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INTEGRATION OF SOLAR, WIND, AND REGENERATIVE BRAKING TECHNOLOGIES IN ELECTRIC GOLF CARTS FOR SUSTAINABLE TRANSPORTATION

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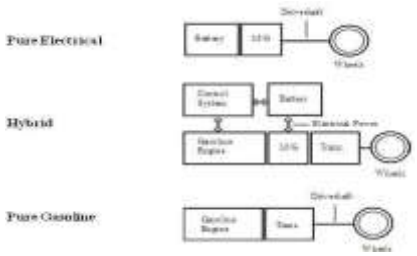
ABSTRACT

Electric golf carts have emerged as an environmentally friendly alternative for short-distance transportation, particularly in recreational and urban settings. This paper investigates the feasibility and benefits of integrating renewable energy sources, namely solar and wind power along with regenerative braking technology, into electric golf carts. By harnessing solar and wind energy to charge the cart's batteries and implementing regenerative braking to capture kinetic energy during deceleration, these carts can achieve greater energy autonomy and reduce their overall environmental footprint. We explore the potential advantages of such integration, including extended range, improved efficiency, and reduced dependence on grid-supplied electricity, typically derived from fossil fuels. Through this interdisciplinary approach, we aim to provide insights into creating a more sustainable and eco-friendly transportation solution for electric golf carts, paving the way for a greener future in recreational and urban mobility.

Index terms: Fossil fuels, renewable energy sources, battery energy storage system, hybrid vehicle.

Introduction: An electric vehicle is one powered by an electric motor rather than a traditional petrol/diesel engine. This electric motor is powered by rechargeable batteries that can be charged by common house hold electricity. Consistent with the definition of hybrid above, the hybrid electric vehicle combines a gasoline engine with an electric motor. An alternate arrangement is a diesel engine and an electric motor, a HEV is formed by merging components from a pure electrical vehicle and a pure gasoline vehicle. The Electric Vehicle (EV) has an M/G which allows regenerative braking for an EV; the

M/G installed in the HEV enables regenerative braking. For the HEV, theM/G is tucked directly behind the engine. In Honda hybrids, the M/G is connected directly to the engine. The transmission appears next in line. This arrangement has two torque producers; theM/G in motor mode, M-mode, and the gasoline engine. The battery and M/G are connected electrically. An electric scooter is a battery-operated one-person capacity vehicle that is specially designed for people



with low mobility. It is generally used by those who have difficulty walking for long periods. Scooters are available in three common designs, those intended for indoor use, those for outdoor use, and those that are used for both. An electric scooter may have three or four. Since it runs on battery power, it does not create pollution. The servicing requirements for electric vehicles are lesser than conventional petrol or diesel vehicles. Therefore, the yearly cost of running an electric vehicle is significantly low. So, behalf of these advantages, we have chosen this project.

Literature review

Regular vehicles offer many benefits like lengthy drive range, great execution, and simple refueling. Thus, they are ruling the vehicle market. Anyway, ordinary vehicles have constraints like air contamination and wasteful utilization of petroleum derivative. The need of great importance is eco-friendly and low-discharge vehicle without for feiting the vehicle's presentation, dependability, and wellbeing. Contamination issues can be limited by utilizing zero emission electric vehicles (EV) at the expense of a restricted drive range. Decrease in Green House Gas (GHG) emanations, expansion in oil costs, and reliance on unfamiliar oil are significant impetuses for the turn of events and sending of Electric Vehicles (EVs). Contrasted and regular vehicles, produce extensively low commotion, ozone harming substance, and ozone-forerunner outflows [4-8]. Electric thought process power began in 1827, when Hungarian minister Anyos Jedlik constructed the primary rough however reasonable electric engine, which utilized a stator, Rotor, Commutator, and the one year from now he involved it in a little vehicle [9]. In 1835, Teacher Sibrandus Stratingh of the College of Groningen, in the Netherlands, assembled the limited scale electric vehicle, and at some point somewhere in the range of 1832 and 1839, Robert Anderson

of Scotland created the principal rough electric carriage, controlled by non-battery-powered essential cells American

metal forger and innovator Thomas Davenport fabricated a toy electric train, controlled by a crude electric engine,

in 1835. In 1902, the Studebaker Auto Organization entered the auto business with electric vehicles, however it likewise entered the fuel vehicles market in 1904. In 2009, During the culmination, Copenhagen environment meeting in excess of 70 nations created plans to arrive at net zero in the long run. For some nations, taking on

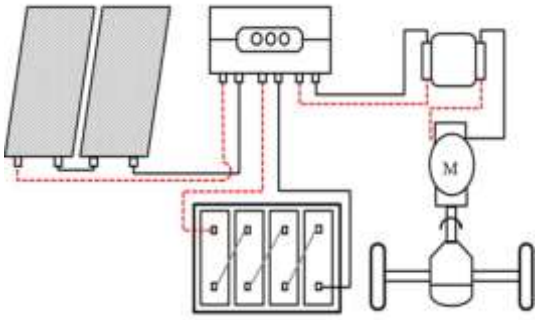
more EVs will assist with lessening the utilization of fuel. Asif Faiz; Christopher S. Weaver; Michael P. Walsh (1996). Air

Contamination from Engine Vehicles: Guidelines and Advancements for Controlling Discharges. World Bank Distributions. p. 227. From the first on 4 July 2021. Recovered 4 December 2017. Hamid, Umar Zakir Abdul (2022).

"Independent, Associated, Electric and Shared Vehicles: Upsetting the Car and Versatility Areas".Recovered 11 November 2022**.**

Methodology and working principle

Block diagram



Vehicle block diagram

The research methodology is carried out based on the following:

Information gathering: The information for this exploration is accumulated through the audit of existing reports on Electric Vehicle, uses and sorts of sun based, wind, and programmed slowing mechanism, and the monetary significance of electric vehicles through looking through books, articles, diaries, and producer sites and furthermore space master was evaluated to figure out how things are as of now finished.

Data Analysis: Data analysis is done through a feasibility study to determine if this project work is worth doing and how to do this task at a sensible expense. This assisted in this undertaking in view of with costing, dependability, similarity, and accessibility rules. Specialized, financial, and functional practicality questions were tended to.

Coding:

TheArduinoboardwouldbecodedusingtheArduinoIDEwhichisbasedonCprogramming to drive the Arduino microcontroller and controls the two-way DC Converter and sends the speed comparison signal to the frequency converter. Furthermore, electrical and mechanical parameters such as voltage, current, and speed have been noticed.

Testing:

Both unit and system testing would be performed to ensure the proper functioning of the equipment parts and programming of the framework.

Solar panel

The term sunlight powered charger is best applied to a level sun based warm gatherer, for example, a sun powered boiling water or air board used to warm water, air, or generally gather sun based nuclear power. However, 'sunlight powered charger' may likewise allude to a photovoltaic module which is a gathering of sun-oriented cells used to produce power. In all cases, the boards are regularly level, and are accessible in different levels and widths an exhibit is a get together of sunlight based warm boards or photovoltaic (PV) modules; the boards can be associated either in equal or series relying on the plan objective. Sunlight based chargers normally track down use in private, business, institutional, and light modern applications. Sun-powered warm boards saw far- reaching use in Florida and California until the 1920s when tank-type water radiators supplanted them.

Solar panel

No one the less, sunlight- based warm boards are still under way,and are normal in bits of the reality where energy costs, and sun-oriented energy accessibility, are high.

PV module production on a large scale has recently grown in popularity. In regions of the planet with fundamentally high in isolation levels, PV yield and their financial aspects are upgraded. PV modules are the essential part of most limited-scope sun-based electric power-producing offices. Bigger offices, for example, sun-oriented power plants ordinarily contain a variety of reflectors (concentrates), a beneficiary, and a thermodynamic power cycle, and in this manner utilize sun-based warm as opposed to PV.

DEFINITION

*"*A photovoltaic framework is a framework that utilizes at least one sunlight-powered charger to

change sun- oriented energy into power. It comprises numerous parts, including the photovoltaic modules, mechanical and electrical associations and mountings, and method for controlling and additionally altering the electrical result"

PHOTOVOLTAICCELL

Silicon and other semiconductors are used in the construction of PV cells. For sun-based cells, as lender semiconductor wafer is uniquely treated to frame an electric field, positive on one side and negative on the other

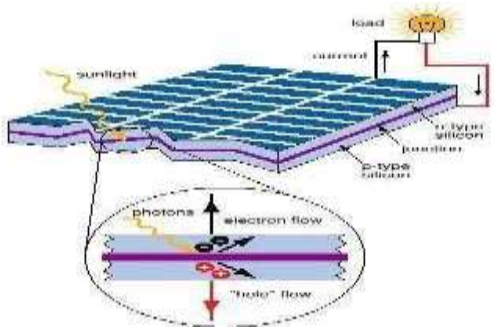


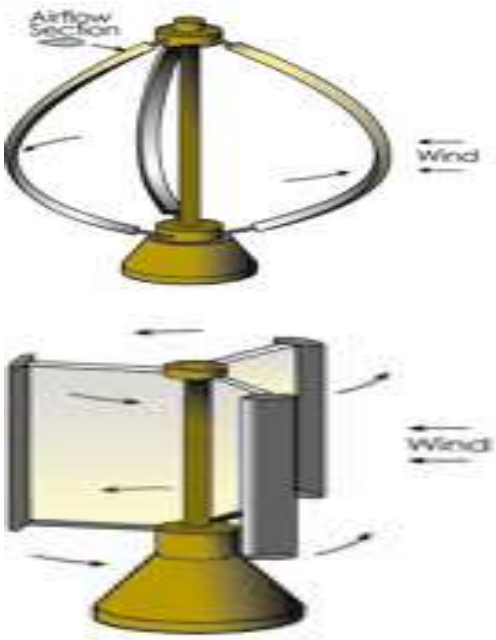
Photo voltaic cell

At the point when lighten energy strikes the sun-powered cell, electrons are thumped free from the molecules in the semiconductor material. Assuming electrical conveyors are appended to the positive and negative sides, shaping an electrical circuit, the electrons can be caught as an electric flow-that is, power. This power can then be utilized to drive a load. A PV cell can either be round about or square in development

Wind Turbines: working principles

Most wind turbines (WT) are machines built to convert the containing power in the wind into electricity. The main classification of those machines is according to the interaction of their blades with the wind by aerodynamic forces - drag or lift or a combination of both; and the orientation of the rotor axis with respect to the ground and to the tower upwind or downwind (Ahmed, 2011). According to the orientation of the axis there are two types:

The Horizontal Axis Wind Turbine, or HAWTS, and Vertical Axis Wind Turbines, or VAWTS (Figure2.10).

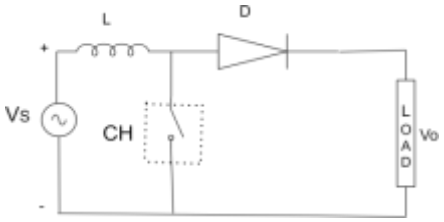


Among the Vats machines we highlight the Antonius mostly used for water pumping and the Darius WT. They have the advantage of receiving wind from any direction not requiring tracking mechanisms of the wind direction and that the

coupling between the rotor and the generator can be made at ground level, allowing easy access for maintenance meaning that smaller towers gets reduced costs. The main disadvantage is that it has no self-starting, high torque fluctuations and limited options of regulations at high wind speed

DC to dc converter

A DC-to-DC converter is a gadget that acknowledges a DC input voltage and produces a DC yield voltage. Regularly



The result deliver dis at an alternate voltage level than the info. Also, DC-to-DC converters are used to give commotion seclusion, power transport guideline, and soon.

Boost converter –step up converter

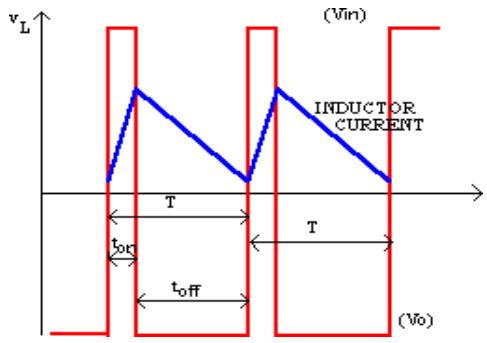
Boost converter schematic diagram

fundamental lift converter. This circuit is utilized when a higher result voltage than input is required.

While the semiconductor is ON Vx=Vin, and the OFF express the inductor current moves through the diode giving Vx =Vo.For this examination it is expected that the inductor current generally stays streaming (ceaselessconduction). The voltage across the inductor and the typical should be zero for the typical current to staying consistent state. This can be modified and for a loss less circuit the power balance guarantees

Voltage and current wave forms(Boost Converter)

Since the obligation proportion "D" is somewhere in the range of 0 and 1 the result voltage should continuously be higher than the info voltage in size. The negative sign demonstrates an inversion of the feeling of the resulting voltage

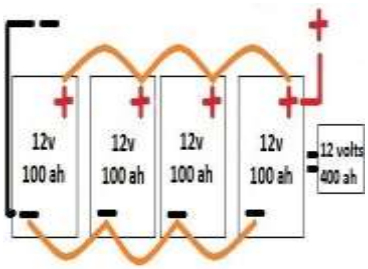


Waveforms of boost converter

Materials and model

Battery

A rechargeable battery, storage battery, or accumulator is a type of electrical battery. It



comprises one or more electrochemical cells and is a type of energy accumulator. It is known as a Secondary cell because its electrochemical reactions are electrically reversible. In this project, we are using a12v, 7A1ed dry acid battery.

Rechargeable battery:

The most commonly used for batteries type was in the past, the lead- acid battery. For its use of low price per storable energy quantity, the achievable maintenance, the low self-discharge and the relatively high efficiency of about 80% spoke. The losses in lead-acid batteries can be explained in part by the out gassing of hydrogen –oxygen during charging. With maintenance-free lead-acid batteries the gas emissions are reduced. They are optimized for a particularly long service life, cycle stability and behavior at low discharge. Typical are numbers of cycles of 1200 {with a depth of discharge of about 80%} residual capacity of 80%, since then a battery is considered defective from, maintenance-free lead acid batteries have the advantage that there are no or only forms a minimum stratification she sure but allow only a much smaller number of cycles from 400 to 600. An additional circulation of acid prevents completely stratification and the lead-acid batteries. This is especially important in stationary operation.

battery bank

Lithium-ion batteries are also used recently as a solar battery, which is due to sharp fall in prices of lithium-ion batteries in addition, lithium-ion batteries have some very high cycle stability of more than 10,000 charge and discharge cycles and a long service life of up to 20 years. In particular, lithium iron phosphate batteries are used which, and by a high cycle stability, high security small price excel and come as traction batteries for use. Partly also used batteries are used, which no longer have enough capacity for

other applications for example, peddle or electric cars, as solar battery, but still suffice.

D.C Motor:

The DC motor has two basic parts: the rotating part called the armature and the stationary part that includes the wirecoils. The stationary partial so called the stator. Figures how picture of a typica lDC motor,24V,250W DC Motor is used.

A brushless DC motor (known as BLDC) is a permanent magnet synchronous electric motor which is driven by direct current (DC) electricity and it accomplishes electronically controlled commutation system (commutation is the process of producing rotational torque in the motor by changing phase currents through it at appropriate times) instead of a mechanically commutation system. BLDC motors are also referred as trapezoidal permanent magnet motors.

Unlike conventional brushed type DC motor, wherein the brushes make the mechanical contact with commutator on the rotor so as to form an electric path between a DC electric source and rotor armature windings, BLDC motor employs electrical commutation with permanent magnet rotor and a stator with a sequence of coils. In this motor, permanent magnet (or field poles) rotates

and current carrying conductors are fixed

Final results

Energy Generation: Solar panels on the vehicle's surface capture sunlight and convert it into electricity, which can be used to charge the battery or power auxiliary systems. Wind turbines, if integrated, harness airflow during vehicle movement to generate electricity. Regenerative braking captures kinetic energy during braking and converts it into electrical energy.

Range Extension: Solar power and regenerative braking help extend the vehicle's range by continuously generating electricity during operation. Solar panels can charge the battery while the vehicle is parked or in motion, while regenerative braking recovers energy that would otherwise be lost during braking.

Efficiency: integrating renewable energy source and regenerative braking enhances the overall efficiency of the vehicle. It reduces energy consumption and reliance on external charging infrastructure, making electric vehicles more self-sufficient and sustainable.

Environmental impact: By utilizing renewable energy sources and reducing energy waste through regenerative braking, electric vehicles with these technologies have a lower carbon footprint compared to conventional vehicles. They help mitigate air and noise pollution, contributing to a cleaner and healthier environment.

Cost Considerations: While the initial investment in integrating these technologies may be higher, they offer long-term cost savings through reduced fuel or electricity consumption and lower maintenance requirements. Over the vehicle's lifetime, the cost of ownership may be lower compared to conventional vehicles.

Practicality and Implementation: The practicality of integrating solar power, wind power and regenerative braking depends in various factors such as vehicle design, efficiency or energy conversion, available space for installation, and technological advancements. Manufacturers need to balance these considerations to ensure safety, performance and feasibility.

Infrastructure and Support: Adoption of these technologies may require supporting infrastructure such as charging stations equipped with renewable energy sources. Government incentives, policies and infrastructure development play a crucial role in promoting the adoption of electric vehicles with integrated renewable energy systems.

Conclusion

In conclusion, integrating solar, wind and regenerative braking technologies into Electric Vehicles (EVs) offers a compelling solution to

enhance efficiency, sustainability and overall performance. By harnessing renewable energy sources and optimizing energy usage, these advanced systems contribute to reducing greenhouse gas emissions, minimizing reliance on non-renewable resources and lowering operational costs.

Solar panels mounted on the vehicle's surface, coupled with wind turbines strategically positioned to capture airflow, provide supplementary power generation, extending the vehicle's range and reducing the need for external charging. Additionally, regenerative braking systems enable the recovery of kinetic energy during deceleration, further improving energy efficiency and enhancing driving dynamics.

This innovative approach not only aligns with global efforts to mitigate climate change but also delivers tangible benefits to consumers, including reduced fuel expenses, increased autonomy, and a reduced environmental footprint. However, challenges such as cost-effectiveness, limited scalability and variability in renewable energy availability remain to be addressed to realize the full potential of these technologies.

Overall, the integration of solar, wind and regenerative braking systems represents a significant step forward in advancing the sustainability and performance of Electric Vehicles, driving us towards a cleaner, greener transportation future. Continued research, development and adoption of these technologies are essential to unlock their full potential and accelerate the transition to a more sustainable ecosystem.

References

1. M. E. Kowalok, "Environment: Science and Policy for Sustainable Development Common Threads: Research Lessons from Acid Rain , Ozone Depletion , and Global Warming," no. June 2013, pp. 37–41, 2010.
2. D. Akal, S. Öztuna, and M. K. Büyükakın, "A review of hydrogen usage in internal combustion engines (gasoline-Lpg-diesel) from combustion performance aspect," Int. J. Hydrogen Energy, vol. 45, no. 60, pp. 35257–35268, 2020, doi: 10.1016/j.ijhydene.2020.02. 001.
3. V. R. J. H. Timmers and P. A. J. Achten, "Non-exhaust PM emissions from electric vehicles," Atmos. Environ., vol. 134, pp. 10–17, 2016, doi: 10.1016/j. atmosenv.2016.03.017.
4. R. Xiong, Y. Zhang, J. Wang, H. He, S. Peng, and M. Pecht, "Lithium-Ion Battery Health Prognosis Based on a Real Battery Management System Used in Electric Vehicles," IEEE Trans. Veh. Technol., vol. 68, no. 5, pp. 4110–4121, 2019, doi: 10.1109/TVT.2018. 2864688.

5. C. Y. Lin and K. H. Wang, “The fuel properties of three-phase emulsions as an alternative fuel for diesel engines,” Fuel, vol. 82, no. 11, pp. 1367–1375, 2003, doi: 10.1016/S0016-2361(03)00021-8.
6. N. Nisrina, M. I. Kemal, I. A. Akbar, and T. Widianti, “The Effect of Genetic Algorithm Parameters Tuning for Route Optimization in Travelling Salesman Problem through General Full Factorial Design Analysis,” Evergreen, vol. 9, no. 1, pp. 163–203, 2022, doi: 10.5109/4774233.
7. F. C. C. CHAN, “An Overview of Electric Vehicle Technology,” IEEE, vol. 81, no. 9, pp. 1–12, 1993.
8. M. Motinur Rahman et al., “Energy Conservation of Smart Grid System Using Voltage Reduction Technique and Its Challenges,” Evergreen, vol. 9, no. 4, pp. 924–938, 2022, doi: 10.5109/6622879.
9. Safril, Mustofa, M. Zen, F. Sumasto, and M. Wirandi, “Design of Cooling System on Brushless DC Motor to Improve Heat Transfers Efficiency,” Evergreen, vol. 9, no. 2, pp. 584–593, 2022, doi: 10.5109/ 4794206.
10. John M. Miller, “Energy storage system technology challenges facing strong hybrid, plug-in and battery electric vehicles,” IEE Explore., 2009.