

Captive Energy Generation by Using Gym Equipment

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Abstract

This project aims to create a sustainable energy source by converting exercise equipment into devices capable of generating electrical power. Traditionally, the mechanical energy produced during workouts is wasted as it dissipates within exercise machines. This project aims to capture and convert that otherwise unused energy into usable electricity. By integrating an alternator-based system into fitness equipment, the mechanical motion generated by users during exercise can be transformed into electrical energy. This approach not only promotes sustainable energy practices but also adds value to routine workouts. The generated power can be stored or used to operate small devices, making gyms more energy-efficient and environmentally friendly while encouraging users to contribute to clean energy generation through physical activity. By integrating exercise equipment with an alternator, users' physical effort is transformed into electrical energy. This generated power can be utilized to run devices like lights, computers, or other equipment. The system not only promotes fitness but also encourages sustainability, allowing gym-goers to contribute to renewable energy generation while working out.

Keywords: Renewable energy, exercise equipment, microcontroller, human power generation, sustainable energy, real-time energy

INTRODUCTION

The project revolves around the development of an innovative and efficient electricity generation system that addresses both the need for sustainable energy solutions and the desire for cost-effective power generation. This system integrates a stationary bicycle with an advanced electrical setup to produce electricity, store it in a 12-V battery, and convert it into usable forms for powering various devices. The design prioritizes user convenience and practicality, making it a versatile and accessible option for a wide range of applications. The system's ability to generate approximately 60 W of power under normal operation is sufficient to power small household devices such as lights, amplifiers, and chargers, while also accommodating potential future expansions for additional loads [1–3].

A key advantage of the system is its efficiency and reliability, as it can provide up to 5 h of continuous operation at full load with an equivalent charging time. By integrating multiple interconnected subsystems, the design ensures optimal energy conversion and utilization. From the mechanical energy transferred by pedaling to the alternator, which generates AC voltage, to the rectifier that converts AC to DC for battery storage, and the inverter and transformer that further process the power for broader applications, each component works harmoniously to deliver seamless performance.

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The system is also equipped with a backup power supply that ensures continuous battery charging even when manual pedaling is unavailable, further enhancing its reliability. This project stands out for its blend of mechanical ingenuity and electrical efficiency, showcasing how renewable and user-driven energy generation can be effectively harnessed to meet modern power needs.

By leveraging simple yet effective technology, the project offers a practical solution for small-scale energy generation, with potential applications in remote areas, emergency scenarios, and environments where traditional power sources are unreliable or unavailable. This innovative approach not only underscores the potential of human-powered energy systems but also highlights the importance of integrating sustainable practices into everyday life [4].

This project introduces a groundbreaking approach to small-scale electricity generation, combining mechanical and electrical systems to create a user-driven, sustainable, and cost-effective power solution. At its core, the system leverages the simple action of pedaling a stationary bicycle to convert human kinetic energy into electrical energy, showcasing an efficient means of producing clean power. The electricity generated is stored in a 12-V lead-acid battery, capable of delivering approximately 60 W of output power, sufficient to meet the energy needs of various low-consumption devices such as lights, amplifiers, and chargers. Designed with practicality in mind, the system accommodates continuous use for up to 5 h under full load, making it suitable for a variety of scenarios, including off-grid living, disaster recovery, and educational demonstrations on renewable energy principles [5].

The system is built around a series of meticulously designed subsystems that ensure seamless conversion and utilization of energy at each stage. Beginning with the mechanical subsystem, the pedaling motion of the bicycle is transmitted via a mechanical connection to an alternator, which forms the electrical core of the system. This alternator converts the rotational motion into alternating current (AC), which is then processed by a rectifier to produce direct current (DC) suitable for charging the battery. A charge controller regulates the energy flow, optimizing battery life and ensuring efficient power management. This stored energy in the battery is subsequently converted back into AC power by an inverter and further stepped up from 12 to 230 V using a transformer, enabling compatibility with a wide range of electrical devices typically found in households or small-scale applications.

SYSTEM OVERVIEW

We have developed a uniquely designed electric generation system that combines innovation with practicality, delivering a cost-effective and convenient solution for small-scale electricity needs. The system is designed to utilize human power efficiently, leveraging the pedaling action of a stationary bicycle to generate electricity and store it in a 12-V battery [6]. By generating approximately 60 W of output power under standard operation, the system is capable of powering a range of devices, including lights, amplifiers, iPod chargers, and other small electrical loads. This output can be scaled up depending on the user's requirements, making it versatile and adaptable for various applications. Engineered for both efficiency and durability, the system can sustain up to 5 h of continuous operation under full load conditions and requires a comparable amount of time for recharging. This cycle of energy production and consumption is designed to support sustainable and reliable energy generation without relying on conventional grid power [7].

The system is an integration of seven interconnected subsystems, each playing a crucial role in ensuring efficient energy production, storage, and usage. The first subsystem, the mechanical connection, translates the user's pedaling motion into rotational energy. This energy is then transferred to the second subsystem, the electrical alternator, which converts the rotational movement into alternating current (AC) voltage through its rotor mechanism. The alternator is designed to operate at varying speeds, allowing for a flexible range of power generation between 50 and 150 W based on the user's effort and speed of pedaling [8].

The third subsystem is the rectifier, a critical component that transforms the AC output of the alternator into direct current (DC) power. This conversion is essential for compatibility with the fourth subsystem, which includes the battery and battery charger. The battery is a 12 V lead-acid unit that serves as the primary storage medium for the system, ensuring a steady and reliable power supply. A charge controller is integrated within this subsystem to regulate the flow of electricity, preventing overcharging or discharging of the battery and significantly enhancing its efficiency and lifespan.

Once the energy is stored as DC power, it is routed to the fifth subsystem, the inverter, which converts the 12 V DC into 12 V AC power for initial use. To further broaden the system's applicability, the sixth subsystem, a step-up transformer, is employed to elevate the 12 to 230 V AC. This higher voltage level allows the system to power a wider range of standard household appliances and devices, significantly increasing its utility [9].

The seventh and final subsystem is the backup power supply, which ensures that the battery remains charged even when the stationary bicycle is not in use. This subsystem incorporates a single-phase AC supply from an external source, along with a rectifier and a step-down transformer. These components work together to provide a consistent energy input to the battery, ensuring that the system is always ready for use without relying solely on manual operation.

This innovative system is designed with modularity and scalability in mind, allowing users to add or replace components based on their specific energy needs. Its applications extend beyond household use, offering solutions for off-grid energy generation, emergency power supplies, and even educational demonstrations to teach principles of energy conversion and renewable energy technologies.

The system is built using readily available materials and straightforward construction methods, making it accessible and affordable for a wide audience. By combining mechanical ingenuity and electrical efficiency, this system provides a sustainable, user-friendly, and reliable solution for generating clean energy, empowering users to take control of their power needs while promoting environmental sustainability [10].

This system also addresses the global need for sustainable and renewable energy solutions, especially in regions with limited access to traditional power grids. By leveraging human power, the system eliminates reliance on fossil fuels and significantly reduces carbon emissions. Its eco-friendly approach aligns with global efforts to combat climate change, making it an ideal choice for environmentally conscious individuals and organizations seeking alternative energy sources.

Moreover, the system's adaptability makes it particularly well-suited for deployment in remote or rural areas where grid power is unreliable or unavailable. For instance, it can provide essential lighting and charging capabilities to off-grid households or serve as a reliable power backup during natural disasters or power outages. Its potential as a portable energy source also opens avenues for outdoor enthusiasts, campers, and field workers requiring convenient and sustainable electricity solutions in remote locations.

In addition to its practical applications, this system serves as an educational tool for teaching and demonstrating fundamental principles of physics, mechanics, and electrical engineering. Its transparent design allows users to observe the energy conversion process firsthand, fostering greater understanding and appreciation for renewable energy technologies.

GRAPHICAL REPRESENTATION

In a pull-up machine-based energy generation system (Figure 1), the graphical representation can be structured as a sequential flowchart, illustrating how the system converts mechanical motion from the user's pulling action into stored and usable electrical energy. At the top of the diagram, the pull-up machine can be depicted as the starting point, where the user's motion generates mechanical energy. This energy is transmitted through a mechanical linkage to an alternator, which converts the mechanical motion into alternating current (AC) voltage. An arrow labeled "Rotational Energy" connects the pull-up machine to the alternator, visually representing this energy transfer [9].

Next, the alternator is shown converting the motion into AC power. The output from the alternator flows to the rectifier, represented by an icon of a diode or bridge rectifier, which transforms the AC power into direct current (DC).

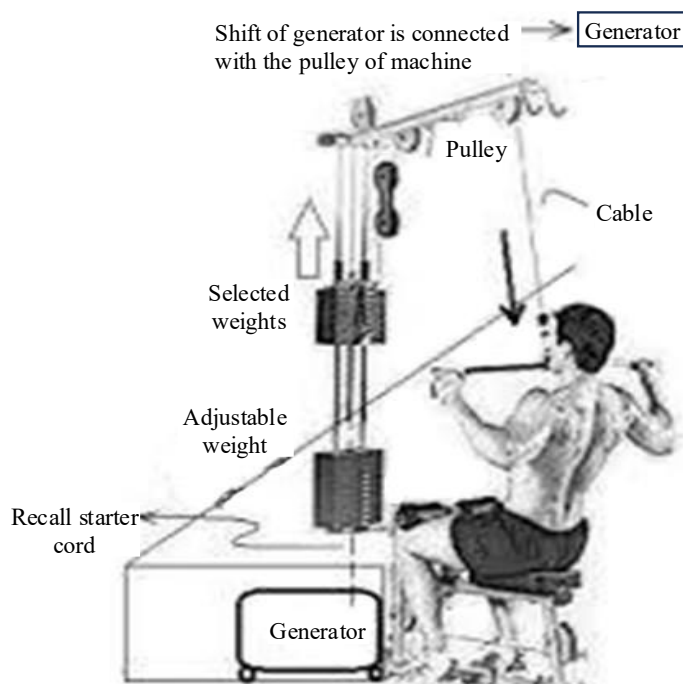


Figure 1. Pull-up machine.

A generator connects the alternator to the rectifier, indicating the conversion process. From the rectifier, DC power flows to the battery and charger subsystem, shown as a battery icon with a charge controller included. This subsystem stores the energy for later use while regulating the flow of power to prevent overcharging or over-discharging.

The stored DC power is then routed to an inverter, which converts the 12 V DC into 12 V AC, represented by an AC waveform icon. The inverter output is directed to a step-up transformer, shown as transformer coils, which elevates the voltage from 12 to 230 V AC. An arrow labeled "Step-Up Voltage" connects the inverter to the transformer. This high-voltage AC power is finally made available for powering devices such as lights, chargers, and small appliances, represented by icons of the respective devices.

Block Diagram (Figure 2)

The concept behind this gym equipment-powered alternator is to harness mechanical energy produced during exercise to generate electricity. To accomplish this, a piece of gym equipment such as a stationary cycle or elliptical machine is mounted on a fixed stand, allowing the rotational or reciprocal motion generated by the user's workout to be converted into usable electrical energy. As the individual pedals or moves, the kinetic energy from the equipment is transferred via a chain and belt drive system to an alternator, which is connected directly to the belt. This mechanical input turns the alternator, creating a three-phase alternating current (AC). A DC power supply from a battery is given to the alternator to produce a magnetic field in the rotor, allowing the alternator to convert the motion into three-phase AC power [1].

This AC power is then passed through a three-phase bridge rectifier to convert it to direct current (DC). Once converted, the DC supply is routed through a voltage regulator, which stabilizes it at 12 V. This regulated 12 V DC can then be used to charge a battery. Additionally, this DC power is fed into an inverter, constructed with MOSFETs and a driver circuit, which converts it into 12 V AC at a 50 Hz frequency. A step-up transformer is then employed to increase this 12 to 230 V AC, which can be used to power household appliances or stored for later use [3].

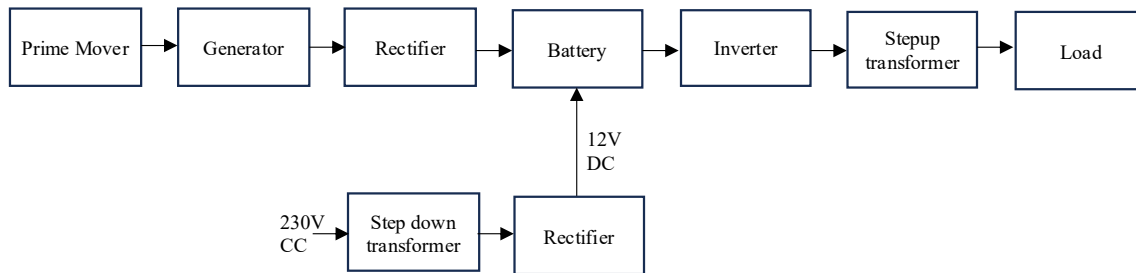


Figure 2. Block Diagram, of proposed system.

When the gym equipment is idle, an auxiliary charging system engages to maintain the battery's charge using the main power supply. In this backup charging mode, a step-down transformer reduces the main supply to 12 V AC, which is subsequently converted to DC via a bridge rectifier. The DC output from this rectifier connects directly to the battery, ensuring it remains charged even when the equipment is not in use. For demonstration purposes, a 40 W incandescent bulb is used as a load in this project, showcasing the capacity.

ENVIRONMENTAL IMPACT

The environmental impact of the pull-up machine-based energy generation system is overwhelmingly positive, as it promotes sustainability and reduces reliance on traditional, fossil-fuel-based power sources. By utilizing human power to generate electricity, this system eliminates greenhouse gas emissions that are typically associated with conventional energy production. This makes it a viable eco-friendly alternative, especially in applications where small-scale electricity needs can be met without tapping into the grid or using fuel-powered generators [5].

One significant benefit of the system is its ability to reduce waste and promote energy efficiency. The components are designed to optimize energy transfer and storage, minimizing losses throughout the system. Furthermore, the use of readily available and recyclable materials, such as lead-acid batteries, ensures that the environmental footprint of manufacturing and disposing of the system is minimal compared to more complex and resource-intensive energy systems.

Additionally, the system's modularity and scalability allow it to be adapted for various applications, such as off-grid households, emergency power backup, or educational tools. This versatility supports broader adoption in areas where renewable energy solutions are most needed, thereby reducing the pressure on conventional energy infrastructure. By encouraging active participation in energy generation and promoting awareness of sustainable energy practices, this system fosters a culture of environmental stewardship and empowers individuals to contribute to a cleaner, greener future.

EXPECTED OUTCOMES

1. Electricity Generation.
2. Energy Storage and Utilization.
3. Environmental Benefits.
4. Cost-Effectiveness and Accessibility.
5. Education and Awareness.
6. Versatility and Adaptability.

CONCLUSION

The concept of generating power through gym equipment is a sustainable way to harness human energy while promoting fitness. By equipping machines like stationary bikes, treadmills, and rowing machines with energy-generating components, gyms can convert workout mechanical energy into electrical energy. This energy can be stored in batteries, used to power gym facilities, or even fed back into the grid, helping to offset energy costs. Such systems provide both practical and environmental

benefits by reducing dependence on traditional power sources and lowering the gym's carbon footprint. Given that gyms use significant energy for lighting, heating, cooling, and equipment, human-generated power can make a notable impact. Additionally, real-time energy tracking can serve as a motivational tool for members, offering a sense of accomplishment and reinforcing sustainable values. However, challenges include high initial costs for outfitting machines with generators, converters, and storage systems, as well as increased maintenance requirements. While the power generated per user is relatively small compared to a gym's overall energy needs, it serves as a valuable supplement. This innovative approach can attract eco-conscious members and support a more sustainable gym model, positioning power-generating equipment as an exciting, eco-friendly feature of modern fitness centers.

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