Republic of Korea: low-carbon economy pathway and climate proof society

Where are we?
Korea\(^1\) is actively participating in international efforts to tackle climate change. Korea adopted an ambitious Green Growth Strategy in 2009 and established the Framework Act on Low Carbon, Green Growth to promote the development of the national economy by laying down the foundation necessary for low carbon society, green growth and by utilising clean energy technology and green industries as new engines for growth. As such, Korea pursues the harmonised development of the economy and the environment and aims to contribute to the improvement of the quality of life of every citizen and the transition to a mature, top-class, advanced country that shall fulfil its responsibility in international society through the realisation of a low-carbon economy and society.

With this act and strategy, Korea has officially employed the cap-and-trade system and the operation applies to major companies that account for approximately 63\% of the nation’s GHG emissions. To prove this activity, the Korean government built a Monitoring, Reporting and Verification (MRV) system with the initiated Greenhouse Gas inventory & Research Center. The GHG emission volume of each controlled entity is verified by the verification agency; it is then submitted to the management agency for further verification, and finally confirmed by the Greenhouse Gas Inventory & Research Center (GIR) for approval. To prevent current market failures, the government plays a key role in green R&D, particularly for basic research, in fostering green finance and in developing renewable energy resources.

Despite wide climate efforts, Korea’s GHG emissions grew strongly from 1990, being 690.2 MtCO\(_2\)e in 2015 due to the growth in industry activity and building energy use. South Korea submitted its Intended Nationally Determined Contribution (INDC) on 30 June 2015 and proposed an economy-wide target to reduce its greenhouse gas (GHG) emissions by 37\% below business-as-usual (BAU) levels of 850.6 MtCO\(_2\)e by 2030. The target is equivalent to limiting GHG emissions in 2030 to 536 MtCO\(_2\)e, which is 81\% above 1990 emission levels, excluding emissions from the land-use, land-use change and forestry sector (LULUCF).

Under the Framework Act on Low Carbon Green Growth, the Korean government set a long-term renewable energy plan with increasing Renewable Portfolio Standards (RPS) obligation. After NDC submission, the Korean government changed the energy mix focus from nuclear to LNG and renewable energy in its long-term energy plan due to the widespread nuclear security issue due to earthquakes and air-pollution concerns. The new government’s energy policy is likely to be challenging Korea’s NDC due to the issue of the substitution of nuclear power plants.

The Korean government held a green growth committee on July 18, 2018 and deliberated and voted on ‘the amendment and supplementation of the basic roadmap for 2030 national greenhouse gas reduction’. Korea will maintain the NDC emissions target of 536 million tons corresponding to the target of 37\% reduction compared to the BAU projections in 2030. Korea will increase the amount of reductions in the domestic sector from 25.7\% to 32.5\% and decrease the amount of overseas reductions from 11.3\% to 4.5\%. Various reduction measures such as utilisation of forest sink, seeking cooperation between South and North Korea, and establishment of hydrogen economy infrastructure are also discussed.

A technical analysis for setting the 2030 target was conducted by a Joint Working Group of national research institutions, including the GIR and the Korea Energy Economics Institute (KEEI). The KEEI-EGM System model was used to produce the BAU emission pathway. The TIMES and KEI-Linkages models were used to evaluate emission reduction potentials in low-carbon scenarios and to calculate economic impacts respectively.

---

\(^1\) We acknowledge funding from the COMMIT project, Climate pOlicy assessment and Mitigation Modeling to Integrate national and global Transition pathways. The project is financed by the European Commission’s Directorate-General for Climate Action (DG CLIMATE). More info on: https://themasites.pbl.nl/commit/
Total Korean GHG emissions consisted of 87.1% from the energy sector, 7.6% from industrial processes, 2.9% from agriculture, and 2.4% from wastes in 2015. Emissions from fuel combustion make up 99.3% of the energy sector emissions, which is equivalent to 86.5% of total national emissions. In terms of the increase in emissions by sector, the energy sector and wastes showed an increase of 0.6% and 6.4%, respectively, and industrial processes and the agricultural sector showed a decrease of 5.5% and 0.7% relative to 2014.

Where do we want to go?
The Korea government activated many policies and roadmap under the Act on Low Carbon as follows:

- Climate change response plan (2016)

The 2030 National Greenhouse Gas Emissions Reduction Roadmap was amended to adopt public concerns and the new power generation plan. It proposes policies to encourage companies to develop climate change response technology and investment through the national roadmap to promote market-centred emission reduction measures. In consideration of the Paris Agreement, Korea will prepare its Mid-term low-carbon development strategy with the participation of major institutes. Korea Environmental Institute (KEI) and KEEI currently explore 2050 low-carbon transition scenarios consistent with the Paris Agreement objectives. KEI suggests policies and measures for transforming to the climate proof society by 2050 including options that need socioeconomic system transformation with a dramatic increase of energy efficiency, low-carbon electricity expansion, economic structure reform, and land use change in a climate-proof way. KEEI draws the Korea’s vision for a 2050 low-carbon economy, which is defined as “decarbonised and resilient economy promoting sustainable growth”. The core ideology of the vision includes sustainable growth, prosperity, decarbonisation, and resilience, which serve as a guide to the thinking, attitude and behaviour change of the Korean society members. The envisioned future encompasses specific targets for greenhouse gas reduction and transition targets for industry, transportation, and the energy system. In addition, the application of end-of-pipe technologies to prevent air-pollution and the realisation of a low-carbon economy can contribute to finding a long-term and fundamental solution for the problem of fine dust, which has become a major social issue in recent years. Furthermore, it can be used for the government’s long-term energy mix planning. Korea government and civil society have launched a public consultation on a strategy for long-term Korea GHG emissions reduction reflecting on a vision for a low-carbon, climate-proof economy. The low-carbon scenario shows a steady decline of emissions to about 396 MtCO₂e in 2050. This represents a 50% reduction from the 2050 BAU case and 39% relative to 2015 emissions. The Korea’s long-term strategy describes pathways with various options for decarbonisation and their implications for technology choices and socioeconomic factors. The energy supply sector is the major contributor to emission reductions combined with electrification of final energy uses, driven by extensive expansion of wind, solar PV, and CCS in power production (Figure 1). Currently discussed Korea’s long-term strategy with government power generation plan is beyond Paris Agreement targets (limit global warming to 2/1.5 °C above pre-industrial levels). Current scenario’s cumulative emission is 21.8Gt in the 2010-2050 period. In the global model estimation², Korea’s carbon budget is 17Gt in the 2010-2050 period for cost-optimal scenarios assuming a global carbon budget of 1000 Gt CO₂, considered equivalent to likely below 2 °C. Korea’s “low carbon” scenario, therefore, needs more significant emissions reductions to be consistent with cost-optimal pathways to limit global warming to below 2 °C and 1.5 °C.

How do we get there?
The model-based analysis shows that the key options to decarbonise the energy system include (Figure 2):

- Decarbonisation of power generation mainly driven by nuclear, solar PV, and CCS;
- Rapid expansion of RES both in power generation and in final demand sectors;
- Electrification of final energy uses both in heating and mobility sectors;
- Fuel switching in final energy mix towards electricity and natural gas to cope with air-pollutants.

High RES expansion is driven by significant cost reduction due to accelerated technical progress by 2050. The role of electricity is central in the Korea’s low-carbon transition; the electrification of final energy demand complemented with decarbonised power supply has a critical role for the cost-efficient energy system decarbonisation by 2050. Closing the current emissions gap with low-carbon pathways consistent with the Paris Agreement can be achieved with substantially renewed, immediately more ambitious NDCs.

The power generation sector is projected to undergo a profound restructuring towards the dominance of variable renewables, with the share of solar PV and wind power in power generation increasing from 4% in 2015 to 11% in 2030 and 38% in 2050. The restructuring of the energy system implies significant changes in the energy mix. The energy-related costs for households will increase driven by the high costs of LNG and renewable energy. On the other hand, the low-carbon transition has clear positive implications for security of energy supply, air quality and human health. Emission trading will change industrial activity, while concrete sector-specific measures to trigger sufficient clean energy investment in transport and buildings are required. In parallel, gas-fired capacities have a strategic role for balancing and reserve to complement expansion of intermittent RES especially in case that Korea nuclear phase out plan is implemented.
The role of LNG and nuclear power in Korean low-carbon transition

A key strategy of the Korea government is expanding the use of LNG to reduce carbon emissions as well as air-pollutants. The imports of LNG have recently increased in many countries due to policy implementation to reduce urban air pollution. This option holds a potential risk of import due to price surge. Second, the potential of renewable energy, such as solar and wind, is limited in Korea. Technical potential of solar and wind calculated by Korea Institute of Energy Research is 886 Mtoe per year, which can cover future energy demand fully. However, the economic and market potential is quite low when considering environmental impacts, costs, political and social constraints. Although installing solar panels on a small scale can be an option, large solar power plants are preferable, but they require a relatively large area and would pose challenges to the forest and upland as 64% of the land is mountains area. This situation could become even more serious if the development of solar PV plants proceeds around natural ecologically sensitive areas. Third, nuclear power should keep its share in low-carbon transition pathways consistent with the Paris Agreement targets. However, in reality, the government policy direction to phase-out nuclear energy is clear and public acceptance of nuclear energy is not positive, which makes Korea face additional domestic challenges to participate in global efforts to limit the global temperature increase to well-below 2 °C (and even 1.5 °C) above pre-industrial levels. To reduce nuclear power generation, the use of fossil fuels has to be increased given the limited renewable energy potential. For this purpose, the development of CCS technology is very important to achieve strong GHG emission reductions in power supply by 2050. However, the deployment of CCS technologies may remain relatively limited, as the analysis considers the current difficulties for licensing CO₂ storage sites, acceptability issues and scarcity of storage sites. So, Korea needs to consider keeping nuclear power generation until technology innovation of CCS and social agreement on renewable energy expansion have materialised.