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Fundamental Review on the Concept of Non Pollution Power Generators (NPPGs).

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Abstract*: The concept of non-pollution power generators (NPPGs) has gained significant attention as the world focuses on reducing its carbon footprint and mitigating climate change. This paper provides a comprehensive outlook with the current state of non-pollution power generation technology, defining the term and discussing the different forms of renewable energy, including solar, wind, hydro, geothermal, and nuclear power. The paper explores the advantages and disadvantages of each technology, highlights the current energy status, and examines the policy measures being implemented to promote the adoption of non-pollution power generation technology, including incentives and subsidies, and regulatory frameworks. It concludes by summarizing the key findings and highlighting the opportunities for future research in this field. The transition to non-pollution power sources is crucial for a more sustainable future and requires further investment and collaboration from the global community. This is a valuable resource for policymakers, industry leaders, and anyone interested in the future of energy production and the fight against climate change.*

Keywords: Non-pollution power generator, pollution, sustainable energy, global warming, emissions.

1.0 INTRODUCTION

Non pollution generators came to limelight around 17th and early 18th-century with the advent of industrial revolution as the increase in pollution along with the energy demand was on the rise [1]. To address this, engineers and scientists have created a variety of environmentally friendly power generators to lessen the pollution that comes from conventional energy sources [2], [3]. James Watt created the steam engine in 1775, which was the first clean generator. The electricity produced by this kind of machine, which can power lamps, machinery, and other devices, is produced using steam [4].

Over time, green energy sources have advanced to the point that today's power generators are more effective, economical, and ecologically benign, all in an effort to minimize environmental effects.

The development of green power generators has assisted in reducing the focus on fossil fuels and harmful emissions into the atmosphere, while contributing to a greener future. These generators are a great option to cut the carbon footprint as they don't emit any emissions or toxic byproducts, and have many other advantages, such as lower utility costs, enhanced energy security, and opportunities in the renewable energy sector [5]. However, the expense of the technology and infrastructure required to implement these generators, as well as the environmental impact with respect to the dependability of renewable energy sources, remain a challenge. The world's most significant energy sources are fossil fuels, which include coal, oil, and natural gas. However, the combustion of these fuels contributes to climate change and air pollution by releasing carbon dioxide and other pollutants into the environment [6].

Modern energy sources such as non-polluting power generators (NPPGs) can provide electricity without emitting any damaging byproducts that cause pollution. NPPGs are fueled by renewable energy sources, which include the sun, wind, water, and geothermal sources that can refill spontaneously and without human interference [7].

1.1 Working principles of Nonpolluting power generators

Renewable energy sources form the basis for non-polluting power generation are examples of natural energy sources that replenish over time and are known as "renewable energy sources" [8]. By using these resources, electricity can be produced without the need for fossil fuels, which release harmful pollutants and contribute to climate change. Non-polluting power generation captures and transforms energy from these renewable resources into electricity that can power buildings, including residences, businesses, and other establishments.

The primary concept behind non-polluting power generation is to obtain energy from renewable sources and convert it into a useful form. Solar panels, windmills, and turbines are commonly used for this purpose. The electricity generated from these sources can efficiently and sustainably power homes, businesses, and other facilities.

There are many advantages to producing power without pollution. In addition to reducing our reliance on fossil fuels, it offers clean, renewable energy at a lower cost than conventional energy sources. Additionally, renewable energy sources tend to be more reliable and consistent than fossil

fuels because they are not affected by external factors such as weather [9].

1.2 Categories of Non-Polluting Power Generators

1.2.1 Solar Power generator

Solar energy is a renewable energy source that harnesses the sun's energy to generate power, reducing dependence on fossil fuels with affordable and sustainable choices. Solar power systems use photovoltaic (PV) cells to convert solar energy into electrical power [10]. These cells contain semiconductors, such as silicon, that absorb the sun's rays and produce an electric field [11]. The electricity generated by this electric field can then be used to power buildings, commercial enterprises, and other devices.

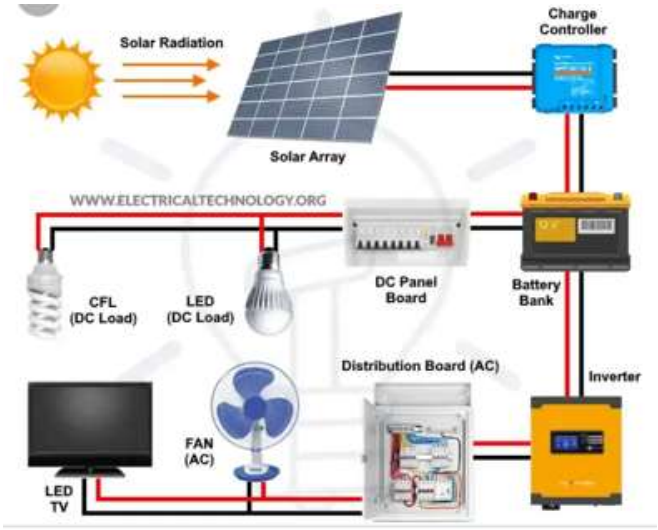

Fig. 1.Solar power system

1.2.2 Wind turbines

Wind turbine power generators are devices that generate electricity by harnessing the kinetic energy of the wind. Wind power is a non-polluting source of energy, as it does not emit greenhouse gases or other pollutants into the environment during normal operation.

Wind turbine power generators use large blades to capture the wind's energy and rotate a rotor, which powers a generator to produce electricity. It is a renewable and sustainable source of energy, as the wind is continually replenished by natural weather patterns [12].

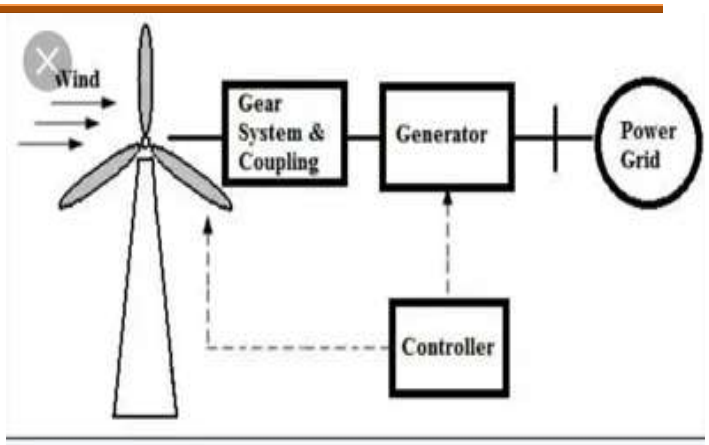

Fig.2. Wind turbine power system

1.2.3 Biomass

Biomass power generators are devices that generate electricity by burning organic materials such as wood, crops, or agricultural waste. Biomass power is a non-polluting source of energy, as it does not emit greenhouse gases or other pollutants into the environment during normal operation.

Biomass power generators use the heat generated from burning organic materials to produce steam, which drives a turbine to generate electricity. The organic materials used in biomass power generation are renewable and sustainable, as they can be grown and harvested repeatedly [13].

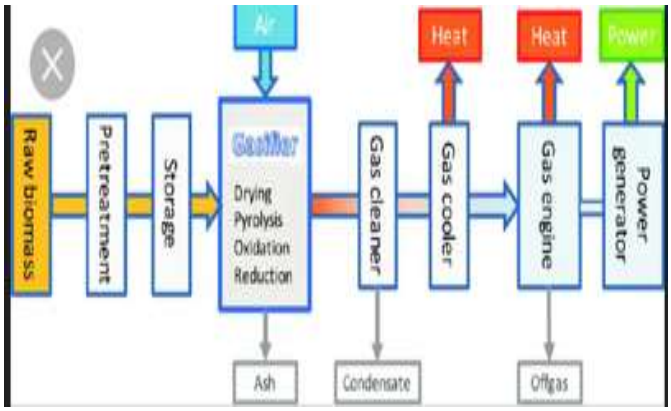

Fig.3. Biomass power system

1.2.4 Hydroelectric

Hydroelectric power generators are devices that convert the kinetic energy of falling water into electrical energy. Hydroelectric power is a non-polluting source of energy, as it does not emit greenhouse gases or other pollutants into the environment during normal operation. Hydroelectric power generators use a dam or other structure to block the flow of a river and create a reservoir. The water is then released through turbines, which spin a generator to produce electricity. The kinetic energy of falling water is a renewable and sustainable source of energy [14].

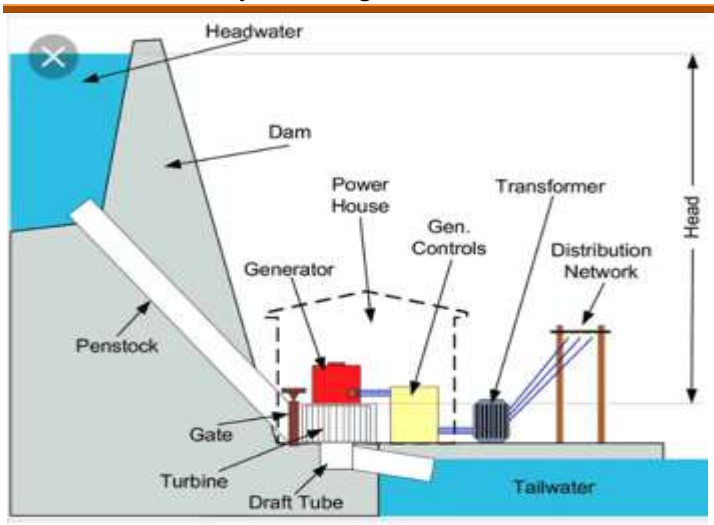

Fig.4 .Hydroelectric power system

1.2.5 Geothermal

Geothermal power generators are devices that harness the natural heat of the Earth to generate electricity. Geothermal power is a non-polluting source of energy, as it does not emit greenhouse gases or other pollutants into the environment during normal operation.

Geothermal power generators use a well drilled deep into the Earth's crust to access hot water or steam. The steam or hot water is then used to drive a turbine, which powers a generator to produce electricity. The Earth's heat is continually replenished, making geothermal power a renewable source of energy [15].

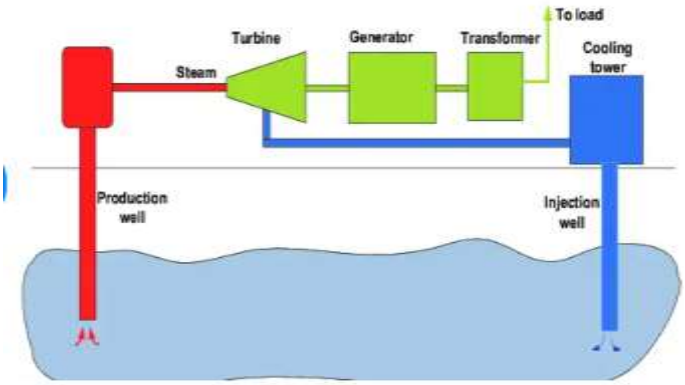

Fig.5. Geothermal power system

1.2.6 Nuclear power

Nuclear power generators are devices that generate electricity by harnessing the energy released from nuclear reactions. Nuclear power is a non-polluting source of energy, as it does not emit greenhouse gases or other pollutants into the environment during normal operation. Nuclear power generators use a controlled nuclear reaction to heat water and produce steam, which drives a turbine to generate electricity. The fuel used in nuclear power generators, typically uranium or plutonium, is highly concentrated and can produce large amounts of energy from a relatively small amount of fuel [16].

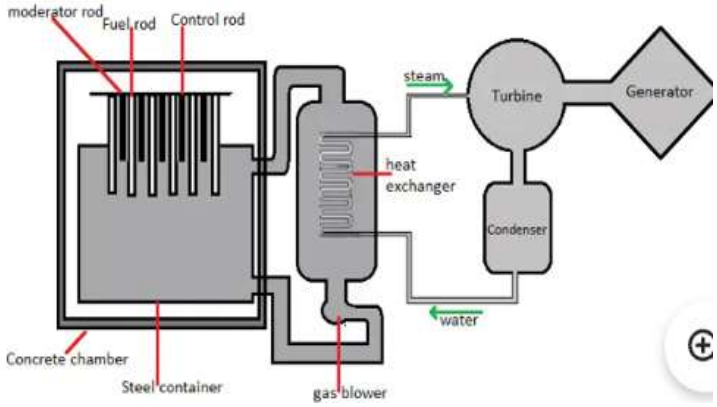

Fig.6. Nuclear power system

NPPG	System/Type	Principle	Application	Advantage	Disadvantage	Efficiency	Cost	Environmental Impact
Solar generator	• Photovoltaic • Thermal	This is based on the photovoltaic effect, which is the ability of certain materials to convert light energy from the sun into electrical energy.	• Residential homes • Commercial and industrial buildings • Remote locations. • Agriculture • Transportation • Space	• Renewable and Sustainable: • Clean and Environmentally Friendly: • Low Operating Costs: • Energy Independence • Flexible and Scalable: • Cost-Effective	• Intermittency • Energy Storage Challenges. • Upfront Cost. • Land Use: • Manufacturing and Recycling: • Geographic Limitations:	High	Medium/High	Low

Table 1. Non pollution power generator (Solar Power)

NPPG	System/Type	Principle	Application	Advantage	Disadvantage	Efficiency	Cost	Environmental Impact
Wind turbine Power generator	• Horizontal-axis • Vertical – axis	This is based on the conversion of kinetic energy from the wind into electrical energy	• Electricity generation • Off-grid power systems: • Water pumping: • Telecommunications: • Transportation: • Disaster relief:	• Clean and renewable: • Cost-effective: • Domestic energy production: • Job creation: • Land use • Scalability: • Low operating costs:	• Intermittency: • Land use and visual impact: • Noise pollution: • Wildlife impact: • Upfront costs • Grid integration:	Medium	Medium	Low

Table 2. . Non pollution power generator (Wind turbine)

NPPG	System/Type	Principle	Application	Advantage	Disadvantage	Efficiency	Cost	Environmental Impact
Biomass Power generator	• Stoker boilers • Fluidized bed boilers • Gasifiers • Combined heat and power	This is to convert the energy stored in organic matter, such as wood chips,	• Electricity generation • Heat generation • Combined heat and power (CHP)	• Renewable energy source • Carbon-neutral • Reduced greenhous	• Land use requirements • Air pollution • Water usage	Medium	Medium	Medium

	(CHP) systems • Organic Rankine cycle (ORC) systems • Pyrolysis systems • Micro-scale systems	agricultural waste, or other types of biomass, into usable forms of energy, such as electricity and heat.	• Biofuels • Waste management • Rural electrification	e gas emissions • Waste reduction • Job creation • Energy security: • Scalability	• Greenhouse gas emissions • Feedstock variability • Cost			

Table 3. . Non pollution power generator (Biomass)

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NPPG	System/Type	Principle	Application	Advantage	Disadvantage	Efficiency	Cost	Environmental Impact
Hydroelectric	• Impulse turbines • Reaction turbines • Pumped-storage hydroelectric plants • Run-of-river hydroelectric plants • Small hydroelectric plants.	This is based on the conversion of the potential energy of water into electrical energy	• Electricity generation • Load balancing • Energy storage • Irrigation • Flood control • Water supply	• Renewable and sustainable • Reliable and efficient • Low operating costs • Long lifespan • Versatile • Clean energy	• Environmental impact. • Limited availability of suitable sites • High initial costs • Vulnerability to drought • Risk of dam failure • Displacement of communities	High	High/Medium	Medium

Table 4. Non pollution power generator (Hydroelectric)

NPPG	System/Type	Principle	Application	Advantage	Disadvantage	Efficiency	Cost	Environmental Impact
Geothermal	• Binary Cycle Power Plants • Flash Steam Power Plants	This is based on the heat energy that is naturally stored within the Earth's crust. Geothermal power plants	• Electricity generation • Direct use • Industrial processes • Aquaculture • Agriculture	• Renewable and sustainable • Baseload power • Low emissions • Small land footprint	• Location-specific • Upfront costs • Resource depletion • Water usage • Environmental impacts • Limited scalability	High	High	Low

		harness this heat energy to generate electricity.		• Long lifespan • Local economic benefits				

Table 5. Non pollution power generator (Geothermal)

NPPG	System/Type	Principle	Application	Advantage	Disadvantage	Efficiency	Cost	Environmental Impact
Nuclear	• Pressurized Water Reactors (PWR) • Boiling Water Reactors (BWR) • Pressurized Heavy Water Reactors (PHWR) • Fast Reactors • Small Modular Reactors (SMRs) • Molten Salt Reactors (MSRs)	This use the energy released by a controlled nuclear reaction to generate heat, which is then used to produce steam that drives a turbine and generates electricity.	• Electricity generation • Spacecraft propulsion • Medical applications • Industrial applications • Research	• Low carbon emissions • High energy density • Reliability • Energy security • Cost competitiveness • Low operating costs	• Radioactive waste • Risk of accidents • Security risks • High construction costs • Long construction time • Decommissioning costs	High	High	Medium

Table 6. Non pollution power generator (Nuclear)

Solar, wind, hydroelectric, geothermal, biomass and nuclear are all considered part of the efficient non-pollution power generators which are individually capable of conversion into direct electricity [17], [18], [19], [20].
It is imperative to acknowledge that the efficiency and cost of non-pollution power generators can vary depending on the specific technology used and the location of the power generation. Additionally, the environmental impact of non-pollution power generators should be evaluated on a case-by-case basis, considering the specific technology, location, and the way it is implemented.

2.0 GENERAL ADVANTAGES AND DISADVANTAGES OF NON-POLLUTION POWER GENERATORS

These includes;
Clean Energy: Non-pollution power generators are a clean and sustainable source of energy because they don't emit any harmful emissions or pollutants. This may help lessen the consequences of climate change and air pollution [21].

Renewable Energy: Power generators that do not produce pollution are sources of energy that can be trusted to last for a reasonable amount of time. Renewable energy sources, in contrast to finite fossil fuels, may be produced sustainably as long as they are replenished [22].

Cost-effective: As technology advances and the price of renewable energy sources falls, the cost of non-polluting power generators approaches that of conventional energy sources [23].

Decentralized energy: Renewable energy such as wind and solar power can be generated by individuals and communities, enabling decentralization and democratization of energy systems [24].

2.1 Current challenges and opportunities in the field

The field of non-pollution power generators, also known as renewable energy sources, faces several challenges and opportunities.

High upfront costs: The cost of technology and infrastructure required to implement non-pollution power generators can be high. This can be a barrier to the development and deployment of renewable energy, especially in developing countries [25].

Weather dependent: The reliability and consistency of non-pollution power generators such as solar, wind, and hydroelectric power can be affected by weather patterns. This can be a challenge for grid integration and can lead to volatility in power supply [26].

Limited resources: Some non-pollution power generators, such as geothermal power, are limited by the availability and sustainability of the resources used as fuel. This can make it difficult to scale up these technologies [27].

Environmental impact: Some non-pollution power generators, such as hydroelectric power, can have significant environmental impacts, such as displacement of local communities and habitat destruction [28].
Storage: The storage of energy generated from non-pollution power generators remains a challenge to be addressed. The lack of appropriate and cost-effective storage solutions can limit the use of renewable energy and make it difficult to integrate renewable energy into the grid [29].

Cost competitiveness: The costs of renewable energy technologies have been decreasing in recent years, making them increasingly competitive with traditional forms of energy. This can create opportunities for the development and deployment of renewable energy [30].

Decentralization: The decentralization of energy systems can create opportunities for individuals and communities to generate their own renewable energy, which can help to democratize energy systems and increase access to clean energy [31].

Technical advancements: Advances in technology and innovation can create new opportunities for the development and deployment of renewable energy. For example, advances in energy storage technology can help to overcome the challenges of weather-dependent renewable energy sources [32].

Government policies: Government policies and regulations can create opportunities for the development and deployment of renewable energy. For example, government incentives and subsidies can help to reduce the costs of renewable energy technologies and increase the deployment of renewable energy [33].

Increasing demand for clean energy: The increasing demand for clean energy, driven by concerns about climate change and air pollution, can create opportunities for the development and deployment of renewable energy [34].

3.0 CURRENT STATUS OF NON-POLLUTION POWER GENERATORS IN NIGERIA

The current status of non-pollution power generators, also known as renewable energy sources, varies globally and nationally. However, there has been a rising trend in the use of non-pollution power generators in recent years, as international bodies and organizations recognize the benefits of renewable energy in terms of the reduction in harmful environmental emissions having more sustainable energy supply. Currently, the most widely used non-pollution power generators in the world are hydroelectric, wind, and solar power [35].
According to the International Energy Agency, hydroelectric power is the largest source of renewable electricity in the world, followed by wind and solar power [36]. In 2020, hydroelectric power accounted for around 7% of the world's total electricity generation, wind power accounted for around 5%, and solar power accounted for around 2% [36].
In terms of cost competitiveness, solar and wind power have seen significant reductions in costs in recent years and are becoming increasingly competitive with traditional forms of energy [37].

The cost of solar power has decreased by 84% since 2010, and the cost of wind power has decreased by 47% since 2010 [38].
In Nigeria, the current status of non-pollution power generators is still in the developing stage as the country is heavily dependent on fossil fuels for its energy mix, but there has been an increasing interest in renewable energy in recent years [39]. The country has a relatively high potential for solar and wind power, and there are various ongoing projects to develop solar and wind power in the country [39].
However, the country still faces several challenges in developing its renewable energy sector, such as lack of infrastructure, lack of funding, and limited capacity to develop and manage renewable energy projects. The Nigerian government has set a target of generating 30% of its electricity from renewable energy by 2030 [39].
Generally, the current status of non-pollution power generators is showing a positive trend towards increasing the use of renewable energy sources in the world, however, there is still a long way to go to reach a sustainable energy systems. In Nigeria, there is a significant potential for non-pollution power generators, but the country still faces several challenges that need to be addressed to develop its renewable energy sector.

3.1 Global and regional trends in the use and development of non -pollution power generators.

The global and regional trends in the use and development of non-pollution power generators, also known as renewable energy sources, have been increasing in recent years.

This is driven by a growing recognition of the benefits of renewable energy in terms of reducing harmful emissions and creating a more sustainable energy mix.
The following are some of the key trends in the global and regional use and development of non-pollution power generators:

Increasing use of renewable energy: The use of renewable energy has been increasing globally in recent years. According to the International Energy Agency, the portion of renewable energy with the basic power distribution has been increasing and reached 26% in 2020 [40].

Decentralization of energy systems: There is a growing trend towards decentralization of energy systems, with an increasing number of individuals and communities generating their own renewable energy. This is driven by the falling costs of renewable energy technologies, which have made it more affordable for individuals and communities to invest in their own renewable energy systems [41].

Increasing use of solar and wind power: Both solar and wind power generators are the fastest-growing renewable energy sources globally. According to the International Energy Agency, the share of solar and wind powers in the global electricity supply has been increasing and reached 2% and 5% respectively in 2020 [42].

Growing investment in renewable energy: There has been a growing trend towards investment in renewable energy globally. According to the United Nations Framework Convention on Climate Change, global investment in renewable energy reached $318 billion in 2020, an increase of 4% compared to 2019 [43].

3.2 Regional trends in the use and development of non-pollution power generators

The use and development of non-pollution power generators vary regionally. For example, in Europe, the use of renewable energy is relatively high, driven by the European Union's target of achieving a 32% share of renewable energy in the EU's final energy consumption by 2030 [44].
In Africa, the use of renewable energy is still relatively low, but there is a growing trend towards increasing the use of renewable energy, driven by a growing recognition of renewable energy and an increasing demand for clean energy [45]. The global and regional trends in the use and development of non-pollution power generators show an increasing trend towards the use of renewable energy, driven by a growing recognition of the benefits of renewable energy and a decrease in the costs of renewable energy technologies. However, there are still significant challenges to be addressed to fully realize the potential of renewable energy, such as the lack of infrastructure and limited capacity to develop and manage renewable energy projects.

3.2 Future **directions for Non-pollution Power Generators**.

The future direction for non-pollution power generators, also known as renewable energy sources, is expected to be shaped by a number of factors such as technological advancements, policy developments, and market trends. Some of the key future directions for non-pollution power generators include:

Increased penetration of renewable energy: The share of renewable energy in the global energy mix is expected to increase in the future. The International Energy Agency projects that renewable energy will account for more than 60% of the world's electricity generation by 2050 [46].

Continued decrease in costs: The costs of renewable energy technologies are expected to continue to decrease in the future. This will make renewable energy more cost-competitive with traditional forms of energy and enable more widespread deployment of renewable energy [47].

Decentralization of energy systems: There is an expected trend towards decentralization of energy systems in the future, with an increasing number of individuals and communities generating their own renewable energy. This can help to democratize energy systems and increase access to clean energy [48].

Advancements in energy storage: Advancements in energy storage technology are expected to play a critical role in the future of renewable energy. Improved energy storage will enable the integration of renewable energy into the grid, making it more reliable and consistent [49].

Increased use of electric vehicles: The increasing use of electric vehicles is expected to drive an increase in demand for renewable energy. Electric vehicles can be charged using renewable energy sources, which can help to reduce the emissions associated with transportation [50].

More stringent regulations: With the growing concern over the effects of climate change and air pollution, governments around the world are expected to adopt more stringent regulations to promote the use of renewable energy and reduce the use of fossil fuels [51].

Micro grids and Community-based systems: The future of non-pollution power generators is also expected to see an increase in the development of micro grids and community-based systems.
These systems can help to increase access to clean energy in remote and underserved areas, and also provide resilience to the grid during crises [52].

4.0 ADVANCEMENTS IN TECHNOLOGY AND RESEARCH THAT ARE LIKELY TO SHAPE THE FUTURE OF NON-POLLUTION POWER GENERATORS

Some of the key advancements in technology and research

that are likely to shape the future of non-pollution power generators include:

Improved Solar Cells: Advancements in solar cell technology, such as the development of perovskite solar cells, are likely to increase the efficiency and decrease the cost of solar power. This can help to make solar power more cost-competitive with traditional forms of energy and enable more widespread deployment of solar power [53].

Offshore wind power: Offshore wind power has the potential to generate more electricity than onshore wind power because of stronger winds and less interference from buildings and other obstacles.
Advancements in turbine technology and installation methods are making offshore wind power more cost-effective and efficient [54].

Advanced Hydropower: Research and development in advanced hydropower technologies such as run-of-the-river, tidal, and ocean energy can help to increase the efficiency and decrease the environmental impact of hydropower [55].

Enhanced geothermal systems (EGS): EGS can help to increase the availability of geothermal energy by drilling deeper into the earth's crust and creating artificial geothermal reservoirs.
This can help to increase the scale of geothermal power and make it more cost-competitive with traditional forms of energy [56].

Advanced Biomass: Advancements in technology and research in advanced biomass technologies such as algae-based biofuels, can help to increase the efficiency and decrease the environmental impact of biomass power [57].

Nuclear fusion: Nuclear fusion is a promising technology that has the potential to generate large amounts of clean energy with minimal waste and no carbon emissions.
Advancements in nuclear fusion technology can help to make nuclear fusion more cost-effective and efficient [58].

Energy storage: Advancements in energy storage technology, such as the development of advanced batteries and hydrogen fuel cells, can help to overcome the challenges of weather-dependent renewable energy sources and make it more reliable and consistent [59].

4.1 Potential for increased integration and use of non-pollution power generators

Renewable energy has several advantages over traditional forms of energy, such as reducing emissions and creating a more sustainable energy mix. Some of the key factors that can help to increase the integration and use of non-pollution power generators in the energy mix include:

Cost competitiveness: The costs of renewable energy technologies have been decreasing in recent years, making them increasingly competitive with traditional forms of energy. This can help to increase the deployment of renewable energy and make it more cost-effective for consumers [60].

Government policies: Government policies and regulations can play a critical role in increasing the integration and use of renewable energy. For example, government incentives and subsidies can help to reduce the costs of renewable energy technologies and increase the deployment of renewable energy [61].

Grid integration: Advancements in technology and research can help to increase the integration of renewable energy into the grid. Improved energy storage and grid management technologies can help to make renewable energy more reliable and consistent [62].

Decentralization: The decentralization of energy systems can help to increase the integration and use of renewable energy. This can enable individuals and communities to generate their own renewable energy and increase access to clean energy. Increased demand for clean energy: The increasing demand for clean energy, driven by concerns about climate change and air pollution, can help to increase the integration and use of renewable energy [63].

Technological advancements: Advancements in technology and research can help to increase the efficiency and decrease the cost of renewable energy technologies.
This can make renewable energy more cost-competitive with traditional forms of energy and enable more widespread deployment of renewable energy [64].

5.0 CONCLUSION

Non-pollution generators such as solar, wind, hydroelectric, geothermal, biomass, and nuclear power generators has been gaining momentum in both the local and global environments. These sources of energy have been identified as a way to mitigate the environmental impacts of traditional energy sources while providing a sustainable and reliable energy supply. Solar energy is considered one of the most promising sources of renewable energy. The widespread availability of sunlight makes it a viable option in many parts of the world. Furthermore, advancements in technology have made solar panels more efficient, making them a cost-competitive alternative to traditional sources of energy. Wind energy is another source of renewable energy that is being increasingly used globally. Wind turbines can be installed in areas with strong winds, providing a source of energy that is both renewable and non-polluting. Hydroelectric power is also a well-established source of renewable energy. The utilization of hydropower has been widespread for many years, and it is considered one of the most reliable sources of renewable

energy. Geothermal energy is a relatively new source of renewable energy. The utilization of geothermal energy has been limited to certain regions due to the need for a heat source, but advancements in technology have made it more accessible in other parts of the world. Biomass energy is also a promising source of renewable energy. The use of biomass energy has been widespread for many years, and it is considered a low-carbon alternative to traditional sources of energy.

Nuclear power is a highly controversial source of energy. While it is considered a low-carbon source of energy, there are concerns about the potential risks associated with nuclear power, including the risk of nuclear accidents and the disposal of radioactive waste. The concept of non-pollution generators such as solar, wind, hydroelectric, geothermal, biomass, and nuclear power generators holds significant promise for mitigating the environmental impacts of traditional sources of energy.

These sources of energy provide a sustainable and reliable source of energy, and advancements in technology have made them more accessible and cost-competitive. It is important for policymakers to continue to support the development and deployment of these sources of energy in order to ensure a sustainable energy future for the world. Non-pollution power generators are an excellent way to produce electricity without damaging the environment.

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