, results, and conclusion.

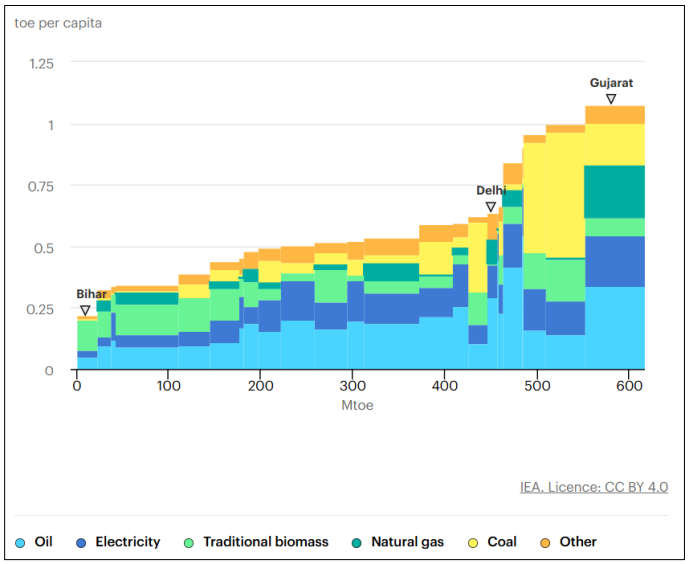

Figure 1 Energy Consumption Per Capita [14]

1.1. Commercial Buildings Existing Set-up

Current buildings in majority of the cities in India have no provisions of EV loads provided from building power at a large scale [15] [14]. EV charging loads require new electrical power feed as they add up to 1000W each for fast chargers. Figure 2 shows a scenario where the building may provide power to either slow or fast charging for the EVs. This concept is going to draw power from the existing building, which doesn't necessarily reduce the dependence on fossil-fuel power generation from the power generation companies. There are additional considerations the author in [2] emphasized when planning the transition to fully electric vehicles for the United States. Based on this analysis and concepts of energy management presented in [1] for residential and in [2] for commercial buildings, the EV transition fruition for existing buildings is possible without burdening the existing grid. Simultaneously the proposed methodology in [1]- [2] directs

energy management system for buildings with roof-top solar or any form of renewable energy generation in the captivity.

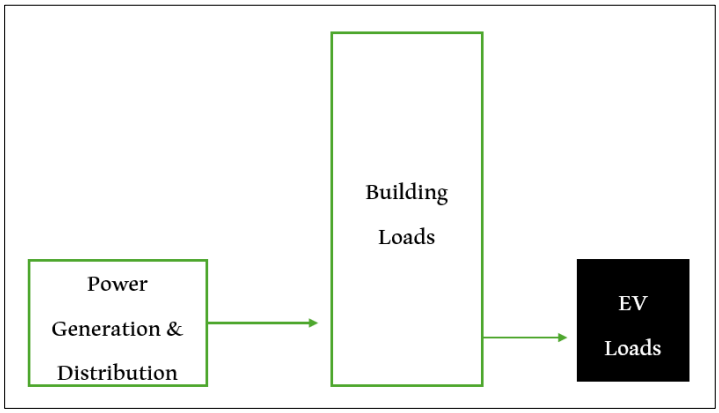

Figure 2 EV Loading

1.2. Analysis of Roof-top and Covered Parking Solar

Buildings in India are gaining traction on roof-top solar and wind energy. The surge is contributed to the reduction in dependence on the fossil-fuel generation by reducing costs of energy bills. The motivator is the cost reduction for building operation together with carbon emission containment from renewable energy generation for the commercial buildings. The property value increases from the installed solar for both roof-top solar and covered parking lots to serve the needs of the increased charging loads from the electric vehicles. Both of the solar applications at the commercial buildings significantly reduces the dependence on fossil-fuel generated power from the utility. Some advanced concepts in acquiring certifications for reduced environmental footprint through green buildings certification orients in the same direction of this research. Since EV transition is evident from [16], this paper in contrast addressed the risen demand from electric vehicles charging needs.

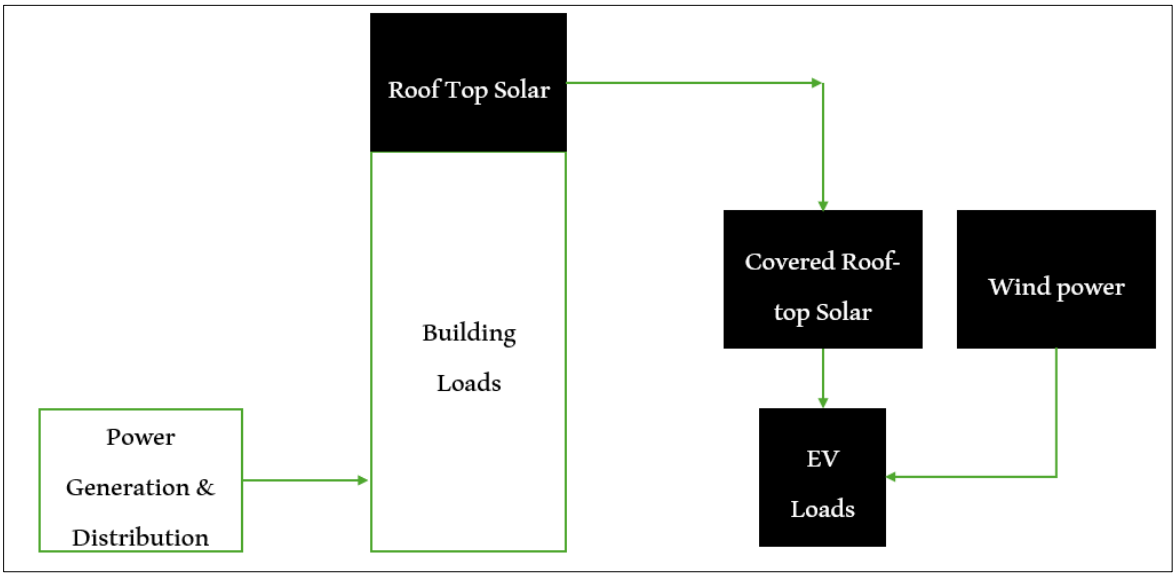

Figure 3 Renewable Penetration at Commercial Building

The accurate prediction of the roof-top solar is constrained by the solar irradiance values and building occupancy. Similarly, the EV charging stations are based on the occupancy of the building and type of usage. Much of the EV charging loads for commercial buildings are day loads. However, some vehicles parked overnight at these building utilize the slow charging options overnight. The modeling in this paper starts with determination of the building square footage, occupancy level, parking spaces, and available space for the roof-top for the building and covered parking. The practical application was applied for a building of total square footage of 150,000 sq-feet with available roof-top space of 16,800 sq-feet and parking space availability of 40,000 sq-feet, located in the Delhi National Capital Region.

2. Results

Based on the proposed model to obtain building occupancy, and EV loads based on square-feet, the estimated EV loads were calculated as 1000-1500 persons (based on occupancy of 100 to 150 sq feet per person). Therefore, total EV charging loads for 80% of tenants, intending to charge between 30-80% SoC, becomes 28,000-42,000 kWh for weekly demands. As per the Figure 4-5, total generation from 740kW-dc system installed on both roof-top and covered parking generates about 1,152,946 kWh annually. This is about 52.8% of the upper limit of energy demand from the EV charging for the building occupants.

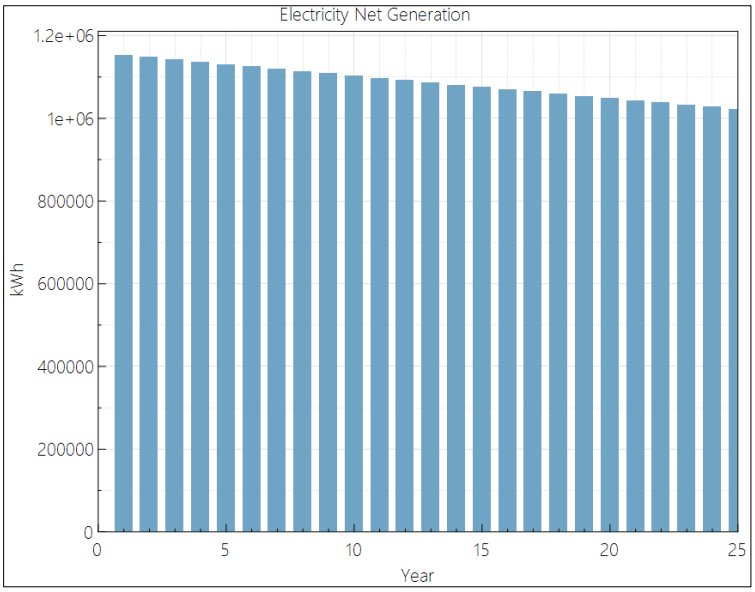

Figure 4 Electricity Generation

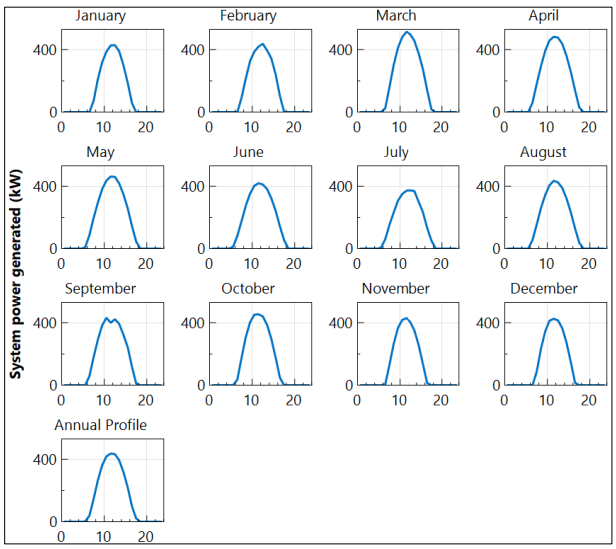

Figure 5 Yearly Generation Profile

3. Discussion

The integration of electric vehicles (EVs) and renewable energy from solar, wind, or geothermal in commercial buildings of varying sizes in India presents a promising solution for reducing utility companies' reliance on less eco-friendly fossil-fueled electricity generation. This synergy of the India's ambitious goal of achieving net-zero emissions aligns with the motivation of this research paper. Commercial buildings account for a significant portion of the demand curves for India's electricity consumption and, therefore, are increasingly adopting roof-top solar to reduce carbon emissions and

dependence on fossil-fueled generation. The government is supporting this transition by giving out some of the initiatives in the subsidies and incentives, making solar power gain financial attraction from the commercial customers. By generating clean energy on-site from these buildings for the EV charging infrastructure, it creates a symbiotic relationship that further results in the reduced fossil fuel dependence. The adoption of EVs in the commercial sector could lead to substantial benefits that will promise increased renewable penetration in the market. Additionally, this shift could result in a decrease in particulate matter and NOx emissions, CO2 emissions, and overall GHG emissions compared to business-as-usual cases. However, challenges continue to remain in this sector, including the need for widespread charging infrastructure of varying types and the current dominance of internal combustion engine vehicles fueled by petrol or diesel in the Indian market. Overcoming these technological and administrative hurdles will require continued government support, technological advancements, and increased awareness of the environmental and economic benefits of EVs and renewable energy in the commercial sector.

4. Conclusion

The integration of renewable energy for the EV loads for the commercial buildings is a powerful strategy in the resilience measures for India's fossil-fuel generation. Reduction of carbon emissions by the synergy developed between the sustainable development and the EV transition for enlarged decarbonization. The EV adoption will mitigate the effects of the increased oil prices and reduce the import reliance on the fossil fuels. Simultaneously, the momentum gained from the commercial buildings with roof-top solar systems will boost the nation's sustainable development and the targets for the decarbonization measures. The net carbon zero emissions in the upcoming 50 years in the commercial sector play a pivotal role. This transition not only addresses the immediate challenges of reducing fossil fuel consumption and air pollution but also positions India as a leader in sustainable urban development and clean energy innovation. A practical application for a commercial building was analyzed for solar power generation from roof-top and covered parking spaces for EV charging needs

References

[1] P. Sankhwar, "Energy Reduction in Residential Housing Units," International Journal of Advanced Research, vol. 12, no. 8, pp. 667-672, 2024.

[2] P. Sankhwar, "Evaluation of transition to 100% electric vehicles (EVs) by 2052 in the United States," Sustainable Energy Research, vol. 11, no. 35, pp. 1-21, 2024.

[3] V. S. Prabhu and K. Mukhopadhyay, "The economic and environmental consequences of the electric vehicle transition in India," Energy for Sustainable Development, vol. 81, pp. 1-22, 2024.

[4] B.-H. Jiang, C.-C. Hsu, N.-W. Su and C.-C. Lin, "A Review of Modern Electric Vehicle Innovations for Energy Transition," Energies, vol. 17, no. 12, pp. 1-20, 2024.

[5] NITI AAYOG & ROCKY MOUNTAIN INSTITUTE, "INDIA'S ELECTRIC MOBILITY TRANSFORMATION," NITI AAYOG & ROCKY MOUNTAIN INSTITUTE, 2019.

[6] S. Khan, "India's transition to electric vehicles - the road ahead," OPML, November 2021. [Online]. Available: https://www.opml.co.uk/insights/indias-transition-electric-vehicles-road-ahead.

[7] A. Ghate, R. Soat and R. Raunak, "Can India's Mobility Sector Say Farewell to Fossil Fuels?," RMI, 19 November 2024. [Online]. Available: https://rmi.org/can-indias-mobility-sector-say-farewell-to-fossil-fuels/.

[8] P. Sankhwar, "Application of Floating Solar Photovoltaics (FPV) for Great Salt Lake, Utah for Reducing Environmental Impact and Power Electric Vehicle Charging Stations," International Journal of Innovative Research in Engineering & Multidisciplinary Physical Sciences, vol. 12, no. 6, pp. 1-10, 2024.

[9] P. Sankhwar, "Future of Gasoline Stations," World Journal of Advanced Engineering Technology and Sciences, vol. 13, no. 01, pp. 012-017, 2024.

[10] P. Sankhwar, "Suitability of Electric Vehicle Charging Infrastructure and Impact on Power Grid Due to Electrification of Roadway Transportation with Electric Vehicles," International Journal of Science and Research, vol. 13, no. 12, pp. 374-383, 2024.

[11] P. Sankhwar, "Li-ion Battery," in Electric Vehicle Charging Stations Design Guide and Industry Challenges, Columbia, SC, Amazon, 2024, pp. 7-9.

[12] P. Sankhwar, "Application of Permanent Magnet Synchronous Motor for Electric Vehicle," Application of Permanent Magnet Synchronous Motor for Electric Vehicle, vol. 4, no. 2, pp. 1-6, 30 August 2024.

[13] V. Kumar, "Heavy-duty electric vehicle battery replacement for improving battery life and reducing cost of transportation in supply chain management by advancing AI," PARIPEX - INDIAN JOURNAL OF RESEARCH, vol. 13, no. 12, pp. 30-31, 2024.

[14] Indian Energy Outlook 2021, "Energy in India today," January 2021. [Online]. Available: https://www.iea.org/reports/india-energy-outlook-2021/energy-in-india-today.

[15] C. Lata, "Utilities Vital to the Success of India's EV Transition," NRDC, 6 June 2023. [Online]. Available: https://www.nrdc.org/bio/charlotte-steiner/utilities-vital-success-indias-ev-transition.

[16] A. Harikumar, H. Jain and A. Soman, "India's EV Transition," CEEW, New Delhi, 2022.