Technical Assistance Consultant's Report

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Impact Evaluation Report of a Solar Carport with Battery Energy Storage System (BESS) and Electric Vehicle (EV) Chargers.

Prepared by EY LLP

For ADB

Asian Development Bank


STATUE OF UNITY

TABLE OF CONTENTS

Executive Summary 5

Background 6

Pilot Demonstration- Solar Carport with Battery Energy Storage System (BESS) and Electric Vehicle (EV) Chargers 10

Technical Specifications of the Solar Carport 16

Performance of the Solar Carport 22

Electric Vehicle Charging Summary 23

Framework for Scaling-Up and Replication 27

List of Abbreviations

- **ADB:** Asian Development Bank
- **AT&C Losses:** Aggregate Technical and Commercial Losses
- **BESS:** Battery Energy Storage System
- **CapEx:** Capital Expenditure
- **CESL:** Convergence Energy Services Limited
- **C&I:** Commercial and Industrial
- **CO2:** Carbon Dioxide
- **DISCOM:** Distribution Company
- **EA:** Executing Agency
- **EESL:** Energy Efficiency Services Limited
- **EMS:** Energy Management System
- **EPC:** Engineering, Procurement, and Construction
- **ESG:** Environmental, Social, and Governance
- **EV:** Electric Vehicle
- **EVCI:** Electric Vehicle Charging Infrastructure
- **EWCD:** Elderly, Women, Children, and Disabled
- **FAME:** Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles
- **GEF:** Global Environment Facility
- **GHG:** Greenhouse Gas
- **GW:** Gigawatt
- **HDGI:** Hot-Dip Galvanized Iron
- **ICE:** Internal Combustion Engine
- **kWh:** Kilowatt-hour
- **kWp:** Kilowatt-peak
- **LFP / LiFePO4:** Lithium Iron Phosphate
- **MoU:** Memorandum of Understanding
- **NDC:** Nationally Determined Contribution
- **O&M:** Operation and Maintenance
- **PCU:** Power Conditioning Unit
- **PMO:** Prime Minister's Office
- **PV:** Photovoltaic
- **SOC:** State of Charge
- **SoU:** Statue of Unity
- **SOUADTGA:** Statue of Unity Area Development & Tourism Governance Authority
- **TA:** Technical Assistance
- **T&D:** Transmission and Distribution

Executive Summary

This report presents the impact evaluation of a pilot project: an **off-grid solar carport** integrated with a **Battery Energy Storage System (BESS)** and **Electric Vehicle (EV) chargers** at the Statue of Unity (SoU) in Kevadia, Gujarat. The project, supported by the Asian Development Bank (ADB) and the Global Environment Facility (GEF), was implemented by Convergence Energy Services Limited (CESL) to demonstrate a sustainable model for EV charging that alleviates pressure on the grid and reduces carbon emissions.

The pilot addresses India's core energy challenges—balancing growing demand with sustainability and grid stability—by showcasing a decentralized solution. The 52.3 kWp solar carport, equipped with a 307 kWh BESS and EV chargers, successfully operates independently of the grid. Its smart energy management system prioritizes solar power for direct EV charging, stores excess energy in the BESS, and uses stored power during non-sunny hours, ensuring a reliable and 100% green energy supply for mobility and running the overall system.

Key performance data from October 2024 to 31ST December 2025 showcases the project's technical viability:

- The system generated **~30,000 kWh** of clean electricity as on 31st December 2025.
- Around **14,000 kWh** of this energy was utilized for charging of EVs at SoU
- **16,000 kWh** of the energy was utilized for running of the overall system including auxiliary load.
- This has resulted in an estimated reduction of **~19 tons of CO2 emissions** by displacing grid power over a period of 1 year from the date of commencement.

The project also incorporated inclusive design features for Elderly, Women, Children, and Disabled (EWCD) users and serves as a high-visibility demonstration site to build stakeholder confidence.

The report concludes that the off-grid solar carport is a replicable and scalable solution. It outlines a framework for scaling up across various scenarios, including remote locations, highways, commercial complexes, and weak-grid areas. The success of this pilot provides a valuable proof-of-concept, demonstrating that integrated solar-plus-storage carports can play a critical role in India's transition to e-mobility, enhance energy security, create green jobs, and contribute significantly to the nation's climate goals.

Background

1.0: The Indian Energy Imperative and the Emergence of Distributed Solar Solutions

India is at a pivotal juncture in its economic and developmental trajectory. As one of the world's fastest-growing major economies, the country's energy demand is surging, driven by rapid urbanization, industrial expansion, and rising standards of living. The central challenge lies in meeting this escalating demand in a manner that is sustainable, secure, and equitable, while simultaneously honouring India's ambitious international commitments to combat climate change. This complex energy trilemma—balancing security, affordability, and environmental sustainability—has catalysed a fundamental transformation of the power sector.

Within this transformation, solar energy has emerged as a cornerstone of India's energy strategy, supported by its vast resource potential and rapidly declining costs. While the traditional model of large-scale, grid-connected solar parks plays a critical role, it addresses only part of the challenge. Increasingly, there is a need to complement centralized generation with decentralized and distributed solutions. Such models can reduce pressure on the national grid, minimize transmission and distribution (T&D) losses, and supply electricity directly at the point of consumption.

One promising innovation in this space is the **off-grid solar carport**. By integrating solar photovoltaic (PV) panels with parking infrastructure, solar carports not only generate clean electricity but also offer practical co-benefits: shading vehicles and serving as convenient nodes for electric vehicle (EV) charging. This dual functionality makes them uniquely relevant for India's transition toward e-mobility while enhancing localized renewable generation.

This report situates the technology within the broader national context—highlighting India's policy drivers for renewable energy adoption, the Asian Development Bank's (ADB) strategic intervention under the Global Environment Facility (GEF)-7 program, and the pressing need to pilot and assess off-grid solar carports at iconic and high-footfall locations such as the Statue of Unity in Gujarat.

2.0 The Existing Energy Scenario in India: A Landscape of Growth and Challenge

India's energy sector is one of the most complex and dynamic in the world. The country is the **third-largest global energy consumer**, yet **its per capita electricity consumption remains significantly below the global average**, indicating substantial latent demand. The installed electricity generation capacity has seen remarkable growth, exceeding **430 Gigawatts (GW) as of early 2024**. However, this expansion coexists with deep-rooted structural challenges that call for a diversified and innovative approach to energy supply.

2.1 Continued Reliance on Fossil Fuels: Despite rapid progress in renewable energy deployment, **coal remains the backbone of India's power system**, constituting nearly **50% of installed capacity** and more than **70% of total generation**. This dependence has critical implications:

- **Environmental**: Coal-fired power is a leading source of GHG emissions and local air pollution.
- **Economic**: Heavy reliance on both domestic and imported coal exposes the country to volatile global prices and supply disruptions.

- **Transition challenge**: While renewables are scaling up, replacing coal at the speed required to meet India's climate goals remains a formidable task.

2.2 Grid Constraints and T&D Losses: India's power grid has undergone major improvements, particularly through the **"One Nation, One Grid"** initiative, which has enhanced integration and system reliability. Yet significant issues persist:

- **Congestion and stability risks** limit the seamless flow of renewable energy across regions.
- **Aggregate Technical and Commercial (AT&C) losses**, though gradually declining, remain high—often **exceeding 15–20%** in several states.
- These inefficiencies represent a **substantial financial burden** on distribution companies (DISCOMs) and hinder consistent power supply to end consumers.

2.3 Emerging Demand from Transport and E-Mobility: India's commitment to electric mobility is expected to **reshape electricity demand patterns**:

- Growing adoption of **electric vehicles (EVs)** will significantly increase localized demand, especially in urban clusters.
- This creates a **two-fold challenge**: ensuring reliable charging infrastructure while meeting demand sustainably without deepening dependence on fossil-based generation.
- Innovative solutions such as **solar carports and decentralized renewable-powered charging stations** can play a crucial role in bridging this gap

3.0 The Renewable Energy Revolution: National Policies and Targets

Recognizing the challenges of a fossil fuel–dependent energy system, the Government of India has embarked on an **ambitious journey to green its energy mix**. Climate change is being framed not only as a challenge but also as an opportunity to build a **self-reliant ("Aatmanirbhar Bharat") and modern economy**, with renewable energy at its core.

3.1 The National Renewable Energy Mission: At the heart of India's energy transition is the target of achieving **500 GW of installed non-fossil capacity by 2030**, including **280 GW of solar power**. To operationalize this vision, the government has introduced a suite of flagship programs:

- **Solar Park Scheme**: Facilitating utility-scale solar deployment through dedicated zones with ready infrastructure.
- **PM-KUSUM (Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan)**: Enabling farmers to install solar pumps and decentralized solar plants, ensuring both clean energy and rural income security.
- **Rooftop Solar Initiatives**: Promoting consumer participation by incentivizing solar adoption in residential, commercial, and institutional sectors.

3.2 The Role of Distributed Generation: Policy emphasis is steadily shifting toward **distributed and decentralized renewable energy systems**. Rooftop solar and communitybased models are designed to empower consumers as **"prosumers"**—both producers and consumers of energy. The benefits are multifold:

- Reduction in **T&D losses** by generating electricity closer to demand centers.
- **Deferred grid investment** by reducing the need for large-scale transmission upgrades.
- Enhanced **energy security and resilience** at the local level.

The **off-grid solar carport** concept exemplifies this distributed generation philosophy. By embedding solar PV into parking infrastructure, it combines practical utility with localized clean energy generation, while simultaneously supporting the EV ecosystem.

3.3 The Electric Vehicle Push: Alongside renewable energy expansion, India is pursuing an **aggressive electric mobility transition**, initially through the **Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles (FAME) scheme** and now through the **PM e-Drive scheme**, complemented by a growing suite of **state-level EV policies**. While this transition is central to decarbonizing the transport sector, it also introduces a new dynamic into the energy landscape:

- **Substantial grid load** from simultaneous EV charging, particularly where high-capacity fast chargers are deployed in urban clusters.
- **Stress on local distribution infrastructure**, as many transformers and feeder lines are not designed to handle concentrated, high-power charging demand.

To mitigate these challenges, it is imperative to **integrate EV charging infrastructure with localized renewable generation**. Solar-powered solutions—such as **off-grid solar carports**—offer a practical and scalable approach. By generating clean electricity directly at the point of demand, they:

- Reduce stress on the grid,
- Enhance resilience of the distribution system, and
- Seamlessly align India's renewable energy expansion with its transport electrification goals.

Together, these innovations can ensure that the EV revolution evolves in a **sustainable, affordable, and grid-friendly** manner.

4.0 The Niche for Off-Grid Solar Carports: Addressing Multiple Challenges Simultaneously

An **off-grid solar carport** is a dual-purpose infrastructure that combines **vehicle shelter** with **rooftop solar photovoltaic (PV) panels**, supported by **battery energy storage systems (BESS)** to function independently of the grid. It represents the convergence of **clean energy generation, storage, smart infrastructure, and EV enablement**. In the Indian context, its relevance is particularly strong, offering solutions to multiple pressing challenges simultaneously:

4.1 Optimal Land Use: In urban and semi-urban areas where land is scarce and expensive, carports make efficient use of already dedicated parking spaces for renewable energy generation. This approach avoids the land acquisition hurdles associated with large-scale solar parks and promotes compact, high-value infrastructure deployment.

4.2 Generation and Consumption Co-location: By producing electricity directly at the point of consumption—whether for office complexes, shopping malls, residential societies, or tourist destinations—off-grid solar carports eliminate T&D losses. The generated power can support parking facility operations, adjacent buildings, and, most importantly, EV charging.

4.3 Energy Security and Grid Independence: For critical facilities such as hospitals, data centers, and strategic institutions, as well as for remote or grid-weak regions, solar carports paired with adequate storage offer reliable, resilient power supply. This reduces dependence on polluting diesel generators, enhances operational continuity, and strengthens energy security.

4.4 Enabling EV Infrastructure: Carports provide a ready-made platform for EV charging stations. By supplying renewable electricity directly to EVs, they ensure the transport loop is truly low-carbon—overcoming the critique that EVs are only as clean as the grid mix. This synergy makes solar carports a strategic enabler of India's e-mobility goals.

4.5 Additional Benefits: Beyond energy, solar carports deliver co-benefits:

- **Vehicle protection** from sun and rain, reducing wear and lowering cooling loads.
- **Brand and sustainability value**, signalling an organization's commitment to climate-friendly practices.
- **Revenue opportunities** in commercial settings, through EV charging services or surplus energy utilization.

4.6 Scalability and Replicability: Solar carports are inherently modular and scalable, making them adaptable to diverse contexts—from high-footfall tourist attractions (such as the Statue of Unity) to commercial complexes, industrial parks, educational campuses, transport hubs, and residential societies. Successful pilots can provide valuable lessons for large-scale replication across India, positioning solar carports as a mainstream component of the distributed renewable energy and EV charging ecosystem**.**

While the potential of off-grid solar carports is evident—addressing land efficiency, energy security, EV enablement, and sustainability—**their adoption in India remains limited**. High upfront costs, lack of proven business models, policy and regulatory uncertainties, and limited awareness among stakeholders continue to act as barriers. Given these challenges, it becomes essential to undertake **demonstration and pilot projects** at strategically chosen sites. Such pilots can validate the technology's technical, financial, and operational viability, generate real-world data, and build confidence among policymakers, investors, and end-users.

5.0 Barriers to Adoption and the Need for Piloting

Despite the clear technical and environmental rationale, the widespread adoption of off-grid solar carports in India faces several barriers that limit their mainstreaming:

5.1 High Initial Capital Expenditure (CapEx): Integrating solar PV panels with durable structural design and battery storage systems sized for off-grid operation entails a significantly higher upfront investment compared to conventional parking shades or even grid-tied solar systems. The lack of mature financing mechanisms for such hybrid projects further amplifies this barrier.

5.2 Technical and Operational Complexity: Ensuring reliable, round-the-clock performance requires careful system design, including optimal sizing of the solar array and battery bank, deployment of advanced energy management systems (EMS), and skilled operation and maintenance. Currently, there is limited availability of standardized models and localized expertise for such integrated systems in the Indian market.

5.3 Regulatory and Policy Ambiguity: While India's policy framework strongly supports solar power and electric mobility, specific regulatory clarity around off-grid and hybrid systems with storage is still evolving. Issues such as banking of power, licensing requirements, and hybrid system interconnections remain ambiguous, creating uncertainty for developers and investors.

5.4 Perception of Risk: Financial institutions and potential project developers often perceive higher technology and performance risks in integrated solar-plus-storage systems compared to conventional solar projects. The absence of robust operational data and long-term performance benchmarks from within the Indian context further inhibits investor confidence.

Therefore, there is a compelling need for a high-visibility, meticulously monitored pilot project that can serve as a proof-of-concept. Such a pilot can generate invaluable data, demonstrate operational viability, validate models, build technical capacity, and create a replicable template for scaling across the country.

Pilot Demonstration- Solar Carport with Battery Energy Storage System (BESS) and Electric Vehicle (EV) Chargers

The **Asian Development Bank (ADB)**, through technical assistance (TA) from the **Global Environment Facility (GEF)**, is supporting India's e-mobility transition. The TA aims to enable the **Government of India** and relevant stakeholders to:

- Decarbonize transport systems,
- Catalyze access to finance for large-scale adoption of Electric Vehicles (EVs) across multiple vehicle segments, and
- Reduce urban air pollution by promoting the scale-up of electric mobility in India.

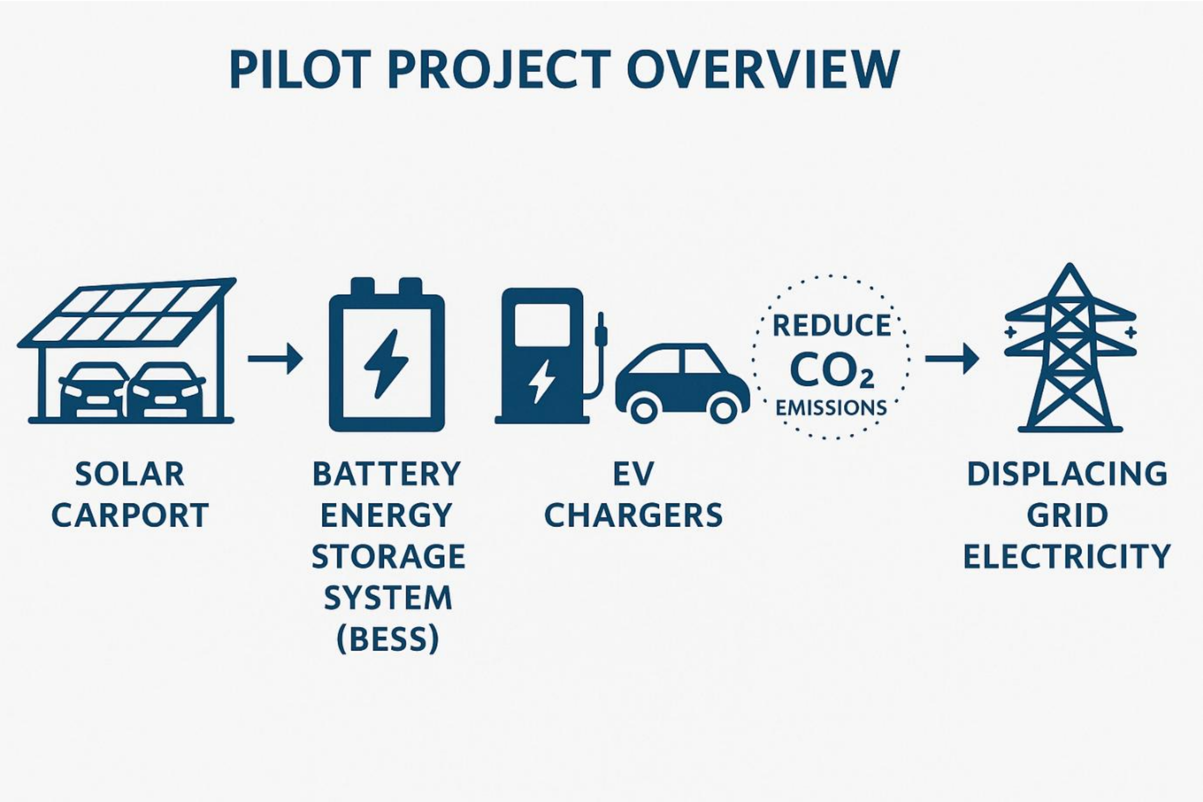
Energy Efficiency Services Limited (EESL) serves as the **Executing Agency** for the **TA-9874 IND program**, while **Convergence Energy Services Limited (CESL)**, under the **Ministry of Power**, is responsible for **procurement, implementation, and monitoring** of the pilot program. The program's key objectives include:

- Facilitating the scale-up of e-vehicle markets through pilot demonstrations,
- Creating enabling conditions for e-mobility investments, including the development of new business models, and
- Preparing city-level EV charging infrastructure plans.

To demonstrate end-to-end clean EV charging, a pilot project was designed to evaluate the feasibility of solar carports integrated with Battery Energy Storage Systems (BESS) and EV chargers. Key features of the pilot include:

- Deployment across 10 Indian cities, divided into two lots,
- Each lot comprising four 25 kWp and one 50 kWp solar installations,
- Integration with EV charging infrastructure powered primarily by the solar-plus-storage system,
- Targeted reduction of CO_2 emissions through displacement of grid electricity and promotion of renewable-based mobility.

This pilot serves as a proof-of-concept for deploying solar-powered EV charging solutions, generating valuable operational, financial, and technical insights for replication and scale-up nationwide.



Tendering and Site Selection: Implementation Status and Performance

Under Lot I, bids were received, and Topsun Energy Limited was shortlisted for setting up the solar carport at 5 sites. However, under Lot II, no bids were received, indicating possible market or procurement constraints.

The Executing Agency initially approached high-profile government locations, including the Prime Minister's Office (PMO), Parliament Secretariat, and Rashtrapati Bhavan (President's House), however due to significant space limitations and the critical challenge of persistent shading from surrounding trees and heritage structures rendered these iconic sites unsuitable for effective solar generation, making installation unfeasible.

Subsequently, the EA signed a **Memorandum of Understanding (MoU)** with the **Statue of Unity Area Development & Tourism Governance Authority (SOUADTGA)** to establish a **50 kWp solar carport** at **Kevadia, Gujarat**, in proximity to the Statue of Unity (SoU).

The **SoU**, being an iconic national monument and a major tourist destination, provided an **ideal demonstration site**. Its high footfall of tourists and policymakers offered excellent **visibility**, creating the **“demonstration effect”** necessary to convince stakeholders—including policymakers, investors, and developers—of the technology’s replicability.

CESL will be responsible for the operation and maintenance (O&M) of the asset through the vendor for a period of six years from the date of commissioning. The asset ownership will transfer to SOUADTGA at the beginning of the sixth year. However, the vendor, Topsun Energy Limited, will perform the O&M services for the entire six-year duration, including the final year after the asset's transfer.

1.0 Site Description

The Statue of Unity Pilot: A Symbolic and Strategic Choice

The selection of the Statue of Unity (SoU) under SOUADTGA in Gujarat for this pilot assessment was both strategic and symbolic. The SoU is not only the world’s tallest statue but also a major national tourist destination, attracting thousands of visitors daily.

- **High Visibility and Demonstration Effect:** Being a landmark of national pride, a successful technology demonstration at the SoU has garnered significant attention from central and state governments, public sector undertakings, private developers, and the media.
- **Platform for Advocacy and Awareness:** The site serves as an unparalleled platform to showcase the benefits of solar carport installations, driving awareness and adoption across India.

Figure 1:Site for setting up solar carport at SoU

Site Visit Report

Date : 16/05/2024

Proposed Installation Location Information

Purpose : Design Engineering Supply & Installation of 50kWp Solar PV along with Battery Energy Storage System of 200 kWh with EV Chargers

Project location : Shopping Complex Garden Area,
Near Rewa Bhavan, Statue of Unity,
Kevadia, Gujarat
Pincode - 393151
India

Coordinates : Latitude - 21.8791
Longitude - 73.6947

Satellite view of Location

Main Features & System of the Project

- Solar PV based Carport - 50 kWp
- Battery Energy Storage System - 200 kWh
- EV Chargers
  - DC 60KW CCS II - 2 Nos
  - AC Type II - 2 Nos
  - AC Bharat 001 - 1 Nos

Layout of the Solar Carport

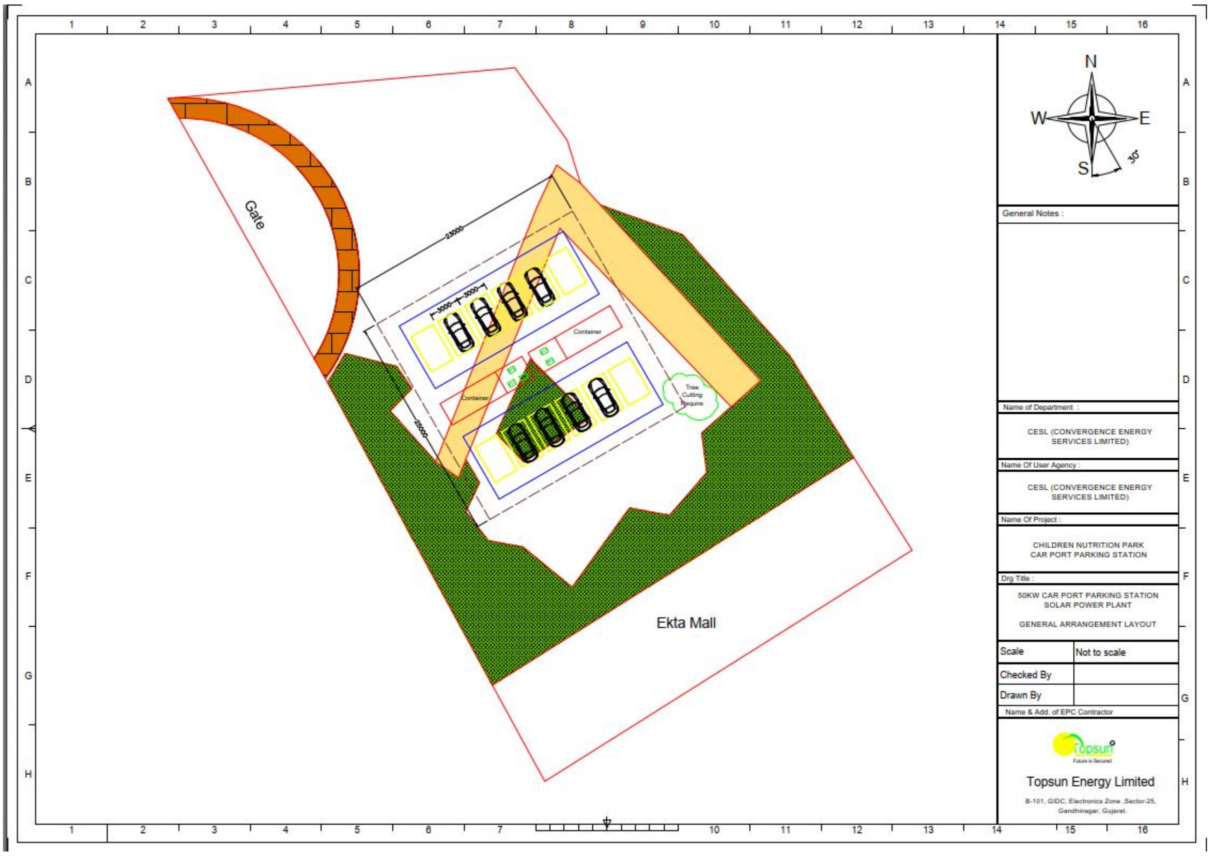


Figure 2: Layout of carport

Energy Management and Power Flow Logic for Off-Grid Solar Carport with BESS

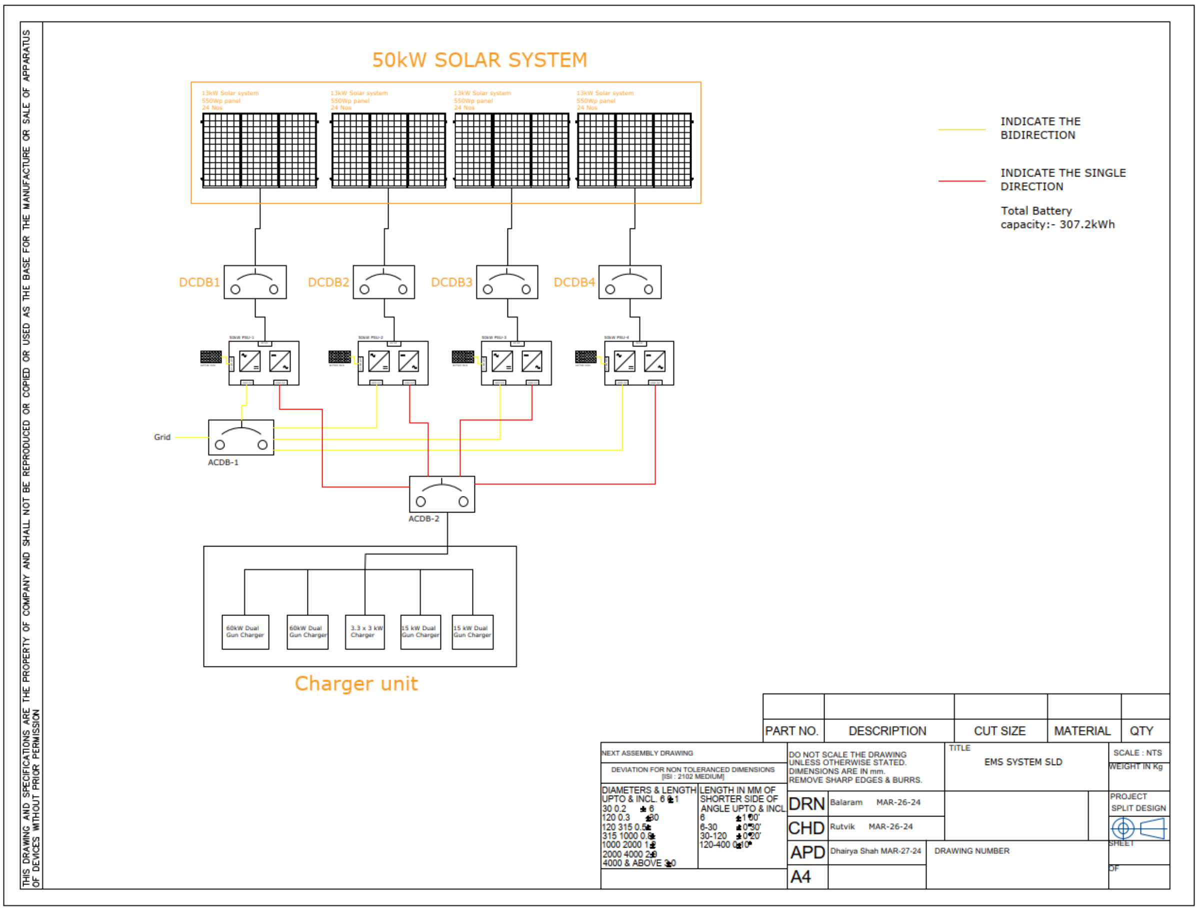


Figure 3: System Design - Energy Flow

The operational philosophy of the off-grid solar carport is governed by a control strategy designed to maximize the consumption of solar generation, ensure the availability of electric vehicle (EV) charging, and maintain the health of the Battery Energy Storage System (BESS). The system operates according to the following logic:

1. Primary Mode: Solar Generation Available

- **Priority 1: Direct Solar EV Charging.** Whenever solar irradiance is sufficient, the PV-generated power is first allocated to connected EVs to meet their charging demand.
- **Priority 2: BESS Charging with Excess Solar.** If instantaneous solar generation exceeds the EV charging demand, the surplus energy is directed to charge the BESS.
- **Contingency: Hybrid Solar-BESS EV Charging.** When EV charging demand temporarily exceeds available solar generation, the BESS supplements the deficit, ensuring uninterrupted EV charging at the requested power level.

2. Secondary Mode: No Solar Generation (Night/Overcast Conditions)

- **Sole-Source BESS Charging.** During periods of negligible or zero solar generation, all power required for EV charging is supplied exclusively by the BESS.

3. Battery Protection Mode: BESS at Low State of Charge (SOC)

- **BESS Recharge Priority.** A critical system safeguard is activated when the BESS reaches a pre-defined deep discharge threshold (low SOC). In this state, all available solar generation is automatically diverted to recharge the BESS.

- **Controlled Access to EV Charging.** EV charging services are temporarily suspended or limited until the BESS SOC is restored to a minimum operational level (e.g., 20-30%), as determined by the system management software. This protocol ensures the BESS retains sufficient energy to support critical system functions and avoids damage from deep discharge cycles.

Technical Specifications of the Solar Carport

Location: Shopping Complex, Near REWA Bhawan, Statue of Unity, Kevadia, Gujarat
Commissioning Date: 31st October 2024

General Information	Product Information
Carport Structure	
Type of Structure: (e.g., Steel, Aluminium, Wood)	HDGI
Structural Integrity: (Check for signs of corrosion, damage, and alignment):	NORMAL
Safety Compliance: (Confirm compliance with local safety codes)	Complied
Solar Panel Array	
Number of Panels:	96
Type of Panels: (e.g., Monocrystalline, Polycrystalline)	GLASS TO GLASS BIFACIAL HALF CUT MONO CRYSTALLINE
Manufacturer and Model:	WAREE
Installed Tilt and Orientation:	Tilt -10º Orientation- South
Maximum Rated Power of Panels:	545 Wp
Battery Energy Storage System (BESS)	
Battery Type: (e.g., Lithium-Ion, Lead Acid, Flow Battery)	LIFEPO4(LFP)
Total Capacity (kWh):	307kWh
Manufacturer and Model:	MINDRA
Inverter/Charger Model:	50KW X 4 Nos
Date of Installation:	26/10/2024
EV Charging System	
Number of EV Chargers:	5
Charger Type: (e.g., Level 2, DC fast charger)	DC FAST CHARGER - 2Nos, AC Charger - 2Nos, AC Charger 10kW(3.3*3) - 1Nos
Manufacturer and Model:	MINDRA
Charging Capacity (kW):	60kW- 2 Nos. (Dual Gun) 15kW- 2 Nos. (Dual Gun) 10kW - 1 Nos. (3.3 X 3)

This section outlines the technical specifications of a state-of-the-art Solar Carport with an integrated Battery Energy Storage System (BESS) and Electric Vehicle (EV) charging station commissioned at the Statue of Unity (SOU). This project represents a significant step towards sustainable infrastructure development, aligning perfectly with ADB's goals of promoting renewable energy, reducing carbon emissions, and fostering climate-resilient transport solutions. The facility leverages cutting-edge technology to provide clean energy, ensure grid stability, and support the transition to e-mobility at one of India's most prominent national monuments.

1. Technical System Overview

The installation is a comprehensive clean energy ecosystem designed for efficiency, reliability, and multi-functionality.

1.1. Carport Structure & Foundation

- **Material:** Constructed with Hot-Dip Galvanized Iron (HDGI), providing exceptional resistance to corrosion and ensuring long-term structural integrity in the varied climatic conditions of Kevadia.
- **Compliance:** The structure fully complies with local safety and building codes, guaranteeing public safety and durability.

1.2. Solar Photovoltaic (PV) Array

- **Capacity & Configuration:** The system comprises 96 high-efficiency panels with a total rated capacity of approximately 52.3 kWp (96 nos. x 545 Wp).
- **Panel Technology:** Utilizes advanced Glass-to-Glass Bifacial Half-Cut Mono-crystalline panels. This technology offers several advantages:
    - **Bifacial:** Captures sunlight on both the front and rear sides, increasing energy yield by utilizing reflected light from the ground and the carport surface.
    - **Half-Cut Cells:** Reduce internal resistance and shading losses, improving performance in partial shade conditions and enhancing overall reliability.
    - **Durability:** The glass-glass construction offers better mechanical strength, longer lifespan, and reduced degradation rates.
- **Orientation:** Optimally tilted at 10 degrees and oriented true South, maximizing solar irradiance capture in this location.

1.3. Battery Energy Storage System (BESS)

- **Technology**: Employs Lithium Iron Phosphate ($LiFePO_4$ or LFP) chemistry, renowned for its safety, long cycle life (typically over 6000 cycles), and thermal stability.
- **Capacity:** The system has a substantial 307 kWh storage capacity. This large-scale storage is critical for the project's objectives.

- **Power Conversion:** Managed by four (4) units of 50 kW inverters (total 200 kW), enabling efficient bi-directional power flow for charging and discharging.
- **Primary Functions:**
    1. **Energy Time-Shifting:** Stores excess solar energy generated during the day for use during peak evening hours or at night, maximizing self-consumption.
    2. **Demand Charge Reduction:** Mitigates high power draws from the grid, leading to significant operational cost savings.
    3. **Grid Support:** Can provide backup power and enhance the stability of the local electricity network when connected to the Grid.

1.4. Electric Vehicle (EV) Charging Infrastructure

- **Comprehensive Charging Portfolio:** The station is equipped with five (5) chargers to cater to a wide range of electric vehicles:
    - **DC Fast Chargers (2 Nos.):** Each rated at 60 kW with dual guns, capable of charging most EVs to 80% in under 45 minutes for employees and visitors.
    - **AC Chargers (2 Nos.):** Each rated at 15 kW with dual guns, suitable for longer-duration charging for employees and visitors.
    - **AC Charger (1 No.):** A 10 kW unit with triple sockets (3.3 kW x 3), ideal for charging smaller EVs or e-rickshaws simultaneously.

Figure 4: EV Chargers at SOU

2. Alignment with ADB Strategic Objectives & Impact Assessment

2.1. Sustainable Transport and E-Mobility

- **Catalysing EV Adoption:** By providing critical charging infrastructure at a major tourist destination, this project directly addresses "range anxiety" and supports the growth of electric mobility in the transport sector.
- **Green Charging:** EVs charged at this station will be powered primarily by solar energy and stored clean power, ensuring truly zero-emission transportation. This moves beyond simply shifting emissions from the tailpipe to the power plant.

3. Elderly, Women, Children and Disabled (EWCD) features

The pilot has given special attention to ensure that the gender equality and social inclusion considerations are included at the solar carport site. Solar carport has been made elderly, women and disabled-friendly by incorporating various design features such as:

- vehicle charging space with ~11X20 feet dimensions;
- clear ground space at the same level as the vehicle charging space;
- charger positioned at an unobstructed side reach;
- accessible operable parts;
- high contrast labels on keys for visual controls;
- adequate lighting around the carport area to improve visibility, especially during low-light conditions;
- use of non-slip surfaces for the flooring and walkways to prevent slips and falls, particularly in wet or slippery conditions;
- clear and visible signage including do's and don'ts and emergency contact numbers;
- comfortable seating areas with shade;
- long and light-weight cable for ease of charging;
- installation of emergency call buttons / communication systems to provide assistance in case of emergencies.
- 24-hour CCTV surveillance for the safety of users and their vehicles
- App-Based Monitoring: Allows users to monitor their vehicle's charging status in real-time via a mobile app.

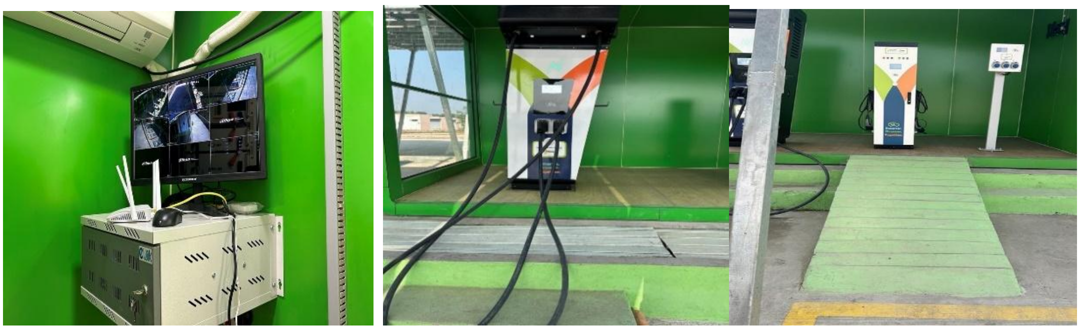


Figure 5: EWCD features- CCTV, ramp, long charging cables

Further, the Executing Agency (EA) has proposed to SOUADTGA to allow public access to the solar carport for EV charging, including:

- **Individual EV owners**, and

- **Public shared transport vehicles**, such as **pink autos driven by women**.

This approach is expected to:

- **Increase revenue and site utilization**, and
- **Enhance emission reduction benefits**, as allowing charging for vehicles beyond the SoU fleet expands the overall clean energy displacement.

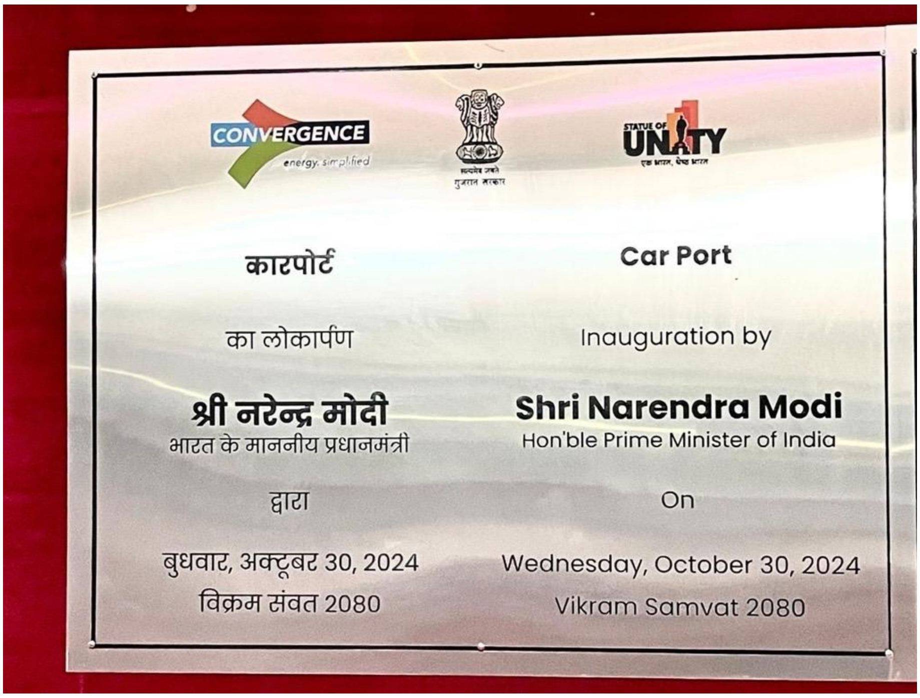


Figure 6: Inauguration by Hon'ble PM of India

The carport was inaugurated by Hon’ble PM in October 2024

Figure 7: EV of SOUGDTA charging at site

Performance of the Solar Carport

This section focuses on the performance of the solar carport from the date of commencement till 31st December 2025.

The **50 kWp solar panel system** has the capacity to generate approximately **72,000 kWh annually**, assuming an average generation of 4 kWh per kW per day. During the operational period, the **carport has generated around 30,000 kWh.** This lower generation is mainly due to limited charger utilization, as the number of vehicles using the facility is relatively low and the administrative office operates its own independent charging stations.

As a result, vehicles typically come to the carport only for top-up charging, which accounts for about **14,000 kWh (i.e., 19% charger utilization)** of consumption so far. Once utilization reaches full scale, with more vehicles and consistent charging demand, the energy generation and consumption will gradually align with the system's expected performance, ultimately leading to a **projected charger utilization of ~68% by the end of the 25-year period.**

The auxiliary consumption additionally represents about **22% of the total energy generation capacity i.e., around 16,000 kWh** and primarily supports the overall operation of the system. This includes powering air conditioners, appliances, inverters, and other essential equipment required to keep the system running efficiently.

It is estimated that the **total emission reduction achieved in the year 1 is 19 tCO2eq.** through the Solar Carport and as the vehicle & charging demand increases, the estimated reduction potential **over a 25-year period** will amount to **approximately 608 tCO2eq**.

Assumptions:

- A year-on-year increase of 4.5% in charger utilization has been considered, based on the expectation that more electric vehicles will be added to the fleet over time. As the number of vehicles grows, the overall charging demand is projected to rise accordingly.
- Additionally, the auxiliary consumption is expected to increase by 0.5% annually, as ageing appliances tend to draw more power over time and the overall connected load gradually rises.

Detailed calculations at Annexure 1:

The below table depicts the performance of the solar carport system from 31st October 2024 to 31st December 2025. The system generated ~30,000 kWh and consumption for charging of EVs was ~14000 kWh.

Data collected as on 31st December 2025

Electric Vehicle Charging Summary

A portal has been developed by the vendor for monitoring and verification of the usage of EV chargers installed at the SoU. Charger-wise consumption summary is as below[1]:

Consumption Summary (Units)															
	31st Oct	Nov 2024	Dec 2024	Jan 2025	Feb 2025	March 2025	April 2025	May 2025	June 2025	July 2025	August 2025	September 2025	October 2025	November 2025	December 2025
TOPSOU60-1 Connector 1	21.54	159.22	116.05	147.03	211.69	326.92	498.78	564.22	603.56	397.07	515.82	312.02	901.15	562.04	326.27
TOPSOU60-1 Connector 2	6.16	342.44	182.93	285.4	249.25	318.25	275.44	469.01	372.49	326.22	376.85	329.57	836.92	546.63	305.75
TOPSOU60-2 Connector 1	9.25	80.24	29.13	53.68	84.95	135.19	169.13	128.68	69.87	50.51	193.84	292.85	394.97	206.01	97.40
TOPSOU60-2 Connector 2		30.94	41.33	19.28	69.8	45.18	40.15	9.31	97.98	102.84	121.45	85.82	266.18	49.60	88.02
TOPSOU15-1 Connector 1					0.15										
TOPSOU15-1 Connector 2		0.456													
TOPSOU15-2 Connector 1															
TOPSOU15-2 Connector 2		0.882													
Energy Consumed (kWh)	**36.95**	**614.178**	**369.44**	**505.39**	**615.84**	**825.54**	**983.50**	**1171.22**	**1143.90**	**876.64**	**1207.96**	**1020.26**	**2399.22**	**1364.28**	**817.44**
Total Energy Consumed (kWh)	**13951.758**														

Based on the EV charging summary represented above, it is observed that out of ~30,000 kWh generated through the off grid solar carport, 13,951.758 kWh have been utilized till 31st December 2025 for charging of electric vehicles at the site.

[1] https://mindra.electreefi.com/Account/Login

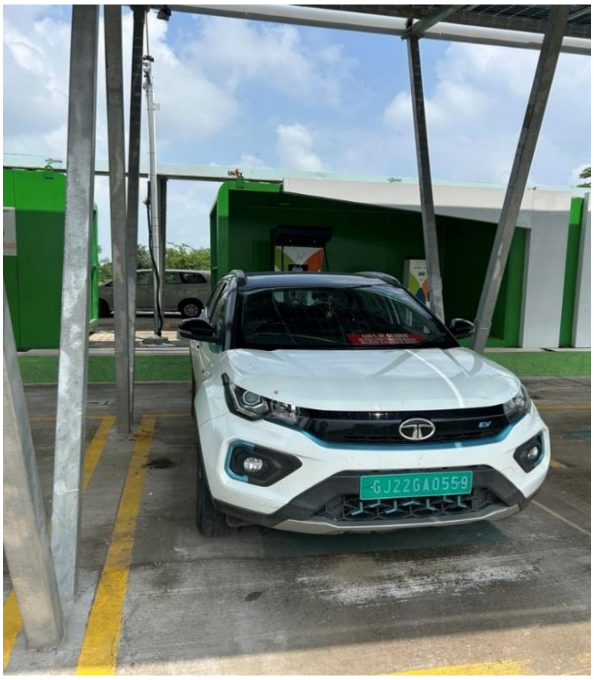


Figure 8: EV charging at SoU site

Figure 9: EV charging at SoU site

Figure 10: Night time charging at SoU site

Emission Reduction

The calculation assumes each charging session services a *unique* EV that has replaced an ICE vehicle. In reality, it might be the same cars coming back multiple times. Since, the carport is an off-grid solution, it is assumed that energy generated at site is 100% clean and the emission reduction has been calculated based on energy utilized for EV charging and running the overall system during the period:

- The solar carport has generated approximately 30,000 kWh of clean energy to date. Of this,14,000 kWh has been utilized for EV charging, and 16,000 kWh has been consumed as auxiliary load.
- Each kWh of solar energy used for EV charging directly offsets an equivalent kWh that would otherwise be generated from fossil fuels. Switching one ICE vehicle to EV powered by solar results in an annual emission reduction of 4,120 kgCO_2 *(detailed calculation at annexure 2)*
- Similarly, each kWh of solar energy used for auxiliary consumption also avoids fossil-fuel-based grid electricity.
- CO2 emission factor: 0.81kg of CO_2

- Days Considered in a year = 360
- Energy utilized for EV charging per day = 14,000 kWh/360 = 39 kWh/day
- 1 EV 4W requires 27 kWh of electricity to be charged (*considering at 80% efficiency and 10% losses*)
- Maximum number of EV cars that can be charged in a day = Energy utilized for charging EVs per day/ Electricity required to charge 1 EV = 39/27 = 1.44 cars per day
- Emission Reduction in 2025 through EV Charging = 1.44 * 4,120 kgCO_2 = 6 tCO_2eq.
- Emission Reduction in 2025 through Auxiliary Consumption = 16,000 kWh * grid emission factor (0.81KgCO_2) = 13 tCO_2eq.

Total Annual Emission Reduction= Emission Reduction in 2025 through EV Charging + Emission Reduction in 2025 through Auxiliary Consumption
= 6 + 13 tCO_2 = 19 tons of CO_2

*The off-grid solar carport system has resulted in a total reduction of approximately **19 tons of CO_2 during its operational period**, through a combination of EV charging and auxiliary clean energy usage.*

Framework for Scaling-Up and Replication

The transition from a single pilot to widespread market adoption requires a multi-pronged strategy targeting key customer segments with tailored business models.

With a prime focus to generate end to end clean energy for EV Charging, CESL plans to scale up the off-grid solution, through the pilot demonstration conducted at SOU, Gujarat. It is envisaged that the pilot demonstration shall act as a catalyst in transitioning from a high-cost, niche demonstration technology to a mainstream, commercially competitive infrastructure solution.

This transition is being powered by the relentless global and domestic scale-up of solar and battery manufacturing, which is systematically driving down the two largest line items in the project's budget.

The tailored solar carport solution serves as a key enabler for scaling up EV adoption and EVCI deployment across the country as it:

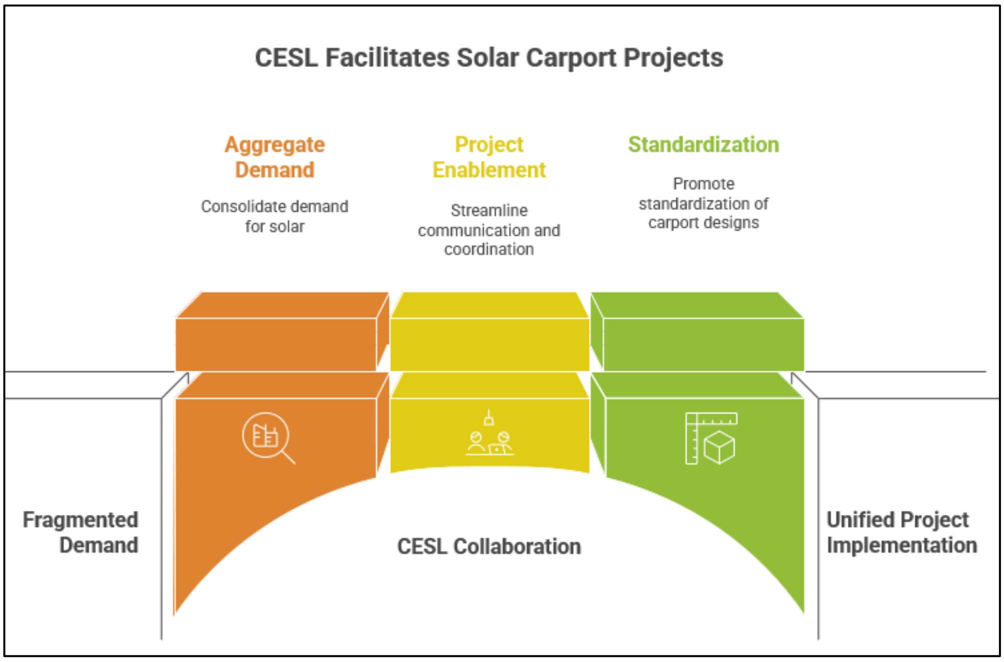
- **Eliminates grid dependency** in highways, tier 2/3 cities, and rural areas,
- Acts as a **source of revenue generation** and **job creation** in remote locations where grid expansion is economically unviable, and
- Offers **flexible energy management**—through **BESS integration and net metering**, excess energy can either be fed back to the grid or used as a **power backup in remote areas**.

This approach ensures that the pilot not only demonstrates technical feasibility but also establishes a **replicable, commercially viable model** for nationwide adoption.

CESL proposes to launch **"CESL Carport,"** a pan-India service providing off-grid electric vehicle (EV) charging and auxiliary power through solar carports. CESL will act as an aggregator and facilitator for setting up solar carport on turnkey basis. The model involves:

- **Demand Aggregation:** CESL will use its brand and market position to identify, validate, and aggregate demand from strategic locations.
- **Vendor Partnership:** CESL will empanel qualified vendors (ESCos, EPC companies, OEMs) to install, operate, and maintain the solar carports.
- **Revenue Sharing:** Vendors will share a pre-defined percentage of their revenue (from charging, power sales, carbon credits) with the land owning agency and CESL shall take the PMC charges from the land owning agency for providing the aggregated demand and infrastructure setup.
- **Strategic Locations:** Initial focus will be on highways with weak grids, remote tourist destinations, industrial clusters using diesel gensets, and defense /strategic installations.

This asset-light model minimizes capital risk for CESL while accelerating the deployment of clean energy EV infrastructure in underserved areas, directly supporting India's e-mobility and net-zero goals.



For the carport initiative, CESL will be:

- **The Aggregator:** The single point for market intelligence and demand pooling.
- **Defining customized specifications:** Defining technical, operational, and service level standards.
- **Facilitator:** Managing the vendor empanelment process and ensuring project bankability.
- **Monitor:** Using technology to track performance, energy generation, and revenue for transparent sharing.
- **Brand:** Leveraging its government-backed reputation to build trust with site hosts and customers.

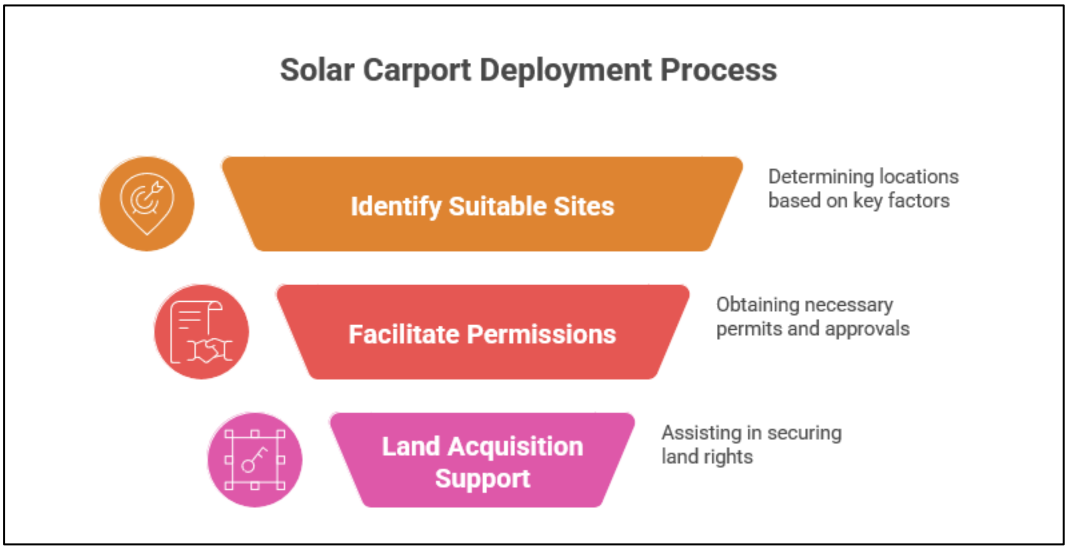
3. "Off-Grid Solar Carport as a Service"

This is a turnkey solution for location owners (e.g., hotel managers, highway restaurateurs) where they provide the land and get access to clean power and EV charging without any upfront investment.

Key Components of each carport unit:

- **Robust Carport Structure:** Designed to withstand local weather conditions.
- **Solar PV Panels:** Mounted on the carport roof (typically 10 kW - 50 kW per unit).
- **Battery Energy Storage System (BESS):** Critical for providing 24/7 power and charging, storing solar energy for use at night and on cloudy days.
- **EV Chargers:** A mix of AC (for 4-wheelers) and DC fast chargers (for cars and commercial vehicles).
- **Smart Energy Management System:** Manages energy flow between solar, battery, grid (if any), and the loads (EVs, auxiliary power).

- **Payment Gateway:** Integrated digital payment system (QR code, RFID, UPI) for a seamless customer experience.



4. Market Analysis & Potential Locations

The target market consists of locations where the grid is unreliable, unavailable, or expensive.

A. Highway Corridors: The Prime Focus

- **Rationale:** Long-distance EV travel requires reliable mid-point charging. Grid power is often weak or unavailable.
- **Potential Highways:**
  - **Leh-Manali Highway (NH3):** Extremely weak grid, high tourist traffic, strategic importance.
  - **Mumbai-Goa Highway (NH66):** Hilly terrain with grid instability.
  - **Chennai-Kanyakumari Highway (NH44):** Long stretches with limited high-power infrastructure.
  - **Highways connecting Industrial Clusters:** E.g., Delhi-Mumbai Industrial Corridor (DMIC) spurs.

B. Remote Tourist Destinations

- **Rationale:** Hotels and resorts often rely on expensive diesel gensets. EV-owning tourists need a place to charge.
- **Potential Locations:**
  - **Ladakh & Spiti Valley:** High solar insolation, weak grid.
  - **Andaman & Nicobar Islands:** Diesel-dependent, high cost of electricity.
  - **Wildlife Sanctuaries & National Parks:** E.g., Ranthambore, Kabini, Corbett, where silent, non-polluting power is a value-add.

    - **Hill Stations:** Ooty, Coorg, Tawang.

C. Industrial & Commercial Clusters with DGs

- **Rationale:** High cost of diesel makes solar + storage an economically attractive alternative for auxiliary power and fleet charging.
- **Potential Locations:**
    - **Industrial Parks** in Gujarat, Tamil Nadu, Karnataka.
    - **Logistics Hubs & Warehouses** on city outskirts.
    - **Telecom Towers** in remote areas.

D. Defence & Strategic Installations

- **Rationale:** Energy security and independence are critical.
- **Potential Locations:** Border outposts, remote airfields, naval bases where grid connection is a vulnerability.

5. Business & Revenue Model

1. Vendor Empanelment:

- CESL will release a tender/RFP to empanel vendors based on financial strength, technical expertise, and O&M capability.
- Vendors will be responsible for all capital expenditure (CAPEX) and operational expenditure (OPEX).

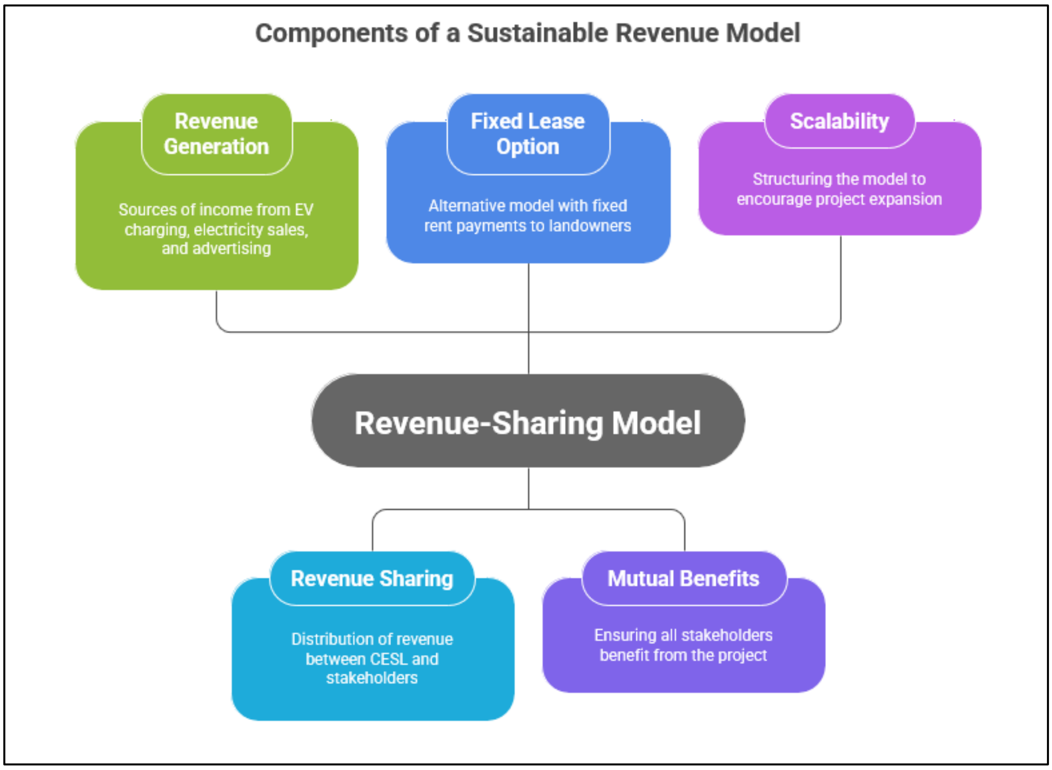
2. Demand Aggregation & Site Onboarding:

- CESL will market the carport service to potential site hosts (highway dhabas, hotels, industries).
- CESL will sign a **Tripartite Agreement** between **CESL**, the **Vendor**, and the **Land-Owning Agency**.

3. Revenue Streams & Sharing Mechanism:
Some of the proposed revenue streams are as below:

- **Stream 1: EV Charging Services:** Income from selling electricity to EV users.
- **Stream 2: Auxiliary Power Sales:** Sale of excess solar power (from the carport or BESS) to the Grid or Land Owning Agency for their internal use (e.g., lighting, appliances), displacing their grid or diesel power.

Proposed Revenue Share Model:



- There may be multiple revenue sharing streams depending on the model being implemented between land owning agency and CESL.

Additional Monetization Avenues:

- **Carbon Credits:** CESL, in partnership with vendors, can claim carbon credits (under international mechanisms or domestic schemes) for displacing diesel. The revenue from credits can be shared as per a separate agreement.
- **Data Monetization:** Anonymized data on EV usage patterns, energy demand, and travel routes can be valuable for market research and government planning.

6. Marketing & Sales Strategy

- **B2B Outreach:** Direct engagement with industry associations (FHRAI for hotels, NHAI for highways), logistics companies, and industrial bodies.
- **Digital Presence:** A dedicated "CESL Carport" microsite with a map of locations and a portal for site hosts to express interest.
- **Government Synergy:** Leverage partnerships with state nodal agencies (SNAs) and other ministries (Tourism, Defense, Highways) for site access and approvals.
- **Pilot Projects:** Launch high-visibility pilot projects at 3-5 strategic locations (e.g., one highway, one tourist spot, one industrial unit) to demonstrate proof-of-concept and build market confidence.

7. Management & Operations

- **CESL Core Team:** A small, dedicated team for Vendor Management, Site Acquisition, Contract Management, and Performance Monitoring.
- **Technology Platform:** Implement a central **Cloud-Based Monitoring Platform** that receives real-time data from all carport units on energy generated, consumed, revenue earned, and system health. This ensures transparency for revenue sharing.
- **Vendor Responsibilities:** All installation, 24/7 maintenance, customer support, and local marketing.

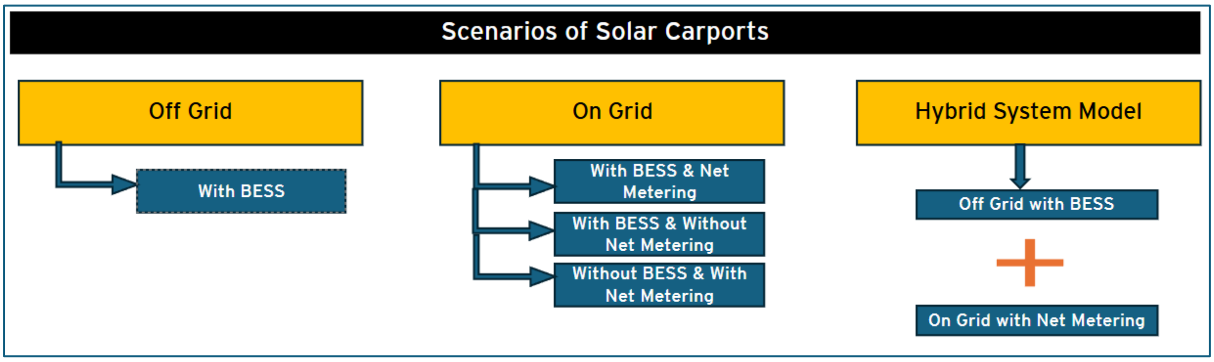


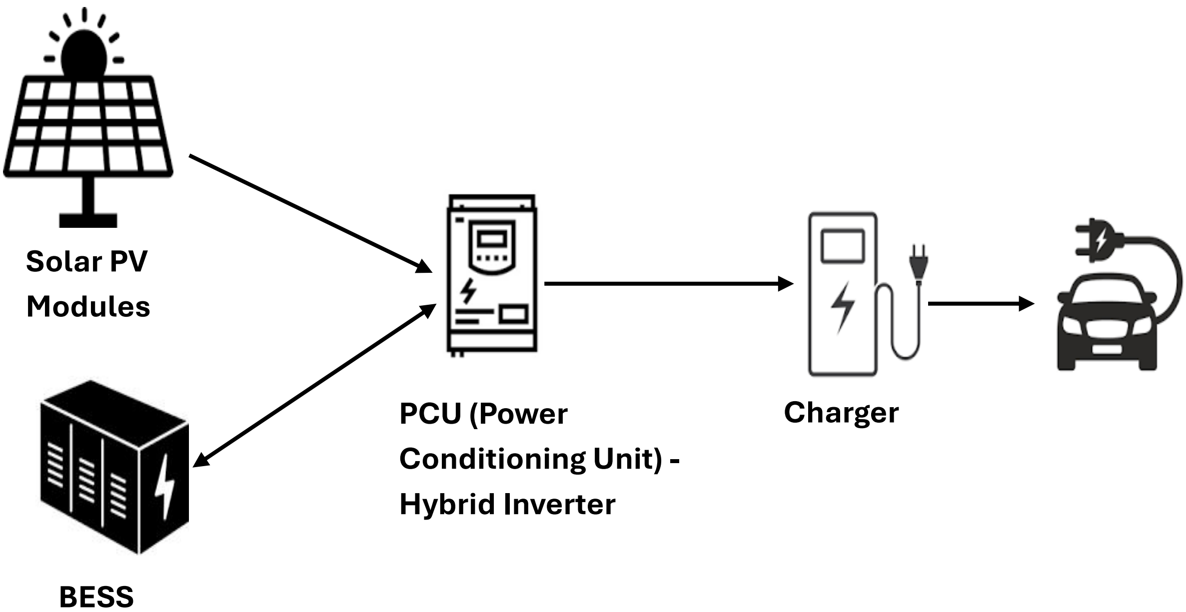
Figure 11: Different models developed for scaling up

Besides highways and locations with limited grid availability, the carport solution provides a potential revenue stream for large corporate offices, hotels, and hospitals, driven by high electricity costs, ESG commitments, and the need for reliable power.

It also presents an attractive opportunity for EV fleet operators and large residential societies aiming to offer “green charging” while reducing costs associated with grid infrastructure.

Details of different scenarios has been illustrated below:

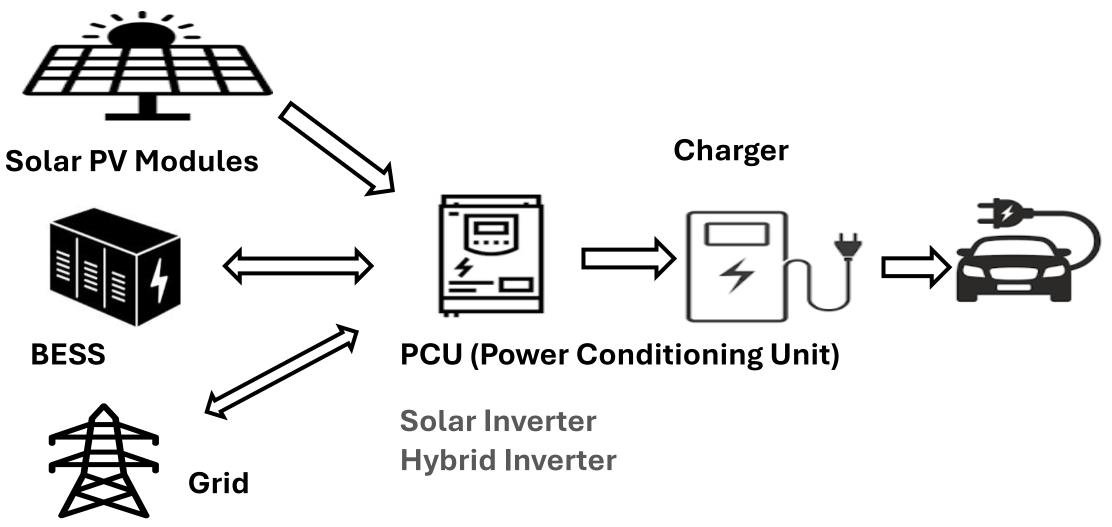
Scenario 1: Energy Flow for Off Grid Solar Carport with BESS



Operation

- Solar power is used to meet load demand, charge the BESS, and power the EV charger.
- Excess solar energy is stored in the BESS for use at night or during low solar generation.
- The EV charger operates only when sufficient solar or battery power is available.

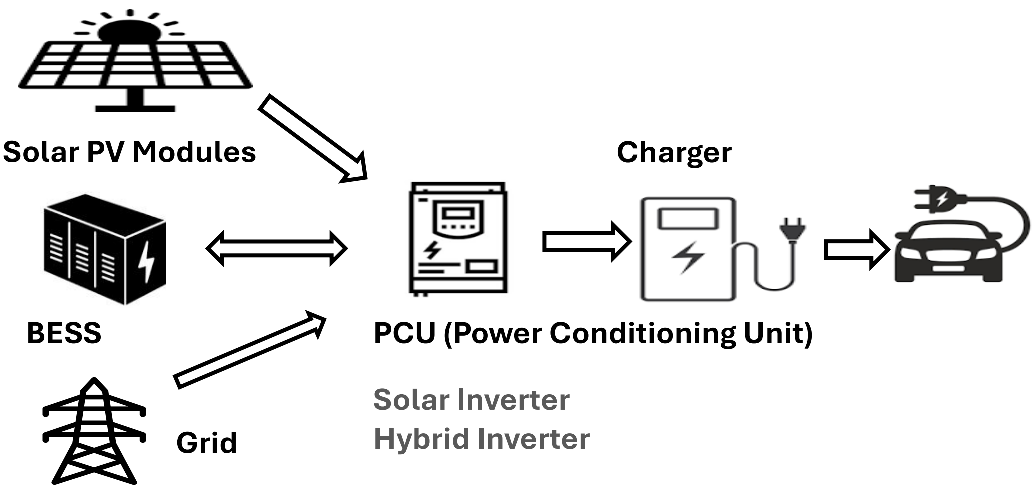
Scenario 2: Energy Flow for On Grid Solar Carport with Net metering and BESS



Operation:

- During the day, solar power is used to meet load demand, charge the BESS, and power the EV charger.
- Excess solar energy is exported to the grid through net metering.
- At night energy is drawn from the BESS and if the BESS is depleted, power is drawn from the grid.
- The EV charger can be powered by solar, BESS, or grid, depending on availability and cost optimization.

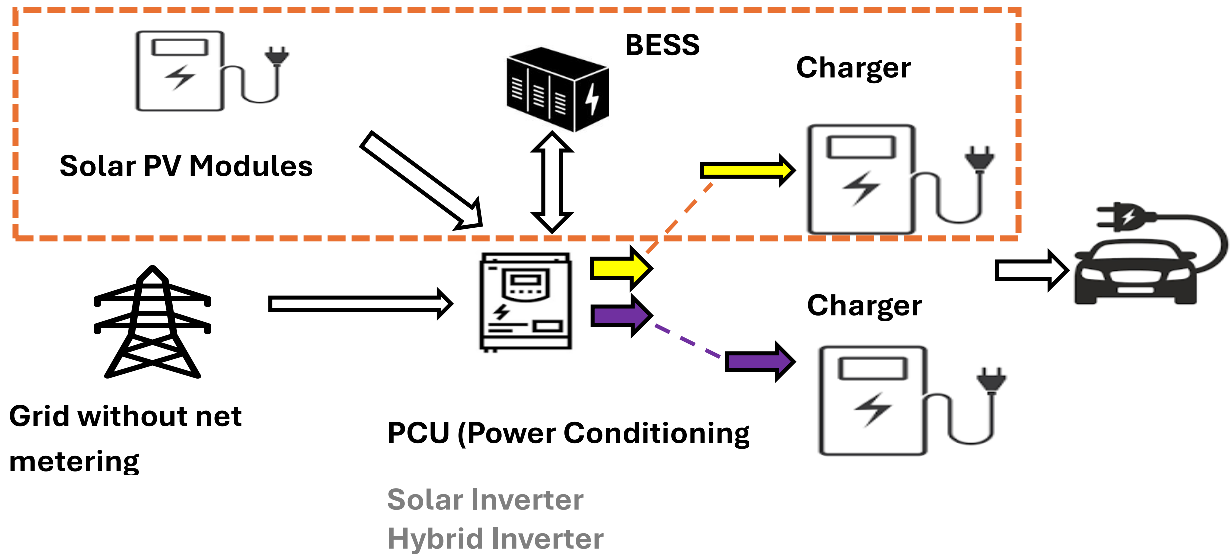
Scenario 3: Energy Flow for On Grid Solar Carport with BESS and without Net metering



Operation:

- During the day, solar power is used to meet load demand, charge the BESS, and power the EV charger.
- At night energy is drawn from the BESS and If the BESS is depleted, power is drawn from the grid.
- The EV charger can be powered by solar, BESS, or grid, depending on availability and cost optimization.

Scenario 4: Energy Flow for On Grid Solar Carport with BESS and without Net metering (Grid on Separate charger)



Operation:

- **During the day, solar power is used to meet load demand, charge the BESS, and power the EV charger.**
- **At night energy is drawn from the BESS and If the BESS is depleted, power is drawn from the grid for slow charging.**
- **The system has two chargers one for fast charging with Solar and BESS and slow charger connected to the grid.**
- **In case of charging through the grid, maximum power withdrawn will be as per the grid availability.**
- **The EV charger can be powered by solar, BESS, or grid, depending on availability and cost optimization.**

Long-Term Benefits for India: The Scalability and Replication Potential

The successful demonstration of the off-grid solar carport at the Statue of Unity is envisioned to yield profound long-term benefits for India, paving the way for widespread replication.

Carbon Emission Reduction: Widespread adoption would directly displace electricity drawn from the fossil-fuel-dominated grid and completely eliminate the use of diesel generators for backup power in the covered facilities. When coupled with EV charging, it enables a fully decarbonized mobility segment.

Enhanced Grid Stability: By operating in off-grid mode for their designated loads, these systems reduce the demand on the local distribution grid, especially during peak hours. This "peak shaving" effect enhances the stability and reliability of the grid for other consumers and defers costly grid upgrades.

Market Creation and Job Generation: The replication of this model would create a new market segment for engineering, procurement, and construction (EPC) companies, technology providers (for solar, storage, and EMS), and operations and maintenance (O&M) service providers. This will generate high-skilled and semi-skilled green jobs within the country.

Energy Access and Security: For commercial and industrial (C&I) consumers, who often pay high tariffs for grid power and for DG backup, this model offers a path to reduced energy costs and enhanced energy independence. For remote institutions and campuses, it can provide a reliable and clean source of power.

Policy Formulation: The data and lessons learned from this pilot will provide empirical evidence to central and state governments to formulate targeted policies, potential subsidies, or financial incentives to accelerate the deployment of similar integrated renewable energy systems across India.

Conclusion- From Demonstration to Transformation

India's journey towards a sustainable energy future is a necessity dictated by economic, environmental, and geopolitical imperatives. While progress in large-scale renewables is commendable, maximizing the impact requires innovation at the distributed level. The off-grid solar carport represents a sophisticated, multi-beneficial solution that addresses energy generation, grid constraints, air pollution, and the integration of electric vehicles simultaneously.

The ADB-GEF 7 pilot project at the Statue of Unity is far more than the installation of a single energy asset. It is a strategic intervention designed to catalyze a market for a transformative technology that sits at the nexus of energy, transportation, and urban infrastructure.

By successfully demonstrating the technical and economic viability of the off-grid solar carport at SoU, Gujarat, the proposed scaling-up framework—segmenting the market, promoting diversified business models, and advocating for an enabling environment—provides a clear pathway for proliferation.

The long-term benefits for India are profound: reduced fossil fuel dependence, enhanced grid stability, accelerated EV adoption, and significant progress towards its Nationally Determined Contributions (NDCs) under the Paris Agreement. This pilot serves as the vital first step in a journey towards making decentralized, renewable-based infrastructure a default standard, contributing to a more sustainable and secure energy future for India

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Annexure I

Solar Carport Calculations:

Parameters	Units	Years 0	1	2	3	4	5	6	7	8	9	10	11	12	13
			2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
Total Energy generation capacity per year	kWh		72,000	71,280	70,567	69,862	69,163	68,471	67,787	67,109	66,438	65,773	65,116	64,464	63,820
Energy Utilized for EV Charging	kWh		14,000	14,630	15,288	15,976	16,695	17,447	18,232	19,052	19,909	20,805	21,742	22,720	23,742
Auxiliary Load	kWh		16,000	16,080	16,160	16,241	16,322	16,404	16,486	16,568	16,651	16,735	16,818	16,902	16,987
Actual Energy Generated at Site	kWh		30,000	30710	31449	32218	33018	33851	34718	35621	36561	37540	38560	39622	40729
Energy Utilzed for charging EVs per day	kWh		39	41	42	44	46	48	51	53	55	58	60	63	66
Maximum No. of Cars that can be charged per day	Nos		1.44	1.51	1.57	1.64	1.72	1.79	1.88	1.96	2.05	2.14	2.24	2.34	2.44
Emission Reduction per year through EV Charging	tCO2		6	6	6	7	7	7	8	8	8	9	9	10	10
Emission Reduction through Auxiliary Consumption	tCo2		13	13	13	13	13	13	13	13	13	14	14	14	14
Total Emission Reduction through Solar Carport	tCO2		19	19	20	20	20	21	21	21	22	22	23	23	24
Annual Charger Utilization	%		19%	21%	22%	23%	24%	25%	27%	28%	30%	32%	33%	35%	37%
Annual Carport Utilization	%		42%	43%	45%	46%	48%	49%	51%	53%	55%	57%	59%	61%	64%

Total Emission Reduction through EV Charging in 25 years	tCO2	264
Total Emission Reduction through Auxilary Consumption in 25 years	tCO2	344
Total Emission Reduction through Solar Carport in 25 years	tCO2	608

Parameters	Units	14	15	16	17	18	19	20	21	22	23	24	25
		2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049
Total Energy generation capacity per year	kWh	63,182	62,550	61,924	61,305	60,692	60,085	59,484	58,889	58,300	57,717	57,140	56,569
Energy Utilized for EV Charging	kWh	24,811	25,927	27,094	28,313	29,587	30,919	32,310	33,764	35,283	36,871	38,530	38,534
Auxiliary Load	kWh	17,072	17,157	17,243	17,329	17,416	17,503	17,590	17,678	17,767	17,856	17,945	18,035
Actual Energy Generated at Site	kWh	41883	43084	44337	45642	47003	48422	49900	51442	53050	54727	56475	56569
Energy Utilzed for charging EVs per day	kWh	69	72	75	79	82	86	90	94	98	102	107	107
Maximum No. of Cars that can be charged per day	Nos	2.55	2.67	2.79	2.91	3.04	3.18	3.32	3.47	3.63	3.79	3.96	3.96
Emission Reduction per year through EV Charging	tCO2	11	11	11	12	13	13	14	14	15	16	16	16
Emission Reduction through Auxiliary Consumption	tCo2	14	14	14	14	14	14	14	14	14	14	15	15
Total Emission Reduction through Solar Carport	tCO2	24	25	25	26	27	27	28	29	29	30	31	31
Annual Charger Utilization	%	39%	41%	44%	46%	49%	51%	54%	57%	61%	64%	67%	68%
Annual Carport Utilization	%	66%	69%	72%	74%	77%	81%	84%	87%	91%	95%	99%	100%

Annexure II

#	Code	Description		ICE	EV+Grid	EV+Solar
1	A	Vehicle Model		Nexon XM	Nexon XM	Nexon XM
2	B	Vehicle Range (KM)		1020	312	312
3	C	Battery Capacity (kWh)		-	30	30
4	D	Fuel Tank Capacity(Ltr)		44	-	-
5	E	Fuel Mileage (KM/Ltr)		23.22	-	-
6	F=1/E, C/B	Fuel/Energy Consumption per KM		0.04	0.10	0.10
7	G	Daily Running KM		100	100	100
8	H	Days in a year (nos)		360	360	360
9	I=F*G*H	Fuel Consumption per year (lts)/ kWh		1552.94	3461.54	3461.54
11	J	Cabon emission of fuel (kgCO2/liter)		2.653	-	-
12	K	Grid Emission factor(kgCO2/kWh)		-	0.81	0
13	L=I*J, I*K	Carbon Emission (kgCO2)		4120.00	2810.00	0.00
14	M	**Reduction in Carbon emission (kgCO2)**		**0.00**	**1310.00**	**4120.00**

Annexure III

Inspection Format for Solar Carport with Battery Energy Storage System (BESS)
Project Name: Scaling Up Demand-Side Energy Efficiency Sector Project Design, Supply, Erection & Commissioning and O & M of 25/50 kWp Bi-facial Vertical Solar PV along with Battery Energy Storage System with EV Chargers
Location: Shopping Complex, Near REWA Bhawan, Statue of Unity, Kevadia, Gujarat
Commissioning Date: 31st October 2024
Inspection Date: 29 November 2024

1. General Information	Product Information	Comments	Status (Pass/ Fail)
Carport Structure			
Type of Structure: (e.g., Steel, Aluminium, Wood)	HDGI	As per tender conditions	Pass
Installation Date:	26/10/2024		
Structural Integrity: (Check for signs of corrosion, damage, and alignment) :	NORMAL		
Safety Compliance: (Confirm compliance with local safety codes)	Complied		
Solar Panel Array			
Number of Panels:	96		Pass
Type of Panels: (e.g., Monocrystalline, Polycrystalline)	GLASS TO GLASS BIFACIAL HALF CUT MONO CRYSTALLINE	As per tender conditions	
Manufacturer and Model:	WAREE		
Installed Tilt and Orientation:	Tilt -10° Orientation- South		
Maximum Rated Power of Panels:	545 Wp	As per tender conditions	
Battery Energy Storage System (BESS)			
Battery Type: (e.g., Lithium-Ion, Lead Acid, Flow Battery)	LIFEPO4(LFP)	As per tender conditions	Pass
Total Capacity (kWh):	307KW		
Manufacturer and Model:	MINDRA		
Inverter/Charger Model:	50KW X 4 Nos		
Date of Installation:	26/10/2024		
EV Charging System			
Number of EV Chargers:	5		

Charger Type: (e.g., Level 2, DC fast charger)	DC FAST CHARGER - 2Nos, AC Charger - 2Nos, AC Charger 10KW(3.3*3) - 1Nos	As per tender conditions	Pass
Manufacturer and Model:	MINDRA		
Charging Capacity (kW):	60KW- 2 Nos. (Dual Gun) 15KW- 2 Nos. (Dual Gun) 10KW - 1 Nos. (3.3 X 3)	As per tender conditions	
Charger Installation Date:	26/10/2024		
2. Visual Inspection			
2.1 Solar Carport Structure			
Roof Condition:			
No visible damage or leaks	Checked and Verified		Pass
Surface integrity intact (no rust or cracks)	Checked and Verified		Pass
Proper drainage (no water pooling)	Checked and Verified		Pass
Support Columns:			
Secure and upright	Checked and Verified		Pass
No structural damage or cracks	Checked and Verified		Pass
Carport Lighting:			
Functioning correctly	Checked and Verified		Pass
Wiring and connections secure	Checked and Verified		Pass
2.2 Solar Panels			
Panel Integrity:			
No physical damage (e.g., cracks, chips)	Checked and Verified		Pass
No discoloration or burn marks	Checked and Verified		Pass
Panel Orientation and Alignment:			
Panels are properly aligned and tilted per design specifications	Checked and Verified		Pass
Wiring and Connections:			
Wiring secure and properly fastened	Checked and Verified		Pass
No visible wear, exposure, or water infiltration	Checked and Verified		Pass
2.3 Battery Energy Storage System (BESS)			
Battery Enclosure:			

Free of leaks, rust, or cracks	Checked and Verified		Pass
Ventilation is adequate	Checked and Verified		Pass
Battery Condition:			
No visible swelling or signs of thermal damage	Checked and Verified		Pass
Terminals are clean and properly connected	Checked and Verified		Pass
Inverter/Charger:			
No abnormal noise or heat from inverter/charger	Checked and Verified		Pass
Proper grounding in place	Checked and Verified		Pass
2.4 EV Charging System			
Charger Housing:			
Secure and free from cracks or damage	Checked and Verified		Pass
Adequate signage and user instructions	Checked and Verified		Pass
Charger Condition:			
No visible damage to cables, connectors, or display	Checked and Verified		Pass
Properly mounted and accessible	Checked and Verified		Pass
Electrical Connections:			
Charger cables and wiring secure	Checked and Verified		Pass
No signs of fraying or wear on cables	Checked and Verified		Pass
3. Electrical System Inspection			
Solar Panel Wiring:			
All connections are tight and free from corrosion	Checked and Verified		Pass
Properly sized wire for current load	Checked and Verified		Pass
Circuit Breakers and Fuses:			
Rated appropriately for the system capacity	Checked and Verified		Pass
No signs of tripping or faults	Checked and Verified		Pass
String Combiner Box:			
Properly sealed and free from debris	Checked and Verified		Pass
All fuses intact and operational	Checked and Verified		Pass
Battery System Wiring:			
Secure connections to battery terminals	Checked and Verified		Pass
No exposed or frayed cables	Checked and Verified		Pass

Inverter:			
Correct wiring and placement of DC and AC connections	Checked and Verified		Pass
Inverter efficiency is within expected range (check display)	Checked and Verified		Pass
No overheating signs	Checked and Verified		Pass
EV Charger Wiring:			
Secure and properly fastened to the carport and electrical panel	Checked and Verified		Pass
Properly sized wires for charging current	Checked and Verified		Pass
Grounding System:			
Grounding for all components in place	Checked and Verified		Pass
No corrosion on grounding connections	Checked and Verified		Pass
4. Functional Tests			
Solar Panel Output Test:			
Voltage & Current Output:	Checked and Verified		Pass
Power output: Is it consistent with design specs?	Checked and Verified		Pass
Check for shading or debris on the panels affecting performance	Checked and Verified		Pass
Battery Charge/Discharge Test:			
Battery state of charge (SOC) levels:	Checked and Verified		Pass
Verify charging efficiency: (Battery charging properly with expected input)	Checked and Verified		Pass
Test discharging: (Check if power can be drawn correctly)	Checked and Verified		Pass
Inverter Operation:			
Inverter is providing the correct AC voltage	Checked and Verified		Pass
Inverter shut-off and restart works as expected	Checked and Verified		Pass
EV Charger Functionality:			
Test EV charger(s) with an electric vehicle	Checked and Verified		Pass
Verify charging capacity and time	Checked and Verified		Pass

Check display for any error messages or alerts	Checked and Verified		Pass
Emergency Shutdown (if applicable):			
Test emergency shutdown system (if applicable)	Checked and Verified		Pass
5. Safety Checks			
Fire Suppression System (if installed):			
Functional and accessible	Checked and Verified		Pass
No blockages or corrosion	Checked and Verified		Pass
Access and Egress:			
Pathways around the carport and BESS are clear	Checked and Verified		Pass
Proper signage and labeling of electrical components	Checked and Verified		Pass
Personal Protective Equipment (PPE):			
Ensure that all personnel have appropriate PPE (e.g., gloves, helmets, eye protection)	Checked and Verified		Pass
CCTV	Checked and Verified		Pass
6. Performance Monitoring			
Monitoring System:			
Check system logs for faults or alerts	Checked and Verified		
Verify that performance monitoring software is functioning	Checked and Verified		Pass
Review historical performance data (solar production, battery usage)	Checked and Verified		Pass
System Efficiency:			
Verify that efficiency is within expected ranges for both solar panels and battery storage	Checked and Verified		Pass
7. Maintenance Recommendations			
Immediate Repairs/Adjustments Needed:			
Structural:	NO		
Electrical:	NO		
Battery:	NO		
Inverter:	NO		
EV Chargers:	NO		

Ongoing Maintenance Suggestions:			
Panel Cleaning Frequency:	Every 15 days		
Battery Monitoring Recommendations:	OK		
EV Charger Cable and Connector Inspection:	Every 15 days		
8. Final Comments/Observations			
General condition of the installation	Satisfactory		
Any safety concerns	No		
Recommendations for improvements		Regular Site Cleaning to be carried out through SoU and equipment maintenance and periodic cleaning to be carried out by the vendor as per the schedule mentioned in the Rfp.	
Date: 29 November 2024			