VIEW POINT

SCALING VEHICLE-TO-GRID (V2G) WITH A PLATFORM BASED SOLUTION

1. Abstract

This paper delves into the critical role of Vehicle-to-Grid (V2G) technology in shaping the future of the energy industry. It explores the current landscape of EVs, their impact on utilities, and the potential of V2G to address grid challenges and create new revenue streams.

A comprehensive V2G platform is presented as a solution to maximize business flexibility, operational excellence, customer centricity, and energy optimization. Key features include an Energy Management System, Congestion management tools, Real-time monitoring and User-friendly interfaces.

The paper also discusses the platform's architecture, emphasizing its cloud-based infrastructure, modularity, and security measures. By leveraging V2G technology and a robust platform, the energy industry can transition towards a more sustainable and efficient future.

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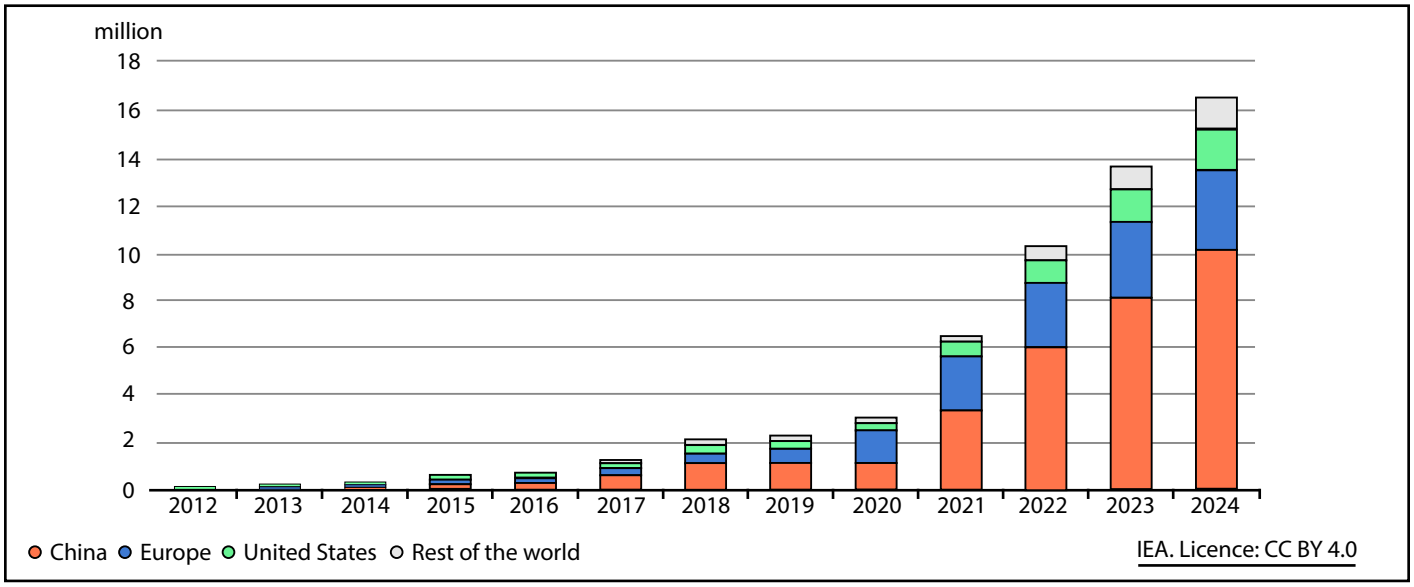
2. Current Global Landscape of EVs

The electric cars industry is one of the most resonant in the clean energy segment. In 2021, sales of electric cars (EVs) reached a new high of reached a new high of 14 million, a 35% increase on year-on-year basis. This has gone up more than 6 times in just last 5 years. Over 250,000 new registrations were made every week in 2023, surpassing the yearly total from 2013, a decade earlier. As a result, there are now over 40 million electric vehicles worldwide [2]. According to a Gartner report, Automakers are investing heavily to the advancement of fully electric and plug-in hybrid automobiles. Electric vehicle shipments are predicted to rise at a CAGR of 16% to reach 53 million units by 2032, up from 11 million in 2022, according to technology and service companies. Several factors contribute to the growing trend of EVs with continuous government incentives, favorable climate policies and EV cost reductions being the main contributors. In 2021, public investment on EV incentives and subsidies almost increased to around USD 30 billion [3]. A growing number of nations have made the commitment to phase out internal combustion engines or have set high goals for the electrification of vehicles in the next several decades. Many automakers, meanwhile, have electrification plans for their fleets that surpass legislative targets. Ultimately, the availability of new EV models increased fivefold between 2015 and 2024, making them more appealing to buyers.

Based on current climate-focused policy announcements and pledges, the IEA Announced Pledges Scenario (APS) assumes that EVs would account for over 30% of all vehicles sold globally in 2030, excluding two- and three-wheelers. Despite assuming significance, these numbers still fall far short of the 60% share that will be required by 2030 in order to put the trajectory towards net zero CO_2 emissions by 2050.

Car CO_2 emissions can be brought into line with the Net Zero Emissions by 2050 Scenario if the growth in EV sales over the last two years continues.



Current Global Landscape of Electric car sales, 2012-2024

Current Landscape of EVs in India

In line with the global phenomenon, the landscape of electric vehicles (EVs) in India is rapidly evolving, with a growing number of models and charging infrastructure being introduced. The government has also implemented various policies and incentives to encourage the use of EVs, such as offering subsidies to EV manufacturers and buyers, tax breaks. While the initial uptake has been slower compared to some other countries, the EV market in India is promises a rapid growth in the near future, driven by factors like rising fuel prices, increasing environmental concerns, and advancements in EV technology. India's EV sector is rapidly gaining momentum. With a significant 5% market share between October 2022 and September 2023, EVs are poised to dominate the market, potentially reaching a 40% penetration rate by 2030, primarily driven by the 2-wheeler and 3-wheeler segments. With more affordable and accessible EV options, coupled with improved charging infrastructure and government support, India is poised to become a major player in the global electric vehicle market [9]. India has established an objective to elevate the proportion of electric vehicle (EV) sales to 30% in private cars, 70% in commercial vehicles, 40% in buses, and 80% in two-wheelers and three-wheelers by the year 2030 [8].

Impact of EVs on Utilities Sector

The popularity of electric vehicles (EVs) is a part of a larger trend known as transportation electrification (TE), which is using electricity as the preferred fuel for transportation. Along with the growth of EVs, this shift also entails the alteration of infrastructure, including ports and roads, to enable charging. For utilities, the change has significant ramifications. They must get ready to fulfil TE's energy demands in a way that will allow them to lead the transition and benefit from it as well. For utilities that can accomplish this, there is a great deal of opportunity: according to estimates from the Boston Consulting Group, the adoption of EVs could generate $3 billion to $10 billion in additional value for the typical utility.

Utilities must take three steps to enable Value Realisation:

1

Wisely invest in improving the grid's infrastructure:

The grid's overall capacity (in kilowatts) will need to increase to accommodate demand spikes in specific areas and during peak charging hours.

2

Back federal TE initiatives and directives:

To assist TE, utilities can implement new rate plans, rebates, and promotions, among other measures.

3

Expand into new markets by offering EV-related goods and services like setting up, running, and maintaining EV charging stations.

3. Vehicle to Grid (V2G): Driving the future of Utilities and Energy

By using a specialized bi-directional charger that is managed by a remote management system, V2G technology enables an EV to synchronize with the electrical grid and inject power back into it. The advanced power converters found in such chargers may either recharge the EVs' batteries or return power to the grid during periods of high demand, helping to balance the grid. V2G technology would help stabilize the electricity grid by incentivizing the individual customers to allow the local grid operator to use some of their EV battery capacity for grid support services.

V2G technology requires specialized bidirectional chargers that can both send and receive electricity. Equipped with intelligent communication systems, these chargers coordinate with the grid and the EV to determine the optimal times for charging or discharging. When the grid needs additional power, V2G-enabled EVs can contribute to the supply, helping to stabilize the grid and reduce reliance on traditional power plants.

Following are the pre-requisites for a V2G ecosystem:

1. An EV with V2G capability
2. A bidirectional charger compatible with the EV
3. Grid Operator capability

Smart - V2G

Bi-directional smart charging with energy flow that can supply power directly into the grid as needed. Managed by a more sophisticated energy management system (e.g., third-party service provider), it provides energy supply and ancillary services (e.g., frequency response) to the grid and enables consumers to earn a source of income.

NB: The broken arrows highlight the capability of the system to control (start/stop) when charging occurs

V2G technology is expected to be a major driver in transforming the utilities and energy industry in a few keyways:

Grid balancing and stability:

With increasing reliance on renewable energy sources like solar and wind, the grid faces challenges due to their variable nature. V2G can act as a giant distributed energy storage system. Thousands of EVs plugged into V2G chargers can collectively respond to grid demands, soaking up excess power during low-demand periods and feeding it back during peak hours. This reduces the need for expensive "peaker" plants that typically run on fossil fuels.

Revenue opportunities for utilities and EV owners:

Utilities can leverage V2G to offer time-based electricity rates. EV owners can charge their vehicles at cheaper rates during off-peak hours and even earn money by selling excess power back to the grid during peak hours.

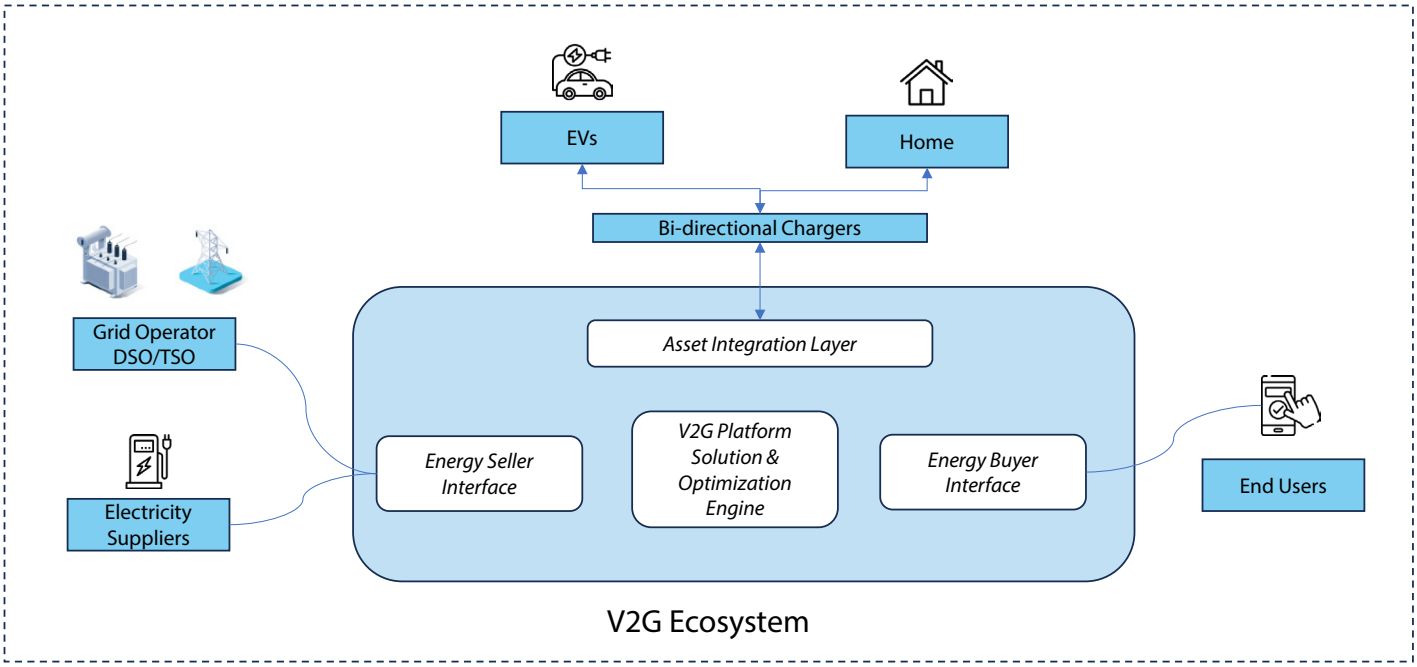
Renewable Energy integration:

V2G has the potential to greatly improve the integration of renewable energy sources. By providing additional storage capacity, V2G allows utilities to capture and utilize more renewable energy when it's available, reducing reliance on traditional power plants.

Reduced emissions and environmental impact:

V2G can help create a greener and more sustainable energy grid by balancing out energy demand and boosting reliance on renewable sources.

4. V2G Ecosystem



V2G Ecosystem

The entire V2G ecosystem consists of EV batteries with bi-directional chargers, Grid Operators, retail energy suppliers and end-users who would be connected to the V2G platform through a mobile application. The V2G platform seamlessly integrates and manages a fleet of millions electric car chargers, electric batteries. The application can optimize device charging schedules to minimize costs and carbon emissions, aligning charging patterns with periods of abundant green energy on the grid. This domestic flexibility is then offered to the grid to help balance supply and demand.

The entire ecosystem provides a win-win scenario for energy buyers as well as energy sellers. Customers benefit from platform-connected devices. The platform collects data on individual asset needs through a mobile or a web app and combines it with information from the likes of retail energy suppliers. This enables the platform to create charging paths that meet both customer requirements (like fully charged EVs by a specific time) and system needs. By shifting the demand away from peak times, the platform would help reduce energy costs and carbon emissions for energy retailers. These savings can then be passed on to customers in the form of lower energy bills.

5. A Platform Approach to drive V2G Success

Flexibility to Business

The focus of any organization in today's world is on increasing revenue and making sure that they deliver on the commitment of providing flexibility even during constant changes and disruptions.

Maximizing the customer experience is critical to ensure the smoother adoption of V2G and this can be realized with optimizing the monetization by offering the flexibility in terms of the various charging options – slow charging, fast charging, ultra-fast charging etc., and in terms of the billing plans – fixed charges, hourly variable charges, peak time charges suiting to the needs to customers as they require. Payment methods in terms of the Payment gateways also is required to add operational and business flexibility. EV users should have the ability to connect to other operators and must ensure peer-to-peer roaming protocols like Open Charge Point Interface (OCPI) are adopted.

Ensuring client data is accurate across all parameters is crucial to maintaining good customer relationships and this will ensure all customer touchpoints are error and hassle free. A platform-oriented solution will address all the above points and help maximise business flexibility.

Operational Excellence

It is quite complicated to manage EV charging networks. Also ensuring that the chargers are running both effectively and efficiently is critical for the entire V2G ecosystem to be fully functional.

A V2G platform will help to oversee the entire charging network and track if there are any concerns with the chargers thereby providing clear visibility of the charger status across the entire network. A platform also ensures that chargers' issues which are of critical nature if found, would be addressed on top priority with the help of issue management tools embedded in the platform to identify the root cause, track, and resolve the issue quickly and easily.

Along with the capability of issue detection and fixing, a V2G platform has the capability to fix issues automatically through the intervention by the platform tools before the stakeholders are affected by that issue. This proactive issue resolution will enable a steady environment and a seamless user experience while improving the supplier/operators Total Cost of Ownership.

Thus, a V2G platform provides operational excellence by delivering lower TCO, improved monetization and ROI.

Customer Centricity

A V2G platform ensures that the entire end-to-end solution is driven towards meeting the needs of the users since the success of the V2G is more dependent on the adoption and usage by the consumers. The platform being intuitive and simple, provides a seamless experience to the consumers. An A V2G platform driven by AI ensures that insights are derived from the usage patterns of the individual users are used to modify the platform functionalities more aligning to the user requirements. A comprehensive platform solution will support different business stakeholders in the ecosystem such as EV fleet owners, facility managers, etc. A Customer-centric platform solution enhances customer satisfaction and loyalty, minimizes client costs, and establishes a whole ecosystem.

Energy Optimization

The impact of EV on the grid needs to be managed by balancing across the EV user's power demands, power consumption requirements of building, the supply from the grid, use of Battery storage systems and add-ons from renewables. V2G platforms help to manage the grids by deploying specialized algorithms which will ensure that the charging supply is optimized based on the number of vehicles accessing the chargers in a location and the type of vehicles along with supporting spot pricing & time of use pricing. The energy management system which is part of the V2G platform has the capability to handle energy optimization, load balancing, demand response, prioritisation of EV fleets, and integration with the local distribution, renewables and flexibility market. The charging algorithms helps to flatten the energy demand curve by balancing the demand and supply.

Scalability

V2G platforms provide the required scalability to support expansion from within a single region to across countries. This will ensure that business can scale the network easily, quickly, efficiently and with little to no interferences to the existing business operations.

Open & Future-proof

An open & a future proof V2G platform supports various open protocols like OCPP and OCPI; supports the various charger types; and provides complete modularity thereby ensuring that the platform caters to the various stakeholders across the value chain.

6. V2G Platform Solution Overview

A comprehensive V2G platform solution should include a wide range of features to ensure effective management, control, and optimization of vehicle-to-grid interactions.

Energy Management System (EMS) with Adaptive & Dynamic Load Management

It is important to manage the maximum power delivered for charging and the reverse flow from the battery to the grid. This will be managed through the adaptive and dynamic load management capability of the platform. Through the A&DLM, the maximum consumption for the chargers and the reverse flow onto the grid will be always maintained below the defined power threshold. This will help eliminate the need for investing further in upgrading the existing electrical infrastructure and help manage the peak power demand. Along with tracking every charging session, A&DLM monitors the load across all major electrical system and optimizes the charging based on overall electrical usage of the site.

Congestion Management

Congestion Management tool designs prioritized rules determining how much power is used during a specific period in the day in the defined areas and the EV charging will be optimized based on both energy production (which is variable with addition of more renewable energy sources) and the grid capacity.

Capacity Adjuster

In order to better manage the load based on the electricity supply's restrictions, a capacity maximiser will evaluate how much power needs to be allocated for each EV charger. This will work in tandem with the A&DLM and enable the management of large charging sites with multiple electrical circuits and feeders such as a multi-level car park.

In long term parking sites, A predefined priority algorithm will rotate the charging turns by putting some charging sessions on hold when insufficient charging power is available so that the EV drivers' cars which are to be urgently charged can be done even when there is no capacity once they plug in based on the preassigned priority status of the EV.

Real-Time Monitoring and Control

The platform provides real-time data on vehicle status, battery levels, charging/discharging rates. It also manages the flow of electricity between the grid and EVs, ensuring safe and efficient charging/ discharging.

Dynamic Pricing

Based on the inbuilt AI models, the platform has the capability to come up with up real-time pricing models reflecting current grid conditions. The customers will be charged after a charging event or will be credited with the amount if they supply power to the grid directly on their bank account or payment card. Integration with payment gateways ensures that all transactions are seamless.

User Interface

The main touchpoint for the end-users is the mobile app which would be made available both for iOS and Android as well as a desktop application. This would provide details of

- V2G accessibility
- Start and stop of V2G events
- View all V2G interaction history
- Dashboards displaying key metrics and insights.
- Notifications and alerts for critical events or actions needed

Predictive Analytics

Advanced ML models help in:

- Forecasting energy demand and supply which would help:
    - o Charging station installers could design charging infrastructure to provide a better service to EV owners by understanding the usage patterns and requirements
    - o Utility providers can gather insights on electricity load requirements based on the charging pattern and consumption patterns of the EV owners.
- Optimizing the charging patterns by EV owners to help reduce the electricity cost
- Getting insights into how various charging and driving behaviors affects battery degradation which would be helpful for OEMs for providing predictive maintenance for EV batteries and charging infrastructure

Fleet Management Tools

The platform will provide specialized features for managing large EV fleets which will be beneficial for large fleet operators. This will assist them with scheduling, tracking, and optimization for fleet operations.

Energy Trading Platform

The Energy trading feature will act as a marketplace for trading stored energy between EV owners and the grid. It will deploy automated matching of buyers and sellers based on real-time conditions.

Customer Support and Engagement

A 24/7 customer support through various channels will be integrated into the platform. Also, an educational resources and tutorials portal will be available for the users as a self-help guide for quickly understanding and leveraging the capabilities of the platform.

Platform Architecture

Designing a platform architecture for a V2G solution involves several layers and components to ensure seamless integration, efficient operation, and security. The basic tenet of the platform is that will be cloud based with the modular and extensible architecture.

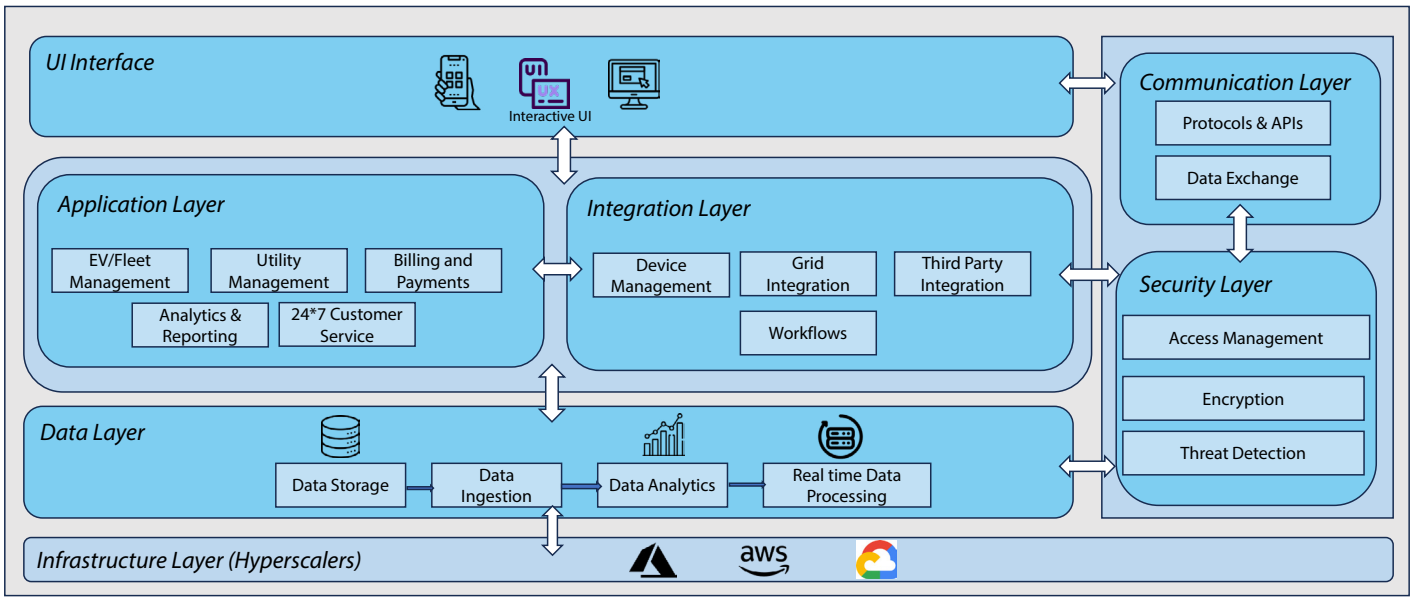
Cloud-Based Infrastructure

The platform will harness the power of cloud and deploy Scalable cloud services to handle increasing data and user loads. Since massive amounts of data flow happens across the platform, edge computing will be deployed which will enable low-latency, localized data processing and provide faster data and insights to the end users.

Modular and Extensible Architecture

A modular and extensible Architecture will be utilized by the platform which will enable easy addition of new features and functionalities and also provide the capability to create customized modules to cater to specific user needs.

High-level overview of the architecture:



User Interface Layer

The user interface layer comprises of the features for web portal, Dashboards and Mobile Apps.

Mobile Apps:

For EV owners to monitor and control their vehicle's V2G activities.

Web Portal:

For utilities, fleet managers, and other stakeholders to manage and monitor the V2G operations.

Dashboards:

Real-time visualizations for energy flow, grid status, and economic incentives.

Communication Layer

The communication layer focusses on setting up the standardized protocols and APIs for data exchange

Protocols and APIs:

Standardized communication protocols (e.g., OCPP, ISO 15118) and APIs for interoperability between EVs, chargers, and the grid.

Data Exchange:

Secure data transmission channels for real-time updates and control signals.

Application Layer

The application layer manages the core applications built as part of the V2G platform: Energy Management system, Billing & Payments and Analytics & Reporting

Energy Management System (EMS):

Manages the flow of electricity between EVs and the grid, optimizing charging and discharging based on grid demands.

Billing and Payments:

Handles dynamic pricing, invoicing, and payment processing for energy transactions.

Analytics and Reporting:

Provides insights, forecasts, and reports based on historical and real-time data.

Integration Layer

The Integration layer focusses on the integration in terms of the devices connected to the platform, the grids and the other external third-party applications

Device Management:

Manages and controls connected devices (EVs, chargers) ensuring they operate efficiently and securely.

Grid Integration:

Interfaces with the utility grid for demand response and grid stabilization.

Third-Party Integration:

Integrates with external services such as renewable energy sources, storage systems, and market platforms.

Data Management Layer

The data management layer manages the storage, processing and analysis of the data captured

Data Storage:

Centralized storage for historical data, transaction records, and user profiles.

Real-Time Data Processing:

Processes real-time data for immediate actions and decision-making.

- Charging Optimization
- EV Range Prediction

Data Analytics:

Uses machine learning and AI for predictive analytics and optimization.

Security Layer

The security layer manages the authentication & authorization, data encryption and threat detection

Authentication and Authorization:

Ensures secure access control for all users and devices.

Encryption:

Secures data transmission and storage with encryption.

Threat Detection:

Monitors and mitigates potential cyber threats.

Infrastructure Layer

The infrastructure layer looks into the hosting requirements

Cloud Services:

Provides scalable cloud infrastructure for hosting the platform and handling large volumes of data.

Edge Computing:

Processes data closer to the source (e.g., at charging stations) for faster response times and reduced latency.

Load Balancing:

Ensures even distribution of computational tasks to maintain performance and reliability.

The Synergy of V2G and Emerging Technologies

A V2G solution can seamlessly integrate with latest advancements in Utilities such as Advanced Metering Infrastructure (AMI) 2.0 to create a powerful synergy. AMI 2.0 provides the foundation for real-time communication between utilities and consumers, enabling granular data collection and control. By combining V2G with AMI 2.0, utilities can optimize grid operations, enhance energy efficiency, and provide innovative services to customers. The integration of these technologies can lead to a more resilient, sustainable, and customer-centric energy future. Also, AMI 2.0 is poised to enable Distributed Energy Resources (DER), allowing meters to measure the value of DERs and integrate demand-side flexibility into grids. By incorporating V2G technology, utilities can harness the additional storage capacity provided by EVs to capture and utilize more renewable energy.

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Chaitanya is a Senior Consultant with Infosys Consulting with over 11 years of cross functional experience across Energy, Utilities and Manufacturing industries. He has led various roles across Project & Product management in these domains. Mahajan is passionate about leveraging his domain experience in enabling organizations to transform their digital transformation journey.

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He is passionate about Sustainability & Net Zero Goals and supports clients in their drive to adopt sustainability initiatives.

Sarath holds an MBA and is the recipient of Chairman's Gold Medal from IIM Lucknow

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