Chapter 9

Republic of Korea Country Report

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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 in the southern half of the Korean Peninsula and shares a 238 km border with North Korea. It occupies 100,188 square kilometres and includes about 3,000, mostly small, uninhabited islands. Korea is a mountainous country with lowlands accounting for only 30 percent of the total land area. The climate is temperate, with heavy rainfall in summer. As of 2015, Korea has a population of 50.62 million, over 90 percent of which live in urban areas. Korea has recorded tremendous economic growth over the past half century. Its gross domestic product (GDP) plunged by 7 percent in 1998 due to the financial crisis, but has since rebounded. Another recent global economic crisis in 2008 could not keep Korea from continuing economic growth. However, due to the recent deterioration in the global economy, growth slowed, recording 2.3 percent in 2012, before recovering to 2.9 percent in 2013 and 3.3 percent in 2014.[1] The Korean economy is dominated by manufacturing, particularly electronic products, passenger vehicles, and petrochemicals. Agriculture, forestry, and fishing made up only 2.1 percent of total GDP in 2014.

Korea has no domestic oil resources and has produced only a small amount of anthracite coal. It imports most of its coal, which is bituminous coal. In 2013,

[1] Bank of Korea, 2015.

Korea had to import 95.7 percent of its energy needs. It is the fifth-largest oil importer and the second largest importer of liquefied natural gas (LNG) in the world.

Total primary consumption in 2013 was 263.83 Mtoe, increasing by 4.6 percent per year from 1990. Although primary energy supply is dominated by oil and coal, nuclear power and LNG also supply a significant share of the country's primary energy. The strongest growth from 1990 to 2013 occurred in natural gas (13.2 percent per year) and coal (5.0 percent per year). Oil and nuclear uses increased at the relatively slower rates of 2.9 and 4.3 percent per year, respectively.

Final energy consumption in 2013 was 167.84 Mtoe, increasing at an average annual rate of 4.2 percent from 1990. The industry sector accounted for 28.4 percent of final energy consumption in 2013, followed by 'others' (26.8 percent) and transportation (18.7 percent). Consumption of natural gas in the industry sector has grown two and half times in the last decade and oil accounts for nearly half of the industry sector's energy consumption.

In 2013, electric power generators in Korea produced 537.89 terawatt-hour (TWh) of electricity, with coal and nuclear combined providing more than two thirds of Korea's electricity. Natural gas accounted for 26.9 percent of generation in 2013. Total electricity consumption grew at an average annual rate of 7.3 percent from 1990 to 2013. When broken down by fuel, coal, natural gas, and nuclear grew at an average annual rate of 11.7 percent, 12.5 percent, and 4.3 percent, respectively, from 1990 to 2013. But over the same period oil recorded much lower growth, at an annual average rate of 0.6 percent. Other energy sources such as new and renewable energies showed rapid growth, at an annual rate of 45.7 percent.

Since the 1990s, the Korean government has produced five Basic Plans for Rational Energy Use. They are revised every 5 years and contain a variety of policy tools and programmes developed and implemented under the auspices of the Ministry of Trade, Industry, and Energy (MOTIE). Several energy savings measures were announced to encourage the general public to voluntarily conserve energy.

As part of the measures, voluntary energy conservation campaigns were launched to reduce heating fuel consumption. Furthermore, the government urged energy-intensive industries to enhance energy efficiency of their products. In addition, MOTIE 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 current Basic Plan for Rational Energy Use has a variety of key policy tools and programmes to attain the energy savings target. Among them are voluntary agreements, energy audits, energy service companies, appliance labelling and Standards, Fuel Economy, and Public Transit and Mode Shifting. These policy tools have been and will continue to play important roles in energy savings.

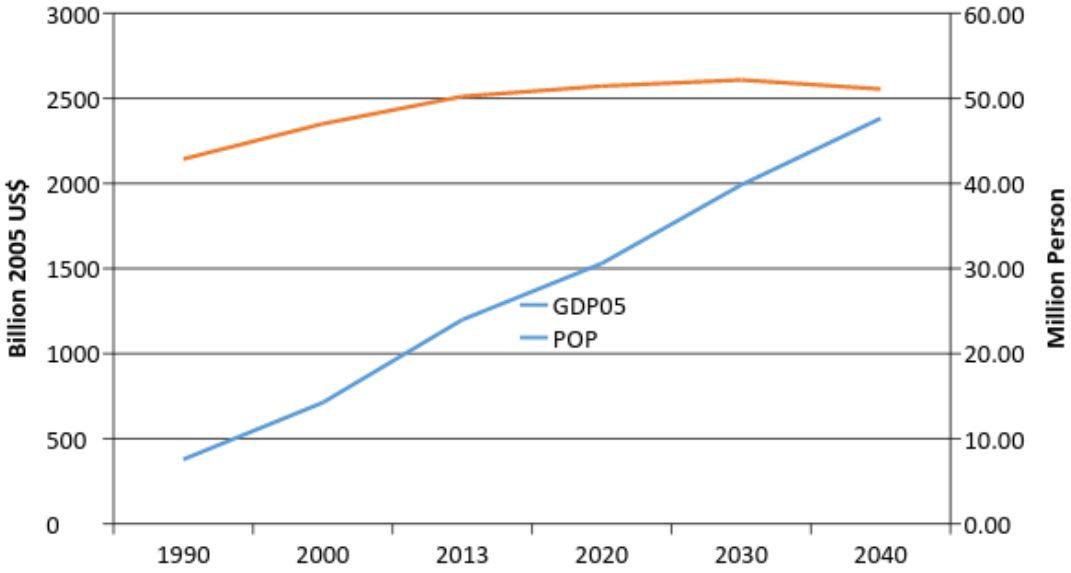
2. Modelling Assumptions

Korea's GDP expanded at an average annual rate of 5.1 percent between 1990 and 2013. In this report, Korea's GDP is assumed to grow at an average annual rate of 2.6 percent from 2013 to 2040. Following the global recession in 2009, the Korean economy has been a little bit shaken, but it is still in good shape and growth is expected to recover to an annual average 3.5 percent from 2013 to 2020, before slowing to an annual average 2.7 percent from 2020 to 2030, and to 1.8 percent from 2030 to 2040.

Korea is expected to continue to rely heavily on coal and nuclear energy for power generation to meet the base load. Gas-fired power generation is projected to increase between 2013 and 2040, whereas oil-fired generation is projected to decline. Generation from hydro sources is projected to remain relatively stable. There is projected to be strong growth in electricity generation from wind power and solar photovoltaic (PV), driven by the renewable portfolio standards (RPS), launched in January 2012.

Korea's energy saving goal can be attained through implementing energy efficiency improvement programmes in all energy sectors.

Figure 9-1. Assumptions for GDP and Population



GDP = gross domestic product; GDP05 = GDP at constant 2005 prices; POP = population.
Source: Author's calculation.

In the industrial sector, energy saving is expected from the expansion of Voluntary Agreements, the highly efficient equipment programme, the development of alternative energy and improvements in efficient technologies. The transport sector aims to save energy by enhancing the efficiency of the logistics system, expanding public transportation, and improving the fuel economy of vehicles. In the residential and commercial ('others') sector, a minimum efficiency standards programme is projected to induce huge savings in addition to 'e-Standby Korea 2010.'

3. Outlook Results

3.1. Final Energy Consumption

Korea's final energy consumption registered annual average growth of 4.2 percent from 64.9 Mtoe in 1990 to 167.84 Mtoe in 2013.[2] The non-energy sector had the highest growth rate during this period, at 8.5 percent per year, followed by the industry sector with 4.0 percent. Energy consumption in the

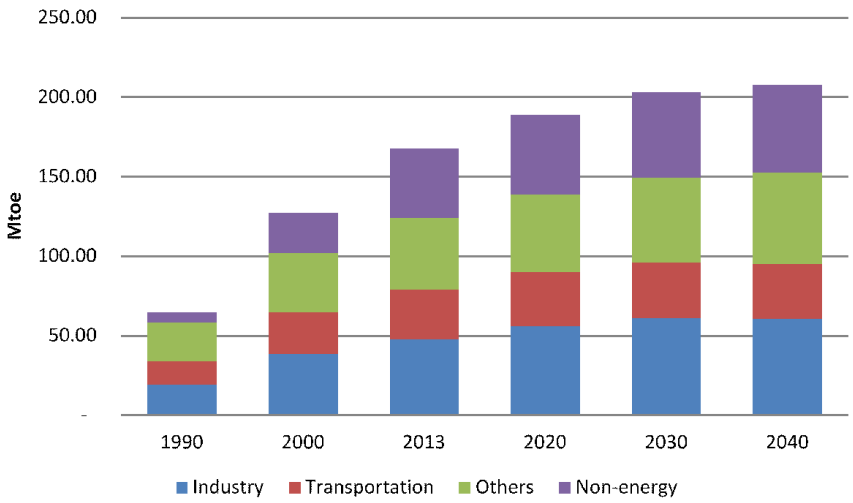
[2] Energy consumption is calculated based on net calorific values, as converted by IEEJ from original data submitted by the Republic of Korea.

residential/commercial/public (other) sector grew at a relatively slow pace of 2.7 percent per year. Oil was the most consumed product, with its 1990 share of 67.3 percent declining to 50.4 percent in 2013. The share of coal in final energy consumption fell by 12.3 percentage points between 1990 and 2013, whereas the share of electricity doubled to become the second most consumed product.

3.2. Business-as-Usual Scenario (BAU)

With an assumption of low economic and population growth, final energy consumption in Korea is projected to increase at a low average rate of 0.8 percent per year between 2013 and 2040 under the Business-as-Usual scenario (BAU). This is largely due to low projected growth of energy consumption in transportation, where it is expected to slow to an annual average rate of 0.3 percent between 2013 and 2040. Growth in final energy consumption is expected to be led by the industrial and the non-energy sector up to 2020, at 2.3 percent and 1.8 percent, respectively, per year, before being overtaken by the other sectors, such as the residential, commercial, and public sectors, and grow at only 0.9 percent up to 2030. After 2030, all sectors are expected to slow to a rate of less than 0.5 percent or see negative annual average growth of -0.1 percent except for the 'others' sector.

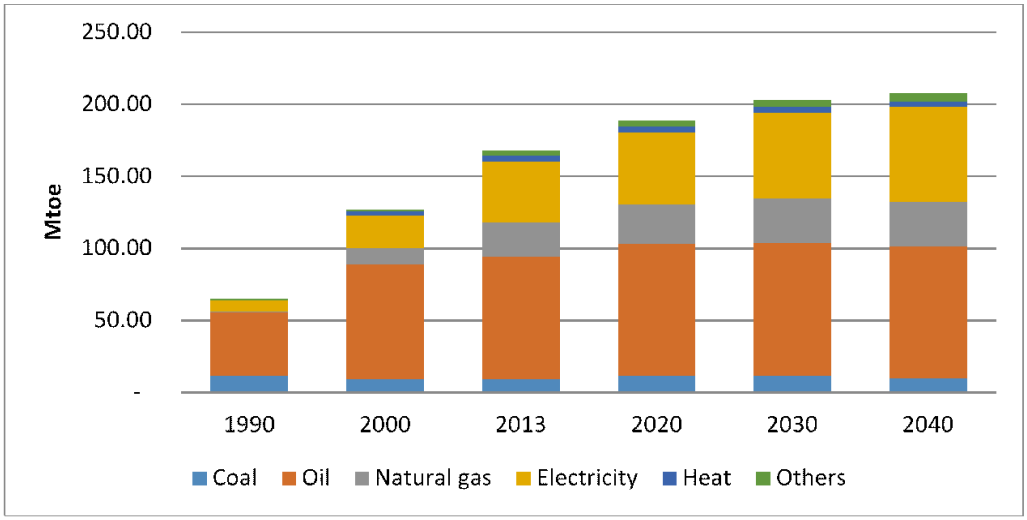
Figure 9-2. Final Energy Consumption by Sector, BAU



BAU = Business-as-Usual scenario; Mtoe = million tons of oil equivalent.
Source: Author's calculation.

Final energy consumption by energy types is expected to see a pattern similar to that of energy consumption by sector. The average annual growth rate for 2013 to 2040 is projected at 0.1 percent for coal, 0.3 percent for oil, 0.9 percent for natural gas, 1.7 percent for electricity, and -0.3 percent for heat. Heat energy consumption is anticipated to peak between 2013 and 2015, and slowly decrease thereafter, showing a negative growth rate. This is because of the projected decrease in population and changing life styles that use more electricity for heating. Other energy types, including renewable energies, are expected to grow at 1.8 percent per year, faster than other energies. Increasing use of renewable energies, in addition to natural gas, as clean and green energy, will make a significant contribution to the projected reduction in carbon dioxide (CO_2) emissions.

Figure 9-3. Final Energy Consumption by Energy, BAU



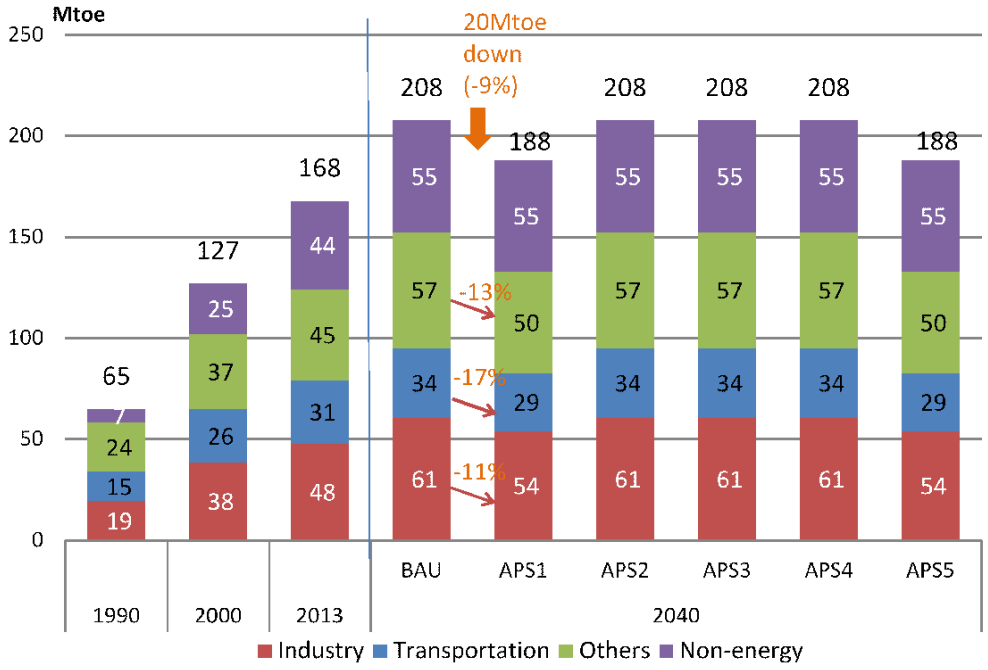
BAU = Business-as-Usual scenario; Mtoe = million tons of oil equivalent.
Source: Author's calculation.

3.3. Alternative Policy Scenarios (APS)

In this section, five alternative scenarios are developed based on the focus of policy options: first, improved efficiency of final energy consumption (APS1); second, more efficient thermal power generation (APS2); third, higher contribution of renewable energy to total supply (APS3); fourth, contribution of nuclear energy to total supply (APS4); and finally, the combined effects of APS 1–4 (APS5).

Final energy consumption by sector in each APS is shown in Figure 9-5. Total final energy consumption is to be reduced only in the case of APS1 (improved efficiency), showing 188.0 Mtoe, which is 19.7 Mtoe (9.5 percent) lower than that in the BAU. Other APS are the same, with 207.7 ktoe for APS2–APS4. The total amount and share of final energy consumption by sector is the same as in the case of BAU. Accordingly, APS5, which combines all APS, gives 188.0 Mtoe, 19.7 Mtoe (9.5 percent) lower than in the BAU, and the same as in APS1.

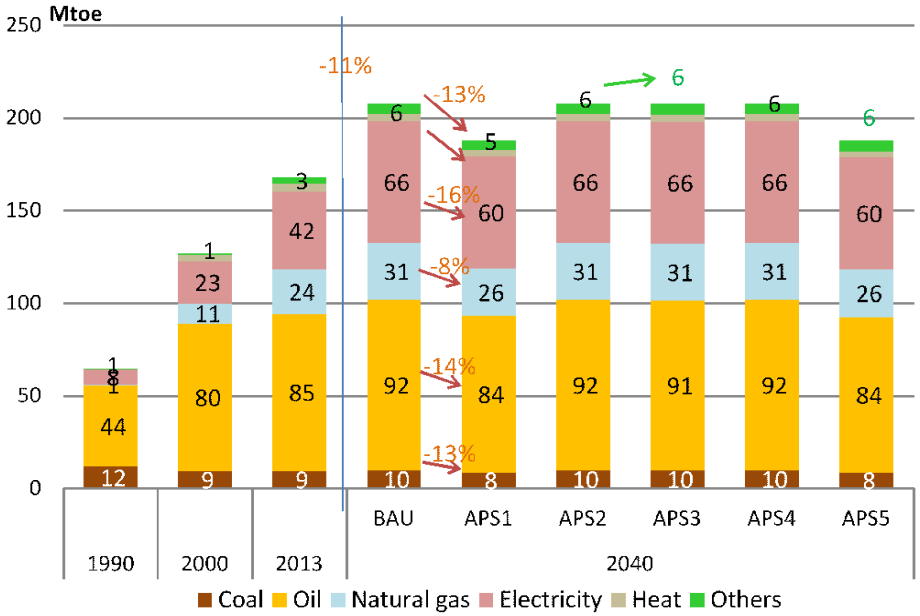
Figure 9-4. Final Energy Consumption by Sector, BAU and APS



BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario; Mtoe = million tons of oil equivalent.
Source: Author's calculation.

Final energy consumption by energy in all scenarios is shown in Figure 9-5. In APS1 (improved efficiency), electricity accounts for the largest share of energy saving, followed by oil and natural gas. Unlike in the case of final energy consumption by sector, energy demand by energy source shows only a little change depending on the specific policy approach of each scenario. In APS3 (higher contribution of renewable energy to total supply), the category of 'others,' including renewable energy, is to be increased by 0.5 Mtoe more than in all other APS. Other than that, APS1 and APS5 are identical in terms of total energy demand, share of energy demand by sector, and energy source.

Figure 9-5. Final Energy Consumption by Energy, BAU and APS



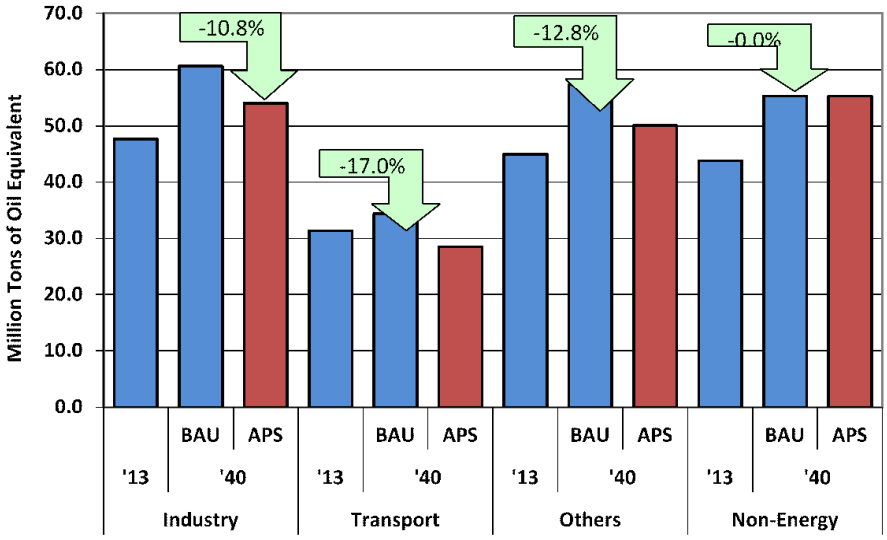
BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario; Mtoe = million tons of oil equivalent.
Source: Author's calculation.

In APS5, which combines APS1, APS2, APS3, and APS4, final energy consumption is projected to increase at an average annual rate of 0.4 percent from 167.8Mtoe in 2013 to 188.0 Mtoe in 2040. Energy demand in the transportation sector is projected to decrease at an annual average rate of -0.4 percent over the same period. The rate of growth is much slower across all sectors as compared with the BAU (Figure 9-6).

3.4. Primary Energy Supply

Primary energy supply in Korea grew at an average rate of 4.6 percent from 92.9 Mtoe in 1990 to 263.8 Mtoe in 2013. Among the major energy sources, natural gas was the fastest growing at an average annual rate of 13.2 percent. In contrast, coal grew at a rate of 5.0 percent a year, followed by nuclear and oil at 4.3 percent and 2.9 percent, respectively, over the same period.

Figure 9-6. Final Energy Consumption by Sector, BAU and APS



BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario.
Source: Author's calculation.

Other energy sources, mainly renewable energies such as solar, wind, biomass, and ocean energy, grew rapidly at a rate of 8.8 percent over the same period, which indicates that the Korean government has been successfully implementing its Low Carbon Green Growth policy.

Business-as-Usual Scenario (BAU)

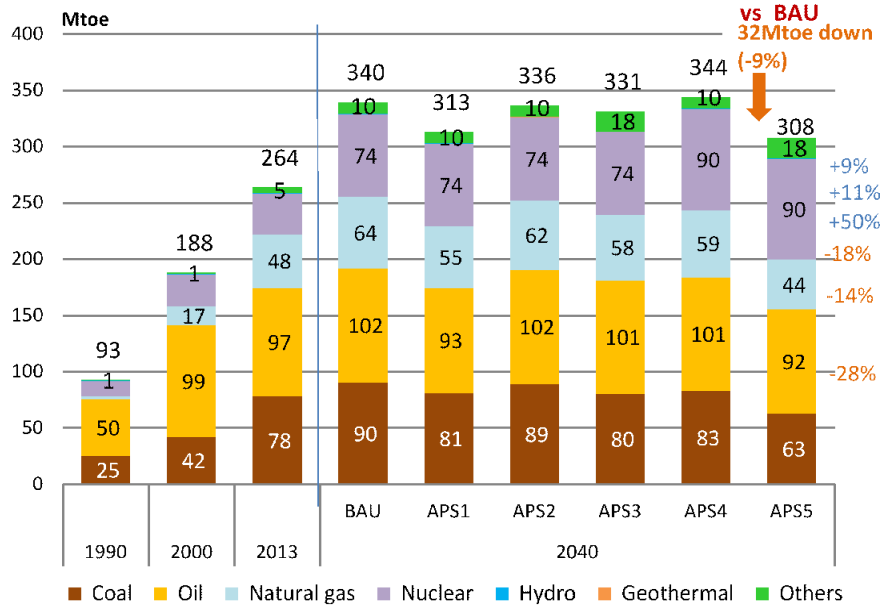
In BAU, primary energy supply in Korea is projected to increase at an annual average rate of 0.9 percent from 263.8 Mtoe in 2013 to 339.6 Mtoe in 2040. Growth for all the energy sources is projected to slow. Consumption of nuclear shows the fastest growth with a rate of 2.7 percent per year, and natural gas and coal show much slower average annual growth rates of 1.1 percent and 0.5 percent, respectively, from 2013 to 2040. The projected growth in nuclear will largely be at the expense of oil, with the share of oil expected to decline from 36.6 percent in 2013 to 29.9 percent in 2040.

Alternative Policy Scenario

Based on the projection and analysis of final energy consumption by sector and by energy source, primary energy supply is projected for all five scenarios.

Unlike in final energy consumption, each APS has different amounts and shares by energy source depending on their specific policy focus. Except for APS4 (contribution of nuclear energy to total supply), APS1, APS2, and APS3 have a primary energy supply lower than BAU. Among those APS, APS1 (improved efficiency of final energy consumption) has the lowest consumption, at 313.0 Mtoe, which is 7.8 percent lower than that in the BAU, followed by APS3 (higher contribution of renewable energy to total supply), at 331.4 Mtoe, and APS2 (more efficient thermal power generation), at 336.5 Mtoe. In APS1, the largest reduction is in the consumption of natural gas, 14.0 percent, followed by coal, 10.1 percent, and oil, 8.1 percent. Nuclear and others (renewable energies) are the same as in the BAU.

Figure 9-7. Primary Energy Supply by Energy, BAU and APS



BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario; Mtoe = million tons of oil equivalent.
Source: Author's calculation.

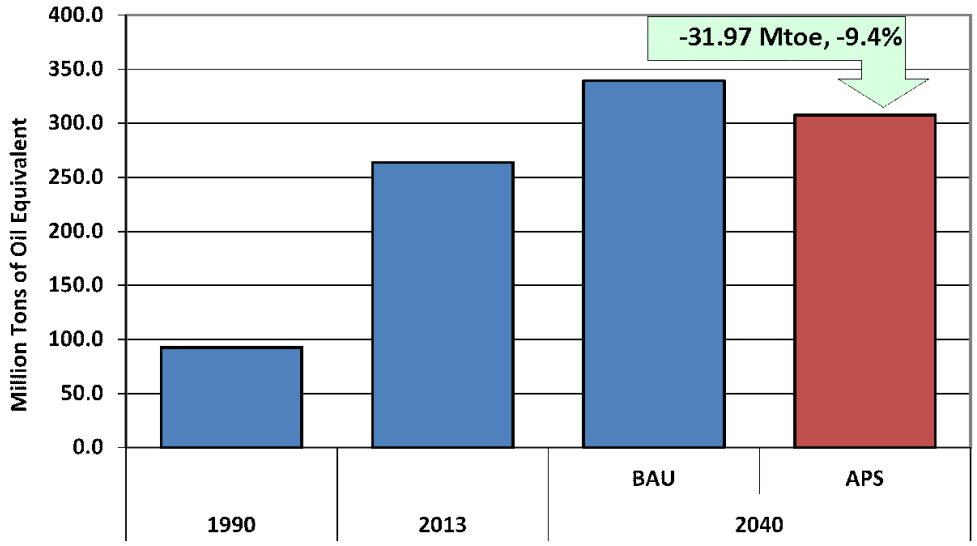
In APS5, which combines all other APS, primary energy supply is projected to increase at a lower rate of 0.6 percent per year from 263.8 Mtoe in 2013 to 307.57 Mtoe in 2040. Fossil fuels such as coal, oil, and natural gas will gradually decrease their consumption from 2013 to 2040, whereas nuclear and renewable energies will increase their consumption by 3.4 percent and 4.7 percent per year, respectively (Figure 9-7). Energy efficiency and conservation (EEC) measures on the demand side will be the main contributors to the projected reduction in consumption growth.

Projected Energy Saving

Major energy policy approaches to reducing energy demand in Korea are as follows: First, energy policy should be shifted from a supply-oriented approach to a demand-oriented one. Reform of energy pricing and energy taxation is the most pressing issue. In this context, market mechanisms should be introduced in energy pricing so that rational energy use is induced through the sharing of full information on the cost of energy production and consumption. Second, transformation of the industrial structure into a less energy-intensive one, which is currently underway, should be accelerated towards knowledge-based, service industries and green industries, which consume less, and cleaner energies. Third, energy efficiency standards and codes should be applied in product design and production processes as well as in the design and construction of systems such as factories, buildings, and plants. Under these policy directions, the Korean government should develop and implement an action plan that contains milestones and strategies with specific and cost-effective policy tools.

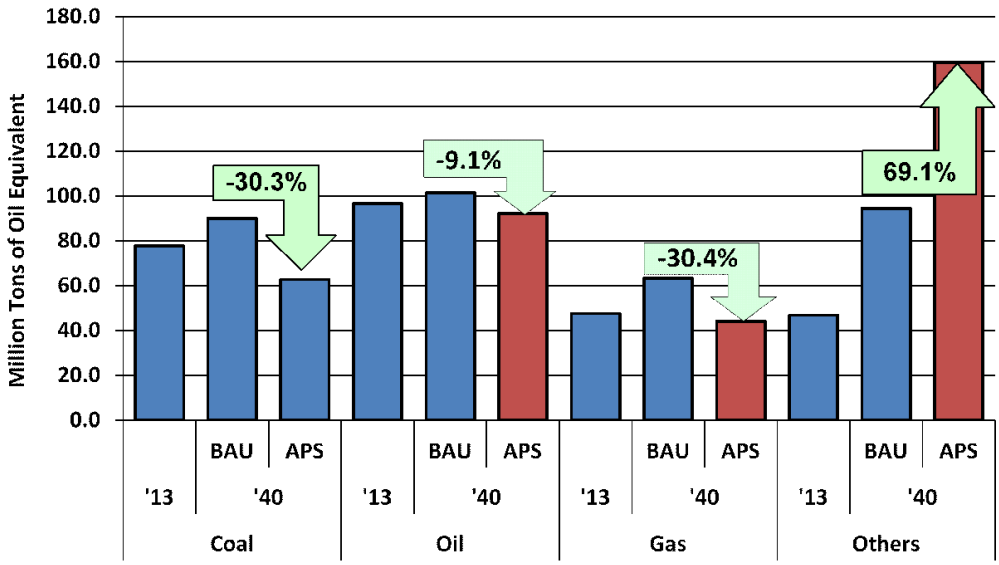
The energy savings that could be derived from the energy saving targets, action plans, and policy tools in Korea, as briefly mentioned in the previous paragraph, is 31.97 Mtoe, the difference between primary energy supply in the BAU and the APS in 2040 (Figure 9-8). This is equivalent to 12.1 percent of Korea's consumption in 2013. Figure 9-9 shows the energy savings potential by energy source. Among the energy sources, gas and coal have the largest projected reduction in energy demand at rates of -30.4 percent and -30.3 percent, respectively, followed by oil at -9.1 percent. In contrast, other energy sources such as nuclear and renewable energies increase by 69.1 percent compared with the BAU.

Figure 9-8. Total Primary Energy Supply, BAU and APS



BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario; Mtoe = million tons of oil equivalent.
Source: Author's calculation.

Figure 9-9. Primary Energy Supply by Source, BAU and APS



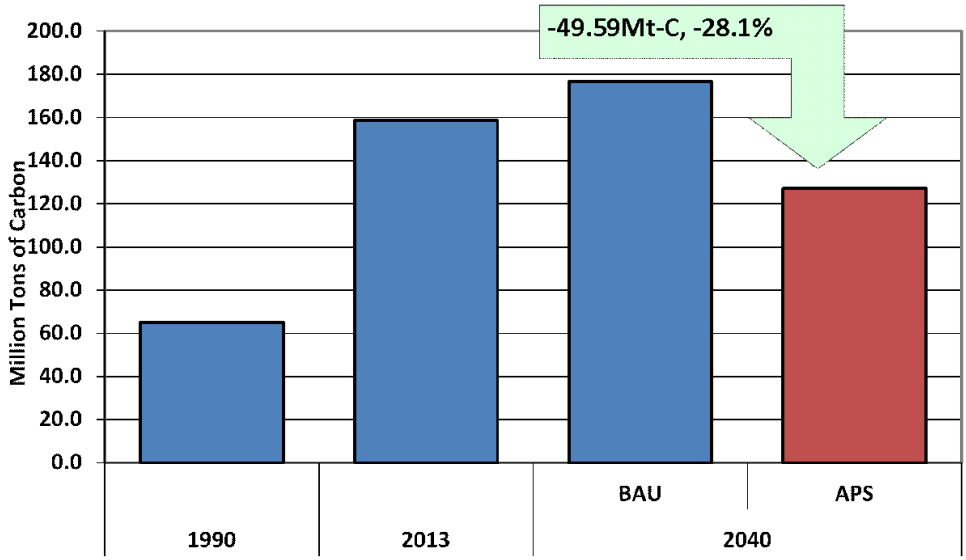
BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario.
Source: Author's calculation.

3.5. Carbon Dioxide (CO_2) Emissions from Energy Consumption

CO_2 emissions from energy consumption are projected to increase at an annual average rate of 0.4 percent from 158.7 Mt C in 2013 to 176.7Mt C in 2040, based on the BAU. This growth rate is slower than that for primary energy supply, indicating that Korea will be using less-carbon intensive fuels such as nuclear, natural gas, and renewable energies and employing more energy efficient, green technologies.

In the APS, CO_2 emissions are projected to decline at an annual average rate of -0.8 percent between 2013 and 2040. The difference in CO_2 emissions between the BAU and APS is 49.59 Mt C, a -28.1 percent decrease (Figure 9-10). To attain such an ambitious target, the Korean government will have to develop and implement cost-effective and consensus-based action plans for energy saving and CO_2 emissions reduction.

Figure 9-10. CO_2 Emission from Energy Consumption, BAU and APS

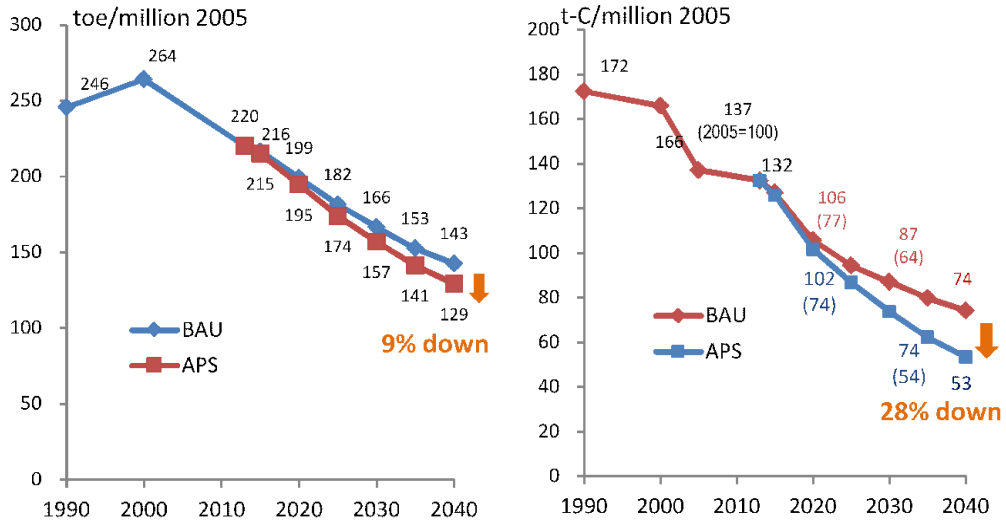


BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario; Mtoe = million tons of oil equivalent.
Source: Author's calculation.

3.6. Energy and Carbon Intensity

As a result of energy savings, the energy intensity of GDP is projected to improve, as shown in Figure 9-11. In the BAU, energy consumption per unit of GDP (toe/million 2005 US$) is projected to fall from 220 to 143, which is a 35.2 percent improvement. In the APS it is expected to improve by 41.4 percent. The energy intensity in the APS is 10 percent below that in the BAU. Carbon intensity is also projected to improve for both the BAU and the APS, mainly due to the forecast reduction in the primary energy supply in terms of energy intensity. The improvement in carbon intensity, CO_2 emissions per unit of GDP (t-C/million 2005 US$), is more salient than the improvement in energy intensity. It is projected to decrease from 132 to 74 and 53 for BAU and APS, by 44 percent and 60 percent, respectively.

Figure 9-11. Energy and Carbon Intensities



toe = tons of oil equivalent; t-C = tons of carbon; BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario.
Source: Author's calculation.

4. Implications and Policy Recommendations

Korea, even without any domestic energy resources economically available, has been making great strides in economic growth, unprecedented in any other countries. Such huge economic growth would not have been possible without a stable and continuous supply of energy, which is a basic element in modern

economic activities. This nexus between economic development and energy consumption had been accepted as inseparable until the end of the 20th century. But entering the 21st century, the Korean government shifted its energy policy to a sustainable, efficient, and energy saving approach, which was to some extent reflected in the 1st (2008) and 2nd (2013) National Energy Basic Plans.

Korea's total primary and final energy consumption in the 1990s had rapidly increased at a rate faster than that of GDP, growth of which had been 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, the shift to a less energy-intensive industrial structure takes time, which means that energy-intensive industry will prevail for the short- to mid-term future. But in the longer term, Korea will and has to transform its industrial structure into a less energy-intensive one.

As mentioned above, the government recently released the 2nd National Energy Basic Plan,[3] with a complete shift from a supply-oriented to a demand-oriented approach. Its basic policy direction consists of six major agendas, with demand-oriented energy policy as a first priority. The other five are (i) building a distributed generation, (ii) harmonisation of the environment and safety, (iii) strengthened energy security, (iv) stable energy supply, and (v) implementation of energy policy with people's support.

As the first priority, energy policy will shift to a demand-oriented approach. The target is to save 13 percent of the total primary energy supply along with 15 percent of electric power consumption. Under this agenda, four policy tasks are proposed: (i) reform of energy-related taxation, (ii) reform of energy pricing, (iii) information and communications technology (ICT)–based demand management, and (iv) strengthening programmes by sector. Reform of energy-related taxation as well as energy pricing is intended to induce a rational use of electricity by coordinating relative prices between electricity and non-electricity energy.

[3] The Korean government worked on the 2nd National Energy Basic Plan in 2013, releasing its report in early 2014.

Additionally, it was proposed that social costs such as nuclear safety, reinforcement of transmission lines, and reduction in greenhouse gas (GhG) emissions, should be duly reflected.

Over the past 3 decades, the major concerns of successive Korean governments have been energy security, energy efficiency, and environmental preservation. The energy security issue has been dealt with by promoting foreign resource development-import and renewable energy development. The issue of energy efficiency improvement has been addressed through programmes supported by the series of Five Year Basic Plans of Rational Energy Use. The environmental issue caused by consumption of fossil and nuclear energy has been dealt with by the relevant offices of the Ministry of Environment. Now is the time for Korea to synergise those efforts exerted so far by selection and concentration of policy tools and programmes through coordination among relevant ministries, as clearly specified in the Second Energy Basic Plan.

It is highly recommended that Korea keep up with the current policy goals of transforming into a less energy-intensive, greener economic structure and implementing policies to decouple the long-cherished nexus of economic growth and energy consumption by implementing the major policy agendas and their corresponding policy tools and programmes. Such nationwide efforts and campaigns should eventually transform the Korean economy into a less energy-intensive and greener one in terms of energy savings as well as reduced CO_2 emissions. Such an achievement would position Korea as one of the leading nations globally in terms of low-carbon green growth.