

Energy Industry in South Korea



General State of the Economy

South Korea, officially the Republic of Korea, is a country in East Asia, in the southern Korean Peninsula. Its capital city is Seoul. The country has a land border with the DPRK, and sea borders with Japan and China. South Korea has access to the Yellow Sea (to the west), to the Sea

of Japan (to the east), and to the Korean Strait and the East China Sea (to the south). South Korea, is the 109th largest country in the world, and is home to more than 51,8 million people, as of 2022.



Sources:

1. GDP (purchasing power parity), 2020 est. / The World Factbook/Library/Central Intelligence Agency *228
2. GDP - per capita (PPP), 2020 / The World Factbook/Library/Central Intelligence Agency *229
3. Inflation rate (consumer prices), 2019 est. / The World Factbook/Library/Central Intelligence Agency *228
4. Charges for the use of intellectual property, receipts (BoP, current US\$), 2020 / International Monetary Fund, Balance of Payments Statistics Yearbook, and data files. / License: CC BY-4.0 *88
5. The Global Competitiveness Index 2019 / Rankings / Reports / World Economic Forum *141
6. High-technology exports (current US\$) 2019-2020 / United Nations, Comtrade database through the WITS platform / License: CC BY-4.0 / Data *134
7. 2021 Index of Economic Freedom / International Economies / The Heritage Foundation *178
8. Reserves of foreign exchange and gold, 2017 est. / The World Factbook / Library / Central Intelligence Agency *195
9. Annual average GDP growth in %, for the last 10 years (2011-2020) / World Bank national accounts data, and OECD National Accounts data files / License: CC BY-4.0 *206
10. Public debt (% of GDP), 2017 est. / The World Factbook / Library / Central Intelligence Agency (from smallest to largest) *210

* Total number of countries participating in ranking

Figure 1. Economic indices of South Korea

In terms of population density the country is 24th in the world from 248 countries considered [1,2,3]. The total length of the country's coastline is 2,413 km [3].

South Korea is a presidential republic and the official language is Korean. The administrative map of the country is divided into 9 provinces [3].

South Korea has a modern diversified market economy, which is reflected in Figure 1. For 8 out of 10 indices, South Korea places in the top 25% of the leading countries in the world included in the rating.

From the early 1990s the country experienced sustained GDP growth in purchasing power parity, both in general and per capita [4,5]. GDP at purchasing power parity increased from \$2.035 trillion in 2017 to \$2.187 trillion (14th place in the world) in 2020 [3]. The country's GDP at purchasing power parity per capita is lower (37th place in the world), but has also been demonstrating positive dynamics: from \$39,500 in 2017 to \$42,300 in 2020 [3]. The level of inflation changed from 1.9% in 2017 to 0.3% in 2019. South Korea is 34th in the world out of 227 countries ranked by levels of inflation, low to high. This marker does not always correspond to the real state of the economy [3].

According to The Global Competitiveness Report 2019, presented by the World Economic Forum, South Korea is 13th (out of a total of 141 countries considered), ahead of China. This rating measures the effectiveness of the use of the country's own resources for sustainable development. In addition to a number of economic indicators this index also takes into account such variables as education, health, level of innovation, etc.

Energy resources

South Korea does not have significant reserves of fossil energy resources (Table 1). In terms of gas reserves, which in 2017 were estimated at 7.079 billion m³, the country was 80th in the world [3]. The main fossil energy resource of the country is coal. In 2021 coal's share in

In the list of countries that exported high-tech products in 2019-2020, South Korea was 4th, considerably ahead of the world average and second only to China in the region. According to the Index of Economic Freedom, which is based on freedom of business, freedom from government intervention, property protection, and freedom from corruption, the country ranked 24th in 2021, out of 178 countries considered.

In terms of gold reserves and foreign exchange reserves, South Korea was 9th in 2017, behind China, Japan and Taiwan in the region.

According to the indicator for the average GDP growth in percentage over the last 10 years, in 2020 the country was 95th out of 206 countries considered. In terms of public debt, calculated as a percentage of the country's GDP, South Korea was ranked 133rd out of 210 countries considered in 2017.

For more information on the South Korea economy see the attached link library by clicking [here](#).

the country's energy balance was 97.3%; natural gas accounted for the remaining 2.7% (Fig. 5). Coal reserves, as of 2014, were estimated at 359 million short tons [6], and 326 million tons at the end of 2020 [7].

Table 1. Fossil energy resources of South Korea

Resource/ explanations	Crude oil	Natural gas	Coal	Shale Gas	Coal mine methane	Tight Oil
Value	Nodata	7.079	326	No data	3.26-8.15	no data
Unit	-	Bcm	Mln tonnes	-	Bcm	-
Year	-	2021	2020	-	2017	-
Source	-	[3]	[7]	-	[7,8]	-

According to calculations by Advanced Energy Technologies, the methane utilization potential (according to the methodology based on methane emissions from coal production [8] and its reserves), was 3.26-8.15 Bcm, as of 2016 [7].

South Korea has a variety of renewable sources for energy production, including significant potential for wind energy. A selection of basic indicators of this type of resource is presented in Table 2.

The level of global horizontal irradiation for the majority of the country is low – between 3.5-4.2 kWh/m²/day [9]. The distribution of wind resources is as follows: for the majority of the country wind speed does not exceed 5.0-

7.0 m/s; along the Korean Strait wind speed can reach 7.0-7.5 m/s [10].

Table 2. Renewable energy resources of South Korea

Resource/ explanations	Solar Potential (GHI)*	Wind Potential (50 m)*	Hydro energy Potential**	Bio Potential (agricultural area)	Bio Potential (forest area)	Municipal Solid Waste
Value	3.5–4.2	5.0–7.0	19	18.1	63.9	1.00
Unit	kWh/m ² /day	m/s	TW/year	% of land area	% of land area	Kg/per capita/day
Year	2018	2018	2008	2018	2018	2016
Source	[9]	[10]	[11]	[13]	[14]	[15]

*data for 10% sunniest/windiest areas

**economically exploitable capability

The economically exploitable hydropower capability is rated at 19 TW/year [11], and wave energy potential is 15-20 kW/m per year [12].

According to data for 2018, 18.1% of the territory of the country is occupied by agricultural land, the area of which has been steadily decreasing during the last half-century [13]. As of 2018, there has been a slight decrease in forest area to 63.9% of the country's territory, compared with 66% in 1990 [14].

The level of municipal waste generation in South Korea was 1.24 kg per capita per day, which is lower, than for example, in Australia – (1.54 kg per capita per day), but

larger than in Japan – (0.95 kg per capita per day). By 2025, this figure is projected to reach 1.4 kg per capita per day [15]. Korea has almost completely moved away from landfilling, and seeks to reduce waste incineration and minimise and recycle waste as much as possible. This resource is a valuable raw material for recycling or energy production, the technologies of which have reached a high level of development in South Korea.

A detailed list of sites and special reports on South Korean energy resources can be found [here](#).

Energy Balance

According to the BP Statistical Review of World Energy 2022, South Korea's total primary energy consumption in 2021 was 12.58 exajoules, around 42.8% of which was from oil, 24.2% from coal, 17.9% from natural gas, 11.4% from nuclear energy, 3.5% from renewable energy, 0.2% from hydropower [7].

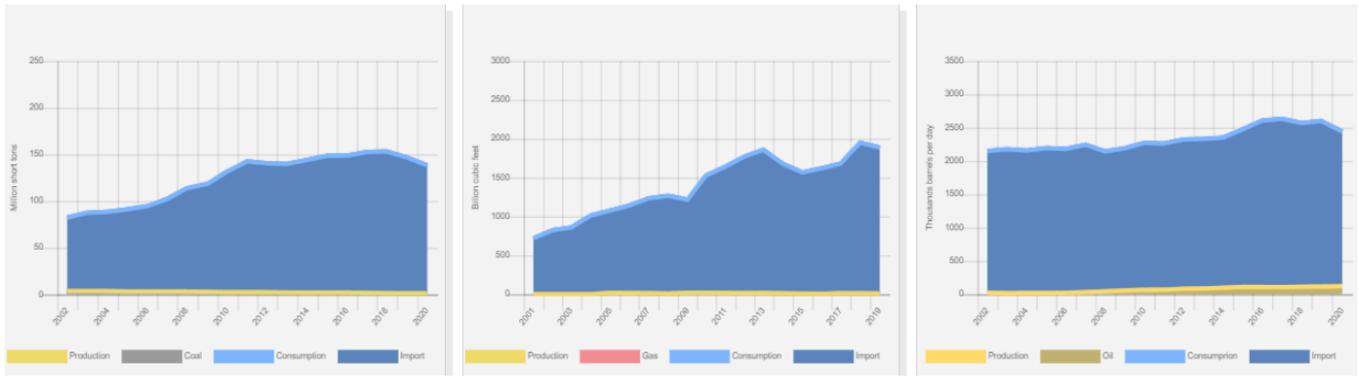
Using the data from [3,7] we calculated South Korean GDP per unit of primary energy use in 2017 to be \$7.78 per kg of energy expended (the equivalent of energy contained in one kg of oil equivalent/\$ PPP per kg of oil equivalent), which is significantly lower than the world average level of GDP energy efficiency.

According to data from 2019, South Korea was among the ten largest energy consumers [16]. Between 2001-2018 oil production grew steadily, and in 2020 totalled 119 thousand barrels/day [17]. The volume of oil consumption in the country also showed moderate growth (Fig. 2), amounting to 2437 thousand barrels/day in 2020

[17]. Oil imports, according to [16], amounted to about 2.9 million barrels/day in 2019 and 3.034 million barrels/day in 2018 according to [16 and 3]; in terms of this indicator the country ranks 5th in the world. Saudi Arabia (27%) was the largest oil supplier to South Korea in 2020, followed by Kuwait (14%), the USA (14%), Iraq (11%) and United Arab Emirates (8%) [16]. South Korea is the third largest importer of LNG in the world after China and Japan [16].

According to [3], in 2019 South Korea imported 55.41 billion cubic metres of natural gas, or about 2 Tcf of LNG [16].

The main LNG importer to South Korea is Qatar, which accounts for 27% [16], followed by Australia, the USA and Malaysia. Gas production in South Korea in 2019 was 8.5 Bcf, against a consumption of 1886 Bcf.



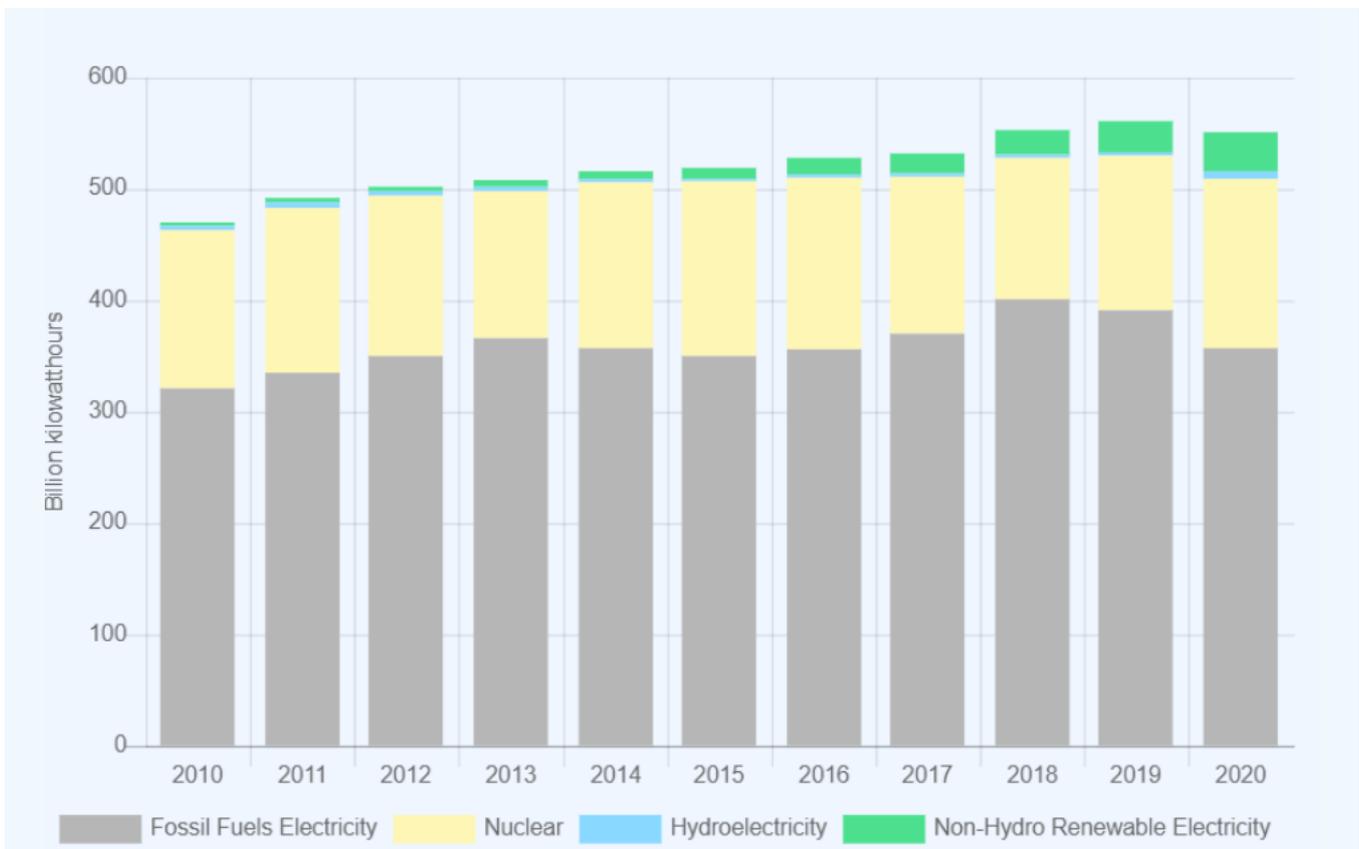
Source: U.S. Energy Information Administration (Dec 2021) / <https://www.eia.gov/>

Figure 2. The production and consumption of fossil fuels in South Korea (coal-left, gas-in the center, oil-right)

According to [16] in 2019 South Korea was the world's fourth largest coal importer. Coal consumption in the country has been gradually increasing since 2001, and in 2021 totalled 139 MMst [16,17]. According to BP's review, coal consumption in 2021 was 3.04 exajoules [7]. In 2021 the country imported about 138 MMst of coal,

mainly from Australia (35%), Indonesia (21%) and Russia (20%).

Historically, South Korea has predominantly relied on fossil energy sources for electricity production (Fig. 3).

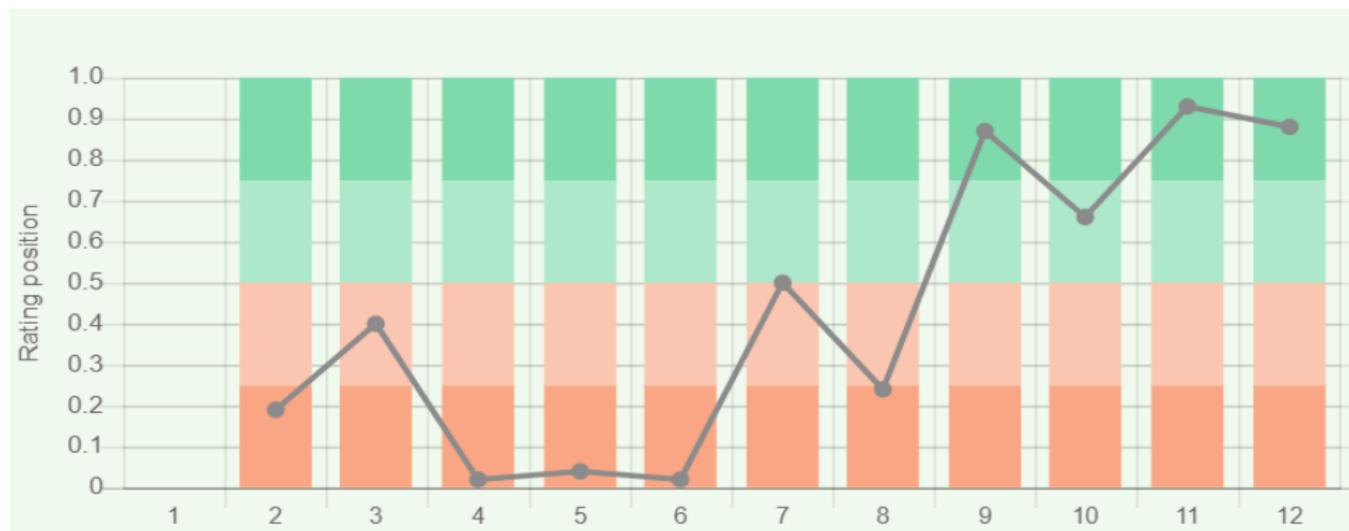


Sources: U.S. Energy Information Administration Dec 2021) / <https://www.eia.gov/>

Figure 3. Electricity generation in South Korea

According to the U.S. Energy Information Administration, South Korea produced 549.87 TWh of electricity in 2020, where fossil fuels accounted for 64.9%, nuclear power – 27.7%, renewables – 5.3%, and hydropower 1.1% (Fig.6).

South Korea's position in the comparative diagram of energy index is shown in Figure 4.



Sources:
 1. Crude oil proved reserves, 2021 / International Energy Statistic/Geography / U.S. Energy Information Administration (Nov 2021)*98
 2. Natural gas proved reserves 2021 / International Energy Statistic / Geography / U.S. Energy Information Administration (Nov 2021) *99
 3. Total recoverable coal reserves 2019 / International Energy Statistic / Geography / U.S. Energy Information Administration (Nov 2021) *81
 4. Combination production-consumption for Crude oil 2018 / International Energy Statistic / Geography / U.S. Energy Information Administration (Nov 2021) *219
 5. Combination production-consumption for Natural gas 2019 / International Energy Statistic / Geography / U.S. Energy Information Administration (Nov 2021) *123
 6. Combination production-consumption for Coal 2019 / International Energy Statistic / Geography / U.S. Energy Information Administration (Nov 2021) *128
 7. Electricity – from other renewable sources (% of total installed capacity), 2017 est. / The World Factbook / Library / Central Intelligence Agency *170
 8. GDP per unit of energy use (PPP per unit of oil equivalent), 2020 *66
 Primary energy consumption - BP Statistical Review of World Energy 2021/BP;GDP (purchasing power parity) - The World Factbook/Library/Central Intelligence Agency
 9. Energy use (primary energy use of oil equivalent per capita) 2020 *127
 Primary energy consumption – BP Statistical Review of World Energy 2021; Population - United Nations, Department of Economic and Social Affairs, Population Division (2019). World Population Prospects 2019, custom data acquired via website. Retrieved 15 November 2021*66
 10. The Global Energy Architecture Performance Index Report (EAPI) 2017 / Rankings / Reports / World Economic Forum
 11. Electric power consumption (kWh per capita), 2016 *217
 Electricity Consumption - The World Factbook / Library / Central Intelligence Agency; Population - United Nations, Department of Economic and Social Affairs, Population Division (2019). World Population Prospects 2019, custom data acquired via website. Retrieved 15 November 2021
 12. Combination of electricity production-consumption (kWh)/The World Factbook/Library/Central Intelligence Agency *216
 * Total number of countries participating in ranking

Figure 4. Energy indices of South Korea

As already mentioned, fossil energy resources in South Korea are relatively limited, so the first six indices are either at the bottom half of the diagram or the country is not included.

In another rating from 2017 listing countries by their production of electricity from renewable sources (excluding hydropower), South Korea was 85th out of 213 countries selected for consideration.

In the Energy Architecture Performance Index 2017, which is based primarily on the level of economic growth, environmental safety and energy independence of the country, including access to energy, South Korea was 43rd out of 127 countries selected for consideration; it should be noted that during the previous 8 years the country has gained 5 ranking positions.

Energy Infrastructure

A territorial map showing the distribution of the largest infrastructure projects of the fossil fuel sector in South Korea is shown in Figure 5.

The largest natural gas field is Donghae-1, with proven reserves of 186 Bcf [19]. Gas is imported to South Korea

South Korea is 56th out of 66 countries ranked by the ratio of GDP per unit of energy use in 2020; the energy consumption per capita is much higher – 8th out of 66 countries.

In terms of electricity consumption per capita, the country is 16th in the world; similarly, for combined electricity production-consumption, South Korea placed 25th in the ranked list of 216 countries, ahead of a number of Asian countries.

More information about the energy balance of South Korea can be found in the documents from our reference library [here](#).

via five LNG terminals; the largest is Incheon, KOGAS LNG Import Terminal, with an installed capacity of 38.0 mln tons/year [20]. The Ulleung-Basin hydrates deposit was discovered in the east of the country (Fig. 5). The installed capacity of oil refineries in South Korea totalled 3,169 thousand barrels/day in 2016 [21].



Figure 5. Basic infrastructure facilities of the fossil fuel sector in South Korea

The largest refinery, owned by SK Energy, is situated in Ulsan and has an installed capacity of 840 000 barrels/day [22]. One of the main oil terminals is situated in Incheon and the largest petroleum products storage facility is located in Pangyo, with a storage capacity of 2,059,000 barrels [23]. Transportation of crude oil and petroleum products is carried out via pipelines with a length of 16 km and 889 km, respectively (Fig.5).

The largest coal field is Jang Seong owned by Korea Coal Co., which produced around 272,000 tons in 2018 [24]. With regard to the country's coal infrastructure, the largest coal gasification plant is Gwangyang with an installed capacity of 500 MW [25]. The map of the territorial distribution of the largest infrastructure objects of electricity generation in South Korea is shown in Figure 6.

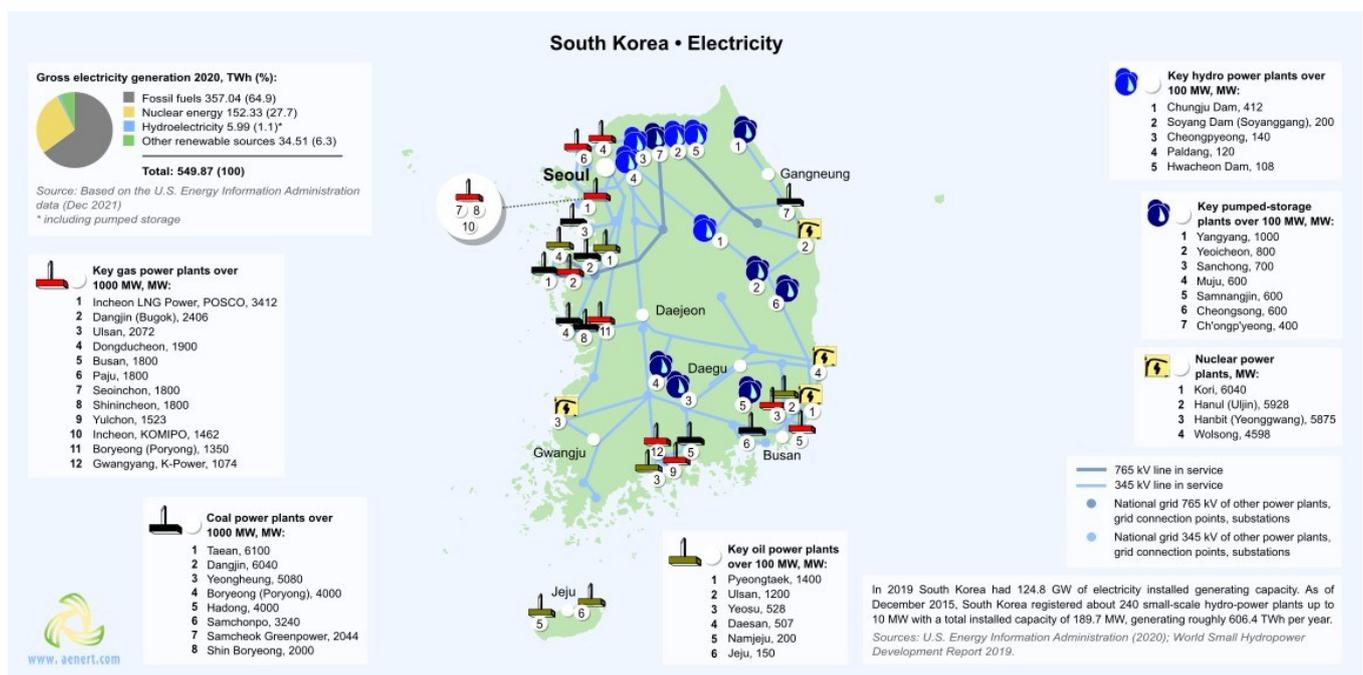


Figure 6. Electricity production in South Korea

According to the U.S. Energy Information Administration, the share of fossil fuels in electricity generation in South Korea in 2020 was about 64.9% (Fig. 6).

The country has a significant number of stations for the production of electricity from hydrocarbons, including 12 gas power stations with an installed capacity of at least 1,000 MW, 8 coal power stations with an installed capacity of at least 1,000 MW, 6 oil power stations with an installed capacity of at least 100 MW, and 4 nuclear power stations with an installed capacity of at least 4,000 MW (Fig. 6).

The largest South Korean power plants are: Incheon gas power plant with a capacity of 3,412 MW [26], Taean coal power plant with a capacity of 6,100 MW [27],

Pyeongtaek oil power plant, with a capacity of 1,400 MW [28], Kori nuclear power plant with a capacity of 6,040 MW [29].

Hydropower in South Korea has a small share in electricity generation (1.1%) and is represented by seven large pumped storage stations, five hydroelectric power stations and 240 small hydroelectric power stations, with a total capacity of 189.7 MW (Fig. 6). The largest pumped-storage power station is Yangyang with an installed capacity of 1,000 MW [30]. The main hydroelectric power plant is Chungju Dam with an installed capacity of 400 MW [31].

Figure 7 shows the main infrastructure facilities in South Korea for the production of renewable energy.

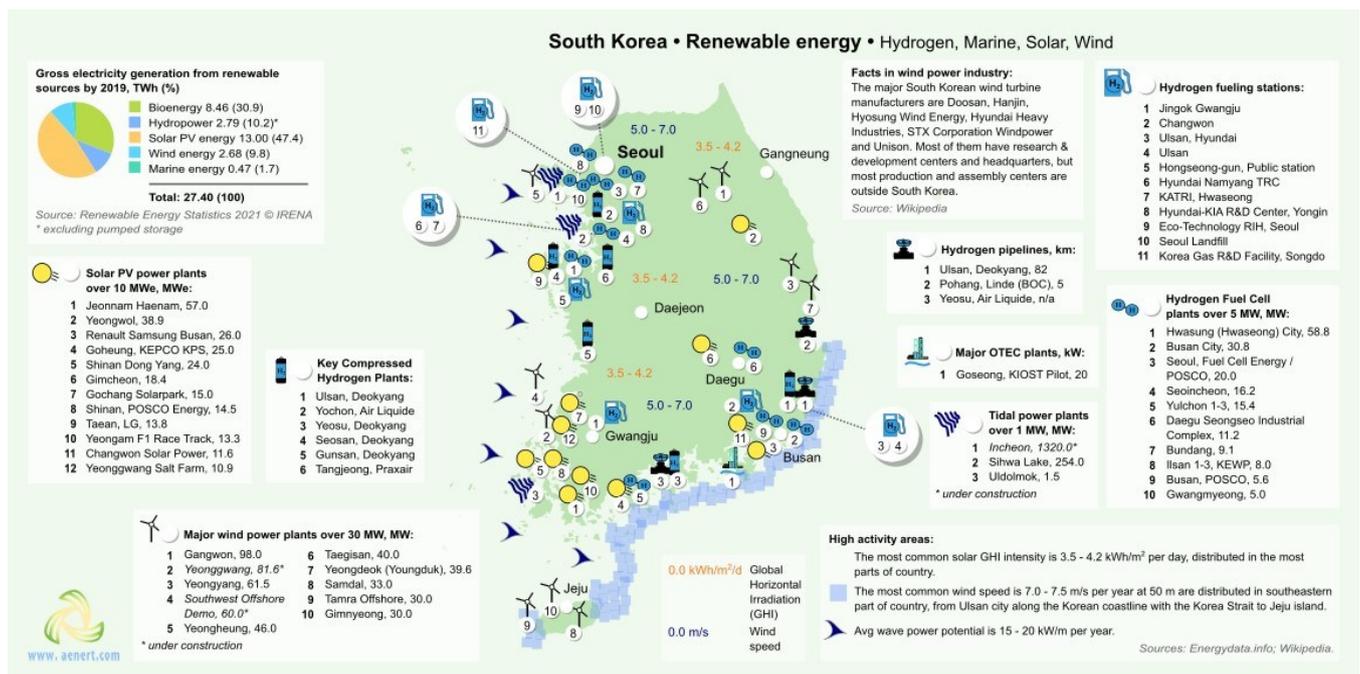


Figure 7. Renewable energy in South Korea: solar, wind, marine and hydrogen

As noted above, renewable energy (excluding hydroenergy) in South Korea accounts for 6.3% (34.51 TWh) of electricity generation (Fig. 6).

In zones of high wind activity, in the south and south-east of the country, there are 9 wind parks, with a capacity of more than 30 MW. In 2017 the total installed capacity of wind power in South Korea was 1,143 MW [32]. The largest wind park is Gangwon with an installed capacity of 98 MW [33].

As mentioned earlier, the level of direct solar radiation in some areas of the country can reach 4.2 kWh/m², which is a sufficient resource for electricity production by means of photovoltaics [11]. Consequently, there are a large number of solar energy facilities, including 12 photovoltaic stations with a capacity of more than 10 MW. The largest solar park is Jeonnam Haenam with an in-

stalled capacity of 57 MW [34]. As already mentioned, the wave energy potential is 15-20 kW/m per year [13], however, the potential of tidal energy is higher, and in the Incheon Bay area the largest power station in the country is being constructed that will utilise wave energy with a planned installed capacity of 1,320 MW [35]. The Ocean Thermal Energy Conversion Plant, located in the south of the country, uses ocean energy and has an installed capacity of 20 kW [36]; it is one of the largest enterprises of this type in the world. This technology is based on the process of converting the thermal energy of the ocean (OTEC), by using a temperature difference between warm layers of sea water on the ocean surface and cold sea water at a depth of between 800 - 1 000 metres for electricity generation.

South Korea is actively developing hydrogen as an energy source for vehicles. At the beginning of 2022, more than 110 hydrogen filling stations were operating in the country. There are also several plants producing hydrogen in the country, including the largest one in Ulsan, managed by Deogyang with an installed capacity

of 64,000 Nm³/hr [37]. In addition South Korea is actively using Hydrogen Fuel Cell Plants, the largest one of which is Hwasung with an installed capacity of 58.8 MW [38]. Hydrogen is transported via a network of three pipelines (Fig. 7). Figure 8 shows the main bioenergy objects of the country for energy production.

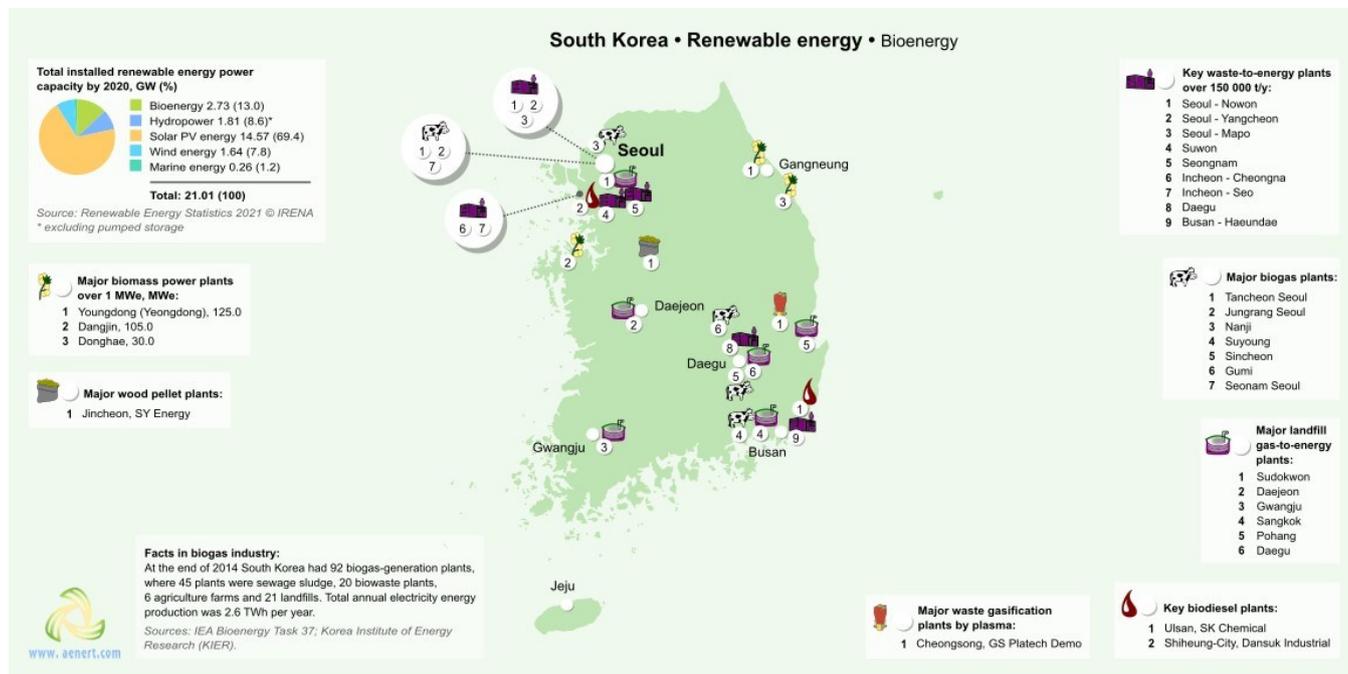


Figure 8. Renewable energy in South Korea: Bioenergy

Bioenergy is being actively developed in South Korea and in 2020 the installed capacity of biomass was around 2.73 GWe (Fig.8).

The Hydrogen Economy Promotion and Hydrogen Safety Management Act (“Hydrogen Act”), the world’s first hydrogen law, took effect on February 5, 2021 in the South Korea. Five South Korean conglomerates and other companies (including Hanwha, Hyosung, Hyundai, SK Group, and POSCO) have committed a combined \$38 billion to boosting the country’s hydrogen economy by 2030, following the enactment of a hydrogen law in 2021. At the same time, the participants plan to multiply the production and consumption of hydrogen by 2030.

The country has biomass and municipal waste processing plants, biodiesel, and pellet production (Fig.8). In 2017, KOSEP converted the Young Dong Unit 1 (Yeongdong) coal-fired power plant into a biomass power plant using pellets as feedstock with an installed capacity of 125 MW [39].

South Korea is engaged in the production of biodiesel, and Ulsan, owned by SK Chemical, can produce 120,000 tons of fuel annually [40]. In the field of biogas production the leader is Jungrang Water Recycling Centre, capable of producing about 5,112 m³ per day [41]. The leaders in the generation of electricity from municipal waste are: Cheongsong demo waste gasification plant

by plasma with a capacity of 50 kW [42]; Seoul – Now on waste to energy plant with a capacity of 281,000 tons/year [43]; Sudokwon, which processes about 18,000 tons of landfill gas daily [44]. and the Jincheon enterprise, owned by SY Energy, which is capable of producing 300,000 tons of pellets/year [45].

At the end of 2017 South Korea was at the final stage of shaping the country’s energy strategy until 2030. According to Reuters, the priorities of this strategy are to reduce the share of coal and nuclear power in the production of electricity to 36.1% and 23.9%, respectively (currently the cumulative share is about 70%); and to increase the capacity of the renewable energy sector and increase its share to 20% by 2030. To achieve this goal, it is planned to increase the production capacity of solar energy by 30.8 GW and wind power by 11.3 GW [46]. As such, it is planned to build an offshore wind park with a total capacity of 96.8 MW in the Saemangeum area, which will provide 62,000 families with electricity annually [47]. The government also plans to increase the number of hydrogen filling stations to 200 by 2025 [48].

For current information on the development of energy in the country see [here](#). More information about South Korean energy infrastructure is also available [here](#).

Education and Innovation

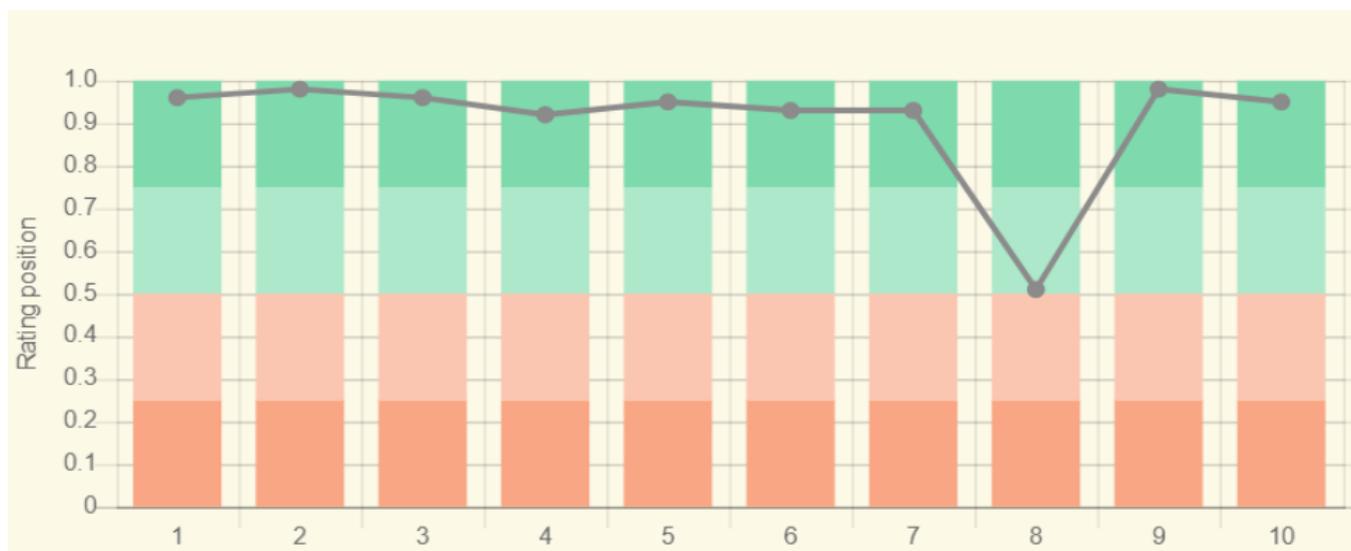
The set of indices reflecting the position of South Korea among other countries in the field of education and innovation can be seen in Figure 9.

It can be seen from the diagram that South Korea has a very high level of academic achievement.

South Korea placed 5th out of 132 countries considered in the Global Innovation Index 2018 (see diagram). According to the number of patents granted to Korean nationals, both domestically and abroad, the country ranks 4th in the world, second to Japan and China in the region. Similarly, by the number of patents in force, the country is above the world average – 4th place, indicating the country's favourable conditions for innovation.

In terms of government expenditure on education as a percentage of the country's GDP, the country

demonstrates a result slightly below the world average – 86th out of 177 countries selected for consideration. Nevertheless, 39 South Korean universities are included in the rating of the world leading universities – “QS University Rating”. It is also worth noting that the country's GDP is high, therefore, in absolute terms the level of government expenditure on education is considerable. In terms of public expenditure on research and development as a percentage of GDP, the country is 2nd. South Korea is very well positioned when considering the number of publications of specialists in scientific and technological journal and patent activities. The country is 13th out of 240 participating countries in the Scimago ranking, and in Scientific and Journal Activities is ranked 9th out of 197 countries, behind China, Japan and India in the region. The country is also among the leaders in the region in terms of the number of Internet users.



Sources:

1. The Global Innovation Index 2021, Rankings / Knowledge / World Intellectual Property Organization / Cornell University, INSEAD, and WIPO (2021): Energizing the World with Innovation. Ithaca, Fontainebleau, and Geneva *132
2. Patent Grants 2011-2020, resident & abroad / Statistical country profiles / World Intellectual Property Organization *185
3. Patents in Force 2020 / Statistical country profiles / World Intellectual Property Organization *109
4. QS World University Rankings 2022 *97
5. SCImago Country Rankings (1996-2020) / Country rankings / SCImago, (n.d.). SIR-SCImago Journal & Country Rank [Portal]. Retrieved 17 Nov 2021 *240
6. Internet users in 2018 / The World Factbook / Central Intelligence Agency *229
7. Internet users in 2018 (% Population) / The World Factbook / Central Intelligence Agency *229
8. Government expenditure on education, total (% of GDP), 2019 / United Nations Educational, Scientific, and Cultural Organization (UNESCO) Institute for Statistics. License: CCBY-4.0 / Data as of September 2021 *177
9. Research and development expenditure (% of GDP), 2018 / UNESCO Institute for Statistics. License: CCBY-4.0 / Data *119
10. Scientific and technical journal articles, 2018 / National Science Foundation, Science and Engineering Indicators. License: CCBY-4.0 / Data *197

* Total number of countries participating in ranking

Figure 9. The indices of education and innovation in South Korea

South Korean universities, such as Pohang University of Science & Technology, Seoul National University, Yonsei University, and Yeungnam University train specialists in various fields of energy, including Environmental Engineering, Energy Engineering, and Mining Engineering, etc.

In the field of unconventional oil, Korea Research Institute of Chemical Technology (KRICT), Korea Institute of Energy Research (KIER), SK Innovation Co. Ltd., SK Energy Co. Ltd. should be mentioned.

The Korea Institute of Energy Research (KIER), Korea Research Institute of Chemical Technology (KRICT), Korea Institute of Science and Technology (KIST) are actively engaged in research in this field.

In the field of synthetic fuel production, leaders in patenting among South Korean companies are POSCO, CRI Co. Ltd., SK Innovation Co. Ltd. Research and development in this field is carried out by Sejong University, the INHA University, and Kangwon National University. Another area in which South Korean companies patent their inventions is associated gas, and here the leaders are Korea Institute of Science and Technology (KIST), Korea Research Institute of Chemical Technology (KRICT). Leading research organizations in this field are Seoul National University, Samsung Heavy Industries Co. Ltd., and Korea Gas Corporation. The leading patent holders in the field of coalbed methane are Chonnam National University, Hanyang University, and the Korea Institute of Geoscience and Mineral Resources (KIGAM) conduct their research in this field.

In the field of hydrocarbon production from reservoirs with low permeability – GE Engineering and Construction, Korea Institute of Geoscience and Mineral Resources (KIGAM), Korea Research Institute of Chemical Technology (KRICT) and the following research agencies are actively engaged in research: Hanyang University, the Korea Institute of Geoscience and Mineral Resources

(KIGAM), and the Korea Advanced Institute of Science and Technology (KAIST).

The leading patent holders in the field of bioenergy are the Korea Institute of Energy Research (KIER), SK Innovation Co. Ltd., Korea Research Institute of Chemical Technology (KRICT). The Korea Advanced Institute of Science and Technology (KAIST), Korea Institute of Energy Research (KIER), and Seoul National University are conducting research in this area.

A large number of companies patent technical solutions in the field of energy production from renewable sources. In the field of solar energy are Anycasting Co. Ltd., Korea Institute of Energy Research (KIER), Samsung Electronics Co. Ltd. Leading research organizations in this field are the Korea Institute of Energy Research (KIER), Hanyang University, and the Korea Advanced Institute of Science and Technology (KAIST).

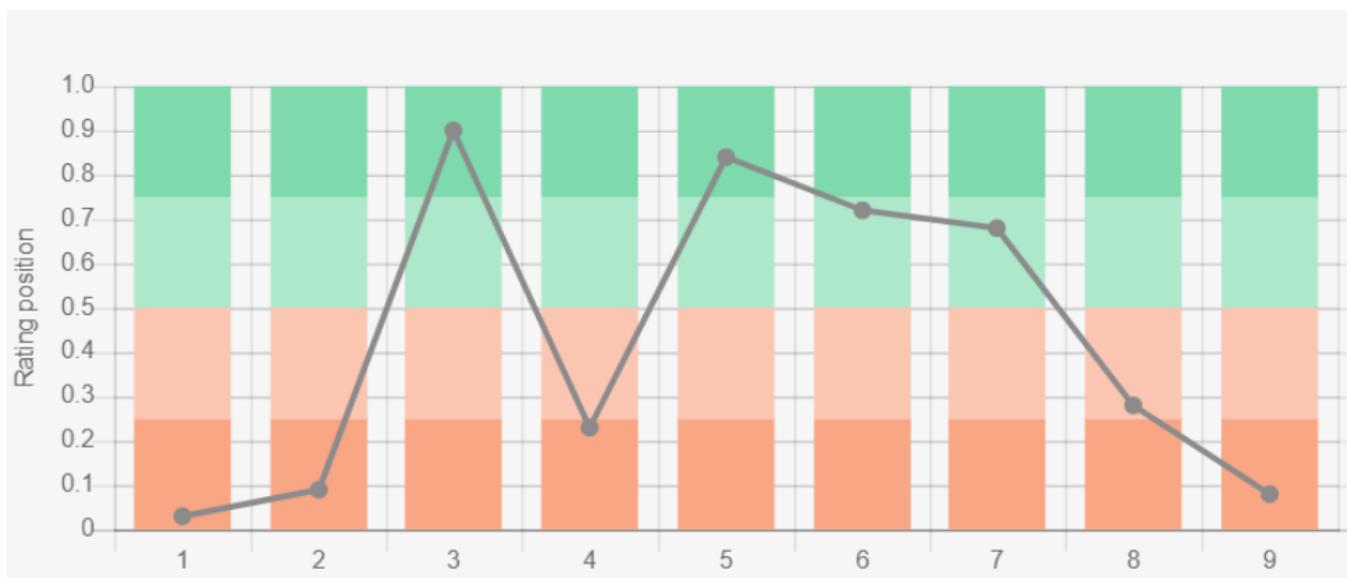
Samsung Heavy Industries Co. Ltd., Doosan Heavy Industries and Construction, Chonbuk National University are all ahead in the number of patents in the field of wind power; research in this field is being conducted by Chonbuk National University and Hanyang University.

Additional information about education in the country can be obtained [here](#), and the list of research institutes [here](#).

Ecology and Environmental Protection

The diagram of environmental indices presented in Figure 10 to some extent reflects the ecological situation in

the country. South Korea demonstrates a relatively high level of CO₂ emissions, both in general, and per capita.



Sources:

1. CO₂ total emission by countries 2020 / European Commission / Joint Research Centre (JRC) / Emission Database for Global Atmospheric Research (EDGAR)*208
2. CO₂ per capita emission 2020/European Commission/Joint Research Centre (JRC) / Emission Database for Global Atmospheric Research (EDGAR) *208
3. Forest area 2020 (% of land area) / The Global Forest Resources Assessment 2020 / Food and Agriculture Organization of the United Nations *234
4. Forest area change 2010-2020 (1000 ha/year) / The Global Forest Resources Assessment 2020 / Food and Agriculture Organization of the United Nations *234

5. The Environmental Performance Index (EPI) 2020 / Rankings / Yale Center for Environmental Law & Policy / Yale University *180
 6. Annual freshwater withdrawals (m³ per capita), 2017 *179
Annual freshwater withdrawals, total (billion m³), 2017 – Food and Agriculture Organization, AQUASTAT data. /License: CC BY-4.0; Population – United Nations, Department of Economic and Social Affairs, Population Division (2019).
World Population Prospects 2019, custom data acquired via website. Retrieved 15 November 2021
 7. The National Footprint Accounts 2017 (Biocapacity Credit / Deficit) / Global Footprint Network *188
 8. Methane emissions (kt of CO₂ equivalent), 2018 / Data for up to 1990 are sourced from Carbon Dioxide Information Analysis Center, Environmental Sciences Division, Oak Ridge National Laboratory, Tennessee, United States. Data from 1990 are CAIT data: Climate Watch. 2020. GHG Emissions. Washington, DC: World Resources Institute. Available at: License : Attribution-NonCommercial 4.0 International (CC BY-NC 4.0) *191
 9. The Climate Change Performance Index (CCPI) 2022 / Overall Results / Jan Burck, Thea Uhlich, Christoph Bals, Niklas Höhne, Leonardo Nascimento / Germanwatch, NewClimate Institute & Climate Action Network *60
- * Total number of countries participating in ranking

Figure 10. South Korean environmental indices

It is also necessary to note the high level of methane emissions in the country. South Korea is included in the Climate Change Performance Index (CCPI) 2022, which consists of 61 positions and includes the countries responsible for more than 90% of global energy-related CO₂ emissions; South Korea occupies 59th place as a "very poor" performer (among countries with a high level of negative influence among those selected for consideration); such a low result is indicative of the increasingly coal reliant infrastructure in the country.

In terms of forest area as a percentage of the country, South Korea was 24th in the world in 2020; however, the trend associated with its change from 2010-2020 looks very negative and according to this indicator, the country is 135th in the world. In the Environmental Performance Index (EPI) rankings, which focuses primarily on assessing the environmental performance of national gov-

ernments, the country was 60th out of 180 countries in 2018, but in 2020 rose to 28th.

According to the Environmental Vulnerability Index, which is based on years of observations and 50 indicators that include, for example, changing climatic characteristics or the quality of water resources, waste volumes, oil spills and other hazardous substances, etc. South Korea is 205th out of 234 countries, and is characterized as "extremely vulnerable". According to the Ecological Footprint Atlas rating, South Korea is among a number of ecological debtors.

For more information on the energy industry of South Korea, see the attached link library by clicking [here](#).

References

- [1] List of sovereign states and dependencies by area / Wikipedia / https://en.wikipedia.org/wiki/List_of_sovereign_states_and_dependencies_by_area
 - [2] List of countries and dependencies by population density / Wikipedia / https://en.wikipedia.org/wiki/List_of_countries_and_dependencies_by_population_density
 - [3] South Korea / The world factbook / Library / Central Intelligence Agency / <https://www.cia.gov/>
 - [4] GDP, PPP (constant 2011 international \$) / World Bank, International Comparison Program database. License: CC BY-4.0 / Data / The World Bank / <http://www.worldbank.org/>
 - [5] GDP per capita, PPP (current international \$) / World Bank, International Comparison Program database. License: CC BY-4.0 / Data / The World Bank / <http://www.worldbank.org/>
 - [6] Coal Reserves / U.S. Energy Information Administration (December 2021) <http://www.eia.gov/>
 - [7] BP Statistical Review of World Energy 2021 (PDF) / BP / <https://www.bp.com/>
 - [8] 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2, Energy, Fugitive Emissions (PDF) / The Intergovernmental Panel on Climate Change (IPCC) / www.ipcc-nggip.iges.or.jp
 - [9] Solar resource data obtained from the Global Solar Atlas, owned by the World Bank Group and provided by Solargis / Global Solar Atlas / <http://globalsolaratlas.info/>
 - [10] Wind Map / Global Wind Atlas 2.0, a free, web-based application developed, owned and operated by the Technical University of Denmark (DTU) in partnership with the World Bank Group, utilizing data provided by Vortex, with funding provided by the Energy Sector Management Assistance Program (ESMAP). For additional information: <https://globalwindatlas.info>
 - [11] World Energy Resources: Hydro World Energy Council / 2013 / Publications / World Energy Council / www.worldenergy.org/
 - [12] World wave energy resource map / Wikipedia / https://en.wikipedia.org/wiki/Wave_power#Potential
 - [13] Agricultural land (% of land area) / Food and Agriculture Organization, electronic files and web site. License: CC BY-4.0 / Data / The World Bank / <http://www.worldbank.org/>
 - [14] Forest area (% of land area) / Food and Agriculture Organization, electronic files and web site. License : CC BY-4.0 / Data / The World Bank / <http://www.worldbank.org/>
 - [15] What a Waste 2012 (PDF) / Resources / The World Bank / <http://www.worldbank.org/>
 - [16] South Korea / U.S. Energy Information Administration (November 6, 2020) / <http://www.eia.gov/beta/international/>
 - [17] International Energy Statistic / Geography / U.S. Energy Information Administration (Jan 2020) / <http://www.eia.gov/beta/international/>
 - [18] Korea / Statistics / © OECD / IEA 2018, IEA Publishing, Licence: www.iea.org/t&c / International Energy Agency / <https://www.iea.org>
 - [19] Korea National Oil Corporation / <http://www.knoc.co.kr/>
-

- [20] Incheon, KOGAS LNG Import Terminal / Source Watch / https://www.sourcewatch.org/index.php/Incheon_LNG_Terminal
- [21] OPEC Annual Statistical Bulletin 2017 (PDF)/ Organization of the Petroleum Exporting Countries (OPEC) / <http://www.opec.org/>
- [22] SK Ulsan Refinery / A Barrel Full / <http://abarrelfull.wikidot.com>
- [23] Main Facilities / Daehan Oil Pipeline Corporation (DOPCO) / <http://www.dopco.co.kr/>
- [24] Domestic / Korea Coal Corporation / <https://www.kocoal.or.kr/>
- [25] Gwangyang - Posco Gas Power Plant / Industry About / <https://www.industryabout.com/>
- [26] Incheon LNH Combined Cycle Power Plant / POSCO Energy / <http://eng.poscoenergy.com/>
- [27] Taean power station / Source Watch / <https://www.sourcewatch.org/>
- [28] Pyeongtaek Oil Power Plant / Industry About / <http://www.industryabout.com/>
- [29] Kori Nuclear Power Plant / Wikipedia / http://en.wikipedia.org/wiki/Kori_Nuclear_Power_Plant
- [30] ALSTOM to supply equipment to South Korean pumped-storage project / 2015 / Press release / ALSTOM / <http://www.alstom.com/>
- [31] Chungju Dam / Wikipedia / http://en.wikipedia.org/wiki/Chungju_Dam
- [32] Wind power in South Korea / Wikipedia / https://en.wikipedia.org/wiki/Wind_power_in_South_Korea
- [33] Project List / Eurus Energy / <http://www.eurus-energy.com/>
- [34] "국내 최대 57MW 태양광발전소친환경 전기 생산 (Eco-friendly electricity production of 57 MW solar power plant in Korea)" / Industry News / <http://www.industrynews.co.kr/>
- [35] Incheon Tidal Power Station / Wikipedia / https://en.wikipedia.org/wiki/Incheon_Tidal_Power_Station
- [36] Ocean Thermal Energy Conversion Technology Brief 1. June 2014 (PDF)/ International Renewable Energy Agency (IRENA) / <http://www.irena.org/>
- [37] Merchant Hydrogen Plant Capacities in Asia / Hydrogen Tools / <https://h2tools.org/>
- [38] Hydrogen Industry and Association of KOREA Association Of KOREA (PDF) / International Energy Association / <https://www.iea.org/>
- [39] Aging Coal Plant Reopens as Biomass Plant / The Korea Bizwire / <http://koreabizwire.com/>
- [40] Biodiesel production begins at plant in South Korea / Agribusiness Intelligence / <https://iegvu.agribusinessintelligence.informa.com/>
- [41] Korea 2013 / Country Reports / IEA Bioenergy / <http://www.iea-biogas.net/>
- [42] Waste-to-Energy System Using Ballard Fuel Cells Successfully Supplies Power to S.Korean Grid / CISION PR Newswire / <https://www.prnewswire.com/>
- [43] Seoul – Now on Waste-to-energy plant / Industry About / <http://www.industryabout.com/>
- [44] Sudokwon Landfill Site Management Corp. / Ministry of Environment / <http://eng.me.go.kr/>
- [45] Largest Pellet Production Plant in South Korea now producing/ Largest Pellet Production Plant in South Korea now producing / BcB Business con BIO / <http://www.business.conbio.info/>
-

[46] South Korea finalizes energy plan to boost renewable power generation / DECEMBER 29, 2017 / Reuters / <https://www.reuters.com/>

[47] South Korea to Set Up 96.8MW Offshore Wind Farm at Saemangeum / offshoreWIND.biz / <https://www.offshorewind.biz/>

[48] South Korea-Government Committed to Increase Number of Station by 2020 / FuelCellsWorks / <https://fuelcellsworks.com/>

The sources of charts and curves are specified under the images.