KOREA

- *Korea's primary energy supply is projected to grow at an average annual rate of 0.5%, from 229 Mtoe in 2009 to 270 Mtoe in 2035.*
- *Energy demand growth will slow over the outlook period as a result of Korea's population growth tailing off and of the continued structural change in the economy toward less energy-intensive industries.*
- *The shift in Korea's energy policy toward sustainable development is expected to facilitate the replacement of oil with renewable and nuclear energies, improvements in energy efficiency, and the optimal diversification of the economy's energy supply.*

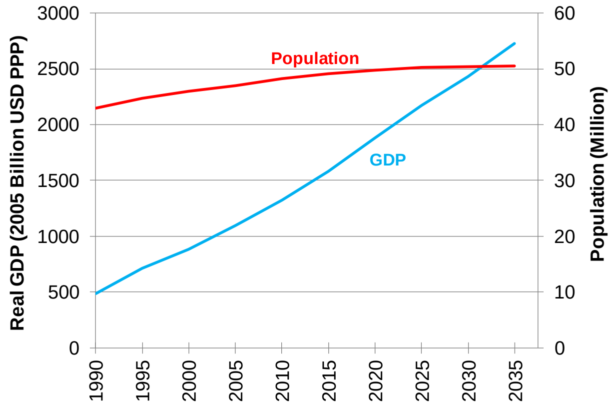
ECONOMY

The Republic of Korea is located in North-East Asia between China and Japan. The economy's geography is largely made up of hills and mountains, with wide coastal plains in the west and the south. The climate is relatively moderate with four distinct seasons. Air conditioning is commonly necessary during the tropical hot summers and buildings need to be heated during the bitterly cold winters.

Since the 1990s, Korea has been one of Asia's fastest growing and most dynamic economies. Gross domestic product (GDP) increased at a rate of 5.1% per year from 1990 to 2009, reaching USD 1244 billion (in 2005 USD PPP) in 2009. Per capita income in 2009 was USD 25 941, more than four times higher than it was in 1990 (Global Insight, 2012).

Korea's major industries include the semiconductor, shipbuilding, steel, automobile, petrochemicals, digital electronics, machinery, parts and materials industries.

Figure ROK1: GDP and Population



Sources: Global Insight (2012) and APERC Analysis (2012)

Korea's population in 2009 was around 48 million people. The economy had an urbanization rate of 80% in 2010. Korea's population density is very high, with an average of more than 480 people per square kilometre. More than 20% of the population lives in Seoul, Korea's capital and its largest city.

The economy's population is projected to grow at an average annual rate of 0.2% during the outlook period and to exceed 50 million people by 2020. The projection for the period 2020 to 2030 is for no population growth (KOSIS, 2012). In addition, Korea's population is ageing rapidly. After 2030, 24% of the population will be over the age of 65 years—a substantial increase from 9% in 2005 (KOSIS, 2012). The effect of these population changes on the size and composition of the labour force will have an impact on future economic growth.

The fast development of Korea's economy was based on a world class public transport system.

There are eight international and six domestic airports connecting Korean cities with almost anywhere in the world. The Incheon Airport hub consolidates Korea's position as one of the main Asian aviation transport centres.

Since 2004, Korea's KTX high speed trains have connected the economy's main cities, and almost all its towns are served by regional bus services. Six of Korea's major cities have subway systems and, in combination with extensive city bus systems, they make getting around the economy's cities easy and cost effective.

Korea has the world's largest ship building industry and it is host to a vast system of ferry and cargo services to the public. There are four major ports in Korea: Incheon, Mokpo, Pohang and Busan.

The total length of Korea's roads in 2009 was 104.9 thousand kilometres (km), 79% of which was paved. The economy had 3776 km of highways connecting its major cities (KAMA, 2012). Further development of highways is planned to overcome the congestion around the economy's big cities due to the high rates of private vehicle ownership.

In 2011, Korea was in the global top five for motor vehicle production. The economy maintained its fifth place following China, Japan, the United States (US) and Germany. Vehicle production in 2011 hit a new record of 4.6 million units. Domestic vehicle sales were over 1.4 million units (including imported vehicles) in 2011 and the total number of registered vehicles in Korea reached 18.4 million units. Most of these were passenger cars (76.6%), 17.5% were trucks, 5.5% were buses, and 0.4% were other vehicles. Under a business-as-usual scenario, the number of registered vehicles in Korea will increase by 0.5–1% annually and by 2035 there will be around 23 million units (KAMA, 2012).

ENERGY RESOURCES AND INFRASTRUCTURE

Korea has few indigenous energy resources. To sustain its high level of economic growth, Korea imports large quantities of energy products. The economy imported 86% of its primary energy supply in 2009 on a net basis. By the end of the outlook period in 2035, Korea will import 72% of its primary energy supply on a net basis with long-term stategy aimed to promote nuclear and NRE energy.

The economy has no oil resources. Korea's total reliance on oil imports has led to a policy of securing its oil supply by long-term contracts (about 70% of supply), spot oil transactions and overseas development.

Korea's refining industry is efficient. It had a combined crude refining capacity of about 2.8 million barrels per day in 2012.

Korea has 3 billion cubic metres of offshore natural gas reserves. This allows the production of a small amount of natural gas, satisfying only about 2% of the annual demand. Korea will continue to rely on imported LNG (liquefied natural gas) for most of its natural gas consumption. LNG imported through the Korea Gas Corporation's (KOGAS's) existing terminals in Pyongtaek, Incheon and Tongyeong will continue to be the economy's main source of natural gas used as city gas and in electricity generation. A pipeline to provide a natural gas supply from Russia is under negotiation and may be introduced after 2016.

There are 326 million tonnes of recoverable coal reserves, mainly anthracite. Existing production capacities allow the production of only 2–2.5 million tonnes of anthracite annually or about 3% of Korea's coal demand in 2010. Korea imports all its bituminous coal (KEEI, 2012).

Given these limited indigenous energy resources, Korea uses a combination of thermal (oil, natural gas and coal), nuclear and hydro electricity generation capacities, and the facility mix has not changed much since the 1990s.

Nuclear energy has retained a high share (around 35%) of the power generation mix over the last two decades. Under a business-as-usual scenario, this is expected to increase to about 49% over the outlook period in response to climate change and energy security pressures.

New and renewable energy (NRE) sources have been widely introduced in Korea and the shares of those power sources will expand during the outlook period. Solar energy will expand for use in the residential sector, mostly for the production of hot water. Bioenergy will continue to be the largest NRE source in Korea. Bio gases will be used for electricity generation and heat production, and biodiesel will be widely used for transportation. There will be an increasing trend to use wind and geothermal energy, due to technology developments and the government's active support.

The economy-wide multi-loop electricity transmission grid has a high reliability, and Korea plans to accelerate the construction of new 765 kV large capacity transmission systems.

Korea's district heating market has expanded steadily, with about 13% of Korean households using it in 2010 (KEEI, 2012). The economy has ambitious plans for the expansion of district heating through its planning policy and tax incentives.

ENERGY POLICIES

In the past, Korea's energy policy focused on ensuring a stable energy supply to sustain economic growth. The government is now seeking a new direction in energy policy to support sustainable development that fully considers the 3Es (energy, economy and environment).

The responsibility for energy policy development and its implementation is divided between a number of government institutions. The Ministry of Knowledge Economy (MKE) is the primary government body for energy policy.

In August 2008, faced with high energy prices and rising concerns over climate change, Korea announced a long-term strategy that will determine the direction of its energy policy until 2035. The strategy suggests the orientation of energy policy towards a vision of Low Carbon, Green Growth.

The primary goals are to improve energy intensity by 47%, and to reduce the economy's dependence on fossil fuels based on the policy of Green Growth.

The nuclear industry is viewed as a realistic alternative to reduce import dependency and to improve greenhouse gas emissions. The government will need to strengthen international cooperation in safety measures and to increase social acceptance of nuclear energy power generation if it is to push forward its plans in a post-Fukushima environment.

The Korea Government plans to expand the share of NRE in the total primary energy supply from 2.2% in 2008 to 11–12% by 2030, focusing on solar, wind and bioenergy resources. It will do this by directly investing in R&D and NRE facilities construction and by providing incentives for businesses participating in NRE development (KEEI, 2012).

Heavy dependence on the Middle East for its crude oil supply has led the economy to a policy of diversifying its oil supply during the outlook period. The state-owned Korea National Oil Corporation (KNOC) will continue to be responsible for the economy's preparedness for an oil emergency situation by operating oil stockpiling facilities and pursuing stakes in oil projects around the world.

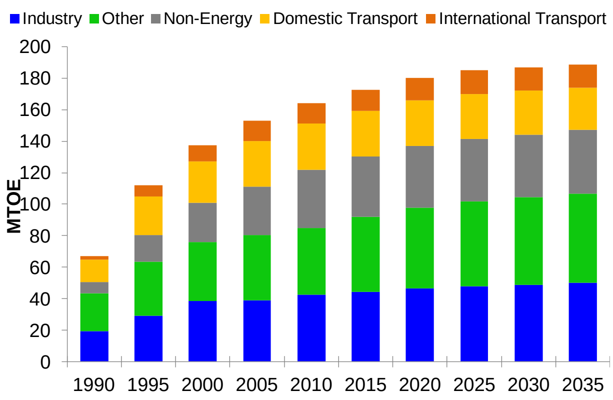
In the natural gas industry, the state-owned monopoly KOGAS will continue to be responsible for managing the import, storage, transmission and wholesale distribution of LNG. The electricity industry will continue to be dominated by the state-owned Korea Electric Power Corporation (KEPCO). It is possible there may be stages of restructuring and liberalization over the outlook period, allowing more private participation in the oil, gas and electricity industries.

BUSINESS-AS-USUAL OUTLOOK

FINAL ENERGY DEMAND

Korea's total final energy demand is projected to grow at an average annual rate of 0.6% over the outlook period, led by the residential and commercial sectors.

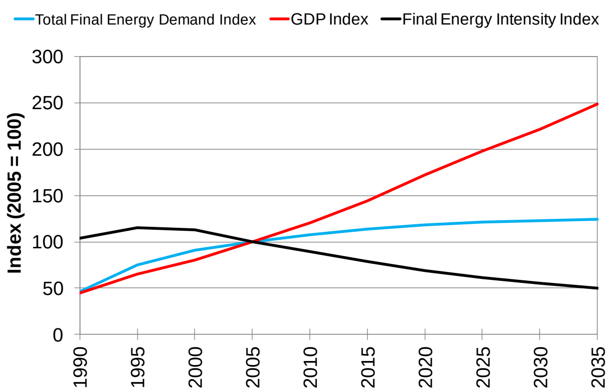
Figure ROK2: BAU Final Energy Demand



Source: APERC Analysis (2012)
Historical Data: *World Energy Statistics 2011* © OECD/IEA 2011

Final energy intensity is expected to decline by about 50% between 2005 and 2035.

Figure ROK3: BAU Final Energy Intensity



Source: APERC Analysis (2012)

Industry

Energy demand in the industry sector is projected to grow at an average annual rate of 0.6% from 2010 to 2035. Electricity is the dominant energy source for the industry sector, although the sector's demand for natural gas is projected to increase substantially.

Transport

The domestic transport sector's final energy demand is projected to decline at an average annual rate of 0.3% over the outlook period. This is mainly because vehicle ownership is expected to level off as economic growth slows and as population growth begins to decline after 2018.

Well-developed public transport systems (such as subway and bus services), especially in Seoul, will also help to slow the growth in transport energy demand.

The international transport sector's final energy demand, however, will increase at an average annual rate of 0.6%, as Korea's airports provide an increasing number of international aviation services.

Other

The final energy demand in the 'other' sector, which includes commercial and residential users, is projected to increase at an average annual rate of 1.2% over the outlook period. The increased demand is based on an expected growth in high-value-added commerce within the commercial subsector.

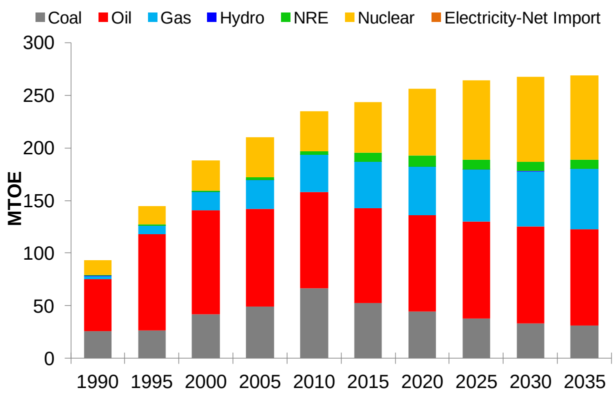
Electricity demand is expected to grow at an average annual rate of 1.6%. Demand will be driven by the spread of air conditioning and the introduction of a wider range of electrical appliances. It will be offset by the expected peaking of population growth.

Natural gas is expected to increase at an average annual rate of 0.7%. This will be driven by an increase in the demand for city gas, although that itself is expected to slow down over the outlook period compared with the growth witnessed from 1990 to 2010. That slowdown will be because the expansion of the trunk pipeline network is almost completed.

PRIMARY ENERGY SUPPLY

Korea's primary energy supply is projected to grow at an average annual rate of 0.5% over the outlook period. This growth rate is much lower than the growth rate of 5.6% between 1990 and 2005. The projected lower growth rate will be due to energy efficiency improvements and limited population growth.

Figure ROK4: BAU Primary Energy Supply

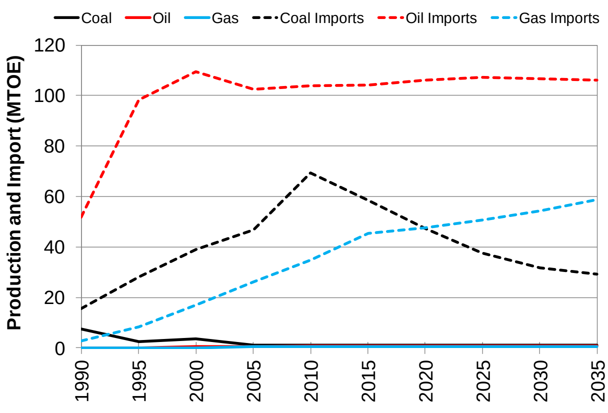


Source: APERC Analysis (2012)
Historical Data: *World Energy Statistics 2011* © OECD/IEA 2011

Oil is expected to remain the dominant energy source through to 2035 but its share will stay constant at around 36%. About half of the oil demand will be for non-energy use by 2035. At the same time, natural gas is projected to increase its share from 14% in 2010 to 23% by 2035; it will grow at an average annual rate of 2.2%. Renewable energy is estimated to grow at a high average annual rate of 5% from 2010 to 2020, and at 2–3% from 2020 onwards, as a result of efforts to diversify energy resources to improve the economy's energy security. However, its share will continue to be small.

Korea will continue to import large quantities of energy products. By 2035, oil imports will be 105 million tonnes of oil equivalent (Mtoe), which is similar to the 2010 level, and natural gas 60 Mtoe. Securing a stable supply of oil and natural gas will be the main energy agenda for Korea over the outlook period. Coal imports will decline, mainly due to the ecological restriction on the use of coal for power generation.

Figure ROK5: BAU Energy Production and Net Imports



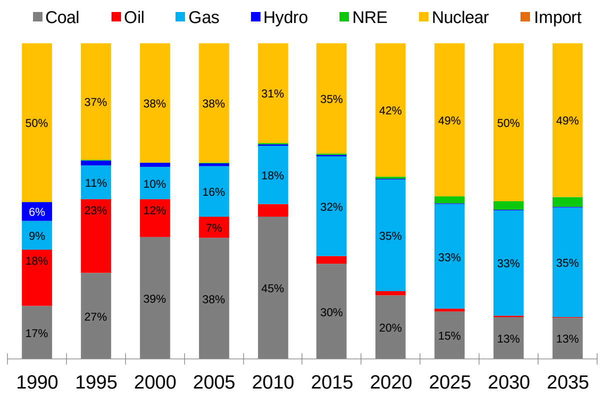
Source: APERC Analysis (2012)
Historical Data: *World Energy Statistics 2011* © OECD/IEA 2011

ELECTRICITY

Korea's electricity demand is projected to grow at an average annual rate of 1.1% over the outlook period. This is much lower than the 9.3% annual growth recorded between 1990 and 2005. More than half of this demand growth is expected to come from the 'other' sector, followed by the industry sector.

The electricity generation mix is expected to change slightly if the government's 2008 long-term strategy is followed. The nuclear share will expand to 49% by 2035 from 31% in 2010, while oil will account for less than 1% (a substantial decrease from its 7% share in 2005). At the same time, natural gas is projected to increase from 18% in 2010 to 35% of the mix in 2035. Renewable energy is expected to grow the fastest, at an average annual rate of 8%, although its share will be less than 5% in 2035. There are no plans for the further development of hydro power in Korea due to a lack of suitable locations.

Figure ROK6: BAU Electricity Generation Mix

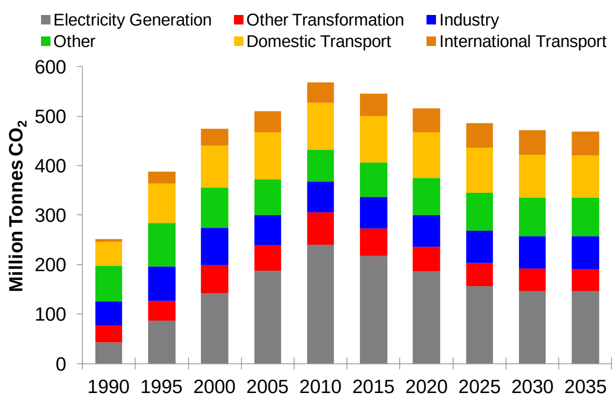


Source: APERC Analysis (2012)
Historical Data: *World Energy Statistics 2011* © OECD/IEA 2011

CO_2 EMISSIONS

Korea's CO_2 emissions are estimated to decline by 18% over the outlook period, from 570 million tonnes of CO_2 in 2010 to 470 million tonnes of CO_2 by 2035. This is because natural gas and nuclear energy are expected to increase their shares in the electricity generation mix by 2035.

Figure ROK7: BAU CO_2 Emissions by Sector



Source: APERC Analysis (2012)

From the decomposition analysis shown in Table ROK1, it can be seen that economic growth underlies Korea's CO_2 emissions increase through the outlook period. This will be offset by a change in energy intensity (energy efficiency) and carbon intensity (fuel switching).

Table ROK1: Analysis of Reasons for Change in BAU CO_2 Emissions from Fuel Combustion

(Average Annual Percent Change)

	1990-2005	2005-2010	2005-2030	2005-2035	2010-2035
Change in CO_2 Intensity of Energy	-2.6%	10.3%	0.6%	0.5%	-1.4%
Change in Energy Intensity of GDP	0.0%	-2.0%	-2.2%	-2.2%	-2.3%
Change in GDP	5.5%	3.8%	3.2%	3.1%	2.9%
Total Change	2.8%	12.3%	1.6%	1.3%	-0.8%

Source: APERC Analysis (2012)

CHALLENGES AND IMPLICATIONS OF BAU

Korea's energy policy shift towards sustainable development is expected to be maintained through to 2035. However, the achievement of a cleaner energy supply for the economy is less certain.

The expansion of nuclear energy power generation may not progress as planned, due to public opposition. Even though there is a good understanding of the importance of nuclear energy by the Korean public, the acceptance of a new power plant at a local level can still be a significant barrier. Delays in nuclear energy power plant construction may result in other energy sources being retained for power generation.

Furthermore, the achievement of the government's target for increasing renewable energy's contribution to the primary energy supply (11% after 2030) is also uncertain. Strong and constant government support for the efforts to increase renewable energy use will be essential if the target is to be achieved.

Energy security will remain a critical issue for any economy such as Korea that relies on imports for most of its energy resources. Even with an expanded share of the primary energy supply coming from nuclear and renewable sources, the projected continuing emphasis on coal for electricity generation, oil for transport use and LNG in the residential sector will leave Korea importing the majority of its energy resources. It is therefore assumed Korea will experience significant challenges in its efforts to better secure its energy supply.

ALTERNATIVE SCENARIOS

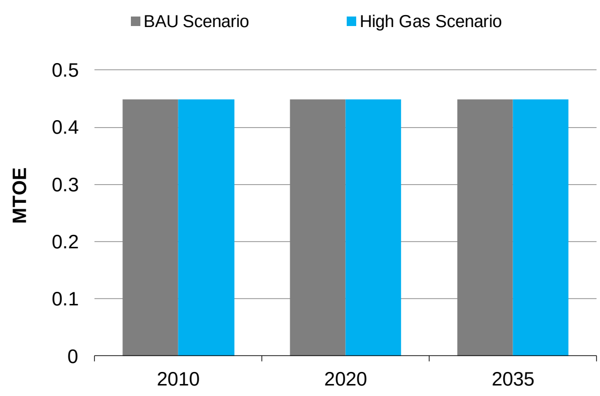
To address the energy security, economic development, and environmental sustainability challenges posed by the business-as-usual (BAU) outcomes, three sets of alternative scenarios were developed for most APEC economies, including the Republic of Korea.

HIGH GAS SCENARIO

To understand the impacts higher gas production might have on the energy sector, an alternative 'High Gas Scenario' was developed. The assumptions behind this scenario are discussed in more detail in Volume 1, Chapter 12. The scenario was built around estimates of gas production that might be available at BAU prices or below, if constraints on gas production and trade could be reduced.

The High Gas Scenario for Korea assumed the production levels would be kept constant at 0.45 Mtoe, as shown in Figure ROK8, through to 2035. The High Gas Scenario assumption primarily removes the import restrictions, including for the possible pipeline supply from the Russian Federation.

Figure ROK8: High Gas Scenario – Gas Production

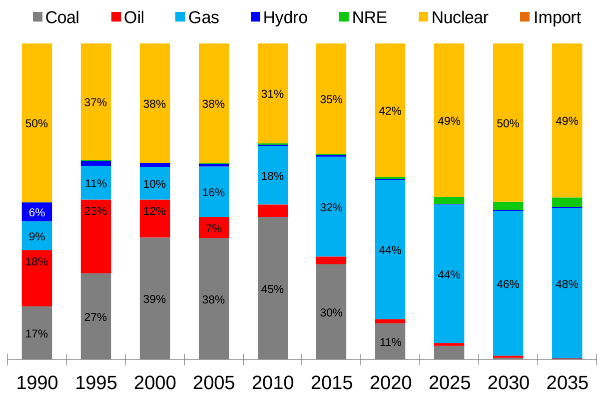


Source: APERC Analysis (2012)

Additional gas consumption in Korea in the High Gas Scenario will depend on the gas market situation in the APEC region. In a high gas availability situation, additional gas will be used to totally replace coal in electricity generation by 2035.

Figure ROK9 shows the High Gas Scenario electricity generation mix. This graph may be compared with the BAU case graph shown in Figure ROK6. It can be seen that the gas share has increased by 13% by 2035, while the coal share has declined from 13% to zero.

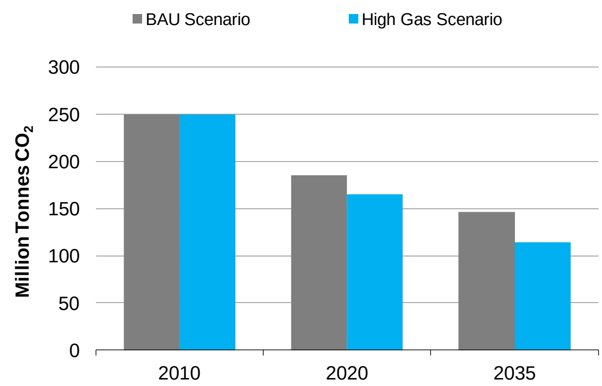
Figure ROK9: High Gas Scenario – Electricity Generation Mix



Source: APERC Analysis (2012)
Historical Data: *World Energy Statistics 2011* © OECD/IEA 2011

Since gas has roughly half the CO_2 emissions of coal per unit of electricity generated, this had the impact of reducing CO_2 emissions in electricity generation by 21% by 2035. Figure ROK10 shows this CO_2 emissions reduction.

Figure ROK10: High Gas Scenario – CO_2 Emissions from Electricity Generation



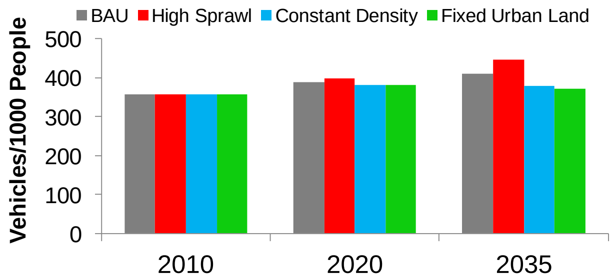
Source: APERC Analysis (2012)

ALTERNATIVE URBAN DEVELOPMENT SCENARIOS

To understand the impacts of future urban development on the energy sector, three alternative urban development scenarios were developed: 'High Sprawl', 'Constant Density', and 'Fixed Urban Land'. The assumptions behind these scenarios are discussed in Volume 1, Chapter 5.

Figure ROK11 shows the change in vehicle ownership under BAU and the three alternative urban development scenarios. Urban planning has a direct effect on the expected level of vehicle saturation on long-term vehicle ownership. Since vehicle ownership is near saturation in Korea, the impact of a change in urban planning on vehicle ownership for large Korean cities like Seoul, Busan and Daegu is significant.

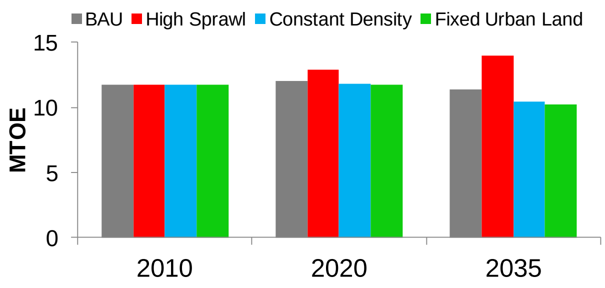
Figure ROK11: Urban Development Scenarios – Vehicle Ownership



Source: APERC Analysis (2012)

Figure ROK12 shows the change in light vehicle fleet oil consumption under BAU and the three alternative urban development scenarios. The impact on oil consumption from the change in the size of the light vehicle fleet is compounded by the change in the distance travelled per vehicle. In compact cities, modelled by the Fixed Urban Land scenario, travel distances per vehicle are typically lower than in sprawling cities modelled by the High Sprawl scenario. As a result, light vehicle oil consumption would be 23% higher in the High Sprawl scenario compared to BAU in 2035, and about 9% and 10% lower in the Constant Density and Fixed Urban Land scenarios respectively.

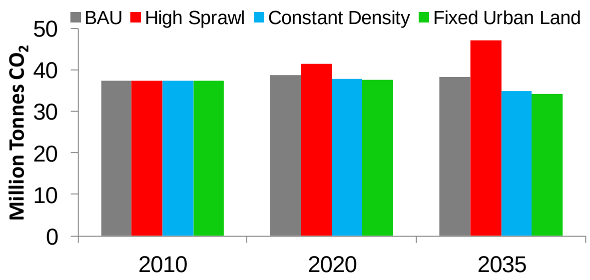
Figure ROK12: Urban Development Scenarios – Light Vehicle Oil Consumption



Source: APERC Analysis (2012)

Figure ROK13 shows the change in light vehicle CO_2 emissions under BAU and the three alternative urban development scenarios. The impact of urban planning on CO_2 emissions is similar to the impact of urban planning on energy use, since there is no significant change in the mix of fuels used under any of these scenarios.

Figure ROK13: Urban Development Scenarios – Light Vehicle Tank-to-Wheel CO_2 Emissions



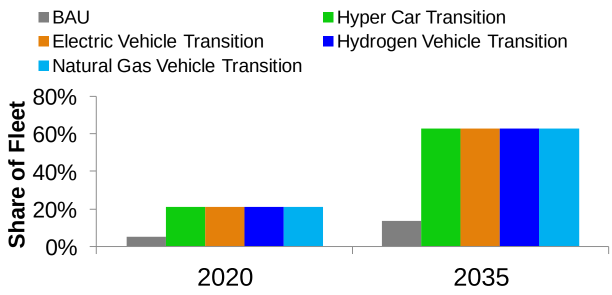
Source: APERC Analysis (2012)

VIRTUAL CLEAN CAR RACE

To understand the impacts of vehicle technology on the energy sector, four alternative vehicle scenarios were developed: 'Hyper Car Transition' (ultra-light conventionally-powered vehicles), 'Electric Vehicle Transition', 'Hydrogen Vehicle Transition', and 'Natural Gas Vehicle Transition'. The assumptions behind these scenarios are discussed in Volume 1, Chapter 5.

Figure ROK14 shows the evolution of the vehicle fleet under BAU and the four 'Virtual Clean Car Race' scenarios. By 2035 the share of the alternative vehicles in the fleet reaches around 60% compared to about 10% in the BAU scenario. The share of conventional vehicles in the fleet is thus only about 40%, compared to about 90% in the BAU scenario.

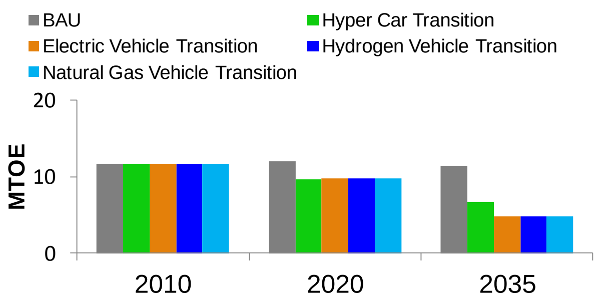
Figure ROK14: Virtual Clean Car Race – Share of Alternative Vehicles in the Light Vehicle Fleet



Source: APERC Analysis (2012)

Figure ROK15 shows the change in light vehicle oil consumption under BAU and the four alternative vehicle scenarios. Oil consumption drops by 53% in the Electric Vehicle Transition, Hydrogen Vehicle Transition, and Natural Gas Vehicle Transition scenarios compared to BAU by 2035. The drop is large as these alternative vehicles use no oil. Oil demand in the Hyper Car Transition scenario is also significantly reduced compared to BAU—30% by 2035—even though these highly-efficient vehicles still use oil.

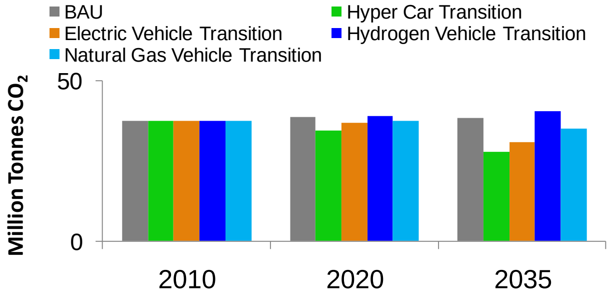
Figure ROK15: Virtual Clean Car Race – Light Vehicle Oil Consumption



Source: APERC Analysis (2012)

Figure ROK16 shows the change in light vehicle CO_2 emissions under BAU and the four alternative vehicle scenarios. To allow for consistent comparisons, in the Electric Vehicle Transition and Hydrogen Vehicle Transition scenarios the change in CO_2 emissions is defined as the change in emissions from electricity and hydrogen generation. The emissions impacts of each scenario may differ significantly from their oil consumption impacts, since each alternative vehicle type uses a different fuel with a different level of emissions per unit of energy.

Figure ROK16: Virtual Clean Car Race – Light Vehicle CO_2 Emissions



Source: APERC Analysis (2012)

In Korea, the Hyper Car Transition scenario is the winner in terms of CO_2 emissions savings, with an emissions reduction of about 28% compared to BAU in 2035. Reflecting Korea's relatively low-carbon electricity generation, the Electric Vehicle Transition scenario comes in second, with an emissions reduction of 20% compared to BAU in 2035. Reflecting the lower carbon-intensity of natural gas compared to oil, the Natural Gas Vehicle Transition scenario achieves an emissions reduction of about 8% compared to BAU in 2035. Reflecting the inefficiency of producing hydrogen vehicle fuel from natural gas, then converting the hydrogen to electricity in the vehicle, the Hydrogen Vehicle Transition scenario would actually increase emissions by 6% compared to BAU in 2035.

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