



IEA Bioenergy
Technology Collaboration Programme

Implementation of bioenergy in the Republic of Korea - 2021 update

Country Reports

IEA Bioenergy: 10 2021



This report was prepared from the 2021 IEA World Energy Balances and Renewables Information, combined with data and information provided by the IEA Bioenergy Executive Committee and Task members¹. Reference is also made to FAOstat as well as data from national statistics. All individual country reports were reviewed by the national delegates to the IEA Bioenergy Executive Committee, who have approved the content. General background on the approach and definitions can be found in the central introductory report for all country reports.

Edited by: Luc Pelkmans, Technical Coordinator IEA Bioenergy

Contributions: In-Gu Lee, Nayoung Kim (Korea Institute of Energy Research)

HIGHLIGHTS

- Renewables make up a modest share of 3.2% of final energy consumption in the Republic of Korea in 2019. Around two thirds of renewable energy is from biomass (including renewable waste). Oil products, coal and natural gas are still largely dominating the Korean energy system.
- Coal is the most important source for power production, followed by natural gas and nuclear energy. Since 2015 there has been some growth of biomass use for power production, but levels are still very low (<2%) compared to the 43% produced by coal.
- Only 3% of heat comes from renewable sources, predominantly biomass. Heat provision is dominated by natural gas, followed by oil products, coal and industrial waste.
- Diesel is the dominant transport fuel in Korea. Biodiesel is blended at an average share of 3.5% (by volume) in diesel fuel. There is no reporting of bio-ethanol use.
- The Republic of Korea has important opportunities to further deploy bioenergy, particularly through the replacement of coal by solid biomass in existing assets, the increase of transport biofuels and the increase of biogas. There are also further opportunities to deploy (renewable) energy from MSW.

¹ While data for 2020 are starting to become available at national level, it was decided to consider trends up to 2019 for good comparability and benchmarking between the different IEA Bioenergy member countries. Care should also be taken when using 2020 data for analysing trends as these data are distorted by the COVID19 Pandemic.

COUNTRY PROFILE

Population and land use

The Republic of Korea is situated in East Asia and forms the southern part of the Korean peninsula. It has a total land area of 97.5 thousand km² and a population of 51.2 million people, which represents a very high population density of 525 persons per km². Most of the population lives in urban areas. The country is largely industrialised and has an important tertiary sector.

Around two thirds of the land area is forest land (*of which 7% protected*). 17% is agricultural land, which is mostly arable land.

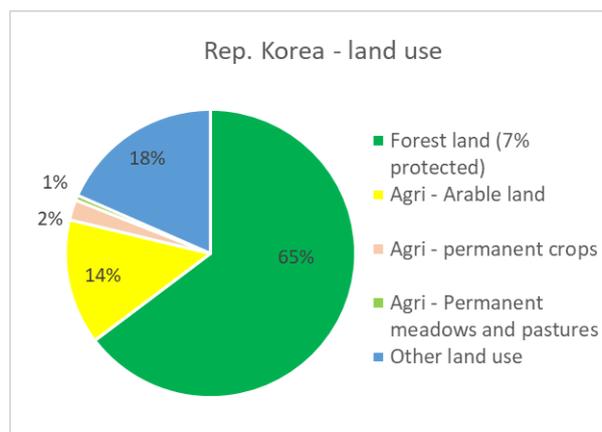


Figure 1: Land use in The Republic of Korea (2018 figures - Source: FAOstat)

Final energy consumption

Overall final energy consumption in the Republic of Korea (*also including non-energy use of oil, natural gas, and coal in industry*) equates 3.55 tonnes of oil equivalent (toe) per capita, which is considerably higher than the average of IEA Bioenergy member countries. This is mainly related to the high energy consumption in industry, and particularly also the non-energy use of oil. Energy use in the tertiary sector (services) is also high.

Table 1: Distribution of the final consumption of energy carriers by sector in The Republic of Korea (2019 figures - Source: IEA (2021) World Energy Balances and Renewables Information)

Final consumption energy carriers	Toe/capita (2019)	% of total	Median* (toe/capita)
Industry (energy use)	0.92	26%	0.67
Industry (non-energy use)	1.03	29%	0.21
Transport	0.72	20%	0.69
Residential	0.40	11%	0.57
Commercial & public services	0.41	11%	0.34
other	0.08	2%	
Total	3.55		2.34

* Median of the 25 member countries of IEA Bioenergy²

² Comparative figures of the different IEA Bioenergy member countries are discussed in the central Countries' Report.

NATIONAL POLICY FRAMEWORK IN THE REPUBLIC OF KOREA

TARGETS AND STRATEGIES

For 2030, under the 2015 Paris Agreement, Korea has committed to reduce GHG emissions by 37% compared to the BAU scenario of 851 Mt CO₂-eq, implying that emissions will reach 536 Mt CO₂-eq in 2030. This is equivalent to 24.4% below 2017 emissions. Korea is committed to increasing the share of renewables in power generation up to 20% by 2030.³

In a speech to parliament on 28 October 2020, President Moon Jae-in declared that the country would pursue the aim of achieving carbon neutrality by 2050. In December 2020, the government adopted the carbon-neutral strategy towards a sustainable and green society. The strategy will support innovative climate technologies promoting carbon neutrality, but also all efforts towards making South Korea a leading example in the attainment of this goal. The strategy has the following five key elements⁴:

1. expanding the use of clean power and hydrogen across all sectors;
2. improving energy efficiency significantly;
3. commercial deployment of carbon removal and other future technologies;
4. scaling up the circular economy to improve industrial sustainability;
5. enhancing carbon sinks.

The strategy will support innovative technologies such as energy storage systems (ESS) for reliable power supply and hydrogen fuel cells for auxiliary power sources. South Korea plans to phase out coal power plants or to convert them to LNG power plants. In addition, CCUS technology will be applied to coal-fired power plants in order to minimise GHG emissions.

On December 29, 2020, Korea's Ministry of Trade, Industry and Energy (MOTIE) unveiled two crucial long-term energy policy plans. The 9th Basic Plan on Supply and Demand of Electricity and the 5th Basic Plan for New & Renewable Energy provide additional clarity on how Korea's primary energy regulator intends to manage the nation's energy transition from its current reliance on fossil fuel to achieve carbon neutrality by the year 2050.

The **9th S&D Basic Plan** reaffirms the government's will to:

- expand new and renewable energy facilities;
- accelerate the phase-out of domestic coal and nuclear power production; and
- rely on LNG to compensate for the phase-out of coal and nuclear power production in the short-to-mid-term.

The following table sets out changes in generation capacity by power source as projected by the 9th S&D Basic Plan.

³ Source: IEA: Korea 2020 – Energy Policy Review: https://iea.blob.core.windows.net/assets/90602336-71d1-4ea9-8d4f-efeeb24471f6/Korea_2020_Energy_Policy_Review.pdf

⁴ [https://www.europarl.europa.eu/RegData/etudes/BRIE/2021/690693/EPRS_BRI\(2021\)690693_EN.pdf](https://www.europarl.europa.eu/RegData/etudes/BRIE/2021/690693/EPRS_BRI(2021)690693_EN.pdf)

Table 2: Annual Changes by power source in Korea - 9th S&D Basic Plan⁵

9 th S&D Basic Plan Overview				
Annual Changes by Power Source				
Coal				
Capacity:	<u>2020</u>	→	<u>2022</u>	→
	35.8GW		38.3GW	→
			<u>2030</u>	→
			32.6GW	→
				<u>2034</u>
				29.0GW (6.8GW↓)
Nuclear				
Capacity:	<u>2020</u>	→	<u>2022</u>	→
	23.3GW		26.1GW	→
			<u>2030</u>	→
			20.4GW	→
				<u>2034</u>
				19.4GW (3.9GW↓)
LNG				
Capacity:	<u>2020</u>	→	<u>2022</u>	→
	41.3GW		43.3GW	→
			<u>2030</u>	→
			54.5GW	→
				<u>2034</u>
				58.1GW (16.8GW↑)
Renewables				
Capacity:	<u>2020</u>	→	<u>2022</u>	→
	20.1GW		29.4GW	→
			<u>2030</u>	→
			58.0GW	→
				<u>2034</u>
				77.8GW* (57.7GW↑)

* The 77.8GW of target capacity of new and renewable energy for 2034 includes 45.6GW from solar power and 24.9GW from wind power.

The 5th Basic Plan on Renewable Energy includes energy portfolio targets, measures to reduce greenhouse gas emissions, methods to evaluate technology standards, and related issues for purposes of encouraging technology development and use of new and renewable energy. The Plan (covering years 2020 to 2034) proposes the following five initiatives:

1. promotion of new and renewable energy supply;
2. improvement of the market system;
3. creation of various demands for new and renewable energy;
4. strengthening research and development; and
5. reinforcement of relevant systems (including transmission grid infrastructure) and maintenance of the operating system.

The 5th Basic Plan sees the share of renewables in power production reaching 22.2% by 2034, or 25.8% if it includes "new energy" such as integrated gasification combined cycle (IGCC) turbines and fuel cells.

⁵ https://www.kimchang.com/en/insights/detail.kc?sch_section=4&idx=22940

Table 3: renewable energy and climate targets in the Republic of Korea.

Sector	Share of renewables in gross final consumption per sector	GHG reduction target
Overall target	12.4% of total energy supply by 2034	-37% by 2030 compared to BAU* (= -24.4% compared to 2017) Carbon neutral by 2050
Buildings & industry sector		-26.6% by 2030 compared to BAU*
Electricity	22.2% by 2034	42.2%
Transport		-29.3% compared to BAU*

* Based on *GHG Reduction Roadmap (December 2016)*; BAU = business as usual scenario

At the COP26 climate conference in Glasgow (November 2021), President Moon Jae-in pledged to cut the nation's greenhouse gas emissions by 40% from 2018 levels by 2030.

A description of renewable energy and climate policies and measures in the Republic of Korea is available at the IEA's Policies and Measures Database: <https://www.iea.org/policies?country=Korea>

Specific policies related to renewable electricity, renewable heat and transport biofuels will be highlighted in the chapters about the role of bioenergy in different sectors.

THE CONTRIBUTION OF BIOENERGY IN NATIONAL ENERGY SUPPLY

TOTAL ENERGY SUPPLY

The total energy supply (TES) of the Republic of Korea in 2019 amounted to 11.7 exajoule (EJ) with fossil fuels (oil, coal, gas) contributing 83%. Oil products (4.4 EJ) are the dominant fuel, representing 37% of total energy supply. Coal (3.4 EJ) represents another 29% and natural gas around 17% (2.0 EJ). Nuclear energy accounts for 14% (1.6 EJ). Renewable energy sources represent a small share of 2% of TES (0.23 EJ), around two thirds being bioenergy.

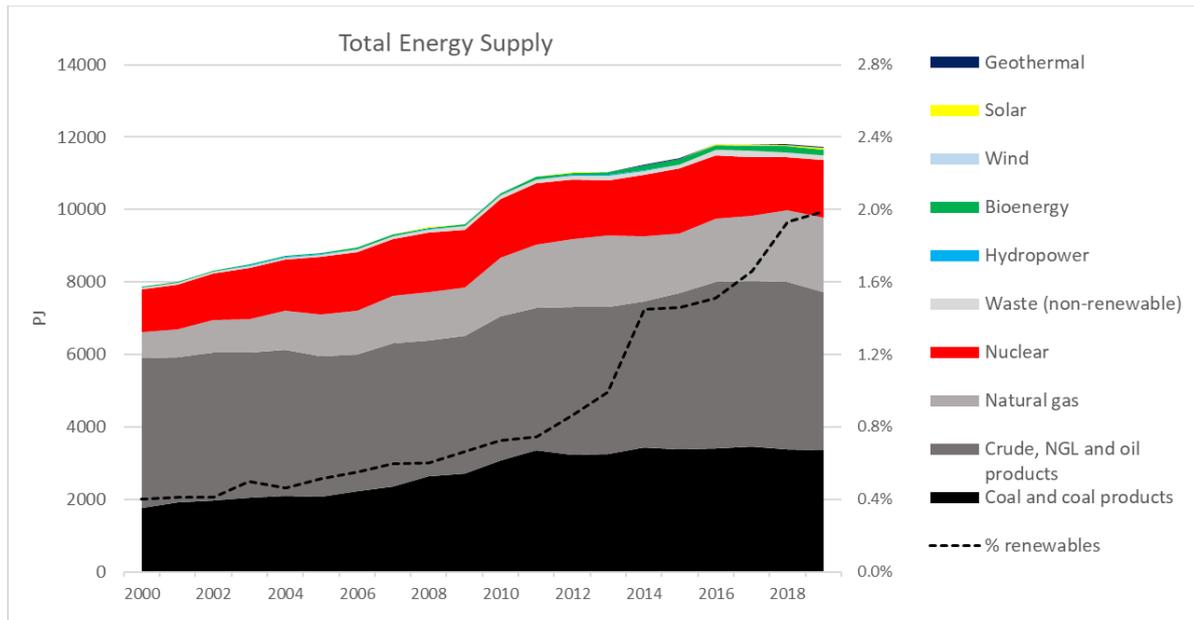
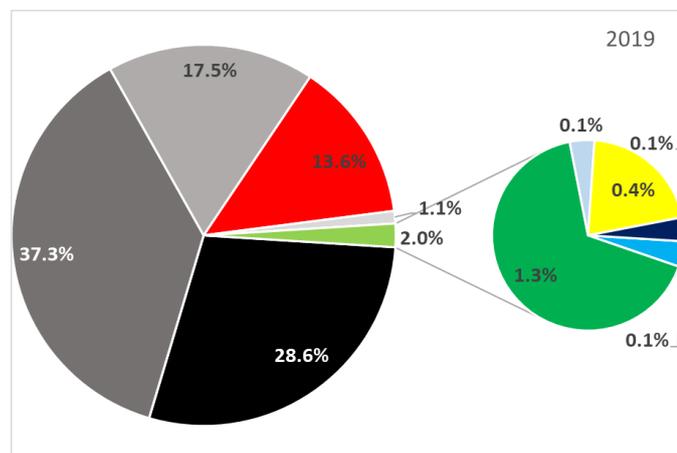


Figure 2: Total energy supply⁶ and the contribution of different energy sources in the Republic of Korea, with distribution in 2019 (Source: IEA (2021) World Energy Balances and Renewables Information)



Total energy supply in the Republic of Korea has steadily increased up to 2016, after which it stabilized around 11.8 EJ. **Oil** products are still dominant, and their share in TES was fairly stable between 36 and 40%. **Coal** increased from 1.7 EJ in the early 2000s to 3.3 EJ in 2010; in the past decade it was very stable around 3.4 EJ. **Gas** was relatively stable in the past decade around 1.7-1.8

⁶ Total energy supply refers to the use of resources. In terms of the role in the energy system this distribution overestimates the role of resources producing electricity with a high share of unused waste heat (like nuclear plants).

EJ and is slightly growing in the past few years, reaching 2.0 EJ in 2019. **Nuclear** energy was also relatively stable between 1.5 and 1.8 EJ in the past decade.

Renewable energy saw some increase in the past decade, albeit at low levels (from 0.7% to 2% of TES). Bioenergy was the most important source of renewable energy and its amount grew from 50 PJ in 2010 to around 160 PJ currently, with almost a doubling from 2013 to 2014. Solar energy increased steadily in the past 10 years from 4 to 50 PJ in 2019, now representing 0.4% of TES. Hydropower, wind power and geothermal energy each only represent 0.1% of TES.

Figure 3 shows the evolution of the different types of bioenergy. Solid biomass represents a little over half of bioenergy; liquid biofuels one third, and renewable waste and biogas the remaining share.

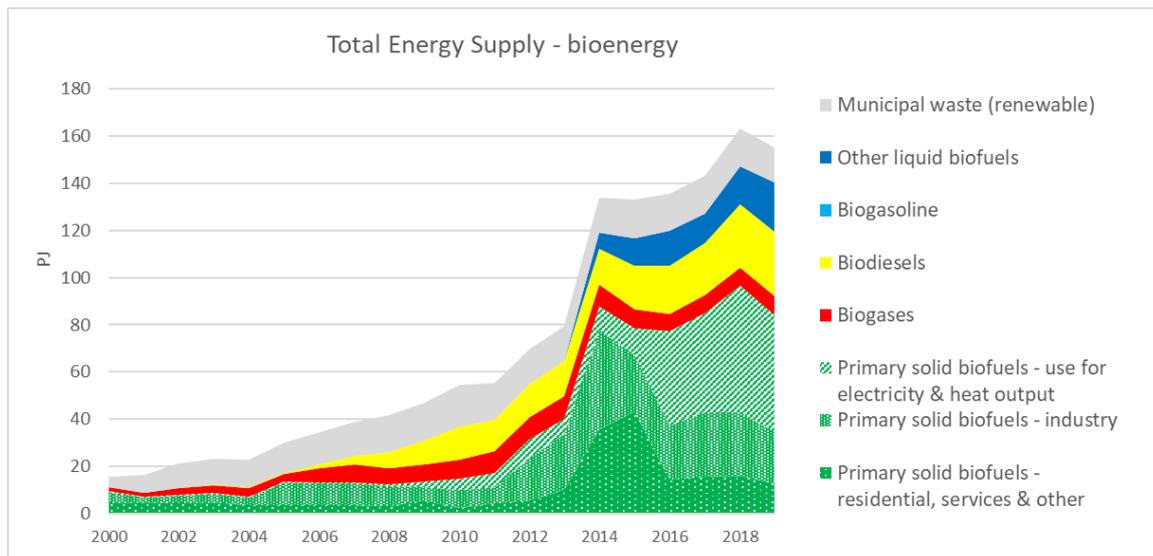


Figure 3: Development of total energy supply from bioenergy in the Republic of Korea 2000 - 2019 (Source: IEA (2021) World Energy Balances and Renewables Information)

Evolution of the bioenergy carriers:

- Up to 2015, solid biofuels were mainly used for energy in industry and also in the tertiary sector (services). Since 2015 there has been a steady growth of biomass use for power production, reaching 50 PJ in recent years, which is still very low compared to the country's coal use of 3350 PJ.
- Biodiesel was introduced around 2005; amounts have consistently grown to 27 PJ in 2019. There are also 21 PJ liquid biofuels that are used for electricity production – this was initiated in 2014.
- There is a small amount of biogas (8 PJ), an amount that has been quite stable since 2007.

Table 4 displays the 2019 total bioenergy supply values on a per capita basis. Compared to the other 24 member countries of IEA Bioenergy (expressed per capita), the Republic of Korea ranks at the lower end for renewable MSW, liquid biofuels and biogas, and very low for solid biofuels.

Table 4: Total energy supply per capita in 2019 for different bioenergy carriers

	Supply per capita	Median IEA Bioenergy members
Bioenergy	3.0 GJ/cap	10.6
Solid biofuels	1.6 GJ/cap	7.0
Renewable MSW	0.3 GJ/cap	0.8
Biogas	0.2 GJ/cap	0.7
Liquid biofuels	0.9 GJ/cap	1.5

Source: IEA (2021) World Energy Balances and Renewables Information

Table 5 indicates the amounts of the different bioenergy carriers compared to some relevant reference points, namely the amount of forest in the country (for solid biomass), the amount of generated MSW (for renewable MSW used for energy), the amount of natural gas consumed in the country (for biogas) and the amount of fossil oil products consumed (for liquid biofuels).

Table 5: Comparison of the supply of different bioenergy carriers in 2019 to specific reference points

	Compared to reference points		Median*
Bioenergy	1.3 %	of total energy supply	7.2 %
Solid biofuels	14.3 GJ/ha_forest	compared to the domestic hectares of forest land (excl. protected)	21.3 GJ/ha_forest
Renewable MSW	0.82 GJ/ton_MSW	compared to the total generated MSW in the country	1.4 GJ/ton_MSW
Biogas	0.004 GJ/GJ_NG	compared to natural gas supply	0.023 GJ/GJ_NG
Liquid biofuels	0.011 GJ/GJ_oil	compared to oil products supply	0.028 GJ/GJ_oil

Source: energy data from IEA (2021) World Energy Balances and Renewables Information; forest figures from FAOStat; waste figures from World Bank

* Median of the 25 member countries of IEA Bioenergy⁷

Specific comments in relation to the reference points:

- The amount of solid biofuels compared to the domestic forest area is quite low (less than 1 ton_{dry mass} of wood per hectare⁸); moreover, part of this is imported biomass. South Korea's wood pellet imports were around 3 million tons in 2019.
- The use of renewable MSW for energy production is modest - there still are considerable opportunities to develop this further.
- Biogas and liquid biofuels are also low currently, so there is much opportunity to further develop.

⁷ Comparative figures of the different IEA Bioenergy member countries are discussed in the central Countries' Report.

⁸ Counted with a typical calorific value of wood (dry mass) of 19 GJ/ton_{dry mass}

ROLE OF BIOENERGY IN DIFFERENT SECTORS

OVERVIEW

The overall 2019 share of renewables in **final energy consumption** among electricity, transportation and heat sectors is a little over 3%, with bioenergy making up 2% of the energy share (Table 6). Note that these figures are higher than the shares in total energy supply (where unused waste heat, e.g., in nuclear and fossil power production, is also included).

Table 6: Role of bioenergy and renewable energy in electricity, transport energy and fuel/heat consumption in 2019

Sector	Share of bioenergy	Share of renewable energy	Overall consumption
Electricity ⁹	1.5%	4.7% (2.3% solar)	575 TWh (2070 PJ)
Transport energy (final consumption)	1.7%	1.8%	1535 PJ
Overall fuel and heat consumption ¹⁰	Direct biomass: 2.3% Biobased heat: 0.5%	2.8%	2002 PJ
TOTAL FINAL ENERGY CONSUMPTION	2.0%	3.2%	5596 PJ

Source: IEA (2021) *World Energy Balances and Renewables Information*

The following paragraphs will consider the evolutions in the different sectors.

ELECTRICITY

Overall electricity consumption in Korea has steadily grown in the 2000s. In recent years there seems to be a stabilisation around 580 TWh. Coal represents 43% of power generation (250 TWh), a level that has been quite stable in the past decade. Nuclear energy and natural gas both represent another 25%. While nuclear power was fairly stable around 140-160 TWh in the past decade, natural gas actually increased from around 80 TWh in 2008 to 150 TWh recently. Oil is steadily phased out for electricity generation and now only represents 1.5% of power.

⁹ Renewable electricity production compared to final consumption. Potential renewable shares of imported electricity are not included.

¹⁰ This includes final consumption of fuels and heat in industry, the residential sector, commercial and public services and agriculture/forestry. Transport fuels are excluded. Energy used for transformation and for own use of energy producing industries is also excluded. Electric heating (direct or through heat pumps) is not included in these figures as this is not separately reported.

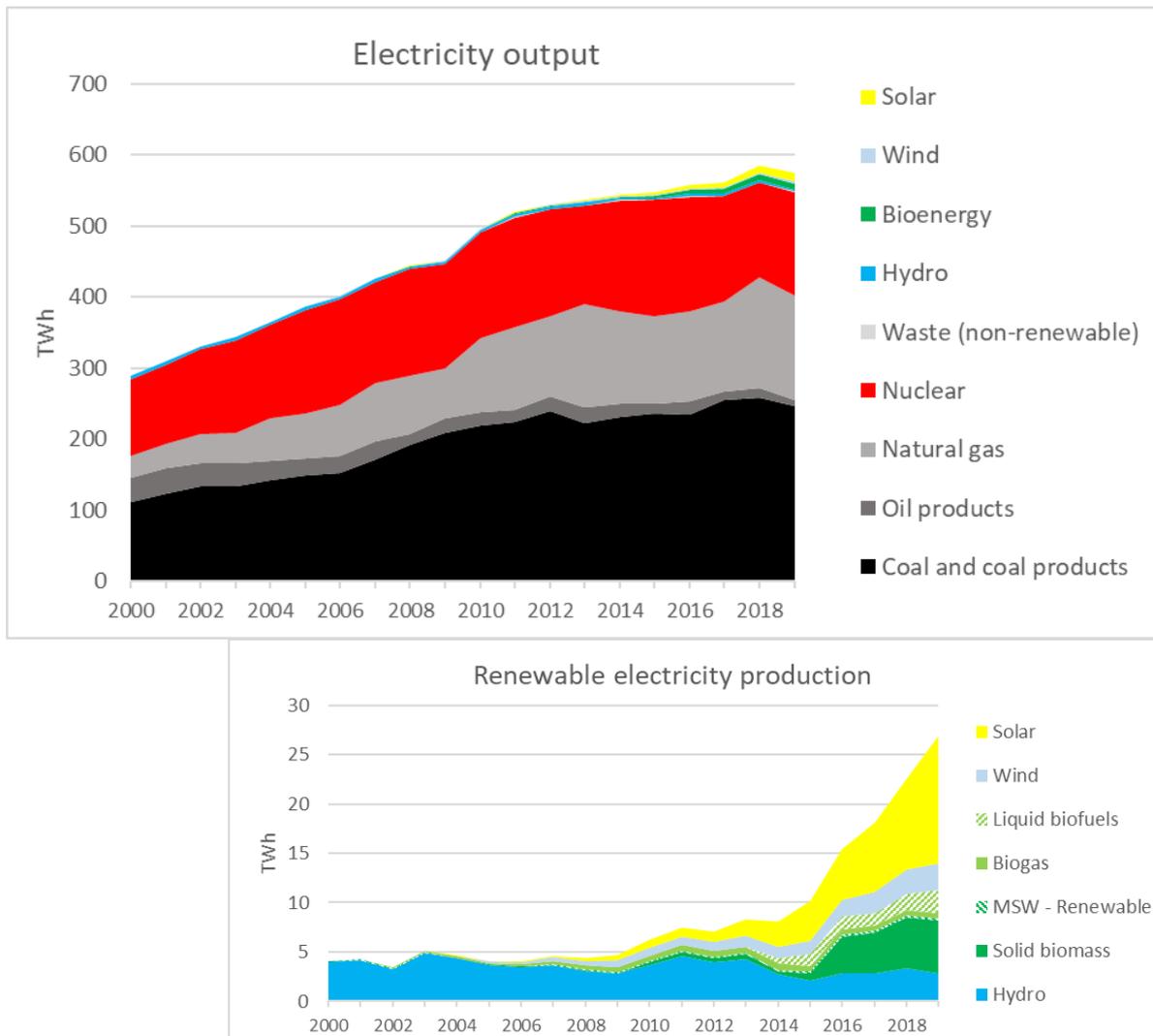


Figure 4: Evolution of the electricity mix in the Republic of Korea 2000 - 2019 (Source: IEA (2021) World Energy Balances and Renewables Information)

Less than 5% of power production in the Republic of Korea was renewable in 2019. In 2009 the renewable share was even only 1%. The main growth has been in solar power (now almost half of renewable electricity at 13 TWh) and biomass-based electricity (now at 9 TWh). Wind and hydropower each only represent 0.5% of power production (~3 TWh).

Policy framework

The main relevant policy instruments behind these evolutions are:

- The Act on Allocation and Trading of Greenhouse Gas Emissions Allowances (Emissions Trading Act) of May 2012 and its Enforcement Decree, passed in November 2012, paved the way for the

Korea Emissions Trade Scheme (K-ETS)¹¹, launched in January 2015. Some 73.5 % of all GHG emissions, including in energy and industry, are subject to the K-ETS.

- **Renewable Portfolio Standard (RPS)**: In January 2012, the Renewable Portfolio Standard (RPS) replaced the previously in place feed-in tariff system in order to accelerate Korea's renewable energy deployment with a goal to create a competitive market environment for the sector. RPS programme requires 13 largest power companies (with installed power capacity larger than 500 MW) to steadily increase their renewable energy mix in total power generation in period of 2012-2024. The target was recently raised from 10 % to 25 %. Target can be met by electricity generated from the following renewable energy sources: Wind, solar, biomass, biogas, waste-to-energy, landfill gas, tidal, hydro, integrated gasification combined cycle (IGCC). Power producers involved in RPS system receive certain amount of Renewable Energy Certificates (RECs). Number of RECs allocated for produced electricity from renewable sources varies depending on the technology used.¹²

HEAT/FUEL

Figure 5 shows the role of different fuels/energy carriers for providing heat in different sectors (industry, residential sector, commercial and public services and other). It also includes heat sold to customers, e.g., through district heating. Fuel use by energy producing industries for transformation and for own use is excluded. Mind that electric heating (direct or through heat pumps) is not included in these figures as this is not separately reported.

The overall provision of fuels/heat is largely dominated by fossil fuels, with 43% natural gas, 23% oil products, 16% coal; another 5% is from non-renewable waste. The direct use of biomass for heat represents only 2.5% (50 PJ), an amount which has fluctuated somewhat in the past decade. About two thirds of direct biomass use is in industry; the other third is in commercial and public buildings.

¹¹

https://icapcarbonaction.com/en/?option=com_etsmap&task=export&format=pdf&layout=list&systems%5B%5D=47

¹² <https://www.iea.org/policies/4837-renewable-portfolio-standard-rps>

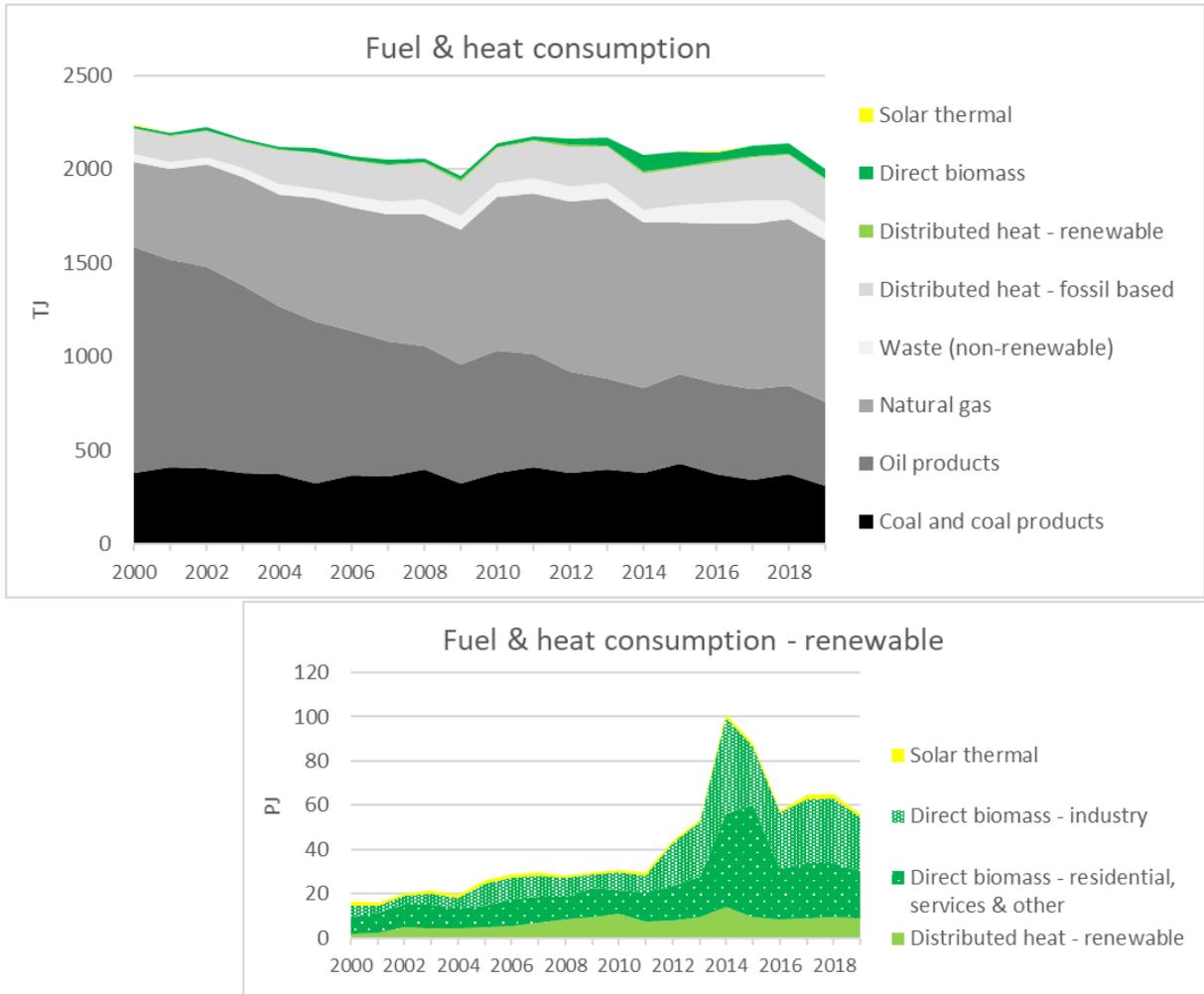
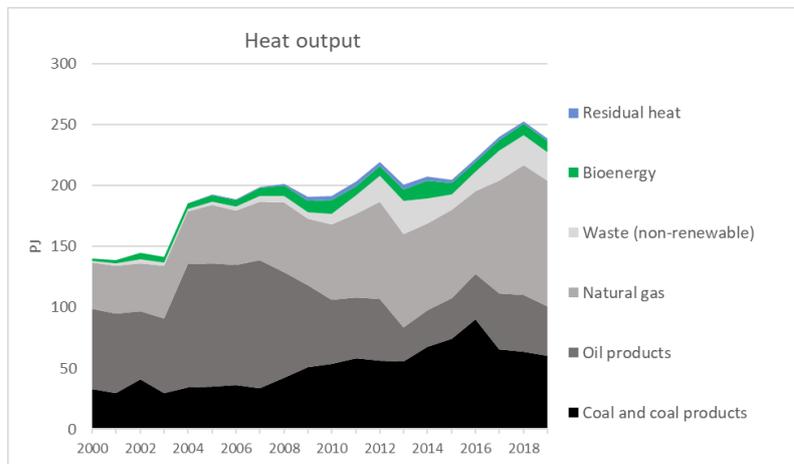


Figure 5: Evolution of fuel and heat consumption in the Republic of Korea 2000 - 2019 (Source: IEA (2021) World Energy Balances and Renewables Information)

Heat output generated and sold by CHP plants and heat plants represents around 12% of fuel/heat provided, a share which has clearly increased in the past decade. As shown in Figure 6, this is still for more than 85% fossil based, with a dominant – and still growing - role for natural gas (now 43% of heat output). Coal produces 25% of heat, and oil products 17%. Non-renewable waste represents 10%. The use of biomass (of which around half renewable waste) for heat output was relatively stable around 4% in the past decade.

Figure 6: Evolution of fuels for heat output in the Republic of Korea 2000 - 2019 (Source: IEA (2021) World Energy Balances and Renewables Information)



TRANSPORT

Figure 7 shows an overview of the energy used in transport in the Republic of Korea, split up by different fuels/energy carriers.

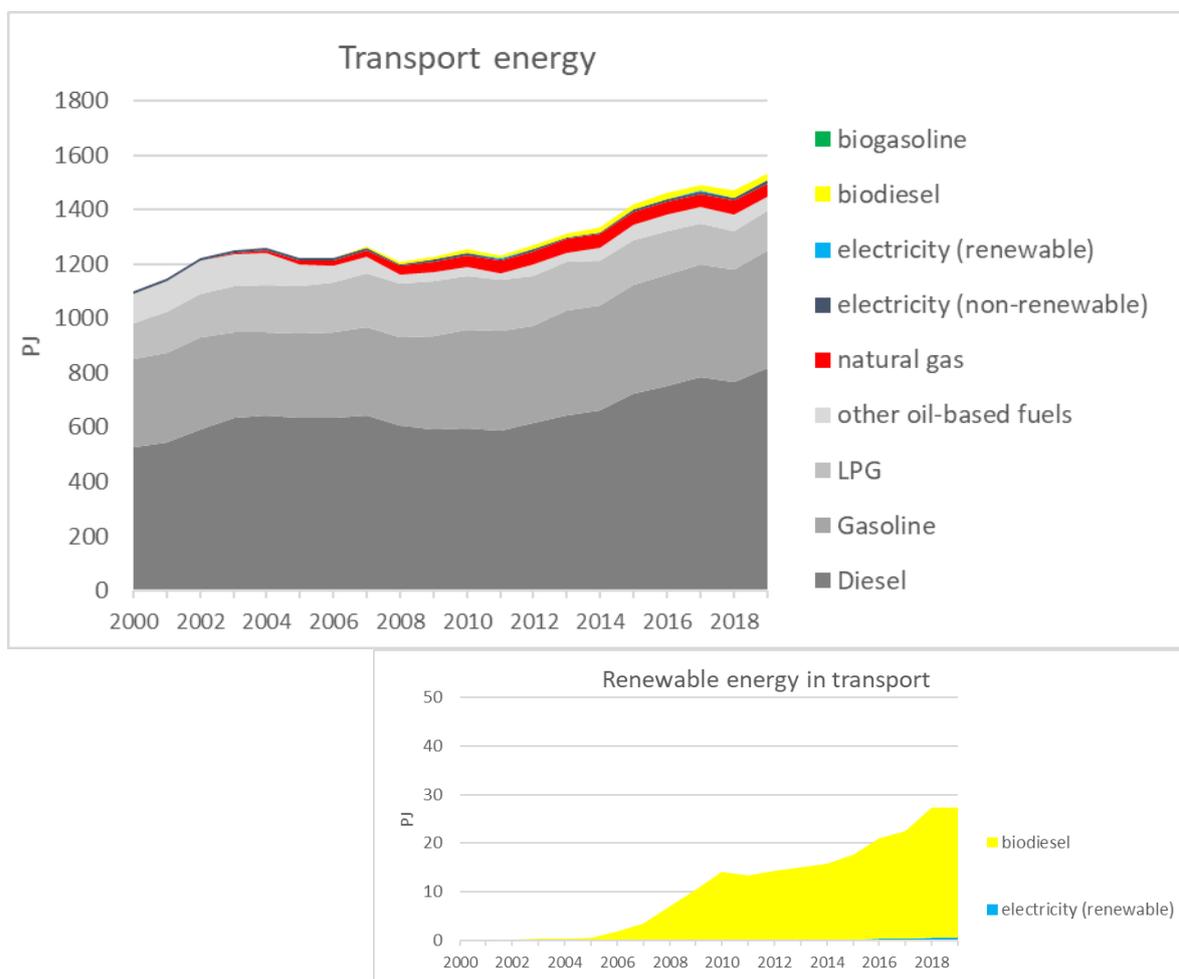


Figure 7: Evolution of transport fuels in The Republic of Korea 2000 - 2019 (Source: IEA (2021) World Energy Balances and Renewables Information)

After a stabilisation around 1250 PJ in the 2000s, total transport energy use has continued to rise again in the past decade up to 1535 PJ in 2019. Diesel is the dominant transport fuel in Korea, representing 53% of transport fuel consumption and its consumption continues to grow. Gasoline represents 28% of transport fuels. There is also an important use of LPG and natural gas in Korea, representing respectively 10% and 3% of overall transport fuel consumption. Other oil-based fuels (mainly jetfuels) represent another 3%.

In 2006 biodiesel were introduced and there was a steady growth up to a (still modest) level of 1.7% of transport fuel consumption in 2019. Biodiesel represents an average share in diesel fuel of 3% by energy. The main biofuel remains biodiesel, which is also consistent with the dominant role of diesel fuels in the Korean transport system. There is no reporting of bioethanol use.

Electricity represents a modest share of 0.7% of total transport energy use. There is no specific reporting on electricity use in road vehicles.

Policy framework

The Renewable Fuel Standard is the primary tool to promote renewable energy use in the transport sector. It obliges oil refiners, importers, and exporters to blend a certain amount of biodiesel into transportation fuels. The blending obligation rate was set at 2.5% in 2015 and is bound to increase to 3% in 2020.

RESEARCH FOCUS RELATED TO BIOENERGY

- Pilot-scale production of advanced biofuel from lignocellulosic biomass by a combination of fast pyrolysis and chemical upgrading techniques
- Demo-scale production of biodiesel from low-quality fatty acids by esterification techniques
- Production of biofuel from lignin residues by liquefaction in supercritical fluids

LINKS TO SOURCES OF INFORMATION

IEA (2020). Korea 2020 – Energy policy review: https://iea.blob.core.windows.net/assets/90602336-71d1-4ea9-8d4f-efeeb24471f6/Korea_2020_Energy_Policy_Review.pdf