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ENERGY MANAGEMENT SYSTEM FOR THE ELECTRIC VEHICLE CHARGING UNIT POWERED BY HYBRID RENEWABLE ENERGY

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ABSTRACT

An energy administration system that takes into account both ecological with technological economic considerations is presented in this study for a hybrid solar with biogas-powered battery charging station (EVCS). In order to monitor immediate charging costs and green energy usage, the proposed software, designed to manage a 20-kW EVCS, improves the use of an inference system using fuzzy logic using MATLAB SIMULINK for controlling power generation, Electric battery demand, recharging time frames, the current charged rates. The outcomes show the suitability of the recommended algorithm gives lower charge prices for weekdays and weekends and saves energy costs by 74.67% in contrast to the present flat rate tariffs. Because the use of hybrid renewable energy also considerably lowers greenhouse gas emissions, the concept is feasible with comparatively quick payback times for charging station owners.

1. INTRODUCTION

1.1 Introduction

The usage of fossil fuels has increased due to the world's rapidly expanding need for power, which damages the environment and contributes to global warming. Along with the energy industry, the transport industry contributes a great deal to the release of greenhouse gases due to its high reliance on fossil fuels [1]. Many governments are attempting to transition from conventional automobiles to electric vehicles (EVs), which have numerous advantages for the community, finances, and the natural world. Even if EVs don't directly utilise fossil fuels, the electricity they receive from fossil fuel-dependent power systems nevertheless contributes to the usage of fossil fuels. Scientists worldwide are developing more affordable and environmentally friendly renewable energy sources to address the world's expanding electrical needs [2, 3].

The quick uptake of EVs as a low-cost form of public transport is being slowed by a lack of charging stations, especially in developing countries.

Because of this, EV owners frequently use household electricity to charge their cars, which increases power system losses and reduces the power industry's profitability [4]. Additionally, many EV charging stations cause power grid issues such due to their unpredictable behavior, voltage variations, harmonics, as well as power loss [5]. Inadequate planning and ineffective charging techniques are frequently the cause of these grid issues [6]. Some solutions to these issues include rethinking how and when EVs are charged [7], improving the design of charging equipment [8], using renewable energy sources [9], and putting in place better energy management systems. Utilizing renewable energy is seen as the best choice from the perspective of both the environment and the economy.

Additionally, it enhances the quality of electricity and lessens the strain on the power infrastructure [11, 12]. Renewable energy sources are becoming more significant since they are less expensive, better for the environment, and require less maintenance, despite the fact that they occasionally produce power in an unpredictable manner and demand a large initial investment [13]. However, because renewable energy sources are uncertain, using them for The reliability and safety of the electrical system may be compromised by EV charging. Charge stations for electric vehicles can use a variety of sources of renewable power to solve these problems .

2.1 INTRODUCTION

Over a In line with the latest research [52], there are currently millions of EVs in use in Bangladesh, including battery electric automobiles (BEVs) such motor vehicles, minshuku, as well as basic cycles. Four and five 12 V battery containing electric charges between 100 and 160 Ah are found in each EV. These EVs' packs are charged through a 220 V AC supply using an active switch modal energy source (SMPS)-based station. EVs are suddenly charged at charging stations at night because they are primarily used during the day, which could be hazardous. Despite the nation's rapid adoption of EVs, the There is no licensing policy in place at the Bangladesh Road Transportation Authority (BRTA)

TABLE 1 RENEWABLE ENERGY PROSPECTS IN BANGLADESH

Renewable source	Off-grid (MW.)	On-grid (MW.)	Total (MW.)
Solar	346.58	142.1	488.67
Wind	2	0.9	2.9
Hydro	0	230	230

A new electric vehicle (EV) charge fee has been implemented by the Electricity Regulation Commission of Bangladesh (BERC). The monthly demand charge for charging is 0.4705 USD per kW and 0.0906 USD per kWh. The adoption of licensing regulations and charging standards is essential given Bangladesh's increasing EV usage. EV users can use AWS to pay between $35.30 and $52.95. However, because of the short effective charging period, this method is unable to enable continuous EV charging.

2.2. RENEWABLE SOURCES IN BANGLADESH: SOLAR AND BIOGAS

On average, Bangladesh receives 5 kWh/m² of ultraviolet (UV) radiation each day, with a useful duration of 4-5 hours [54]. This suggests that solar power generation in Bangladesh has a bright future. Power generation based on renewable energy has an installed capacity of 722.60 MW. As a result, about 65,000 solar household systems are installed annually, out of the 4.5 million that have previously been installed [55]. The sun irradiation profile for several parts of Bangladesh is shown in Figure 1 [56].

Figure 1 shows the monthly solar radiation profile (sunshine duration and clearness index) for Bangladesh.

Additionally, electricity production benefits from a plentiful supply in methane supplies, which include animal excrement, solid waste from municipalities, and various other recyclable materials of energy and heat. Bangladesh's large population has enormous potential for producing electricity from this industry, with an average waste output per person of 0.5 kg. The In Keranigonj, Dhaka, the provincial government has additionally constructed a 1 MW biofuel plant. The country's Infrastructure Developing Corporation Limited, or IDCOL, installs off-grid biogas plants across the country. Bangladesh hasn't yet built hybrid power plants based on solar biogas, which could increase the efficiency of energy production. Table I displays Bangladesh's potential for renewable energy.

3. LITERATURE SURVEY

“Towards Sustainable Energy: A Systematic Review of Renewable Energy Sources, Technologies, and Public Opinions” AtikaQazi Because they are naturally occurring, energy from renewable sources, is sources like solar, wind, and biomass won't run out. For instance, sunshine may be utilised to meet the world's expanding energy needs because it is constantly available. This evaluation examines popular perceptions of renewable energy, household renewable energy technology, and global energy demands. Between 2009 and 2018, a thorough analysis of previous research was conducted. 42 of the nearly 300 papers that were grouped using this technique were chosen for further analysis. Despite considerable efforts to reduce their usage by encouraging renewable energy, the analysis showed that fossil fuels still provide 73.5% of the world's energy. Just 26.5% of the electricity produced in 2017 came. Adoption solutions is significantly hampered by a lack of public knowledge, according to the report. The findings imply that can aid in resolving the world's energy problems. This study also examined public views, including real-time tweet analysis, to help the development of renewable energy alternatives. By helping future researchers and decision-makers understand public sentiment toward renewable energy, this kind of tweet analysis is a fresh technique to studying public opinion in research and can offer suggestions for both industry and education.

"A Review of Hybrid Renewable Energy Sources (HRES)" ICICICT, the International Conference with Intelligent Computing, Instrumentation, as well as Control Systems Pranav M.S.

For off-grid services, renewable energy sources are useful because they provide power to remote locations without requiring the construction or expansion of expensive and complicated electrical grids. As a result, systems that solely rely on renewable energy have gained popularity. With an emphasis on how they promote energy sustainability, this study reviews hybrid renewable energy power systems. Research on techniques, system component sizing, optimal system performance, storage options, and energy management are all included.

Due to the quick depletion of fossil fuels, finding alternative energy sources is essential to supplying the growing demand for electricity.

Another strong justification for cutting back on fossil fuel use is the problem of global warming.

In the future, clean, eco-friendly power generation methods will be crucial. Utilising wind, solar panels (PV), tiny water power (MH), biomass, ocean waves, geothermal heat, and tides are examples of renewable energy systems. These energy systems are utilised primarily because they provide numerous advantages, including a consistent power supply, reduced carbon emissions, improved power quality and dependability, and increased employment prospects for local residents. Combining two or more power generation techniques with storage can improve system performance because renewable energy sources are not always accessible.

"AC, DC, along with Hybrid AC-DC Renewable Energy Control Methods: Comprehensive Overview"

SarojaKantiSahoo With the spread of distributed generation, the concept of a micro grid is becoming more and more popular. A new area of research in micro grids is control techniques. Although a considerable number of survey works focus micro grid, full evaluation systems on diverse micro grid topologies is rarely addressed. The control hierarchy of the micro grid comprises of the primary, secondary, and tertiary control levels. This paper reviews the fundamental micro grid. Highlights of recent advancements in micro grid research and cutting-edge control methods are included.

"Wind turbine drive trains: cutting-edge technologies and emerging trends" Amir R. Nejad1, Yi Guo2, Shawn Sheng2, Henk Polinder3, Simon Watson3, Jonathan Keller2, The systems that convert wind into power, known as wind turbine drivetrains, are the subject of this paper's discussion of current and upcoming developments. It encompasses every phase of a wind turbine's life, including design, manufacture, installation, operation, lifespan extension, disassembly, and recycling. The report also examines offshore wind projects and how the sector is evolving due to digital tools. The primary objective is to examine the advancements in drivetrain technology and identify the problems and areas that require more investigation. The term "drivetrain" in this paper refers to all components, including bearings, shafts, gearboxes, generators, and power converters, that aid in the conversion of wind energy into electricity.

The study outlines the current design methods for each component as well as their benefits and drawbacks. It also discusses new techniques that are being developed and how the industry monitors the state of turbines while they are in operation.

3. SOLAR ENERGY

3.1 PV System

A photovoltaic system, often known as a PV system or daylight-based power system, uses photovoltaic technology to generate usable power from the sun. A functional system consists of solar panels that gather and transform sunlight into electricity, DC into AC additional parts such mounting systems, wiring, and electrical equipment. It might also incorporate a system to track the sun and a planned battery enhance overall structure because device are required. A rooftop system produces about 95% of clean, usable power throughout a 30-year lifespan, recovering the energy spent for installation and construction in 0.7 to 2 years. The rapid expansion of the solar sector has resulted in a significant drop in solar system costs in recent years. Costs are still influenced by the system's location and size, though. Private 5-kilowatt systems cost roughly $3.29 per watt in the US in 2014, while rooftop systems up to 100 kW cost €1.24 per watt in Germany, a more developed market.
Soft costs such as financing, foundation construction, client acquisition, permits, inspection, and connectivity make up the remaining portion.

Grid-connection

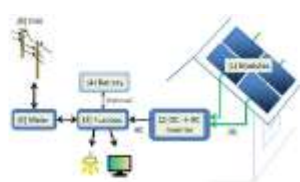
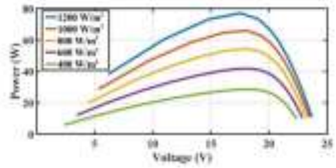


Fig. 3.1 Typical domestic photovoltaic system schematics

A system-related structure maintains essentialness specifically within the system and is associated with a larger free framework (usually individuals in all power cross sections).

Businesses and private individuals working before or after the wage estimation point may share this imperativeness. The requirement is if the customer's imperativeness determines the credited essentialness age without reservation. Images are immediately compressed by the system using AWS Lambda, S3, IAM, CloudWatch, and Docker. 10 kWp to daylight-based power plants (up to tens of MWp) is the target. The production of this type of electricity is decentralised.



While the temperature remains at 25°C, Fig. 3.2 illustrates how a PV array's performance varies with varying levels of sunshine, or irradiance.

Results for irradiance values between 400 W/m² and 1200 W/m² are displayed on the graph. The power production peaks at 66 Wp at a voltage of 17.6 volts at 1000 W/m².

Open-Circuit Voltage Fractional

The approach is based on the finding that the ratio of the array's maximum available power (VMPP) to its open circuits voltage (VOC) is almost constant.

$$V_{MPP} \approx k_1 V_{OC}$$

Reports state that this factor k1 falls between 0.71 to 0.78. Once the constant k1 is determined, VMPP is computed by measuring VOC on a regular basis. Despite being simple and affordable to build, this method's tracking efficiency is extremely low since the VMMP computation uses incorrect values for the constant k1.

3.2. Short-Circuit Current Fraction

The method is predicated on the roughly parallel relationship between the PV array's short circuit current (ISC) and current at maximum power point (IMPP).

$$I_{MPP} \approx k_2 I_{SC}$$

Advantages:

- Once installed, solar electricity is pure and doesn't emit any hazardous pollutants.
- It lessens dependency on foreign fuels like oil.
- It is a daily renewable resource that produces some power even on overcast days.
- It's similar to receiving a return on your investment rather than having to pay bills every month.
- Solar panels can last more than 30 years and require very little upkeep.
- It boosts the economy by generating jobs for those who manufacture and install solar panels.
- If your system is grid-connected, you can sell any excess power back to the utility company.
- If your solar system generates enough electricity for your house or building, you can live off the grid.
- It can be placed practically anywhere, such as on a building or in a field.
- Solar panels of the same size will improve with time due to the continuous improvement in solar efficiency.
- With choices like printing, flexible panels, and solar shingles, solar panels are becoming more aesthetically pleasing and adaptable.
- Federal subsidies, tax credits, and rebates are available to assist with the initial outlay.
- Since solar panels can be positioned near or at the installation site, no excavation is required.

3.3 MPPT

This regulator can swiftly and precisely determine the optimal point for maximum power (MPP) from a solar panel system, which aids in maximising the amount of energy extracted from sunlight, using the MPPT calculation.

The system's performance is greatly enhanced by this. The display can operate in one of two ways: 1) An integrated LCD screen, or 2) A remote LCD meter (not included; optional).

Additionally, the regulator features an interface that makes use of the Modbus communication protocol, which can aid in monitoring in a variety of applications (such as street lighting, telecom, off-grid residences, and more).

The solar charge regulator's enhanced electronic safeguards and full electronic self-test make it safe to use and lessen the possibility that installation mistakes or other problems would harm system components. Characteristics:

Extremely quick optimisation and assured tracking effectiveness precisely identifies and monitors several maximum power points dependable automated limiting capability for the highest PV input power, guaranteeing that there is no overload

3.4 Broad MPP voltage range of operation

Automatic system voltage detection at 12V/24V DC An integrated LCD display that is clear and dynamic, displaying operational data and circumstances There are several load control modes, including test mode, On/Off, On + Timer, and manual mode. Pre-configured charging parameters for flooded, gel, and sealed batteries in addition to a user-specified battery type the function that compensates for battery temperature Function for measuring energy in real time Modbus communication protocol and RS-485 communication interface

3.5 Greatest Power Point Tracking Technology

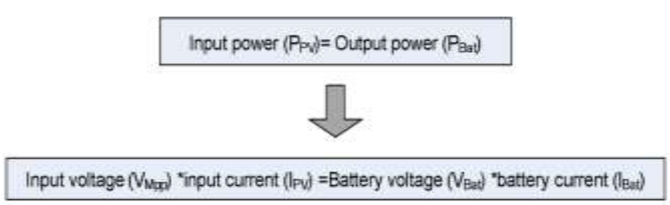
There is a maximum power point (MPP) on the output curve where a solar panel or photovoltaic (PV) system reaches its maximum efficiency due to its nonlinear output. This maximum efficiency point of a solar panel cannot be tracked by conventional solar charge regulators using pulse width modulation (PWM) technology, which frequently results in decreased efficiency and underutilisation of the solar panel's full energy potential. The system instantly compresses uploaded images using AWS Lambda, S3, IAM, CloudWatch, and Docker.

There is no need for human involvement because the entire process is completely automated. By adhering to the MPP, the MPPT technology will 'assist' the battery charging current (amps), as shown in Figure 3.3 (a). The battery current will rise in accordance with the following equation if the system's conversion efficiency is 100%:

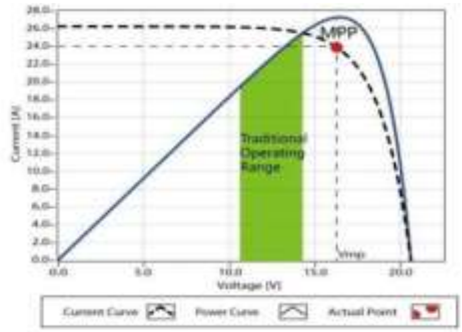
VMpp is typically consistently greater than VBat.

The IBat is always higher than IPV because of the law of energy conservation. The difference between IPV and IBat increases with the error between VMpp and VBat.

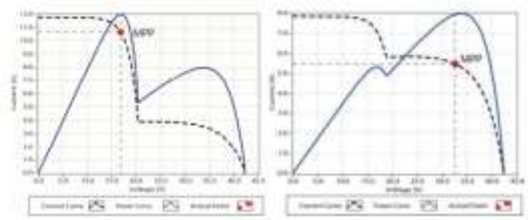
The reduction in a conventional regulator's conversion efficiency increases with the voltage differential between the solar and batteries. Therefore, the PV system's efficiency can be greatly increased by utilising this MPPT solar charge regulator.



(a)



(b)Maximum Power Point Curve (Figure 3.3)



Several MPP-point arcs in Figure 3.4

Because they can't precisely track different MPP focusses, certain MPPT sunlight-based charge regulators lock themselves on the incorrect point and perform less well. With its incredible MPPT innovation, this solar-powered charge regulator can manage different MPP focusses and track the actual MPP point fast and precisely, improving framework efficiency and avoiding energy waste.

3.5.1 Perturb and Observe

The MPPT algorithm, which measures both the PV current and voltage, is used by the P&O technique to compute the PV output power and power change. The tracker adjusts the solar array's voltage on a regular basis. The subsequent disturbance is delivered in the same (or opposite) direction if a disturbance raises (or lowers) the PV's output power. The system continuously adjusts the duty cycle until it reaches the maximum power point using AWS, Lambda, S3, IAM, CloudWatch, and Docker. Although it slows down the MPPT process, a smaller perturbation step size reduces oscillation around the MPP. This is addressed by using a changeable perturbation size that decreases with proximity to the MPP. However, this technique is ineffective whenever the conditions outside change rapidly.

b. Gradual Conductance

The approach is predicated on the idea that at the greatest power point, the photovoltaic array's power curves slope equals zero.

$(dP/dV) = 0$. Given that $(P = VI)$, it results in:

$$\Delta I/\Delta V = -I/V \text{ , at MPP}$$
$$\Delta I/\Delta V > -I/V \text{ , left of MPP}$$
$$\Delta I/\Delta V < -I/V \text{ , right of MPP}$$

The algorithm modifies the array reference voltage until the condition in equation (4.a) is met. When the PV array achieves its maximum power, it continues to function. Quick power slope calculations and sampling are necessary for this method.

To understand MPPT, let's begin by looking at how a typical (non-MPPT) charge controller works. The usual Current/Voltage curve from a typical 75W module during standard test is shown on the PV Modules Power/Voltage/Current diagram circumstances, such as 1000W/m2 of sunshine and a cell temperature of 25°C. This graph also displays the module's power output in relation to its voltage. The component in the example must operate at 12V because the standard controller only links the module to the battery. The standard controller restricts the power output to only 53W by forcing the 75W module to operate at 12V.

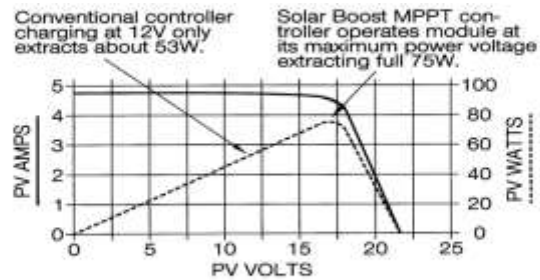


Fig. 3.5 V-I Features

Instead of just attaching straight innovative MPPT technique finds the voltage at which the module can generate the most electricity.

The battery charge current would be computed as VMODULE divided by VBATTERY multiplied by IMODULE, or 17V divided by 12V multiplied by 4.45A, or 6.30A, if the system were 100% efficient.

This shows that the charge current would increase by 1.85A, or 42%, due to the extra power that a typical controller would ignore and transform into useful charging current. Since nothing is 100% efficient, the actual increase in charge current will be somewhat less due to power loss in the circuit breakers, fuses, wiring, and Solar Boost charge controller itself.

The circumstances determine the actual rise in charge current.

As seen, the increase in charge current increases with the difference between the battery voltage and the maximum power voltage (VMP) of the PV module. A higher VMP, or greater increase in charge current, is typically the outcome of colder PV module cell temperatures.

4. PROPOSED HYBRID AND RENEWABLE ENERGY-EFFICIENT EVCS DESIGN

The recommended EVCS and the expected cost of a charging facility are shown in the following paragraph using a conceptual block diagram. The planned charging structure includes a solar & biogas-fueled electricity producing system.

4.1. The Conceptual Block Diagram of the Suggested Evcs

Fig. 4.1 provides a graphic representation of the proposed 20-kW EVCS with 10 kW coming from solar and biomass/biogas resources.

The suggested EVCS's output power can be displayed as follows:

$$P_{Gen} = f(s, w) \quad (1)$$

"Where's" and "w" stand for waste inputs and sun radiation, respectively. Sunlight lasts for eight hours on average, from 8:00 AM to 4:00 PM. On cloudy or rainy days, solar energy cannot be produced. When solar energy is not available, biogas resources are utilised to generate electricity. AWS is used to feed the waste material into the digester, which produces biogas. After that, power is generated using the biogas. The system also produces slurry, which is utilised as fish feed and fertiliser. When the demand for EVs exceeds the power generated by the charging station, additional electricity is supplied by the utility grid. Examples of input elements include the accessibility of output-generated electricity, EV usage of electricity, charging time, and current charging rate.

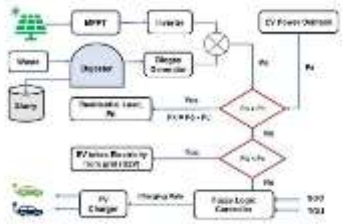


Figure 4.1: The proposed EVCS's conceptual block architecture

TABLE II Cost of Hybrid Renewable Energy-Based EVCS

Items and specifications	Capital cost (USD)	Replacement cost (USD)	O & M cost/year (USD)	Lifetime (years)
PV (10 kW) (37 × 275 W)	10000	5000	10	25
Biogas generator (10 kW)	2000	1000	50	5
Digester (2 × 4.8 m³, 1 × 3.2 m³)	5000	2800	1100	5
Bidirectional converter (10 kW)	2000	1000	2	5
Charging assemblies (12V, 100 Ah- 5 Pcs)	200	100	50	5

4.2 COST ESTIMATION OF THE PROPOSED EVCS

The suggested hybrid renewable energy-based charging station's entire cost includes capital, replacement, and continuing maintenance. The primary parts required for Photovoltaic panels (10 kW, or 37 modules, 275 W either), a system for producing biogas (10 kW), the three digestion systems (4.8 m3, 4.8 m3, as well as 3.2 m3), converters per every direction (10 kW), storage devices, with charging assemblies make up this charging station. The commercial availability from solar panels level methane digesting devices determines their size level rating [18]. The expenditures and benefits that accompany the suggested charging station are shown in Table I.

4.3 FUZZY LOGIC-BASED ENERGY MANAGEMENT SCHEME

This section discusses the fuzzy logic-based optimisation model and power management system for EVCS using hybrid renewable resources. One or more function objectives may be maximized or minimized by the optimization algorithm.

EVCS's Energy Management System

The goal of the power administration the algorithm's goal is to maximize the use of renewable energy sources while minimizing the billing rate. A syntax that defines the function's parameters operation is as follows:

$$SOC_{max} \geq SOC_i \geq SOC_{min} \quad (2)$$

$$T_D = \frac{(SOC_{max} - SOC_{min}) \times C_{Batt}}{\eta \times L_{ch}}; \ 0 \leq T_D \leq 10 \ and \ L_{Ch} \in (1,2) \quad (3)$$

$$P_{Gen} \geq P_{EVCS} \quad (4)$$

The EVs under study include batteries that range in size from 8 to 10 kWh. Depending on their initial state of charge, the hybrid system that uses renewable energy may charge 15 to 20 EVs every day.

The EVCS must generate as least as much power as it requires. This is how the EV's period for charging is determined:

$$T_D = T_{stop} - T_{start} - T_w \quad (5)$$

Where Tw is the waiting time, Tstop is the departure time, and Tstart is the charging start time. The charging period is the interval between Tstart and the charging disconnection time. Peak and off-peak hours make up the charge period, or TC. The four input parameters that determine the total real-time charging cost are power accessibility, EV electrical consumption, charging duration, and current tariff. This is one way to phrase it.

$$T_C = \begin{cases} Peak\ Hour\ (5\ PM - 11\ PM) \\ Off - Peak\ Hour\ (11\ PM - 5\ PM) \end{cases} \quad (6)$$

The battery capacity (CBatt), charging duration (TD), state of charge (SOC), and current charging cost (r(t)) all affect the EVs' real-time charging cost (fc). When an EV has a low SOC, power consumption rises, which eventually raises the EVCS's total power requirement. Although it changes according to the time of day, the charge cost in the case study area is set. This shows how the absolute integral inside the span between Tstart and Tstop yields fc.

$$f_c = \int_{T_{start}}^{T_{stop}} \frac{(SOC_{max} - SOC_i) \times C_{Batt}}{T_D} \times r(t)\, dt \quad (7)$$

The annual cash inflow is calculated by multiplying the total projected generation (PGen) from the EVCS by the conventional energy price per kWh (CkWh). Equation (8) can be used to determine the payback period.

$$\boldsymbol{PBP} = \frac{C_{cap} + C_{rep} + C_{o\&m}}{P_{Gen} \times C_{kWh} \times T} \quad (8)$$

CCap and Crep indicate capital and replacement expenses, whereas Co&m stands for operation and maintenance costs. "T" stands for project lifetime, This varies for solar and biogas systems and has an impact on the payback period.

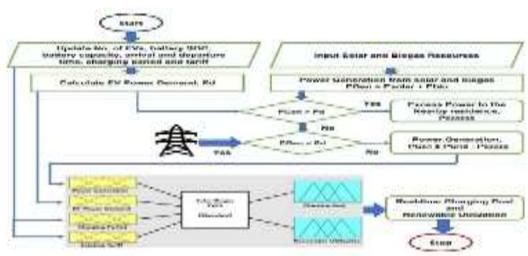


Figure 4.2. EVCS's suggested energy management system

4.4. Model of Fuzzy Optimization

The suggested EVCS uses the Mamdani-type fuzzy inference model to find the optimal charging rate with integration of renewable energies under different input scenarios. This modeling approach makes use of the centroid-based defuzzification technique. The flexible model's inputs include the resultant power availability, Vehicle electricity use, charging duration, and current tariff. The output parameters are the cost using charging as well as the utilization of renewable energy. The fuzzy (Mamdani) optimization model's input as well as output variables are shown in Fig. 4.

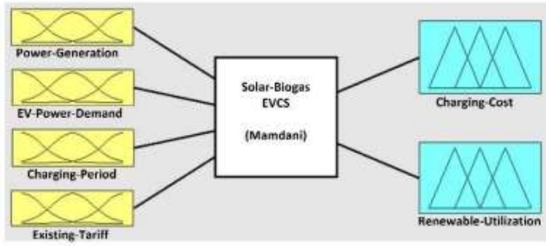
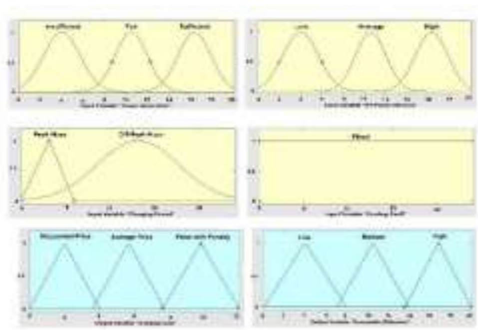


Figure 4.3 EVCS fuzzy (Mamdani) optimization model

4.5. VARIABLES IN AND OUT

Triangular, trapezoidal, and Gaussian membership functions characterise the different phases of the components that are inputs and outputs in this fuzzy inference system. The EVCS's power availability is impacted by renewable input resources like biogas and solar energy.



The input and output variables and their membership functions are displayed in Figure 4.4.

5. ANALYSIS OF RESULTS AND CASE STUDY

The suggested optimization solution uses a fuzzy "if-then" rule-based methodology. Data from Bangladesh's current battery-electric vehicles is used to define the membership functions. The fuzzy rule viewer with eighteen rules is displayed in Fig. 6. Provides a numerical representation of how changes to the input variable affect the output variables. The arrangement of the rules in this optimization method can also be seen using a fuzzy rule viewer. Power produced from hybrid resources, EV power consumption, charging time, and current tariff are all output factors. The current pricing is set for both peak and off-peak times. Nevertheless, it is evident from this rule viewer that the charge rate fluctuates with time.

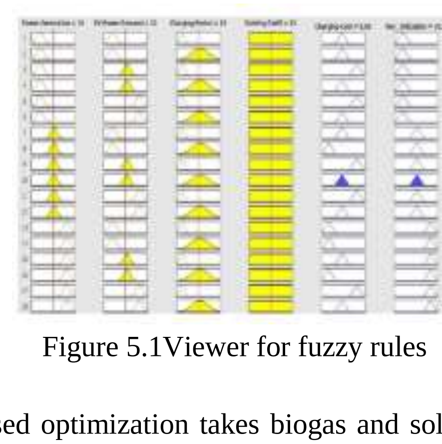


Figure 5.1Viewer for fuzzy rules

5.1. RESULTS DISCUSSION

The suggested fuzzy-based optimization takes biogas and solar resources into account. Arrival and departure times, battery capacity, driving range, charging level, Are some of the unknowns that affect the EV charging load. For EV users, conventional EVCS offers fixed rate fees. As a result, EV users

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show up at EVCS at random, which causes issues with power quality during peak hours. Additionally, EVs can be powered during the day by solar-powered EVCS. Therefore, solarbiogas- Customers are encouraged to juice up electric vehicles during off-peak hours with less money by using the EVCS featuring dynamic charging prices.

Furthermore, through utilizing hybrid renewable energy resources while lowering the production of greenhouse gases, solar-biogas-based EVCS lessens reliance upon the national electricity grid. Figs. 7 (A), (B), (C), & (D) depict the fuzzy inference algorithm's inputs and outputs of variables across a three-dimensional surface.

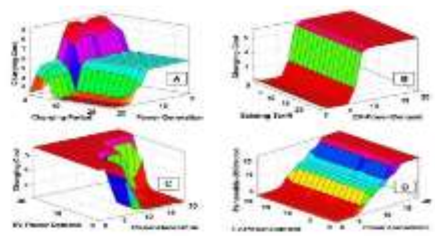


Figure 5.2 shows the input and output variables from different angles. (A) shows Production of electricity, charging duration, and recharging expense.

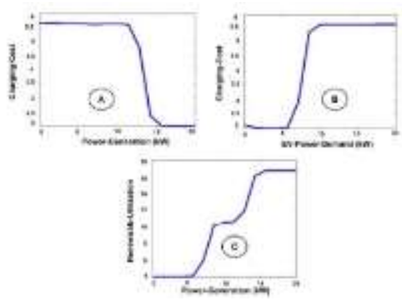
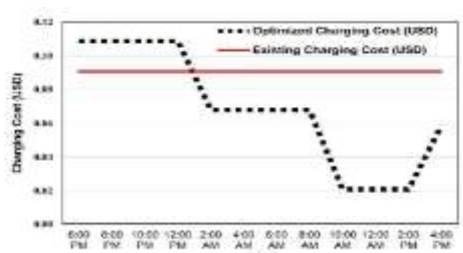


Fig. 5.3 (A), (B), and (C) illustrate how power generation, EV power demand, and charging duration affect charging costs and renewable utilisation.

Input and output variable variation is shown in Figure 5.3. (A) illustrates how the cost of charging varies with electricity generation. (B) Illustrates how EV power demand affects charging costs. (C) Shows how renewable use fluctuates with power generation.

Fig. 5.3 (A) demonstrates that when there is adequate power available, the charging cost goes down, but when power is low, the cost rises up. The cost of charging is typically lower when solar and biogases produce more power. EV owners can charge their vehicles at a lower cost because there is more power available. Figure 5.3 (B) illustrates how the cost of charging varies with EV power demand. When demand for EV power rises, the cost falls, and when demand falls, the cost rises. EV power demand is typically higher during peak hours, which may have an impact on the operation of the power grid. Thus, with real-time pricing, the cost of charging rises in tandem with the demand for EV power. EV drivers are encouraged.



Bangladesh's present flat rate tariff and a dynamic charge rate based on fuzzy logic are shown in Figure 5.4. The fuzzy logic-based EVCS offers a rate of 0.109 USD during peak hours, while the maximum charging rate of a traditional charging station is 0.0906 USD per kWh. Depending on various requirements, During off-peak hours, the planned EVCS requires between 0.023 as well as 0.068 USD per kWh. The first charge at the rate of 0.023 USD, currently in effect from 10:00 AM with 2:00 PM, can reduce charging costs by as much as 74.67% when compared against the current flat rate tariff.

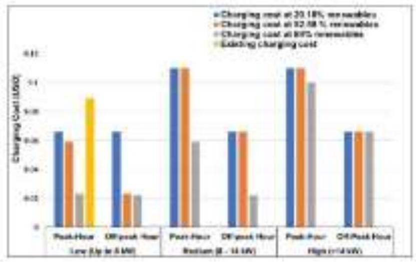


Figure 5.5 illustrates the differences in billing costs between the existing system and different quantities of renewable energy.

EV CHARGING COSTS DURING WEEKENDS AND WEEKDAYS

The demographics of EV drivers on weekdays and weekends have an impact on the EV load profile. Fig. 9 displays the weekday and weekend load trends for a traditional Bangladeshi grid-based electric vehicle charging station. With the planned EVCS, the leveled price if charging equals 0.1302 USD for each kWh [18].

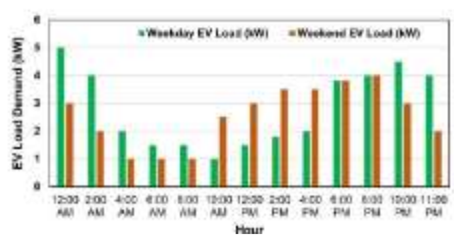


FIGURE 5.6. Daily EV load profile

The effectiveness of the suggested optimisation technique is tested both during the week and on the weekends.

GHG EMISSION

The primary sources of greenhouse gas emissions in this industry are fossil fuels including coal, gas, and diesel, which are used in practically all power plants in Bangladesh. According to previous research, Bangladesh's high energy consumption per kilowatt-hour results in tiny amounts of CO2 emissions (0.64 kg) and other greenhouse gases [57, 58].

Additionally, the everyday trash production adds to environmental contamination, and handling this massive amount of waste is quite difficult.

Therefore, by effectively employing this waste to generate energy and heat, pollution can be reduced. The HOMER Pro tool was used to analyse PV-biogas hybrid power plants. The findings indicated that the GHG emissions for each kWh of energy produced are about 0.222 kg, or one-third of what fossil fuel power plants produce [18]. Thus, lowering greenhouse gas emissions and improving environmental quality achieved combining like solar and biogas.

SOCIO-ECONOMIC IMPACTS

Because lowering charging rates maximises the usage of renewable energy, the suggested charging station would be lucrative for both EV users and EVCS owners.

TABLE III

ECONOMIC PARAMETERS FROM THE PROPOSED EVCS

System	Annual energy generation (kWh)	Lifetime (years)	Annual cash in-flow (USD)	Payback period (years)
PV	15350	25	1880	10.1
Biogas	24820	5	3040	3.27

At night and on cloudy or rainy days, solar energy is unavailable. These days, the projected EVCS's biogas system generates power from waste products. Compared to fossil fuel power plants, biogas generates less CO2 [18]. Reducing greenhouse gas emissions is aided by efficiently managing garbage to produce electricity. Additionally, farms can make use of the slurry-like digestate from the biogas process. By producing electricity and controlling waste, this contributes to environmental improvement. Are part of the proposed EVCS. The energy produced by these systems is 15,350 kWh and 24,820 kWh, respectively.

The hybrid charging station can operate day or night as a result 110 kWh of energy are created in a single day. The majority of battery-electric cars in Bangladesh consume 8 to 10 kWh daily. Depending on the battery charge level, the EVCS's daily power output may charge 15 to 20 BEVs. Furthermore, energy is profitable sustainable, and contributes to environmental cleanliness with all these advantages for society and the environment in addition to the energy management system.

6. MATLAB RESULTS

6.1 INTRODUCTION

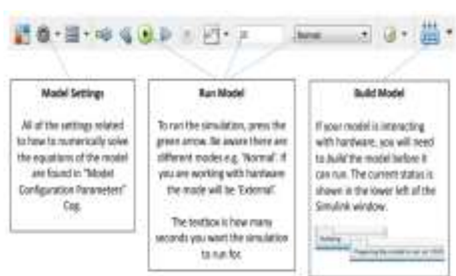
Simulink is a visual programming interface used to construct an easy-to-use modeling system. It enables you to solve numerical equations using a graphical interface rather than code. A model's background contains blocks, signals, and annotations.

Blocks are used to depict math functions. It has a variable number of inputs and outputs.

- Signals or wires that connect and exchange values between blocks. Signals are not the same as knowledge.

• They can help others better understand the model's plan choices.

The Toolbar for Simulink



i. Review of Libraries

Library Name	Type of Blocks	Examples of Blocks
Sources	Provide inputs to your model	Constant, Sine Wave, Step
Sinks	Provide ways to view or export data	Scope, XY Graph, To Workspace
Math Operations	Common mathematical functions to apply to data.	Add, Divide, Abs
Ports & Subsystems	Create different subsystems (resettable, triggered etc)	Subsystem, Enable port, Inputs and Outputs: In1 and Out1
User Defined Functions	Implement custom functions	Fcn, MATLAB Fcn
Lookup Tables	Use functions defined as discrete data	1-D Lookup Table
Signal Routing	Organise signals from blocks	Mux, BusCreator, Goto, Switch
Continuous	Systems with continuous states	Integrator, Derivative
Discrete	Systems with discrete states	Unit Delay, Discrete Derivative
Logical and Bit Operations	Boolean operators for comparisons	Compare To Zero, Logical Operator

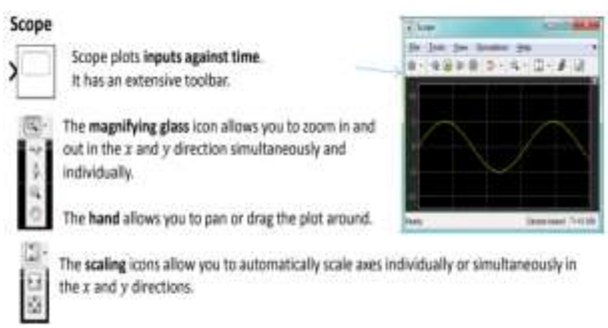
Table 4.1 Library names

ii. Sources Library

The table below, which includes important squares from this collection, shows more prevalent occasional capacities:

Block	Key Block Parameters	Block	Key Block Parameters
Sine Wave	• Amplitude and Frequency • Bias and Phase Time can be input as external signal	Pulse Generator	• Amplitude • Period (seconds) • Pulse Width (% of period) • Phase Delay (seconds)
Step	• Step Time • Initial Value • Final Value	Signal Generator	• Waveform: Sine, Square, Sawtooth or Random • Amplitude • Frequency • Units (rad/sec or Hertz)

iii. Sinks Library



Typically, the model's review data is used with the squares in this library.

[a] Scope

View signals are produced throughout the simulation process. A scope block shows the simulation time and its inputs. The oscilloscope block includes one axis for each port. Every axis tracks the freelancing Y-axis's usual course throughout time. You may modify the displayed input value's duration and fluctuation in this section. Throughout the simulation, adjust oscilloscope parameter settings and move and resize the oscilloscope window.

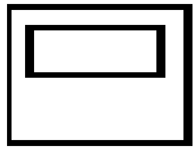


Fig. 4.1 Scope

[b] Continuous Integrator Library

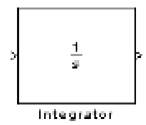


Fig. 4.2 Integrator

The Integrator block returns the required input at that particular time step. Block y's starting state is y0 as a property of entry u.

Where the vectors of features at simulated time t are denoted by y and u

[c] Breaker

Put in a circuit breaker that activates when
role of libraries

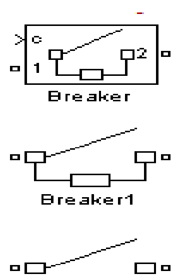


Fig 4.3 Breaker

The circuit breaker block's fuse can be timed using either an the setup, a fuse and a Rs-Cs snubber circuit are linked in series. A snubber is required for circuit breaker blocks linked in series with power circuits, inductive circuits, or power sources. When the control mode is applied to the control panel of the circuit breaker block, the switching time starts. When the circuit breaker is closed, a resistive block pulls. In comparison to other parameters, the Bockos value is lowered to the bare minimum need to be negligible **[**usually 10 m**]**. There is an endless amount of resistance when the breaker trips.

[d] Qualities

The input library declares the following function:
Scientific functioning

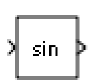


Fig 4.4 Features

Performing common trigonometric functions is the aim of the Trigonometric Function block.

[e] IGBT/Diode.

Putting an ideal IGBT, GTO, or MOSFET into practice with an anti-parallel diode library: Electronic Power

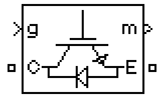
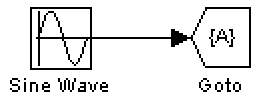


Fig. 4.5IGBT/Diode

An IGBT/diode block is a simpler IGBT [or GTO or MOSFET]/diode pair that does not require diode forward voltage or forced commutation components.

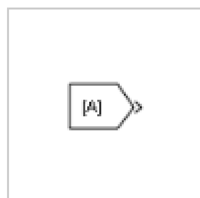
[f] Go on to the explanation.

Input is sent to the relevant From blocks using the Goto block. The input could be any type of vector or a signal with real or complex values. To communicate between blocks without combining them, use the From and Goto blocks.



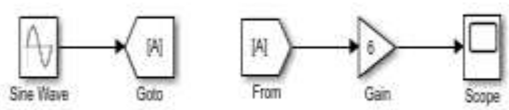
[g] From the block

A matching Goto block sends a signal to the From block, which generates it. The input and output of the Goto block are of the same data type. To send a signal from one block to another without linking them, you can use the From and Goto blocks.



A matching Goto block sends a signal to the From block, which generates it. The Goto block's input and output have the same data type. To transfer a signal across blocks without combining them, utilize the From and Goto blocks.

For instance, a Goto and a from block are used in this paradigm.



iv.Math Operations Library

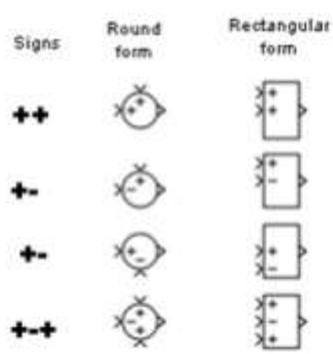
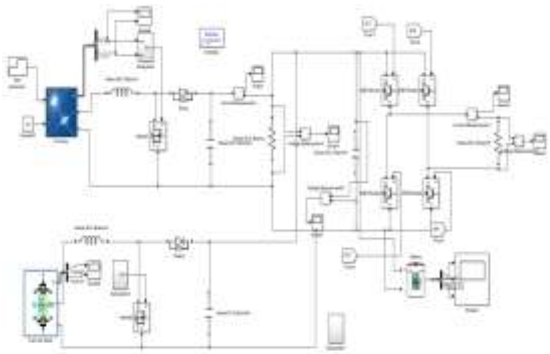


Fig. 4.6 Operations

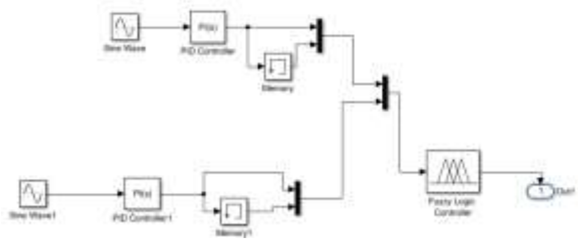
This library's squares correspond to standard numerical capabilities.

The Add, Subtract, and Sum squares are essentially the same as the Include, Subtract, and Sum blocks. You may switch one into the other by altering the icon's form and the list of signs in the square parameter [see right].

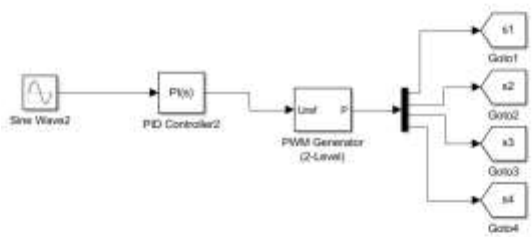
6.2 MATLAB CIRCUIT



(a)

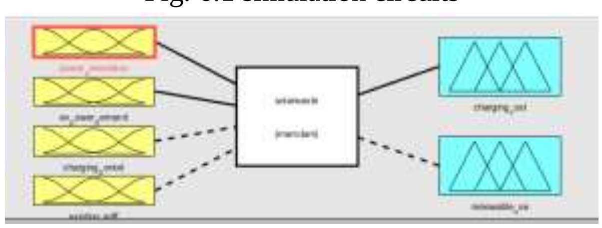


(b)

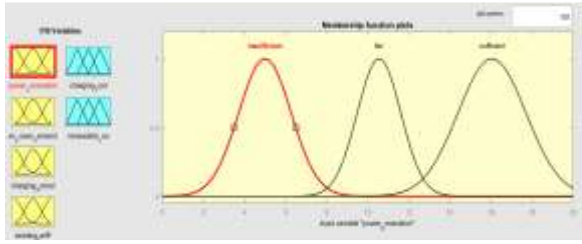


(c)

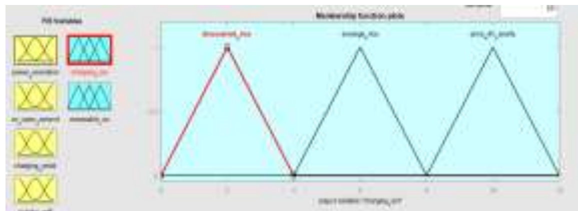
Fig. 6.1 simulation circuits



(a)

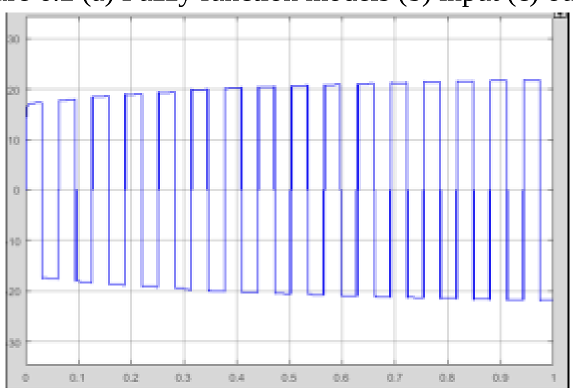


(b)

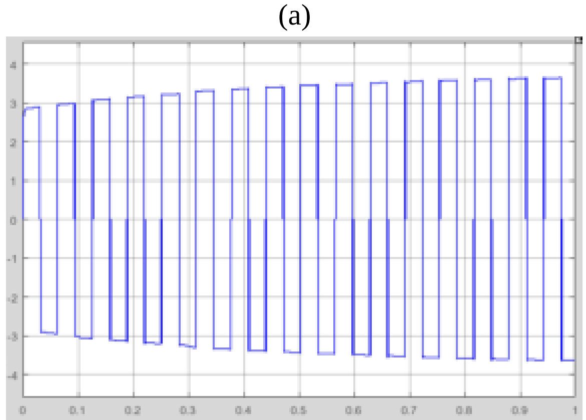


(c)

Figure 6.2 (a) Fuzzy function models (b) input (c) output



(a)



(b)

Figure 6.3 output voltage and current

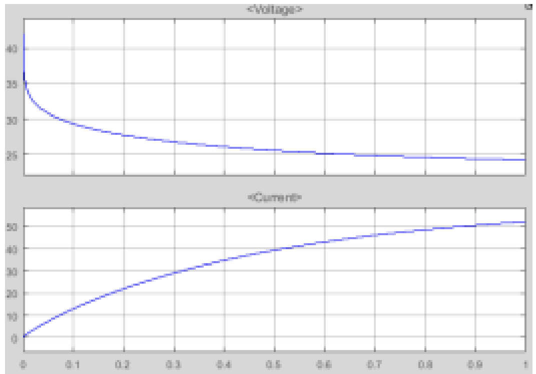


Figure 6.4 fuel stack results

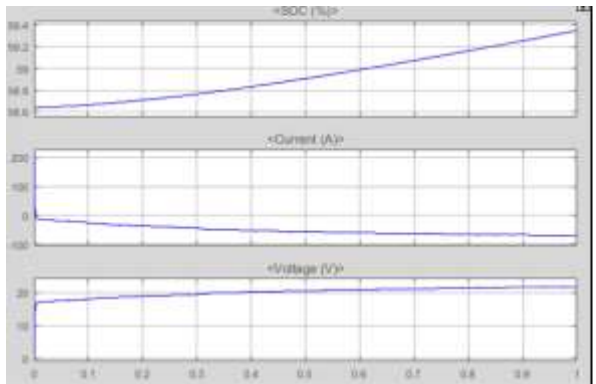


Figure 6.5 battery results

7. CONCLUSION

Research on The growing number various electric automobiles (EVs) allows for the incorporation with renewable energy resources. The objective of this project was to use solar and biogas/biomass resources to build and create an optimisation algorithm for an EV charging station (EVCS). It also examines the enormous the potential for renewable resources to create electricity off the grid. The recommended approach has advantages for effectively utilizing the currently accessible renewable resources to lower the release of greenhouse gases (GHG) and lessen grid stress through EV charging. The system optimises pricing times and rates based on power availability to maximise renewable use by compressing images instantly upon upload using AWS Lambda, S3, IAM, CloudWatch, and Docker.

It shows that by offering lower energy costs, a hybrid renewable energy-based EVCS motivates EV recharge. By reducing demand, it also lessens problems with power quality during peak hours. In addition, compared to the average rate, the daily charge cost is lowered by 55.22% on weekends and 46.15% on weekdays. It shows that when 84% of renewable resources are utilised, CO2 emissions are 54.86% less than those from the conventional grid-based system using the proposed EVCS. With percentages reaching 52.50% & 20.10%, respectively, renewable resources reduce GHG emissions down 34.28% and 13.12%. The main goals of this project are to build an efficient energy management system to manage the planned EV charging station and to use solar & biogas resources in a combination with the EVCS.

Globally, sustainable charging infrastructure can be established by putting the suggested optimisation strategy into practice. Lastly, a new strategy called V2G (Vehicle to Grid) technology can be developed for the EVCS as a smart grid-like bidirectional energy transfer system. During peak hours and outages, this initiative enables EVs to transmit energy to the power grid.

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