Training Course on Grid Integration of EVs and Vehicle-to-Grid (V2G)

Professional Development Training Course Outline

Category	Engineering	**Duration**	10 Days
Base Fee	$3,000 USD	**Delivery Mode**	Online / On-site Hybrid

Course Introduction

Introduction

This specialized training course provides an in-depth exploration of Grid Integration of Electric Vehicles (EVs) and Vehicle-to-Grid (V2G) technologies, equipping participants with the critical knowledge and practical skills to manage the symbiotic relationship between electric vehicles and the smart grid. The curriculum meticulously covers the principles of EV charging infrastructure, smart charging, demand-side management, and the bidirectional power flow enabled by V2G. Attendees will gain expert-level understanding of how EVs can transition from being mere loads to active Distributed Energy Resources (DERs), providing valuable services such as frequency regulation, voltage support, peak shaving, and renewable energy integration. Training Course on Grid Integration of EVs and Vehicle-to-Grid (V2G) is essential for power system engineers, utility professionals, EV charging solution providers, and energy policymakers shaping the future of resilient and sustainable energy systems.

The program emphasizes practical implementation and addresses trending topics in the evolving energy landscape, including cybersecurity for V2G communications, the role of blockchain in transactive energy markets, advanced forecasting for EV charging/discharging, interoperability standards (e.g., ISO 15118), and the economic and regulatory frameworks supporting V2G deployment. Participants will delve into the complexities of grid impact analysis, local energy management (V2H, V2B), and the optimization of EV fleet participation in energy markets. By the end of this course, attendees will possess the expertise to design, analyze, and implement robust solutions for EV grid integration and V2G, unlocking new revenue streams, enhancing grid reliability, and accelerating the transition to a cleaner, more efficient, and decentralized energy future. This training is indispensable for professionals leading the energy transformation.

Programme Curriculum

Training Course on Grid Integration of EVs and Vehicle-to-Grid (V2G)

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Course Objectives

1. Understand the fundamental concepts of EV grid integration and the evolving role of EVs.
2. Differentiate between uncontrolled, controlled, and smart charging strategies for EVs.
3. Comprehend the principles of Vehicle-to-Grid (V2G) and its various applications.
4. Analyze the impact of EV charging and V2G on grid infrastructure (distribution, transmission).
5. Master communication protocols (OCPP, ISO 15118) for smart charging and V2G.
6. Design and implement load management and demand response programs involving EVs.
7. Evaluate the potential of V2G for providing ancillary services (frequency regulation, voltage support).
8. Integrate renewable energy sources with EV charging and V2G for enhanced sustainability.
9. Assess economic and business models for V2G participation and revenue generation.
10. Address cybersecurity challenges and mitigation strategies for V2G systems.
11. Understand regulatory frameworks and policy incentives supporting EV grid integration and V2G.
12. Explore advanced forecasting techniques for EV charging/discharging patterns.
13. Implement optimization algorithms for coordinated charging/discharging of EV fleets.

Organizational Benefits

1. Optimized management of EV charging infrastructure, reducing grid strain and costs.

2. Enhanced grid stability and reliability by leveraging EVs as flexible grid assets.
3. New revenue streams from V2G participation in energy markets and ancillary services.
4. Improved integration of renewable energy sources by using EVs for energy storage.
5. Accelerated development of smart grid initiatives and distributed energy resources.
6. Reduced infrastructure upgrade costs by optimizing EV charging loads.
7. Competitive advantage in the rapidly evolving clean energy and transportation sectors.
8. Compliance with future regulations promoting V2G and smart grid functionalities.
9. Strengthened cybersecurity posture for grid-connected EV assets.
10. Contribution to corporate sustainability goals through intelligent energy management.

Target Participants

- Power System Engineers (Utilities, ISOs, RTOs)
- Smart Grid Developers and Researchers
- EV Charging Solution Providers
- Automotive Engineers (EV Powertrain, Connectivity)
- Energy Management System (EMS) Developers
- Fleet Managers with EV fleets
- Urban Planners and Policymakers
- Renewable Energy Developers
- Data Scientists in the Energy Sector

Course Outline

Module 1: Introduction to Electric Vehicles and Grid Impact

- **EV Market Trends and Adoption:** Global outlook, regional differences.
- **EV Powertrain Overview:** Key components and energy flow.
- **Basic Charging Concepts:** AC vs. DC charging, power levels.
- **Initial Grid Impact of EVs:** Increased load, peak demand challenges.
- **Case Study:** Analyzing the projected load increase on a local distribution feeder due to growing EV adoption.

Module 2: EV Charging Infrastructure and Technologies

- **Charging Levels (AC L1/L2, DCFC):** Characteristics, use cases, power capabilities.
- **Charging Connectors:** CCS, NACS, CHAdeMO, GB/T, interoperability.
- **Charging Station Components:** EVSE, power electronics, communication modules.
- **Installation Considerations:** Residential, commercial, public charging.
- **Case Study:** Comparing the technical specifications and deployment scenarios for different types of public EV charging stations.

Module 3: Smart Charging and Managed Charging

- **Uncontrolled Charging:** "Plug-and-charge" behavior, peak load exacerbation.
- **Controlled Charging:** Time-of-Use (TOU) tariffs, simple scheduling.
- **Smart Charging Strategies:** Dynamic pricing, grid signals, demand response.
- **Load Management Techniques:** Peak shaving, valley filling, rotation.

- **Case Study:** Designing a smart charging program for a university campus EV fleet to minimize peak demand charges.

Module 4: Fundamentals of Vehicle-to-Grid (V2G)

- **V2G Concept:** Bidirectional power flow, EV as a Distributed Energy Resource (DER).
- **V2G Hardware:** Bidirectional inverters, smart meters, communication units.
- **Key Services Offered by V2G:** Ancillary services, energy arbitrage, backup power.
- **V2G vs. V2H/V2L:** Differentiating applications (Home, Load).
- **Case Study:** Illustrating the power flow and communication signals in a V2G enabled home charging setup.

Module 5: Grid Services from V2G

- **Frequency Regulation:** Providing primary and secondary reserves.
- **Voltage Support:** Reactive power injection/absorption.
- **Peak Shaving and Valley Filling:** Managing demand and supply.
- **Black Start Capability:** Potential for grid restoration.
- **Case Study:** Quantifying the potential revenue generation for an EV fleet participating in a grid frequency regulation market.

Module 6: Communication Protocols for Smart Charging and V2G

- **OCPP (Open Charge Point Protocol):** Control and management of EVSE.
- **ISO 15118 (Plug & Charge, V2G):** Secure vehicle-to-grid communication, automated payment.
- **OpenADR:** Demand response communication with grid operators.
- **Other Protocols:** Modbus, IEC 61850 for smart grid integration.
- **Case Study:** Tracing the communication flow during a V2G energy transaction, highlighting roles of ISO 15118 and OCPP.

Module 7: Grid Impact Analysis and Mitigation Strategies

- **Distribution Grid Impact:** Voltage drop, transformer overloading, line congestion.
- **Transmission Grid Impact:** Increased generation requirements, stability concerns.
- **Power Quality Issues:** Harmonics, flicker from power electronics.
- **Mitigation Measures:** Grid upgrades, smart charging, V2G, distributed energy storage.
- **Case Study:** Performing a basic load flow analysis to assess the impact of unmanaged EV charging on a residential feeder.

Module 8: Renewable Energy Integration with EVs and V2G

- **EVs as Flexible Storage for Renewables:** Buffering intermittent generation.
- **Time-Shifting Renewable Energy:** Charging during high generation, discharging during low.
- **Local PV and EV Charging Optimization:** Maximizing self-consumption.
- **Microgrids with EV Fleets:** Enhancing resilience and energy independence.
- **Case Study:** Designing a microgrid system for a commercial building integrating rooftop solar, battery storage, and V2G-enabled EVs.

Module 9: Economic and Business Models for V2G

- **Value Streams for V2G:** Ancillary services, wholesale energy markets, capacity markets.
- **Stakeholders:** EV owners, CPOs, DSOs, TSOs, aggregators.
- **Revenue Sharing Models:** Incentivizing EV owners to participate.

- **Total Cost of Ownership (TCO) for V2G-enabled EVs:** Economic benefits.
- **Case Study:** Developing a business case for an aggregator to manage a fleet of V2G vehicles for grid services.

Module 10: Policy, Regulations, and Standards

- **Government Incentives:** Tax credits, grants for EVs and V2G.
- **Regulatory Frameworks:** Grid codes, market rules for DERs.
- **International Standards:** IEC, ISO, SAE for EV charging and V2G.
- **Interoperability and Certification:** Ensuring seamless operation across products.
- **Case Study:** Analyzing recent policy changes in a specific country designed to accelerate V2G adoption.

Module 11: Cybersecurity for Grid-Integrated EVs and V2G

- **Threat Vectors:** Communication hijacking, data manipulation, unauthorized control.
- **Secure Communication Protocols:** Authentication, encryption, integrity.
- **Physical Security of Chargers:** Preventing tampering.
- **Cybersecurity Standards for Smart Grids:** NIST, IEC 62351.
- **Case Study:** Identifying potential cybersecurity vulnerabilities in an ISO 15118 V2G communication flow.

Module 12: Forecasting EV Charging/Discharging Patterns

- **Data Sources:** Smart meter data, telematics, traffic patterns, weather.
- **Time-Series Forecasting Models:** ARIMA, Prophet, LSTMs for EV load.
- **Probabilistic Forecasting:** Quantifying uncertainty in EV behavior.
- **Impact of User Behavior and Incentives:** Modeling response to DR signals.
- **Case Study:** Building a machine learning model to predict the daily charging and discharging patterns of a residential EV.

Module 13: Optimization of EV Fleet Charging/Discharging

- **Objective Functions:** Cost minimization, revenue maximization, grid impact reduction.
- **Optimization Algorithms:** Linear programming, mixed-integer programming, Reinforcement Learning.
- **Constraints:** Battery SoC limits, grid capacity, user preferences.
- **Centralized vs. Decentralized Optimization:** Scalability.
- **Case Study:** Using an optimization algorithm to schedule charging and V2G events for a corporate EV fleet to minimize electricity bills.

Module 14: Pilot Projects and Real-World Deployments

- **Lessons Learned from V2G Pilot Projects:** Technical, economic, regulatory challenges.
- **Case Studies of Successful Deployments:** Examples from Denmark, Japan, USA.
- **Scalability Challenges:** Moving from pilot to widespread adoption.
- **Upcoming Scheduled Sessions**

Start Date	End Date	Location	Price
23 Nov 2026	04 Dec 2026	Online	$2,000

Start Date	End Date	Location	Price
23 Nov 2026	04 Dec 2026	Physical	$3,000
23 Nov 2026	04 Dec 2026	Physical	$6,000
23 Nov 2026	04 Dec 2026	Physical	$6,000
23 Nov 2026	04 Dec 2026	Physical	$12,000
23 Nov 2026	04 Dec 2026	Physical	$9,000
23 Nov 2026	04 Dec 2026	Physical	$12,000
23 Nov 2026	04 Dec 2026	Physical	$12,000

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