

Energy Perspectives of Korea (Republic of) with a General Outlook on Renewable Energy

Numan Yanar* and Heechul Choi**

Abstract: *As global warming has become a severe issue; the attention of world governments has started to shift towards the sustainable use of energy to reverse the previous mistakes. The main initiative in this regard was almost 200 nations agreeing, through the Paris Agreement, to undertake ambitious targets. However, these targets are not enough to deal with the expected global temperature rise. In this regard, Korea has introduced strict policies for a steep transition to renewable energy. The first step aims to reduce greenhouse gas emissions by 26 percent through raising the ratio of renewable energy to 20 percent by 2030 by investing in solar and wind power plants.*

Introduction

Over the last two decades, global warming has become an increasingly important issue. The average temperature of the Earth's atmosphere and its oceans has gradually increased from 0.4 to 0.8 °C (Live Science), which is already resulting in permanent alterations to the Earth's climate.

Global Temperature Increase

Over the past five decades the common use of fossil fuels, land clearing, agriculture, and all other human activities has resulted in a high amount of pollutants, primarily carbon dioxide and also other greenhouse gases. Eighteen of the Earth's warmest years have occurred in the last 136 years. Critically, 17 of those 18 years have occurred since 2001, with 2016 being the warmest (NASA's Jet Propulsion Laboratory, 2018). These severe effects are expected to intensify and the average temperature increase by 2100 is expected to be between 1.4 and 5.8 °C.

The increase in the heat in the atmosphere is absorbed by the oceans (Potter, Cabbage, & McCarthy, 2016), which means that oceans are also getting warmer. On the top 700 meters of oceans, there has been a 0.1678°C increase since 1969 (Levitus et al., 2009). Such an increase may seem insignificant for humans, but it creates a life-threatening scenario for ocean plants and animals, starting from plankton. As algae and plankton are the base of the food chain, this is already having serious con-

sequences for humans. One of the dire consequences of the temperature rise in oceans is that it hinders the photosynthesis of algae until they eventually die, while coral splits, leading to a white coloration known as bleaching. This food chain destroying situation is currently occurring in all oceans.

Furthermore, warming oceans and atmosphere further affect the ice masses in the Greenland and Antarctic. According to Gravity Recovery and Climate Experiment of National Aeronautics and Space Administration (NASA), Greenland and Antarctica lost 281 billion tons and 119 billion tons of ice, respectively, between 1993 and 2016.

In addition, all around the world the effects of global temperature increase resulting in retreating glaciers, the decline in arctic sea ice, the over-melting of spring snow cover and the intensifying rainfalls, have resulted in rising sea levels (20.32 cm in the last century).

Ocean acidification as a result of carbon dioxide absorption by oceans is also a further concern that endangers the life in the oceans and seas (NASA).

As discussed above, the results of global warming are threatening human existence.

Emissions of Greenhouse Gases and Renewable Energy

Although global warming is a natural phenomenon, the main reason behind the accelerated rate is human activities. The reliance on non-renewable energy sources

* Numan Yanar, School of Earth Science and Environmental Engineering, Gwangju Institute of Science and Technology.

** Prof. Heechul Choi, President, Korean Society of Environmental Engineers (KSEE), Professor at Gwangju Institute of Science and Technology.

like as fossil fuels: coal, petroleum, and natural gas has brought us to this point. Fortunately, the importance of renewable energy sources has been recognized worldwide, which is encouraging many nations to act before it's too late. In last decades, the reliance on coal has been replaced by nuclear energy, which releases fewer greenhouse gases. Nonetheless, it is controversial to rely on nuclear sources due to the ultimate adverse effects of radioactivity on humans and nature, not to mention the cost of nuclear energy. The US Energy Information Administration declared that the cost of nuclear energy is more than 50 percent greater than that of solar power or wind power (U.S. Energy Information Administration, 2017).

In order to shift toward renewable energy, world countries started to take some measurements on the basis of the Paris Agreement (Richardson, 2018). In 2015, almost 200 nations agreed to help limit the warming on the Earth's surface to a maximum of 2°C to avoid the irreversible consequences. According to the projection of the Integrated Global System Model (IGSM), the measures agreed upon are not enough to realize the goal and not go beyond the 2°C mark. The projected temperature rise, ranges from 1.9°C to 2.6°C by 2050 and 3.1°C to 5.2°C by 2100, depending on the climate sensitivity. Therefore, more realistic and stronger *targets* should be taken (Nancy W. Stauffer, 2017). In this regard, the world's largest energy-consuming countries are taking the main responsibility for application of the further measures, with Korea at one of the forefront.

Energy Use in Korea

According to the BP Statistical Review of World Energy 2018, Korea is the eighth-largest energy consumer in the world (British Petrol, 2018b). As a result of insufficient domestic resources, Korea ranks among the world's top five importers of liquefied natural gas, coal, crude oil, and refined products.

Since the 1970s, Korean energy sources were based on nuclear and coal-fired plants (Chung & Kim, 2018). The country produced an estimated 1.6 million short tons (MMst) of coal from its anthracite reserves out of total 151 MMst consumption in the country in 2017.

Several coal-fired plants started operation in 2016 and 2017 as a result of forced shutdowns of some nuclear plants (safety issues before a major earthquake), which resulted in a 12 gigawatts (GW) capacity increase (U.S. Energy Information Administration, 2018a). Another large portion of the energy in Korea is sourced by nuclear plants; 24 reactors provide approximately one-third of total electricity from 23 GWe of plant (World Nuclear Association, 2018).

Energy Policies of Korea

In 2016, electricity production of the country was comprised of 41.2 percent from steam plants, 30.2 percent from nuclear plants, 17.9 percent from combined cycle plants (127 TWh), 1.2 percent from hydropower plants, 0.1 percent from internal combustion and 9.5 percent from other sources. The main energy sources were nuclear (30 percent), coal (39.65 percent), petroleum (2.6 percent), hydro (1.2 percent), and other sources (4.2 percent), for a total of 540,441 GWh electricity (Korea Energy Economics Institute, 2017). This high dependency on coal and nuclear energy is caused by the previous energy policies. However, in 2017, the Korean government introduced the 7th Basic Plan for Long-term Electricity Supply and Demand for a transition to renewable energy till 2030. The new green policies were further introduced by the election of President Moon Jae-in in May 2017. Since then, Korea has started to focus more on the transition to renewable energy. President Moon aims to increase the use renewable energy for the national electricity from just 4.7 percent to 20 percent by 2030 (Normile, 2017). Coal-sourced energy is expected to fall from about 43 percent in 2015 to 22 percent by 2030, while nuclear is projected to drop from 31 percent today to 22 percent by 2030. Furthermore, the government's policy aims to phase out nuclear power over a period of 40 years (World Nuclear Association, 2018).

Renewable Energy in Korea

Renewable energy carries great importance for the green future of Korea. According to 2017 data, Korea holds seventh place in the world for CO₂ emission, with 679.7 million tons of carbon dioxide and a 2.5 percent growth rate (British Petrol, 2018a). This is mainly caused by the

high coal consumption in electric power sector. Due to the high demand from the power sector, coal consumption increased by more than 50 percent between 2007 and 2017. However, the country's 8th Basic Plan for Electricity Supply and Demand aims to push renewable energy and suspend the plans for new coal-fired capacity as well as shutting the seven old coal plants. Furthermore, the government also plans to transform six coal projects into LNG plants to reduce carbon emission (US Energy Information Administration, 2018b).

Although internal combustion energy production and consumption is at the lower end relying in fossil fuels as a source of energy not only add to the GHG emissions, but it is also releases more toxic particles into the air than any other source. Another problem is created by the use of fuel oil, which greatly reduces greenhouse gas emissions, but also increases air toxicity significantly (Reuters, 2018). Therefore, the goal for 2030 includes cutting fine dust levels by 62 percent in addition to reducing greenhouse gas emissions by 26 percent from business-as-usual (BAU) levels; this will be done by raising the ratio of renewable energy to 20 percent by 2030 by investing in solar and wind power plants (Eun-jung, 2017). Currently, the renewable energy production of Korea is provided by solar (thermal/photovoltaic), wind, tidal-ocean, hydropower, geothermal, waste and biomass sources. As of 2017, Korea has a capacity of 5.7 gigawatts of solar power and 1.2 gigawatts of wind power. It is planned to add 30.8 gigawatts capacity to solar and 16.5 gigawatts to wind power capacity by 2030. These additional capacities will be obtained from both major and minor individual projects such as conversions of the energy sources of households, farms and small businesses to renewable energy. Korea even aims to equip one in 30 households with solar power generation by 2022 and generate the solar capacity of about 5 gigawatts between 2018 to 2022 (Reuters, 2017).

Korea also has strong roots in hydropower. The country's hydropower potential was analyzed as 505,093 GWh/year with the capacity of 57,659 MW (Table 1) (Korea Energy Management Corporation).

River system	Capacity (MW)	Potential (GWh/Yr)
Han River	18,936	165,878
Nakdong River	19,254	168,665
Keum River	8,989	78,746
Sumjin River	5,356	46,917
Youngsan River	2,903	25,435
Jeju	2,221	19,452
Total	57,659	505,093

Table 1. Hydropower Generation in Korea

Korea is a world-leader in tidal-ocean energy. These energy sources are inexpensive and available for large-size productions with clean energy. Currently, Korea has the largest tidal power plant of the world, Shihwa Lake. This tidal power plant can reduce the generation of CO₂ by 315,000 tons per year, with a capacity of 254 MW and a generation of 552 million kWh per year, which can supply energy for 500,000 houses (K-Water, 2018).

The 2030 plan also includes energy from biomass and geothermal power. In 2007, biomass accounted for 6.0 percent of new and renewable energy, but the country plans to try to expand the use of biomass by raising this to 30.8 percent for 2030. As 63 percent of Korea's land is comprised of forests, biomass is an efficient source for green energy production with the creation of new job opportunities (Asia Biomass Office).

When it comes to geothermal energy productions, there have been some recent concerns. Korea has a geothermal capacity to produce energy. The average heat flow is 64 ± 14 mW/m², while the area of sedimentary rock contains 74 mW/m², sedimentary/volcanic rock area 62 mW/m², plutonic rock area 63 mW/m², and metamorphic rocks area 61 mW/m² (Kim & Song). The country's first geothermal power plant was constructed in 2017 with a capacity 6.2 MW. However, due to power-plant-related suspicions regarding an earthquake occurred in Pohang,

the power plant suspended operations in 2018 (Changwon, 2018).

One Less Nuclear Power Plant

These renewable energy goals of Korea are further supported by the country's city municipalities. As Seoul is the largest city of Korea and the second-largest metropolitan area in the world, with more than 25.6 million people (approximately half the entire population of the country) (World Population Review, 2018), the energy policy of Seoul has a high impact on the country's goals. Depending on the reduction in the energy consumption in Seoul, the burden of power generation in other regions would also be reduced. Through the One Less Nuclear Power Plant initiative, 2 million total of oil equivalent (TOE) energy was reduced in Seoul from 2012 to 2014. The program also aims to increase Seoul's self-sufficiency rate of energy to 20 percent by 2020.

The One Less Nuclear Power Plant initiative consists of five policy categories (Seoul Metropolitan Government):

- Seoul, Dreaming of Energy Independence
- Seoul, Enhancing Energy Efficiency
- Seoul, Riding Green Transportation
- Seoul, Practicing Green Consumption
- Energy Government Made by Citizens

These categories include "increasing renewable energy-based power production" and 78 specific projects.

Conclusion

Due to the industrial developments of the previous centuries and the over consumption of energy, the Earth is suffering from the severe effects of global warming. As we are all responsible for the current situation, we must also take precautions all together to reverse or at least slow down the end of our aging earth, before it is too late.

Even though the globally accepted Paris Agreement is a good place to start, as we look at the projections about the temperature rise caused by global warming in near future, the measurements taken by the countries that signed the Agreement does not seem to generate the de-

sired outcomes. That leaves us with one conclusion that we need to take even more critical measurements.

With its detailed 2030 plan, Korea shows that the country understands the stakes and is willing to take the necessary steps to further limit its greenhouse gas emissions and leap ahead in renewable energy productions. The overall goals include limiting the dependency on coal and nuclear energy and replacing them with renewable sources such as solar, wind, tidal, biomass, geothermal and hydropower. If all nations would join in these efforts, we might start hope in having a greener future for Seoul, Korea and the world.

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