International Journal of
Science, Architecture, Technology and Environment

Progress Theories and Limitation of Free Energy Generator as a Sustainable Energy Source: A Review

J. S. Shadrach[1*], M. E. Emetere[1,2], J. A. Akinpelu[2]

[1]Department of Physics, Bowen University, Iwo, Nigeria

[2]Department of Electrical Engineering Technology, University of Johannesburg, South Africa.

*Corresponding author

DOI: https://doi.org/10.63680/ijsate092601.12

Abstract

The campaign for alternative to clean energy has been rekindled as climate change realities are evidently impacting upon renewable energies. A potential alternative clean energy is the flywheel energy generator that works on electromagnetic principles. Its prospects are huge because it has the market viability to replace fossil fuel generators. The drawbacks of the flywheel energy generator are energy losses due to self-discharge, operational abnormalities, high conversion losses, scalability issues, theoretical misconceptions, and fossil-fuel politics. Despite its discovery in nearly two decades, not much progress has been reported. The focus of this review is to identify the current realities of flywheel generator and also, address the most issues identified from literatures. It was observed that only few flywheels flywheel (free) energy generators attain a voltage of 200 V. Most devices in literature reported voltage less than 20V. The shortcoming of selected designs was discussed to guide future work. It is recommended that further research work should focus more on the scalability issues to enable the device to dominate the energy generator market.

Keywords: Free energy, flywheel, generator, clean energy, SDG 7

1. Introduction

The increasing demand for affordable and sustainable energy around the world has prompted research into alternative energy-producing techniques, such as flywheel (free) energy generators and renewable energy (Smith & Johnson, 2020). The ability of these ideas to produce a steady supply of electrical power has been investigated. Examples include systems based on neodymium magnets or permanent-magnet and flywheel configurations coupled with batteries (Olabi et al., 2021).

Energy becomes economically free only when continuous generation no longer requires payment after the system has been put into commissioning (Grover et al., 2014). The idea of employing magnets to generate power has existed for some time. According to Faraday's Law of Electromagnetic Induction, electromagnets provide over 90% of the world's electricity (Grover et al., 2014).

The term “free energy” is still constantly misunderstood, however as earlier stated, energy is only

“free” once the system is connected and functioning, with no ongoing costs for generation or fuel. It is conceivable to generate continuous motion in which energy produce by using the magnetic force of magnets (Williams, 2024). Even so, this idea is in accordance with the established physical principles: it involves initial physical setup cost and relies on verified scientific laws rather than imaginary foundation of limitless power (Ioannidis et al., 2021).

There are many uses for electricity in daily lives. The majority of energy comes from nonrenewable sources, including nuclear, kerosene, and gasoline, all of which regrettably produce pollution. In many respects, these approaches are inconvenient. The combustion of non-renewable fuels poses environmental risks (Nagasankar et al., 2023).

Electricity is the primary power source driving most technologies; hence, it is demanded in large capacities across every area of human endeavour (Noku et al., 2023). Generally, free energy refers to a method of obtaining energy from the surrounding environment without using fuel. In the current difficult economic climate, where energy prices have been steadily increasing for years, many homeowners are considering alternative or “green” energy systems to reduce household power costs. Solar panels are the most popular option, followed by geothermal heat pumps and wind turbines. Although less well known, another clean and renewable energy system exists that is suitable for domestic use (Basit et al., 2020).

Free energy is frequently confused with renewable energy. In reality, renewable energy is abundant and occurs naturally (Noku et al., 2023). As technology advances, it is necessary to conserve electrical energy and discover more effective methods of utilisation.

However, due to their volatile and intermittent nature, high integration of RES into the traditional power grid requires significant flexibility within existing power networks and substantial effort to achieve maximum grid efficiency (Shahzad and Jasińska, 2024).

Numerous inventions and studies have been conducted by scientists and researchers, significantly affecting electricity tariff rates and reliability due to energy losses during power transmission.

They operate in plug-and-play mode with the smart grid (SG) and provide resilience, security, and mitigation of grid disturbances during faults (Rahim et al., 2016). Despite being effective, ecofriendly, and reliable backup systems, synchronisation with the main grid remains challenging and requires substantial space and maintenance for energy storage (Al‐Shetwi et al., 2025).

Energy particularly electricity is essential for the modern existence of humanity and large percentage of human activities electricity. Power is generated using various fuels, such as coal, gas, nuclear, and hydro, among others (Solarin et al., 2021). However, each method has significant drawbacks and environmental consequences, some of which pose severe radioactive risks in the event of leakage. Therefore, under current conditions, there is a need to develop electricity generation techniques that are both affordable and environmentally friendly (Kumar and Rathore, 2023).

One advantage of alternative energy is that it can be stored, does not pollute the environment, and does not deplete natural resources, as it is organically produced and continuously renewed. Widely recognised subcategories include geothermal, hydro, biomass digesters, wind, solar, and biofuels, among others. Each category faces unique challenges; for example, regional climatic disturbances can significantly affect solar and wind energy systems (Emetere and Akinyemi, 2015).

Biomass energy relies on biodegradable waste derived from living or dead organisms. Compared with fossil fuels, biomass has a lower greenhouse effect on the planet's surface. Depending on its source, free energy could serve as a viable alternative energy option (Hosseini and Wahid, 2020).

However, in developing nations, free energy concepts have largely been suppressed or ignored. According to well-known conspiracy theories, such repression is linked to governments, corporations, or advocacy organisations (Van and Vugt, 2018).

Consequently, the free energy option has not yet been demonstrated to be technologically practical, pollution-free, or cost-free. Its inclusion as a subcategory of alternative energy may be based on the latter's established advantages, including affordability, sustainability, reduced greenhouse effects, job creation, and economic feasibility. This study suggests that developing countries could potentially meet their energy demands by adopting free energy options (Emetere et al., 2016).

Despite the growing global need for clean and sustainable energy, conventional energy sources remain limited by high costs, environmental impact, and technical constraints. The system of physical setup which uses magnetic, gravity and spring to produce energy continuously with minimal input is considered free energy generator device (Graves et al., 2022).

Nevertheless, free energy operation still conflict with the established laws of thermodynamic and its lack scientifically validation models for now. It is believed that modifications to existing theories could improve the efficiency of these devices and their usage (Dhar et al., 2021).

This research aims to critically examine the theoretical foundations and operational designs of proposed free energy systems, identifying both their potential and limitations through computational design, modelling, and prototype construction (Obieke et al., 2023). The absence of verified large-scale prototypes and sufficient peer-reviewed performance data has significantly slowed public acceptance and commercial development of free energy generator technologies (Smith & Taylor, 2019).

2. Remarks on the Progress of Free Energy Generators

White et al. (2001) worked on "Design and Modelling of a Vibration-Powered Micro-Generator." The paper presented the design and testing of two types of micro-generators: an electromagnetic induction device incorporating a magnet and coil, and a piezoelectric device using PZT-based thick-film material. However, the intermittent nature of vibration remains a limitation, necessitating energy storage solutions. Additionally, analytical and FEA models may have limitations in accurately capturing stress distributions and resonant behaviour. Mikalsen (2008) worked on paper titled "An Investigation into the Free-Piston Engine Concept and Its Potential for

High Efficiency and Low Emissions Power Generation." The research work shows that the freepiston engine system, proposed a particular design, and developed detail simulation models to measure performance and operational features. Results showed potential superiority over traditional engines in flexibility, emissions, and mechanical efficiency. However, piston motion control remains a major challenge, requiring further investigation, particularly regarding emissions formation.

Grover et al. (2014) researches on "The Free Energy Generator," neodymium magnets was on a DC fan motor to produce motion through magnetic repulsion. It was mounted on a two-wheeler which uses air turbulence, with voltage and current measured using a multimeter. The outcome indicates that a voltage booster increased output, with voltage rising up with speed before curving sharply. The highest power output is 0.9 W at 70 km/h was achieved, successfully charging a mobile phone battery to 43% in 35 minutes at 40 km/h. Challenges included low power output, speed-dependent efficiency, and mechanical losses.

Bhure and Ambulkar (2014) work on a conceptual design for a "Magnetric Generator" using neodymium magnet repulsion to produce motion and electricity energy. While the design suggests cheaper, eco-friendly, and applicability for household and remote power supply, although, lacking a functional prototype. Emetere et al. (2016) investigated "Free Energy Option and Its Relevance to Improve Domestic Energy Demands in Southern Nigeria." life-cycle cost analysis was used, the result shows free energy options to be more economical and affordable than fossil fuel, solar, and wind generators. While its merit includes environmentally friendly and cheap to install, the challenges are noise pollution, maintenance variability were identified and load capacity.

Choong (2016) empirically designed of a magnetic generator using neodymium magnets. The stable power output was observed under varying loads was generated by the generator, its practical application is limited due to overheating of the motor and low power generated.

Vinoth et al. (2017) conduct work on a free energy generator using disc-shaped neodymium magnets, producing adequate output to power up a 22 W bulb. However, low output limits it economic viability which necessitate further optimization.

Zamri et al. (2017) analyzed generator design for wave energy conversion using FEA. However, simulation outcome was promising, no experimental endorsement was conducted. June (2019) investigated a flywheel-based free energy device generating approximately 4.167 kW with near100% efficiency. The flywheel which serves as an energy generating system with a calculated capacity of 1472.61 J, is suitable for multiple applications for households' usage.

Kattimani and Inayath (2019 worked on a flywheel-based system capable of feeding generated power back into the motor. Its produces sufficient power but the challenges are inadequate efficiency data and machine-driven losses. Bat (2020) investigate the simulation and experimental validation of a 100 W free-piston Stirling engine generator, achieved 60–70 W during passive demonstration, with solid agreement between simulation and experimental outcomes. Kashyap et al. (2020) presented a water-wheel-based free energy device that was able to generate a 2 kW. Challenging issues included unverified friction losses and inadequate comparative data. Damacharla and Ford (2020) developed a rolling electrical generator for wave energy conversion, validated through FEA. Fabrication and price constraints remain challenges. Khatri et al. (2020) surveyed magnetic repulsion-based generators, noting attained rotation with lower input, but low efficiency occurs because of friction and magnet degradation. Abdalla et al. (2020) fabricated and tested a low-cost free energy generator system using traditional electrical components. It demonstrated pollution-free operation without machine-driven input. Hidayat et al. (2021) studied perpetual motion machine concepts, highlighting small-scale feasibility, but cannot be applied to large-scale deployment. Riaz et al. (2021) designed a gravity wheel and dynamo-based free energy generator, showing potential, but for the design to work effectively other conditions need to be improved. Meyyappan and Ravichandran (2022) worked on a compact flywheel system validated using MATLAB simulation programming language. However, physical implementation was lacking.

Lakshman and Preetham (2023) fabricated a neodymium magnet-based prototype that generates very low voltage outputs, though it highlighted economic and thermodynamic challenges. Singh et al. (2023) designed an integrated flywheel system achieving near-100% efficiency but without accounting for mechanical losses. Mostaman et al. (2023) designed a Free Energy Magnetic Generator (FEMG), demonstrating improved voltage output over traditional designs but requiring further optimisation. Nagasankar et al. (2023) evaluated a frictionless flywheel-based generator which generated output power of approximately 12 V, however, voltage stability and reliance on initial input are the challenges. Khatate et al. (2024) examines assessed free energy generator feasibility, result shows that most concepts violate established thermodynamic laws, while noting that future research in quantum effects and advanced materials may provide new insights.

3. Guiding principle identified with flywheel energy generator

A study by Johnson et al. (2024) proposed a low-cost electromagnetic power generator design utilising neodymium magnets. The research highlighted the reliability of magnetic field induction as a potential renewable energy source capable of converting magnetic fields into electrical power.

A study conducted by Patel and Ahmed focused on the initial design of a generator for both industrial and domestic applications. The Free Energy Magnetic Generator (FEMG) uses traditional induced-voltage generation techniques. JMAG Designer software was used for modelling and analysis. Results indicated that the generator could deliver a high-efficiency, constant output power supply with minimal cogging torque, measured at 2.1 Nm (Patel & Ahmed, 2023). The first and second laws of thermodynamics that is energy conservation and entropy constantly conflict with the governing principles in which the free energy generator operate. Flywheel (free) energy generators are claimed to produce more energy than they consume by utilising natural forces such as magnetic fields or zero-point energy, although such devices are not generally accepted within the scientific community. A 2024 study discussed the theoretical foundations of free energy generators, emphasising that their primary claim is the ability to harness and convert energy from non-conventional sources, such as ambient environmental energy (Alzeer, 2024). A key principle frequently cited in free energy generator design is zero-point energy (ZPE), which refers to the theoretical concept of extracting energy from the quantum vacuum. Zero-point energy is hypothesised to be a limitless energy source, although it remains unproven and highly speculative. One of the often-used method in the operation of free energy generator includes the use of magnetic field and electromagnetic energy harvesting. Magnetic fields are used to generate continuous motion and energy these idea lies on concept of perpetual motion. A 2017 study by Annapureddy et al. explained the part of magnetism play in free energy devices and proposed that magnetic system always tends to produce continuous power, however some practical limitation may occur such as friction and electrical resistance which prevent operation indefinitely (Annapureddy et al., 2017).

For the planning and construction of the proposed motor, Maxwell's equations applied under Lorenz gauge conditions were used to understand the process by which radiant energy is theoretically extracted and applied from the vacuum in the idealised system. Energy extraction from the vacuum was critically analysed using a self-consistent set of Maxwell's equations to achieve the desired goal.

Electric Gauss's Law is the first equation of Maxwell's is used to define the quantity of enclosed charges by representing the electric field outward to the charge distribution for the calculation of electric field.

$$\nabla . E = \frac{\rho_0}{\epsilon_0} \text{..} (1)$$

Here, E, $\rho 0$ and $\in 0$ are the electric field strength, charge density, and free space permittivity, respectively.

Ampere's Law is used to calculate the magnetic field around BCs which are current carrying coils, the Ampere's law is employed.

Its differential form is stated as follow,

$$\nabla X B = \mu_0 \left(j + \epsilon_0 \frac{\partial E}{\partial t} \right) = \sigma E \text{..} (2)$$

Where, $\nabla \times B$ is the driving force, is the vacuum's conductance, $J^{\rightarrow}$ is the vacuum's electric charge density, and $\frac{\partial E}{\partial t}$ is the rate of change in electric charges in free space.

Faraday's law of Induction can prediction amount of electromotive force as a result of interaction between magnetic field and electric circuit (SSG), following equation is considered,

$$\nabla X E = -\left(\frac{\partial B}{\partial t}\right) \ldots\ldots (3)$$

E & $^{\rightarrow}$ is the electric field lines flow only when there is a change in magnetic flux concerning time.

Gauss's Law of magnetism, this equation has been applied as a restriction to ensure that there are no free magnetic poles. If magnetic monopoles are present, the total flux through a closed surface must be zero.

$$\nabla . B = 0 \ldots\ldots (4)$$

Lorenz gauge transformation, all of the aforementioned equations are reduced to two simpler potential equations by introducing the potential vector $A^{\rightarrow}$ and applying the Lorenz gauge notion.

The pair of equations is provided as

$$\nabla^2 \times V + \frac{\delta}{\delta t}(\nabla . A) = \frac{\rho_0}{\epsilon_0} \ldots\ldots (5)$$

$$\nabla^2 \times A - \mu_0 \in_0 \frac{\delta^2}{\delta t^2} - \nabla(\nabla . A + \mu_0 \in_0 \frac{\delta v}{\delta t}) = \mu_0 j \ldots\ldots (6)$$

Here, V is the electric potential variable. According to Lorenz gauge transformation conditions the parameter $\nabla^2 \times A - \mu_0 \in_0 \frac{\delta^2}{\delta t^2} - \nabla(\nabla . A + \mu_0 \in_0 \frac{\delta v}{\delta t}) = \mu_0 j$ & and d' Alembertian operator is $\boxdot^2 \equiv -\mu_0 \in_0 \frac{\delta^2}{\delta t^2}$ Then the equation (5) and equation (6) reduce to,

$$\boxdot^2 = -\frac{\rho_0}{\epsilon_0} \ldots\ldots (7)$$

$$\boxdot 2\, A^{\rightarrow} = -\mu 0 J^{\rightarrow} \ldots\ldots (8)$$

The conductance at vacuum is denoted by $J^{\rightarrow} = \sigma E \&^{\rightarrow}$, which is comparable to the Maxwell displacement current. The vacuum, also known as the zero-point energy state, is a stage of little energy from the environment, according to T.D. Lee. Thus, the Maxwell's equations are as follows when $\rho! = 0$ and $J^{\rightarrow} = 0$.

$$\nabla . E = 0 \ldots\ldots (9)$$

$$\nabla X B = \mu_0 \in_0 \frac{\partial E}{\partial t} \ldots\ldots (10)$$

$$H = \frac{1}{\mu_0} B + M \ldots\ldots (11)$$

$$\nabla X B = 0 \ldots\ldots (12)$$

Here, H stand for magnetization and M stand for magnetic field strength,

Our energy harvester schematics' proposal and employed principles are based on the vacuum effect, which is already mention in all of above Maxwells equation.

4. Issues with constructing the free energy generator

Flywheels are essential for providing continuous power in systems where the energy source is not constant. They help to smooth out fluctuations in angular velocity, especially in reciprocating engines. In such engines, a crankshaft flywheel stores energy from a firing piston and returns it to compress air and fuel. This process enhances engine efficiency and reduces mechanical stress.

Flywheel serve as energy burst at power level which may be greater than the main source (Figure 1). This is gradually achieved by storing energy and discharging it quickly when needed. These functions make them valuable in power hammers and exciting machines. Flywheels also function as gyroscopes, helping to control direction and counteract unwanted motion. They are used in ship stabilisation systems to maintain balance in rough waters. Satellites use reaction wheels, a type of flywheel, to control their orientation in space. Instrumentation gyroscopes rely on flywheels for precise measurements. They also keep toys spinning through friction motors, while magnetically levitated objects use flywheels for stabilisation. Flywheels are widely used in energy generating systems to regulate power supply. Their ability to store and release energy rapidly enhances overall system efficiency. Power is stabilized in renewable energy operation by the vital role they played. Most recent electric cars use an application of flywheel to recover and store braking energy. Highperformance mechanical systems benefit from their ability to reduce power fluctuations. Flywheel serves as generating systems that transfer energy and their efficiency and durability position them for long-term energy solution. As technology advances, flywheels continue to find new applications in modern engineering (June, 2019).

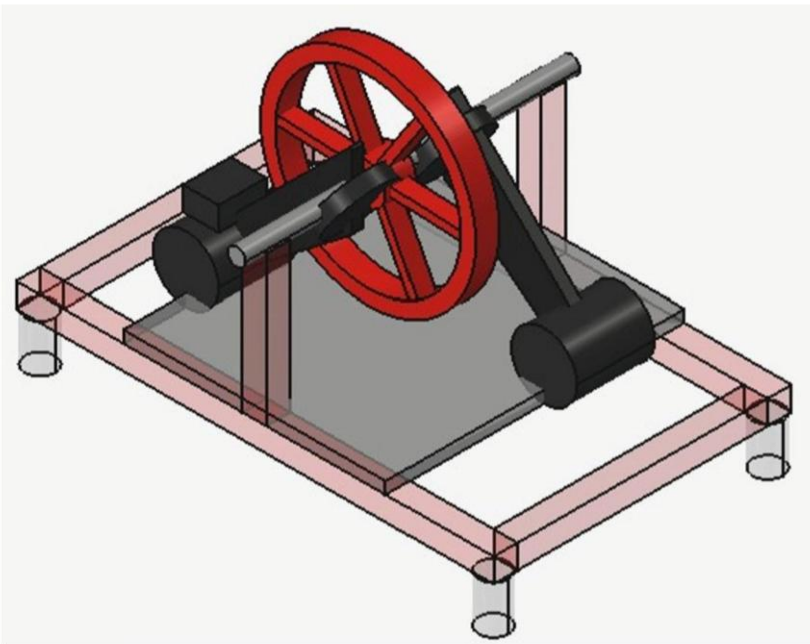

Figure 1: Flywheel Energy Generating System Components

Groove as drive elements that accommodates belts, ropes or chains, a pulley is a wheel on a shaft designed to guide and change direction of a taut cable. The ratio of pulley diameters that varies with mechanical advantage are usually used in belt drives for smooth or crowned pulley (Soyaslan et al., 2023). This style which was commonly used in earlier machinery but now has mostly been substituted by more versatile technology, enable variable speed and torque. Additionally, the combination of flywheel with motor and generators store and supply energy by translating or converting electrical energy to mechanical energy and vice versa. Their effectiveness in energy systems is further improved by continuous developments (June, 2019).

Analysis of the similarities and differences between flywheel (free) energy generators and automobile-type devices (such as fossil fuel generators and cassava grinding machines), along with explanatory graphics for enhanced comprehension using almost similar technology (i.e., cassava grinding machine and fossil fuel generator) is presented in Figures 2 & 3 below.

Table 1: Similarities Between Automobile Machines (e.g., cassava grinding machine and fossil fuel generator) and Free Energy Generator

Feature	Description
Mechanical Output	All of them transform mechanical energy into work that can be used for motion, grinding, or the production of electricity. (Singh et al., 2024)
Spinning Parts	Energy is transfer by the Use of shafts, rotors, bearings and gears.
Energy Conversion	Transform one type of energy into another, such as chemical, kinetic, or electromagnetic (Dong et al., 2024).
Preservation Needs	Regular lubrication, cooling and inspection is needed for property functioning (Sultana et al.,2019).
Response of load	load is responsible for performance, rising in demand affects output (Pamungkas, 2025).
Limitations of Efficiency	In accordance with the laws of thermodynamic energy losses due to heat friction, etc. (Ahmad et al., 2025).

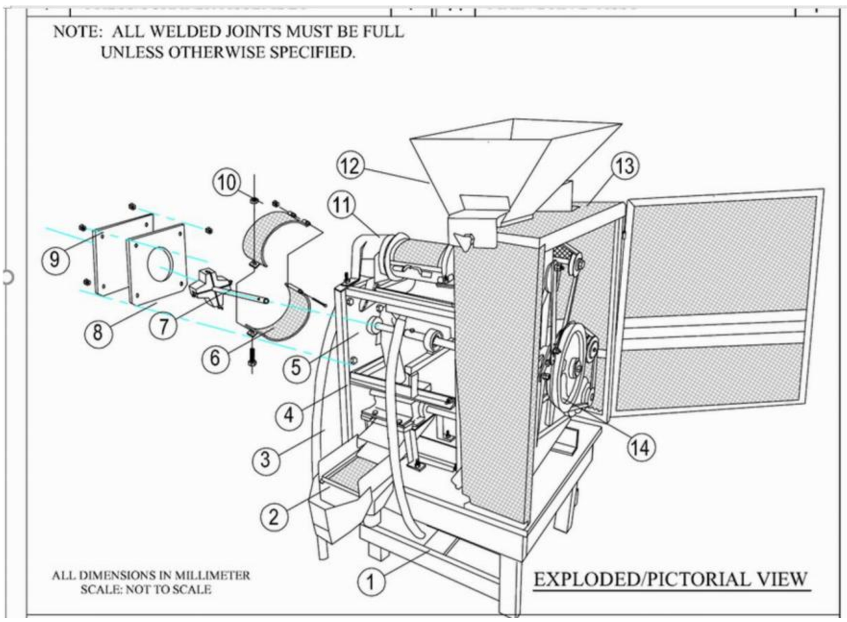

Figure 2: Cassava Mash Machine

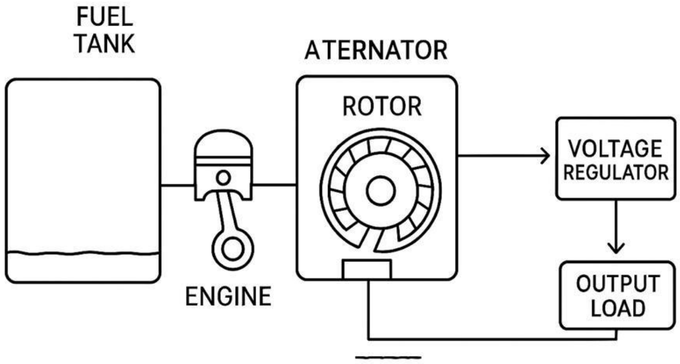

Figure 3: Fossil fuel Generator

Future designs of the flywheel generator should incorporate some of the known technologies of the cassava grinding machine and fossil fuel generator to solve issues such as self-discharge, operational abnormalities, high conversion losses, and scalability. By integrating these advancements, it may be possible to enhance the overall efficiency and reliability of flywheel systems. Additionally, exploring hybrid models that combine renewable energies could further optimise performance and sustainability.

5. Operational perspective on free energy generator

A grouping of skepticisms, new ideas, and examination of different energy sources characterizes the current viewing platform on free energy benefactors. Some important observations are, in the research community, several claims for flywheel (free) energy generators are viewed with critical inquiry (Olabi, et al., 2021).

These technologies are said to violate the principles of thermodynamics, as they are typically claimed to generate energy without any input. There is universal conformity by large number researchers that free energy technologies lack a solid scientific principles or theories due to this doubt, which comes from the familiarity that energy cannot be created or destroyed (Meirinhos et al., 2022). Explore into ambient energy harvesting has grown traction, concentrating on capturing energy from the natural surroundings, such as solar, wind and current energy. These approaches are seen as more practicable alternatives to the notion of free energy, as they leverage remaining natural resources rather than suggesting to create energy from zero point (Friston, 2010). The idea of free energy has generated a lot of public attention, which has led to numerous business endeavours claiming to be developing such technologies (Taylor, 2021). However, these regularly have problem being accepted, and they require to be thoroughly verified to show their claims. Numerous of these enterprises have drawn disapproval for their lack of scientific indication and transparency (Prager et al., 2019).

Figure 4 presents an in-depth examination of the progress of flywheel energy generator voltage and its associated speed. Both Grover (2014) and Albert (2019) produce rising raw voltages as speed increases, with Grover achieving the highest values at the top speed, while Mirondo and Babirye (2022) remain close to zero at all speeds. It was observed from the comparative studies mentioned above that the adoption of power electronics can be adopted into the framework of the flywheel energy generator to convert a relatively low and speed-dependent generator output into a higher voltage suitable for practical use. Grover's setup is the only one with an efficient boost converter, which quickly raises the output to about 14–15 V and then holds it nearly constant as speed increases further.

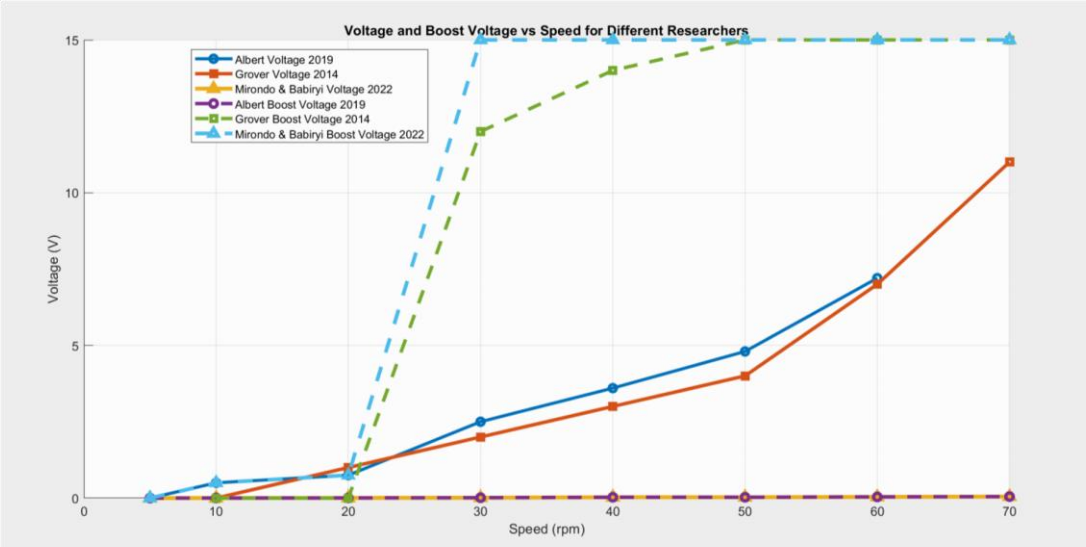

Figure 4: The above graph shows the variation of voltage and Boost voltage against speed from different researchers.

Figure 5 presents a comparative study of the power production drop of flywheel energy generators over time. The power of the design presented in Díaz–González (2012) swiftly decreases, starting at around 3 kW and reducing to about 1.6 kW inside about 8 seconds. Over an identical brief time span, the flywheel energy generator created by Kattimani and Inayath (2019) starts dropping at about 1.8 kW and then gradually drops to about 1.4 kW, demonstrating a slight drop of power. The flywheel generator designed by Lijesh and Dutta (2015) shows a power drop from 3 kW to roughly 0.7 kW within 40 s, demonstrating how the power of their system steadily declines over time. In other words, the reality of self-discharge and high conversion losses are significant issues with the flywheel generator. These challenges highlight the need for ongoing research and development to improve efficiency and reduce energy losses. Addressing these factors could enhance the viability of flywheel energy generating systems in a broader range of applications.

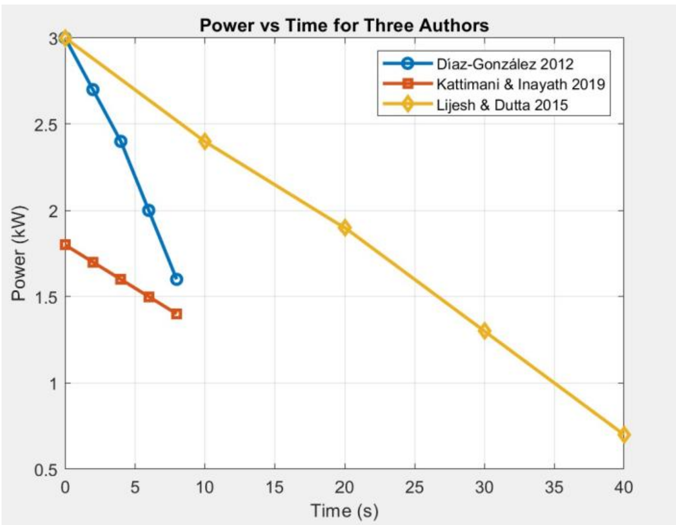

Figure 5: Power output decline over period for three studies

The essentialities of demonstrating how output current rises with revolving speed was observed by flywheel energy generator (FEG) designs presented research works (Sairamkrishna, 2017, Yadav, 2018; Kattimani, 2019, Mevekar, 2020 and Jibhakate, 2021) as presented in Figure 6. All authors' proposed an almost linear rising trend as speed increases from 100 to 600 rpm, suggesting that increased rotational speed generates a larger current in each scenario. Yadav (2018) generates the lowest current values while Kattimani (2019) consistently forecasts the maximum current at all speed, followed by Mevekar (2020). Jibhakate and Sairamkrishna, the other two authors, fall in the middle and exhibit comparable mid-range performance throughout the entire speed range.

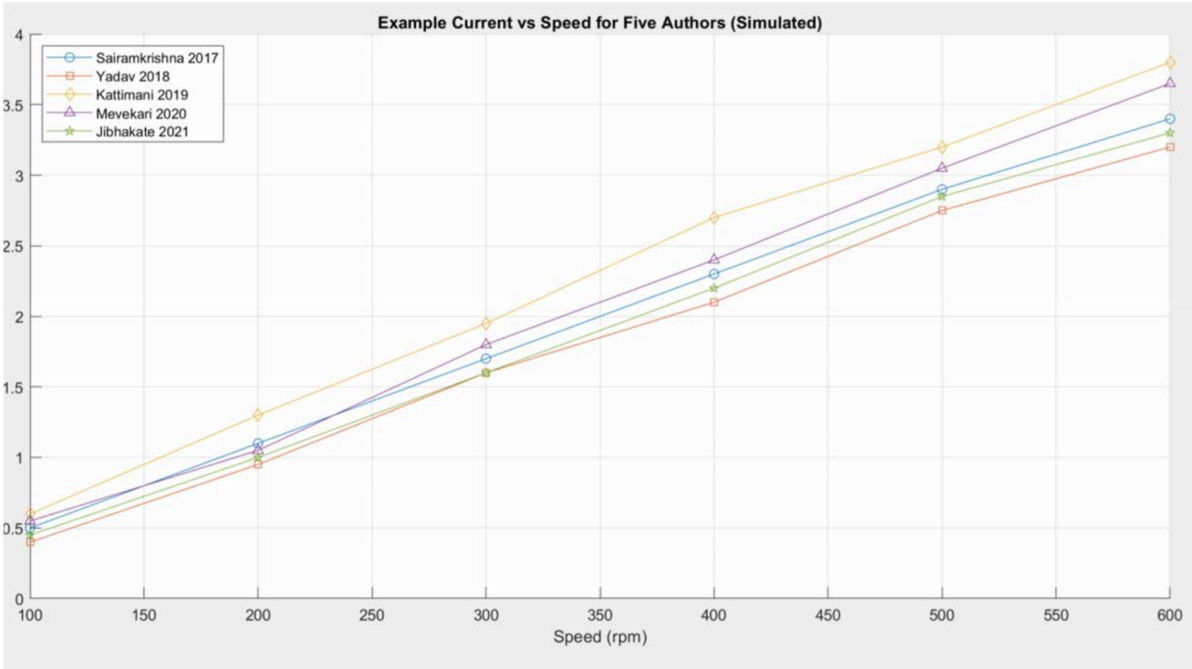

Figure 6: The graph shows the variation of current against time from five different studies.

Figure 7 demonstrates the current output difference over time for five dissimilar flywheel or freeenergy generator surveys, indicating a stable decline in current as the stored revolving energy drops. Itoh and Yamada (2014) FEG design. illustrates a lower and smoother decrease beginning

1.8 A to 1.4 A over the same time, although Díaz-González (2012) FEG design begins at roughly 3.0 A and steadily drops to around 1.6 A within 8 seconds. A significantly slower discharge, beginning 3.0 A at 0 seconds to approximately 0.7 A at 40 seconds, is shown by the FEG design of Kattimani and Inayath (2019), proposing a greater flywheel inertia. Furthermore, the FEG design of Lijesh & Dutta (2015) show a constant decline over 20 seconds beginning 2.5 A to 1.2 A. In contrast, the FEG design of Villafafila-Robles and Karrari (2012/21) show a faster decrease starts at 2.8 A to 1.3 A within 12 seconds. Generally, Figure 7 demonstrates that although all systems finally lose current, the pace of decay differs according to the flywheel size, mass, capacity, efficiency, and design that each author used or describes.

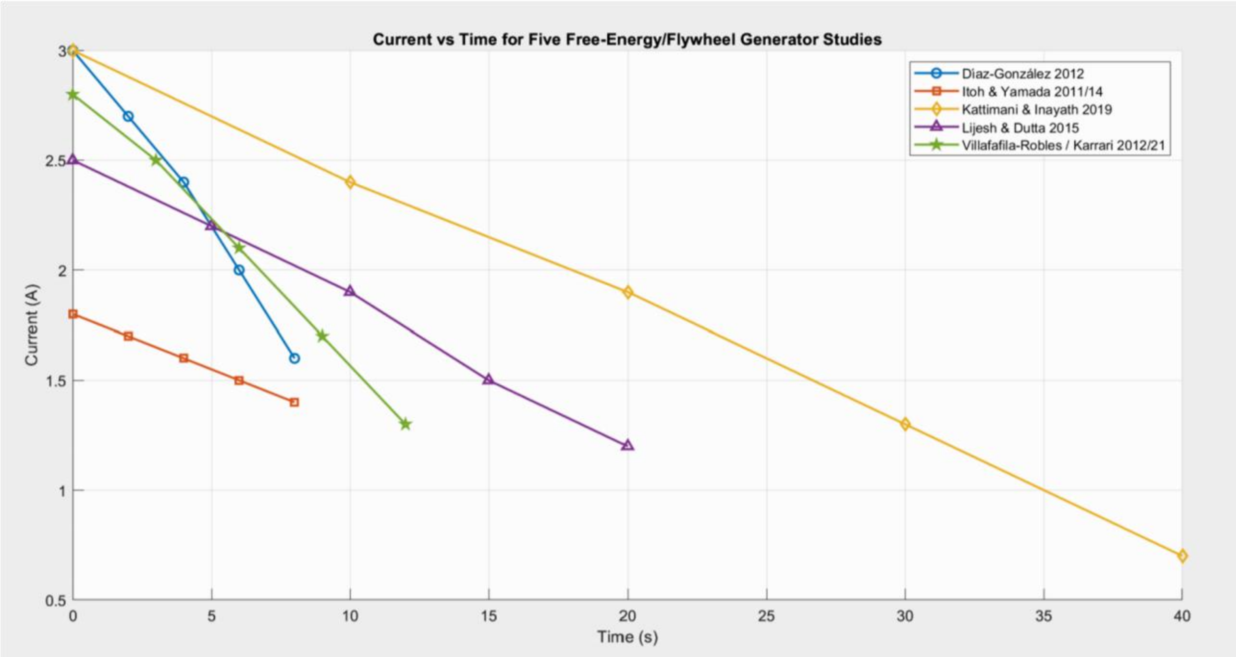

Figure 7: Current Flywheel/Free-Energy Generator Decline Physical characteristics from Five Distinct Researched.

Figure 8 display the computation and analysis carried out, it was thought that there was a linear relationship between the flywheel and generator pulley speeds. But the quantity of voltage generated and the amount of the labor done on the system will change if the size of either the flywheel or the motor wheel attached to the generator is altered. Therefore rising either of them rise will raise the generator's speed and consequently the voltage generated.

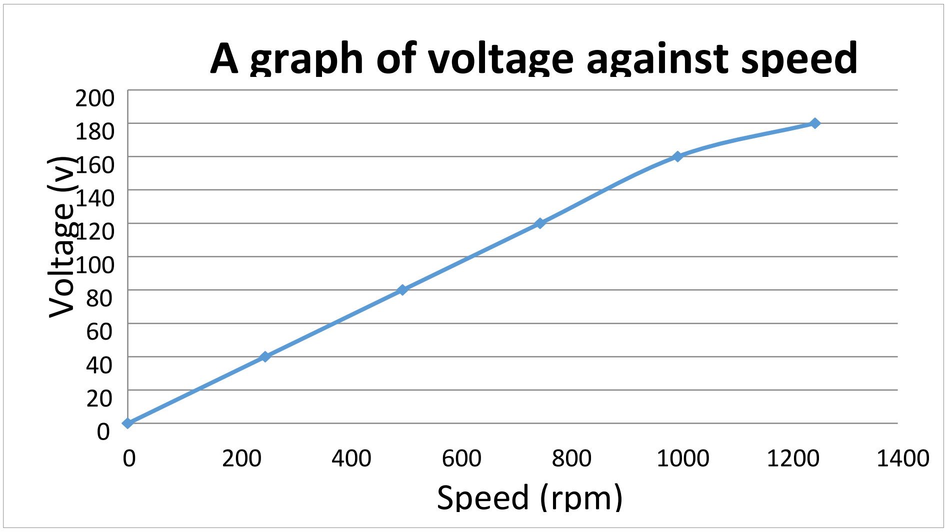

Figure 8: A graph of generated voltage and speed

Relationship between generator speed and power produced

From the analysis, It was found that the electric generator's power outputs increase as its rotational speed increased, therefore, in order harness a large power output from the generator, the generator 's speed must be maintained at its maximum intensity. Additionally, It was noted that in order to maintain generator's high speed the flywheel must rotate at a very high speed. As a result, frictional losses caused by air drag between the flywheel surface and air must always be eliminated a magnetic bearing I used to pulverize frictional effect on the flywheel, increasing its rotational speed, Which in turn increased the generator electrical output and consequently, the generator's efficiency. Therefore, the generator's speed must be maintained at its highest intensity in order to harness a large power output. It was also noted that the flywheel must rotate at a high speed in order to maintain the generator high speed. In order to increase the plywood rotational speed and consequently, the generator 's speed, which in turn Increases electrical output and ultimately, the generator efficiency, frictional losses caused by air drag between the flywheel surface and air should always be eliminated and magnetic bearings used to pulverize frictional effects on the flywheel.

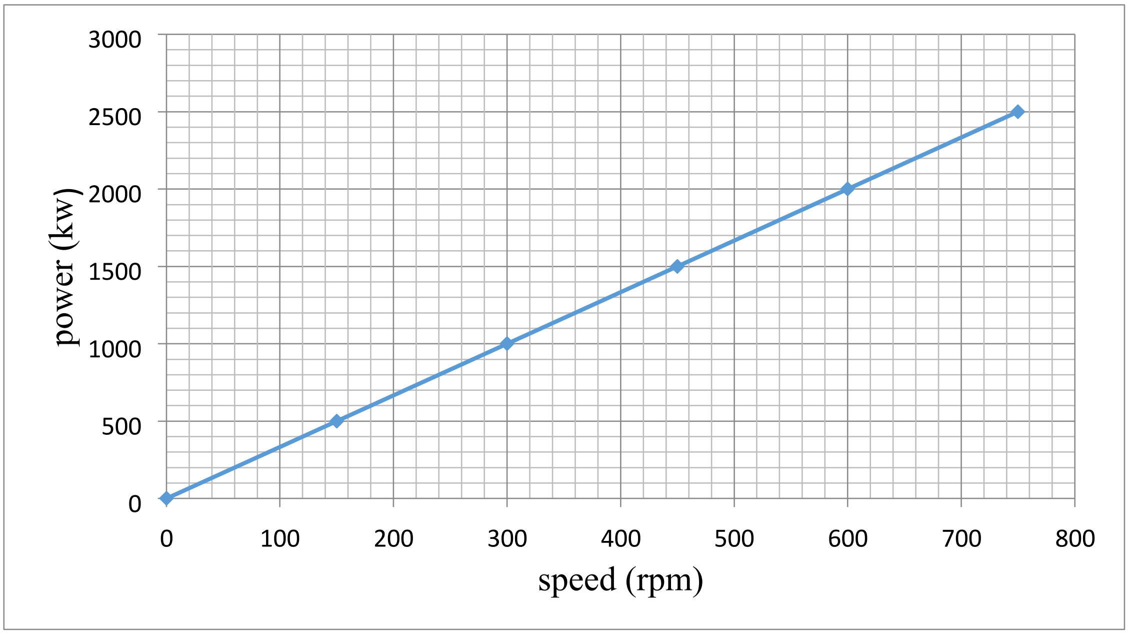

Figure 9: A graph of power against speed

6. Prospect of free energy generator

The technology readiness level (TRL) of flywheel energy generators is still at levels 4-6, i.e., prototype development and lab validation. This reality may be disappointing because its components are at TRL 8-9. Further research and development are expected to advance these systems towards higher TRLs, ultimately leading to commercial viability. This progression will significantly enhance energy generation capabilities in various applications, such as domestic and grid power generation solutions. In this section, the acceptability of FEG in different parts of the world was discussed to justify why its TRL is still low despite its potentials.

As noted by Bazilian et al. (2012), the lack of economic and financial encouragements for renewable and experimental energy machineries is a key obstacle to sustainable energy advancement in low-income areas or zone. High levels of exploitation, corruption, rules and regulations, and bureaucratic inefficiencies always interruption or completely obstruct licenses, certifications, and authorizations for new energy technologies. This frustrates local entrepreneurs, stakeholders and foreign investors from participating in groundbreaking energy projects (Transparency International, 2019). Transparency International (2019) reports shows that corruption within energy departments, sectors and governing bodies in developing nations demoralizes the enactment of clean energy technologies.

Revolution in free energy systems needs important investment in research and development, which is regularly underfunded in developing nations. National energy policies often fail to prioritise scientific research or create partnerships with academic and technical institutions (O'Dwyer et al., 2023).

Authors argue that low levels of public funding for clean technology R&D limit indigenous innovation and adaptation in developing countries (Ockwell et al., 2008). Free energy technologies are not part of the agenda and goal of Nigeria government. The lack of recognition within national policy frameworks discourages innovation, funding, and standardisation of such technologies (Pittri et al., 2025).

This creates a regulatory vacuum where untested or fraudulent devices can thrive, reducing public confidence and investor interest (Iwayemi, 2008). In India, although invention is exciting, flywheel (free) energy generators frequently fall into the realm of speculative science due to a deficiency of peer-reviewed endorsement. This restrictions partnership with scientific establishments and limits subsidy from formal research and development frequencies, slowing authentic growth (Bhattacharyya, 2012).

In Kenya, the informal marketplace frequently sponsors unconfirmed technologies, leading to consumer disappointment and distrust. Free energy devices are sold without operational verification or after-sales backing, causing economic losses for end-users and discourage future technology rollouts for inventors and users (Ondraczek, 2014). In Ghana, free energy systems announced by local inventors repeatedly fail after deployment due to the absence of trained personnel for servicing and repairs. The lack of professional training in non-conventional energy sector intensifications operational failure rates (Agyemang-Bonsu and Banini, 2013).

In Uganda, local communities are highly careful of free energy systems, especially when announced without clear educational awareness. The absence of awareness generates suspicion and confrontation, reducing acceptance even in energy-deprived communities (Murungi and Jensen, 2011). Haiti's post-disaster situation provides productive ground for low-cost energy inventions, but weak establishments and lack of monitoring enforcement make it hard to differentiate between correct product and fake product. Exploitation and a lack of consumer protection destabilize trust (World Bank, 2015). In Nepal, the mountainous terrain and poor transportation infrastructure make distribution of hardware and technical services for free energy systems difficult. Rural users are frequently cut off from provision networks needed for services and repair or training (Mainali and Silveira, 2011).

Flywheel (free) energy generators have the power to change electricity charges, decline reliance on imported fuels, and increase energy accessibility in rural populations, according to research conducted in developing countries. According to investigate conducted between 2020 and 2023, they can improve quality of life, reduce energy poverty, and boost local economics by providing jobs in production, installation, and maintenance services. These resolutions have the potential to reduce carbon emissions and improve sustainable growth (Getie, 2020). However, in order to assure long-term preservation and reliability, successful deployment necessitates tailoring technology to rural technical and financial conditions. The commercial potential of free energy systems is display by their capacity to lower generating charges, assist small enterprises, and boost local productivity in countries like Nigeria, India, Kenya, Pakistan, Bangladesh, Ghana, Uganda, and Haiti (Okesiji, 2025).

However, there are still significant hindrances to overcome, such as slack regulation, a lack of methodological standards, limited funding options, and the opportunity that unproven or lowquality technology will find its way into the marketplace (Yang and Duncan, 2021).

The economic advantage of these systems eventually depends on robust legislative backing, local capacity building like seminars, workshop, and thorough verification to ensure safety, dependability, and long-term sustainability, even though they could lower national fuel price and strengthen micro-industries and scale enterprises (Revadi et al., 2025).

6. CONCLUSION AND RECOMMENDATION

This review work identifies the current landscape of flywheel energy generators (FEGs) as a burgeoning but technically constrained sustainable energy source. Based on the findings regarding their operational challenges, theoretical conflicts, and socio-economic barriers, the study concludes that while flywheel energy generators possess significant potential to serve as a clean, decentralized alternative to fossil-fuel-based generators, particularly in developing nations like Nigeria, their current Technology Readiness Level (TRL) remains limited to stages 4–6. The primary technical obstacles identified include high energy losses due to self-discharge, friction, and electrical resistance, alongside significant scalability issues that prevent these systems from moving beyond lab prototypes. Furthermore, a persistent gap exists between the theoretical claims of "free energy" and established thermodynamic laws, which has hindered broader scientific acceptance and commercial investment. Despite these drawbacks, the research highlights that integrating power electronics, such as efficient boost converters, can successfully stabilize and enhance the low, speed-dependent voltage outputs common in current designs.

To advance the development and adoption of flywheel energy generators, the following actions are recommended. Future research should shift focus from small-scale lab prototypes to the development of verified large-scale systems, specifically addressing mechanical losses through advanced materials or frictionless bearings. New FEG designs should incorporate established engineering principles from existing machines, such as the cooling and lubrication techniques found in fossil-fuel generators and industrial machinery, to mitigate operational abnormalities. Implement high-efficiency power electronic frameworks to convert variable, low-voltage outputs into constant, practical power supplies suitable for domestic and industrial use. Governments and energy sectors, particularly in developing countries, should establish clear regulatory frameworks and national policies to distinguish genuine innovations from fraudulent devices, thereby boosting investor confidence. Developing localized expertise through professional training, workshops, and seminars is essential to ensure the long-term maintenance and reliability of these non-conventional systems post-deployment.

Declaration of Conflicting Interests

The authors declare no potential conflicts of interest with respect to the research, authorship and publication of this article.

Funding

The author received no financial support for the research, authorship and publication of this article.

References

Abdalla, R. A., Elmaleeh, M. A., & Mahmoud, D. M. A. (2021). Design of a dedicated free energy generator. In 2020 International Conference on Computer, Control, Electrical, and Electronics Engineering ,2021, 1-6, doi: 10.1109/ICCCEEE49695.2021.9429679 adaptation in coastal areas. Int. J. Renewable Energy Res. 5 (3), 821–825.

Ahmad, S., Ullah, I., Shukat, S., & Ali, M. (2025). Lorentz force and Brownian motion features on entropy optimization in nanofluid swirling flow through porous configuration. Multiscale and Multidisciplinary Modeling, Experiments and Design, 8(2), 152.

Al‐Shetwi, A. Q., Atawi, I. E., El‐Hameed, M. A., & Abuelrub, A. (2025). Digital Twin

Technology for Renewable Energy, Smart Grids, Energy Storage and Vehicle‐to‐Grid Integration: Advancements, applications, key players, challenges and future perspectives in modernising sustainable grids. IET Smart Grid, 8(1), e70026.

Alzeer, J. (2024). Harnessing the power of choice: How to thrive in a universe of entropy. Am J Med Chem, 5(1), 2-6.

Andi Pawawoi & Syafii Syafii, (2017) On Load Characteristic of the New Design Permanent

Magnets Reluctance Generator. International Journal of Applied Power Engineering (IJAPE) 6(3), 193-198.

Annapureddy, V., Palneedi, H., Hwang, G. T., Peddigari, M., Jeong, D. Y., Yoon, W. H., ... & Ryu, J. (2017). Magnetic energy harvesting with magnetoelectrics: an emerging technology for self-powered autonomous systems. Sustainable Energy & Fuels, 1(10), 2039-2052.

Basit, M. A., Dilshad, S., Badar, R., & Sami ur Rehman, S. M. (2020). Limitations, challenges, and solution approaches in grid‐connected renewable energy systems. International Journal of Energy Research, 44(6), 4132-4162.

Bazilian, M., Nussbaumer, P., Rogner, H., Brew-Hammond, A., Foster, V., Pachauri, S., ... & Howells, M. (2012). Improving access to modern energy services: insights from case studies. Energy, 47(1), 1-9. https://doi.org/10.1016/j.energy.2012.03.014

Bhattacharyya, S. C. (2012). Energy access programmes and sustainable development: A critical review and analysis. Energy for Sustainable Development, 16(3), 260–271. https://doi.org/10.1016/j.esd.2012.05.002

Bhure G., & Ambulkar S. (2016). Concenptual Research on Free Energy Magnetric Generation. Journal of Research in Engineering and Applied Science, 1(3), 124-128.

Brown, C., Taylor, D., & Singh, A. (2018). Neodymium magnet applications in power generation. International Journal of Energy Research, 32(4), 345-352.

Chen, Y., & Kumar, S. (2022). Emerging trends in perpetual motion machines and energy efficiency. Journal of Clean Energy Innovation, 9(5), 563-574.

Chen, Y., Jensen, S., Albert, L. J., Gupta, S., & Lee, T. (2023). Artificial intelligence (AI) student assistants in the classroom: Designing chatbots to support student success. Information Systems Frontiers, 25(1), 161-182..

Chen, Z., Wang, J., Liu, K., Gong, J., Sun, L., Wu, Z., ... & He, C. (2025). NTIRE 2025 challenge on real-world face restoration: Methods and results. In Proceedings of the Computer Vision and Pattern Recognition Conference. 1536-1547

Choong, C. G. (2016). Experimental designs of magnetic generator using neodymium magnets. Jurnal Kejuruteraan, Teknologi dan Sains Sosial, 2(1), 1-11.

Damacharla, P., & Fard, A. J. (2020). A rolling electrical generator design and model for ocean wave energy conversion. Inventions, 5(1), 3. https://doi.org/10.3390/inventions5010003

David, A. P. J. (2019). Electro-magnetic induction: Free electricity generator (SSRN Scholarly

Paper No. 3486740). Social Science Research Network. https://doi.org/10.2139/ssrn.3486740 de la Bat, B.J.G. & Dobson, R.T. & Harms, T.M. & Bell, A.J., (2020) Simulation, manufacture and experimental validation of a novel single-acting free-piston Stirling engine electric generator, 263© DOI: 10.1016/j.apenergy.2020.114585.

Dhar, S., Guo, J., Liu, J., Tripathi, S., Kurup, U., & Shah, M. (2021). A survey of on-device machine learning: An algorithms and learning theory perspective. ACM Transactions on Internet of Things, 2(3), 1-49.

Dong, X., Zhang, P., Zang, Y., Cao, Y., Wang, B., Ouyang, L., ... & Wang, J. (2024). Internlmxcomposer2-4khd: A pioneering large vision-language model handling resolutions from 336 pixels to 4k hd. Advances in Neural Information Processing Systems, 37, 4256642592.

Emetere, M. E., Okoro, U., Etete, B., & Okunbor, G. (2016). Free energy option and its relevance to improve domestic energy demands in southern Nigeria. Energy Reports, 2, 229-236.

Emetere, M.E., Akinyemi, M.L., 2015. Weather effect on photovoltaic module

Friston, K. (2010). The free-energy principle: a unified brain theory?. Nature reviews neuroscience, 11(2), 127-138.

Getie, E. M. (2020). Poverty of energy and its impact on living standards in Ethiopia. Journal of Electrical and Computer Engineering, 2020(1), 7502583.

Graves, J., Kuang, Y., & Zhu, M. (2022). Pendulum energy harvester with torsion spring mechanical energy storage regulator. Sensors and Actuators A: Physical, 339, 113505.

Grover, M., Kumar, B. L., & Ramalla, I. (2014). The free energy generator. International Journal of Scientific and Research Publications, 4(12), 2250-3153

Grover, M., Kumar, B. L., & Ramalla, I. (2014). The free energy generator. International Journal of Scientific and Research Publications, 4(12), 1-4.

Hidayat, M. N., Chairandy, S. P., & Ronilaya, F. (2021, March). A review on how a Perpetual Motion Machine generates electrical power. In IOP Conference Series: Materials Science and Engineering 1098. 042063, https://doi.org/10.32628/IJSRSET2310125

Hosseini, S. E., & Wahid, M. A. (2020). Hydrogen from solar energy, a clean energy carrier from a sustainable source of energy. International Journal of Energy Research, 44(6), 41104131.

IJCRT2409637 International Journal of Creative Research Thoughts (IJCRT) www.ijcrt.org f705

Ioannidis, S., Livanios, V., & Psillos, S. (2021). No laws and (thin) powers in, no (governing) laws out. European Journal for Philosophy of Science, 11(1), 6.

Iwayemi, A. (2008). Nigeria's dual energy problems: policy issues and challenges. International Association for energy economics, 53(1), 17-21.

Johnson, K., et al. (2024). Modeling, design and optimization of integrated renewable energy systems. Sustainable Energy Research, 5(2), 1-15.

Johnson, T., Smith, L., & Martin, D. (2024). Conceptual design of an electromagnetic power generator: Efficiency and sustainability evaluation. Renewable Energy Journal, 34(5), 256270.

June T. L, (2019) Design Calculation of Flywheel Free Energy Generating System with MotorGenerator. International Journal of Innovative Science, Engineering & Technology, 6(8), 2348 – 7968

June, T. L. (2019). Design calculation of flywheel free energy generating system with motor generator. International Journal of Innovative Science, Engineering & Technology, 6(8)167-171.

Kashyap, A., Jagan, C., Chinababu, L., Abhiram, S., & Saiphani, S. (2020). Water wheel free energy device. Pramana Research Journal, 10(4). 142-151.

Kattimani, M. A., & Inayath, M. A. (2019). Free energy generation using flywheel. International Journal of Scientific Research & Engineering Trends, 6(5), 200-210. https://doi.org/10.32628/IJSRST196522

Khatate, M. B., Momin, H. S., Daspute, D. B., & Korade, E. S. (2024). Free energy generator: An analysis of concepts and feasibility. International Journal of Creative Research, 12(9), 705708. https://doi.org/10.48047/ijcrt/2024.12.09.637

Khatri, S., & Gupta, S. (2020). Free energy generator neodymium magnets repulsion. International Journal of Scientific Research & Engineering Trends, 6(6), 3622-3624.

Kumar, S., & Rathore, K. (2023). Renewable energy for sustainable development goal of clean and affordable energy. International Journal of Materials Manufacturing and Sustainable Technologies, 2(1), 1-15.

Li, H., Chen, G., & Wang, Z. (2024). Advances in energy harvesting technologies for wearable devices. Micromachines, 15(7), 884.

Mahendra B. k, et at (2024) Free Energy Generator: An Analysis Of Concepts And Feasibility. International Journal of Creative Research Thoughts Volume 12, ISSN: 2320-2882

Mainali, B., & Silveira, S. (2011). Financing off-grid rural electrification: Country case Nepal. Energy, 36(4), 2194–2201. https://doi.org/10.1016/j.energy.2010.06.059

Meirinhos, G., Malebo, M., Cardoso, A., Silva, R., & Rêgo, R. (2022). Information and public knowledge of the potential of alternative energies. Energies, 15(13), 4928.

Meyyappan C., Ravichandran C. R (2022). Generation of Free Energy using a Compact Flywheel," 2022 International Conference on Electronics and Renewable Systems (ICEARS), Tuticorin, India, (2022) 174-180, doi: 10.1109/ICEARS53579.2022.9751917.

Mikalsen, R. (2008). An investigation into the free piston engine concept and its potential for high efficiency and low emissions power generation. International Journal of Creative Research, 8, (6), 56-61

Ming, H., Luo, Z. Z., Zou, Z., & Kanatzidis, M. G. (2025). Strategies and prospects for highperformance Te-free thermoelectric materials. Chemical Reviews, 125(7), 3932-3975.

Mirondo, W. R., & Babirye, P. (2018). Free electric energy candle (Unpublished undergraduate project). Makerere University, Uganda. Retrieved from

https://competition.landartgenerator.org/media/entries/mannheim2022/WFDWUF82/WF DWUF82.pdf

Mostaman, N. A., Sulaiman, E., Jenal, M., & Somroo, I. A. (2023, December). Initial Design of

Free energy magnetic generator (FEMG). In IOP Conference Series: Earth and Environmental Science, 1261(1), 012005). DOI: 10.1088/1755-1315/1261/1/012005

Murungi, D., & Jensen, C. (2011). Electrification and productivity in Uganda. Energy Economics Review, 2(1), 33–42.

Nagasankar, P., Harzathkumar, N., Dilipkumar, K., & Saranraj, K. R. (2023). Frictionless energy generation using flywheel. International Journal of Scientific Research in Science,

Engineering and Technology,10(1), 191-196. doi https://doi.org/10.32628/IJSRSET2310125

Noku, A. A., Jabire, H., Gapshie, P. N., Terry, B., & Alex, I. (2023). Development of 3 kVA free energy generator using flywheel for domestic use. Taraba Journal of Engineering and Technology (TAJET), 3(1), 86–92'

O'Dwyer, M., Filieri, R., & O'Malley, L. (2023). Establishing successful university–industry collaborations: barriers and enablers deconstructed. The Journal of Technology Transfer, 48(3), 900-931.

Obieke, C. C., Milisavljevic-Syed, J., Silva, A., & Han, J. (2023). A computational approach to identifying engineering design problems. Journal of Mechanical Design, 145(4), 041406.

Ockwell, D., Watson, J., MacKerron, G., Pal, P., & Yamin, F. (2008). Key policy considerations for facilitating low carbon technology transfer to developing countries. Energy Policy,

36(11), 4104-4115. https://doi.org/10.1016/j.enpol.2008.06.019

Okesiji, S. O. (2025). Decentralized renewable energy systems: A pathway to climate resilience in low-income regions. Sustainability and Climate Change, 18(2), 119-131.

Olabi, A. G., Wilberforce, T., Abdelkareem, M. A., & Ramadan, M. (2021). Critical review of flywheel energy storage system. Energies, 14(8), 2159.

Ondraczek, J. (2014). Are we there yet? Improving solar PV economics and power planning in developing countries. Renewable and Sustainable Energy Reviews, 30, 751–761. https://doi.org/10.1016/j.rser.2013.11.012

Pamungkas, C. N., Hidayati, N., & Abadi, C. S. (2025). Boiler Efficiency Analysis with Indirect Method PT. Indonesia Power UBP PLTU Lontar Unit 2. FLYWHEEL: Jurnal Teknik Mesin Untirta, 11(2), 81-87.

Patel, M., Gupta, R., & Zhang, W. (2019). Feasibility analysis of free energy generators. Energy Systems Review, 14(1), 23-34.

Patel, R., & Ahmed, S. (2023). Initial design and modeling of free energy magnetic generators for residential applications. Energy Innovation Review, 29(6), 321-339.

Pittri, H., Godawatte, G. A. G. R., Esangbedo, O. P., Antwi-Afari, P., & Bao, Z. (2025). Exploring barriers to the adoption of digital technologies for circular economy practices in the construction industry in developing countries: A case of Ghana. Buildings, 15(7), 1090.

Prager, E. M., Chambers, K. E., Plotkin, J. L., McArthur, D. L., Bandrowski, A. E., Bansal, N., ... & Graf, C. (2019). Improving transparency and scientific rigor in academic publishing. Journal of neuroscience research, 97(4), 377-390.

Revadi, C. E., Armadani, E., & Siregar, L. S. (2025). Enhancing Supply Chain Performance for Sustainable Development in the Small and Micro Industries The Role of Organizational and Local Culture, Support from Financial Institutions, and Government. Journal of Sustainable Economics, 3(1), 42-54.

Riaz, M. T., Umer, S. M., Baig, H., Talha, M., Fatima, A., & Ejaz, H. M. A. (2021, March). Design of a Free Energy Generator using Gravity Wheel & Dynamo. In 2021 4th International Conference on Energy Conservation and Efficiency (ICECE) (2021), 1-5.

Shahzad, S., & Jasińska, E. (2024). Renewable revolution: A review of strategic flexibility in future power systems. Sustainability, 16(13), 5454.

Singh, S., Sharma, P. K., Moon, S. Y., & Park, J. H. (2024). Advanced lightweight encryption algorithms for IoT devices: survey, challenges and solutions. Journal of Ambient Intelligence and Humanized Computing, 15(2), 1625-1642.

Singh, V., Akbar, S., & Singh, H. (2023). Energy free flywheel. International Journal of Research Publication and Reviews, 4(3), 2757-2761.

Smith, A., & Johnson, B. (2020). Innovations in magnetic energy systems. Renewable Energy Journal, 45(3), 220-230.

Solarin, S. A., Bello, M. O., & Olabisi, O. E. (2021). Toward sustainable electricity generation mix: an econometric analysis of the substitutability of nuclear energy and hydropower for fossil fuels in Canada. International Journal of Green Energy, 18(8), 834-842.

Sovacool, B. K. (2012). Deploying off-grid technology to eradicate energy poverty. Science, 338(6103), 47–48. https://doi.org/10.1126/science.1222307

Soyaslan, M., Avşar, Y., Fenercioglu, A., & Sarıhan, F. (2023). Design and production of belt drive elevator traction machine: Modelling of double side belt system. Politeknik Dergisi, 27(3), 1069-1080.

Taylor, L. (2021). Public actors without public values: Legitimacy, domination and the regulation of the technology sector. Philosophy & technology, 34(4), 897.

Transparency International. (2019). Corruption in the energy sector: An overview. Retrieved from https://www.transparency.org

Van Prooijen, J. W., & Van Vugt, M. (2018). Conspiracy theories: Evolved functions and psychological mechanisms. Perspectives on psychological science, 13(6), 770-788.

Vinoth, M. A., Sivasankar, P., & Lingaraj N. (2017). Experimental Design and Optimization of Free Energy Generator by Using Neodymium Magnets. International Journal of Advanced Research in Management, Architecture, Technology and Engineering, 3(9), 97-100.

Vinoth, M. A., Sivasankar, P., & Lingaraj N. (2017). Experimental Design and Optimization of Free Energy Generator by Using Neodymium Magnets. International Journal of Advanced Research in Management, Architecture, Technology and Engineering, 3(9), 97-100.

White, N.M., Glynne-Jones, P., Beeby, S.P., Tudor, M.J. and Hill, M. (2001) Design and modelling of a vibration-powered micro-generator. Measurement and Control, 34 (9), 267-

71. (doi:10.1177/002029400103400903).

Williams, H. (2024). A "perpetual motion machine" powered by electromagnetism. The Physics Teacher, 62(1), 47-49.

World Bank. (2015). Haiti: Towards a new narrative Systematic country diagnostic. Washington, DC: The World Bank 12(9), 2320-2882

WSultana, M. N., Dhar, N. R., & Zaman, P. B. (2019). A review on different cooling/lubrication techniques in metal cutting. American Journal of mechanics and applications, 7(4), 71-87.

Yakovlev, A., Sobolev, A., & Kazun, A. (2014). Means of production versus means of coercion:

can Russian business limit the violence of a predatory state?. Post-Soviet Affairs, 30(2-3), 171-194.

Yang, T., & Duncan, T. V. (2021). Challenges and potential solutions for nanosensors intended for use with foods. Nature nanotechnology, 16(3), 251-265.

Zhang, X., Yang, G., Yan, M., Ang, L. K., Ang, Y. S., & Chen, J. (2021). Design of an all-day electrical power generator based on thermoradiative devices. Science China Technological Sciences, 64(10), 2166-2173.

Zhang, Y., & Lee, H. (2020). A low-cost electric energy generator for efficient mechanical input utilization. IEEE Energy Systems Journal, 15(4), 1121-1135.