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Highlight

- Comprehensive study on renewable and new sources of energies to produce electricity power
- Advantages and disadvantages of new sources of energies are discussed
- Challenges of using and producing of renewable sources are discussed

Graphical Abstract

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A Survey on Renewable and New Sources of Energies for Electricity Power Production and Its Challenges

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ABSTRACT

Common sources of electricity production, such as fossil fuels, create a large amount of pollution; furthermore, these sources will run out in the future. Therefore, the use of new sources and renewable energies are very vital for electricity production. This paper provides a comprehensive study to explore and analyze new and renewable electrical energy sources for the production of electricity. The study assesses the awareness, perceptions, and preferences of individuals regarding innovative technologies and sources that have the potential to reshape the landscape of electrical power generation. In this research, various types of novel and renewable sources for electricity production are explained and the challenges, advantages, and disadvantages of each of these methods are discussed.

1. Introduction

Using new and renewable sources of energy instead of traditional fossil fuels is increasing every year in the world. In this paper, different types of these renewable sources of energy are discussed. Furthermore, some challenges and the solution to each challenge are explained.

The investigation of renewable energy sources for generating electricity is on the rise as a viable and environmentally friendly substitute for conventional fossil fuels. Wind power, solar system, and geothermal heat are examples of such sources, offering the benefit of emitting minimal CO_2 into the air [1]. The use of renewable energy can help address the energy crisis and reduce traditional sources like oil, gas, and coal [2]. It also has a great effect on air pollution and many problems of using traditional fuels. The impact of renewable energy on carbon emissions and sustainability is complex. Factors such as per capita GDP, urbanization, and the percentage of total renewable energy reliance can influence the carbon intensity of electricity production [3]. Policymakers need to consider the time frame required for new energy policies to have a full impact on carbon emissions from electricity generation [4].

The diversity of renewable energy sources and individual country-level approaches in the world highlights the ongoing energy transition and the importance of supportive measures.

Renewable energy sources are being increasingly explored for electricity production as a sustainable solution to address the challenges of climate change and energy security. The depletion of conventional energy sources and the need for clean energy have led researchers to focus on alternative energy sources such as wind, solar, hydropower, and biomass. These sources offer advantages such as low-cost, high-energy efficiency, and fewer polluting gases [5,6]. Some studies have shown that renewable energy can contribute to reducing carbon emissions and achieving sustainable development [7].

However, the implementation of renewable energy projects still faces challenges such as logistics, conversion technologies, financing, regulation, and social acceptance. These challenges decrease the speed of development of new sources of energy especially in poor and advancing countries. The challenges are different in each area. The first challenge is logistics. Developing renewable energy projects often requires extensive logistical planning, especially for large-scale installations such as wind farms or solar parks [8]. This includes transportation of equipment, materials, and personnel to remote or difficult-to-access locations. The second problem is conversion technologies. While renewable energy sources like sunlight and wind are abundant, the technologies used to convert these sources into usable electricity are still evolving. Improvements in efficiency, reliability, and cost-effectiveness of conversion technologies are needed to make renewable energy more competitive with fossil fuels. Another challenge of renewable energy sources is related to financing issues [9]. The upfront costs of renewable energy projects can be significant, and securing financing can be challenging, particularly for smaller-scale projects or in regions with limited access to capital. Financial incentives, subsidies, and innovative financing mechanisms are often necessary to attract investment in renewable energy. Another problem of expanding renewable energy sources is called regulation: Regulatory frameworks play a crucial role in shaping the development and deployment of renewable energy projects. In some cases, outdated regulations or bureaucratic hurdles can impede progress, while in others, supportive policies such as feed-in tariffs or renewable energy mandates can drive investment and innovation [10]. Finally, each new technology such as new source of energy must be accepted by society and each nation.

In this paper, different new sources of energy are discussed. The challenges and the solutions to each challenge of these renewable sources of energy will be explained technically in another part of the paper. Addressing these challenges requires a multi-faceted approach involving collaboration between governments, industry stakeholders, financial institutions, and research institutions. By overcoming these obstacles, we can accelerate the transition to a more sustainable and environmentally friendly energy system powered by renewable sources.

Renewable sources of energy are progressing in the world every year. The European Union (EU) has set targets to increase the share of electricity from low-carbon sources, leading to significant changes in electricity production in EU countries [11]. Countries like India, the United States, China, and Germany have made significant progress in utilizing renewable energy for electricity generation, primarily from agricultural and forestry waste. Overall, the exploration of renewable energy sources for electricity production is crucial for achieving a sustainable and environmentally friendly energy system. The next parts of this paper provide an overview of the current state of electrical energy production, highlighting the challenges associated with traditional sources and the need for exploring new alternatives. There are various types of new electrical energy sources that researchers are exploring to meet the increasing demand for sustainable and cleaner energy.

This paper is organized as follows: in section two, some traditional power energy sources are explained. Section three is the main part of the paper that presents renewable sources of energy. In section four the challenges of new sources of energy and the solution of each are discussed. Renewable energy sources in Iran are explained briefly in section five. Finally, the conclusion is reported in the last section.

2. Traditional energy sources

Crude oil, natural gas, and coal are some of the most popular and traditional sources to produce electrical power. Coal is the cheapest option for electricity production, while natural gas is more expensive but more efficient. However, almost it does not specifically mention crude oil as a popular source of power generation [12]. The main challenge of these sources of energy is related to air pollution. The air pollution caused by energy generation, including the burning of fossil fuels like crude oil, natural gas, and coal is a big problem in large cities. The pollutants have become a leading environmental hazard and cause many different illnesses [13]. Therefore, using new sources of energy and renewable sources of energy plays a great role in modern countries and it is one of priority of each advanced area.

3. New sources of electrical energy

3.1. Solar power

Advancements in solar cell technologies, such as perovskite solar cells, tandem solar cells, and flexible solar panels, have shown promise in improving efficiency and lowering costs. Tandem solar cells, which combine different types of sub-cells, have achieved high power conversion efficiencies, with recent studies reporting efficiencies of up to 32.5% [14]. Perovskite-based tandem solar cells have also demonstrated high efficiency, with one study achieving an efficiency of 29.8% [15]. Additionally, perovskite-based solar cells offer higher conversion efficiency at lower costs compared to standard market options [16]. Flexible solar panels, such as those based on perovskite materials, provide a lightweight and sustainable solution for photo voltaic [17]. These advancements in solar cell technologies have the potential to significantly improve the efficiency and cost-effectiveness of solar energy generation.

3.2. Wind power

Wind power is a form of renewable energy that has the potential to contribute significantly to the global energy mix. The uncertainty associated with wind power generation poses challenges for its effective utilization. Various methods have been developed to address this issue, including the use of generative models to accurately describe the uncertainty of wind power output [18]. Additionally, advancements in wind turbine technology, such as shrouded wind turbines, have been made to improve the efficiency of wind power generation [19]. Furthermore, innovative power generation mechanisms, such as those utilizing planetary gear sets, have been proposed to enhance the conversion rate of wind energy into electric energy [20]. Forecasting methods have also been developed to optimize the management of wind power systems, with a focus on short-term forecasting to evaluate production possibilities [21]. Overall, these advancements and forecasting methods contribute to the efficient control and utilization of wind energy resources. To better provide this new source of electricity power it is necessary to increase turbine efficiency, advancements in offshore wind technology, and research on vertical-axis wind turbines are notable developments. Onshore wind turbines refer to placing them on land to harness wind energy. Furthermore, installed in bodies of water, typically in the ocean, they capture strong and consistent winds.

3.3. Hydropower

This type of energy is based on the energy potential of water. Focus on innovative turbine designs, such as fish-friendly turbines, and advancements in small-scale hydropower systems. Hydropower is one of the oldest power generation technologies and remains responsible for most of the renewable electricity generation globally. It has advantages such as providing sustainable energy and increasing production flexibility. However, its development has been accompanied by environmental and social challenges. Sustainable hydropower projects are possible with good planning and careful system design. The impact of power generation on existing hydropower varies from region to region, but globally it is expected to be small or slightly positive. Hydropower can contribute to a reduction in system electricity price and price volatility, especially at higher percentiles. It also has the potential to increase energy storage and play a significant role in mitigating power generation and changing water availability. However, it is important to address the environmental and social costs associated with hydropower [22].

Hydropower can be divided into some groups. Traditional hydropower utilizes the energy of flowing or falling water to generate electricity. Another form of this energy is based on tidal and wave energy that captures energy from the motion of tides or waves in oceans and seas[23].

The majority of hydropower dams in North America and Europe were constructed before 1975. However, in recent years, the focus of new dam construction has shifted towards Asia and South America. This trend has been particularly prominent over the last two decades. According to the World Resources Institute (WRI) database, out of the 7,155 hydropower dams listed, approximately 6,200 were built before 2001. Among these, around two-thirds are situated in North America (2,063) and Europe (1,922) [24].

Some researchers published a paper that is related to the potential impact of hydropower on local communities. This study presents a comprehensive assessment of the global effects of dam construction, utilizing various global spatial databases. Specifically, it offers valuable insights into the repercussions on the economy, population, and environmental quality resulting from the establishment of around 600 newly constructed hydropower dams, categorized by region and size. The findings reveal a significant decline in the local economy, population, and greenery within a 50-kilometer radius of the dam sites, particularly in regions belonging to the Global South. These outcomes contradict the notion that dams enhance the well-being of individuals and ecosystem services. Consequently, this research underscores the necessity for policy interventions aimed at mitigating the impacts on populations and urban areas adjacent to small and medium-sized dams [25].

Hydropower dams play a crucial role in both the economy and population, despite covering a small portion of the total land area. This outcome is not entirely unexpected, given that humans have historically settled in areas with convenient access to water sources. Fang and Jawitz [26] conducted a study on the distance of human populations to water sources in the United States between 1790 and 2010, highlighting the increasing importance of water in determining settlement patterns after industrialization. Additionally, Kummu et al. [27] demonstrated that over half of the global population resides within a 3-km radius of a freshwater body, while only 10% live beyond a 10-km distance. It is worth noting the regional disparities, with North America and Europe leading in both economic output and population density in near of across nearly all dams, and South America significantly surpassing other regions in terms of economy and population in a circular boundary within 50 km of a dam for recently constructed dams.

3.4. Geothermal power

Geothermal energy is a reliable and sustainable source of renewable energy that has the potential to contribute significantly to the generation of electricity. It offers advantages such as low-carbon emissions, constant availability, and a lower cost of electricity. Geothermal reservoirs can serve as the base load demand for local grid systems, reducing dependence on fossil fuels [27]. Using enhanced geothermal systems (EGS) and the utilization of low-temperature geothermal resources for direct-use applications is one of the preparations for this source of energy. Another way of employing this source is related to geothermal heat pumps. They use the earth's consistent temperature beneath the surface to heat and cool buildings. The last technology is geothermal power plants that extract heat from the earth's interior to generate electricity.

3.5. Nuclear power

Nuclear power is considered a potential source of electricity generation, but it comes with various considerations and challenges. It has been used to meet power needs in many countries, but there are legal implications, high initial capital investment, and environmental consequences associated with its use. Nuclear energy is often seen as a backup alternative to renewable energy sources to reduce $CO2$ emissions and maintain energy stability [28]. However, the main problem with nuclear energy lies in the management of nuclear waste [29]. Additionally, implementing a nuclear power plant (NPP) in countries with small economies and electricity grids can be challenging due to financial constraints and the need for grid modifications. Despite these challenges, research has been conducted on developing new types of nuclear batteries that can serve as low-power sources. Overall, nuclear power has its advantages and disadvantages, and its suitability as a new source of electricity power depends on various factors and considerations.

For the better advance of this type of energy, some preparations can be made. Exploration of advanced reactor designs, including small modular reactors (SMRs) and Generation IV reactors, aiming for improved safety and efficiency. Furthermore, using advanced nuclear reactors that Include designs with enhanced safety features, increased efficiency, and reduced nuclear waste. Sometimes this type of power is referred to as fusion power [29]. Advanced reactor designs encompass a range of innovative approaches to nuclear energy production, addressing safety, efficiency, and sustainability concerns [30,31].

These designs include Generation IV reactors, small modular reactors, accident-tolerant fuels, and new research reactor concepts. Advanced modeling and simulation techniques play a crucial role in optimizing these designs, enabling the incorporation of more physics, higher fidelity models, and diverse computing hardware. The development of new reactor types like fast-neutron reactors, high-temperature gas-cooled reactors, molten salt reactors, and small modular reactors is reshaping the nuclear industry [32]. Additionally, the consideration of safeguards and security early in the design process is a key principle guiding the deployment of new and advanced reactors. As the industry transitions towards automation, remote operation, and fewer operators, human factors in reactor design are becoming increasingly important for the successful deployment and operation of these advanced systems.

Small Modular Reactors (SMRs) are gaining global attention due to their innovative design features and potential benefits. SMRs offer advantages such as modularity, passive safety systems, and suitability for cogeneration, making them competitive with large reactors (LRs) despite higher specific capital costs. SMRs are seen as a solution for limited grid capacities in developing countries and can address energy needs efficiently due to shorter build times and design simplification [33].

However, challenges like understanding nuclear fuel behavior, waste management, and ensuring safety through probabilistic risk assessment and nuclear safeguards need to be addressed for the successful deployment of SMRs [34]. Additionally, considering SMRs as sociotechnical systems is crucial to understanding their potential societal impacts and role in reshaping energy production and markets. Overall, SMRs represent a promising technology with the potential to enhance resilience and security in power supply system's [35].

Generation IV reactors represent a new generation of nuclear reactor designs with enhanced safety, sustainability, and efficiency features [36]. These reactors aim to address various energy needs, from electricity generation to process heat and waste minimization. The six main types of Generation IV reactors include Gas-Cooled Fast Reactors (GFR), Lead-Cooled Fast Reactors (LFR), Molten Salt Reactors (MSR), Sodium-Cooled Fast Reactors (SFR), Supercritical-Water-Cooled Reactors (SCWR), and Very-High-Temperature Reactors (VHTR). Research and development efforts are focused on advancing these reactor systems to be sustainable, safe, reliable, economically competitive, and proliferation-resistant. Power-cycle alternatives for Generation IV reactors, such as VHTRs and GFRs, are being explored to maximize their efficiency and performance [37,38].

Nuclear power can be divided into fission and fusion. Nuclear fission is a reaction in which the nucleus of an atom splits into two or more smaller nuclei. The fission process often produces gamma photons and releases a very large amount of energy even by the energetic standards of radioactive decay. Fusion power or nuclear fusion is a process such as the sun's process that combines hydrogen atoms to release energy, offering a potentially limitless and clean energy source.

Fusion could generate four times more energy per kilogram of fuel than fission (used in nuclear power plants) and nearly four million times more energy than burning oil or coal. Fusion offers a potential long-term energy source that uses abundant fuel supplies and does not produce greenhouse gases or long-lived radioactive waste [39]. Fusion energy offers the potential for an inexhaustible source of energy that does not deplete natural resources or produce greenhouse gases. The EU-DEMO project aims to be the first demonstrative power plant based on nuclear fusion, with a focus on the feasibility and realization of the power electrical systems [40].

3.6. Biomass

Biomass is a significant source of renewable energy for electricity production. Advances in bioenergy technologies include the development of more efficient biofuel production methods and the utilization of waste materials for energy production. Bioenergy means converting organic materials such as wood, crop residues, and waste into electricity or heat. Furthermore, biogas refers to captures methane from organic waste for electricity generation. It includes various organic materials such as agricultural residues, forest residues, and municipal wastes [41].

Biomass can be converted into useful forms of energy through processes like Torre faction, pyrolysis, and gasification. These processes can produce charcoal, petroleum oil, natural gas, and liquid and gaseous biofuels from biomass.

The energy potential of biomass residues is substantial, with the ability to generate renewable electrical energy for small-scale electricity generation. Biomass power plants offer economic and environmental benefits, providing an eco-friendly alternative to fossil fuels [42]. The use of biomass for electricity production can reduce dependency on non-renewable energy sources and contribute to a better environment

Producing biomass creates a lot of air pollution that can impact human health. China and Brazil are two important countries that generate electricity from biomass. However, they have distinct patterns of fuel sources. China relies heavily on biomass residues from agriculture and waste-to-energy facilities that burn refuse. Figure 1 indicates some countries with the highest biomass energy production in 2022.

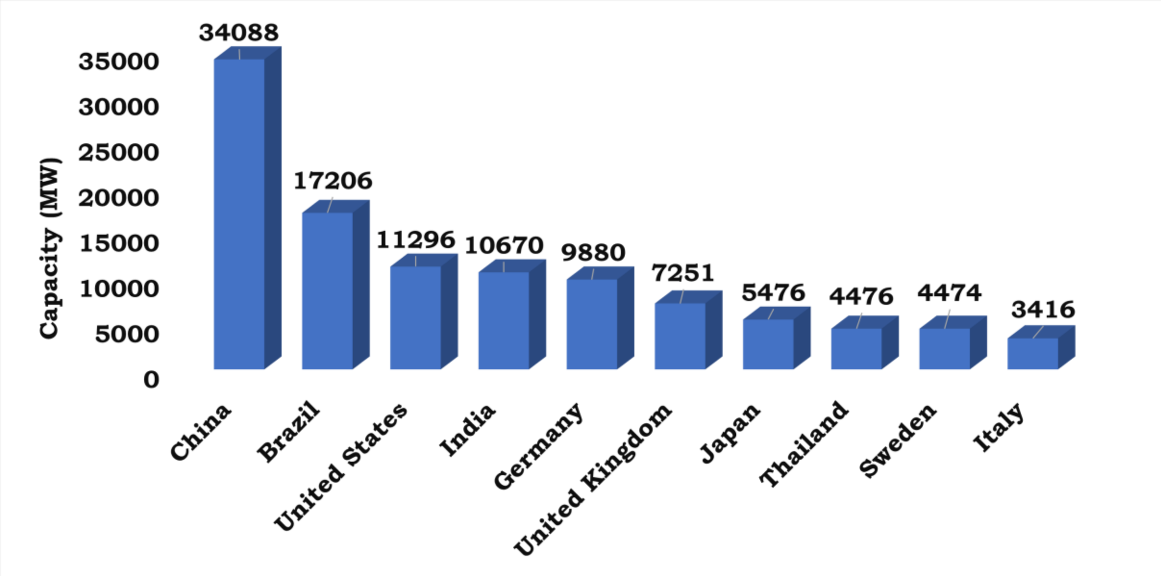

Figure 1. Countries with the highest bioenergy capacity in 2022.

3.7. Electrochemical cells

They are used to produce electricity by combining hydrogen and oxygen, with water as the byproduct. This process is a form of renewable energy for generating electricity. Water electrolysis is a technique that can be used to produce hydrogen without emitting any pollutants, and the hydrogen can then be used to generate electricity using a fuel cell [43]. Renewable sources of energy like solar and wind can be used to generate surplus electricity, which can then be used to produce hydrogen through water electrolysis. Hydrogen can be stored and used as fuel for generating electricity during times when renewable resources are not available or are less available [44]. This approach is part of the push to reduce carbon dioxide emissions and develop low-cost fuels from renewable sources to replace fossil fuels [45].

3.8. Flywheel energy storage

Flywheel energy storage systems use a spinning rotor to store and release energy. The rotor is a fast-rotating mass that stores energy in the form of mechanical energy [46]. These systems have various applications, including smoothing uneven torque in engines and machinery. More recently, flywheels have been developed to store electrical energy, enabled by directly mounted brushless electrical machines and power conversion electronics [47]. Flywheel energy storage systems have advantages such as high charge power, longer lifecycle, the ability to feed power back into the grid, and easy transportability [48]. They are also compared to other energy storage technologies, such as lithium-ion batteries, and are found to have great potential for rapid response, short duration, and high cycle applications. However, cost reduction is necessary for wider adoption, which can be achieved through the use of low-cost.

3.9. Battery storage

To save more energy in battery it is necessary to advance in battery technology for efficient energy storage and release. Also progress in battery technologies, including lithium-ion batteries, solid-state batteries, and flow batteries. For saving a lot of energy they must use grid-scale energy storage solutions.

Battery energy storage systems (BESSs) are being used to store and release energy from renewable power sources such as wind and solar. These systems help to address the intermittent nature of renewables and ensure a steady and stable supply of electricity. BESSs can handle unexpected problems with renewable energy sources and play a crucial role in power generation by assisting other energy sources in meeting load requirements [49]. They can also reduce the negative effects of network congestion on the power system and decrease operational costs [50]. By integrating BESSs with renewable generation units, power fluctuations can be smoothed out, improving the stability, reliability, and power quality of power grids. Optimizing the planning and operation of BESSs is important to control their output power and improve profitability considering technical and lifetime constraints [51].

3.10. Smart grids

Smart grids enable the efficient integration of variable renewable energy sources into the power grid. It adjusts electricity usage in response to changes in supply and demand. Some papers such as [52] discuss the integration of renewable energy sources, such as wind and solar, into smart grids using wireless power transfer technology. Smart grid technology is crucial for the effective utilization of distributed energy resources and can help address the challenges of integrating renewable energy into the grid. Technologies such as dynamic compensation and dynamic line rating can improve grid management in areas with a high concentration of renewable energy sources [53].

Denizli in Turkey serves as a successful example of smart grid implementation, where an IoT-enabled smart grid application effectively utilizes electric vehicles as mobile storage to maintain energy consistency [54]. This particular case study demonstrated uptimes exceeding 100%, underscoring the significant potential of such innovative applications. Overcoming challenges related to integrating renewable energy sources, such as the variability and intermittency of solar and wind generation, requires comprehensive planning and evaluation studies to determine viable integration capacities [55]. Furthermore, the study underscores the significance of interdisciplinary research in smart grid technologies, emphasizing the necessity for heightened awareness and collaboration across diverse fields to expedite adoption and establish a sustainable and efficient energy landscape [56].

Another example of using the smart grid for renewable energy is Copenhagen, Denmark. It serves as an exemplary case study for successful smart grid implementation, aligning with sustainable energy goals. By integrating renewable sources like wind and solar power into its smart grid [57], Copenhagen has significantly reduced its carbon footprint and reliance on fossil fuels. The smart grid technology enables efficient electricity management and distribution, optimizing renewable energy utilization. Additionally, the city's smart grid system showcases benefits like improved energy efficiency, enhanced reliability, and effective integration of distributed energy resources [58]. This holistic approach not only ensures a cleaner and more sustainable energy supply but also demonstrates the potential of smart grids in achieving environmental goals and enhancing overall energy sustainability.

The integration of renewable energy sources indeed comes with challenges that impact power grids. Challenges include the intermittency, variability, and uncertainty of solar and wind generation affecting operational economics [59]. As renewable energy sources replace conventional synchronous generators, grid strength decreases, posing stability challenges during integration. Converter-based sources, like wind and solar photovoltaic, are asynchronously connected to the grid, lacking ancillary services and affecting inertia and system strength, necessitating practical methodologies for evaluation [60]. To combat these challenges, planning, and evaluation studies are crucial to identify feasible integration capacities, analyze power system flexibility, and ensure stability through proper design considerations[61]. Countermeasures, such as battery energy storage systems, are utilized to cope with the variability and uncertainties of renewable energy sources albeit presenting technical challenges.

3.11. Piezoelectric and thermoelectric technologies

Piezoelectricity is a phenomenon where certain materials generate an electric charge in response to applied mechanical stress. This property is harnessed in various applications. Thermoelectric technology was mainly used to mitigate urban heat island effects and pavement rutting; piezoelectric technology can power low-power electronics such as wireless remote sensors for pavement disease and traffic condition monitoring; solar pavement has multiple functions based on its large power density. Future studies should focus on the durability, safety, and life cycle cost of energy generation technologies through a systemic approach [62].

3.12. Ocean thermal energy conversion (OTEC)

Ocean Thermal Energy Conversion (OTEC) refers to a process that uses temperature differences between warm surface water and cold deep water to generate power. Its plants pump large quantities of the deep cold sea or ocean water and warm surface them to run a power cycle and produce electricity. It is a new and clean energy source, environmentally sustainable, and capable of providing massive levels of energy. This new source of energy was first used in the 1880s and the first working power plant was built in Cuba. After that additional demonstration units were built periodically since 1930 [63]. In the case of OTEC, the need for a big temperature difference is balanced by the essentially infinite reservoirs of ocean water that can act as free fuel, so the low efficiency due to an average temperature difference of only 20°C is not as important. The Caribbean Islands are in the best location to be the test bed for scaling up OTEC. This technology can help support the system integration of high penetrations of variable renewable energy sources such as wind and solar [64].

This type of renewable energy has never become a mass-market technology to produce large amounts of electricity, because of the geographical limitations. However, there are countries in the Caribbean and elsewhere in the world that use this new source of energy to produce electricity power.

3.13. Kinetic energy harvesting

Kenotic energy harvesting refers to capturing energy from motion, such as vibrations or footsteps. It is the process of capturing and converting the energy generated by motion into usable electrical power. It involves the use of various mechanisms such as piezoelectric, electromagnetic, and electrostatic transduction to extract electrical power from vibrating or moving systems. Adaptive kinetic energy harvesting is a recent development that aims to increase the operating frequency range of kinetic energy harvesters by tuning the resonant frequency of the generator and widening its bandwidth [65]. Different devices and systems have been proposed for kinetic energy harvesting, including tubular-shaped magnet housings with wire coils and central magnets [66], rotating shells with fixing shafts and driving assemblies, and portable devices with magnets and movable wire coils [67]. These systems can generate alternating current, which can be converted into direct current using rectifiers and used to charge batteries or power portable electronic devices [68]. Additionally, advancements have been made in wearable kinetic energy harvesting, where energy is harvested from human motion to power autonomous wearable devices.

3.14. Other emerging technologies

The most traditional and new sources of electricity power have been mentioned before. However, some other types of new sources can be used for this purpose. RFID Energy Harvesting is one of them. It is a technology that extracts energy from radio frequency signals. This energy can be recycled and used to power low-energy devices in various applications. Despite all previous methods, this energy can be used in low scale consumption. Therefore, it cannot be mentioned as a new source of electricity sources. However, in this part of the paper, it is mentioned to complete the research of this paper [69].

Another type of new emerging technology is the Vertical Axis Wind Turbine (VAWT). It is an alternative design to the traditional horizontal axis of wind turbines. VAWTs have been proposed for use in generating electricity on highways, where the rapid movement of vehicles can drive the turbines and produce power for street lighting and toll plazas [70]. Although VAWTs have lower efficiency compared to Horizontal Axis Wind Turbines (HAWTs), they have the potential to play a significant role in future power production [71]. Small Scale Wind Turbine (SSWT) is another type of wind turbine. It is designed for decentralized energy generation. Small-scale wind turbines (SSWT) are designed to generate power in low wind speed regions. They face challenges such as low power coefficient and start-up difficulty. SSWTs can achieve a power coefficient of 43% at a wind speed of 3 m/s, but a wind speed of 5 m/s is needed to produce 600 W of power for household consumption [72]. Advanced solar technologies, such as emerging photo voltaic (EPVs) and ultrathin organic solar cells, offer flexible, lightweight, and conformable properties [73]. Life cycle assessments (LCAs) are necessary to evaluate the environmental sustainability of these technologies, considering the entire product life cycle. EPVs have the potential to penetrate various application areas, including portable devices, building-integrated power generation, and the transport industry [74].

Chalcopyrite and kieserite thin film solar cells have shown advancements in composition grading, surface passivation, and buffer enhancements. To increase the adoption of solar power, high-efficiency solar cells, and low-cost energy storage technologies are crucial. Multiple junction solar cells have demonstrated high efficiencies, with the theoretical potential to reach more than 70%. Overall, advanced solar technologies hold promise for achieving sustainable and efficient solar power generation [75].
Another type of new source of electric power is named as Concentrator Photo Voltaic (CPV). It uses lenses or mirrors to focus sunlight onto small, high-efficiency solar cells. Photovoltaic solar-energy conversion is one of the most promising technologies for generating renewable energy, and the conversion of concentrated sunlight can lead to reduced cost of solar electricity. Photovoltaic conversion of concentrated sunlight ensures an efficient and cost-effective sustainable power resource [76].

4. Challenges of renewable energy sources

The transition to new sources of renewable energy presents several challenges. Many renewable energy sources, such as solar and wind, are intermittent and variable in nature, meaning they depend on factors like weather conditions and time of day. Integrating large amounts of renewable energy into existing electricity grids can strain grid infrastructure and present technical challenges such as voltage and frequency regulation, grid stability, and grid congestion. Developing cost-effective and scalable energy storage technologies is crucial for enabling the reliable and efficient integration of renewable energy into the grid. Challenges include improving the energy density, cycle life, and cost-effectiveness of battery storage systems, as well as exploring alternative storage technologies such as pumped hydro, compressed air energy storage, and thermal energy storage [77].
Deploying large-scale renewable energy infrastructure, such as solar farms and wind turbines, requires significant land and resource utilization. Balancing the need for renewable energy deployment with land use considerations, environmental impacts, and competing land-use interests (e.g., agriculture, conservation) is a complex challenge. Inconsistent or inadequate policy and regulatory frameworks can hinder the deployment of renewable energy projects and investment in clean energy technologies. Establishing supportive policies, such as renewable energy targets, incentives for renewable energy deployment, and carbon pricing mechanisms, is essential for fostering a conducive environment for renewable energy development [78].
While the cost of renewable energy technologies has declined significantly in recent years, they may still face challenges competing with conventional fossil fuels in some regions, particularly where fossil fuel subsidies exist or where renewable energy resources are less abundant. Continued cost reduction through technological innovation, economies of scale, and supportive policies is necessary to enhance the cost competitiveness of renewable energy [79].
Infrastructure and Supply Chain are other challenges. Scaling up renewable energy deployment requires significant investments in infrastructure and supply chain development, including manufacturing facilities, transportation networks, and workforce

training. Building the necessary infrastructure and ensuring a resilient and diversified supply chain is critical for the sustainable growth of the renewable energy industry.

The most important problem is social acceptance and stakeholder engagement. Renewable energy projects can face opposition from local communities, environmental groups, and other stakeholders due to concerns related to visual impact, noise pollution, land use conflicts, and perceived health effects. Engaging with stakeholders, addressing community concerns, and ensuring transparency and participatory decision-making processes are important for fostering social acceptance and support for renewable energy projects [79]. Addressing these challenges requires a holistic and integrated approach involving policymakers, industry stakeholders, researchers, and communities. Collaboration, innovation, and sustained commitment to the transition to renewable energy are essential for achieving a sustainable and resilient energy future. Table 1 illustrates the challenges of each new method to produce electrical power. Table 1 indicates the challenges of each type of renewable energy source. However, the challenges can be reviewed independent of the type of energy source. In other words, all types of renewable energy sources have some main challenges that can be considered. Table 2 shows these main challenges and their solution [80-83].

Table 1. Challenges of using some renewable and new sources of energy.

Method	Challenges
Solar Power	Issues related to intermittent energy production and the need for effective energy storage solutions. Integration with the existing power grid also poses challenges. Energy reduction in winter and cloudy and rainy days
Wind Power	Concerns related to the impact on avian wildlife, intermittency, and the need for efficient energy storage solutions to handle variable wind conditions. Instability of energy production due to wind changes
Hydropower	Environmental concerns regarding river ecosystems, sedimentation, and the impact on fish migration patterns
Geothermal Power	Site-specific limitations and the need for improved drilling technologies to access deeper and hotter geothermal reservoirs
Nuclear Power	Public perception issues, concerns about nuclear accidents, and the management of nuclear waste remain significant challenges.
Biomass	Competition with food crops for land, concerns about deforestation, and the need for sustainable feedstock sources
Energy Storage	Cost, energy density, and environmental impacts of battery production and disposal
Piezoelectric	Finding suitable piezoelectric materials, sensitive to temperature, fatigue, and degradation over time, cost.
Thermoelectric generators	high temperatures, Thermal Stability and Reliability, durability and robustness of thermoelectric materials, integration into the traditional system
Smart Grids	Grid stability, cyber security concerns, and the need for updated infrastructure to accommodate decentralized energy sources.
Battery Storage	Cost, Batteries degrade over time, Safety concerns, Charging Time, Environmental Impact
Flywheel Energy Storage	lower energy density, mechanical stress, providing a vacuum or near-vacuum environment for Friction, Safety, Temperature, Cost
Ocean Thermal Energy Conversion	Technological Complexity, High Capital Costs, Environmental challenges, Transmission and Distribution, small scales
Kinetic Energy Harvesting	Low Power Density, Durability and Reliability, Environmental Impact, Variable and Unpredictable Sources

Table 2. Essential challenges and their solutions for using a renewable energy source.

Challenges	Comment	Solutions
Uncertainty [83]	Renewable energy sources such as solar and wind are intermittent, meaning their output fluctuates based on weather conditions. This poses challenges for maintaining a reliable energy supply.	**Energy Storage**: Developing cost-effective energy storage solutions such as batteries, pumped hydro storage, and thermal storage can store excess energy during periods of high production for use during low production periods. **Smart Grids**: Implementing advanced grid technologies to balance supply and demand in real-time, optimizing the use of renewable energy and traditional sources.
Grid Integration [84]	Integrating large amounts of renewable energy into existing grids can strain infrastructure and require significant upgrades.	**Grid Modernization**: Upgrading infrastructure to accommodate bidirectional power flows and decentralized generation from renewable sources. **Microgrids**: Establishing microgrids that can operate independently or connect to the main grid when necessary, enhancing resilience and flexibility.
Location Constraints [85]	The best renewable energy resources are often located in remote areas, far from population centers where energy demand is highest.	**Transmission Infrastructure**: Investing in transmission infrastructure to transport renewable energy from remote areas to urban centers efficiently. **Distributed Generation**: Promoting distributed generation closer to demand centers through rooftop solar, small wind turbines, and community-based renewable energy projects.
Cost and Financing [86]	While the cost of renewable energy has decreased significantly in recent years, upfront costs can still be a barrier to adoption.	**Incentives and Subsidies**: Providing financial incentives, tax credits, and subsidies to make renewable energy investments more attractive. **Power Purchase Agreements (PPAs):** Offering long-term contracts between renewable energy developers and consumers, guaranteeing a stable revenue stream for developers and predictable energy prices for consumers.
Resource Variability [83]	The availability of renewable energy resources varies geographically and seasonally.	**Hybrid Systems**: Combining multiple renewable energy sources (e.g., wind and solar) to mitigate variability and increase reliability. **Weather Forecasting**: Utilizing advanced weather forecasting technologies to anticipate renewable energy generation and optimize energy management.
Policy and Regulatory Challenges [84]	Inconsistent policies and regulations can create uncertainty for renewable energy developers and investors.	**Policy Stability**: Establishing long-term policies and regulatory frameworks that provide certainty and support for renewable energy development. **Carbon Pricing:** Implementing carbon pricing mechanisms to internalize the environmental costs of fossil fuel use and level the playing field for renewable energy.
Environmental Concerns [86]	While renewable energy sources are generally cleaner than fossil fuels, they can still have environmental impacts such as habitat disruption and land use.	**Siting and Planning:** Conducting thorough environmental assessments and engaging stakeholders in the siting and planning of renewable energy projects to minimize negative impacts. **Technological Innovation:** Investing in research and development of low-impact renewable energy technologies and practices.

Using these solutions requires collaboration among governments, businesses, communities, and academia to foster innovation, investment, and deployment of renewable energy technologies.

The challenges of producing and using new sources of energy are more complicated than those that are listed in Table 1. For example, for most of them, it is necessary to provide the necessary conditions and temperature levels. Most renewable energy technologies can supply heat at low and medium temperatures [84]. Among different renewable energies, solar energy has the highest potential to be incorporated into this sector. Nevertheless, using solar energy entails a larger area of land and adequate solar resources to produce the required heat [85].

The concentrated solar energy system can generate heat at a temperature of 550 Celsius at the industrial level. Studies on solar energy have reached temperatures at 1000 Celsius using advanced laboratory facilities [86]. Table 3 indicates the level of temperature for some groups of renewable energy sources [85].

Another challenge of the production of energy from renewable sources is related to complicated technology. Table 3 shows the technology type that is required for each kind of renewable energy source. Most renewable energy technologies currently deliver low- or medium-temperature process heat and are thus only applicable for some process requirements [85]. Concentrated solar power technology is showing promising results but requires larger land availability and sufficient solar resources. Currently, commercial applications of concentrated solar power can achieve process heat temperatures of up to 550 ◦ C.

5. Renewable energy sources in Iran

Renewable energy sources in Iran have been studied extensively in many researches [87,88]. They mentioned that Iran has a potential of 42000 MW for the use of renewable energies by 2020, but the capacity of renewable power stations constructed in Iran is only 800 MW [88].

Different regions of Iran have high wind, solar, and geothermal energy potential that has not been fully utilized to meet electricity needs. The country's energy matrix consists mostly of hydrocarbons, but there is a potential for a larger amount of renewable power, including bioenergy, to be incorporated [88].

The use of renewable energy in power generation in Iran has been prioritized using a multi-criterion decision-making approach, with solar PV identified as the most preferable technology for utility-scale power generation [89]. Overall, while Iran has the potential for significant renewable energy utilization, there is a need for further development and implementation of renewable power generation systems in the country. Table 4 shows the potential value of some types of renewable energy sources in Iran [90].

Table 3. Types of technologies and their temperature levels [85].

Category	Technology type	Temperature levels
Renewable source	Biomass, boiler	Low
	Biomass, high-temperature	Medium
	Biomass, combined-heat-and-power	High
	Biogas, anaerobic digestion	Low
	Solar PV	High
	Wind	High
	Heat pump	Low
	Geothermal direct use	Low
	Deep geothermal	Medium
Energy storage	Solar thermal	N/A
	Hydrogen	N/A
	Pump storage	N/A
	Battery storage	N/A

Table 4. Potential production values of some types of renewable energy sources in Iran [90].

Renewable Energy	Potential (MW)
Hydropower	26000
Solar energy	86198
Wind energy	18000
Biomass and biogas	19
Geothermal energy	187

6. Conclusion and future work

This paper provides a comprehensive study of new sources and renewable types of electricity power. Renewable energy sources, such as wind, solar, hydropower, etc. are crucial for meeting climate change targets, increasing energy security, and reducing reliance on fossil fuels. The development and utilization of these renewable sources have been growing rapidly, with 41.4% of energy generated from renewables in 2022 [91]. However, the intermittent and unpredictable nature of renewable energy poses challenges for the secure and stable operation of the electricity system. Attracting investors, integration into traditional power, and some other reasons such as time of acceptance and adaptation to society are other challenges of new technologies. To address this, new power systems based on renewable energy are being studied which can not only improve environmental sustainability but also save electricity costs and increase energy utilization. The investment in renewable power plants is encouraged due to their minimal running costs and potential economic benefits. The future of renewable energy lies in further advancements in wind power, hydropower, solar photovoltaic, etc. The environmental damages of some of these new energies are very small compared to fossil fuels and they are attractive in this sense.

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Declaration of Competing Interest

The author declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. The ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, have been completely observed by the authors.

Credit Authorship Contribution Statement

Mohammad Hossein Shakoor: Conceptualization, Formal analysis, Project administration, Supervision, Validation, Investigation, Methodology, Resources, Roles/Writing - original draft.

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