

## ***Effective Strategies to Accelerate the Use of Clean Energy for Long-Term Sustainability***

### ***- An Analytical Study -***

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#### ***Abstract:***

*This study aims to examine the role of advanced renewable energy technologies in supporting the transition toward clean and sustainable energy systems, while identifying the main challenges facing this transition. The research addresses the central question of how renewable energy sources can effectively meet growing global energy demand and what obstacles limit their widespread adoption. The study adopts a descriptive and analytical methodology based on reviewing scientific literature, international reports, and selected global experiences in clean energy development.*

*The findings indicate that renewable energy sources play a crucial role in reducing greenhouse gas emissions and mitigating climate change. However, the transition to clean energy is constrained by challenges related to energy security, financing, technological development—particularly energy storage—supply chain limitations, and global inequalities between developed and developing countries.*

*The study concludes that supportive government policies, technological innovation, international cooperation, and increased public awareness are essential to accelerating the clean energy transition and achieving sustainable development.*

***Keywords:*** Energy; Renewable energies; Sustainable development; Environmental economy; Agenda2030.

***Jel Classification Codes:*** G21 ; O31

## **1. Introduction:**

The world today faces several natural phenomena such as global warming and changing climate patterns due to the massive use of traditional energy sources like fossil fuels, which cause toxic emissions, pollution from the industrial and transportation sectors, and a lack of human awareness to preserve forest wealth. All these factors have posed a threat to environmental balance and public health, calling for the necessity of adopting clean energy sources that contribute to achieving long-term environmental and economic sustainability. Accelerating the transition to clean energy use is a transformation that faces multiple challenges related to infrastructure, cost, social awareness, and government policies. Therefore, the main issue revolves around: "How can the use of clean energy be effectively accelerated to ensure long-term economic and environmental sustainability?" Within this main question, several **sub-questions arise** :

- What are the challenges facing the transition to clean energy ?
- What is the role of government policies in promoting the use of clean energy ?
- What does social awareness achieve by adopting the use of clean energy sources ?

### **Research hypotheses:**

Hypothesis One: Continuous investment in research and development in clean energy fields will lead to improved energy technology efficiency and reduced costs .

Hypothesis Two: Implementing incentivizing and supportive government policies can significantly contribute to increasing the use of clean energy .

Hypothesis Three: International cooperation in the field of clean energy can help accelerate technology transfer and reduce technical gaps between countries .

Hypothesis Four: Increasing environmental awareness and education in communities will enhance the adoption of clean energy solutions by individuals and companies .

Hypothesis Five: Developing advanced infrastructure for clean energy will contribute to achieving wider and more effective dissemination of these technologies .

### **Research Objectives**

- Identify the main obstacles hindering the transition to clean energy and explore ways to overcome them.
- Analyze current strategies used to accelerate the transition to clean energy and evaluate their effectiveness.
- Explore the role of government policies and international cooperation in achieving a sustainable transition to clean energy .
- Provide recommendations to enhance community awareness and environmental education to support the use of clean energy .

- Propose models for integrated infrastructure to support clean energy and achieve its effective dissemination.

### **Research Methodology**

Previous studies and scientific articles on the topic of clean energy were reviewed, and statistical data were collected from reliable sources such as the International Energy Agency and environmental organizations, using a descriptive analytical approach and case study analysis of successful examples of countries and projects that have achieved effective transitions to clean energy. Lessons learned were extracted and applied to future studies presented in the recommendations section .

## **2. Advanced Technologies in Renewable Energy and the Challenges They Face**

### **2.1 What is clean energy (renewable, sustainable)? And how does it work ?**

It is energy derived from natural sources whose renewal rate is higher than the consumption rate. It is always available and inexhaustible, producing fewer emissions than energy generated from burning fossil fuels. It also contributes to addressing the climate crisis, as the energy present in each type is converted into electrical energy that can be utilized. Its main sources include:

#### **a- Solar Energy**

It is one of the most abundant sources and can be utilized even in cloudy weather, where solar energy is converted into electrical energy through photovoltaic panels or by mirrors that concentrate solar radiation. Solar energy technologies can provide heating, cooling, natural lighting, electricity, and fuel. Recently, the costs of producing solar energy have decreased due to the reduced manufacturing costs of panels, which have a lifespan of thirty years, depending on the degree of panel manufacturing and the materials used in their production .

#### **b- Wind Energy**

This is the energy generated from air movement, where large wind turbines located on land or in the sea and freshwater bodies are driven by using longer turbines and larger rotating diameters. Wind speed varies according to geographic location, with suitable sites typically being in remote areas (Al-Jabouri, 2023). Wind energy, also known as aerodynamic energy, has been used since ancient times for sailing ships, operating windmills to grind grains, or pumping water from wells. Wind units convert wind energy into mechanical energy used directly or convert it into electrical energy through generators (Mousa and Al-Naas, 2021) .

#### **c- Geothermal Energy**

This is high thermal energy of natural origin stored in magma beneath the earth's surface, where it is estimated that more than 99% of the Earth's mass consists of rocks exceeding temperatures of 1000 degrees Celsius. The temperature increases by about 27 degrees Celsius for every kilometer of depth into the earth. This thermal energy is primarily used to generate electricity. There are three types of power plants that generate electricity using geothermal thermal energy, which are as follows:

- Dry steam power plants:

Used in Italy in 1904, these plants utilize naturally occurring water in deep underground layers under high pressure and temperature. It is extracted by drilling deep wells, and it emerges as steam due to its high temperature. Because of the pressure difference, this steam travels through pipes and is then directed to turbines that rotate electric generators producing electrical energy. The condensed water is pumped back into the ground through another well called the injection well.

-Flash steam power plants:

These plants use fluids existing underground at high pressure, which are concentrated in a vessel with a small hole leading to another vessel at moderate pressure. When the fluid moves from the first vessel to the second through the hole, it evaporates due to speed and high pressure difference. The steam moves the turbine, which in turn drives the electric generators producing electricity. The remaining condensed water is pumped back into the ground through the injection well.

-Binary cycle power plants:

These plants use underground fluids with a high boiling point (around 200°C) that are pumped upward to heat water with a normal boiling point (100°C) in another pipe running parallel to the hot pipe (heat exchanger). The water heated by the high temperature of the fluid in the other pipe evaporates, driving the turbine of the electric generator. It then condenses and returns to the hot pipe, circulating continuously in this manner. The extracted water is re-injected into the ground through the injection well (Wikipedia, 2024).

#### **d- Hydropower**

Hydropower is the energy obtained from water, where the turbine converts the kinetic energy of falling water into mechanical energy, and then the generator converts the mechanical energy from the turbine into electrical energy. The requirements for generating electricity from water include four main components:

-Dam: It raises the river water level to create falling water, and the dam also controls the water flow. The reservoir formed is essentially stored energy.

-Turbines: The turbine converts the kinetic energy of falling water into mechanical energy.

-Electric generator: The turbines connected to the water above the turbine blades cause the turbine to rotate. Hydroelectric turbines are similar to windmills except that the energy source is water. Through shafts and possibly gears, when the turbine rotates, it also causes the generator to rotate, converting the mechanical energy from the turbine into electrical energy. Generators in hydroelectric power plants operate like generators in other types of power plants.

-Transmission lines: They transfer electricity from the hydroelectric power plant to homes and businesses (Mahmoud, 2018).

#### **e- Ocean Energy**

Ocean energy, or "ocean thermal energy," emerges as a promising solution for generating clean, sustainable electricity in tropical island countries, in addition to its potential use in desalinating

seawater for the inhabitants of those island communities. It exploits the temperature difference (no less than 20 degrees Celsius) between warm surface waters and cold deep ocean waters to generate electricity, thus providing a continuous source of renewable energy for tropical island nations. However, it has faced financial and technical obstacles, as well as fierce competition from other energy sources the cheapest renewable energy.

Currently, there are only two small ocean thermal energy conversion (OTEC) plants, located in the U.S. state of Hawaii and Japan, which feed electricity into the grid; enough to power about 100 homes.

Global OTEC, a UK-based startup, plans to overcome these challenges and lead the renaissance in ocean thermal energy. The company is developing a commercial offshore platform for ocean thermal energy conversion called Dominique, aiming to provide clean electricity and replace fossil fuels typically used in island nations. Dominique, with a capacity of 1.5 megawatts, will be installed off the coasts of the islands of São Tomé and Príncipe, located in the tropical Atlantic Ocean, by the mid-2030s (Abdulsand, 2023).

#### **f- Bioenergy**

This is energy generated from animal organic waste, agricultural residues, and plants using "biofuel technology" (Al-Otaibi, 2021). It is divided into: energy crops, gas production from animal waste, and energy from garbage and waste.

- Energy crops: plants whose products can be converted into fuel, and plants that produce oils, such as alcohol production from sugar (Ayash, 1981, p. 125).
- Gas production from animal waste: methane gas is produced from animal waste through a method called anaerobic digestion, and the residues left after gas production contain nitrogen, which plants need (Ayash, 1981, pp. 129-130).

**Table 1: Gas production from animal waste, production in liters from one day of animal waste**

| Animal    | Output<br>In Gas | Gas<br>Methane<br>Percentage | Calorific Value<br>per Liter<br>In Gas<br>Kilojoules |
|-----------|------------------|------------------------------|------------------------------------------------------|
| Dairy Cow | 1200             | %59                          | 22                                                   |
| Goat      | 140              | %68                          | 25                                                   |
| Chicken   | 9                | %68                          | 22                                                   |

**Source: (Ayash, 1981, p. 131)**

**-Energy from garbage and waste:** It can be utilized in several ways, including direct incineration, hydrogenation, and pyrolysis .

Many countries and cities have established plants to generate electricity or heat through the direct incineration of solid waste .

In Vienna, the "Spatilo" plant incinerates 250,000 tons of residential sector waste annually, producing 120,000 megawatt-hours of electricity, 500,000 megawatt-hours in the form of district heating, and 6,000 tons of recyclable iron, benefiting 60,000 homes in Vienna for heating .

In Osaka, Japan, the "Miyashima" waste-to-energy plant resembles a children's amusement park, attracting tourists from around the world. The plant burns 330,000 tons of solid waste annually, with a production capacity of 32,000 kilowatts of electricity. There are dozens of similar plants in Japan, but none match the beauty of the "Miyashima" plant .

The Vancouver plant in Canada burns 260,000 tons of waste annually, generating enough electricity to power 16,000 homes. The municipality earns 8 million Canadian dollars annually from electricity sales and 300,000 dollars from the sale of iron and other metals .

The "Lugang Zen" plant in Shanghai, China, is one of the largest plants in the world converting solid waste into energy, burning one million tons of waste per year with a capacity of 60,000 kilowatts of electricity .

In Sharjah (United Arab Emirates), a plant is currently under construction to collect solid waste and convert it into energy with a capacity of 30 megawatts, enough to supply electricity to 28,000 homes. It will process 300,000 tons of waste annually, contributing to Sharjah avoiding sending any solid waste to Landfills by 2021 .

One of the most important benefits of the project is that it will provide 45 million cubic meters of natural gas, quantities that would have been burned to generate electricity if this project had not been built. These quantities will be redirected to the industrial sector for use as raw materials, creating much greater added value than burning them in power plants. The project will also significantly reduce greenhouse gas emissions .

#### **-Benefits of solid waste-to-energy projects**

Waste requires large areas of land, and preparing waste landfills is costly, with the preparation costs for large landfills exceeding 500 million dollars. Shipping waste by land and sea to distant areas or countries for disposal is also expensive. When comparing these costs to the costs of building a plant to burn waste and generate energy from it, there are significant savings. Among the economic benefits are the revenues from selling electricity, hot water, and metals (scrap or junk). In oil and gas producing countries, using waste to generate electricity means saving quantities of oil and gas for export without any additional costs, or using them in fields that yield greater added value than burning oil and gas to generate electricity .

**Methane production:** Waste placed in landfills produces large amounts of methane as it decomposes. Methane is one of the most dangerous greenhouse gases. Therefore, it is disposed of in one of two ways: first, by placing vertical pipes from the core of the landfill to its surface and burning the methane. This is why in some countries and US states, multiple flames light up some hills at night. These hills are nothing but waste landfills. The second method, instead of burning the

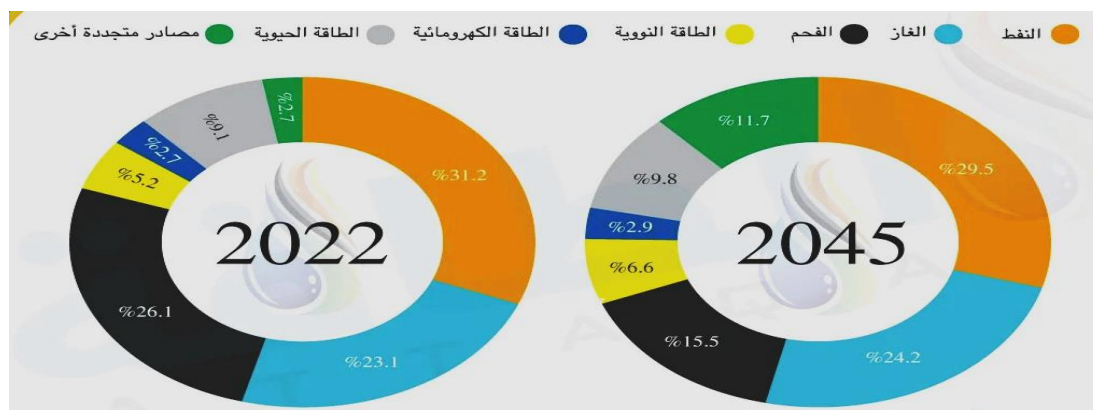
gas, involves extending pipes to a nearby power plant to utilize the gas, or to an adjacent factory to heat water or other things. Others. For example, one of the largest landfills in the state of Georgia, USA, sells methane gas to a nearby factory that produces dog and cat food, where the gas from the landfill is used to cook animal food .

Animal manure: a missed investment opportunity in several Arab countries. In American cattle and pig farms, as well as in some European countries, animal manure is collected in a large pit, mixed with water and some fermentation-stimulating materials, resulting in methane gas, which is collected and sold to a nearby power plant or used on the farm itself either to generate electricity locally or to heat water (Al-Hajji, 2019) .

### **g- Hydrogen**

Hydrogen is one of the most abundant elements in the universe. It is considered a good energy carrier, and for distances greater than 300 kilometers, it is easy to transport energy through special pipelines, and it can also be stored. In hydrogen usage systems, fuel can be sent from production sites via underground pipelines to factories and homes. Hydrogen can also be used directly in industrial processes that require heat, as well as for heating and cooling buildings. For example, burning hydrogen produces water vapor, which is used in many industries such as paper and chemicals, and in iron smelting instead of coal. The electricity needs of factories, homes, and buildings can be produced by hydrogen fuel cells, where hydrogen is mixed with oxygen to produce energy. Due to hydrogen's ideal properties as a fuel and its light weight, it can be used efficiently in the transportation sectors. It can also be converted in internal combustion engines into mechanical energy with about 20% higher efficiency than traditional fuels. If used in airplanes, this leads to fuel savings due to its lighter weight compared to... About conventional fuel (Ramadan and Al-Shakil, 1988) .

**Figure 1: Global energy mix projections by 2045**



**Source: (Shawqi, 2024)**

From the figure, a sharp decline in coal usage is expected by 59.38%, and a slight decrease in oil usage by 5.44%. As for other renewable energy sources, their usage will increase by 400%, while the rest of the sources will see slight increases (Shawqi, 2024)

## **2.2 Main Challenges Facing the Transition to Clean Energy .**

### **a. The Need for Energy Security**

The transition in the energy system must be based on energy security, meaning the provision of sufficient supplies at affordable prices, to ensure public support and avoid major economic disruptions that could lead to serious political consequences .

### **b. Speed of Transition**

There is significant pressure to accelerate achieving a large portion of the 2050 carbon emission targets by 2030. However, sometimes the scale of ongoing efforts seems underestimated. The current transition aims not only to introduce new energy sources but also to fundamentally change the foundations of energy in the global economy, which currently amounts to 100 trillion dollars, and to achieve this within a little over a quarter of a century. This is an extremely ambitious goal, as no attempt at this scale has ever been made before .

### **c. The North-South Gap**

The new gap between the North and South reflects differing views on climate policies and transition and their impact on development, as well as on determining who is responsible for cumulative and new emissions and who suffers from them. Developing countries have faced increased pressures due to global commodity shocks caused by the war in Ukraine, rising interest rates, and subsequent currency devaluations. What appears to be an exceptional focus on emission reductions requires balancing with other urgent priorities, including health, poverty, and economic growth. Billions of people still use wood and waste for cooking, which pollutes indoor spaces and leads to health issues. Many of these countries seek to increase the use of hydrocarbons as a key element in raising living standards .

### **d. Ensuring the provision of new supply chains to achieve net-zero emissions**

There is increased demand for metals that are essential components of renewable energy, which require wind turbines, electric vehicles, solar panels, and more. A group of organizations, including the International Monetary Fund, the World Bank, the International Energy Agency, as well as the U.S. government, the European Union, and Japan, have issued studies on the urgent need to provide these supply chains. The International Energy Agency expects the global economy to shift from a "fuel-intensive energy system to a metal-intensive energy system," which would "increase demand for essential metals," as the main goal of the energy system transition is to shift towards the use of electric energy, and copper is "the metal necessary for the transition to electric energy use. For example, an electric car requires at least two and a half times more copper than a traditional internal combustion engine vehicle. This analysis concluded that the demand for copper must double by the mid-2030s to meet the 2050 targets .

The bottleneck lies on the supply side. With the current growth rate of supply, which includes new mines, mine expansions, increased efficiency, recycling, and substitution, the available amount of copper will be far less than the supply requirements (Yergen, 2022) .

#### **e. Halting Funding**

On the financial level, clean energy production efforts face a problem related to the lack of competitive pricing for clean energy. This was confirmed by some energy sector experts, including Manfred Engelhardt, head of the alternative energy sector and an expert at the Austrian M+W Group, who stated that the main problem with renewable energy in general is its inability to compete with other energy production methods in terms of price. For example, the cost of producing one kilowatt-hour of electricity through solar energy is estimated at about 19 cents/euro, while the cost per kilowatt-hour through nuclear energy is estimated at only 10 to 12 cents. There is also a challenge related to the risks of exchange rate fluctuations, as energy in general is highly sensitive to foreign exchange rate volatility. Investments in clean energy are usually linked either to energy-producing companies or to state projects. Although there is now consensus on climate change caused by thermal and gas emissions and agreement that clean energy research is the way to solve this problem, only a few reports have discussed how this will be funded. There are projects implementing these technological solutions, which further reduces the viability of such projects. The International Energy Agency estimated that the world needs to invest \$17 trillion to finance the global energy expansion, including clean energy projects, over 25 years (Tajin, 2012).

#### **f. Technological Development Challenges (Storage)**

Numerous challenges arise, and technological development will play a key role in solving them, particularly how to store renewable energy sources such as wind and solar power. Advances in this field may allow consumers in the future to generate and store energy without the need for electricity companies.

Big data will play a greater role in the future through the use of sensors in wind and solar facilities to collect real-time data on wind and solar levels and analyze it alongside satellite data and weather stations to accurately predict energy needs. Smart meters will enable electricity companies to analyze consumption patterns and how to reduce waste (Gridini, 2020).

### **3. Effective Strategies to Promote the Use of Clean Energy**

#### **3.1 Government Policies and Legislation**

##### **A. Feed-in Tariffs (FiTs)**

Feed-in tariffs are one of the main government policies used to stimulate the development of renewable energy. Under the feed-in tariff system, renewable energy producers are guaranteed a fixed payment for each unit of electricity they generate and feed into the grid. This provides a stable and predictable source of income for renewable energy projects, making them more financially viable.

For example, in Germany, the feed-in tariff system introduced in 2000 played a crucial role in the rapid expansion of solar energy. This scheme guarantees premium prices for solar power, attracting significant investments and leading to a reduction in the cost of solar panels, making them affordable for consumers.

## **B. Renewable Portfolio Standards (RPS)**

Renewable Portfolio Standards are another important policy tool used by governments to promote renewable energy. Under the RPS system, utilities are required to obtain a certain percentage of their electricity from renewable sources. This creates demand for renewable energy and encourages investment in new renewable energy projects .

California, for example, has one of the most ambitious RPS programs in the United States. The state aims to supply 100% of its electricity needs from renewable sources by 2045. To achieve this goal, California has set incremental targets for utilities to increase their purchases of renewable energy over time .

## **C. Investment Tax Credits (ITCs) and Production Tax Credits (PTCs)**

Governments widely use tax incentives, such as Investment Tax Credits (ITCs) and Production Tax Credits (PTCs), to encourage investment in renewable energy projects. These credits provide financial benefits to developers and investors, reducing initial costs and improving the overall financial viability of renewable energy projects .

For example, in the United States, the federal government offers a 26% investment tax credit for solar energy projects and a production tax credit for wind energy projects. These incentives have been instrumental in driving the growth of renewable energy capacity in the country .

## **D. Green Certificates and Renewable Energy Certificates (RECs)**

Green certificates, also known as Renewable Energy Certificates (RECs), are tradable instruments that represent the environmental benefits of generating renewable energy. These certificates are issued to renewable energy producers for each megawatt-hour of electricity they generate. They can then be sold to utilities or energy consumers, who can use them to meet their renewable energy obligations .

In Europe, the issuance of regional economic groups has served as a key policy mechanism to promote renewable energy. For example, the European Union established the Renewable Energy Directive, which requires member states to achieve a certain percentage of their electricity consumption from renewable sources. Regional economic groups play a vital role in helping countries meet these targets .

## **E. Net Energy Metering (NEM)**

Net energy metering is a policy mechanism that allows owners of renewable energy systems to offset their electricity consumption with the electricity they generate. Under net energy metering, any surplus electricity generated by the renewable energy system is exported to the grid and credited to the system owner's electricity bill. This effectively reduces electricity costs and provides an economic incentive to invest in renewable energy.

California has been at the forefront of net energy metering in the United States. The state's net energy metering program has played an active role in promoting rooftop solar installations, allowing homeowners and businesses to receive credits for the excess electricity they generate from solar power.

These are just a few examples of key government policies and incentives implemented to support the development of renewable energy. It is important for stakeholders in the renewable energy industry to stay informed about these policies, as they can have a significant impact on project economics and market dynamics (Faster Capital, 2024).

### **3.2 Technology and Innovation**

The Low Carbon Technology Partnership initiative by the World Business Council for Sustainable Development is a successful example of global innovation partnerships, comprising more than 160 companies (ESCWA, 2019).

### **3.3 International Cooperation to Achieve Clean Energy Transition**

The 2015 Paris Agreement, as the most important outcome of the 21st United Nations Climate Change Conference, had a significant impact on many countries around the world, especially developing ones. These countries showed greater interest in the nationally determined voluntary contributions to mitigate the effects of climate change and achieve the Sustainable Development Goals, including Goal 7 related to energy, by incorporating specific renewable energy targets into their national plans to diversify the energy mix and develop and implement relevant policies (Facts Newspaper, 2024).

### **3.4 Community Awareness and Education in Enhancing the Acceptance of Clean Energy**

This involves organizing conferences and events to raise awareness about environmental sustainability issues and accelerate the transition to clean energy, launching numerous local and international environmental awards, as well as encouraging institutional and individual efforts to develop innovative solutions that contribute to addressing the consequences of climate change. Climate and sustainability issues should be integrated into the educational system by developing curricula that enhance environmental awareness, establishing programs to train and qualify teachers and educational officials, founding eco-friendly schools, and initiating innovative programs to develop suitable school curricula based on the educational units of the "Sustainable School" initiative and the Sustainable Campus initiative. The goal is to raise environmental awareness among students and encourage actions to reduce the environmental footprint in the country (Community Engagement in Environmental Protection: An Emirati Approach for a More Sustainable Future, 2024).

#### **4. Improving the Efficiency of Available Resources to Develop Clean Energy Infrastructure**

Climate change indicators such as greenhouse gas concentrations, sea level rise, ocean temperatures, and ocean acidification reached new record highs in 2021. The key to addressing this crisis is to end our reliance on energy generated from fossil fuels, as they are the primary cause of climate change. Therefore, the following must be pursued:

##### **4.1 Making renewable energy technology a global public good**

For renewable energy technology to become a global public good—meaning available to everyone, not just the wealthy—it will be necessary to remove barriers that hinder knowledge sharing and technology transfer, including intellectual property restrictions. Core technologies such as battery storage systems allow energy from renewable sources like solar and wind power to be stored and released when individuals, communities, and businesses need it. They help increase the resilience of the energy system due to their unique ability to absorb electricity, retain it, and release it quickly, according to the International Renewable Energy Agency. Furthermore, when paired with renewable generators, battery energy storage technologies can provide reliable and cheaper electricity in isolated grids and off-grid communities in remote areas.

##### **4.2 Improving access to components and raw materials worldwide**

Securing supplies of components as well as raw materials necessary for renewable energy technologies is essential, as is expanding the supply of these vital components and critical raw materials—from the metals needed to produce wind turbines and power grids to electric vehicles. This will require significant international coordination to expand and diversify manufacturing capacity globally. Furthermore, greater investments are needed to ensure a just transition, particularly in skills training, research and innovation, and providing incentives to build supply chains through sustainable practices that protect ecosystems and cultures .

##### **4.3 Achieving equal opportunities regarding renewable energy sources**

There must be existing policies to reduce market risks and stimulate investment in the sector—including by streamlining planning, approvals, regulations, and removing bottlenecks. This may include allocating space to establish these projects on a large scale in dedicated renewable energy zones. Nationally determined contributions should set individual countries' climate action plans to reduce emissions and adapt to climate impacts with renewable energy targets aligned with 1.5 degrees Celsius. The share of renewable energy in global electricity generation should be raised from 29 percent today to 60 percent by 2030. Clear and strong policies, transparent processes, public support, and the availability of modern energy transmission systems are key to accelerating the adoption of wind and solar energy technologies.

##### **4.4 Shifting support from fossil fuels to renewable energy**

Fossil fuel subsidies are one of the biggest financial obstacles hindering the world's transition to renewable energy. Fossil fuel subsidies are inefficient and unfair. In developing countries, shifting support from fossil fuels to renewable energy not only reduces emissions but also contributes to

sustainable economic growth, job creation, improved public health, and greater equity, especially for poor and vulnerable communities worldwide .

#### **4.5 Tripling investments in renewable energy**

At least \$4 trillion must be invested annually in renewable energy until 2030, particularly in technology and infrastructure, to reach net-zero emissions by 2050 (United Nations, 2024) .

### **5. Conclusion:**

Accelerating the transition to clean energy requires a comprehensive approach that includes supportive policies, investment in technology, and enhanced international cooperation. To ensure long-term sustainability, a balance must be achieved between economic growth, environmental protection, and social justice. Through integrated global commitment, sustainable development goals can be achieved, ensuring a brighter future. Key findings of this research include :

- The importance of legislation and policies in stimulating investment and ensuring project continuity .
- The role of technological innovation in reducing costs and increasing energy efficiency .
- The importance of education and awareness in changing societal behaviors toward adopting clean energy.

### **Recommendations**

- Launch continuous awareness campaigns about the benefits of clean energy.
- Include topics of sustainability and renewable energy in educational curricula.
- Organize workshops and training courses to spread environmental knowledge and skills.
- Establish investment funds to support environmental projects.
- Support startups and technology incubators and enhance cooperation between universities and companies in innovation projects.

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