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World on the Road to 100% Renewable Energy

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In the study, the current and future status of renewable energy resources were compiled in the light of large databases of national and international renewable energy institutions, and the latest situation in the world in the transition to 100% renewable energy was examined. The extent of the goal for the transition to 100% renewable energy has been determined, and predictions have been made based on all this information. In today's world where energy and environmental problems are on the agenda, countries' transition to renewable energy is the primary solution. This goal is called the transition to 100% renewable energy, which brings advantages such as providing needed energy and producing clean energy. Today, renewable energy sources account for more than one-third of the global energy capacity, and the world is rapidly moving towards 100% renewable energy. Compared with 2017, the total amount of renewable energy in 2018 increased by 181 GW, and the number of countries with an increase in the proportion of renewable energy increased. Taking into account the external dependence of the use of fossil fuels and environmental issues, this development is at a promising level in the future. In order to shift from highly polluting oil resources to natural gas and renewable resources, this article aims to investigate the current global energy transition trends, and then propose some important strategies to get closer to upstream goals and obligations in this way.

Keywords: 100% Renewable energy; Alternative energy sources; Fossil fuel; Energy policy; Sustainable economics

1. Introduction

Today, energy has become one of the most vital needs of the world and humanity. Due to the increasing demands and the production processes developed to meet these demands, the energy use is also increasing. To find permanent solutions to the energy demands, it is necessary to define energy problems correctly, find applicable solutions, distinguish between old and current best energy technologies, and not use old technologies that do more harm than good [1, 2]. From the perspective of energy market and energy demand, fossil fuels are under pressure, which gives the newly mature renewable energy market an advantage. Renewable energy including solar energy, wind energy, geothermal energy, hydro energy, ocean energy, biomass energy and hydrogen energy can be listed as renewable energy sources [2].

Fossil fuels pose a critical problem, as they cause global climate change and environmental problems. Fossil fuels are not endless resources and are in danger of extinction. Due to the greenhouse gases formed by fossil fuels in energy production. The

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limitation of fossil fuel sources necessitates the diversification of energy sources to ensure the availability of energy. It is predicted that turning to new and renewable energy sources will be the right step in meeting the energy needs of the future [3].

With the development of technology, industrialization and the improvement of living standards, the energy resources of countries, how they use these energy sources, how efficiently they use them, and how they evaluate, control, and develop have also effectively shaped the country's political process. The energy independence of the countries adds political decisiveness. For all these reasons, studies to increase the use of renewable energy sources in production planning for the future are also gaining momentum [4-6].

To meet the increasing energy demand in countries, reduce foreign dependency on energy resources, and make an environmentally friendly production, it is important to use renewable energy resources at the highest level. Various renewable energy sources have a utilizable potential to provide added value to the economy in countries. The fact that the potential is not fully utilized puts the world's economy under pressure and causes negative effects on the ecosystem, especially air pollution and climate change [7].

The most up-to-date and effective solution proposal for improving similar problems experienced on a global scale is accepted as the "Transition to 100% Renewable Energy" approach. Renewable energy includes high entropy resources suitable for realizing and converting energy production of the desired quality [8]. The benefits of transitioning to 100% renewable energy can be listed as a fuel source, possible decrease in energy prices, reducing foreign dependency on energy, a safe and clean energy production, improvement of air, water, and environmental pollution, protection of public health, and regulation of the local economy [9].

Of course, besides the advantages of renewable energy sources such as clean energy and infinite, some disadvantages should be considered. These relate to limited potential, high cost, and energy densities. The high initial investment costs of the projects for renewable energy sources in energy production and energy storage problems create a disadvantage in using renewable energy sources [9].

Renewable energy sources currently account for more than one-third of global energy capacity [10]. More than 1 gigawatts (GW) of renewable power capacity was installed in more than ninety countries in 2018. In recent years, cities and countries have seen an increasing movement towards meeting 100% of energy from renewable sources. Countries such as Norway, Costa Rica, China, Germany, and Sweden have set the targets of their local energy sectors as "100% transition to renewable energy sources" [11].

According to the Renewable Energies 2019 Global Status Report, 2018 experienced a relatively stable market for renewable energy technologies, with a total renewable energy increase of 181 GW compared to 2017, and the number of countries growing their share of renewable energy continues to increase. Renewable energy sources provided an estimated more than 26% of global electricity generation by year-end, but renewable energy options provide only 10% and 3% of the energy needed for heating and transportation. Increasing renewable technologies and improving integration between the energy, heating, cooling, and transport sectors will enable the transition to a fully renewable energy world [12]. Investments in the transition to 100% renewable energy, which started to gain momentum in 2013, increased steadily towards the end of 2015 and reached 290 billion dollars. Due to reducing carbon dioxide emissions released into the atmosphere and creating a healthier environment, the transition to 100% renewable energy is the only way to offer a healthy life to all humanity in a sustainable structure. To become a world that has switched to 100% renewable energy by 2050 using existing renewable energy technologies, it is necessary to use all renewable energy sources together and develop storage technologies [13]. Global pressures due to the negative effects on both national economies and environmental resources, depending on the technologies applied for the extraction and use of the natural resources they use while meeting the countries' energy needs, make the implementation of 100% renewable energy transition policies inevitable. In this context, this study aims for the readers to access the most up-to-date information on the subject by compiling the sources and academic articles of internationally accepted international institutions where the records of up-to-date statistical information are kept. In light of the data obtained in this context, it aims to reveal a road map suitable for the world's socio-economic structure in line with the transition to 100% renewable energy [14].

2. Renewable Energy Sources

This section gives brief information about the current status of renewable energy resources on an international scale.

2.1 Biomass

Biomass is an important renewable and sustainable energy source that is thought to replace fossil fuel sources. Wood, agricultural products, agricultural by-product waste, animal waste, municipal solid waste, sewage sludge from wastewater treatment plants, wastes from food processing, aquatic plants, and algae are the most important biomass sources [15]. It is foreseen that biomass and bioenergy will play a vital role in the future of the global energy scenario in producing heat and power, chemicals, and fuels. Bioenergy has recently received special attention by decreasing fossil fuel resources and increasing environmental concerns[16]. Bioenergy contributes to poverty reduction in developing countries. Bioenergy is considered the best alternative fuel that meets energy requirements. It can meet energy demands in the future, with its advantages such as providing the necessary energy at all times without complex energy conversion and expensive processes and being environmentally friendly. By 2050, it is predicted that more than 25% of the world's primary energy will be obtained from biomass [17]. Bioenergy is among the energy sources that make the most important contribution to the global renewable energy supply. It has been reported to contribute an estimated 12.4% to final global energy consumption as of the end of 2017. 5% of the global heating supply, 3% of the transportation, and 2% of the electricity supply were provided from bioenergy. According to 2018 data, China is the world leader in this field, while the USA, Brazil, India, and Germany are among the countries that follow China [18].

2.2 Geothermal Energy

Geothermal energy, the earth's internal heat, is based on spreading this internal heat from the hot region in the center to the earth and is used in many areas such as electrical energy production, heating, agriculture, greenhouse cultivation, and fishing. The world's installed capacity of geothermal energy is expressed in two ways: power generation and heat generation. Total geothermal power generation in 2018 is estimated at 630 PJ, of which about half is used for electricity purposes (89.3 TWh). A new geothermal energy capacity of 0.5 GW was created in 2018, and the global total was 13.3 GW [13].

With the geothermal energy projects completed in 2018, Turkey increased its installed capacity by 21% (219 MW) to 1.3 GW. Indonesia increased its geothermal capacity by 140 MW and its installed capacity to 1.95 GW [17]. USA, Iceland, New Zealand, Croatia, Philippines, and Kenya follow these two countries. Countries on an active tectonic belt can be mentioned as geothermal-rich due to their geological and geographical location. Approximately tens of thousands of geothermal springs in natural outflows at different temperatures are scattered worldwide[18].

2.3 Hydropower

Hydropower is a renewable energy source that has greatly expanded its role in electricity generation due to factors such as the increase in electricity demand and the increase in turbine efficiency. It is especially popular in emerging markets in Asia, Latin America, and Africa[19]. In 2018, the total installed power in the global hydropower market increased by 20 GW and reached 1132 GW. The top 10 countries in total hydropower capacity (respectively) are China, Brazil, Canada, United States of America, Russian Federation, India, Norway, Turkey, Japan, and France, and these countries represent two-thirds of the global capacity [20].

2.4 Ocean Energy

Wide and powerful oceans store enough energy in heat, current, waves, and tides to meet the total energy demand worldwide many times over. However, ocean energy still makes up only a small part of the world's energy supply today. Concerns about global climate change and other environmental effects of dependence on fossil fuels worldwide have increased interest in renewable energy and ocean energy. As global reliance on renewable energies grows in the future, there will be greater interest in large ocean energy stores. Ocean energy is a renewable energy source that represents the smallest segment of the renewable energy market. Most of the projects with this type of energy are small-scale and pilot projects, and it was calculated that there was an operating capacity of 532 MW in 2018. Although the resource potential of ocean energy is high, its use is unfortunately not common. The support of ocean power technologies, especially by governments in Europe and North America, has strengthened electricity generation with ocean energy [21, 22].

2.5 Solar Energy

Solar energy is a primary energy source widely applied in heating, architecture, urban planning, agriculture, horticulture, transportation, and fuel production applications. Demand for solar energy is increasing in emerging markets and Europe. Solar energy showed the highest electricity production values in 2018 and became one of the most sought-after renewable energy types globally. More than 100 GW of capacity in solar energy was added to the annual global market, and the total capacity was 505.5 GW at the end of the year [23]. Especially in the United States and Europe, solar energy capacity has increased significantly. It also builds solar power plants to run mining, manufacturing, and other industries worldwide [24]. By 2018, solar energy capacity has increased by 1 GW or more in 32 countries [19]. China accounts for approximately 74% of the global capacity in solar energy, followed by Turkey, Brazil, and the USA [25].

2.6 Wind Power

Wind energy is a renewable energy source whose global market is developing steadily, increasing its capacity by approximately 51 GW in 2018. Wind power capacity increased by 9% in 2018 to 591 GW. In 2017, record wind energy capacity was experienced in Europe and India, but this situation did not show the same stability in 2018, while there was remarkable growth in other regions and countries. The largest regional market was Asia with 52%. Seven countries in Europe and two in Asia increased their capacity by 4.5 GW and global capacity by 24% to 23.1 GW [22].

2.7 Hydrogen Energy

Today's increased investment and cheaper renewable energy supply will impact hydrogen production costs and increase the shift from fossil fuels to cheaper renewable energy. This fact confirms that hydrogen energy technologies will play an important role in reaching the 100% renewable energy target [26].

Hydrogen produces nearly zero emissions, and its abundant natural resources can be an ideal sustainable energy source. Unlike hydrogen, fossil fuel sources cause serious environmental problems such as air pollution and global warming. Hydrogen should be produced from clean and rich sources with environmentally friendly methods to eliminate the negative effects of fossil fuel use on the environment, human health, and climate. Hydrogen energy produced from renewable energy sources will pave the way for a permanent energy system [23].

Many projects are being produced globally for hydrogen energy to become widespread, and various pilot plants are being established. The hydrogen-powered bus in many countries, such as Turkey's wind hydrogen production projects, are among the pilot plant studies. Apart from this, there are many examples of pilot-scale projects in the world. Among these projects, small hydroelectric power plants established for hydrogen production in China, hydrogen-producing wind turbines in Argentina, hydrogen-fueled vehicles in South Korea and India are examples of these studies. In addition, it is planned to produce hydrogen with solar panels in Libya, and the use of hydrogen is becoming common in countries such as Portugal, Colombia, Egypt, Russia, and Italy [28].

3. 100% Renewable Energy

Fossil fuels resources face increasing supply, environmental pollution, and climate change problems, while renewable energy can offer the best prospects for energy. Renewable energy sources differ from fossil fuels in many important ways. The concept of transition to 100% renewable energy means using completely renewable energy sources in all areas where energy is used, especially in electricity generation, transportation, and heating/cooling. Achieving this goal will reduce unsustainable energy demand, increase energy efficiency, and produce much cheaper and cleaner energy [11].

In this section, it provides information on the path taken by the world's 100% renewable energy from the past to the present, and explains the work done to accelerate the global and local transition to 100% renewable energy.

3.1 Transition to 100% Renewable Energy in the World

Progress in the renewable energy sector continues to be concentrated in electricity generation, while there is much less growth in heating, cooling, and transportation.

Electricity accounts for only one-fifth of global energy consumption, and the role of renewable energies in the transport and heating sectors remains critical to the energy transition [9]. Globally, 2018 has drawn a stable profile in the transition to 100% renewable energy. Compared to 2017, 181 GW of renewable energy was added and the number of countries making progress in the transition to 100% renewable energy increased. The renewable energy sector generally provided around 11 million (direct and indirect) employments worldwide in 2018 [11]. Although progress has been made in energy efficiency and transition to 100% renewable energy, it is behind the World Sustainable Development Goals and the Paris Agreement globally. Global energy-related carbon dioxide (CO_2) emissions increased by 1.7% in 2018 due to increased fossil fuel consumption. Fossil fuel use has increased by 11% since 2017 [22]. Fossil fuel companies continue to spend hundreds of millions of dollars on advertising to delay, control or thwart climate change policies and influence public opinion.

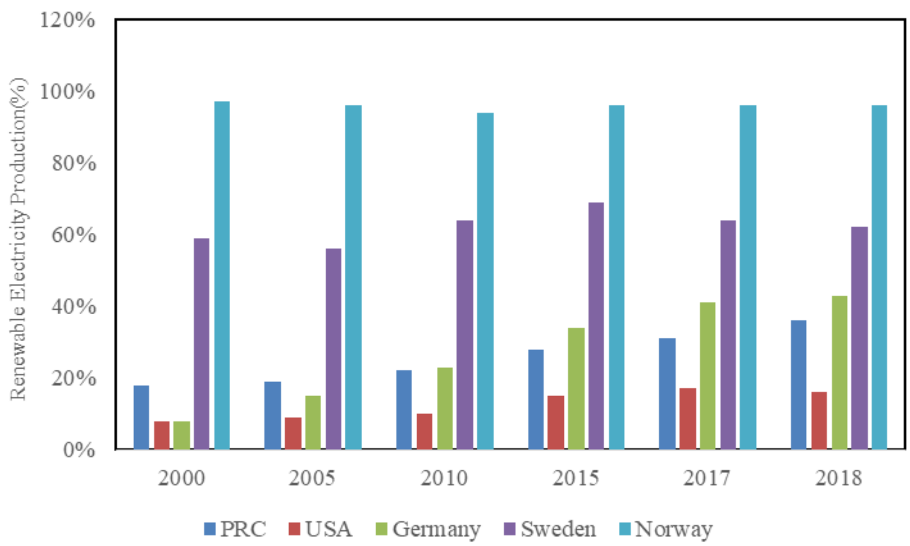

Figure 1. Renewable electricity production (%) of countries [28]

In Figure 1, renewable energy productions of countries that are one step ahead of other countries in the transition to 100% renewable energy are compared. When the renewable energy production of China, the United States of America, Germany, Sweden, and Norway (which is one step ahead of other countries in the transition to 100% renewable energy) is compared with each other, it is seen that Norway has switched to 100% renewable energy. All of its electrical energy is from renewable energy appears to be met. Sweden, closest to the transition to 100% renewable energy, follows Norway in second place. China, the USA, and Germany are also countries that have made progress in the transition to 100% renewable energy with their ever-increasing renewable energy profiles [29].

Figure 2 shows the share of countries' renewable production in total consumption and information about the status of renewable production in total consumption.

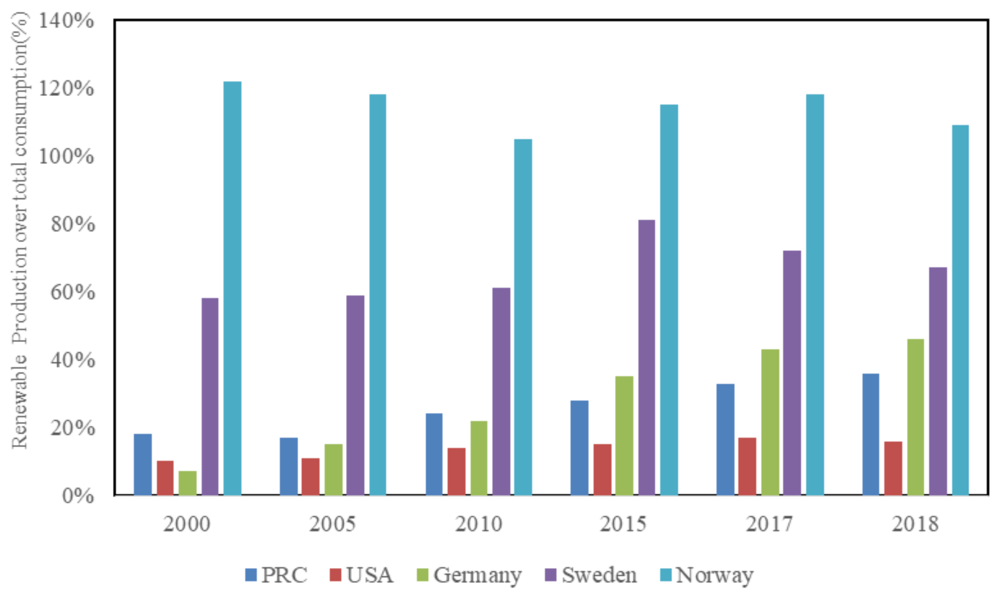

Figure 2. Share of renewable energy production(%) of countries in total consumption [18]

When the data in Figure 2 are analyzed statistically, Norway has a high production rate approaching or even exceeding 120%, because there is more renewable production than consumption in Norway, and the share of renewable production in total consumption is high. Sweden follows Norway in second place. It is observed that the share of renewable generation in the USA total consumption is low. Figure 3 shows the electrical energy consumption in different countries [30].

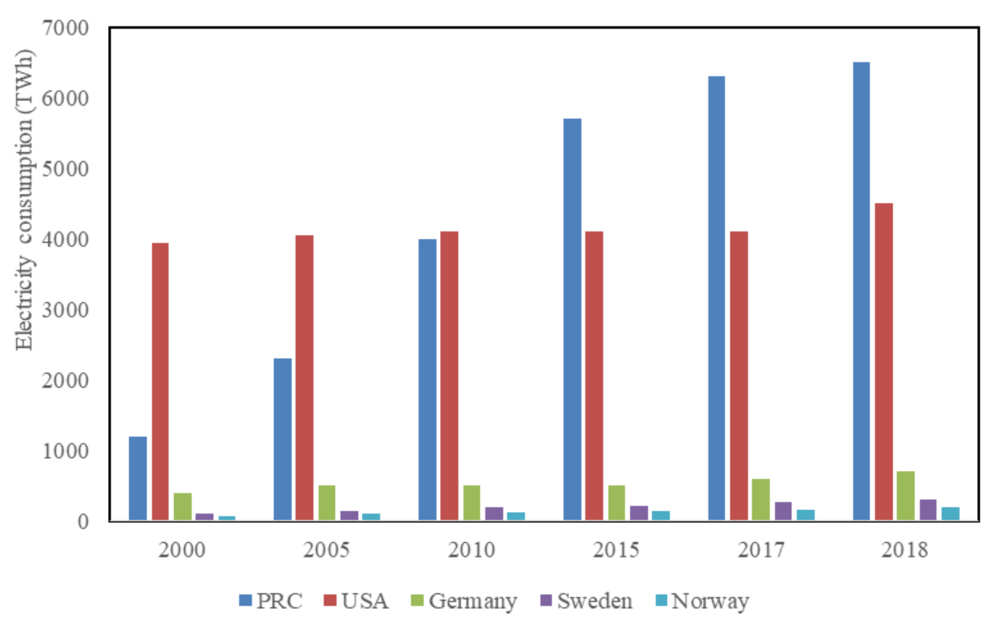

Figure 3. Electricity consumption of countries (TWh) [14]

When Figure 3 is examined, the total electrical energy consumption in China, where the share of renewable generation is low, was 6500 TWh in 2018, only about a quarter of which can be met from renewable energy production. This is also true for the USA. Despite the electricity consumption of 4500 TWh in 2018, only about 18% of this energy is met by renewable generation [15]. In the light of this information, it is seen that although energy consumption is high, the share of renewable generation in this consumption share is low in many countries except Sweden. The energy consumed cannot be satisfied with renewable energy, and there is still a long way to go to satisfy it [31].

Countries aiming to transition to 100% renewable energy have many initiatives, small or large, to achieve this goal. According to 2018 International Energy Agency data, the share of global electricity generation from renewable energy was 26%. This situation shows that there is a 26% transition to 100% renewable energy globally. By 2018, 169 countries aim to transition to 100% renewable energy at the national or state/provincial level [17]. Since buses contribute more to air pollution than other public transport vehicles, solar buses in Uganda, solar ferries in India, and wind-powered trains in the Netherlands have begun to be used to switch to renewable power [19]. Countries also implement several policy measures to move forward on the path to 100% renewable energy. In Australia, the University of New South Wales has become the world's first fully solar-powered university, and it will start working with 100% solar energy by 2020. Again, many universities in Kenya (including Strathmore and Kenyatta Universities) use solar panels for their energy supply and earn money by selling the electricity they produce to the national grid. Scotland aims to produce all its electrical energy from renewable energy sources by 2020. Albania, Norway, and Costa Rica are among the countries that have transitioned to 100% renewable energy [27]. In the Dutch rail network systems, 100% of its trains are powered by the Catholic Diocese wind energy. In England, they have committed to switch to 100% renewable energy and buy renewable energy. In light of all this information, it is possible to say that the share of renewable generation has increased globally, the transition to 100% renewable energy has accelerated, and all developed, and developing countries have taken steps in this regard [32].

3.2 Towards the Future

The energy issue is a big problem all over the world. Most energy problems arise from providing rent, not making the right investments, and risky projects. Switching to renewable and 100% renewable energy will be the cleanest and right solution [11]. For the transition to 100% renewable energy, an energy system based on efficiency, scientifically appropriate, and protected by laws from political influences should be introduced, leaving aside the discussion of profit/loss in the energy sector [9].

Most countries are dependent on foreign sources at a rate of 60-75% in electrical energy production. The regulations that are tried to be implemented within the scope of the Energy Efficiency regulations cannot take a very important distance in this regard. This dependency, unfortunately, also hinders independence in political and economic terms [32-34].

In the transition to 100% renewable energy, the most important thing that can be done to achieve the target is the efforts of local governments to achieve the target [11]. The local government authorities' targeting of transition to 100% renewable energy while creating energy-related policies will also positively affect the applicability. The general steps that can be taken to achieve the target are presented below in articles [27, 35, 36].

- Organize meetings with authorities to explain that the transition to 100% renewable energy is feasible and beneficial.

- Develop a local climate action plan for a rapid transition to 100% renewable energy.
- By increasing the awareness and practice of energy control in the society, to improve energy saving and access, to ensure clean energy production, to support small business activities; saving public money by reducing energy costs in local government buildings, reducing air and water pollution.
- Increasing public transportation in transportation and encouraging the use of renewable energy in transportation.
- To overhaul all transportation systems to make renewable energy healthier, more accessible, and sustainable, reduce fossil fuel dependence in transportation systems and combat climate change and air pollution. (For example, switching to electric energy in public vehicles, reducing and banning fossil fuel-powered cars in the city, incentivizing private electric vehicles.)
- Switch to renewable energy sources wherever possible and make buildings energy-efficient, including local authorities and public offices.
- Working with countries, cities, institutions, and organizations that have switched to 100% renewable energy, using their experiences, sharing ideas, contacting and examining the path they follow.
- Communities most affected by climate change, experiencing the direct effects of fossil fuels such as air, soil, and water pollution, are leaders transitioning to a new energy system[37].
- To ensure the rapid transition of primarily medical associations, hospitals, and health centers to 100% renewable energy, all medical authorities recognize the harm fossil fuels cause to public health, especially air pollution.
- Ensuring worker retraining and re-employment in the expanding renewable energy sector.
- Ensuring that trade unions and youth organizations working on this issue employ the transition to renewable energy for all, including workers in the fossil fuel sector.

4. CONCLUSIONS

The world is at a turning point due to the effects of climate change. The energy issue has become a problem with the increasing population, energy demand, and energy use. Contrary to the environmental pollution and negativities caused by fossil production, the advantages of renewable production necessitate the world's transition to 100% renewable energy. Renewable energy sources, including solar, wind, hydroelectricity, are at the heart of the transition to a less carbon and more sustainable energy system. The sun is only one of the renewable energy sources that can provide much more energy than the whole world can use in a year. Besides, it is an obvious fact that the more investments are made in renewable energy sources, the cheaper the electricity production will be. There is still a long way to go, both locally and globally, to reach a world powered by 100% renewable energy.

In the world, significant progress has been made in the transition to 100% renewable energy. Since 2007, the share of fossil production in electrical energy production globally has decreased from 79% to 68%. The share of renewable generation also increased from 21% to 32%. It has been observed that the world has shown an increase of 6% for the concept of transition to 100% renewable energy in electrical energy production and can switch to 100% renewable energy at a rate of 26%. However, it is possible to increase this share, because the potential of renewable energy sources in different locations is very high. Depending on this potential, it is possible to meet the energy demand of countries with renewable generation. Regionally, Scotland aims to produce all its electrical energy from renewable energy sources by 2020. Albania, Norway, and Costa Rica are among the countries that have transitioned to 100% renewable energy. In the light of all this information, it is possible to say that the share of renewable generation in the world has increased, and the transition to 100% renewable energy has accelerated.

To accelerate this transition and live in a cleaner world, it is necessary to take many steps at the global/local level. First of all, a transition should be made from the grassroots to the national/global level. The transition to 100% renewable energy should be achieved step by step, first in the neighborhood and the city, then in the country, and finally in the world. For this, local governments have a great responsibility. Reducing fossil fuel projects and fossil fuel budget, the transition of all government institutions, primarily local government institutions, to 100% renewable energy, supporting the transition to 100% renewable energy economy are important steps that can be taken. The local government authorities' targeting of transition to 100% renewable energy while creating energy-related policies will also positively affect the applicability. Increasing the awareness and practice of energy control in society and supporting renewable energy in transportation, heating, and electricity production will be important steps in this regard.

The transition to 100% renewable energy will save energy and create the opportunity for clean energy production and create a healthier, more accessible, and sustainable energy system.

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