Solar and Wind Energy are More Than Mainstreams: Global Trends

Anna Tarasova[1, *], Larisa Gorina[2], Tatiana Freze[2]

[1] *Volga State University of Technology Yoshkar-Ola, Russia*
[2] *Togliatti State University, Togliatti, Russia*
[*] *Corresponding author. Email: tarasovaan@volgatech.net*

ABSTRACT
The article aims at describing the status quo and analyzing the factors that encourage countries around the globe to opt for alternative energy sources. There is a constant growth in volumes energy consumption, which is associated with the stability of the global economy, increasing costs for heating and cooling in various parts of the world. However, the most densely populated areas, such as China and India, coal accounts for up to 80 % of the energy balance, which unavoidably increases CO2 emissions. Hereof, the paper discusses the urgency to divert to alternative energy sources, namely wind, solar, hydro, geothermal, biomass, and nuclear energy. The authors analyse the current state of energy sources in developed countries as well as emerging markets. Thus, the authors assume that the growth rate of renewable energy resources is inadequate though being rather advantageous over traditional sources. In this regard, the paper summarizes the factors that facilitate the efficiency of renewable energy sources. In addition, the article pinpoints the barriers that hinder the dispatch for substituting the traditional energy sources with renewables.

Keywords: *solar energy, wind energy, alternative energy source, emerging market.*

1. INTRODUCTION

Renewable energy sources have nearly reached parity in price and productivity compared to traditional ones, both within centralized energy grids and beyond. Moreover, the use of solar power stations and wind power stations can help balance the load on the grid [1]. Additionally, solar-wind energy is strengthening its competitive advantages thanks to the development of new technologies.

The growth in demand for renewable energy sources allows achieving significant results in three areas: low electricity prices, reliability of supply and reduction of carbon emissions [2,3]. However, the priority of these goals for different groups of consumers can differ significantly.

Key groups of electricity consumers include [4]:

- cities integrating renewable energy sources into their strategic plans with the concept of a smart city;
- community energy projects that are expanding access to the benefits of renewable energy sources in and beyond centralized energy grids;
- emerging markets that are taking the lead in introducing renewable energy;
- corporations that are expanding their purchases of solar and wind energy.

It is most likely that in the future those trends will intensify as influenced by two complementary factors. Namely, the influxing new technologies will help to reduce further the cost of renewable energy sources and integrate them in a more effective way into energy systems. The latter will allow an increasing number of consumers to use their most preferred energy sources and will accelerate the transition to renewable energy sources in various countries of the world. Renewable energy sources will become the best solution in terms of security of supply, electricity price and environmental friendliness [5].

Currently, there are no obstacles that have hampered introducing renewable energy sources. The trend can be mainly explained by approaching the grid parity, the possibility of cost-effective and stable integration of power grids, and finally, technological innovations. Previously, it used to be thought that generating energy from sunlight and wind was a too expensive technique that could be employed in certain niche markets.

However, now these sources are already ahead of the traditional ones in terms of the cost of electricity, whose productivity is increasing steadily. The notions that the use of renewables still rises unresolved questions with the integration of power grids have changed. Advances in the integration of wind and solar power systems are helping to solve these issues. Hence, the development of renewable energy no longer merely depends on the development of supporting technologies. Contrariwise, innovations in the renewable energy industry are extensively used that allow renewable energy to outrun traditional energy resources in reputation [6,7].

2. MATERIALS AND METHODS

The way how fast solar and wind power stations are spreading and the cost of solar and wind energy decline may surprise not only industry players but also and analysts. In spite of the prevailing negative perceptions, solar power plants and wind turbines are now successfully competing with traditional energy sources in the world's largest markets. Wind and solar power stations have already reached price parity and are very close at achieving performance parity compared to traditional energy sources. In many countries around the world, the unsubsidized cost of electricity obtained with the help of ground-based wind turbines and solar power stations has actually equalized or become lower than the cost of energy generated by other technologies [8]. Moreover, a number of power sources, such as combined cycle power plants, are more adaptable to the load schedule of the power system [9].

Thence, the growing availability of panels and other innovations is helping to reduce the volatility of wind and solar power generation, which increases the reliability of renewables to compete with traditional sources. In terms of price, onshore wind turbines are the cheapest source of electricity in the world. The unsubsidized levelized cost of wind and solar energy is $ 30-60 per megawatt-hour (MWh), which is below the price range for the cheapest fossil fuel, natural gas ($ 42-78 per MWh) [10,11]. Currently, among the leaders of the onshore wind technologies are China, USA, Germany, India, Spain, France, Brazil, Great Britain and Canada (Fig.1).

Meanwhile, the price parity with traditional energy sources was achieved for onshore wind turbines in the countries mentioned above. However, the cost of wind power can differ greatly. Thus, in the United States it is lowest in regions prone to high winds such as the Great Plains plateau and Texas, and the highest in the northeast of the country. Globally, the lowest prices are registered in the top nine countries listed above, as well as in Eurasia and Australia [12].

Large photovoltaic solar power stations are only slightly inferior to wind turbines, ranking second in terms of efficiency. The upper limit of the range of the normalized cost of electricity for large photovoltaic solar power stations (USD 43–53/MWh) is lower than for any other energy source. The leaders in this field are also China, Japan, Germany, USA, Italy, India and Great Britain. In all of these markets, with the exception of Japan, solar energy has reached price parity with conventional energy sources. Japan has one of the highest solar energy costs in the world, mainly due to high capital costs. It is projected solar energy price parity in Japan will be achieved by 2030. Globally, the lowest electricity prices are in Australia, and the highest, mostly due to

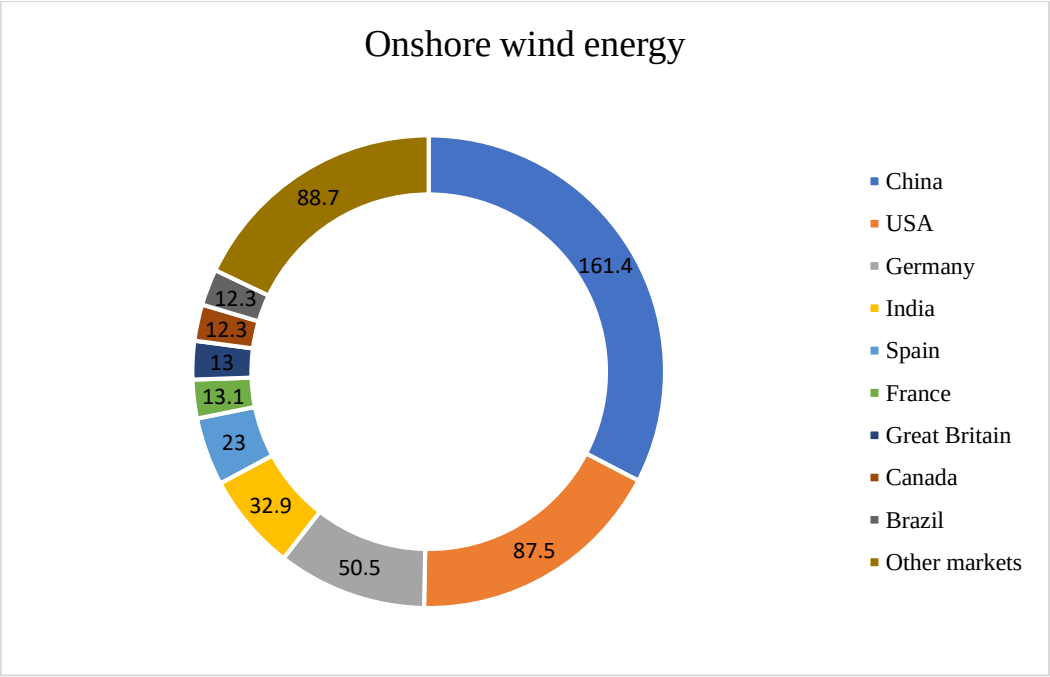

Figure 1. Onshore wind energy: leading markets (in GW)

high investment costs, are in Africa. In addition to the listed leading countries, the price parity of solar and wind energy with energy from traditional sources will also soon be achieved in other countries of the world, since the price gap between these and other sources is constantly increasing.

Modernization and technical re-equipment of wind turbines in developed countries has led to a decrease in the average global cost of wind energy. Energy costs may fall in emerging markets as well; that becomes true as global developers and international organizations are jointly developing various projects. Such partnerships are helping fight against energy imbalances. Good examples could be Japan, Germany and the UK with rather limited solar resources; still these are the leading countries in the field of solar energy. Meanwhile, Africa and South America have the largest amount of solar and wind resources, while a significant part of these resources is underused. As the volume of solar and wind power capacity increases, many conventional sources will demonstrate lower values, that will lead to an increase in the levelized cost indicators for both existing and new conventional power plants [13]. Ultimately, the cost of new solar power plants and wind turbines can be lower not only the cost of new traditional power plants, but also the cost of further operation of existing traditional power plants around the world.

Large power plants and wind turbines with storage facilities are getting more competitive, and achieve parity with traditional power plants. Energy storage facilities make it easier to manage solar-wind energy, which dispels conventional wisdom about the benefits of traditional energy sources. Although the production and subsequent storage of renewable energy is generally more expensive, alternative sources can provide high performance and are able to provide system network services, thus increasing the value. The extent to which monetization of co-benefits is feasible is regulated by market structures. The use of renewable energy sources in combination with energy storage allows achieving price parity with traditional sources [14]. Currently, a number of leading solar energy markets are implementing projects for large solar power plants with energy storage.

3. RESULTS AND DISCUSSION

A recent study has shown that a renewable energy plus energy storage approach can come together with distributed energy and demand management. This will help build clean energy portfolios that, at a lower cost, can provide the same system services as building a new gas-fired power plant or operating an existing one. Small, geographically dispersed power generators such as rooftop solar collectors are nearly achieving price-performance parity with centralized power grids. In the case of distributed electricity generation, price parity is achieved when it becomes cheaper to generate energy on its own than to pay the utility bills. Global markets - the leaders in the field of solar energy, which have already achieved grid parity (except for of India), have already met parity with traditional power plants [15]. Incentives, such as a tax credit or metering the energy that customers generate with renewable energy source (net metering) by utilities, has led to greater changes in private photovoltaic systems. Thus, starting from 2020 photovoltaic systems will become mandatory for installation on the roofs of all

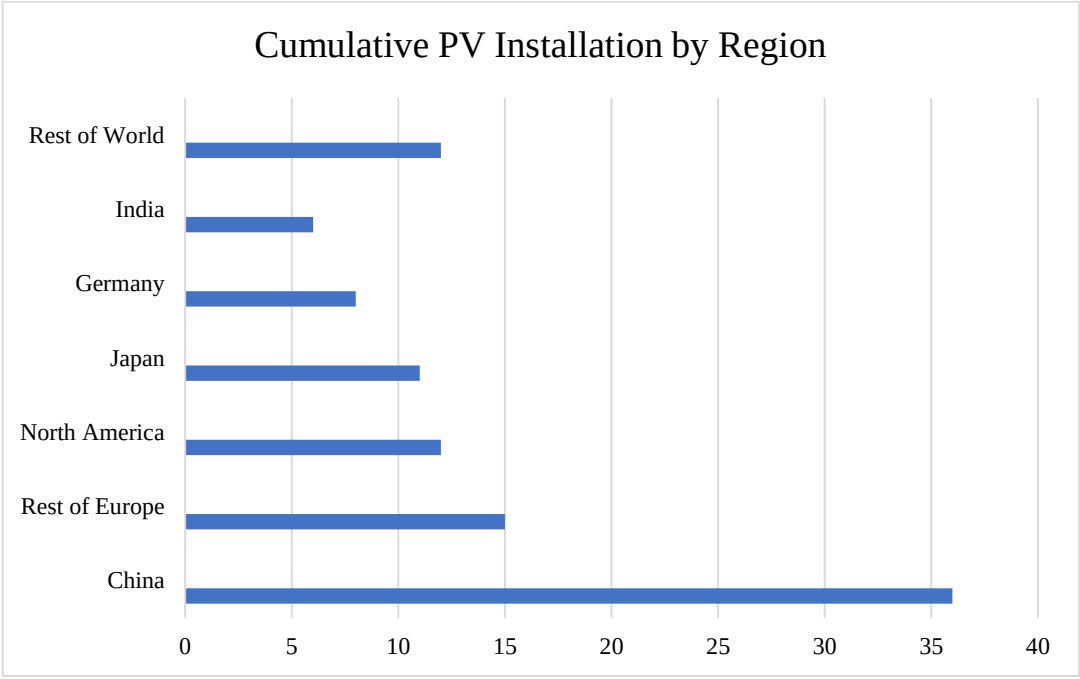

Figure 2. Global Cumulative PV Installation by Region in 2019 (in %)

new residential buildings in the state of California, USA. Homeowners in the USA states, mainly, California and Hawaii, installed more solar panels in the first quarter of 2018 alone than in the previous three years in 19 US states. To install photovoltaic panels with batteries is getting cheaper than buying electricity from a utility company. The same situation is true for several regions in Australia and Germany, where in 2017, respectively, 40% and 50% of the photovoltaic panels installed by households had electricity storage [16]. In Australia and Europe, the number of private and commercial photovoltaic panels installed on rooftops exceeds the number of large solar power stations.

Countries and regions with widespread renewable energy sources, that require complex changes at the system level, made necessary adjustments to the traditional energy networks in order to ensure the cost-effective integration of more new sources. Thus, energy companies in the European Union, China and India have modernized traditional CHP plants so that they can produce heat energy without the use of electricity or coal; additionally, combined cycle power plants have been improved to provide more flexibility and stability to the power system. Another tool that has been extensively employed by Northern Europe and some regions of the United States is interconnecting with neighbouring markets.

Since generating of electricity with the use of solar power plants and wind turbines is associated with zero marginal costs, they replace expensive types of installations, thus resulting in lower electricity prices. The installation of solar power stations has smoothed tariffs in the daytime, while the installation of wind turbines smoothed the daytime tariffs. Fifteen of the top twenty solar-wind energy market US states have electricity prices lower than the national average; another quarter are in the top ten states with the lowest electricity prices. The leading European market for solar and wind energy, Germany, has more than halved retail electricity prices over the past 10 years. Denmark, with the world's highest share of energy generated from wind and sunlight (53%), has one of the lowest prices in Europe for electricity excluding taxes and duties. According to Lawrence Berkeley National Laboratory, once the United States reaches the same level of renewable energy as Denmark (40-50%), electricity tariffs in some states will become so low that there will be no point in using meters [17]. The growth in the share of solar and wind energy is accompanied with an increase in the reliability and stability of energy systems. The US states with the leading solar and wind energy sectors have the lowest power outages. Over the past 10 years, Texas has grown by 645% in wind power generation, while the reliability of the state's grid has improved significantly. The reliability of power systems in Germany and Denmark has also improved over this period. The Danish power grids are integrated with the German and are seen as the most reliable in the world.

The wind turbines provided record production figures in 2018, when the UK faced a natural gas shortage due to a blizzard. In the United States, wind farms exceeded production expectations in 2014, while coal piles froze in a polar cyclone, and in 2017, when coal was wet from Hurricane Harvey. Solar power station and wind turbines may become important grid assets; variable renewables are balancing the load on the grid. The Midcontinent Independent System Operator was able to reduce the most critical power fluctuations at its facilities in the northern states by using wind power in 2017. Meantime, traditional power grids still provide all basic system services related to frequency, voltage regulation and linear power metering. However, the situation may change, since intelligent inverters and advanced control means allow wind turbines and solar power plants to provide these services at the same or even higher level than other types of power plants. Solar power plants and wind turbines, equipped with smart inverters, are able to increase energy production faster than traditional power plants, thus stabilizing the power grid even after sunset and the wind subsides. This means that solar power plants provide a much higher response accuracy than any other energy source. Smart inverters can turn distributed local energy resources into grid assets with minimal impact on energy consumers and make such resources more visible and usable for power plants.

4. CONCLUSION

The renewable energy market is one of the fastest growing areas of the electric power industry and it is now attracting private investments, including those from oil and gas companies. The growing demand for electricity in developing countries, coupled with the concern of the world community about global warming, has become a driver of growing interest in clean energy, the main source of which is renewable energy. Renewable energy source segment has been the fastest growing in terms of investments among the entire energy industry, while solar and wind energy as well as the development of new energy storage technologies are given the most of those investments.

Leading analytical agencies predict that by 2050, up to 77% of all investments in the electric power industry will go to implementing renewable energy projects. Though solar and wind energy will retain their leadership. State support measures are encouraging private companies to invest in renewable energy projects. The main indicator of the growth of their involvement is investments in research and development in the field of renewable energy sources. Investments of private companies in developing and purchasing the shares of technology start-ups in 2018 exceeded the investments of state-owned companies in this area. Global venture

capital and private equity investments are growing the most with the emergence and growth of tech startups around the world. International oil and gas companies such as BP, Shell, Total and others, invest both in the implementation of projects and in the development of technologies.

However, there is a slowdown in investments in developed countries. European countries have become a cradle for renewable energy sources due to government support measures. Payments for the purchase of equipment in the UK, concessional financing of projects in Sweden, a system of granting for the installation of own power stations in the Netherlands all have become the main driver of the development of a new market. The peak of investments in renewable energy in Europe was in 2010-2012. Since Europe has launched many projects, consequently its share in global investment has dropped to 15% in 2017. Thus, investment declined the most in the UK and Germany, as these countries have achieved the highest level of installed renewable energy capacity. Thence, the total energy production from renewable energy sources and nuclear energy exceeded the production from fossil sources in the UK in 2018. The growth of the renewable energy market and government incentives in Europe have become the main drivers for oil and gas companies such as BP, Shell, Total, ENI, Repsol and Equinor to get involved in green energy projects. In the United States, investment growth has slowed as the focus has shifted to shale gas development and large midstream projects. American oil and gas companies, including ExxonMobil and Chevron, are just beginning to show interest in renewables. Another player, Japan, is one of the global leaders in the growth of renewable energy sources. The growth of investments in the country fell on the period after the accident at the Fukushima nuclear power plant, the focus of development was on constructing wind farms in the offshore waters.

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