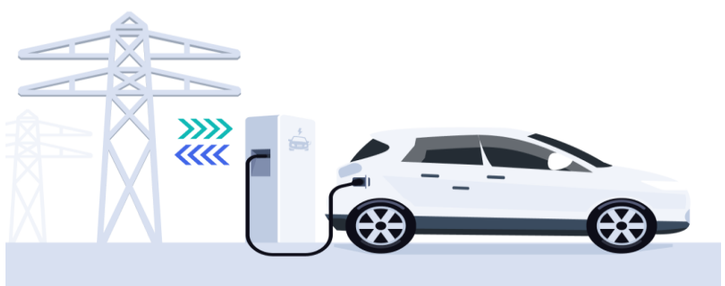
Enabling Vehicle to Grid (V2G) in India

05 November 2025



Anand Singh

India Smart Grid Forum

Introduction to V2G

- **What is V2G**

  The batteries in EVs are charged with electricity from the grid; and these EV batteries can send electricity back to the grid during peak hours to support the grid. This technology is called **Vehicle-to-Grid or V2G.**

- **How it Works**

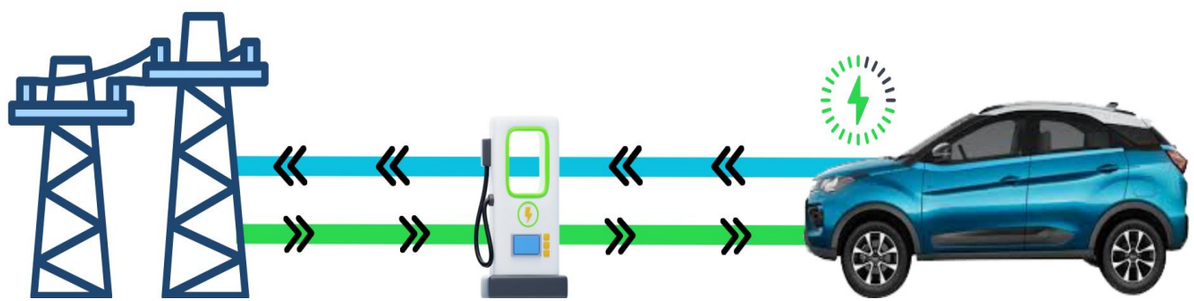
  V2G enables bi-directional charging, allowing EV batteries to both draw power from the grid when there is surplus power on the grid (at reduced tariff) and feed power back into the electric grid during peak hours (at higher tariff) . This provides flexibility and energy storage capabilities to support the grid.

- **Key Benefits**

  V2G can improve grid stability, increase renewable energy integration, reduce power outages, and provide cost savings to both EV owners and grid operators.

- **Technological Advances**

  Ongoing improvements in battery technology, charging infrastructure, and grid integration systems are making V2G more practical and cost-effective.



V2G Pilot Demonstration

- India Smart Grid Forum (ISGF) has undertaken a groundbreaking pilot project to demonstrate Vehicle to Grid (V2G) technology and charging of EVs with green electricity in India.

The key objectives of V2G Technology:

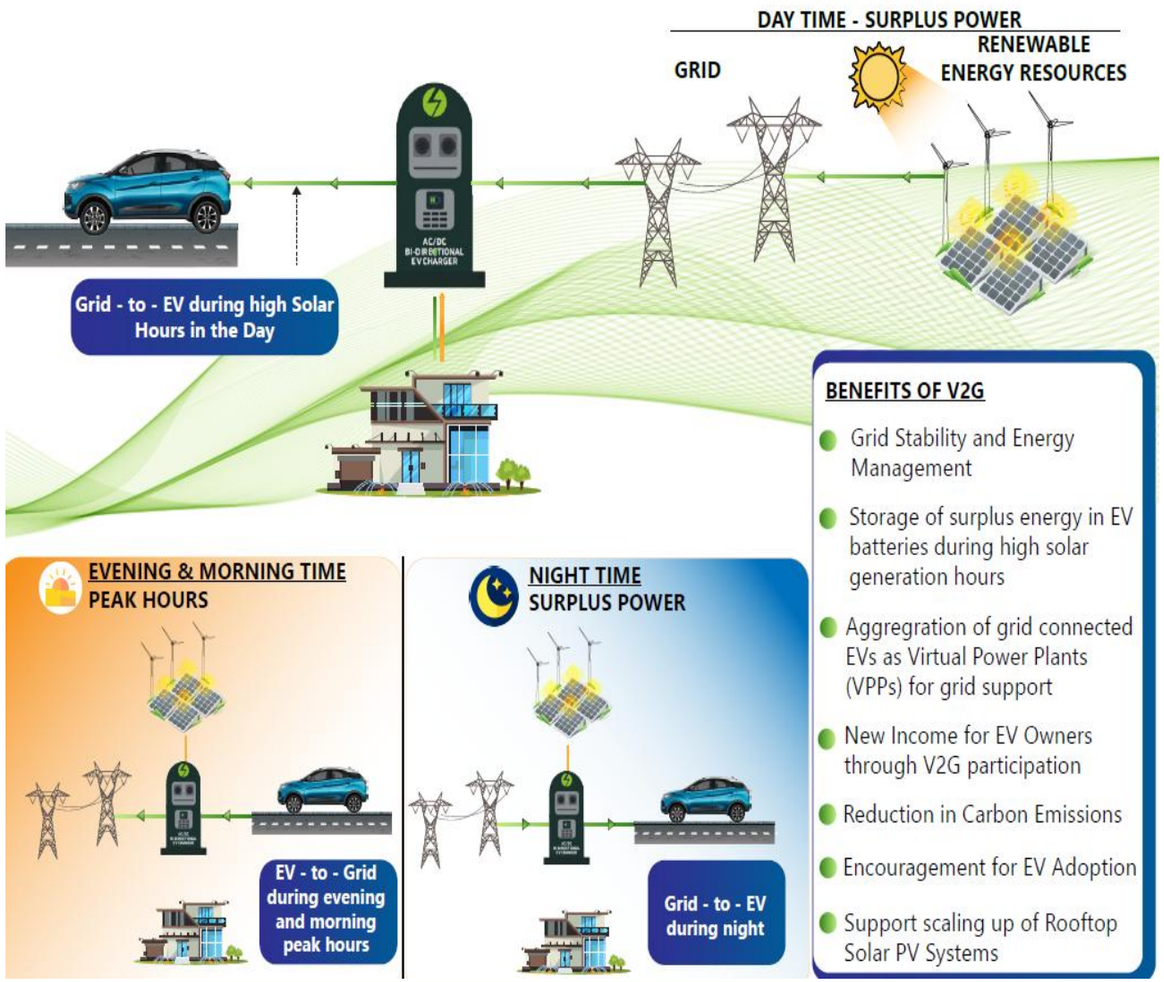
- Promotion of Renewable Energy (RE)
- Grid Balancing
- Reduction in Peak Power Purchase Cost
- Additional Income for the EV Owners
- RE Integration and Virtual Power Plants (VPP)

Scope of Project:

The demonstration project had **2 distinct components:**

Component 1: Demonstration of V2G Technology and Test the Functionalities

Component 2: Charging of EVs with Green Electricity



Component 1: Demonstration of V2G Technology

Technology Partners:

- University of Delaware (UDEL) – Technology Support
- Nuvve Holding Corp – Bi directional Charger
- Watt & Well - BMPU

Project Partners and V2G Demonstration Sites:

- BSES Rajdhani Power Limited (BRPL), Delhi
- BSES Yamuna Power Limited (BYPL), Delhi
- Tata Power Delhi Distribution Limited (TPDDL), Delhi
- Agency for New and Renewable Energy Research and Technology (ANERT), Trivandrum, Kearala

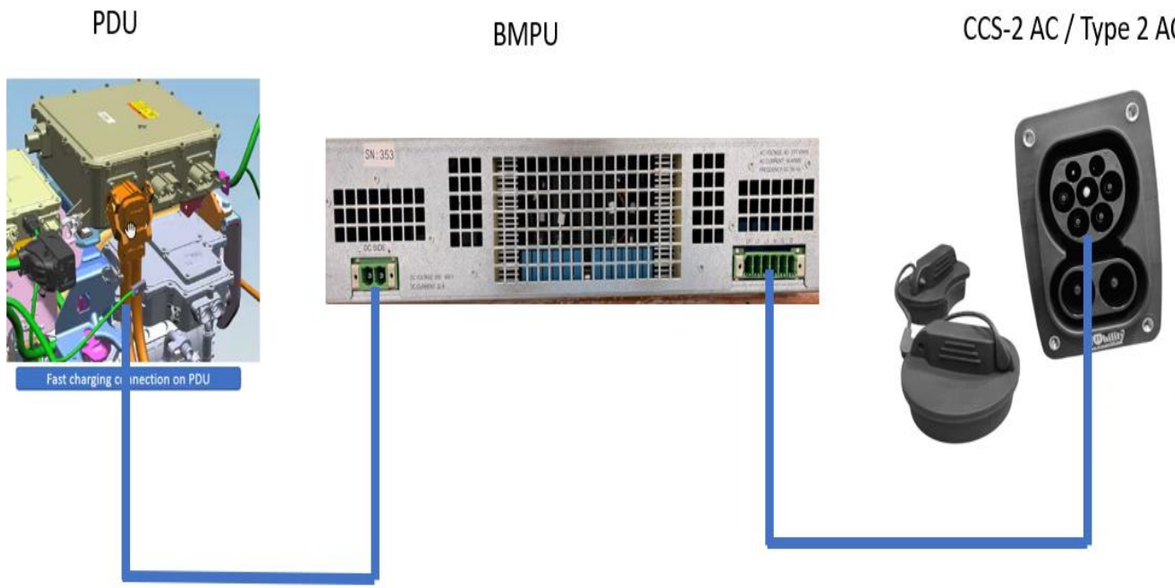
Project Observers:

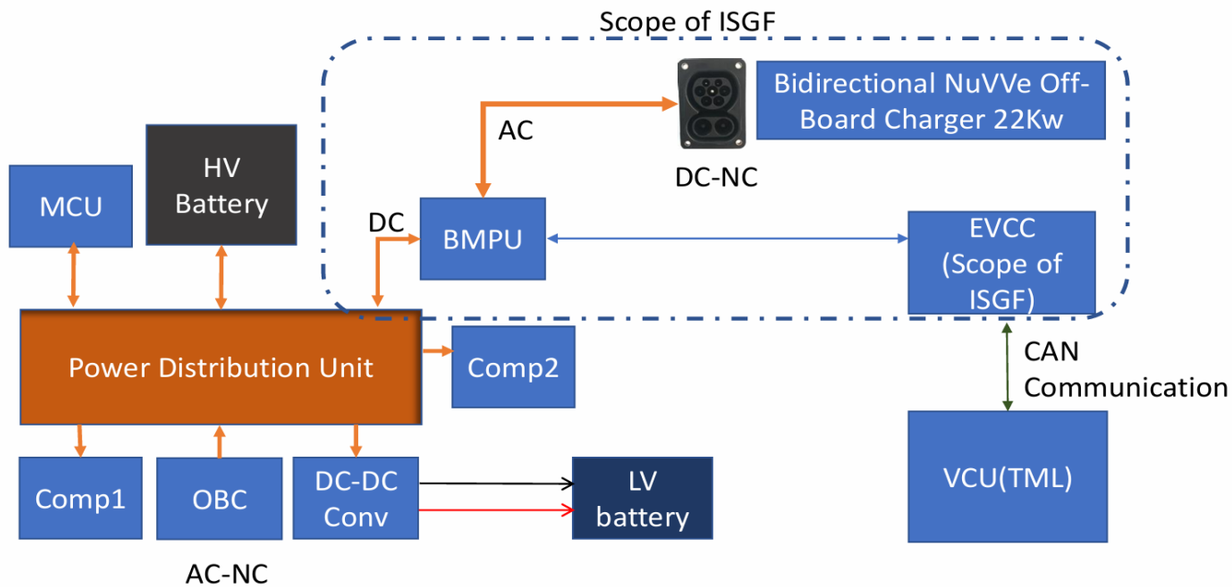
- Central Electricity Authority
- Tata Motors Limited and Tata EV

Project Description:

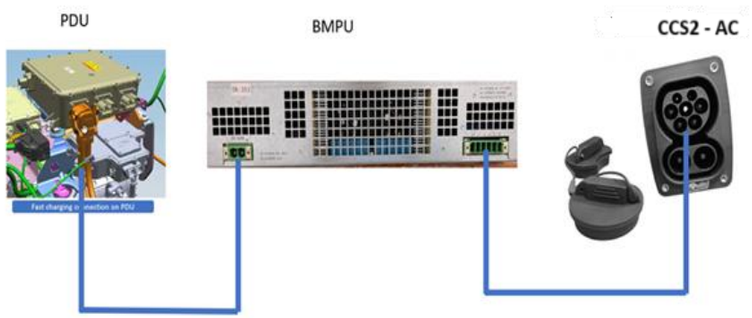
- ISGF with technical support from the University of Delaware (UDEL), USA has executed the first of its kind pilot demonstration of V2G technology in South Asia
- ISGF has retrofitted **4 Tata Nexon EVs with on-board bi-directional power modules**. Most V2G demonstrations in the world have used DC V2G.
- This project tested AC V2G, which should dramatically reduce equipment cost. The **11kW Bidirectional Modular Power Unit (BMPU)** installed in the Tata Nexon were procured from Watt&Well, USA and the **AC bidirectional chargers (19 ~ 52 kW)** were procured from Nuvve Holding Corp, USA.

Retrofitting Architecture

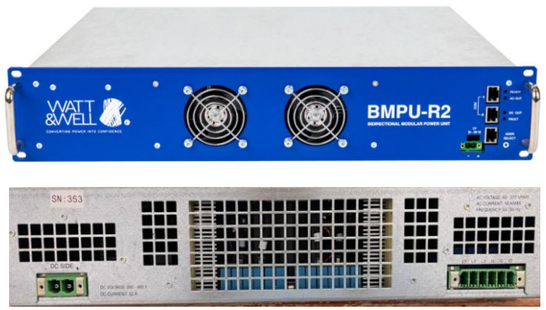




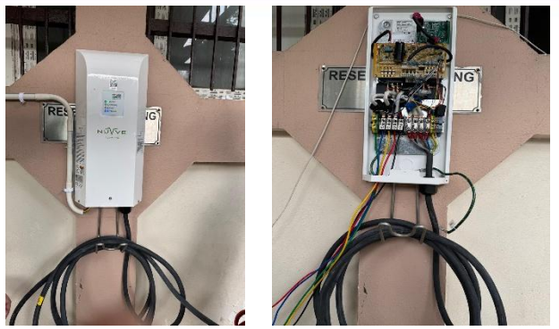
Retrofitting Equipment



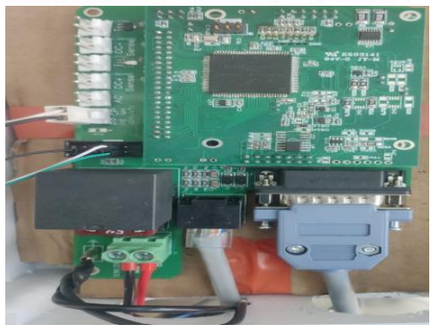
Architecture



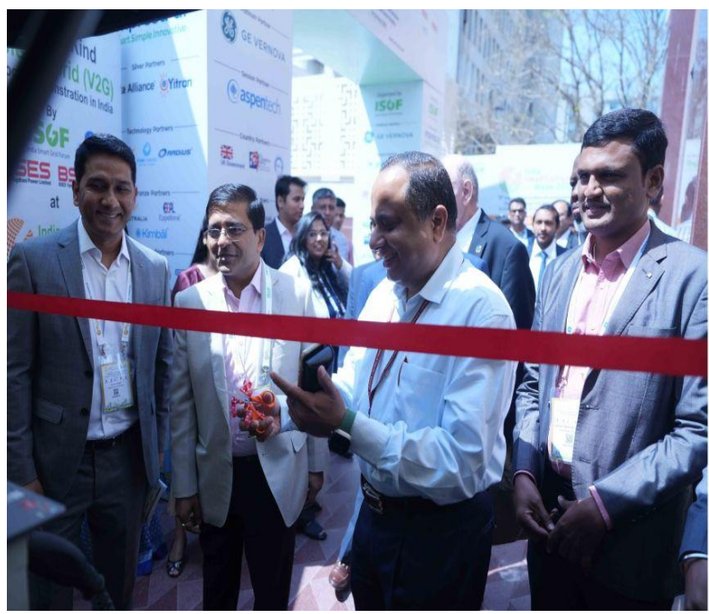
Bidirectional Modular Power Unit (BMPU)



Bidirectional Charger



EV Communication Controller

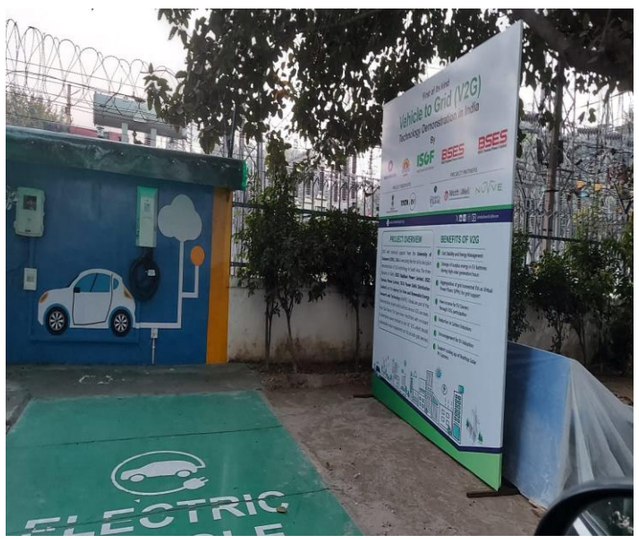


Pilot Projects

The V2G demonstration pilot project was conducted at following sites:

1. BRPL Corporate Office, New Delhi
2. BYPL, BSES Bhawan, Nehru Place, New Delhi
3. Smart Grid Lab, Tata Power Delhi Distribution Limited, Delhi
4. Agency for New and Renewable Energy Research and Technology (ANERT), Trivandrum, Kerala

BRPL



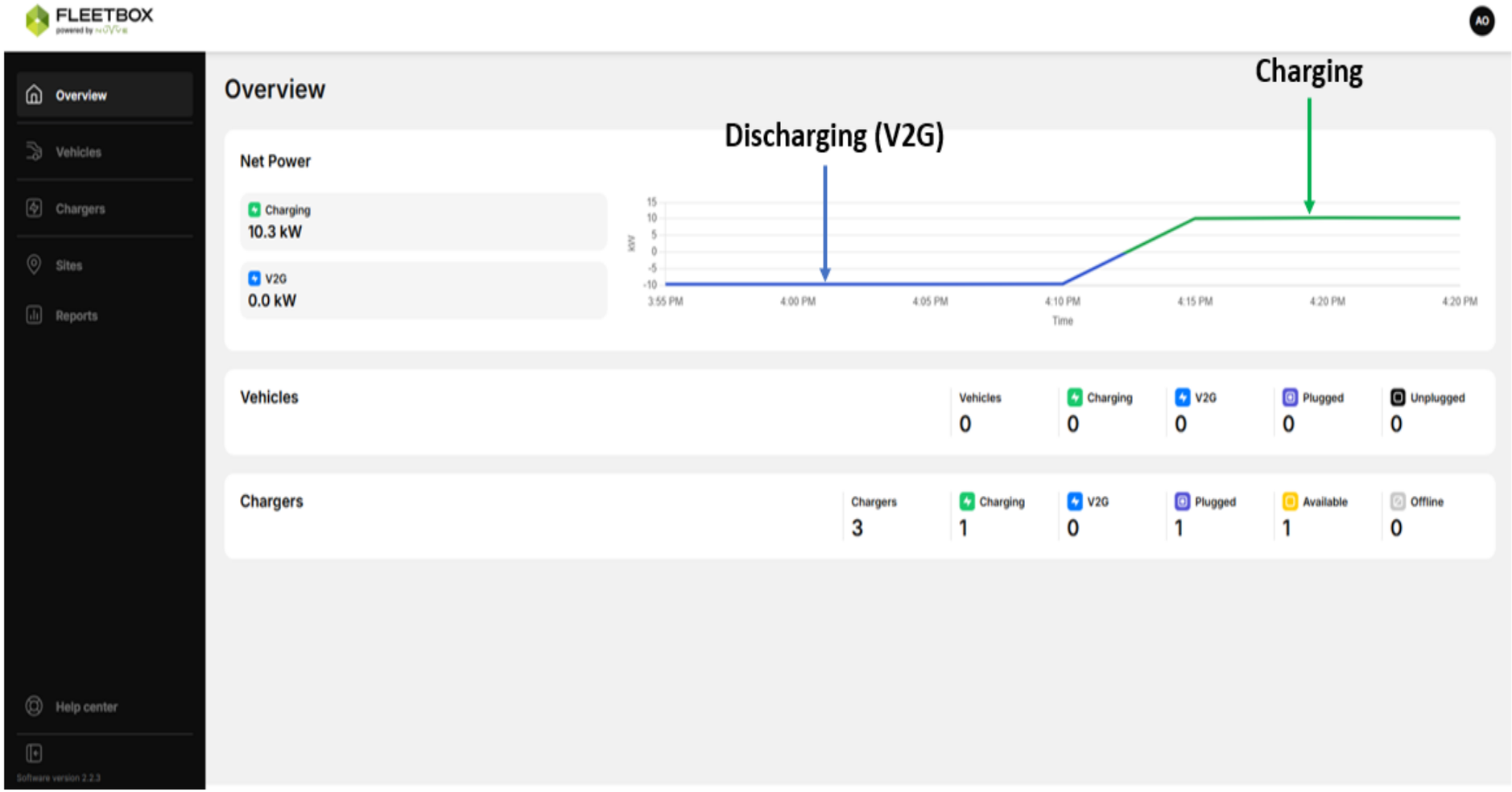
TPDDL

BYPL

ANERT

Fleet Box Platform

Nuvve's Fleet Box Platform is a comprehensive energy management system designed to optimize electric vehicle (EV) fleet operations through intelligent charging, real-time monitoring, and seamless Vehicle-to-Grid (V2G) integration.



Charging and Discharging Pattern of BRPL Vehicle – Sept 2025

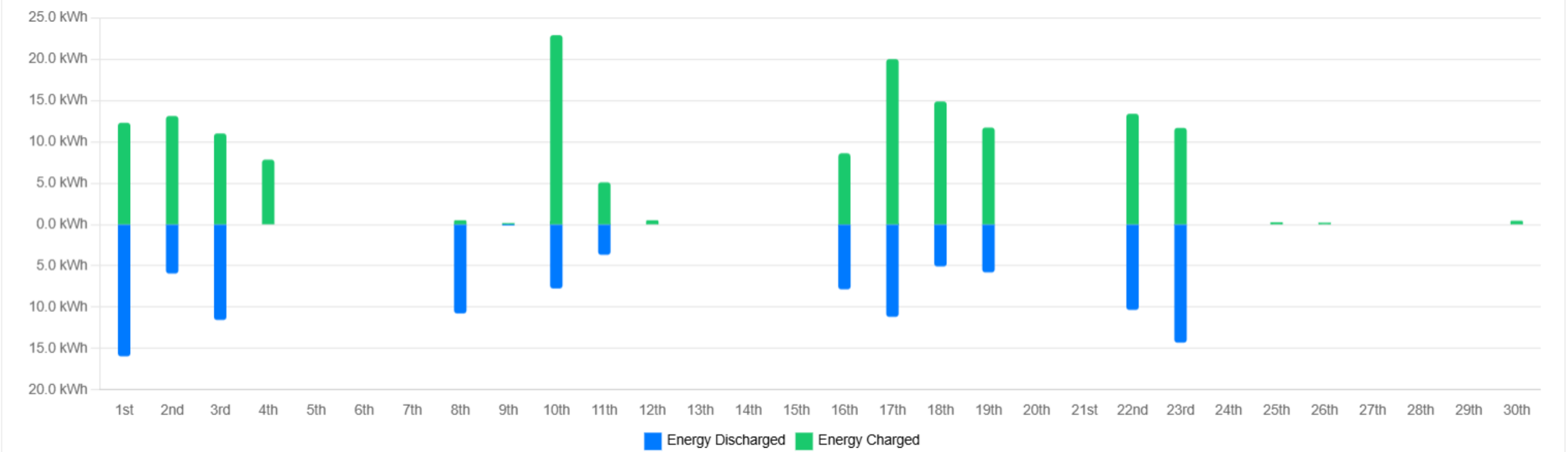
India Smart Grid Forum

BRPL ISGF (E) #01

Nuvve 52.0 kW

Download CSV

Energy Charged	Energy Discharged	Net Energy
153.9 kWh	109.6 kWh	44.3 kWh



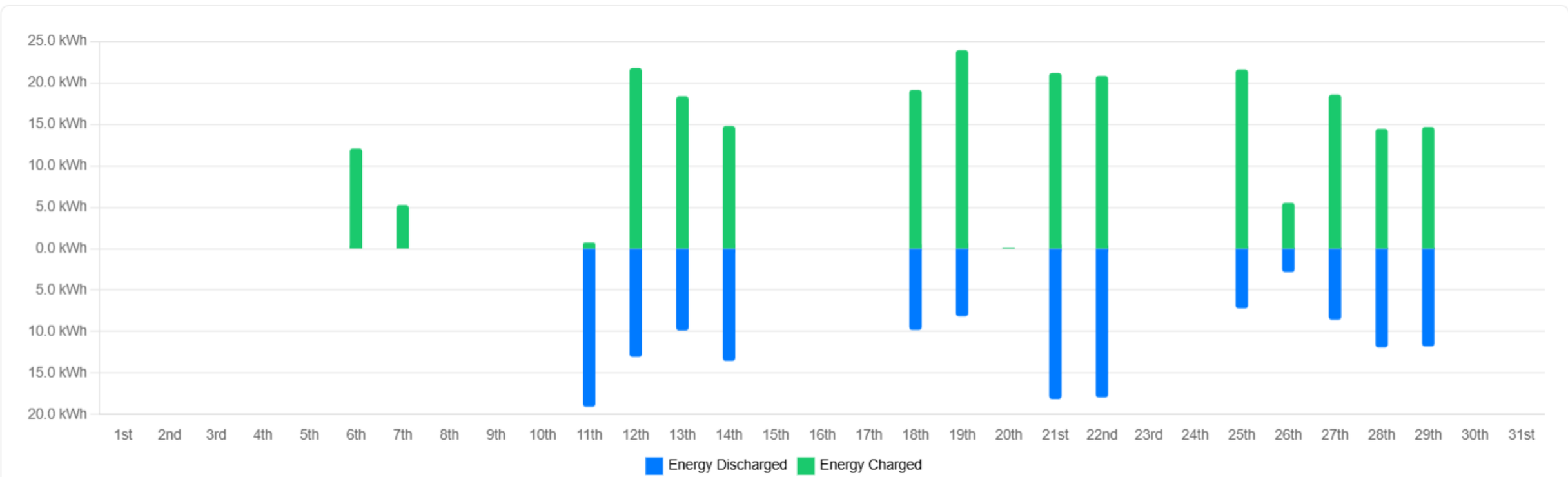
Charging and Discharging Pattern of BRPL Vehicle – Aug 2025

BRPL ISGF (E) #01

Nuvve 52.0 kW

Download CSV

Energy Charged	Energy Discharged	Net Energy
232.6 kWh	151.4 kWh	81.2 kWh



Charging and Discharging Pattern of BRPL Vehicle – July 2025

BRPL ISGF (E) #01

Nuvve 52.0 kW

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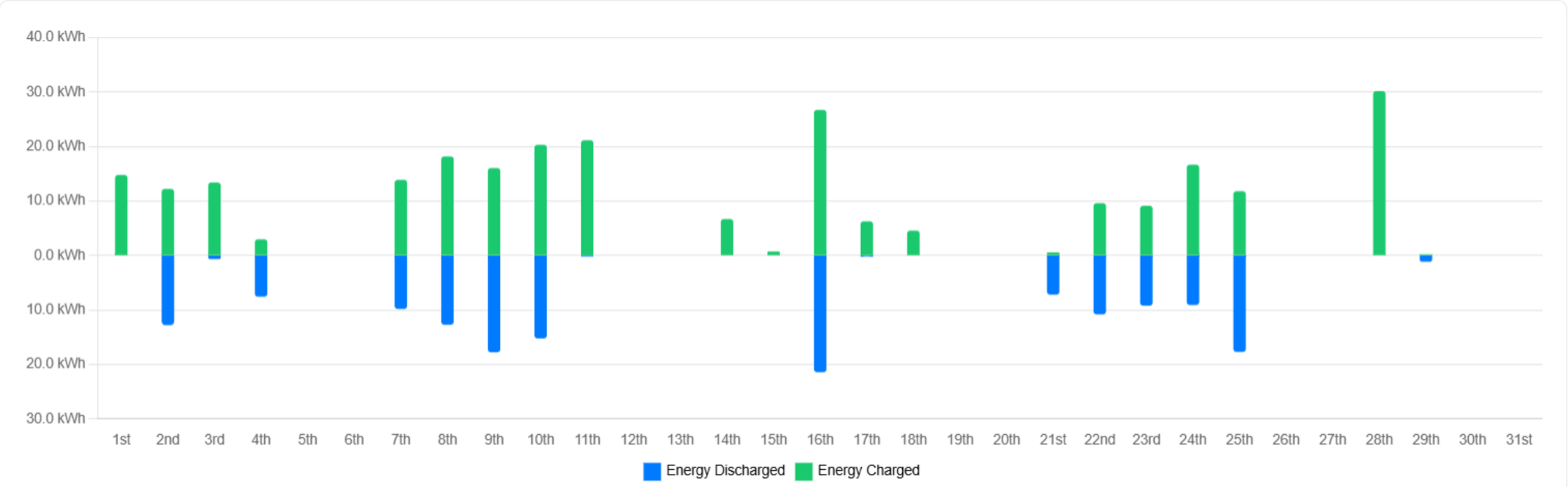
Energy Charged	Energy Discharged	Net Energy
254.2 kWh	152.3 kWh	101.9 kWh



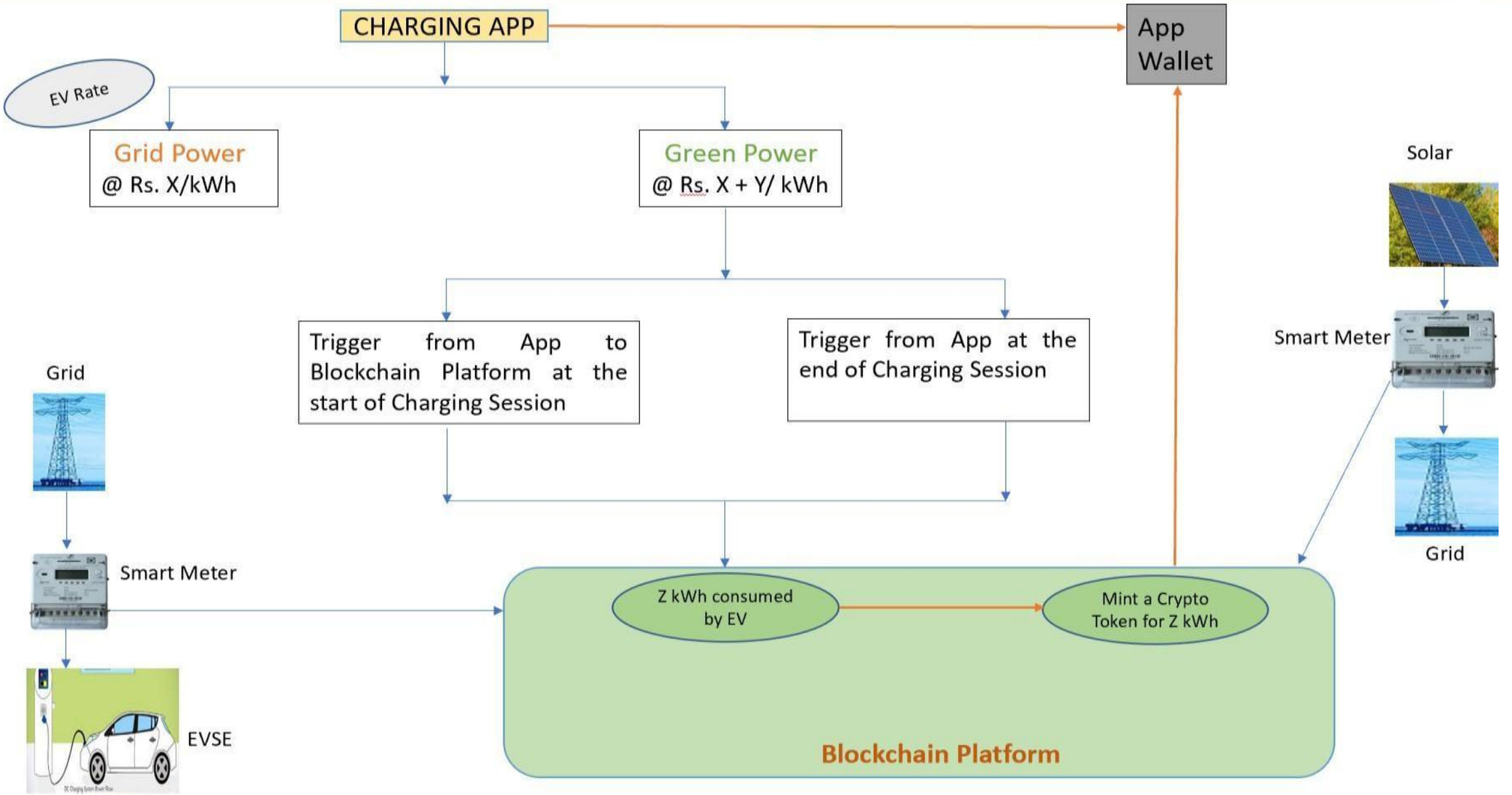
Component 2: Charging of EVs with Green Electricity

- ISGF with technical support from **KrypC Technologies Pvt Ltd, EarthtronEV, Kimbal and ElectreeFi** successfully tested charging of EVs with green electricity in Delhi and issued a Green Energy Certificates on blockchain platform. This demonstration aims to scale up RE adoption and promote clean transportation through EVs powered by RE.

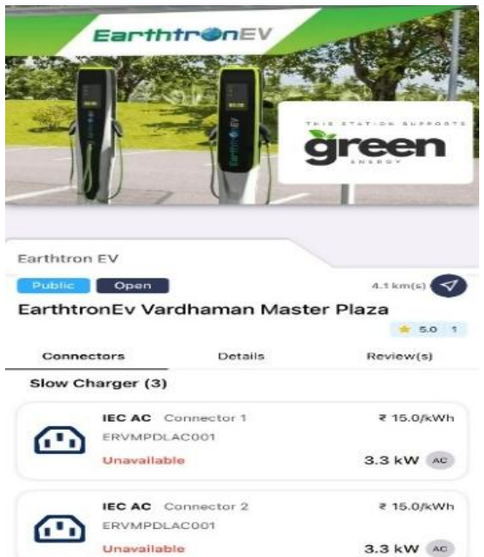
Key Activities:

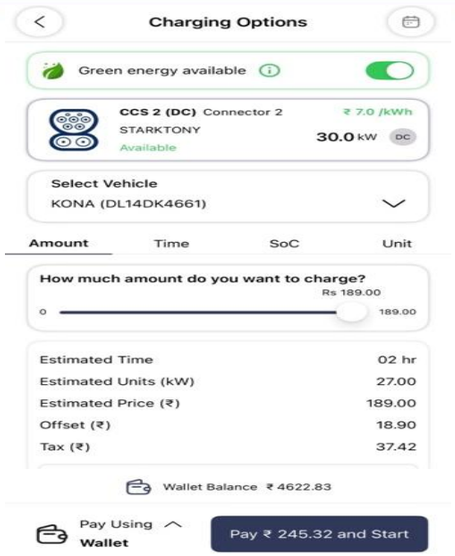
- Collaborated with a CPO and identified a suitable Public Charging Station (PCS)
- Identified a 100 kW rooftop solar plant in a school in West Delhi and connected to BRPL electricity network. Installed smart meter at this solar plant and integrated with blockchain
- Integrated the PCS through ElectreeFi EV charging application with the blockchain platform
- Modified ElectreeFi's EV charging application software to incorporate option to charge EV with green energy
- Enabled green energy certificate minted on KrypC's blockchain platform, when an EV driver opts for green electricity to charge the EV
- Green Certificates issued to the EVs can be aggregated, used against emission reduction targets or traded on carbon markets

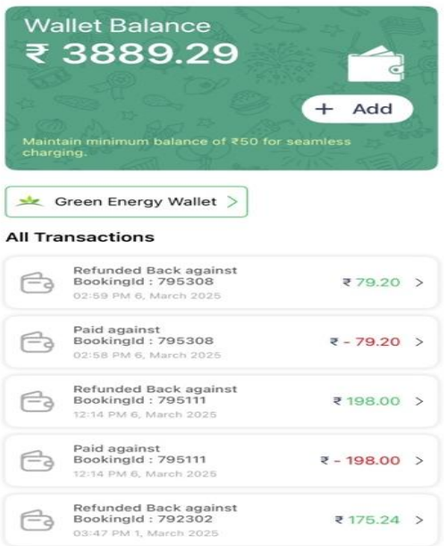
Framework and Solutions for EV Charging with Green Electricity

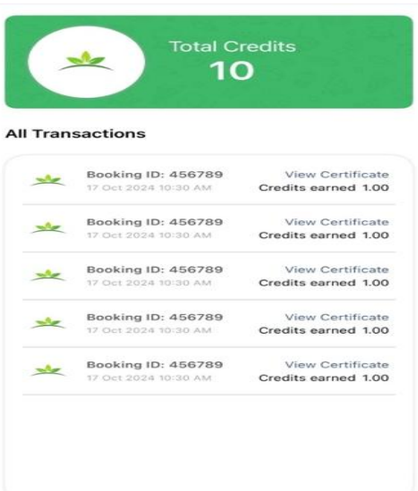


Mobile Application









Green Energy Certificate

Economic Benefits of V2G for Electricity Grid & Consumers

- Flexibility in Power System Operations
- Peak Shaving and Grid Balancing
- Frequency Control (Primary, Secondary and Tertiary Reserve)
- Support RE integration, particularly Rooftop Solar (RTS) – Variations in RTS generation can be smoothened by the EV battery connected to the grid.
- Other Ancillary Services (e.g., Voltage management, Emergency Power during Outages)
- Local Congestion and Capacity Management
- Increasing the Rate of Renewable Energy Self-consumption
- Optimization and Back-up Power and Reducing Grid Infrastructure Investment
- V2G may provide power back to the grid or to specific buildings, such as emergency shelters, hospitals, other critical facilities, or an entire neighborhood during power outages in areas prone due to extreme weather events, such as cyclones, floods etc.
- Potential Revenue Generation from providing grid services like frequency regulation or backup power
- Energy Security - In the event of power outages, V2G-enabled EVs can provide backup power to homes and businesses, enhancing energy security and resilience
- Bring down total cost of ownership of EVs

ISGF submitted the Model V2G Regulations to Forum of Regulators (FOR) in India

- The model regulation cover following:
  - Scope of Regulation
  - Guidelines for V2G Implementation
  - Eligibility for Participation
  - Roles and Responsibilities
  - Technical Standards for V2G Integration
  - Metering Requirement
  - Communication and Interoperability
  - Testing and Certification
  - Forecasting of V2G Availability
  - Scheduling V2G Resources
  - Real-Time Operations
  - Curtailment and Emergency Control
  - System Monitoring and Reporting
  - Tariff Framework for V2G Services
  - Settlement Principles
  - Billing and Payment Mechanism
  - Financial Incentives and Subsidies

Read More: Report on Demonstration of Vehicle to Grid (V2G) Technology in India and Charging of EVs with Green Electricity (*https://indiasmartgrid.org/white-papers-technical-reports*)

Proposed Tariff Framework for V2G Services

- The Commission shall determine or approve tariff mechanisms for V2G services based on one or more of the following:
  - Energy Injection Tariff – compensating EV owners for electricity injected into the grid, which may be linked to Average Power Purchase Cost (APPC), market-linked price, or determined through competitive bidding
  - Ancillary Services Compensation – for services like frequency regulation, spinning reserve, and voltage support, in accordance with guidelines issued by CERC or State Commissions.
  - Time-of-Use (ToU) Incentives – dynamic pricing signals to encourage injection during peak demand and charging at concessional tariff at non-peak hours.

Tariff Design Across World

S. No	Compensation Model	Place	Tariff Benefits
1	Differentiated Tariffs for Bidirectional Charging	Japan, TEPCO's V2G pilot	**$0.20 per kWh** for energy injected into the grid, while EV owners purchase electricity at **$0.10 per kWh during off-peak hours**
2	Time-of-Use (ToU)-Based Payment	UK, Octopus Energy's Powerloop	V2G tariff provides higher payments for energy discharged during peak periods (4-7 PM), incentivizing participation. Allows customers to earn up to **£30 per month** in credits
3	Real Time Pricing and Market Based Signals	Denmark,	EV owners participate in the Nord Pool electricity market, earning payments of up to **€1,500 annually** by responding to real-time price signals.
4	Capacity-Based Compensation (Availability Payments)	California, Pacific Gas and Electric	(PG&E) offers EV owners a ToU rate structure where charging at night (low demand) costs **around $0.13 per kWh**, whereas peak-hour electricity rates can reach **$0.50** per kWh.
5	Synchronization with Renewable Energy Generation	South Australian Power Networks (SAPN) , Australia	In Australia, the "Solar Sponge" tariff introduced by South Australian Power Networks (SAPN) offers super low electricity rates (as low as $0.05/kWh) during midday solar peaks, encouraging EV owners to charge their vehicles when solar generation is at its highest.
	Grid Load Balancing and Stability	Flexpower, Netherlands	In the Netherlands, the "Flexpower" project introduced variable ToU pricing based on grid congestion levels, allowing for a 30% reduction in peak electricity demand due to optimized EV charging.

BRPL Delhi Use Case

- *Urban Peak Shaving: 25,000 V2G EVs can offset ₹146 Cr/year in peak purchase costs while easing transformer loading.*
- *Decentralized Flexibility: Localized discharging at LT level improves grid resilience and supports rooftop-solar optimization.*

Parameter	Assumption	Impact
Peak Demand	1.9 GW	Urban peak stress region
V2G EVs (2030)	25,000	Realistic adoption cluster
Avg Discharge	8 kWh / EV	200 MWh/day to grid
Tariff Differential	₹2 / kWh	₹40 L/day → ₹146 Cr/year savings
Technical Loss Reduction	2 %	+₹10 Cr/year
Total Annual Saving		**≈ ₹156 Cr**
Additional Benefit		Better rooftop-solar utilization, congestion relief

UPPCL Statewide Use Case

- *Affordable Peak Supply: 200,000 V2G EVs can save ₹1,460 Cr/year and defer ₹2,000 Cr in capacity addition.*
- *Clean Mobility-Energy Convergence: 2 million t CO_2 cut annually while creating 10,000 green-tech jobs in the charging ecosystem.*

Parameter	Assumption	Impact
State Peak Load	~28 GW	Summer evening load
V2G EVs	200,000 (20 % of 1 M EVs)	2 GWh/day discharging
Tariff Differential	₹2 / kWh	₹4 Cr/day = ₹1,460 Cr/year
Deferred Capacity	400 MW	₹2,000 Cr capex avoided
Emission Reduction	—	2 Mt CO_2/year
Aggregate Benefit		**≈ ₹3,460 Cr/year + 2 Mt CO_2 saved**

India-Wide Impact

- *Mass Arbitrage Potential: 10 million V2G EVs can save ₹70,000 Cr annually in avoided peak energy purchases.*
- *Nationwide Resilience: 100 GWh/day of mobile storage enables renewable balancing, reducing imports and emissions by 15 Mt CO_2.*

Metric	**Assumption (10 M EVs)**	**Annual Impact**
Energy Discharge	10 kWh / EV / day = 100 GWh / day	—
Tariff Arbitrage	₹2 / kWh	₹200 Cr/day ≈ ₹70,000 Cr/year
Deferred Grid Capex	—	₹20,000 Cr
CO_2 Reduction	15 Mt/year	≈ ₹10,000 Cr social cost saved
Total System Value		**≈ ₹1 Lakh Cr / year**

Way Forward

- Coordinated efforts by policymakers, utilities, EV manufacturers, and technology providers will be needed for commercial rollout of EVs with V2G functionalities.
- Adoption of Standards for V2G by Bureau of Indian Standards (BIS) – ISO 15118 – 20
- The charging and discharging operations integrated with automation systems of the distribution grid - DERMS
- Install bidirectional EVSEs in large buildings, official complexes and residential colonies where EVs will be parked for longer hours
- EV OEMs may explore the capabilities of V2G enabled EVs to manufacture V2G variant EVs
- Policies and Regulations for incentivizing EV owners to participate in V2G programs offered by utilities
- Distribution utilities to build DERMS platforms that can integrate V2G systems
- Domestic OEMs for BMPU and Bi-directional AC Chargers

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