Global trends in the development of renewable Energy and its rational use

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ABSTRACT

The depletion of fossil resources has raised interest in the use of renewable energy worldwide. In this paper, we analyze the global trend of rational use of regenerative energy. In this paper, through analysis of global trends in the rational use field of renewable energy, problems to be improved in the rational use of renewable energy were considered.

1. Research on the global trend of renewable energy

Except for combined-cycle gas plants, the LCOEs of all conventional sources and nonintermittent renewables have either remained flat (biomass and coal) or increased (geothermal, hydropower, and nuclear) over the past eight years, while the LCOEs of onshore wind and utility-scale solar PV have, respectively, fallen by 67 percent and 86 percent as the cost of components has plummeted and efficiency has increased—two trends that are projected to continue [1]. According to Bloomberg New Energy Finance, onshore wind and solar PV generation costs have already fallen 18 percent in the first half of 2018.11 In Europe, Japan, and China, competitive auctions are a major factor further bringing down costs by driving subsidy-free deployment at lower prices. Upgrading, or "repowering," wind turbines in the developed world is also pulling global average costs downward by raising capacity factors. In addition, developing world costs could fall as global developers and international organizations team up to facilitate project development.

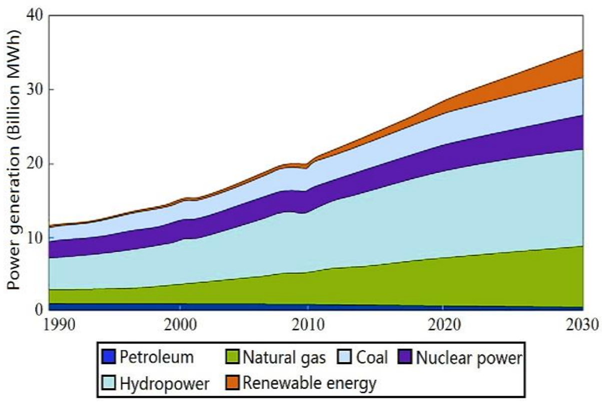

Fig.1. Review and outlook of world energy development（Source： sciencedirect.com）

Such partnerships are helping resolve the resource dissonance created by the fact that Japan, Germany, and the United Kingdom have some of the poorest solar resources but are global solar leaders, while Africa and South America, respectively, have the greatest solar and wind resources, but these remain largely untapped [2]. As wind and solar capacities grow, many conventional sources will start operating at lower capacity factors, causing the LCOEs of both existing and new-build conventional projects to increase. The cost of new solar and wind plants could eventually be not just lower than the cost of new conventional plants, but also lower than the cost of continuing to run existing plants globally. This was already demonstrated by Enel's winning bid last year to build a combination of wind, solar, and geothermal plants in Chile that will sell power for less than the cost of fuels for existing coal and gas plants [3]. Utility-scale solar and wind combined with storage are increasingly competitive, providing grid performance parity in addition to price parity. With the addition of storage, wind and solar become more dispatchable, eroding the long-held advantage of conventional energy sources. While the cost of renewables plus storage is higher, they can provide capacity and ancillary grid services that make them more valuable. Regulatory and market structures determine whether the additional value can be monetized. But even if the services cannot be sold, this combination is more valuable because operators can supply more of their own needs and potentially time shift the use of grid-supplied electricity to off-peak, cheaper hours. Renewables combined with storage are also reaching price parity as lithium-ion battery costs have fallen nearly 80 percent since 2010 and solar penetration has increased [4]. All the top solar markets have utility-scale projects that include storage. In the United States, the storage market frontrunner, solar-plus-storage is already so competitive in some markets that developer Lightsource has announced all its bids in the west will include storage [5].

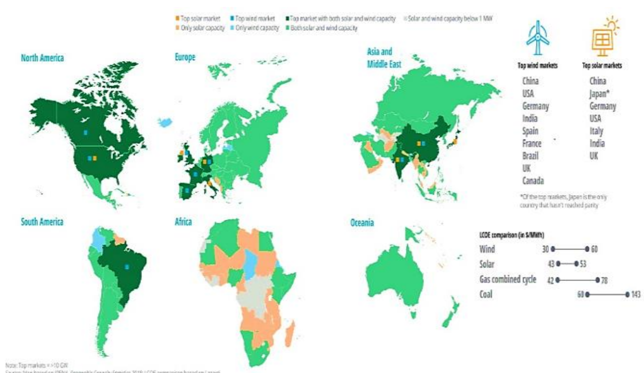

Fig.2.The majority of countries in the world have both wind and solar capacity, and all but one of the top market are at parity（Source：Map based on IRENA, Renewable Capacity Statistic 2018）

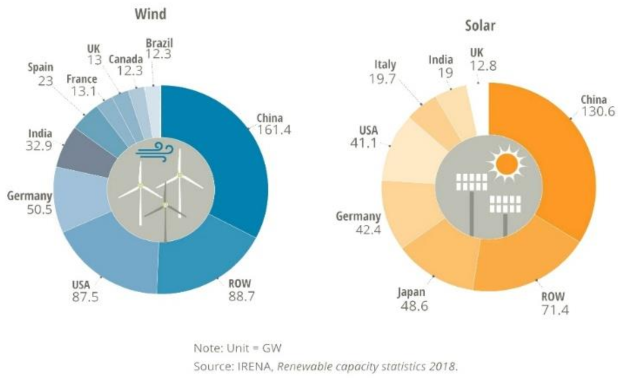

Fig.3. Top onshore wind and solar PV markets（Source：IRENA, Renewable Capacity Statistic 2018）

Factoring in the investment tax credit, the United States will see solar-plus-storage projects at parity beginning next year in Arizona, followed by Nevada and Colorado, which will also feature wind-plus-storage at parity [6]. A recent RMI study shows that renewables plus storage can be combined with distributed resources and demand response to create "clean energy portfolios" that provide the same grid services for less than it costs to build a new gas plant today, and less than it will cost to run an existing one as early as 2026 [7]. Three-quarters of the top 20 US solar and wind states have electricity prices below the US national average; a quarter are among the nation's 10 states with the cheapest electricity, including the wind leader Texas [8]. Wholesale prices in the top European solar and wind market, Germany, have more than halved over the past decade. In Denmark, which has the world's highest share of intermittent renewables (53 percent), electricity prices exclusive of taxes and levies are among the lowest in Europe. Lawrence Berkeley National Laboratory estimates that once the United States reaches Denmark's penetration levels of 40–50 percent renewables, some states will see the dawn of "energy too cheap to meter" [9]. Intermittent renewables are already helping to balance the grid. For example, wind power helped decrease the severity of most of the northern Midcontinent Independent System Operator's steepest three-hour load ramps in 2017 [10]. But conventional generation still provides virtually all essential grid reliability services related to frequency, voltage, and ramping. That may change, though, as smart inverters and advanced controls have enabled wind and solar to provide these services as well or better than other generation sources [11]. When combined with smart inverters, wind and solar can ramp up much faster than conventional plants, help stabilize the grid even after the sun sets and the wind stops, and, for solar PV, show much higher response accuracy (respond faster and with the required amount of power) than any other source [12]. Smart inverters can also turn distributed resources into grid assets with minimal impact on customers and make these resources visible and usable to utilities. The few jurisdictions leveraging these capabilities have mandated them (e.g., Quebec), allowed renewables to sell ancillary services in their markets (e.g., Italy), and/or created new services markets (e.g., the United Kingdom) [13]. Perovskite has been the fastest-developing solar technology since its introduction, making efficiency gains that took silicon over half a century to achieve in less than a decade [14]. In June 2018, a British and German startup demonstrated a record 27.3 percent conversion efficiency on perovskite-on-silicon tandem cells in laboratory settings, beating the laboratory record of standalone silicon cells [15]. Belgian researchers achieved similar efficiency the following month, and both claim that over 30 percent efficiency is within reach [16]. Perovskite has a simpler chemistry, the ability to capture a greater light spectrum, and higher efficiency potential than silicon. Perovskite can also be sprayed onto surfaces and printed in rolls, enabling lower production costs and more applications. Perovskite modules may be commercialized as early as 2019 [17]. On the wind front, additive manufacturing is paving the way for the use of new materials. Two US national laboratories collaborated with the industry to manufacture the first 3D-printed wind-blade mold, significantly reducing prototyping costs and time, from over a year to three months [18]. The next frontier is to 3D print the blades. This would enable use of new combinations of materials and embedded sensors to optimize the blades' cost and performance, as well as onsite manufacturing to eliminate logistical costs and risks. Manufacturers plan to start with on-demand 3D printing of spare parts at wind farms to reduce costs and downtime for repairs [19]. GE is already using additive manufacturing to repair and improve wind turbine blades [20]. Manufacturers are heavily investing in these new technologies because they anticipate growing demand for solar and wind power. As the global leader, China is propelling the ascent of emerging markets in renewable energy growth. China recorded the largest solar and wind growth and total installed capacities in 2017 and is the only market above 100 GW for both sources. China alone accounted for over half of new solar capacity installations as well as two-thirds of global solar PV panel production in 2017. Eight of the top ten solar PV suppliers are Chinese, and the top three Chinese wind company's together account for the largest wind market share [21]. China is also the only country to rank among both the top 10 recipients of emerging market cross-border clean investment and the top 10 investors, and the only emerging market among the latter. From the record cross-border clean investment year of 2015 through the first half of 2017, China invested US$2.23 billion in wind and solar in 11 other emerging markets, and received US$1.34 billion in wind and solar investments from 13 investor countries [22].

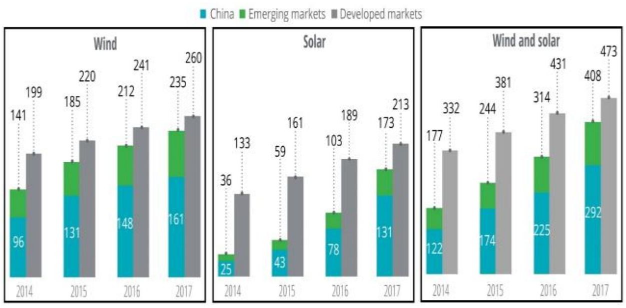

Fig.4. Emerging markets are overtaking developed countries in solar and wind capacity deployment（Source：IRENA, Renewable Capacity Statistic 2018）

As we can see from the literature, as fossil fuel depleted in many countries, the use of renewable energy is the central goal, and it can see that much investment is underway. In particular, it can see from the characteristics of renewable energy that projects to utilize solar and wind energy major actively conducted than other sectors. However, the use of solar and wind energy depends on weather and seasonal conditions. Therefore, research to increase the utilization rate of renewable energy by rational use of solar energy and wind energy has become a global trend. Therefore, in this introduction, we will analyze previous studies conducted in the field of solar energy and wind energy as a part of renewable energy.

2. Background on Rational Use of Wind and Solar Energy

All renewable energy sources on earth, including solar energy and wind power, are precious resources that nature gives us. The world needs more and more to provide power by utilizing renewable energy with the development of science and technology. Several renewable technologies are presently available (a photovoltaic panel or thermal solar, biomass, geothermal, waves, hydropower, and wind). However, among all those technologies and photovoltaic panels and Wind Generator are the most profitable ones, from the economic point of view [23]. Solar and wind energies are the most important renewable energy, and their utilization does not affect the environment, so people are more and more interested in these two energies. The execution of solar and wind energy systems is firmly reliant on climatic conditions in the area. The power generated by a photovoltaic panel system is exceptionally subject to climate conditions [24]. For instance, amid cloudy periods and in the evening, a photovoltaic panel system cannot produce any power. In terms of solar cells, it is necessary to produce electricity by maximizing the efficiency of solar cells while the sun is shining. The solution to this problem is to ensure the cooling conditions to lower the temperature of the solar cell by solar heat, and the solar tracking system must reasonably use so that the solar cell can always receive more solar radiation energy. From these demands, studies to improve the output characteristics of solar cells have intensified around the world. The current output characteristics of solar cells are closely related to the temperature of solar cells [25].

Generally, in the solar cell installed and operated on the surface of the ground. The power generation efficiency decreased as the temperature of the solar cell increases due to the sunlight during its operation. In literature [26-33], studies have conducted to improve the electrical efficiency of solar cells by improving the cooling characteristics of solar cells. In literature [26], the aluminum plate was installed on the back of the solar cell to improve the cooling characteristics of the solar cell, and the superiority of the solar cell cooling system proved through the experimental verification.

The significance of this research was to prevent the decrease of electricity production efficiency due to the increase of the temperature of the solar cell when the solar cell receives the sunlight vertically, and to make the solar cell work at the normal working temperature to produce more power. However, more and more research on just solar cell cooling technology, which costs less and is more advanced than the cooling system described in the literature, is attracting more and more attention. From this, the literature [27] described the research of improving the cooling condition of solar cells using an integrated system combining solar cells and wind generator systems. The wind designed to pass through the rear part of the solar cell to the wind generator so that the heat generated by the solar cell cooled to increase the performance of the solar cell. In this study, the researchers focused primarily on improving the cooling conditions of solar cells. In literature [28], the cooling conditions improved by using air and water with low operating costs as a cooling agent to cool the temperature of the solar cell. Water and air flowed through the thermal device attached to the back of the solar cell lowered the temperature of the solar cell to maintain the electrical efficiency of the solar cell introduced. The literature also shows that the proposed system improves the cooling characteristics of solar cells through experimental studies.

The difference from the research described in the previous literature is that both water and air used as coolants.In literature [29], a hot water heating system was installed on the rear surface of the solar cell to improve the cooling conditions of the solar cell and to ensure the required temperature in the room by heating the hot water with the heat conducted from the solar cell. Recently, Yanping Du et al. [30] investigated using Nano coated heat pipe to remove the excess heat from the photovoltaic panels and to attain even temperatures distribution. Yongtai et al. [31] produced a photothermal conversion model of photovoltaic panel/temperature solar water heater to optimize the photovoltaic panel coverage. Also, in literature [32], a study was performed to install Nanofluid flowing plates on top and bottom of solar cells to filter sunlight and to remove heat generated by solar cells. Through the research, a research result introduced that the proposed system could improve the performance characteristics of solar cells more than other ways. In Literature [33-34], the influences of control variables on the thermal and electrical performance of solar cells comprehensively described. Besides, researches to improve the performance of solar cells by optimizing each control variable described. Next, to improve the efficiency characteristics of solar cells, it is crucial to use a solar automatic tracking system so that solar cells receive more solar energy. For the extraction of maximum energy from the sun, the plane of the solar cell should always be normal to the incident radiation [35]. Literature [36-39] introduced a very single and stable solar tracker. The plane of the solar cell controlled so that it is always perpendicular to the incident radiation by sun trackers that automatically track the position of the sun. In the literature [40-41], research on the development of an automatic solar tracking system operated as a standalone real-time system conducted. If such a solar automatic tracking system used, the output of the solar cell can improve because the solar cell is always operated perpendicular to the sun. This paper presents all the stages of development of a solar tracker for a photovoltaic panel. In the literature [42], a standalone system that can accurately track the sun for a long time described. The stand-alone system, which consists of a two-axis solar tracking system with a small concentration device module, has proved to be much more efficient than the previous solar tracking system. As described in the literature, there are numerous researches to improve the performance characteristics of solar cells. Through literature researches, improvement of the performance characteristics of solar cells considers being the most significant problem to improve the cooling characteristics of solar cells under the condition of the automatic solar tracking system. Besides, while saving the raw materials and materials as much as possible, a right cooling system is installed to improve the efficiency of solar cells is becoming an important research direction. Research in the literature [43] has progressed to improve static and dynamic displacement characteristics of wind generator blades, which suggested in large wind generator design systems. Wind generator systems are occurred vibrations due to various external conditions during operation. This negatively influences the standard operation of wind generators, and the problem of eliminating the vibration of wind generator blades has raised as an essential problem. In the literature [43], a new method proposed to improve the vibration characteristics of wind generator blades and the results of verifying the merits of this method described through experimental and numerical studies. Also, research conducted to improve static and dynamic displacement characteristics of wind generator blades, which currently proposed in large wind generator design systems.

In the literature [44], the performance characteristics of wind power generators used in Northern Africa countries where sandstorms occur have dealt with. In the literature, sandstorms in many of these countries damage the surface of wind generator blades used in these regions, which increase the aerodynamic resistance of wind generator blades and consequently lower the power production capacity of wind generators described. The signification of this research is to improve the performance of wind generators under various adverse conditions, not favorable environmental conditions by using CFD numerical simulation program. The literature [45] described a study that modified the profile of wind generator blades based on wind conditions. Through aerodynamic simulation of the modified wind generator blades, it introduced that the wind flow characteristics of the modified wind generator blades are improved and have superior characteristics to the original wind generator blades. In the literature [46], a model for predicting the pressure and momentum of the vertical axial wind generator presented. The proposed model makes it possible to predict the power output of wind generators by estimating various state amounts, such as momentum applied to wind generators. In the literature [47], the relationship between the wind generators' four coefficients effects on electric power production investigated through the study of the SCADA data, and the relationship between the wind speed and the electrical output of the wind generators also researched. A novel hybrid solar system consisting of photovoltaic panels, Fresnel lens, and thermoelectric generator was proposed and constructed [48]. Like this, many kinds of research have conducted to increase power production by effectively using solar energy and wind energy as the world's richest sources of renewable energy. However, these energies are highly dependent on climatic conditions, making them unable to produce power safely when operated as standalone systems. Nowadays Researches are progressing on the integrating system of renewable energy that combines with wind energy and sunlight in the world to solve problems like this [49-50]. As for numerous renewable energy specialists, half and half electric system that consolidates wind and sunlight based (photovoltaic) innovations offer a few points of interest over the single system [49-50]. As shown in the paper [49-50], you can get a persistent and reliable power supply by utilizing both in a framework that intended to supplement each other. The establishment of this system is more highly entangled and costly than single wind or solar equipment. However, they are the best in giving consistent, reliable power [49-50]. In the literature [51], a new type of wind-solar hybrid system proposed, and the power performance of this system studied in comparison with conventional wind generators. The power output of both systems was measured and simulated by TRNSYS software. However, this method requires the installation of a large number of tubes for lowering the heated temperature and leads to the high cost of metal in manufacturing. Therefore, it is necessary to improve the output of the system by ensuring the operating temperature of the solar cell while reducing the cost in the operation of the wind-solar energy mixing system.

According to the literature, China's new Wind Generator capacity is 31 GW, equivalent to the power generation of 10,000 large Wind Generator, and at least one Wind Generators installed in an hour. The solar cells installed in China have a surface area equal to 10,000 football fields, and at least one solar cell with a surface area equivalent to one football field is added in an hour every year.

3. Current problems and future research directions

Like this, Wind Generators and solar cells, as part of renewable energy sources, occupy ever-larger land with the increase of their production and demand for electricity, which causes hard problems in the countries with limited land. To increase power production by using solar energy to the maximum through research on prior work of literature is to maximize solar light energy received by a solar cell using a solar tracking system. At the same time, improving the cooling conditions to lower the temperature of solar cells is becoming an essential research direction. Besides, to increase power production by using wind energy to the maximum, a wind generator that must safely operate under various adverse environmental conditions designed, and finding multiple methodologies for improving the performance of the wind generator system is the central research direction. Next, we can see that research conduct to improve the stability of power generation by integrating these two systems from the characteristics of renewable energies, which are highly dependent on climatic conditions. They focused on the components of the hybrid system of the wind energy system and the solar cell system. But they did not focus on the conversion of the wind energy system itself into a solar cell system, including the subsequent development of the surface of the Wind Generator. No research conducted to produce electricity more safely while minimizing dependence on climatic conditions and the installation area, which are the most significant problems to be solved in the field of renewable energy applications. Besides, the research has not widely conducted to improve the output of the system by ensuring the working temperature of the solar cell while reducing the cost as much as possible in operating the wind-solar energy hybrid system.

Unlike the generation of electricity through fossil fuels, which allows steady production, the electricity-production which relies on wind and solar energy still has some problems as it is profoundly affected by such conditions as the climate and the installed area. For example, the generation amount of Wind Generator heavily depends on the intensity of the wind, and Wind Generator cannot produce electricity at all when the wind amount is small or empty even if it is efficient enough [52]. Besides, the solar cell cannot produce electricity when solar radiation does not exist on a cloudy day. Thus it is necessary to normalize the operation of renewable energy utilization systems under the condition of decreasing the dependence on climate conditions and minimizing its installation area.

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AUTHOR CONTRIBUTIONS

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