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A Review on Smart EV Charging and Energy Monitoring Using IoT

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Abstract:
Smart EV charging and energy monitoring using IoT in India is an emerging field that combines electric vehicle technology with Internet of Things (IoT) capabilities to optimize charging processes and improve energy management.

Keywords — **Electric Vehicles (EVs), Internet of Things (IoT), Smart Charging, Energy Monitoring.**

INTRODUCTION

The integration of Internet of Things (IoT) technology with electric vehicle (EV) charging infrastructure represents a significant advancement in the transportation and energy sectors. This innovative approach, known as smart EV charging, combines IoT devices, sensors, and data analytics to optimize the charging process, enhance energy efficiency, and improve the overall user experience. Smart EV charging systems utilize a network of interconnected devices to monitor and control the charging process in real-time. These systems collect and ana data from various sources, including the EVs themselves, charging stations, and the power grid. By leveraging this information, smart charging solutions can make intelligent decisions about when and how to charge vehicles, taking into account factors such as energy demand, grid capacity, and user preferences.

Smart EV charging and energy monitoring using IoT (Internet of Things) is an innovative approach to managing electric vehicle charging infrastructure and optimizing energy consumption. This system integrates IoT technology with electric vehicle charging stations to provide real-time data collection, analysis, and control. Key aspects of this technology include real-time monitoring of charging station usage, energy consumption, and grid load through IoT sensors. Dynamic load balancing adjusts charging rates based on grid capacity and demand to prevent overloading. Predictive maintenance enabled by IoT devices monitors charging equipment health, reducing downtime. User-friendly interfaces such as mobile apps and web portals allow users to locate available charging stations, schedule charging sessions, and track energy consumption. Smart pricing models can be implemented based on peak hours and energy availability. The system can communicate with the power grid to optimize energy distribution and support demand response programs. Collected data can to improve charging infrastructure planning and energy management strategies. Remote management capabilities allow operators to monitor and control charging stations, enhancing efficiency and reducing operational costs. By leveraging IoT technology, smart EV
charging and energy monitoring systems aim to improve the efficiency, reliability, and sustainability of electric vehicle charging infrastructure.

India's transition to electric vehicles (EVs) has sparked innovation in smart EV charging and energy monitoring. Leveraging IoT technology, Indian

companies are developing intelligent charging solutions that optimize energy consumption, reduce peak demand, and promote renewable energy integration. Smart EV charging stations, equipped with IoT sensors and real-time monitoring capabilities, enable efficient energy management and automated billing. Moreover, IoT-based energy monitoring systems provide valuable insights into energy usage patterns, facilitating data driven decision-making. As India targets30% EV adoption by 2030, smart EV charging and energy monitoring solutions will play a vital role in ensuring a sustainable and efficient transportation.

2.Monitoring system in India

clean energy usage. IoT devices monitor solar generation, battery storage levels, and grid power consumption to optimize the use of renewable energy for EV charging.

The Indian smart EV charging ecosystem also emphasizes interoperability and standardization. Efforts are being made to develop common communication protocols and payment systems to ensure seamless user experience across different charging networks. This approach aims to address the fragmentation issues often seen in early-stage EV markets.

In urban areas, smart EV charging systems are being integrated with public transportation hubs to promote multimodal transportation. IoT-enabled charging stations at metro stations, bus depots, and park-and-ride facilities allow commuters to conveniently charge their vehicles while using public transport for part of their journey. The integration of smart EV charging with India's growing smart meter infrastructure is another area of focus. This integration allows for more accurate billing, better load management, and the potential for implementing innovative tariff structures that incentivize off-peak charging.

Lastly, the development of a domestic supply chain for smart EV charging components is being prioritized to support the "Make in India" initiative. This includes the local manufacturing of IoT sensors, communication modules, and charging equipment, which can help reduce costs and create employment opportunities in the EV sector.

3. Energy Monitoring Using IoT System and Approach

Smart EV charging and energy monitoring using IoT systems integrate advanced technologies to optimize electric vehicle charging processes and enhance energy management. These systems employ a network of interconnected devices and sensors to collect real-time data on charging station availability, energy consumption, and grid load. IoT-enabled charging stations can communicate with electric vehicles, power grids, and user devices, allowing for efficient scheduling, load balancing, and demand response mechanisms. The collected data to predict charging patterns, optimize energy distribution, and provide valuable insights for infrastructure planning. Users can access real-time information about charging station locations, availability, and pricing through mobile applications, improving convenience and reducing range anxiety. Additionally, these systems can integrate renewable energy sources and energy storage solutions, contributing to a more sustainable and resilient charging infrastructure. By leveraging IoT technology, smart EV charging systems aim to enhance the overall efficiency, reliability, and user experience of electric vehicle charging while supporting the growth of sustainable transportation.

Smart EV charging and energy monitoring using IoT in India is gaining significant traction as the country aims to accelerate electric vehicle adoption and improve its energy infrastructure. The Indian government has set ambitious targets for EV adoption, making the implementation of smart charging systems crucial for managing the increased demand on the power grid. In India, smart EV charging systems are being integrated with existing smart city initiatives to create a comprehensive urban mobility solution. These systems are designed to address unique challenges faced by Indian cities, such as high population density, diverse vehicle types, and varying power supply conditions. One key aspect of smart EV charging in India is the focus on renewable energy integration. Many charging stations are being equipped with solar panels and energy storage systems to reduce dependence on the

grid and promote clean energy usage. IoT devices monitor solar generation, battery storage levels, and grid power consumption to optimize the use of renewable energy for EV charging.

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To address range anxiety and promote EV adoption in rural areas, the Indian government is exploring the concept of mobile charging stations. These IoT-enabled mobile units can be deployed to areas with limited charging infrastructure, providing flexible and on-demand charging solutions. Data privacy and cybersecurity are critical concerns in the Indian context. Smart EV charging systems are being designed with robust security measures to protect user data and prevent unauthorized access to the charging infrastructure. This includes encryption of data transmission, secure authentication mechanisms, and regular security audit.

As shown in Table 1.1, various IoT-enabled smart EV charging approaches are summarized.

Table 1.1 Literature Review

Ref No.	Background	Segmentation Technique	Feature Extraction Technique	Classifier / Recognition	Accuracy	Monitoring System
1	ZigBee communication	Time-of-Use (TOU)	Charging time, energy consu	Fuzzy logic controller	95%	Web-based interface
		pricing	mption			
2	RFID and Wi-Fi	Priority-based charging	Vehicle type, charging time	Decision tree algorithm	92%	Mobile app
3	IoT sensors	Time-series analysis	Energy consumption, charging time	Support vector machine (SVM)	96%	Web-based dashboard
4	Reinforcement learning	Peak shaving	Energy consumption, charging time	Q-learning algorithm	94%	Mobile app
5	LoRaWAN	Clustering analysis	Energy consumption, charging time	K-means	93%	Web-based interface
6	Machine learning	Anomaly detection	Energy consumption, charging time	CNN	97%	Mobile app
7	IoT Sensor	Time series analysis	Energy consumption, charging time	SVM	95%	Web-based dashboard
8	Energy storage	Priority based	Vehicle type, chargi	Decision tree	92%	Mobile app

		chargi ng	ng time	algori thm		
9	Contro l system	Cluste ring analys is	Energ y consu mptio n, chargi ng time	K-mean s cluste ring	96%	Web-base d interf ace
1 0	Real Time Energy monito ring control system	Cluste ring	Energ y consu mptio n patter n	ML	93%	Clou d base d IoT
1 1	Predict ive energy manag ement	Time series foreca sting	Energ y consu mptio n	LST M	96%	Web-base d appr oach
1 2	Real-Time energy monito ring	Anom aly detecti on	Energ y consu mptio n, chargi ng time	One Class SVM	94%	Web-base d dash boar d
1 3	Real-Time energy monito ring	Model predic tive contro l	Energ y consu mptio n, chargi ng time	MPC algori thm	97%	Mobi le app
1 4	Sensor	Cluste ring analys is	Energ y consu mptio n, chargi ng time	K-mean s Clust ering	93%	Web-base d interf ace
1 5	Energy Foreca sting	Time series foreca sting	Energ y consu mptio n,	GRU	98%	Mobi le app
			chargi ng time			
1 6	Smart chargin g system s	Cluste ring	Energ y consu mptio n patter ns	ML	90%	Clou d-base d moni torin g patte rn

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REFERENCES

[1]. Khan, H., & Miah, M. (2021). "IoT-Based Smart EV Charging System for Optimal Energy Management". International Journal of Energy Research, 45(8), 1223–1234.
[2]. Jadhav, A., & Kothari, D. P. (2020). "Energy Consumption Monitoring in Electric Vehicles Using IoT". IEEE Transactions on Smart Grid, 11(4), 3476–3485.
[3]. Sharma, P., & Gupta, R. (2019). "IoT-Enabled EV Charging
Station for Efficient Energy Utilization". International
Conference on Smart Energy Systems (ICSES), 134–139.
[4]. Chen, Y., Zhang, Z., & Li, L. (2022). "Smart Charging
Infrastructure for Electric Vehicles Using IoT and Cloud Integration". Renewable Energy Systems, Elsevier, 45(6), 1043–1056.
[5]. Kumar, S., & Verma, N. (2020). "Energy Monitoring in EV Charging Networks with IoT-

Based Sensors". Sensors and Actuators Journal, 43(7), 354–361.
[6]. Lee, J., & Park, S. (2021). "An IoT-Based Approach to Optimize Energy Consumption for EV Charging Stations". IEEE Access, 9, 27500–27512.
[7]. Venkatesh, R., Kumar, P., & Krishnan, M. (2021).
"Integration of Smart Grids and IoT for Efficient Electric Vehicle Charging". Journal of Electrical Systems, 35(2), 345– 355.
[8]. Zhang, H., Wei, Z., & Wang, J. (2019). "Smart Charging for Electric Vehicles with Energy Monitoring in IoT Frameworks". International Journal of Electrical Power & Energy Systems, 109, 586–593.
[9]. Sahoo, S., & Swain, D. (2022). "IoT-Based Smart Charging Station for Electric Vehicles with Real-Time Monitoring".
International Journal of Green Energy, 19(5), 439–447.
[10]. Patel, J., & Mehta, K. (2021). "Optimization of Energy
Consumption Using IoT in EV Charging Stations". IEEE International Conference on Power Electronics (ICPE), 234– 240.
[11]. Wang, X., Liu, Y., & Yang, J. (2020). "IoT-Based Smart Charging Strategies for Electric Vehicles in Smart Grids". IEEE Transactions on Industry Applications, 56(8), 903–910.
[12]. Choudhury, B., Singh, A., & Verma, R. (2021). "Real-Time
Energy Monitoring and Optimization in IoT-Enabled EV Charging Systems". International Journal of Renewable Energy Research, 12(1), 54–60.
[13]. Alotaibi, F., & Nadeem, A. (2021). "Smart EV Charging
Station with Cloud-Based IoT Monitoring for Energy Efficiency". Journal of Modern Power Systems and Clean Energy, 9(3), 541–549.
[14]. Ramesh, A., & Kumar, S. (2020). "Energy Consumption Analysis for IoT-Integrated EV Charging Infrastructures". Proceedings of the International Conference on Smart Grid and IoT (SG IoT), 78–85.
[15]. Gupta, V., & Chatterjee, S. (2022). "Design and
Implementation of IoT-Based Smart Charging Systems for Electric Vehicles". Springer Lecture Notes in Electrical Engineering, 711, 103–118.
[16]. Huang, J., & Chen, L. (2019). "Smart Charging and Energy Monitoring Framework for EVs Using IoT and Blockchain Technology". IEEE Internet of Things Journal, 6(4), 7250–7258.
[17]. Kumar, N., Patel, S., & Yadav, A. (2021). "IoT-Enabled
Energy Consumption Monitoring for Electric Vehicle Charging Stations". International Journal of Electrical and Electronics Engineering, 48(5), 381–389.
[18]. Zhang, X., Zhou, J., & Li, W. (2020). "An Intelligent EV
Charging System Using IoT and Predictive Analytics". IEEE International Conference on Smart Energy Grid Engineering, 349–355.
[19]. Rajput, M., & Kaushik, P. (2021). "Energy Optimization in IoT-Based EV Charging Networks: A Review". Renewable and Sustainable Energy Reviews, 140, 110734.
[20]. Kim, D., & Lee, S. (2020). "IoT and AI-Based Adaptive EV Charging for Energy Efficiency in Smart Grids". Journal of Energy Storage, 32, 101684.
[21]. Zhou, H., Zhang, L., & Yuan, Q. (2021). "Integration of Renewable Energy in IoT-Based Smart EV Charging Infrastructure". Energy Reports, 7, 2435–2443.
[22]. Sharma, M., & Bansal, D. (2022). "Development of IoT Driven Energy Monitoring Systems for Electric Vehicles". International Journal of Emerging Electric Power Systems, 23(4), 185–197.
[23]. Singh, P., Gupta, A., & Meena, S. (2021). "IoT-Based RealTime EV Charging and Power Management in Smart Cities". IEEE Access, 9, 32467–32479.
[24]. Raj, S., & Bose, M. (2020). "IoT-Assisted Energy
Management System for Electric Vehicles in Smart Charging Stations". Journal of Cleaner Production, 258, 120751.
[25]. Fernandes, F., & Coelho, A. (2021). "Performance

Analysis of IoT-Based EV Charging Management Systems".
International Conference on Intelligent Systems (IS), 567–573.
[26]. Yu, H., Kim, J., & Lee, C. (2022). "A Cloud-IoT-Based Framework for Smart EV Charging Station Management and Monitoring". IEEE Access, 10, 45678–45685.
[27]. Reddy, S., & Rajan, A. (2021). "IoT-Driven Smart EV Charging Infrastructure for Energy Optimization in Smart Cities". Sustainable Cities and Society, 68, 102782.
[28]. Misra, A., & Das, S. (2020). "Energy Monitoring and Demand Prediction for IoT-Enabled EV Charging Systems". International Conference on Power, Energy and IoT Applications, 211–217.
[29]. He, Z., Liu, H., & Zhang, X. (2021). "Optimal Scheduling of
EV Charging Stations Using IoT and Renewable Energy Integration". Journal of Energy Management and Technology, 13(5), 102–110.
[30]. Nguyen, P., & Tran, M. (2022). "A Smart Grid Framework for Energy-Efficient IoT-Based EV Charging Systems". Energies, 15(4), 921.
[31]. Kumar, B., & Prakash, R. (2020). "IoT-Based Real-Time Monitoring and Control of Electric Vehicle Charging Stations". Journal of Electrical Engineering, 45(6), 476–483.
[32]. Lopez, A., & Martinez, P. (2021). "Machine Learning and
IoT for Energy Optimization in EV Charging Networks". IEEE International Conference on Smart Cities and Energy, 122– 128.
[33]. Gao, F., Zhou, Y., & Zhang, H. (2022). "Blockchain and IoT
Integration for Secure and Efficient EV Charging Infrastructure". International Journal of Distributed Sensor Networks, 18(3), 345–356.
[34]. Patel, A., & Singh, N. (2021). "IoT and Smart Sensors for Energy Monitoring in Electric Vehicle Charging". International Journal of Sensors, 29(7), 689–701.
[35]. Wu, J., & Chen, R. (2020). "Energy Management of EV Charging Systems Using IoT and Edge Computing". IEEE Transactions on Smart Grid, 11(9), 738–746.
[36]. Kaur, J., & Sharma, V. (2021). "IoT-Based Smart Charging and Monitoring for Electric Vehicles in Smart Homes". International Conference on Emerging Technologies in Smart Grids, 457–463.
[37]. Ahmed, I., & Khan, S. (2020). "Performance Evaluation of IoT-Enabled EV Charging Solutions for Energy Savings". Journal of Cleaner Energy Solutions, 31, 112–119.
[38]. Zeng, X., Zhang, W., & Ma, L. (2022). "Smart Energy Management for IoT-Based Electric Vehicle Charging Systems". IEEE Smart Grid Applications Conference, 145–152.
[39]. Naik, R., & Kulkarni, M. (2021). "A Comparative Analysis of IoT Technologies for Real-Time EV Charging Energy Monitoring". International Journal of Renewable Energy Engineering, 17(4), 384–392.
[40]. Sen, P., & Roy, T. (2020). "IoT and Data Analytics for Optimized Energy Consumption in EV Charging Infrastructure". Elsevier Energy Reports, 6, 3030–3037.
[41]. Al-Mutawa, A., & Al-Hassani, K. (2021). "IoT-Driven
Framework for Energy Consumption Optimization in EV Charging Networks". International Journal of Smart Grid and Renewable Energy, 12(3), 245–253.
[42]. Farooq, M., & Ali, R. (2022). "An Intelligent IoT-Based EV Charging System for Renewable Energy Integration". IEEE Access, 10, 14732–14741.
[43]. Zhang, Q., Zhang, H., & Yang, X. (2021). "Smart IoT
Solutions for Energy Monitoring and Dynamic EV Charging Management". Journal of Energy Storage, 45, 102376.
[44]. Das, P., & Sharma, R. (2021). "Real-Time Data Analytics and IoT for Smart EV Charging Management in Microgrids". International Conference on Energy Systems, 349
[45]. Li, B., & Zhou, S. (2020). "IoT-Based Energy Monitoring and Optimization of Smart EV Charging Infrastructure". Journal of Energy Management, 54(2), 112–119.
[46]. Thomas, G., & Varghese, A. (2021). "A Predictive Analytics Approach to IoT-Based EV

Charging Stations". IEEE Transactions on Industrial Informatics, 17(6), 4208–4216.
[47]. Kumar, S., & Aggarwal, P. (2022). "Integration of Smart Grids and IoT for Energy Efficient EV Charging Networks"Renewable Energy and Sustainability Journal, 19(8), 734–743.
[48]. Wu, X., & Zhang, Y. (2021). "IoT-Based Smart EV Charging System with Load Balancing and Energy Management". IEEE Internet of Things Journal, 8(10), 8546–8553.
[49]. Roy, S., & Ghosh, A. (2020). "Energy Management in IoT Enabled EV Charging Systems for Grid Stability". Journal of Power Electronics and Smart Systems, 28(4), 310–318.
[50]. Park, J., & Kim, T. (2021). "Development of a Smart EV Charging Station Using IoT and AI-Based Energy Forecasting". Energy Conversion and Management, 229, 113774.
[51]. Hossain, M., & Akhtar, N. (2021). "IoT-Based Demand Side Management for Optimizing EV Charging Load". International Journal of Smart Grid and Clean Energy, 10(2), 123–130.
[52]. Singh, P., & Verma, A. (2020). "IoT and Edge Computing for Optimized Energy Monitoring in EV Charging Networks". IEEE International Conference on Emerging Trends in Energy, 88–95.
[53]. Balaji, V., & Reddy, S. (2021). "Smart Energy Monitoring and Scheduling in IoT-Based EV Charging Systems". International Journal of Renewable Energy Research, 11(3), 872–880.
[54]. Prasad, N., & Kumar, R. (2020). "IoT and Cloud-Enabled
Smart EV Charging Infrastructure with Energy Monitoring Capabilities". Journal of Cloud Computing Research, 22(1), 74–83.
[55]. Zhou, P., & Wei, L. (2022). "An IoT-Based Intelligent EV Charging Framework for Smart Cities". International Journal of Electrical Power & Energy Systems, 136, 107692.
[56]. Gopalakrishnan, K., & Kumar, N. (2020). "Optimized IoT Framework for Monitoring Energy Consumption in Electric Vehicle Charging Stations". IEEE Access, 8, 92456–92467.

