Smart Charging System for Electric Vehicles using Wind Energy

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Abstract:
In order to provide a sustainable and renewable energy source for EV charging, this article proposes the design of a wind-powered EV battery charging unit. The suggested technology converts and stores electricity produced by a wind turbine in a battery bank. The stored energy is transformed into a form that may be used to charge EV batteries by a charging unit. In order to ensure effective and dependable charging, the design takes into consideration both the requirements of EV batteries and the unpredictability of wind energy. Reduced reliance on fossil fuels, lower greenhouse gas emissions, and lower operational costs are only a few advantages of the suggested method. The concept is a workable option for EV charging infrastructure since it may be expanded for commercial use. According to simulation results, the suggested method may effectively use wind energy to charge EV batteries, indicating its potential as a renewable and sustainable energy source for the transportation industry. Furthermore, to maximize energy harvesting, storage, and charging, the suggested system integrates sophisticated control algorithms. To guarantee dependable and safe operation, the system also has safety features like short-circuit and overcharge prevention. The suggested system's design and simulation results show that it is both feasible and efficient in offering a renewable and sustainable energy source for EV charging.

Key words:
Wind blade, Generator, DC-DC Converter, Charging Unit

Introduction:

At the moment, EV chargers come in three different varieties: Level 1, Level 2, and Level 3. Level 3 is sometimes referred to as Direct Current Fast Charging (DCFC). The EV is powered by 120V or 240V AC electricity in Levels 1 and 2. The EV's internal battery charger controls the charging procedure and converts AC power into the DC needed to charge the battery. The DCFC converts the AC power to DC and delivers the DC power directly to the EV battery, avoiding the onboard battery charger. This makes it possible for the DCFC to directly charge the EV battery. At the moment, EV chargers come in three different varieties: Level 1, Level 2, and Level 3. Level 3 is sometimes referred to as Direct Current Fast Charging (DCFC). The EV is powered by 120V or 240V AC electricity in Levels 1 and 2. The EV's internal battery charger controls the charging procedure and converts AC power into the DC needed to charge the battery. The DCFC converts the AC power into DC and delivers the DC power directly to the EV battery via the onboard battery charger. This makes it possible for the DCFC to directly charge the EV battery. Level 1 and Level 2 charging is usually limited by the capacity of the EV's integrated battery charger and the available AC power. The constraints of the DCFC equipment are its rating and the amount of power that is available from the utility or other primary power sources. The best type of EV charging equipment is needed. A variety of parameters, such as the EV's charge rate, range, and dwell time—the amount of time the EV is available for recharging—determine the best type of EV charging system needed for the application.

The most basic charge level entails using a specific electrical cord with the appropriate plugs on both ends to connect the EV to a standard 120V AC outlet. The battery is then charged using the EV's integrated battery charger. This kind of charging is typically restricted by the power that the outlet can provide, which is typically 12-16A or less (1.44-1.92kW), which, assuming an EV with a 3 MP kWh rating, adds up to 5.8 miles per charging hour. If we bill for ten hours It would only increase the battery's range by 58 miles over night. Only EVs with a limited range benefit from level 1 charging when their daily mileage are modest or they have several days to spare between EV uses. Level 2 charges allow the EV to be connected to a 240V outlet, like the one used for an electric clothes dryer or range. Keeping with our example, level 2 chargers are currently available up to around 20kW, so that each hour of charging at 20kW would contribute 60 miles. Many Level 2 chargers are in the 7kW to 10kW range. Enough for most EVs to be recharged overnight. A delivery van or long-distance vehicle with a 100kWh battery may be recharged by a Level 2 10kW charger in just over ten hours, taking system losses into account.

Wind turbine

An apparatus that transforms the kinetic energy of the wind into electrical energy is a wind turbine. This apparatus uses sails affixed to a revolving shaft to harness wind energy. In order to split the force of wind on the sails into two parts, one of which adds rotation to the sail plane, the sails are angled or slightly twisted. movers to take the position of people as a power source.

History of Wind turbine:

One of the earliest known examples of wind powering a machine in history is Hero of Alexandria's wind wheel (10–70 AD). Nonetheless, the earliest known operational wind power facilities date back to the 7th century and were constructed in Sistan, a province in eastern Persia (present-day Iran). With their lengthy vertical drive shafts and rectangular blades, these windmills were known as "Panemone" vertical axle windmills. composed of six to twelve sails with cotton or reed matting covering them. Originally, these windmills were employed in the sugarcane and grist milling industries to crush grain or extract water.

Horizontal Axis Wind Turbine:

The great majority of wind energy generated globally today comes from massive three-bladed horizontal-axis wind turbines (HAWT), which face upwind of the tower with their blades. These turbines, which have a main rotor shaft and electrical generator at the top of a tower, must be pointed into the 33333 wind. Small turbines are targeted by a simple wind vane, however large turbines frequently use a wind sensor in conjunction with a yaw mechanism. The majority feature a gearbox that speeds up the slow rotation of the blades so that it can power an electrical generator. Some turbines utilize a different type of generator that can manage inputs with slower rotational speeds.Despite the fact that permanent magnet direct-drive generators can be more costly due to the rare earth materials required, these gearless turbines are sometimes preferred over gearbox generators because they "eliminate the gear-speed increaser, which is susceptible to significant accumulated fatigue torque loading, related reliability issues, and maintenance costs."

Figure 1: Horizontal axis wind turbine

Literature Survey:

Researchers have been looking into ways to lessen the reliance on fossil fuels and increase the efficiency of electric cars (EVs). The effectiveness of employing renewable energy sources for EV charging in Kazakhstan was examined in one study, "Study of the efficiency using facilities based on renewable energy for charging Electric vehicles" (2023). turbine based on experimental characterization is used in an electric vehicle battery. The study optimized a modest wind turbine's performance through artificial intelligence modeling.EV chargers. An integrated circuit for a mobile device battery charger that doubles as a boost DC-DC converter was created in a paper titled "Switching battery charger integrated circuit for mobile devices in a 130nm BCDMOS process" (2016).Additionally, researchers have been looking for ways to combine EV motor drives with battery chargers. "An isolated battery charger and integrated 20-kW motor drive for plug-in cars" (2013) was one study that created an integrated motor drive and isolated battery charger for plug-in electric vehicles. Both traction and charging modes are available for the system.The application of sophisticated power electronics and motor control strategies to raise EV performance and efficiency has been the subject of further research. One study, for instance, found that the converter employed a motor speed and a battery charger. Bi-directional power converter for usage as a motor speed controller and battery charger in industrial trucks was introduced in "Controller in an Industrial Truck" (2006).Lastly, scientists have been looking into ways to make EV battery chargers lighter and smaller without sacrificing performance. An on-board charger for EVs that uses the stator windings of a three-phase induction motor as a filter was suggested in a research titled "Integrated Battery Charger for EV.by Using Three-Phase Induction Motor Stator Windings as Filter" (no date). The goal of the study was to increase the charger's efficiency while lowering its weight and size. Subotic, M. Jones, N. Bodo, and E. Levi "Asymmetrical nine-phase machine for onboard integrated battery charger for electric vehicles," IEEE Transaction on IE May 2015.

An integrated onboard charger for electric cars that makes use of an asymmetrical nine-phase machine and an inverter is investigated in this work. Only the power electronic components that are already on the vehicle and required for propulsion are used, and charging is done via three-phase mains No new parts have been added. Furthermore, no hardware alteration is required to complete the charging process because the current components and their connections remain unchanged when the system transitions from propulsion to charging mode. Instead, the operational principle is based on the additional degrees of freedom present in nine-phase machines. During the charging process, currents flow through the machine's stator windings; these degrees of freedom are employed to stop the machine from generating electromagnetic torque.This configuration enables both unity power factor and vehicle-to-grid (V2G) operation. A detailed theoretical analysis and exploration of the control for the charging/V2G and propulsion modes are presented. Theoretical analysis is verified by experiments for the charging, V2G, and propulsion operating regimes.The paper "An integrated split-phase dual-inverter permanent magnet motor drive and battery charger for grid-connected electric or hybrid vehicles" was published in November 2012 by S. Haghbin, T. Thiringer, and O. Carlson. Some applications, such high-power drive systems, benefit from multi-phase machines due to their advantages, which include decreased torque ripple and lower power electronic

Block Diagram:

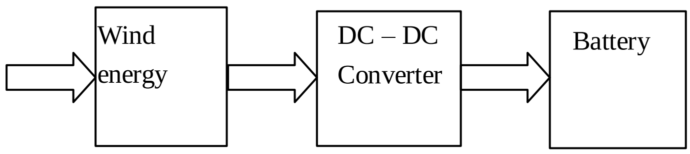

Figure 2: Block diagram of charging unit

Block Diagram Explanation:

Wind Energy

Electric vehicle (EV) batteries may be charged using wind energy, which offers a sustainable and clean energy source. EVs may be charged at wind-powered charging stations.which lowers greenhouse gas emissions and the need for fossil fuels. Excess energy produced by wind turbines can be stored in EV batteries and returned to the grid.

DC to DC Converter:

An electronic device that changes a direct current (DC) input voltage into a different DC output voltage is called a DC-to-DC converter. Numerous applications, such as power supplies, electric cars, and renewable energy systems, make extensive use of these converters. There are various types of DC-to-DC converters, such as fly-back converters, buck converters, boost converters, and buck-boost converters. The choice of converter is based on the particular application and requirements, and each type of converter has pros and cons of its own.

Battery:

One kind of deep cycle battery that is intended to deliver a nominal voltage of 24 volts is the 24V battery. These batteries are extensively utilized in many different applications, such as backup power systems, renewable energy systems, and electric cars. Among the many benefits of 24V batteries are their high energy density, extended cycle life, and low self-discharge. Additionally, they are really little and lightweight, which makes them perfect for applications with little space. Electric vehicles frequently use 24V batteries.

Circuit Diagram:

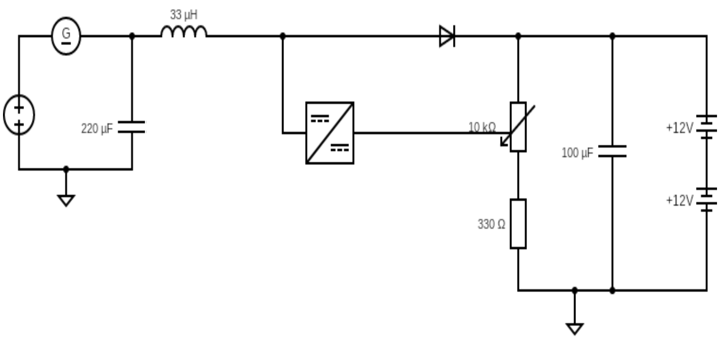

Figure 3: Circuit Diagram

Circuit Diagram Explanation:

The purpose of the wind blades, which are usually composed of composite materials like carbon fiber or fiberglass, is to harness the kinetic energy of the wind. A mechanical shaft attached to the generator is driven by wind.The generator then uses electromagnetic induction to transform this mechanical energy into electrical energy. Because it corrects the electrical energy produced by the generator, the diode (1N5401) is an essential part of the system. This guarantees that electrical energy only flows in one direction, avoiding backflow and possible system damage. Together, the inductor (33uH) and capacitor (220uF) filter out undesirable electrical noise and ripple to create a steady output voltage. The inductor controls the passage of electrical current, and the capacitor stores and releases electrical energy as needed. The output voltage is further adjusted by the LM2577 ADJ adjustable voltage regulator to make sure it satisfies the necessary requirements. This regulator provides a high level of accuracy and stability by adjusting the output voltage using pulse-width modulation (PWM).The system can adjust to fluctuating energy demands because to the 10K variable resistor's ability to simulate different loading scenarios. You can modify this resistor to mimic other loads, such an electrical gadget or a battery. In the meantime, the 330 ohm resistor helps control the flow of electrical energy by dividing voltage and processing signals. You can use this resistor to filter out undesirable signals or divide the output voltage.

Results and Discussion:

Figure 4: Hardware model of charging unit

Table:1 Generated Voltage

Speed in Km/hr	Voltage in Volts
25	3.9
28	5.5
30	9.7
35	10.5
38	14
41	15.5
46	21.6
49	22.3

We have conducted the experiment for generated voltage by using 24V generator coupled to wind blade. we have placed the setup in the vehicle speed is measured in speedometer & voltage is measured by using multimeter

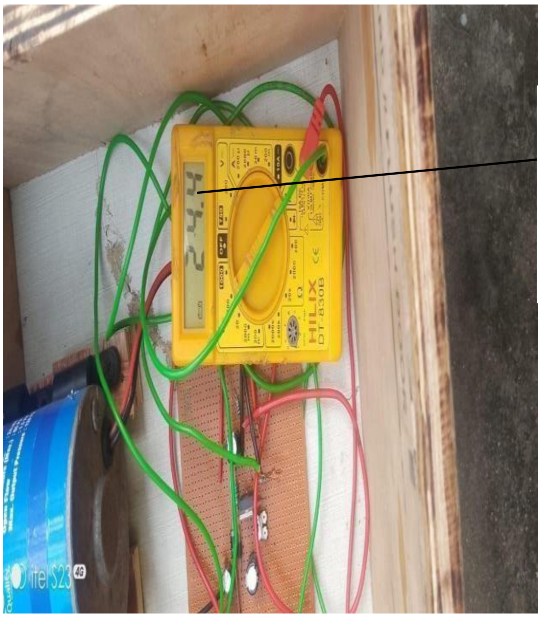

Figure 5: shows the Generated Voltage

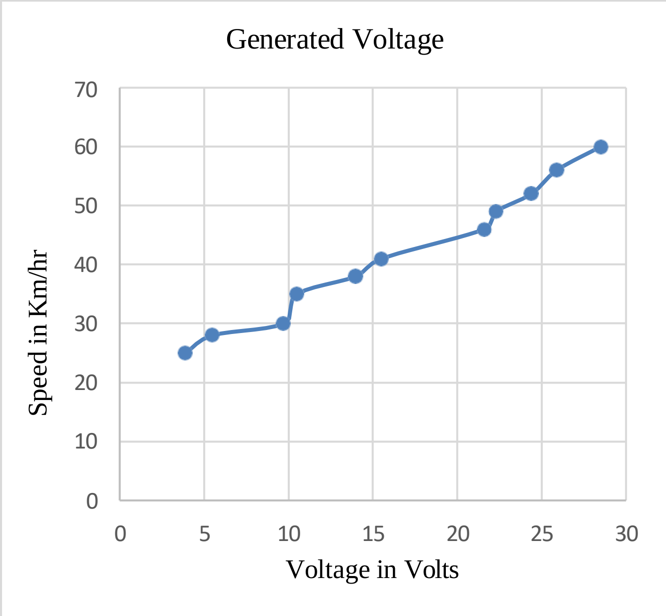

Figure 6: Graphical representation of speed v/s voltage

Table:2 On Load Readings:

Speed in Km/hr	Voltage in Volts
25	8.2
28	12
30	20.7
35	26
38	29.9
40	32.6

We have noted down the on load readings by connecting setup to batteries as a load, speed and voltages are noted down in the table.

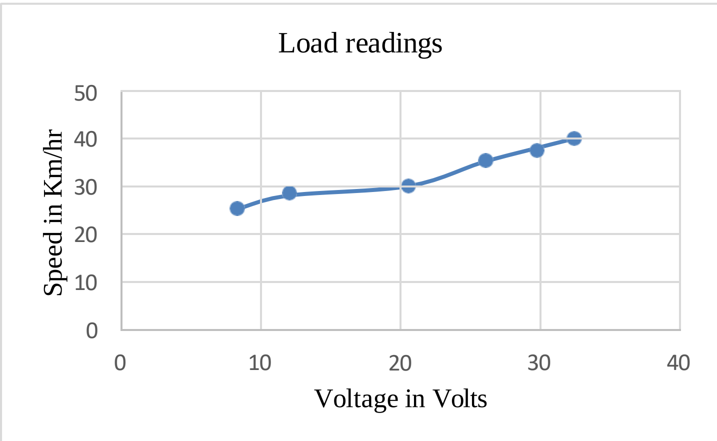

Figure 7: Graphical representation of speed v/s voltage

Table-3 Load Calculations

Load Current in Amps	Voltage in Volts
0.11	24
0.29	20.19
0.49	18.1
1.57	17.2
2.07	16.29

Figure 9: Load test

Load test:

We have conducted the load test by coupling the 48V Generator to the 24V Generator and load current is measured by connecting the batteries and another 24V Motor. The objective of this load test is to verify the performance of 24V Generator under various load conditions. We have used ammeter to measure the load current readings. By gradually increasing the load in increments of 0.5A and observed the various readings of load current as shown in below table.

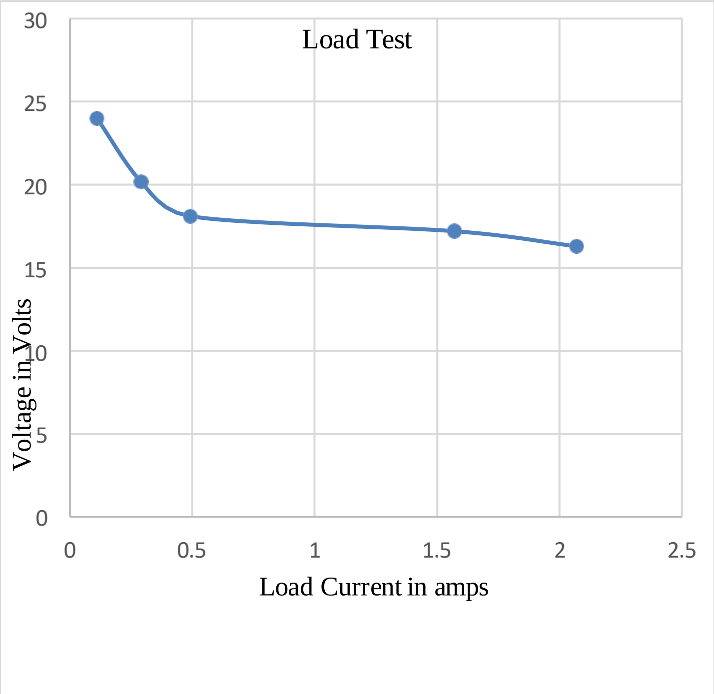

Figure 8: Graphical representation of Voltage v\s Load Current

Calculations:

We have calculated system efficiency, charging time, actual energy, battery energy, distance covered to charge the battery and distanced covered that battery will discharge after fully charged

Efficiency = (output power / input power)* 100

E = (33.72 / 54)*100

E = 62.44%

Charging Time(t) = Capacity of Battery / (Load current*Charging efficiency)

t = 28 / (2.07*0.6244)

t = 21.6hrs

Battery Energy Calculation

Battery Energy (Wh) = Battery Capacity (Ah) x Battery Voltage (V)

= 28Ah x 24V

= 672 Wh

Actual Energy Calculation

Actual Energy (Wh) = Battery Energy (Wh) / Efficiency

= 672 Wh / 0.6244

= 1076 Wh

Energy Generation Calculation

Energy Generation per Hour (Wh) = Output Power (W) x Time (hours)

= 33.72 W x 1

= 33.72 Wh/hour

Distance Calculation

Distance Required to Charge the Battery (km) = Actual Energy / Energy Generation x Speed

= 1076 Wh / 33.72 Wh/hour x 40 km/h

= 127.6 km

Distance Calculation

Distance Required to Discharge the Battery (km) = Actual Energy / Energy Consumption per Hour x Speed (km/h)

= 420 Wh / 250 Wh/hour x 40 km/h

= 67.2km

Conclusion:

EV battery charging in conjunction with wind energy offers a practical solution for eco-friendly driving. EV owners may lessen the effects of climate change and contribute to a cleaner world by utilizing wind energy to drastically cut their carbon footprint and reliance on fossil fuels. Wind energy is a perfect option for EV power because it is a plentiful and renewable resource. The combination of wind energy with electric vehicles (EVs) has the potential to completely transform the transportation industry and drastically lower air pollution and greenhouse gas emissions.The advantages of using wind energy for EV battery charging make it a desirable choice for anyone looking to reduce their environmental impact, even though there are some disadvantages to take into account, such as an erratic energy supply and expensive upfront expenditures. Wind energy integration with EV battery charging is anticipated to be essential to the shift to a low-carbon transportation industry as costs come down and technology improves. Furthermore, by lowering dependency on imported fuels, the widespread installation of wind-powered EV charging stations can boost local economies, generate new employment possibilities in the renewable energy sector, and improve energy security.Additionally, there are economical benefits to using wind energy for EV battery charging, such as decreased energy and operating costs.

Wind energy has become a competitive option for electric vehicle (EV) owners as its cost has decreased over time, allowing them to lower their environmental impact and save money on their energy bills. Furthermore, governments and organizations can provide tax credits and incentives to promote the installation of wind-powered EV charging stations, increasing their viability for both consumers and businesses.

Future Scope:

Wind energy has a bright future when it comes to charging EV batteries. The need for renewable energy sources to power electric vehicles will only increase as the globe moves toward a more ecologically responsible and sustainable transportation system. With its track record of success and technological breakthroughs, wind energy is well-positioned to meet this demand. Costs will be further decreased and the use of wind-powered EV charging stations will rise with the development of more effective wind turbines, better infrastructure, and creative energy storage technologies.Developing a sustainable and eco-friendly transportation system will also heavily rely on the integration of wind energy with other renewable energy sources like solar and hydrogen fuel cells. A strong and resilient energy network that can supply power to the increasing number of electric cars on the road will be made possible by this hybrid strategy. Numerous advantages will result from the widespread installation of wind-powered EV charging stations, such as decreased air pollution and greenhouse gas emissions, enhanced energy security and independence, the creation of new jobs and economic opportunities in the renewable energy sector, and enhanced public health and quality of life.Wind energy will be a major factor in driving the expansion of electric vehicles as the globe moves closer to a more ecologically friendly and sustainable transportation system. Wind energy's enormous potential makes it a prime renewable energy source for EV battery charging, propelling a more sustainable, eco-friendly, and clean transportation future.

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