

CHAPTER 9

Republic of Korea Country Report

Kyung-Jin Boo

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CHAPTER 9

Republic of Korea Country Report

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1. Background

The Republic of Korea (henceforth Korea) is located on the southern half of the Korean Peninsula and shares a 238-kilometre (km) border with the Democratic People's Republic of Korea. It covers 100,188 square kilometres (km²) of land and includes about 3,000 islands (mostly small and uninhabited). Korea is a mountainous country in which lowlands account for only 30% of the total land area. The climate is temperate, with heavy rainfall from June to July. As of 2017, Korea had a population of 51.466 million, of whom more than 80% live in urban areas. Beginning in the 1950s, Korea recorded tremendous economic growth, and it was able to overcome both the 1998 Asian financial crisis and 2007–2008 global economic crisis, after which its growth slowed. Korea's economy is dominated by manufacturing, particularly electronic products, passenger vehicles, and petrochemicals.

As Korea has no domestic oil resources and produces only a small amount of anthracite coal and negligible amount of natural gas, it imports most of its coal (which is bituminous coal) and natural gas, as well as all of its oil. Consequently, as of 2017 Korea was the fifth largest oil importer and fourth largest coal importer. It is also the third largest importer of liquefied natural gas in the world.

In 2017, Korea's total primary energy supply was 282.3 million tonnes of oil equivalent (Mtoe), representing a 4.2% annual increase, on average, since 1990. Although oil and coal dominate the primary energy supply, nuclear power and liquefied natural gas also supply a significant share of

the country's primary energy. Between 1990 and 2017, the strongest annual growth occurred in natural gas (10.8%), followed by renewable energy (9.3%), coal (4.5%), nuclear (3.9%), and oil (3.0%).

Total final energy consumption in 2017 was 183.2 Mtoe, increasing at an average annual growth rate (AAGR) of 3.9% from 1990. Industry accounted for 26.4% of final energy consumption in 2017, followed by non-energy (28.7%) and transportation (19.5%). While coal consumption has gradually decreased, final consumption of natural gas grew rapidly at an AAGR of 13.8% between 1990 and 2017.

In 2017, Korea generated 562.7 terawatt-hours of electric power, with coal and nuclear combined providing nearly three-fourths of the country's electricity, followed by natural gas, at 22.4%. Total electricity consumption grew at an AAGR of 6.4% between 1990 and 2017. When broken down by fuel type, coal grew by an AAGR of 10.4%, natural gas by 10.0%, and nuclear by 3.9% between 1990 and 2017. However, over the same period, oil recorded an AAGR of -1.7% and hydropower an AAGR of -3.0%, while other energy sources such as new and renewable energy (NRE) grew rapidly at an AAGR of 43.8%.

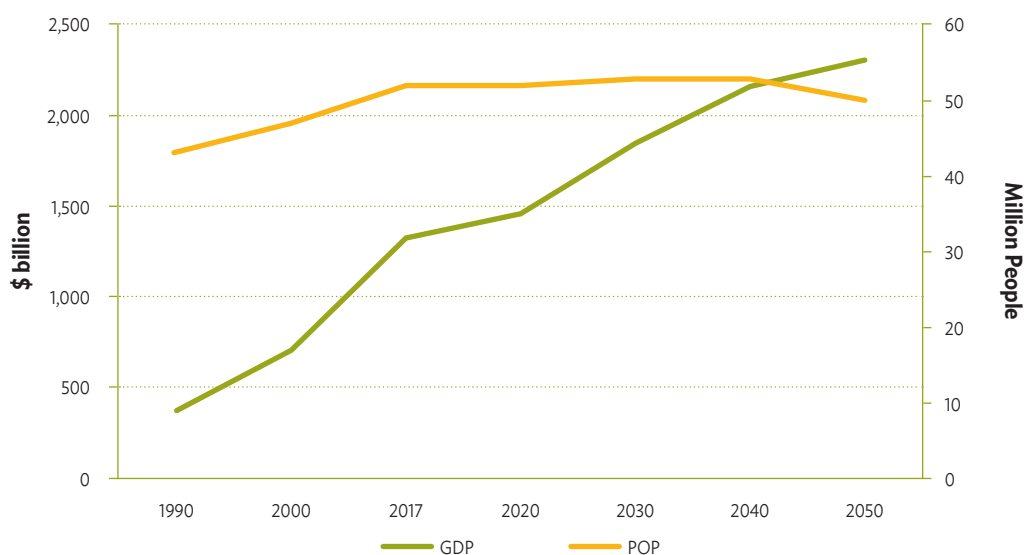
Since the 1990s, the Government of the Republic of Korea has established six basic plans for the rationalisation of energy use; these plans, which are revised every 5 years, contain various policy tools and programmes developed and implemented under the auspices of the Ministry of Trade, Industry and Energy. Several energy saving measures were announced to encourage the general public to conserve energy voluntarily, and voluntary energy conservation campaigns were launched to reduce heating and fuel consumption. The government has also urged energy-intensive industries to enhance the energy efficiency of their products. In addition, the Ministry of Trade, Industry and Energy and the Board of Audit and Inspection of Korea formed a task force to examine 660 public and private organisations to measure their progress in implementing voluntary energy saving plans.

The Fifth Basic Plan for the Rationalization of Energy Use (2013–2017) encompasses various key policy tools and programmes to reach the country's energy savings targets, including voluntary agreements, energy audits, energy service companies, appliance labelling and standards, fuel economies, and public transit and mode shifting. These policy tools have played and will continue to play important roles in energy savings.

2. Modelling Assumptions

Korea's gross domestic product (GDP) grew at an average annual rate of 5% between 1990 and 2017. This report assumes that Korea's GDP will grow at an AAGR of 1.6% from 2017 to 2050. Although the recent global economic slowdown has somewhat shaken Korea's economy, the economy is still in good shape and its growth is expected to recover to 2.4% per year from 2017 to 2030, before slowing to 1.1% per year from 2030 to 2050.

Figure 9.1. Growth Assumptions for Gross Domestic Product and Population (1990–2050)



GDP = gross domestic product, POP = population.

Source: Author.

Korea is expected to continue to rely heavily on coal and nuclear energy to meet its baseload power generation needs, although overall reliance on nuclear is anticipated to decline steadily by the end of the reference period. Gas-fired power generation is projected to increase from 2017 to 2050, while oil-fired generation is projected to decline. Generation from hydropower sources is projected to remain relatively stable after 2020. Moreover, strong growth is expected in electricity generated from wind power and solar photovoltaics driven by the renewable portfolio standards launched in January 2012. A larger uptake of renewable energy is expected thanks to the recently announced Renewable Energy 3020 Plan and the Energy Transition Policy.

Korea can attain its energy saving goals by implementing energy efficiency improvement programmes in all energy sectors. In the industry sector, the expansion of voluntary

agreements, the highly efficient equipment programme, and the development of alternative energy and improvements in efficient technologies are expected to contribute to energy savings. The transport sector aims to save energy by enhancing the efficiency of the logistics system, expanding public transport, and improving the fuel economy of vehicles. In the residential and commercial ('others') sector, the minimum energy efficiency standards programme is projected to induce huge savings in addition to e-Standby Korea 2010¹.

3. Outlook Results

3.1. Final Energy Consumption

Between 1990 and 2017, Korea's final energy consumption grew at an AAGR of 3.9% per year, from 64.9 Mtoe to 183.2 Mtoe.² The non-energy sector had the highest growth rate during this period at 7.9% per year, followed by the industry sector with 3.5%. Energy consumption in the residential and commercial and public ('others') sector grew at a relatively slow pace of 2.4% per year. Oil was the most consumed fuel, accounting for 67.3% of the energy mix in 1990; this declined to 53.1% in 2017. The share of coal in the final energy consumption declined by 13.4 percentage points between 1990 and 2017, whereas the share of electricity almost doubled, making it the second-largest consumed fuel.

Business as Usual Scenario

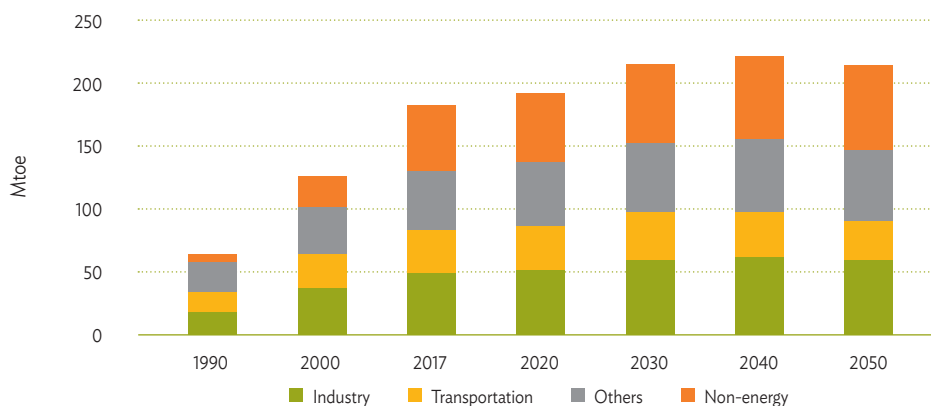
Assuming low economic and population growth, final energy consumption in Korea is projected to reach 215.8 Mtoe by 2050, increasing at a low average rate of 0.5% a year from 2017 to 2050 under business as usual (BAU). This is largely due to the negative growth in energy consumption in the transport sector, which is projected to decrease at an AAGR of -0.4% between 2017 and 2050. Annual growth in final energy consumption up to 2030 is expected to be led by the industry sector (at 1.5%) and non-energy sector (1.3%).

The non-energy sector will then take the lead at an AAGR of 0.5% up to 2050. Nevertheless, all sectors are expected to slow or show a negative AAGR.

¹ In 2010, the Korea Energy Agency introduced the e-Standby Korea programme, a voluntary agreement urging manufacturers to minimise standby power and select sleep mode during standby.

² Energy consumption is calculated based on net calorific values as converted by the Institute of Energy Economics, Japan from original data submitted by Korea.

Figure 9.2. Final Energy Consumption by Sector, Business as Usual (1990–2050)

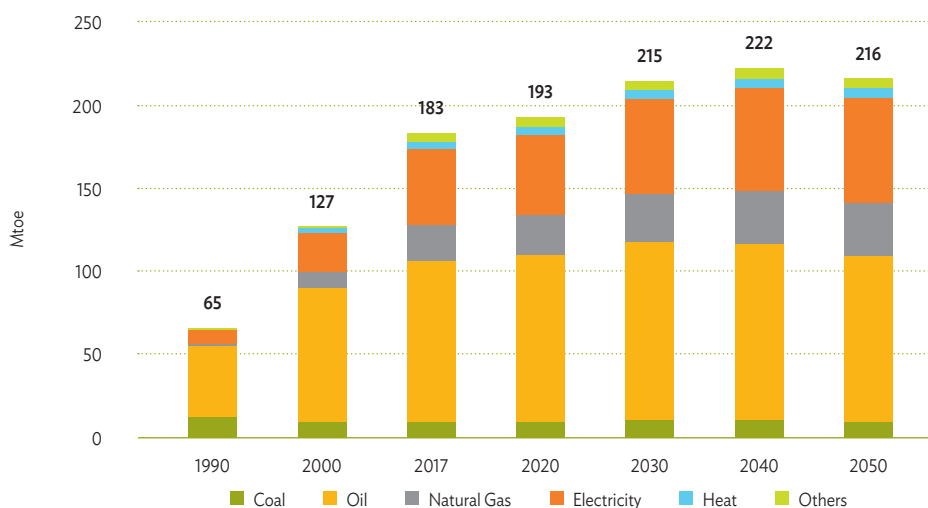


Mtoe = million tonnes of oil equivalent.

Source: Author's calculation.

Final energy consumption by energy type is expected to follow energy consumption by sector. The AAGR is expected to be 0.3% for coal, 0.1% for oil, 1.1% for natural gas, 1.0% for electricity, and 0.4% for heat from 2017 to 2050. Coal consumption is expected to peak around 2040 and oil around 2030, before gradually decreasing, to show negative growth. Heat energy consumption is anticipated to follow the same pattern as oil because of the expected decrease in population as well as changing lifestyles, leading to a tendency to use more electricity for heating. The decrease in oil consumption is more likely due to slowing energy consumption in the transport sector caused by the increased deployment of electric vehicles. Other energy types, including NRE and natural gas, will increase, and clean and green energy will help reduce CO₂ emissions considerably.

Figure 9.3. Final Energy Consumption by Energy, Business as Usual (1990–2050)



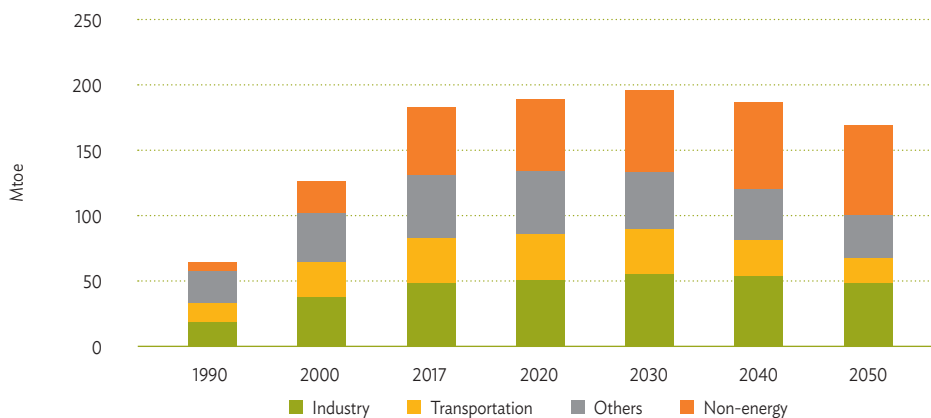
Mtoe = million tonnes of oil equivalent.

Source: Author's calculation.

Alternative Policy Scenario

This section discusses the alternative policy scenario (APS) based on a combination of policy options: (i) improved efficiency of final energy consumption, (ii) more efficient thermal power generation, (iii) a higher contribution of renewable energy to the total supply, and (iv) the contribution of nuclear energy to the total supply. Total final energy consumption in the APS is expected to decrease by 7.5% from 183.2 Mtoe in 2017 to 169.4 Mtoe in 2050, yielding an AAGR of -0.2% . Figure 9.4 shows final energy consumption by sector in the APS. The transport sector shows the fastest decrease at -1.7% per year, followed by 'others' at -1.1% per year. The share of final energy consumption by sector shows a structural change from 2017. The shares of the transport and 'others' sectors are forecasted to decrease, while that of the non-energy sector will increase more quickly, reaching 40.5% in 2050.

Figure 9.4. Final Energy Consumption by Sector, Alternative Policy Scenario (1990–2050)

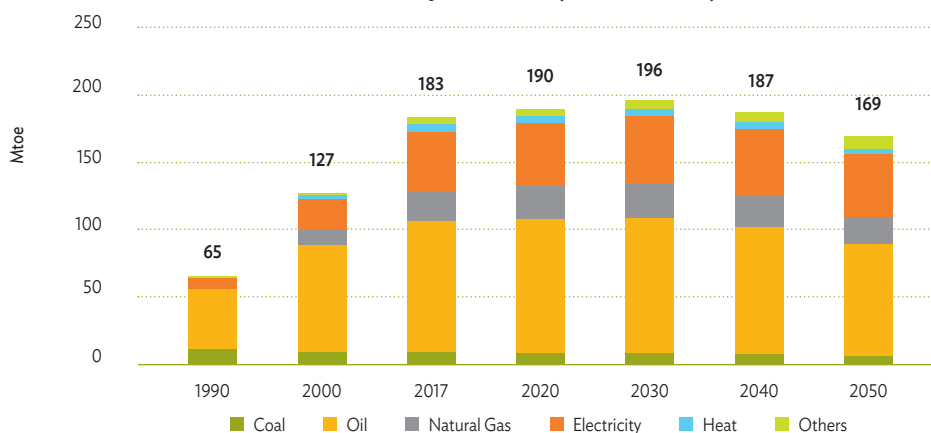


Mtoe = million tonnes of oil equivalent.

Source: Author's calculation.

Final energy consumption by energy type is shown in Figure 9.5. Oil is expected to dominate the energy mix, accounting for 46.4% of its share, followed by electricity at 27.6% and natural gas at 11.8%. Coal will be marginalised as a minor energy source for industrial as well as residential and commercial use.

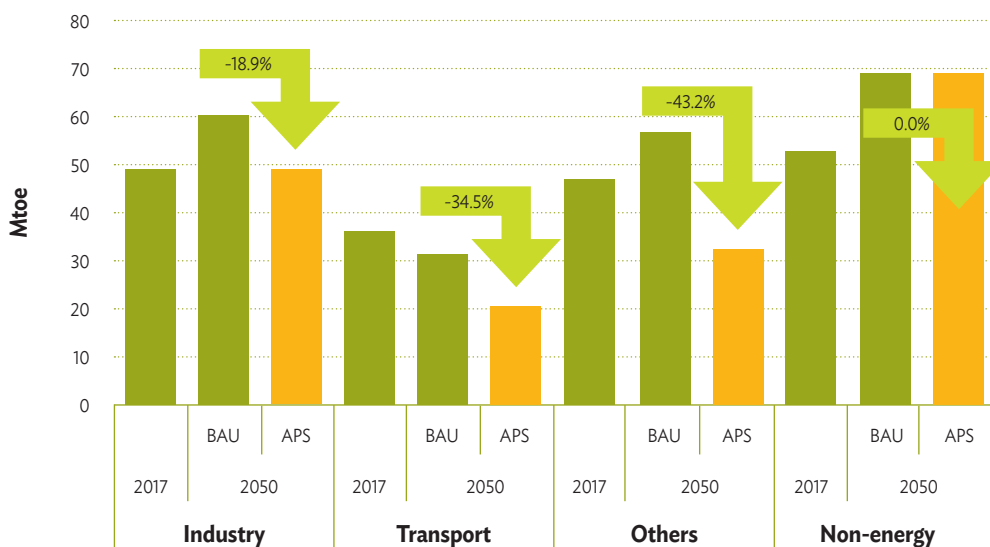
Figure 9.5. Final Energy Consumption by Energy, Alternative Policy Scenario (1990–2050)



Mtoe = million tonnes of oil equivalent.
Source: Author's calculation.

Figure 9.6 shows the final energy consumption by sector under BAU versus the APS in 2050. Under BAU, energy demand is projected to increase by 18% from 2017 to 2050, with the industry and 'others' (residential and commercial) sectors driving this growth. In the APS, 46.4 Mtoe (21.5%) will be saved compared to BAU by 2050; most of these savings will come from the 'others' and transport sectors. Rates of reduction will be -43.2% in the 'others' sector, -34.5% in the transport sector, and -18.9% in the industry sector, whereas almost no change will take place in the non-energy sector.

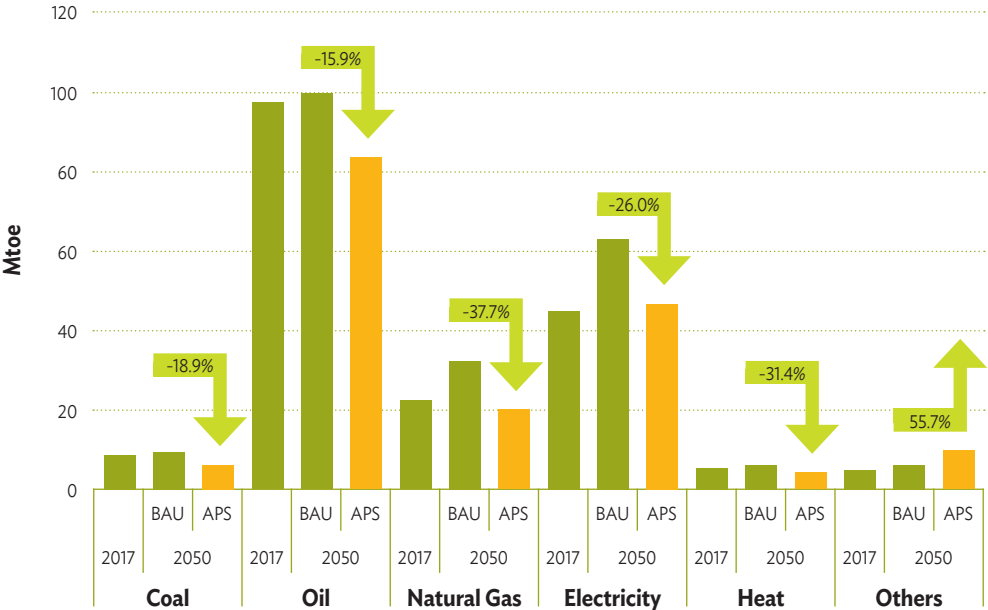
Figure 9.6. Final Energy Consumption by Sector, Business as Usual versus the Alternative Policy Scenario (2017 and 2050)



APS = alternative policy scenario, BAU = business as usual, Mtoe = million tonnes of oil equivalent.
Source: Author's calculation.

Final energy consumption by energy is shown in Figure 9.5. Under BAU, the oil share is projected to stay around 50%, remaining dominant in final energy consumption. In the APS, oil accounts for 15.9 Mtoe of energy savings, the largest share, followed by electricity (16.4 Mtoe) and natural gas (12.1 Mtoe). Most energy savings will come from these three major energy types, which will account for 95.7% of total energy saved. In the APS, improved energy efficiency in the 'other' sectors (residential, commercial, and public) is responsible for a considerable share of the savings in natural gas and electricity.

Figure 9.7. Final Energy Consumption by Energy, Business as Usual versus the Alternative Policy Scenario (2017 and 2050)



APS = alternative policy scenario, BAU = business as usual, Mtoe = million tonnes of oil equivalent.
 Source: Author's calculation.

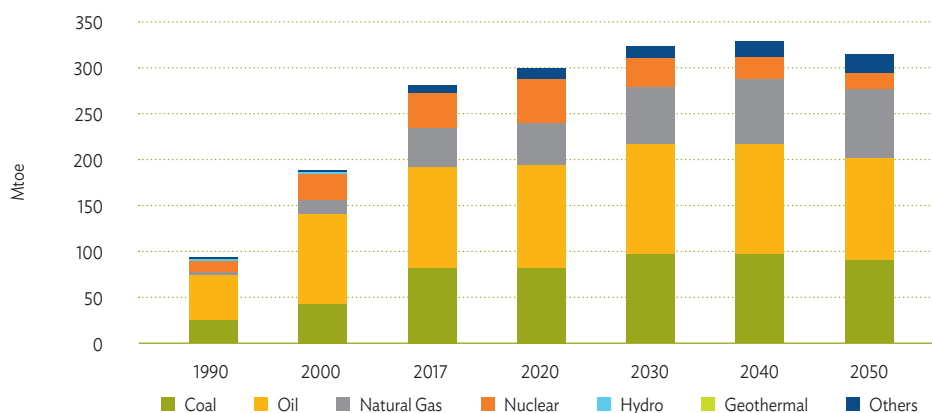
3.2. Primary Energy Demand

Primary energy demand in Korea increased at an AAGR of 4.2%, from 92.9 Mtoe in 1990 to 282.3 Mtoe in 2017. Among the major energy sources, natural gas grew the fastest at an average annual rate of 10.8%, followed by coal at 4.5%, oil at 3.0%, and nuclear at 3.9% over the same period. Although starting from a notably lower base, other energy sources—mainly renewable energy such as solar, wind, biomass, and ocean energy—grew rapidly at a rate of 9.6% over the same period. This indicates that the government has been successfully implementing the Low Carbon, Green Growth and Energy New Industry policies initiated by previous administrations.

Business as Usual Scenario

Under BAU, the primary energy demand in Korea is projected to increase at an AAGR of 0.3%, from 282.3 Mtoe in 2017 to 315.7 Mtoe in 2050. The relative pace of new growth in all energy sources is projected to slow, compared with 1990–2017. Consumption of natural gas grew the fastest at a rate of 1.7% per year, while coal (0.3%) and oil (0.0%) grew much more slowly from 2017 to 2050. The growth in natural gas will largely be at the expense of nuclear, which is projected to decline from 13.7% in 2017 to 5.5% in 2050.

Figure 9.8. Primary Energy Supply by Energy, Business as Usual (1990–2050)



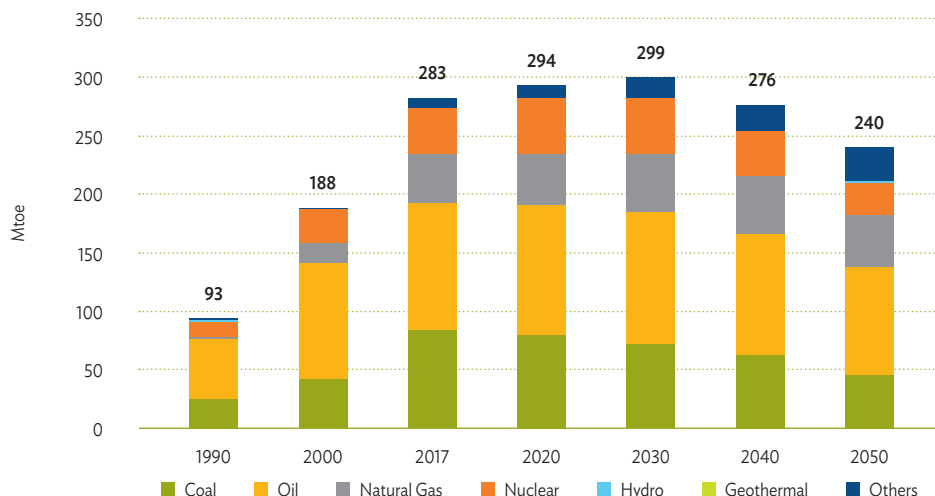
Hydro = hydropower, Mtoe = million tonnes of oil equivalent.

Source: Author's calculation.

Alternative Policy Scenario

In the APS, the primary energy supply is projected to decrease at an AAGR of -0.4% , from 282.3 Mtoe in 2017 to 239.0 Mtoe in 2050. Consumption of coal, oil, and nuclear will gradually decrease from 2017 to 2050, whereas that of hydropower will increase by 0.6% and 'others' (NRE) by 3.7% per year (Figure 9.9). The aggressive implementation of energy efficiency and conservation measures on the demand side, along with a larger uptake of renewable energy on the supply side, will be the main contributors to the reduced consumption of fossil fuels and nuclear energy.

Figure 9.9. Total Primary Energy Supply: Alternative Policy Scenario (2017–2050)



Hydro = hydropower, Mtoe = million tonnes of oil equivalent.

Source: Author's calculation.

Projected Energy Savings

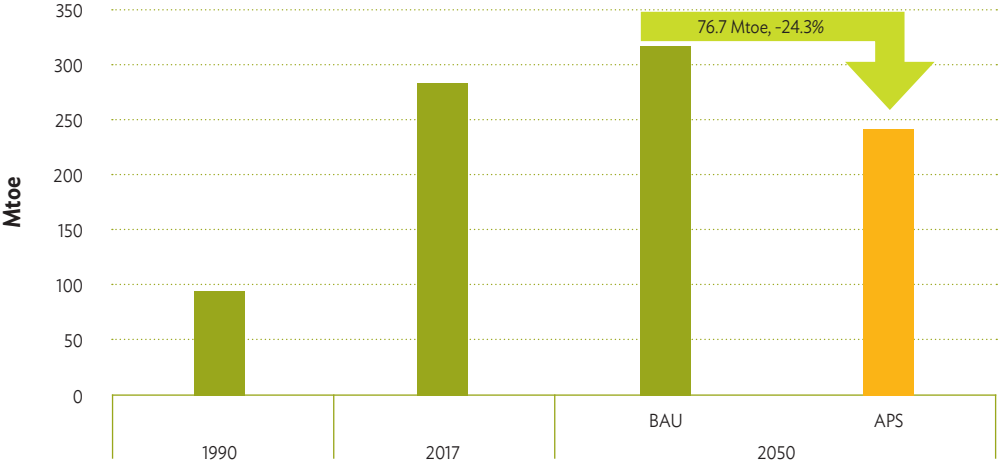
Major energy policy approaches to reduce the energy demand in Korea are as follows:

- (i) Energy policy should be shifted from a supply-oriented approach to a demand-oriented one. The most pressing issue is reform in energy pricing and energy taxation. In this context, market mechanisms should be introduced in energy pricing to induce rational energy use by sharing information on the full cost of energy production and consumption.
- (ii) The transformation of the industrial structure to be less energy-intensive, currently underway, should be accelerated towards knowledge-based, service, and green industries that consume less and clean energy.
- (iii) Energy efficiency standards and codes should be applied in the product design and production process, as well as in designing and constructing systems such as factories, buildings, and plants. Under these policy directions, the government should develop and implement an action plan containing milestones and strategies with specific and cost-effective policy tools.

The energy saving targets, action plans, and policy tools mentioned in the previous paragraph could yield energy savings of 76.7 Mtoe by 2050, the difference between the primary energy supply under BAU and in the APS (Figure 9.10). This is equivalent to a –24.3% reduction from 2017. Figure 9.11 shows the energy saving potential by energy source. Of all the energy sources, coal has the largest potential reduction in energy demand (–50.0%), followed by

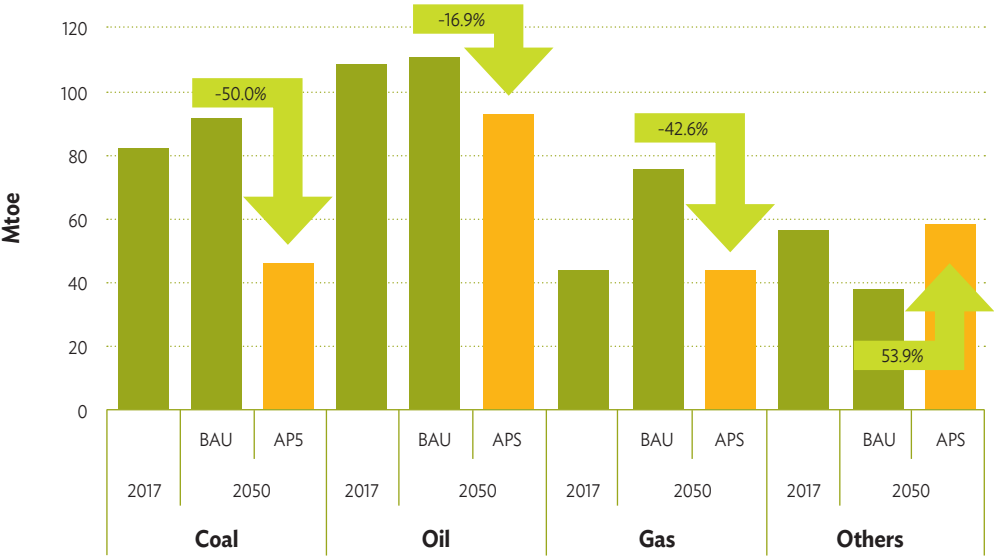
natural gas (-42.6%) and oil (-16.9%). In contrast, other energy sources, primarily renewable energy, will increase by 55.9% over BAU.

Figure 9.10. Total Primary Energy Supply, Business as Usual and the Alternative Policy Scenario (2017 and 2050)



APS = alternative policy scenario, BAU = business as usual, Mtoe = million tonnes of oil equivalent.
 Source: Author's calculation.

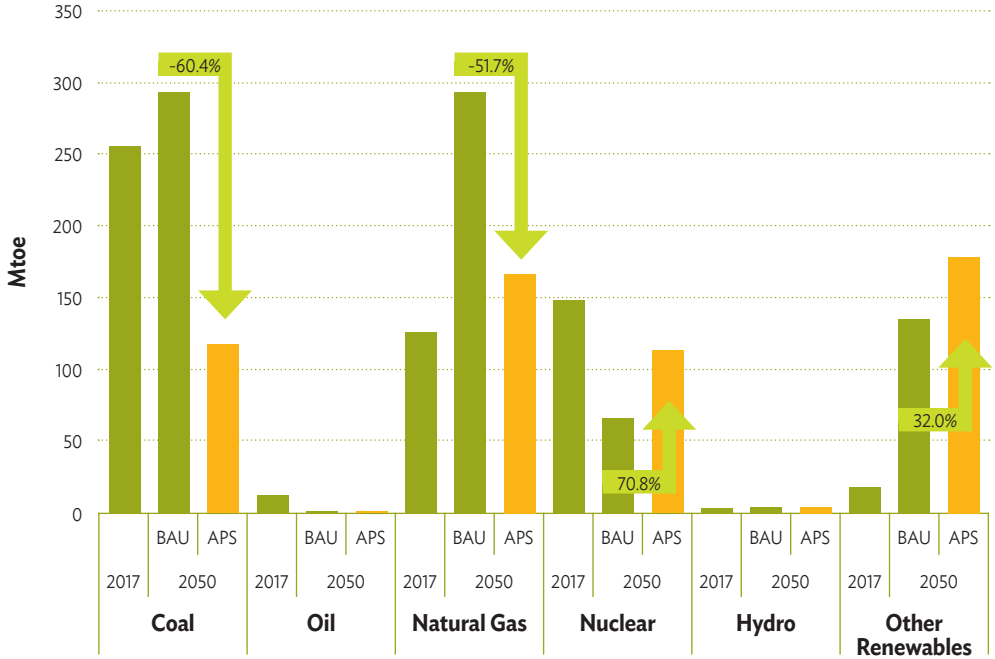
Figure 9.11. Primary Energy Supply by Source, Business as Usual versus the Alternative Policy Scenario



APS = alternative policy scenario, BAU = business as usual, Mtoe = million tonnes of oil equivalent.
 Source: Author's calculation.

Figure 9.12 shows power generation under BAU and in the APS. Under BAU, gas-fired power generation will more than double from 2017 to 2050, only slightly behind coal-fired power as the largest source of generated power. In the APS, zero-emission power sources such as nuclear, hydropower, and other renewables will account for half of power generation, while input from fossil fuels in power generation will also decline to less than half that under BAU, contributing to a comparative reduction in CO2 emissions.

Figure 9.12. Power Generation by Source, Business as Usual versus the Alternative Policy Scenario

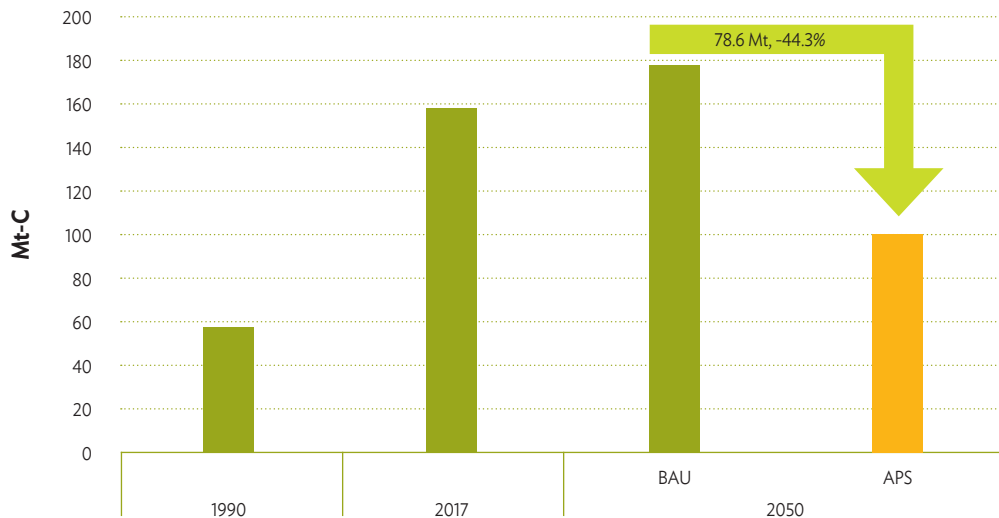


APS = alternative policy scenario, BAU = business as usual, Mtoe = million tonnes of oil equivalent.
 Source: Author's calculation.

3.3. Carbon Dioxide Emissions from Energy Consumption

CO2 emissions from energy consumption are projected to increase at an AAGR of 0.4%, from 158.0 million tonnes of carbon (Mt-C) in 2017 to 177.6 Mt-C in 2050 based on BAU. This growth rate is roughly on par with that of the primary energy supply. In the APS, CO2 emissions are projected to decline at an AAGR of -1.4% between 2017 and 2050. The difference in CO2 emissions between BAU and the APS is 78.6 Mt-C or -44.3% (Figure 9.12). To attain such an ambitious target, the government must develop and implement cost-effective and consensus-based action plans to save energy and reduce CO2 emissions.

Figure 9.13. Carbon Dioxide Emissions from Energy Consumption, Business as Usual and Alternative Policy Scenario (2015 and 2040)



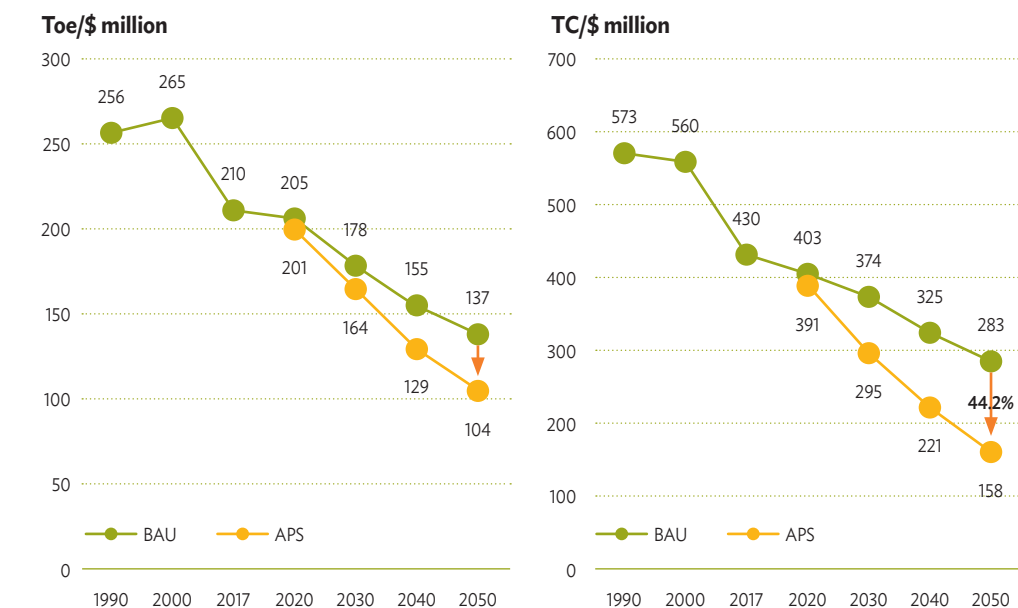
APS = alternative policy scenario, BAU = business as usual, Mt = million tonnes, Mt-C = million tonnes of carbon.

Source: Author's calculation.

3.4. Energy and Carbon Intensity

As a result of energy savings, the country's energy intensity of GDP is projected to improve (Figure 9.14). Under BAU, energy consumption per unit of GDP (tonnes of oil equivalent per million dollars [toe/\$ million]) is projected to decline from 210 toe/\$ million in 2017 to 137 toe/\$ million in 2050, a 3.2% improvement. In the APS, this accelerated to 63.3%. Energy intensity in the APS is 24.1% below BAU. Carbon intensity is also projected to improve both under BAU and in the APS, mainly because of the reduction in the primary energy supply in terms of energy intensity, which will be accelerated by the aggressive introduction of low-carbon energy sources and technologies along with energy efficiency technologies. Improvement in carbon intensity, that is, CO₂ emissions per unit of GDP (tonnes of carbon per million dollars [t-C/\$ million]), is more salient than improvement in energy intensity. It is projected to decline from 117 t-C/\$ million to 77 t-C/\$ million under BAU (a 34.2% decrease) and 43 t-C/\$ million in the APS (a 63.2% decrease). Carbon intensity in the APS is 42.9% less than under BAU.

Figure 9.14. Energy and Carbon Intensities (1990–2040)



APS = alternative policy scenario, BAU = business as usual, TC = tonnes of carbon, Toe = tonnes of oil equivalent.

Source: Author's calculation.

4. Implications and Policy Recommendations

Given its limited economically viable domestic fossil fuel resources, Korea has been importing 98% of its required fossil fuel supplies. Thus, Korea's top energy policy agenda is the maintenance of a stable energy supply to sustain its economy. However, at the beginning of the 21st century, the government shifted its energy policy to a sustainable, efficient, and energy-saving approach, which has been fully outlined in the First (2009), Second (2014), and most recently, Third (2019) Energy Basic Plan.

In the 1990s, Korea's total primary and final energy consumption increased faster than GDP, the growth of which was driven by energy-intensive industries such as the petrochemical, steel, and cement industries. Since 1997, the contribution of these industries to Korea's GDP has gradually declined, resulting in reduced energy intensity. However, as it will take time to shift to a less energy-intensive industrial structure, energy-intensive industries will prevail in the short to medium term. However, Korea will and must transform its industrial structure into a less energy-intensive one in the longer term.

The Second National Energy Basic Plan released in 2014 was the first full-scale energy basic plan with a feasible target and action plan, and set the policy approach of completely shifting

the industrial structure from a supply orientation to a demand orientation. Its basic policy direction consists of six major agendas prioritising demand-oriented energy policy. Five other key agendas include building a distributed generation system, harmonising the environment and safety, strengthening energy security and stabilising the energy supply, and implementing energy policy with public support.

Another policy agenda uses an environmental approach, namely, setting a target for reduced greenhouse gas emissions in response to global climate change. The government announced an ambitious, aggressive target to reduce its greenhouse gas emissions by 37% from BAU (850.6 million tonnes of CO₂) by 2030 across all economic sectors. Domestic activities will meet 25.7% of this target, and the emissions trade in the international market will account for the remaining 11.3%. This is a proactive response to and fulfilment of its international responsibility for the new climate regime established as a follow-up action to the Paris Agreement in December 2015.

Since the 1990s, the government has mostly been concerned with energy security, energy efficiency, and environmental preservation. It had addressed energy security by promoting the import of foreign resources and renewable energy development. It has improved energy efficiency through programmes supported by a series of 5-year basic plans for the rationalisation of energy use. Relevant offices in the Ministry of Environment have tackled the environmental issues caused by the consumption of fossil fuels and nuclear energy. Now is the time for Korea to synergise the efforts exerted so far by selecting and concentrating policy tools and programmes through coordination among relevant ministries, as clearly specified in the Second National Energy Basic Plan.

In 2017, the new government led by President Moon Jae-In proposed reforms to the current energy policy, and announced a new energy policy direction, 'energy transition', which has completely reframed the existing national energy policy. Energy transition rests on two major energy policy agendas: (i) the step-wise reduction of nuclear power plants and coal-fired plants ('de-nuclearisation' and 'de-coalisation' policies), and (ii) the expansion of renewable energy to 20% of the energy mix by 2030 (Renewable Energy 3020 Plan). These policy agendas will be reflected in the Eighth Electricity Demand and Supply Basic Plan and the Third National Energy Basic Plan.

The basic spirit of the energy transition policy direction was fully reflected in the Third Energy Basic Plan, which establishes a national energy blueprint up to the year 2040. This plan builds on the idea of a sustainable energy system stipulated in the First and Second

Energy Basic Plans, while also focusing on the innovative transition of the overall energy system from the supply side to the demand side. In this context, the Third Energy Basic Plan sets the goal of achieving sustainable growth and enhancing quality of life through energy transition.

The Third Energy Basic Plan proposes two strategic goals: (i) transition of the energy supply, consumption, and industry; and (ii) a foundation for energy transition. Under these goals, five basic policy directions are suggested: (i) innovation in the energy consumption structure, (ii) a transition towards a safe and green energy mix, (iii) the expansion of a distributed and participatory energy system, (iv) strengthened global competitiveness of the energy industry, and (v) better infrastructure and market systems for energy transition.

Meanwhile, the government recently announced the Green New Deal, an upgraded version of the previous Low-Carbon, Green Growth plan. Under this new plan, government has pledged to reach zero emissions by 2050 and to pass legislation to support this goal, which will facilitate the country's transition from a high-carbon economy to a low-carbon one. Along with this new initiative, the Third Energy Basic Plan, Renewable Energy 3020, and the Hydrogen Economy Roadmap (2019) have been established to ensure the successful implementation of energy transition.

If successfully implemented, energy transition through the Third Energy Basic Plan and Green New Deal initiatives will result in a complete turnaround from the traditional energy system based on coal and nuclear power to a sustainable energy system based on renewable energy and gas-fired power generation. However, this change in the energy mix does not necessarily signify the end of the nuclear industry in Korea. Recent polling suggests that the public is marginally in favour of continued investment in nuclear power. Keeping nuclear power in the energy mix, along with a larger uptake of renewable energy, will give Korea more options to meet its Paris Agreement targets, which were set by nationally determined contributions.

The impacts and implications of this energy mix reform remain to be seen. Such reform calls for a vast amount of investment in rebuilding infrastructure, hardware, and software, along with a complete institutional rearrangement. It also entails a change not only in the energy sector per se but also in the cultural, political, and social domains. Having successfully effected two energy transitions in the past, the Korean government is highly confident in going ahead with its current policy goals of transitioning to a less energy-intensive, greener economic structure; and implementing major policy agendas and their corresponding policy tools and programmes. Such nationwide efforts and campaigns would eventually make the

Korean economy less energy-intensive and greener in terms of energy savings and reduced CO2 emissions. Moreover, such an achievement will position Korea as a leading nation globally in terms of low-carbon green growth and energy transition.