DESIGN AND DEVELOPMENT OF COMBINED BATTERY CHARGING AND SWAPPING INFRASTRUCTURE FOR FUTURE EVs ENABLED WITH G2V & V2G OPERATION

PROJECT REPORT

Submitted by

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In partial fulfilment for the award of the degree of

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in

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K.RAMAKRISHNAN COLLEGE OF ENGINEERING

(AUTONOMOUS)

SAMAYAPURAM, TRICHY

ANNA UNIVERSITY: CHENNAI 600 025

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INSTITUTE VISION AND MISSION VISION

“To achieve a prominent position among the top technical institutions”

MISSION

- To bestow standard technical education par excellence through state of-the-art infrastructure, competent faculty and high ethical standards
- To nurture research and entrepreneurial skills among students in cutting edge technologies.
- To provide education for developing high-quality professionals to transform the society.

DEPARTMENT VISION AND MISSION

To emerge as a renowned department for high quality teaching, learning and research in the domain of Electrical and Electronics Engineering, producing professional engineers, to meet the challenges of society

MISSION

M1: To establish the infrastructure resources for imparting quality technical education in Electrical and Electronics Engineering.

M2: To achieve excellence in teaching, learning, research and development.

M3: To impart the latest skills and developments through practical approach along with moral and ethical values.

PROGRAM SPECIFIC OUTCOME (PSO)

Students will have the ability to

PSO1: Apply the logical, analytical and technical skills to model and build electrical systems and appliances as per societal requirements.

PSO2: Apply the advanced and fundamentals Electrical and allied Engineering knowledge in the design and development of hardware and software tools for non-conventional electrical power generation and distribution.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

Our graduates shall:

PEO1: Have strong foundation in Electrical and Electronics Engineering to excel in professional career, in higher studies or research.

PEO2: Analyze, design and develop various interdisciplinary projects and products, to solve industrial needs and social issues.

PEO3: Have professional ethics and effective communication skills with life-long learning attitudes.

PROGRAM OUTCOME (PO)

PO1 Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2 Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3 Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4 Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5 Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

PO6 The Engineer and Society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7 Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8 Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9 Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

PO10 Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11 Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12 Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

COURSE OUTCOMES (CO)

COURSE OUTCOMES	KL	DESCRIPTION
C411.1	K1& K2	On Completion of the project work students will be in a position to take up any challenging practical problems and find solution by formulating proper methodology.
C411.2	K1 & K3	Students are able to apply the fundamental knowledge of Electrical and Electronics Engineering in developing novel products/solutions and thereby contributing to society
C411.3	K1&K3	Students become capable of designing and developing system prototypes independently by utilizing latest software's and equipments
C411.4	K1&K2	Intellectual capability and innovative thinking of the students are ignited
C411.5	K3&K5	By team work students are able to develop professionalism, build self confidence and practice ethical responsibilities

COURSE OUTCOMES VS POS MAPPING (DETAILED; HIGH:3; MEDIUM:2; LOW:1):

COURSE OUTCOMES	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C411.1	3	3	0	1	0	0	1	2	3	0	0	0	1	2
C411.2	0	3	2	3	0	3	1	0	3	3	0	2	2	1
C411.3	0	0	3	3	3	0	0	3	3	3	1	2	1	1
C411.4	0	0	0	0	0	0	3	3	3	3	2	3	1	2
C411.5	0	0	0	0	0	0	0	0	3	3	0	3	1	1

** For Entire Course, PO /PSO Mapping; 1 (Low); 2(Medium); 3(High) Contribution to PO/PSO*

ANNA UNIVERSITY: CHENNAI 600 025

BONA FIDE CERTIFICATE

Certified that this Project Report **“DESIGN AND DEVELOPMENT OF COMBINED BATTERY CHARGING AND SWAPPING INFRASTRUCTURE FOR FUTURE EVs ENABLED WITH G2V & V2G OPERATION”** is the bona fide work of **RS.ABINAYA (811519105001), V.AGALYA (811519105002), P.NELSHINI (811519105029), and M.PRIYADHARSHINI (811519105038)** who carried out the work under my supervision. Certified further that to the best of my knowledge the work reported herein does not form part of any other thesis or dissertation on the basis of which a degree or award was conferred on an earlier occasion on this or any other candidate.

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at K.Ramakrishnan College of Engineering (Autonomous), Trichy – 621 112

INTERNAL EXAMINER **EXTERNALEXAMINER**

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ABSTRACT

The transition to electric vehicles (EVs) has been gradually gaining popularity worldwide, with the aim of addressing environmental pollution and reducing dependence on fossil fuels. However, the major challenge of limited driving range and charging infrastructure remains a significant obstacle to widespread adoption of EVs. Design and Development of Combined Battery Charging and Swapping Infrastructure for Future EVs Enabled With V2G and V2G operation that proposes a infrastructure for charging and swapping station for Electric Vehicles. This project establishes the design and development of a combined battery charging and swapping infrastructure for future EVs, enabled with Grid-to-Vehicle (G2V) and Vehicle-to-Grid (V2G) operation to address the challenge of range and charging inconvenience. The proposed system is powered from both solar and grid supply and comprises a centralized charging hub with a smart micro-grid system that can interact with the vehicle's battery management system. The centralized charging hub has a combination of regular and fast-charging modules that can power the batteries of EVs with varying charging requirements. A battery swapping station is integrated into the charging hub to facilitate continuous driving without extended charging times. Additionally, a V2G system is part of the charging hub that enables the charging stations to communicate with the power grid, which allows EVs to feed back their excess battery power to the grid. The proposed system should promote sustainable transportation and mitigate the adverse effects of climate change by providing a fast, reliable, and convenient platform to charge EVs of the future. In addition of software application which mainly book the slots for the customers at anywhere at anytime according to their needs. They can book their slots for nearby stations. This infrastructure helps the customer to decide either for charging or swapping in single station.Software application is mainly works on priority wise based on the booking.

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LIST OF FIGURES

LIST OF ABBREVIATIONS

S.NO	SYMBOL	ABBREVATION
1	EV	ELECTRIC VEHICLE
2	LCD	LIQUID CRYSTAL DISPLAY
3	PV	PHOTO VOLTAIC
4	DC	DIRECT CURRENT
5	AC	ALTERNATIVE CURRENT
6	IDE	INTEGRATED DEVELOPMENT ENVIRONMENT
7	TOU	TIME OF USE
8	AVR	AUTOMATIC VOLTAGE REGULATOR
9	EVSE	ELECTRIC VEHICLE SUPPLY EQUIPMENT
10	LED	LIGHT EMITTING DIODE
11	BCS	BATTERY CHARGING STATION
12	BSS	BATTERY SWAPPING STATION
13	V2G	VEHICLE TO GRID
14	G2V	GRID TO VEHICLE

CHAPTER 1

INTRODUCTION

At present, fuel oil is still the main power source for land transportation, aviation and navigation, and the high demand for fuel oil will also bring a lot of carbon emissions, so the transportation industry has become the second largest source of carbon emissions in the world. Faced with the threat brought by the rapid increase in carbon emissions and oil demand, countries around the world have taken measures such as legislation and policy paths to carry out emission reduction actions. Sustainable transportation has also been proposed and electric vehicles are considered as the most promising sustainable transportation route. The electric vehicle is a vehicle that runs on electricity alone. Unlike conventional vehicles that only use fossil fuels, e-vehicles employ an electric motor to run the wheels.

Electric vehicles (EVs) have developed rapidly over the past decade, and by the end of 2019, the EV population had grown to 7.2 million globally, compared with only 17,000 in 2010. It is widely recognized that the planet is facing increasing risks from carbon emissions and oil supply shortages. Substituting EVs for internal combustion engine vehicles can enhance energy diversification, reduce greenhouse gas emissions, and significantly improve air quality. The promotion of EVs is restricted owing to the high purchase fees battery degradation , long charging time , inconvenient charging facilities and limited traveling distance per charge Hence, researchers have proposed battery charging station (BCS) models to optimize the charging improve operation services, and maximize business profits The material characteristics of batteries and the charging technologies mean that the above optimized BCS models cannot reduce the charging time, which also results in queuing for charging and range anxiety among EV drivers. Hence, the battery swapping station (BSS) model and charging station was proposed as an alternative method for providing energy to EVs. Using the BSS model, an EV owner can drive to a nearby BSS and swap out his/her battery with a low state-of-charge (SOC) for a fully recharged battery in a few minutes, which is comparable to filling a vehicle with fuel at a gasoline station. With the promotion of BSS modes, the BSS service network is maturing in the transportation system, and EV drivers can reach nearby BSSs within an acceptable traveling distance (e.g., 5-10 km) [19]. Advanced battery swapping services, such as battery renting, discount swapping fees and battery upgrade policies, were introduced by NIO to entice drivers to use BSS services. With continuing EV trends, the BSS model is becoming an important method for providing EV energy and is an essential substitution for the BCS model. BSSs can reduce the charging time and improve the operating revenue. Third, the battery packs are charged and managed in a centralized BSS, which can help to improve battery health and reduce the charging cost by allowing an optimal schedule.

1.1 POWER ELECTRONICS

Power electronics is the field of electrical engineering related to the use of semiconductor devices to convert power from the form available from a source to that required by a load. The load may be AC or DC, single-phase or three-phase, and may or may not need isolation from the power source. The power source can be a DC source or an AC source (single-phase or three-phase with line frequency of 50 or 60 Hz), an electric battery, a solar panel, an electric generator or a commercial power supply. A power converter takes the power provided by the source and converts it to the form required by the load. The power converter can be an AC-DC converter, a

DC-DC converter, a DC-AC inverter or an AC-AC converter depending on the application.

1.2 GRID SUPPLY

Grid-tied inverters are designed to feed into the electric power distribution system. They transfer synchronously with the line and have as little harmonic content as possible. They also need a means of detecting the presence of utility power for safety reasons, so as not to continue to dangerously feed power to the grid during a power outage.

1.3 SOLAR PHOTOVOLTAIC (PV)

Solar Photovoltaic (PV) is a technology that converts sunlight (solar radiation) into direct current electricity by using semiconductors. When the sun hits the semiconductor within the PV cell, electrons are freed and form an electric current. Solar PV technology is generally employed on a panel (hence solar panels). PV cells are typically found connected to each other and mounted on a frame called a module. Multiple modules can be wired together to form an array, which can be scaled up or down to produce the amount of power needed.

PV cells can be made from various semi-conductor materials. The most commonly used material today is silicon but other materials, such the ones listed below, are being tested and used to increase the efficiency of converting sunlight to electricity.

- Monocrystalline Silicon
- Polycrystalline Silicon
- Amorphous Silicon
- Cadmium Telluride (CdTe)
- Copper Indium Gallium Selenide (CIGS)

Almost 90% of the world’s PV technologies, today, are based on some variation of silicon. In 2011, about 95% of all shipments by U.S. manufacturers to the residential sector were crystalline silicon solar panels. The major difference between the technologies is the material used to generate electricity out of sunlight. Each type of material has different attributes, resulting in different applications and efficiencies. In general the efficiency of solar PV technologies varies, ranging between 6-18% at the moment.

Solar photovoltaic energy or PV solar energy directly converts sunlight into electricity, using a technology based on the photovoltaic effect. When radiation from the sun hits one of the faces of a photoelectric cell (many of which make up a solar panel), it produces an electric voltage differential between both faces that makes the electrons flow between one to the other, generating an electric current. There are three types of solar panels: photovoltaic, generators of electricity to be supplied to homes; thermal, installed on houses to receive the sun directly; and thermodynamic, which operate in varying weather conditions, i.e. at night, when it’s raining or cloudy. When photovoltaic technology first began, it was used to provide electricity to satellites. According to APPA (the Spanish Association of Renewable Energy Producers), development of photovoltaic panels sped up in the 1950s and has now become an alternative to the use of fossil fuels.

Benefits Of Photovoltaic

Electricity generated by solar photovoltaic panels is inexhaustible and does not pollute, and thus contributes to sustainable development as well as favouring local employment. Likewise, it can be exploited in two different ways: sold to the electricity grid, or consumed in isolated locations where there is no conventional electricity network. As such, it is an especially effective system for remote and rural areas, which cannot be reached by electric power lines, or they are difficult or costly to install, and in countries receiving many hours of sunlight per year. The cost of installing and maintaining solar panels, whose average useful life is over 300 years, has come down noticeably in recent years, as photovoltaic technology has developed. It requires an initial investment and small operational budget, but, once the photovoltaic system is installed, the “fuel” is free and available for life.

1.4 SOLAR INVERTER

A solar inverter is a balance of system (BOS) component of a photovoltaic system and can be used for both, grid-connected and off-grid systems. Solar inverters have special functions adapted for use with photovoltaic arrays, including maximum power point tracking and anti-islanding protection. Solar micro-inverters differ from conventional converters, as an individual micro-converter is attached to each solar panel. This can improve the overall efficiency of the system. The output from several micro inverters is then combined and often fed to the electrical grid.

1.5 POWER ELECTRONICS FOR ELECTRIC VEHICLE

The power electronics for electric vehicle market size was valued at $2.59 billion in 2018, and is projected to reach $30.01 billion by 2026, growing at a CAGR of 35.5% from 2019 to 2026. Power electronics is a circuitry device that transfers power from a source to a load in an efficient, compact, and robust mAIer to ensure convenient utilization. This device is used to control the conversion of electric power from one form to another using diodes, transistors, and thyristors.

In electric cars, power electronic is responsible for converting and controlling electric power in system. Some of the major power electronic components and functionalities are used in electric vehicle system. These include inverter, converter, and on-board charger. Operations at high voltage or high current can be efficiently executed by utilizing power electronic devices, as they deliver faster switching rate at higher efficiency. In addition, power electronics control both unidirectional as well as bidirectional flow of energy, depending on the usage, and the regenerated energy can be sent back to utility.

Power electronic is a key technology used in various applications to optimize energy management, providing the conversion to operate motors, battery storage, and generators. Complex power electronics are represented as the interconnection of conversion blocks in AC/DC, DC/AC, DC/DC, and AC/AC. These complex electrical architectures in marine applications increase the need for power converters with high reliability and simple maintenance requirements.

Power electronics is used in EV that require high power electric energy to rotate the electric motors. Power modules reduce power loss, owing to their high frequency. In addition, the components such as silicon-based power MOSFETs and IGBTs are used as power electronic switches in the power train automotive electric and electronic systems for reducing the overall size.

The major factors that drive the power electronics for electric vehicle market growth include surge in demand for energy-efficient battery-powered devices, stringent emission regulations to reduce vehicle weight and emission, and government initiatives to balance environmental pollution and vehicle emission. However, high cost of vehicle and complexity in designing and integrating advance power electronic components in electric vehicles hinder the power electronics for electric vehicle market growth.

Furthermore, technological advancements in vehicle battery and increase in R&D activities are expected to create lucrative growth opportunities for the power electronics for electric vehicle market. In addition, power electronics support high input impedance and improved parallel current sharing, which increases the adoption of power electronic components in electric cars.

Power Electronics is a field that emerged rapidly in the past 50 years. Power Electronics as a discipline helps to control high current and high voltages (thus significant Power) by the means of semiconductors and modern control system engineering. Power Electronics now has major applications in field like power systems, home appliances and avionics and automotive. These sectors need systems to be controlled based on the amount of power delivery in an efficient mAIer. Thus, Power Electronics is pretty useful in these sectors.

Automotive Sector is seeing a surge of Power Electronics Engineering nowadays. With the advent of modern Electric Vehicles, this discipline is seeing a huge attention. Modern EVs are playground of Power Electronics Engineers and the allied discipline. Let’s find out some applications of Power Electronics in modern EVs which are getting traction.

1.6 VEHICLE DRIVETRAIN:

An EV is driven by motor. Modern EVs use mostly Induction Motors or Permanent Magnet Synchronous Motors. Such motors require Power Electronics for 2 reason, one being that these motors require 3-phase AC to run but the primary power source in an EV is battery pack which produces

DC. Thus, a power electronics converter (DC to AC converter) is a primary requirement.

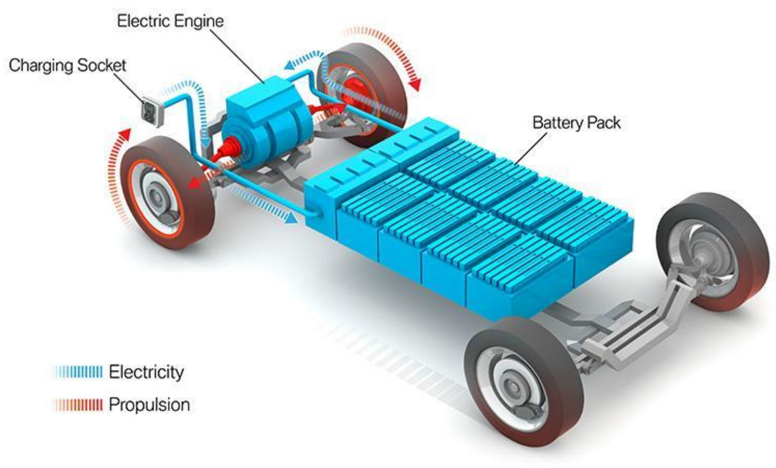

FIGURE 1.1 - VEHICLE DRIVETRAIN

Second being that these motors require current and voltage to be controlled precisely for an efficient operation. Moreover, the power delivery to the motor must be as per the wishes of the driver’s throttle. Thus, precise control is necessary. A 3-phase Voltage Source Inverter is used which is controlled by a Motor Control ECU. These inverters mostly use MOSFETS and IGBT as power switches. The switching can be controlled by the Motor Control ECU based on Field Oriented Control Algorithm or some other advanced control techniques.

1.7 VEHICLE CHARGING:

Off-board chargers/On-board chargers, all are possible due to advances in Power Electronics. In crude terms, chargers are nothing but Rectifiers. Mostly Off-board chargers/fast chargers are 3 phase chargers and on-board chargers are single phase chargers. Fast chargers are 3-phase due to the reason that they consume a higher amount of power which can be supplied only through a 3-phase AC connection. On-board chargers are generally single phase since they are low powered chargers and they can be used in user's residence.

However, modern chargers are more complicated than being a simple rectifier. Modern chargers mostly consist of a PF corrected rectifier at the input or stage 1 to reduce the harmonics injected into the grid from the load. This stage also ensures that AC is converted to DC. After 1st stage, the stage 2 consists of galvanically isolated DC to DC converter to buck or boost the DC voltage as per the demands of battery.

1.8 DC-DC CONVERTER FOR AUXILIARY LOADS:

An EV also has an additional DC-DC converter to drive the lights, horns and to power the ECUs. This is required since the main source of power in an EV is a high voltage battery pack. This voltage will be in range from 48V (for a small low powered EV) to even upto 800 V for buses or trucks. However, the lights, horns, wipers and ECUs run on 12V/24V. Thus, the DC voltage has to be stepped down to lower voltage. These loads are generally referenced to the chassis ground which floats with respect to the high voltage battery pack ground. Thus, a transformer based galvanically isolated DCDC converter is used for this purpose.

1.9 SOME OTHER APPLICATION (MISCELLANEOUS):

The application of Power Electronics is not restricted to only these applications mentioned above. There are other applications like driving compressors for Battery pack cooling, HVAC, EPS and many more. Any place, how small be it, if it requires power to be controlled, it requires power electronics.

CHAPTER 2

LITERATURE SURVEY

2.1 *Albert Y.S. Lam, Yiu-Wing Leung,* "ELECTRIC VEHICLE CHARGING STATION PLACEMENT: FORMULATION, COMPLEXITY, AND SOLUTIONS " - 2014

To enhance environmental sustainability, many countries will electrify their transportation systems in their future smart city plans, so the number of electric vehicles (EVs) running in a city will grow significantly. There are many ways to recharge EVs' batteries and charging stations will be considered as the main source of energy. The locations of charging stations are critical; they should not only be pervasive enough such that an EV anywhere can easily access a charging station within its driving range, but also widely spread so that EVs can cruise around the whole city upon being recharged. Based on these new perspectives, we formulate the EV charging station placement problem (EVCSPP) in this paper. We prove that the problem is nondeterministic polynomial-time hard. We also propose four solution methods to tackle EVCSPP, and evaluate their performance on various artificial and practical cases. As verified by the simulation results, the methods have their own characteristics and they are suitable for different situations depending on the requirements for solution quality, algorithmic efficiency, problem size, nature of the algorithm, and existence of system prerequisite.

2.2 *Zhipeng Liu, Fushuan Wen*, "OPTIMAL PLANNING OF ELECTRIC-VEHICLE CHARGING STATIONS IN DISTRIBUTION SYSTEMS" - 2013

With the progressive exhaustion of fossil energy and the enhanced awareness of environmental protection, more attention is being paid to electric vehicles (EVs). Inappropriate sitting and sizing of EV charging stations could have negative effects on the development of EVs, the layout of the city traffic network, and the convenience of EVs' drivers, and lead to an increase in network losses and a degradation in voltage profiles at some nodes. Given this background, the optimal sites of EV charging stations are first identified by a two-step screening method with environmental factors and service radius of EV charging stations considered. Then, a mathematical model for the optimal sizing of EV charging stations is developed with the minimization of total cost associated with EV charging stations to be planned as the objective function and solved by a modified primal-dual interior point algorithm (MPDIPA). Finally, simulation results of the IEEE 123-node test feeder have demonstrated that the developed model and method cannot only attain the reasonable planning scheme of EV charging stations, but also reduce the network loss and improve the voltage profile.

2.3 *Guibin Wang, Zhao Xu*, "TRAFFIC-CONSTRAINED MULTIOBJECTIVE PLANNING OF ELECTRIC-VEHICLE CHARGING STATIONS" - 2013

Smart-grid development calls for effective solutions, such as electric vehicles (EVs), to meet the energy and environmental challenges. To facilitate large-scale EV applications, optimal locating and sizing of charging stations in smart grids have become essential. This paper proposes a multi objective EV charging station planning method which can ensure charging service while reducing power losses and voltage deviations of distribution systems. A battery capacity-constrained EV flow capturing location model is proposed to maximize the EV traffic flow that can be charged given a candidate construction plan of EV charging stations. The data-envelopment analysis method is employed to obtain the final optimal solution. Subsequently, the well-established cross-entropy method is utilized to solve the planning problem.

2.4 *Weifeng Yao, Junhua Zhao*, "A MULTI-OBJECTIVE COLLABORATIVE PLANNING STRATEGY FOR INTEGRATED POWER DISTRIBUTION AND ELECTRIC VEHICLE CHARGING SYSTEMS" - 2014

An elaborately designed integrated power distribution and electric vehicle (EV) charging system will not only reduce the investment and operation cost of the system concerned, but also promotes the popularization of environmentally friendly EVs. In this context, a multi-objective collaborative planning strategy is presented to deal with the optimal planning issue in integrated power distribution and EV charging systems. In the developed model, the overall annual cost of investment and energy losses is minimized simultaneously with the maximization of the annual traffic flow captured by fast charging stations (FCSs). Additionally, the user equilibrium based traffic assignment model (UETAM) is integrated to address the maximal traffic flow capturing problem. Subsequently, a decomposition based multi-objective evolutionary algorithm (MOEA/D) is employed to seek the non-dominated solutions, i.e., the Pareto frontier. Finally, collaborative planning results of two coupled distribution and transportation systems are presented to illustrate the performance of the proposed model and solution method.

2.5 *Nick Machiels, Niels Leemput*, "DESIGN CRITERIA FOR ELECTRIC VEHICLE FAST CHARGE INFRASTRUCTURE BASED ON FLEMISH MOBILITY BEHAVIOR" - 2014

This paper studies the technical design criteria for fast charge infrastructure, covering the mobility needs. The infrastructure supplements the residential and public slow charging infrastructure. Two models are designed. The first determines the charging demand, based on current mobility behaviour in Flanders. The second model simulates a charge infrastructure that meets the resulting fast charge demand. The energy management is performed by a rule-based control algorithm that directs the power flows between the fast chargers, the energy storage system, the grid connection, and the photovoltaic installation. There is a clear trade-off between the size of the energy storage system and the power rating of the grid connection. Finally, the simulations indicate that 99.7% of the vehicles visiting the fast charge infrastructure can start charging within 10 minutes with a configuration limited to 5 charging spots, instead of 9 spots when drivers are not willing to wait.

2.6 *Hongcai Zhang, Zechun Hu,* "AN INTEGRATED PLANNING FRAMEWORK FOR DIFFERENT TYPES OF PEV CHARGING FACILITIES IN URBAN AREA"- 2015

To build a properly planned infrastructure for plugin electric vehicle (PEV), charging will bolster their market acceptance. Different types of PEV charging facilities for private PEVs, including public charging spots deployed in public parking lots (PLCSs) and roadside fast-charging stations (FCSs), are substitutes for each other. This paper proposes an integrated planning framework for them in an urban area from the perspective of a social planner. The planning objective is to minimize the social costs of the whole PEV charging system. The proposed framework decouples the planning for different types of charging facilities. The spatial and temporal charging demands for FCSs are generated by a charging demand forecasting method, when the quantities of different types of PLCSs are given. The optimal sitting and sizing problem of FCSs is solved by Voronoi diagram together with particle swarm optimization algorithm. By traversing the quantities of different types of PLCSs, the optimal planning results are obtained. The effectiveness of the proposed framework is verified via a case study of a real-urban area in China. The substitution effect between different types of charging facilities is studied. The impacts of the ambient temperature, the private charging spot possession rate, and the service level of PLCSs on the planning results are also assessed.

2.7 ***WencongSu,Mo-Yuen Chow*, "PERFORMANCE EVALUATION OF AN EDA-BASED LARGE-SCALE PLUG-IN HYBRID ELECTRIC VEHICLE CHARGING ALGORITHM" - 2012**

The anticipation of a large penetration of plug-in hybrid electric vehicles (PHEVs) into the market brings up many technical problems that need to be addressed. In the near future, a large number of PHEVs in our society will add a large-scale energy load to our power grids, as well as add substantial energy resources that can be utilized. An emerging issue is that a large number of PHEVs simultaneously connected to the grid may pose a huge threat to the overall power system quality and stability. In this paper, the authors propose an algorithm for optimally managing a large number of PHEVs (e.g., 3000) charging at a municipal parking station. The authors used the estimation of distribution algorithm (EDA) to intelligently allocate electrical energy to the PHEVs connected to the grid. A mathematical framework for the objective function (i.e., maximizing the average state-of charge at the next time step) is also given. The authors considered real-world constraints such as energy price, remaining battery capacity, and remaining charging time. The authors also simulated the real-world parking deck scenarios according to the statistical analysis based on the transportation data. The authors characterized the performance of EDA using a Mat lab simulation, and compared it with other optimization techniques.

2.8 *W.Li, T. Logenthiran, V. T. Phan, and W. L. Woo,* "IMPLEMENTED IOT BASED SELF-LEARNING HOME MANAGEMENT SYSTEM (SHMS) FOR SINGAPORE," IEEE Internet of Things Journal, pp. 1–1, 2018.

Internet of things (IoT) makes deployment of smart home concept easy and real. Smart home concept ensures residents to control, monitor and manage their energy consumption without any wastage. This paper presents a self-learning Home Management System (SHMS). In the proposed system, a Home Energy Management System (HEMS), Demand Side Management (DSM) system, and Supply Side Management (SSM) system were developed and integrated for real time operation of a smart home. This integrated system has some capabilities such as Price Forecasting (PF), Price Clustering (PC) and Power Alert System (PAS) which to enhance its functions. These enhancing capabilities were developed and implemented using computational and machine learning technologies. In order to validate the proposed system, real-time power consumption data was collected from a Singapore smart home and a realistic experimental case study was carried out. The case study has shown that the developed system has performed well and created energy awareness to the residents. This proposed system also displays its ability to customize the model for different types of environments compared to traditional smart home models.

2.9 *Weixian Li , Thillainathan Logenthiran, Van-Tung Phan,* "HOUSING DEVELOPMENT BUILDING MANAGEMENT SYSTEM (HDBMS) FOR OPTIMIZED ELECTRICITY BILLS," Transactions on Environment and Electrical Engineering, vol. 2, no. 2, pp. 64–71, 2017.

Smart Buildings is a modern building that allows residents to have sustainable comfort with high efficiency of electricity usage. These objectives could be achieved by applying appropriate, capable optimization algorithms and techniques. This paper presents a Housing Development Building Management System (HDBMS) strategy inspired by Building Energy Management System (BEMS) concept that will integrate with smart buildings using Supply Side Management (SSM) and Demand Side Management (DSM) System. HDBMS is a MultiAgent System (MAS) based decentralized decision making system proposed by various authors. MAS based HDBMS was created using JAVA on a IEEE FIPA compliant multi-agent platform named JADE. It allows agents to communicate, interact and negotiate with energy supply and demand of the smart buildings to provide the optimal energy usage and minimal electricity costs. This results in reducing the load of the power distribution system in smart buildings which simulation studies has shown the potential of proposed HDBMS strategy to provide the optimal solution for smart building energy management.

2.10 ***C. Yang, J. Yao, W. Lou, and S. Xie*****, "ON DEMAND RESPONSE MANAGEMENT PERFORMANCE OPTIMIZATION FOR MICROGRIDS UNDER IMPERFECT COMMUNICATION CONSTRAINTS," IEEE Internet of Things Journal, 2017.**

A perfect bidirectional communication network is a common assumption in smart grids. However, it is unrealistic, especially in the neighborhood area network of microgrids. Due to the channel fading, large volumes of transmission data and considerable communication cost, the imperfect communications affect the system performance directly. In this paper, we consider the uncertainty of imperfect communications in both supply and demand sides, which affects the microgrid system performance in terms of the packet loss ratio of the power demand data transmission and the forecasting accuracy ratio of the renewable energy generation. We analyze the impacts of imperfect communications on the demand response management (DRM) performance under the real-time pricing scheme. An optimization problem is formulated firstly to maximize the DRM performance of the microgrid system. As these impacts can be mitigated by using sufficient spectrum resources, we then propose a spectrum resource allocation scheme that considers different characteristics of transmission data and system communication cost to balance the tradeoff between the DRM performance and the incurred communication cost. We introduce a joint optimization problem that not only maximizes the DRM performance but also minimizes the communication cost. Simulation results reveal the impacts of imperfect communications on the DRM performance and power price, and the efficiency of the proposed optimization problems.

CHAPTER 3
PRESENT EV BATTERY HANDLING INFRASTRUCTURE BATTERY SWAPPING AND CHARGING STATION

A solar-powered battery charging scheme under partial shading of solar panels. The conventional system uses the Cauchy–Gaussian sine cosine optimization method for the maximum power point tracking.

A large portion has been devoted to introducing scientific/logical approaches to deal with various design and implementation issues. Besides, these works talk about hypothetical instead of functional contextual investigations, utilizing restricted and accepted information, as opposed to genuine and complete informational collections on account of this article.

3.1 BATTERY SWAPPING

An alternative battery recharging method that is receiving global attention is battery swapping, in which a depleted EV battery is removed from the vehicle and replaced with a fully charged one. The technology is being tried out for various EV segments, including e-2Ws, e-3Ws, e-cars and even e-buses.

Manual

The battery swapping station is a standalone device, in which batteries are placed and removed manually from the individual slots, usually by hand. Manual swapping stations are modular and occupy a minimal amount of space. These are used for 2W and 3W battery applications, as the battery pack sizes are smaller and the weight can be handled by one or two persons.

Autonomous

A robotic arm is used in these types of swapping stations with the battery swapping process being semi/fully automated. Robotic swapping is used for 4W and e-bus applications as battery packs are larger and heavier, and require mechanical assistance. These swapping stations are also more expensive and have a higher land requirement.

Battery swapping has some distinct advantages over plug-in charging but is also confronted with several challenges in its development as a mainstream charging method.

At present, battery swapping is considered a feasible solution for commercial EV fleets, especially in the e-2W and e-3W segments. The Ministry of Road Transport and Highways (MoRTH) has allowed the sale and registration of EVs without batteries, which provides a huge boost to battery swapping solutions. Further, industry stakeholders are making large investments in developing the battery swapping ecosystem. This indicates that battery swapping will emerge as a distinct part of EV charging networks in India in the coming years.

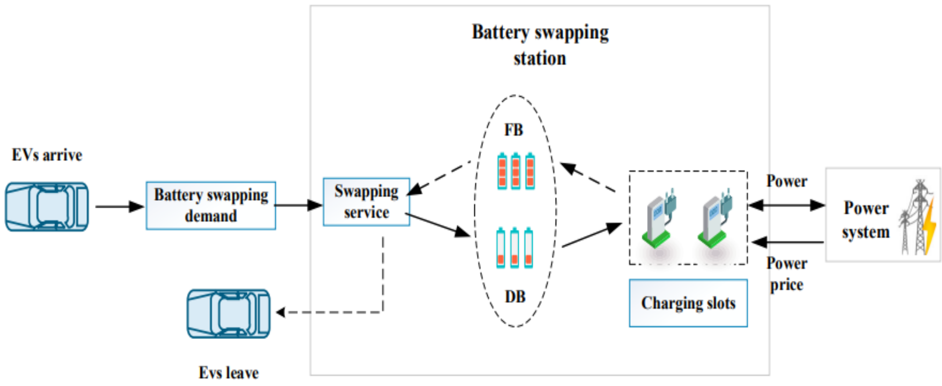

FIGURE 3.1 - OPERATION OF BSS

3.2 CHARGING STATION

Electric vehicles (EV) can be charged in a variety of ways, depending on location and requirement. Accordingly, charging infrastructure for EVs is of different types and designed for different applications. Specifications and standards for EV chargers, also known as electric vehicle supply equipment (EVSE), vary from one country to another, based on available EV models in the market and the characteristics of the electricity grid. Charging stations refer to high-power EVSE, typically Mode 3 or Mode 4 charging, often with multiple charging guns. Charging points refer to normal power EVSE that can be accessed by a portable charging cable. While the initial deployment of public charging infrastructure in India focused on charging stations, it is increasingly evident that most public charging needs can be served by a densely distributed network of charging points.

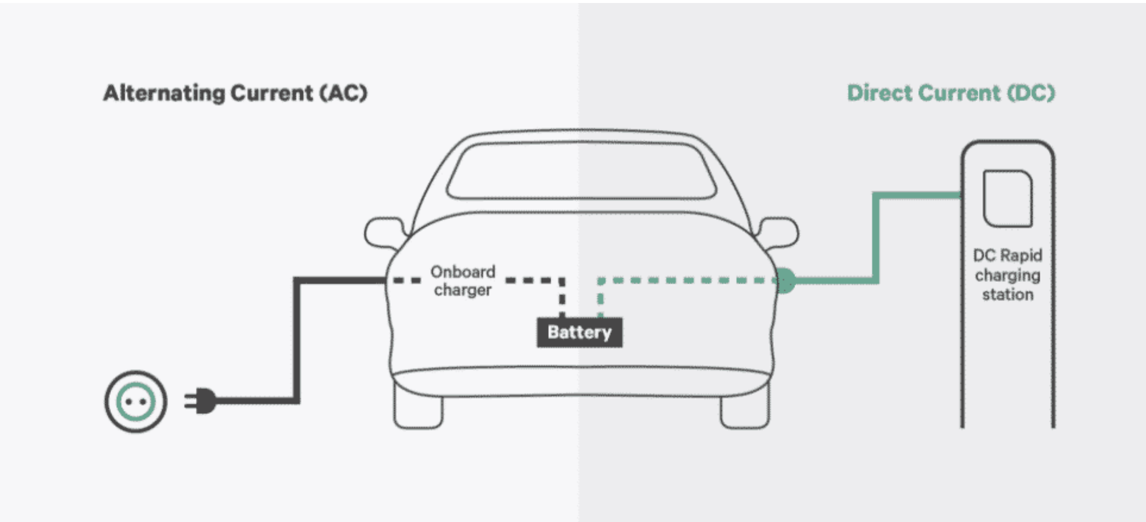

FIGURE 3.2 - OPERATION OF CHARGING STATION

An EV charging network comprising many normal powered charging points is preferable to one with limited high-power charging stations. For EVs, any parking location where the vehicle is stationary, and which has access to an EV charging point, can be an opportunity to recharge the vehicle battery. This is also known as destination charging, as opposed to “on the-go charging” in which vehicles rapidly top up their battery charge to drive onwards to their destinations. Therefore, EV charging infrastructure should be provided in locations where vehicles are parked on a regular basis, rather than carving out new locations for EV charging hubs. This approach to charging infrastructure implementation promotes a distributed network of EV charging points for users to plug into at various locations - at residences, apartment buildings, office campuses, shopping malls, metro and railway stations, bus depots, etc. Such a distributed network approach has multiple advantages for users and operators, ranging from ease of access to financial viability.

3.3 EASE OF ACCESS TO EV CHARGING

By providing EV charging points at locations where vehicles tend to park, EV users can charge their vehicles while they are parked, thereby saving time, and eliminating the distance one must travel to access public charging.

3.4 USE OF NORMAL POWER CHARGING POINTS

A dense network of normal-power EV charging points reduces the need for high power and ultra-high power charging points, which are more expensive and can be detrimental to EV battery health if over-used.

3.5 COST-EFFICIENCY OF CHARGING INFRASTRUCTURE

Normal power charging points are not only less expensive, but they also require less electricity and less space, which further reduces capital costs.

3.6 FINANCIAL VIABILITY OF EV CHARGING

Lowering the upfront costs of setting up charging infrastructure reduces the need for government subsidies and improves the viability of private sector participation in charging operations. An efficient rollout of EV charging infrastructure for a young EV market needs to focus more on increasing the number of accessible charging points. The distributed provision of many normal power charging points, supplemented by a small share of high-power charging stations, can ensure that EV charging needs are efficiently met.

3.7 DRAWBACKS

- Low efficiency than the conventional VSI inverter
- Over filtering takes place due to CL-CL filter
- Higher power conduction loss
- Larger number of components
- Not capable of connecting low voltage input to the grid;

EVs have to overcome the lack of range, long charging times, and the lack of infrastructure before consumers will be willing to buy them. To realize the large-scale popularization of electric vehicles, mature battery technology and the construction of basic charging facilities.

CHAPTER 4

DESIGN OF COMBINED BATTERY SWAPPING AND CHARGING INFRASTRUCTURE

An EV charging demand and swapping assessment can feed into different aspects of charging infrastructure planning. It can be used as input data to set targets for the number of public EV chargers, as we will discuss in this chapter. It can also be used for location planning for public charging and swapping infrastructure and to analyze grid capacity and the need for enhancements.

Location planning for public charging and swapping infrastructure can be conducted through a digitized geospatial analysis or as an on-ground exercise, depending on the scale of planning and the quality of geospatial data available. At an urban or regional scale, a mixed approach to location planning is recommended. A macro-level geospatial analysis can be conducted to identify potential charging demand and the resultant public charging requirements at a unit area level. At the area level, site selection for installation of public chargers can be carried out on-ground, in consultation with landowners and local government representatives in the area.

Plug-in Hybrid Electric Vehicles (PHEVs) offer one form of solution by including a combustion engine, meaning that they can complete most journeys without recharging the vehicle. However, this will not solve the problem for Battery Electric Vehicles (BEVs), which need to be charged much more frequently and urgently.

4.1 PROPOSED BLOCK DIAGRAM

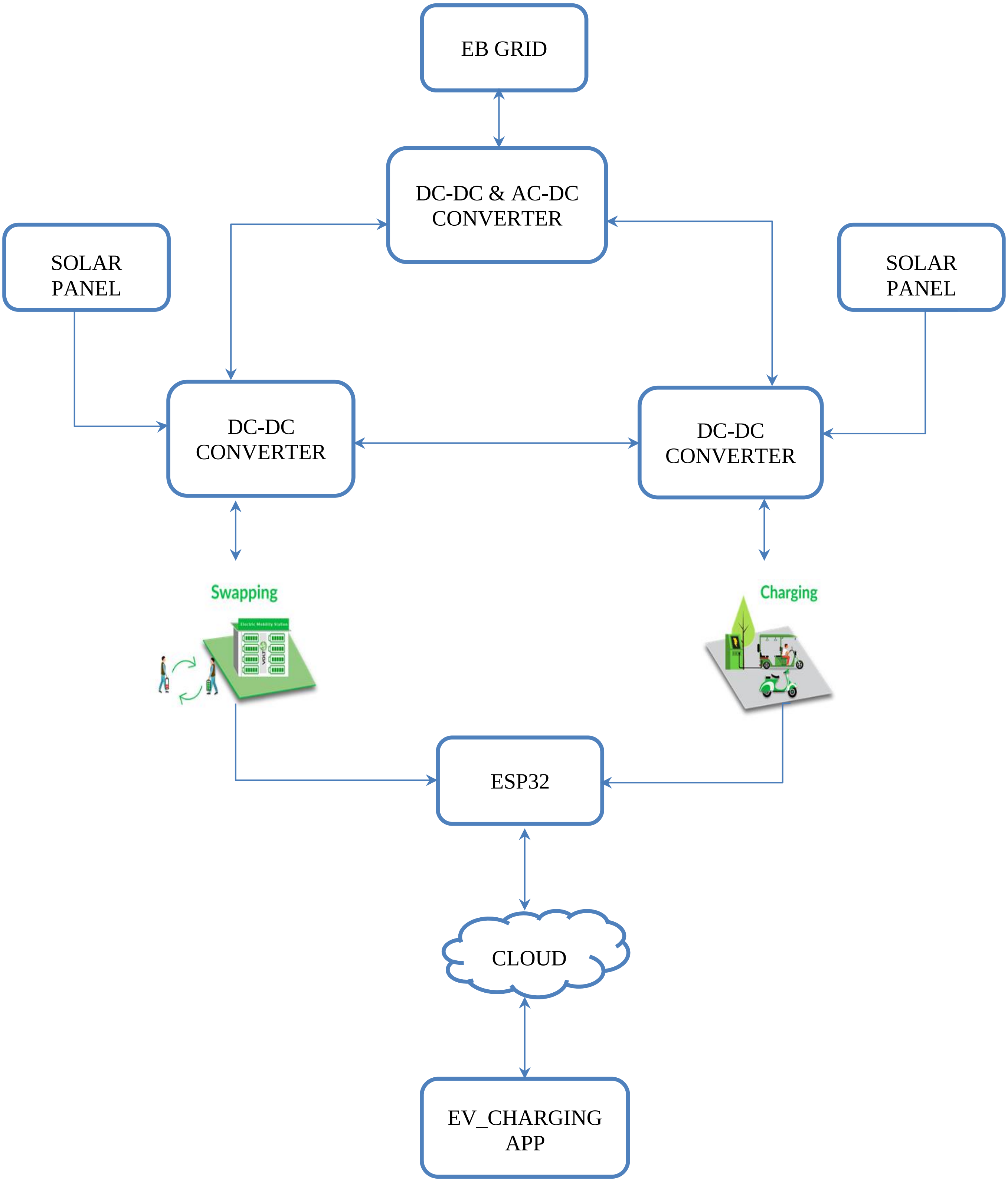

FIGURE 4.1 - BLOCK DIAGRAM

SOLAR PANEL

PV panel is designed for the efficient storage of power system. The power obtained by PV panel is boosting up the power the DC-DC converter is used. This can be helpful for the charging of battery in vehicle automatically while the battery is in ON condition.

EB GRID

EB Grid is also designed for the efficient storage of power system during periods of low solar radiation, the power obtained by the grid is stepped down by step-down transformer

CONVERTER

This is then connected to the AC-DC converter,this can be used to store the power in the grid for further usage. For storing power in station batteries, solar power is stored using a DC-DC converter. A voltage source controller is utilized for achieving efficient conversion of DC power. Similarly, the DC power is fed to the battery source for further charging of the battery. EV charging involves supply of direct current (DC) to the battery pack. As electricity distribution systems supply alternate current (AC) power, a converter is required to provide DC power to the battery.

Conductive charging can be AC or DC. In the case of an AC EVSE, the AC power is delivered to the onboard charger of the EV, which converts it to DC. A DC EVSE converts the power externally and supplies DC power directly to the battery, bypassing the onboard charger.

ESP32

ESP32 microcontroller can be used in the design and development of combined battery swapping and charging infrastructure by solar panel where the values are displayed in the LCD with the help of the controller.

CLOUDS

Clouds is used to access the data from both ESP32 and App.cloud-based management software updates are significant in ensuring the effective management of charging stations, enhancing the value and sustainability of charging infrastructure.

SOFTWARE APPLICATION

The application can also automatically allocate charging and swapping slots based on the availability of resources, such as solar power, battery capacity, and grid demand, to ensure that the process is efficient and effective.

4.2 UPGRADE FROM EXISTING SYSTEM

- The solar hybrid EV charging and swapping station being a financially sustainable model will attract more players to invest in the project.
- This will increase the number of EV charging stations and help in higher penetration of EVs in the market.
- Various segments, for instance, recharging and swapping infrastructure, approach and methodology adopted, and communication, signalling.
- App which helps in booking the slots from everywhere according to our need either for charging or for swapping.
- The most important extra charge from the swapping station is directly connected to the charging station which helps to increase the lifetime of swapping batteries as well as to reduce power consumption.
- All those things which results in less time management, easy control aspects applicable to the EV charging and swapping process.

CHAPTER 5

DEVELOPMENT OF COMBINED BATTERY SWAPPING AND CHARGING INFRASTRUCTURE

5.1 CIRCUIT DIAGRAM OF COMBINED BATTERY SWAPPING AND CHARGING INFRASTRUCTURE

FIGURE 5.1 CIRCUIT DIAGRAM

5.2 HARDWARE REQUIREMENTS

- Grid Supply
- Transformer
- Solar Panel
- DC-DC Converter
- AC-DC Converter
- ESP32
- LCD
- Voltage Sensor
- Relay
- Battery

GRID SUPPLY

Grid power supply is a source of electricity that can be used in conjunction with solar power to provide energy for the combined battery swapping and charging infrastructure. Grid power supply performs several functions in the design and development of combined battery swapping and charging infrastructure by solar panel.

Backup Power: Grid power supply can provide backup power to the charging and swapping infrastructure during periods of low solar radiation or in case of a sudden drop in stored solar power.

Power Management: Grid power can act as a power management source, ensuring that electricity can be distributed appropriately based on the level of demand for charging and swapping stations. This means that charging and swapping stations can receive uninterrupted power during peak hours.

Grid-Saving Energy: Grid power supply can be used as a storage battery for excess electricity generated by solar panels, where the surplus power is relayed back to the grid, reducing grid use.

Charging During Low Solar Radiation: Grid power supply can be used as an alternative source of power to charge electric vehicles during periods of low solar radiation or during the night when solar power is not available, ensuring consistent power supply throughout the day.

Rapid Charging: With the grid, the charging time for electric vehicles can be significantly reduced, thereby satisfying user demands and ensuring adherence to electric vehicle schedules.

In this system where the supply to the batteries is coming from the solar panel, where the power supply from the panels is about 3 volts.

TRANSFORMER

Transformers are electrical devices that are essential in the design and development of combined battery swapping and charging infrastructure by a solar panel. They perform several functions necessary for the proper operation of the infrastructure. Below are the functions of transformers.

Voltage Regulation: Transformers help regulate voltage during the charging of electric vehicle batteries. The voltage coming from the solar panels fluctuates due to changes in sunlight intensity, while electric vehicle batteries require a constant voltage. Transformers ensure voltage consistency, preventing overcharging or undercharging of electric vehicle batteries.

Conversion of AC and DC Power Output: Solar panels produce Direct Current (DC) power, while electric vehicles require Alternating Current

(AC) power. A transformer is used to convert DC power into AC power that is compatible with electric vehicles.

Transformers are essential in the design and development of combined battery swapping and charging infrastructure by solar panel. Their functions include voltage regulation, conversion of AC and DC power output, isolation, protection, efficiency, and scalability.In this system where across 4 to 5 volts is taken from the transformer where this power source is used for the system operation.

SOLAR PANEL

Solar panels are a critical component in the design and development of combined battery swapping and charging infrastructure by solar panel. Solar panels absorb sunlight and convert it into direct current (DC) electricity. Here are some of the functions of solar panels:

Renewable Energy Source: Solar panels allow for the use of renewable energy sources, providing an alternative to traditional energy sources such as fossil fuels or grid power. This reduces reliance on non-renewable energy sources and helps to mitigate climate change.

Energy Independence: By generating electricity via solar panels during the day, charging infrastructure can operate independently of grid power, providing charging solutions in remote areas or areas with insufficient infrastructure.

Solar panels are a crucial component of the design and development of combined battery swapping and charging infrastructure by solar panel. They provide a renewable, sustainable, cost-effective, scalable, and low-maintenance energy source. Additionally, solar panels lead to reduced carbon footprint and energy independence, which can be advantageous in many applications. The use of solar panels makes charging electric vehicle batteries more eco-friendly and sustainable, thereby helping to mitigate climate change.

DC-DC CONVERTER

A DC to DC converter is an electronic device that is used to convert one DC voltage level to another DC voltage level. In the design and development of combined battery swapping and charging infrastructure by solar panel, a DC to DC converter plays an essential role. Here are some of the functions of a DC to DC converter in the design and development of combined battery swapping and charging infrastructure by solar panel:

Energy Efficiency: A DC to DC converter effectively converts the DC voltage levels of the solar panel to match the voltage required for charging the electric vehicle batteries. This ensures efficient power transfer and optimal energy use throughout the system.

Charge Control & Current Limiting: DC to DC converters provide charge limiting, which controls the current supplied to electric vehicle batteries. This allows the user to control and manage the charging process, ensuring that the batteries are charged optimally and adequately to meet the electric vehicle's requirements.

Optimizes charge time: DC to DC converters can decrease charge times by efficiently transforming the voltage level to match the electric vehicle's requirements, thus minimizing a user's wait time and providing efficient use of the charging station.

In this system, 3 volts DC source is converted or boosted to 6 volts DC and it is given to the battery.

AC-DC CONVERTER

. In this system where power supply from the grid is about AC where we know that a battery can't store AC instead of DC as an energy storage device.So here AC-DC converter is provided. In the design and development of combined battery swapping and charging infrastructure by solar panel, AC to DC converters play an essential role. Here are some of the functions of AC to DC converters:

Voltage Regulation: AC to DC converters can regulate voltage levels across various input voltages, ensuring optimal voltage levels for the charging and swapping process.

Efficient Power Transfer: AC to DC converters can transform the AC input to a DC output, allowing for more efficient power transfer to the charging and swapping process.

Charge Control: AC to DC converters can control and regulate the charging process by modifying the input AC power to provide the correct power supply for the charging process.

Increased Efficiency: AC to DC converters have high efficiency, allowing for a more efficient charging and swapping process.

ESP32-S3

ESP32 is a microcontroller that can be used in the design and development of combined battery swapping and charging infrastructure by solar panel. ESP32 comes with various features that make it versatile and suitable for the development of such an infrastructure. Below are some functions of ESP32 in the development of combined battery swapping and charging infrastructure by solar panel.

Connectivity: ESP32 offers various connectivity options such as Wi-Fi, Bluetooth, and Ethernet, providing a reliable and fast connection to the internet or other devices. This allows for remote monitoring, control, and management of the charging and swapping infrastructure.

Sensor Data Acquisition: ESP32 is equipped with analog-to-digital converters (ADCs) that enable it to collect sensor data from sensors such as temperature and humidity sensors. The collected data can be used to monitor the environment where the charging and swapping stations are installed, optimizing the performance of solar panels.

Data Processing: ESP32 can be used to execute complex algorithms for data processing and real-time control of the charging and swapping infrastructure. This allows for the implementation of advanced control systems for efficient charging and swapping of electric vehicle batteries.

Security and Encryption: ESP32 offers data encryption and security features that ensure secure communication between the charging and swapping infrastructure, reducing the risks of data theft and hacking.

Automation: ESP32 can be used to automate the charging and swapping process by integrating with other hardware components such as battery chargers and swapping systems.

ESP32 microcontroller can be used in the design and development of combined battery swapping and charging infrastructure by solar panel where the values are displayed in the LCD with the help of the controller. This controller reads the input (for example values sensed in the batteries and grid) and decide the output to be displayed. It offers connectivity, sensor data acquisition, data processing, security and encryption, automation, and cost-effectiveness.

FIGURE 5.2 - ESP32 – Node MCU

LCD (LIQUID CRYSTAL DISPLAY)

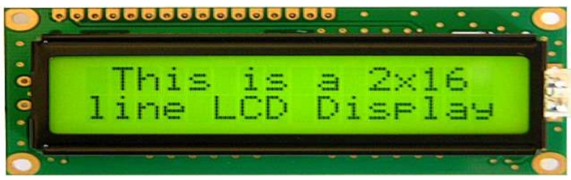

FIGURE 5.3 - LCD DISPLAY

LCD, which stands for Liquid Crystal Display, is a type of display screen that can be used in the design and development of combined battery swapping and charging infrastructure by solar panel. An LCD screen can be used for a range of purposes, including graphical user interface, real-time monitoring, and control functions. Here are some of the functions of an LCD in designing and developing battery swapping and charging infrastructure by solar panel:

User Interface: An LCD can function as a graphical user interface, displaying charging or swapping status, electric vehicle battery viewing, and transaction status. This allows for easy operation of the charging and swapping infrastructure and enhances the user experience.

System Status Monitoring: An LCD can display real-time system status monitoring information, such as the charging voltage, charging and swapping station temperature, and battery charging status. This can aid in system diagnostics, especially during maintenance or fault finding.

Alerts: In case of any fault, such as overcharging, overheating or power surge, an LCD can display an alert message or warning. This can help prevent damage to the charging and swapping infrastructure and protect the safety of equipment and users.

VOLTAGE SENSOR

FIGURE 5.4 - VOLTAGE SENSOR

Voltage sensors are essential in the design and development of combined battery swapping and charging infrastructure by solar panel. Here are some of the functions of voltage sensors:

Battery Monitoring: Voltage sensors can monitor and detect the battery's voltage level and relay the information to the charging station controller, allowing for more precise control of the charging process.

Voltage Regulation: Voltage sensors can accurately measure the input voltage to the charging station and provide information that is used to regulate the voltage levels delivered to the batteries. This helps in preventing potential overvoltage and undervoltage, which could damage the batteries.

Fault Detection: Voltage sensors can detect faults such as grounding or short circuits, that could potentially inflict damage on the charging infrastructure or batteries.

RELAY

Relays play important functions in the design and development of combined battery swapping and charging infrastructure by solar panel. Here are some of the functions of relays in this context:

Power Control: Relays are used to control the power supply to various components of the charging station, including switching between the solar panels and the grid power, and directing power to the battery storage and charging components.

They help in power control, battery swapping mechanism control, overcurrent and overload protection, fault detection, isolation and protection of electrical infrastructure, and more. Relays enhance a safer and reliable charging process of electrical vehicles by allowing precise control and monitoring of the power, which optimizes energy efficiency, reduces costs and promotes high-quality power supply.

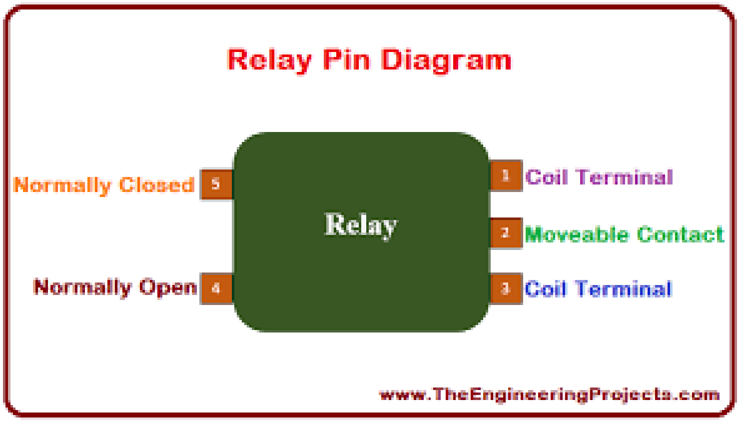

FIGURE 5.5 - RELAY

BATTERY

ChargePoint

A charging station, also known as a charge point or electric vehicle supply equipment (EVSE), is a piece of equipment that supplies electrical power for charging plug-in electric vehicles.

Battery in swapping station

Here 3 lithium ion batteries are used each with 3.7 volts. Battery swapping systems can be categorized into two types: Manual battery swapping systems – This is a system where the batteries are placed and removed from the charging source manually by hand. The Manual swapping stations are modular and occupy less space compared to the other type of charging station.

FIGURE 5.6 - BATTERY FOR SWAPPING

Battery in charging station

Here in this 3 batteries are used which is an lead acid battery each with 4 volts one amps.

FIGURE 5.7 - BATTERY FOR CHARGING

5.3 SOFTWARE REQUIREMENTS

- Arduino IDE

ARDUINO

Arduino is an open-source microcontroller platform that is used in many applications, including the design and development of combined battery swapping and charging infrastructure by solar panel. Arduinos play a significant role in the design and development of combined battery swapping and charging infrastructure by solar panel. They control and automate the charging and swapping process, acquire and process data, integrate with other microcontrollers and devices, provide user interfaces, diagnostic tools, and device management. Arduinos help in making the charging and swapping infrastructure efficient, reliable, and sustainable, thereby enhancing the performance of electric vehicles, and reducing their carbon footprint.

STARTED WITH THE ARDUINO NANO

The Arduino Nano offers the same connectivity and specs of the UNO board in a smaller form factor.

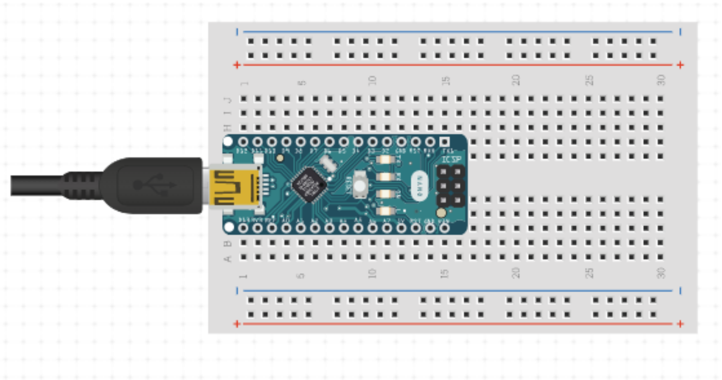

FIGURE 5.8 - ARDUINO NANO INTERFACE

The Arduino Nano is programmed using the Arduino Software (IDE), our Integrated Development Environment common to all our boards and running both online and offline.

Arduino Nano on the Arduino Desktop IDE

To connect the Arduino Nano to your computer, you'll need a Mini-B USB cable. This also provides power to the board, as indicated by the blue LED.

FIGURE 5.9 - NANO INTERFACING USB TYPES OF PORTS

CHAPTER 6

OVERVIEW OPERATION OF COMBINED BATTERY CHARGING AND SWAPPING FOR EV ENABLED G2V AND V2G OPERATION

FIGURE 6.1 - CIRCUIT DIAGRAM

6.2 STEP BY STEP WORKING PRINCIPLE OF COMBINED BATTERY CHARGING AND SWAPPING

STEP 1: The solar panel generates renewable energy by converting sunlight into electricity that powers the charging and swapping infrastructure.

STEP 2: The grid system supplements the charging infrastructure when solar energy is insufficient or as a fail-safe backup

STEP 3: The power obtained from the grid is stepped down using a step down transformer.

STEP 4: From step down transformer it moves to AC-DC converter. AC-DC converter can regulate voltage levels across various input voltages, ensuring optimal voltage levels and transform the AC input to a DC output for the charging and swapping process.

STEP 5: The power obtained from the PV module was boosted by using a boost converter where DC power is converted to DC by DC-DC converter and given to batteries.DC-DC converter used to convert one DC voltage level to another DC voltage level.

STEP 6: From DC-DC converter the swapping and charging station get charged.

STEP 7: The ESP32 connects with the local network to communicate with the charging station controller, authorization server and display information to the user.

STEP 8: The LCD display shows the details about the power supply as to where it is coming either from the grid or from the PV module. The voltage level is also displayed.

STEP 9: Develop a software application that allows EV drivers to book time slots for charging or swapping their batteries, based on their preferences and availability.

STEP 10: Based on the needs of customers they can either swap their batteries or charge their batteries.

STEP 11: The application can also automatically allocate charging and swapping slots based on the availability of resources, such as solar power, battery capacity, and grid demand, to ensure that the process is efficient and effective.

6.3 FUNCTION OF SOFTWARE APPLICATION EV_CHARGING

Generally in electric vehicle charging and swapping station,people have to wait for their turn to get charging as well as swapping. Which requires more time. In this software application ,people can book their slots from anywhere at any time. This applicaton based on the priority wise ,first come will have first priority.

FIGURE 6.2 - HOME PAGE OF APP

In this application there are three login which helps user as well as admin of the stations

- User login
- Charging station
- Admin login

USER LOGIN

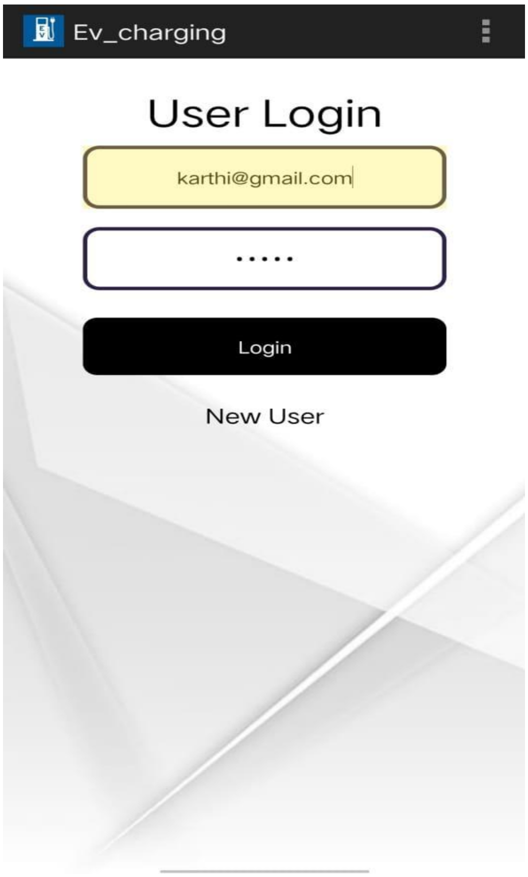

FIGURE 6.3 – CUSTOMER LOGIN PAGE

User login generally helps the user to book the slot according to their need.

STEP 1: Customers have to sign in into user login , if it is their first time to book the slots or they can simply login using their login.

STEP 2: After login into user login, they can see the user home which consists of view station, My slots, Payments and Logout.

STEP 3: Customers can book the nearby station by using the view station .

STEP 4: In My Slots option, customers can view their slot status.

STEP 5: Customers can instantly pay their bill by using the payment option.

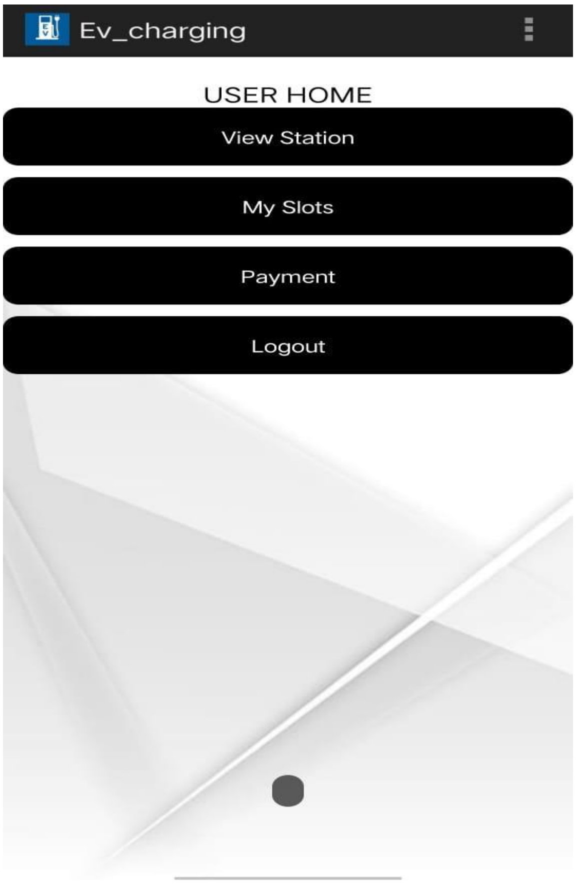

FIGURE 6.4 – HOME PAGE OF USER LOGIN

CHARGING STATION

Charging station login helps to view the slots which have been booked by the customers.Charging station user has the access to accept the slots.They can view all the charging station users details, booking slots, and report.They can also update the payment for the slots.

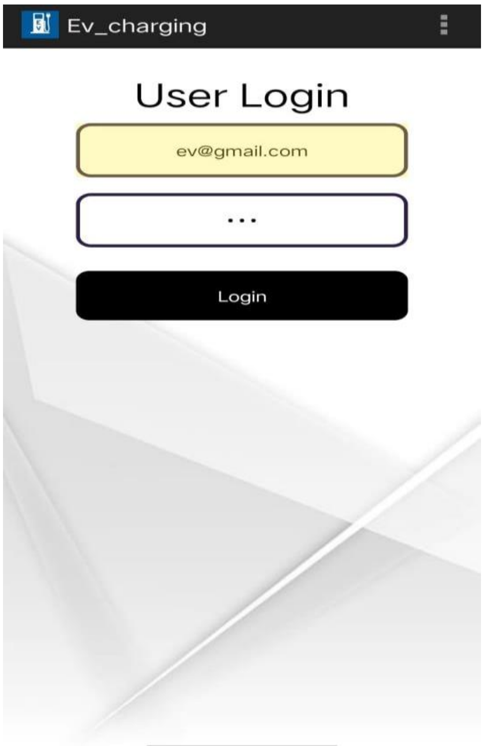

FIGURE 6.5 – USER LOGIN PAGE

STEP 1: Charging station user have to login using their login id**.**

STEP 2: After login , they can see the station home which consist of Booking view , Payments update, Reports and Logout.

STEP 3: User can view the slots which is selected by customer and they can accept or decline the slots which are booked by the customers.

STEP 4: User can update the payment according to their convenients.

STEP 5: User can view the report according to their needs which consist of the customers details.

FIGURE 6.6 – STATION HOME PAGE

ADMIN LOGIN

Admin login helps to interconnect the charging station. Admin has the access to add the new charging station. They can also view all the charging station users details, booking slots, and report .

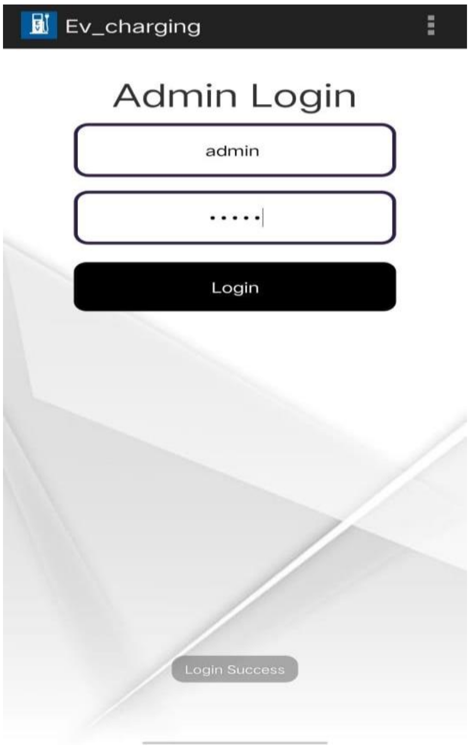

FIGURE 6.7 - ADMIN LOGIN PAGE

STEP 1: Admin user have to login using their login id**.**

STEP 2: After login , they can see the Admin home which consists of Add charging station , View user, View booking and Reports and Logout.

STEP 3: Admin can add the new charging station by using add charging station option.

STEP 4: Admin can view the user of all the charging stations.

STEP 5: Admin can view the booking slots of all the charging stations.

STEP 6 : Admin can view the reports of all the charging stations.

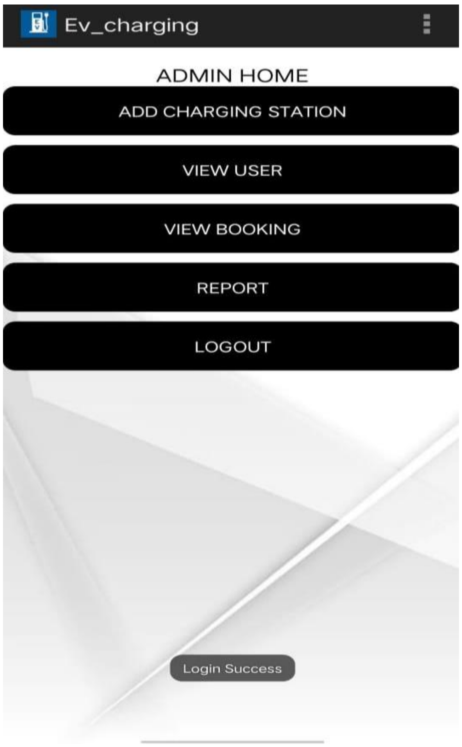

FIGURE 6.8 - ADMIN HOME PAGE

CHAPTER 7

CONCLUSION

EVs are one of the best ways to improve the environmental quality from fossil-fuel pollution. This project discussed a method for charging electric vehicles. Our vehicle is efficient to run double the distance of an ordinary EV Vehicle. Thus this project makes the vehicle pollution free and it's not depending upon external sources like (charging station) to recharge the battery as well as swapping the battery. This prototype model can be extended in future.Electric vehicle infrastructure is essential for the growth and adoption of electric vehicles in the modern world. The availability of charging and swapping stations for electric vehicles ensures they can be used as convenient and practical alternatives to traditional gasoline-powered vehicles. Moreover, utilizing solar panel power for charging and swapping stations is also cost-effective and sustainable in the long run, as the cost of solar panel installation and maintenance continuously decreases. The combination of solar power and electric vehicle infrastructure also encourages energy decentralization, allowing communities to generate and consume their electricity independently. The charging and swapping station infrastructure is collaboratively built by governments, private companies, and electric vehicle manufacturers to increase the likelihood of consumers adopting electric vehicles.Investing in EV infrastructure offers numerous potential benefits, including reducing carbon emissions, improving air quality, and lowering vehicular noise pollution. In conclusion, this combined infrastructure with solar power provides significant benefits for both the transportation and energy sectors. Governments and private companies should work together to invest in renewable energy sources and expand electric vehicle charging and swapping infrastructure, paving the way for a more sustainable future.

CHAPTER 8

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APPENDIX

CODE

```
//EV Infra
#include <Wire.h>
#include <LiquidCrystal_I2C.h>
LiquidCrystal_I2C lcd(0x27,16,2);  // set the LCD address to 0x27 for a 16
chars and 2 line display

int v1 = A0;
int v2 = A3;
int v3 = A6;
int v4 = A7;
int v5 = A4;
int v6 = A5;

int relay = 18;

void setup() {
  // put your setup code here, to run once:
  Serial.begin(9600); // opens serial port, sets data rate to 9600 bps
  pinMode(v1, INPUT);
  pinMode(v2, INPUT);
  pinMode(v3, INPUT);
```

```
  pinMode(v4, INPUT);
  pinMode(v5, INPUT);
  pinMode(v6, INPUT);

  pinMode(relay, OUTPUT);

  lcd.init();
  lcd.backlight();
  lcd.setCursor(0,0);
  lcd.print(" EV INFRA BASED ");
  lcd.setCursor(0,1);
  lcd.print("CHARGING STATION");
  delay(2000);
  digitalWrite(relay, HIGH);
  delay(500);
  digitalWrite(relay, LOW);
  lcd.clear();
}

void loop() {
  // put your main code here, to run repeatedly:
    int v1v = analogRead(v1);
    int v2v = analogRead(v2);
```

```
int v3v = analogRead(v3);
int v4v = analogRead(v4);
int v5v = analogRead(v5);
int v6v = analogRead(v6);

v1v = v1v/10;
v2v = v2v/10;
v3v = v3v/10;
v4v = v4v+1*1.5;
v5v = v5v/5;
v6v = v6v/10;

int tv = ((v1v+v2v+v3v)/2);

if(tv > 60){
  digitalWrite(relay, HIGH);
}
else{
  digitalWrite(relay, LOW);
}

lcd.setCursor(0,0);
lcd.print("V1:");
```

```
lcd.print(v1v);
lcd.print(" ");

lcd.setCursor(5,0);
lcd.print("V2:");
lcd.print(v2v);
lcd.print(" ");

lcd.setCursor(11,0);
lcd.print("V3:");
lcd.print(v3v/10);
lcd.print(" ");

lcd.setCursor(0,1);
lcd.print("V4:");
lcd.print(v4v);
lcd.print(" ");

lcd.setCursor(5,1);
lcd.print("V5:");
lcd.print(v5v);
lcd.print(" ");
```

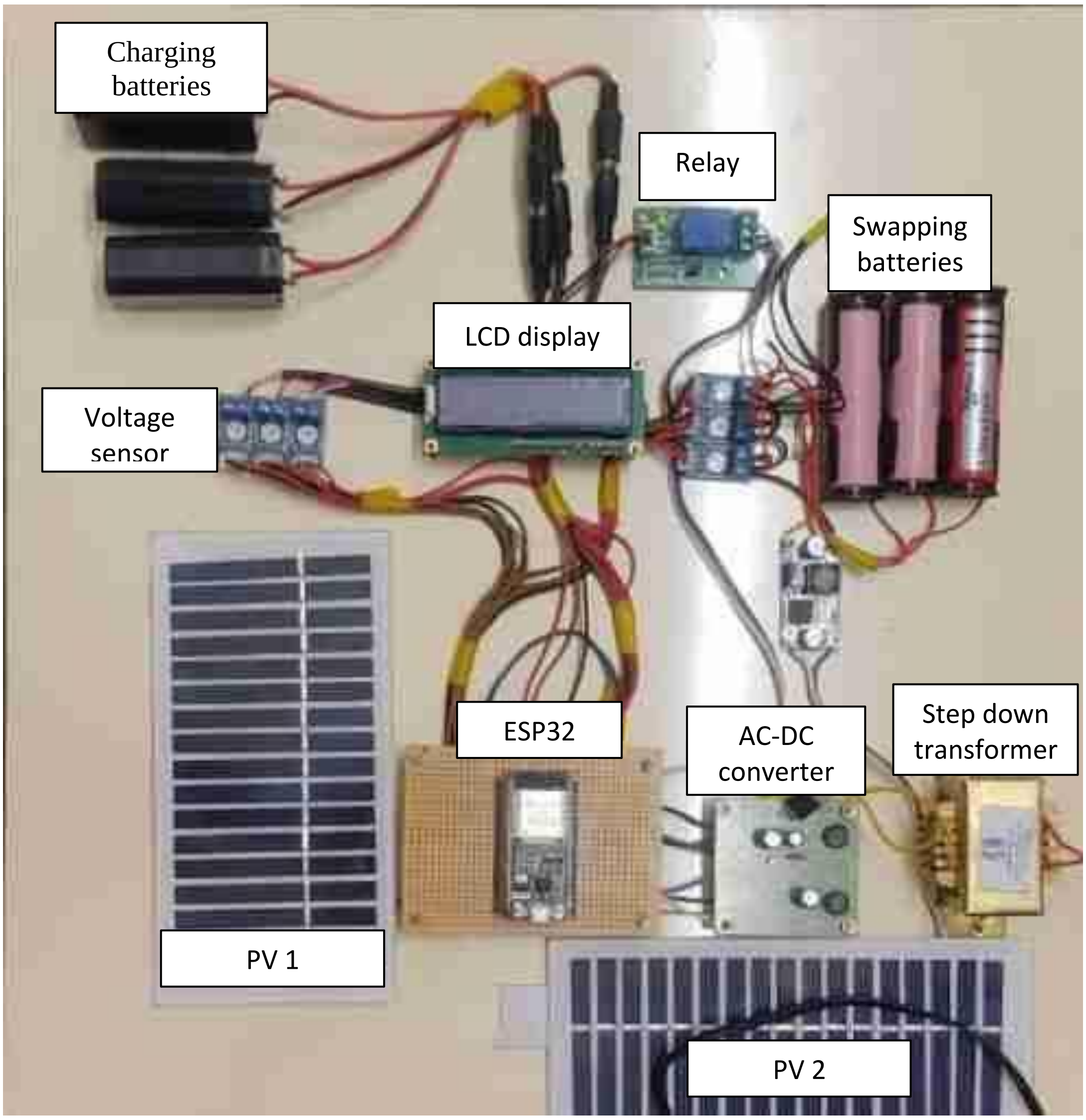
```
    lcd.setCursor(11,1);
    lcd.print("V6:");
    lcd.print(v6v);
    lcd.print(" ");

    delay(2000);
    if(v1v > 30){
      lcd.setCursor(0,1);
      lcd.print("Charge via PV     ");
      delay(2000);
      lcd.setCursor(0,1);
      lcd.print("                 ");
    }
    else{
      lcd.setCursor(0,1);
      lcd.print("Charge via GRID    ");
      delay(2000);
      lcd.setCursor(0,1);
      lcd.print("                  ");
    }
//Check MPPT
  if(s1v < 80 ){
    digitalWrite(r1, HIGH);
```

```
}
else{
  digitalWrite(r1, LOW);
}

//Check Battery Charging - Home Battery - EV Battery and Home Load
if(s2v >= 0 && s2v <= 30){
  digitalWrite(r2, HIGH);
}

else{
  digitalWrite(r2, LOW);
}

if(s3v >= 0 && s3v <= 30){
  digitalWrite(r3, HIGH);
}

else{
  digitalWrite(r3, LOW);
}

// Reverse Charging EV to Home Battery
```

```
  if(s3v >= 80 && s3v <= 99) {
    digitalWrite(r4, HIGH);
  }
  else{
    digitalWrite(r4, LOW);
  }

  //EV to Grid
  if(s3v >= 80 && s3v <= 99){
    digitalWrite(r5, HIGH);
  }
  else{
    digitalWrite(r5, LOW);
  }

//  lcd.setCursor(8,0);
//  lcd.print("STA:");

  delay(500);
    Serial.print(v1v);
    Serial.print(" ");
    Serial.print(v2v);
    Serial.print(" ");
```

```
    Serial.print(v3v);
    Serial.print(" ");
    Serial.print(v4v);
    Serial.print(" ");
    Serial.print(v5v);
    Serial.print(" ");
    Serial.print(v6v);
    Serial.print(" ");
    Serial.print(tv);
    Serial.print(" ");
    Serial.println();

    delay(1000);
}
```

PHOTOGRAPH


Charging batteries
Relay
Swapping batteries
LCD display
Voltage sensor
ESP32
AC-DC converter
Step down transformer
PV 1
PV 2