NORTH-EAST ASIA LOW CARBON CITY PLATFORM

China, Japan, ROK Low Carbon City Policy Comparative Report (draft)

Prepared for the North-East Asian Subregional Programme for Environmental Cooperation

innovative Green Development Program

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Foreword

In the face climate change and rapid urbanization, there is an urgent need for sub-regional cooperation on low carbon city development. North-East Asian (NEA) countries have introduced policies and practices on low carbon city (LCC) development at different levels of government and using various policy tools. There is great scope for the countries in the region to learn from this wide variety of LCC practices. In 2015, the North-East Asian Sub-regional Programme for Environmental Cooperation (NEASPEC) launched the North-East Asia Low Carbon City Platform (NEA-LCCP) for cities in the region to share their low carbon practices and learn from each other.

In March 2017, the Twenty-First Senior Officials Meeting of NEASPEC (SOM-21) approved the launch of a peer review and comparative study initiative under NEA-LCCP. The objective of this initiative is to facilitate knowledge sharing, capacity building, and networking among experts and agencies from cities in the region. The peer review component of this initiative took a close look at the low carbon practices of the Chinese cities of Wuhan and Guangzhou, providing these cities with LCC planning and policy advice from regional and international experts.

This report analyzes and compares the low carbon city practices of China, Japan and the Republic of Korea, with the goal of identifying sector-specific and city-specific good practices that may be instructive to researchers and policymakers in the wider NEA region. It examines key national-level carbon mitigation policies and sector-specific actions, reviews both top-down and bottom-up low carbon city policy and describes specific instances of carbon reduction actions in cities and in sectors in fifteen brief case studies. This report will be used in NEA-LCCP information-sharing activities and to promote regional low carbon cooperation.

Section One, ***Background*** provides a general survey of global and regional trends low carbon city policy. It also describes the driving factors of greenhouse gas emissions in China, Japan and Republic of Korea. Section Two, ***Low Carbon City Policy in China, Japan and Republic of Korea,*** reviews low carbon policy in the three countries. It includes discussion of low carbon policy overall but focuses on low carbon city policy and its respective institutional frameworks in each country. Section Three, ***Comparative Analysis of Low Carbon City Policy***, examines the similarities and differences in the low carbon city policies of China, Japan and Republic of Korea. Section Four, ***Good Practices***, contains case studies of low carbon city policy at both the municipal and project levels that may be instructive to cities in Northeast Asia broadly. Section Five, ***Challenges and Recommendations,*** describes policy challenges common to all three countries in this study, challenges in the low carbon city policies of each country individually, and Section Six offers recommendations for new sub-regional actions.

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1. Background

Trends in Global Low Carbon City Development

Cities have emerged as a major locus of climate action and innovative low carbon policy. An increasing number of cities are showing leadership in combating climate change by seeking to become "low-" or "zero-carbon" through ambitious action both on their own and through partnerships with, or under the instruction of their respective national governments, the private sector, and transnational city networks. The impetus for low carbon city action is twofold: first, the economic and environmental footprints of cities are significant. The world's largest cities have combined GDPs larger than many individual countries (Hoornweg, 2012). Cities consume two thirds of the world's energy, and cities produce over 70 percent of global CO_2 emissions (C40 Cities, 2012). Their importance will also only continue to grow, with projections of population growth and urbanization suggesting that another 2.5 billion people could live in urban areas by 2050 (UNDESA, 2018). A significant proportion of this urban growth will take place in Asia.

Second, cities are often well positioned to pursue climate action and low carbon development agendas: They control a wide range of local assets and policy tools; have a concentration of ground-level expertise and authority; and often have relatively pragmatic policy positions, with officials more directly accountable to local constituents. These features combine to make cities more nimble than national governments while still able to take actions that make an impact at scale. The 2018 United Nations Environment Programme (UNEP) Emissions Gap Report identifies actions by non-state actors, including municipalities and the networks they belong to, as playing an important role in fulfilling national carbon reduction goals. The report finds that successful cooperative subnational initiatives have the potential to make substantial contributions to reducing the emissions gap, particularly by increasing their ambition and membership (UNEP, 2018).

With concentration of transport, population and economic activities, cities are an important symbol of low carbon development and efforts to combat climate change. Some of the most vivid images of environmental crisis come from cities, such as smog and toxic air pollution, as well as the sustainability transition, such as urban cycleways and electric transport. While there is no agreed definition for what counts as a "low-" or "zero-carbon" city, action by urban authorities to tackle climate change and drive low carbon development is a powerful and increasingly prominent 'glocal' (global and local) phenomenon. Cities committed to low carbon development are providing support to one another through a variety of formal networks and bilateral city-to-city partnerships. Cities in China, for example, which are undergoing rapid economic growth and urbanization, are positioned to serve as a model for effective low carbon development strategies at both the national and municipal level (UNDP, n.d.).

Many cities advance and coordinate low carbon development strategies through transnational city networks (TCN), which provide the opportunity for cities to learn from and support each other and receive expert assistance. Prominent global examples of these include the C40 Cities Climate Leadership Group, a network of 94 megacities; ICLEI Local Governments for Sustainability, a network of over 1500 cities, towns, and regions; and the Global Covenant

of Mayors for Climate & Energy (GCoM), which represents as a global network of mayors over 9,200 cities after merging Compacts of Mayors and EU Covenant of Mayors for Climate and Energy in 2017. There are also regional TCNs, such as the Asian Cities Climate Change Resilience Network and the Climate Alliance of European Cities with Indigenous Peoples[1]. TCNs provide a range of functions to support low carbon city development, including information exchange, networking, lobbying, funding, support developing targets and plans, and monitoring and certification (T. Lee & Jung, 2018). Low carbon cities also operate through national networks and platforms. China's low carbon pilot cities are an example of a city network coordinated by a national government, while the American Cities Climate Challenge[2] is a network coordinated by Bloomberg Philanthropies.

Sub-national low carbon activity is also increasingly linked to international climate agreements, showing that sub-national actors are playing an important role in pushing forward global carbon reduction activities. In Europe, the Step Up Now platform has brought together over fifty European businesses, investors, cities and regions calling for net-zero emissions by 2050. This effort is explicitly linked to the 2050 Pathways initiative that emerged from UN Climate Change Conference (COP 22) in 2016. At COP 23 in Bonn in 2017, 330 municipal leaders from about 60 countries gathered at the Climate Summit of Local and Regional Leaders and adopted the "Bonn-Fiji Commitment of Local and Regional Leaders to Deliver the Paris Agreement at All Levels,"[3] declaring their support for the Paris Agreement. Similarly, C40's Deadline 2020 report is gathering input from C40 member cities on how these subnational actors can help implement the Paris Agreement. In 2016 mayors, city networks and urban stakeholders from around the world called for an IPCC Special Report on Cities and Climate Change during IPCC 43. With conference organized by CitiesIPCC in March 2018 under the title of the CitiesIPCC Cities and Climate Change Science Conference to lay the scientific groundwork for the Special Report, production of the Special Report on Cities and Climate Change will be a part of IPCC's seventh assessment cycle.

Defining Low Carbon Cities

While there is no formal technical definition of "low carbon city", the term generally refers to a city that is making a concerted effort to develop or transform itself sustainably and in ways that lead to and are associated with lower GHG emissions. "Low carbon city policy" is an area of policy associated with promoting the development of low carbon cities at either national or subnational levels. (See box 1. "Existing Research on Low Carbon Cities)

[1] For cities networks, see for example, NEASPEC (2015) "North-East Asia Low Carbon City Platform" accessible at http://www.neaspec.org/our-work/low-carbon-cities

[2] American Cities Climate Challenge, https://www.bloomberg.org/program/environment/climatechallenge/#overview

[3] https://unfccc.int/news/cities-and-regions-adopt-bonn-fiji-commitment-on-climate-action

Box 1. Existing Research on Low Carbon Cities

Existing research on low carbon cities tends to fall into one of two categories: (1) policy research that focuses on directly supporting the development of low carbon cities through the sharing of practices and experiences, and (2) academic research that explores the phenomenon of low carbon cities and tries to explain, among other things, its emergence, impact, and implications for governance. This section provides a summary of these two approaches to contextualize the concepts in this report.

The Policy Perspective

A number of organizations and researchers have produced research that aims to help practitioners and policy makers better understand and support low carbon cities. For example, the Rocky Mountain Institute identifies four general areas of activity in municipal carbon reduction efforts: (1) moving away from carbon- and energy-intensive industries, (2) reducing demand of resources and energy, (3) increasing energy efficiency (4) increasing non-fossil fuel energy in the energy mix (RMI, 2017). More specifically, cities pursuing carbon-reductions in a systematic manner often:

- Identify carbon reduction targets in line with national goals
- Identify renewable energy consumption targets
- Pursue energy efficiency goals
- Promote the use of low carbon materials for use in construction
- Promote public transport and green modes of transport
- Promote high-density, compact urban form
- Promote improved municipal waste management
- Promote public awareness low carbon goals, encouraging low carbon consumption patterns
- Promote green spaces as carbon sinks
- Promote economic restructuring away from energy-intensive heavy industry toward the less energy-intensive services sector (Rauland & Newman, 2015).

The World Bank's Low Carbon Cities Guidebook, which is designed to help municipal authorities think systematically about the development and implementation of low carbon plans, breaks down low carbon city activity into four phases:

1. **Initiation**: The municipality maps out all elements and stakeholder input needed to execute a low carbon strategy.
2. **Planning**: Plans out steps required for implementation, including objectives, targets, roles and responsibilities, and institutional coordination.
3. **Execution**: Executes the day-to-day operations and systems, including information management.
4. **Assessment/Evaluation**: Performs assessment and evaluation exercises that are used to assess policy progress and develop new iterations of low carbon plans (Scholz et al., 2014).

Alliances of low carbon cities, which themselves are discussed further below, have also produce a significant body of research aiming to support low carbon city development, both among their member cities and beyond. C40 Cities Climate Leadership Group (C40), for example, has produced reports analyzing city building codes around the globe (C40 Cities & Tokyo Metropolitan Government, 2015, p. 40) (building codes being a major policy lever for promoting low carbon city development) and outlining specific strategies for accelerating city-level climate action (C40 Cities & McKinsey Center for Business and Environment, 2017). The Carbon Neutral Cities Alliance has produced a report based on the experiences of its member cities in developing plans to achieve net-zero emissions by 2050 to guide other cities in similarly ambitious planning (Innovation Network for Communities & CNCA, 2018).

Other research has sought to identify the "co-benefits" generated by low carbon city policies. Articulating co-benefits is often a key step towards building support for a low carbon city agenda. Some co-benefits regularly identified in the literature include making cities more walkable and human-oriented, reducing traffic congestion, improving air and water quality, lowering energy costs over time, and improving public health (Dhakal & Ruth, 2017; Gouldson, Sudmant, Khreis, & Papargyropoulou, 2018; Hoornweg, 2012).

The Academic Perspective

The academic approach to low carbon cities has often considered low carbon cities as an emerging site of climate and environmental governance. Bulkeley (2010) provides a summary of the early years of this research, which sought to explain the rise of urban climate action and its links with national policymaking and institutional capacity. This literature shows that local economic and demographic circumstances have a large influence on the policies adopted by cities pursuing carbon reduction. Cities with modest population and economic growth are likely to place relatively higher emphasis on energy efficiency and deployment of renewable energy, while cities undergoing urbanization that are characterized by high rates of population and economic growth are likely to stress the development of green infrastructure, the construction of compact urban forms, and the promotion of public transport to discourage private car use.

More recent research has often contextualized city climate action in an ongoing "transnationalisation" of climate governance, defined by the increasing involvement of and action by subnational (e.g. cities and provinces) and non-state (e.g. NGOs, private sector) actors (e.g. Bulkeley et al., 2014). Castán Broto and Bulkeley (2013) explore and categorize the range of urban climate "experiments" taking place in cities and note the importance of multi-actor partnerships, as do Westman and Castán Broto (2018). Another large strand of the research on city climate action and low carbon cities has focused on the importance of "multilevel" governance, that is the interactions between initiatives at the national, regional, and local, levels (e.g. Betsill & Bulkeley, 2006; Homsy & Warner, 2015). A report by OECD and Bloomberg Philanthropies notes that national level policies are often critical in shaping local actions. Legislation at the national level defines the responsibilities and resources available to local governments (OECD & Bloomberg Philanthropies, 2014). When possible, however, cities can surpass their national governments in ambition. In the United States, for example, many city governments are

making carbon reduction efforts in spite of vacillation in climate policy in the national government. Lawmakers in the state of New York recently agreed to pass a climate plan that will bring GHG emissions to near-zero by 2050. Cities in China, Japan and Republic of Korea, in contrast, participate in low carbon city promotion schemes under national governments that have made strong commitments to global efforts to reduce emissions.

A major theme in the academic low carbon cities literature is the emergence of transnational city networks as a new form of environmental governance. These are groups of cities that align around some commonality (e.g. aiming for net-zero carbon emissions, in the case of the Carbon Neutral Cities Alliance (CNCA)) and often provide a range of functions such as technical support, capacity-building services, and offering a platform for knowledge sharing, coordination, and collectively raising ambition. Some of these focus specifically on climate action or low carbon development, while others do so in the context of a broader agenda (Niederhafner, 2013). Transnational networks of cities committed to carbon reductions began to emerge in 1990s, continuing to grow and gain in strength in the 2000s and through the present day. While these networks have proliferated, Bansard, Pattberg, & Widerberg (2017) note that participation in them is geographically skewed, with developing countries significantly underrepresented. Table 1 shows the number of cities in China, Japan, and Republic of Korea currently participating in five of the major city networks relevant to low carbon development: the C40 Climate Leadership Group, ICLEI-Local Governments for Sustainability, The Global Covenant of Mayors for Climate and Energy (GCoM), CDP's 2018 disclosure round, the United Cities and Local Governments World Council (UCLG WC), and the CNCA.

Table 1 Chinese, Japanese, and ROK city participation in low carbon city networks

	C40	ICLEI	GCoM	CDP 2018	UCLG WC	CNCA
China	15	1	1	4	20	0
Japan	2	18	17	3	1	1
Republic of Korea	1	39	8	3	8	0

In the post-Paris Agreement era, with an increased focus on implementation and achieving climate mitigation targets, a research agenda has also developed on measuring the impacts of city climate action and low carbon development efforts. Bansard et al. (2017), for example, argue that the ambition of the city networks fails to, overall, exceed that of countries and remains below what is required to meet the goals of the Paris Agreement. On a different note, Hsu et al. (2017) outline a framework for how subnational and regional climate efforts can be brought into alignment together with Paris. Fuhr et al. (2018) and van der Ven et al. (2016) emphasize that the value of city climate action goes beyond the reduction in carbon emissions by affecting local, national, and international policy outcomes more broadly.

Carbon Emission Driving Factors in China, Japan and Republic of Korea

This section reviews the carbon emissions and some factors driving carbon emission trends in China, Japan, and Republic of Korea, i.e., demographics, energy structure and economic structures.

Carbon Emissions

China

China surpassed the United States as the world's biggest carbon dioxide emitter since 2007. It accounts for approximately 28 percent of global emissions as of 2017[4]. As Figure 1 shows, emissions rapidly increased from 2001 to 2013, reflecting the expansion of manufacturing production after China's accession to World Trade Organization in 2001. Emissions reduced slightly from 2014-2016. As of 2017, China's emissions per capita are much higher than the per capita average for the world, while those of Japan and Republic of Korea are much higher than China. Nonetheless, per capita emissions in some Chinese cities are equal to or higher than cities in developed countries.

International Energy Agency (IEA), in its World Energy Outlook 2017, projects China to peak energy-related annual emissions before 2030, and account for 11% of global emissions growth during the period of 2016-2030 under a New Policies Scenario, which takes account of existing and officially announced policies.

In recent years, China achieved significant reduction of emissions intensity, at a faster pace than originally planned. Carbon emissions per unit of GDP during the 12th Five Year Plan (FYP) period (2011-2015) reduced by 20% from 2010 level, more than the planned target of 17%. By 2017, China reached its 2020 carbon intensity emission target of 40%-50% reduction from 2005 level, three years ahead of schedule. [Fig 1b]

Japan

In Japan, CO_2 emissions gradually increased until the recent peak in 2013, except the drop during 2009 followed by rebound. The reduction reflects the economic downturn caused by the global financial crisis in 2008 and associated decrease in energy demand. It also reflects efficiency improvements (unit consumption) due to a rise in the operation rates of facilities at nuclear power plants (Japan Ministry of Environment, 2011).
The economic recovery led expanded energy demand and thus drove the CO_2 emission after the crisis.

Increases in emissions between 2011 and 2013 are related to the Great East Japan Earthquake and subsequent disasters of 2011, which resulted in significant fall of the operating rate for nuclear power generation facilities. The operating rate fell from 67.3% in 2010 to 23.7% in 2011 and to 0% by 2014 (Japan Ministry of Environment, 2019). The energy demand has been filled by an increase in thermal power generation, which drove up the consumption of fossil fuels and thus CO2 emissions.

[4] IEA data

Emissions reduction from 2014 is due to a decrease in electric power consumption, with the power conservation measures carried out in the Eastern area playing a major role. Another contributing factor is improvements to emission factors for electric power (increased introduction of renewable energy, fuel conversion and high efficiency measures in thermal power generation, etc.) (Japan Ministry of Environment, 2014). Along with the total emission, the per capita CO_2 emission and CO_2 emission intensity have also declined slightly since 2014.

Republic of Korea

In Republic of Korea, total CO_2 emissions continuously increased for decades except some years. The emissions in 2017 was 2.6 times higher than that in 1990. Nonetheless, the pace of growth of CO_2 emissions have been slowing down. While the reduction of emissions due to the Asian financial crisis of 1997-1998 was short-lived, the trend in growth of emissions has slowed down since the early 2010's. (Figure 1)

Economic growth led by energy intensive industrialization, electricity and transportation demand rise were the main drivers of national emissions in the past. Recent stabilization of the national emission growth rate is being driven by the slowdown of the Republic of Korea economy.

Per capita emissions increased much faster than China and Japan and as of 2017 it stood more than 2.5 times higher than the 1990. While the per capita CO_2 emission continued to grow except the period affected by financial crisis, it markedly slowed down in 2000s. The energy intensity of the Republic of Korea's economy has continued to improve over the decades through energy efficiency improvement and low carbon energy transition. Emissions intensity per GDP decreased by 27% from 1990 to 2017.

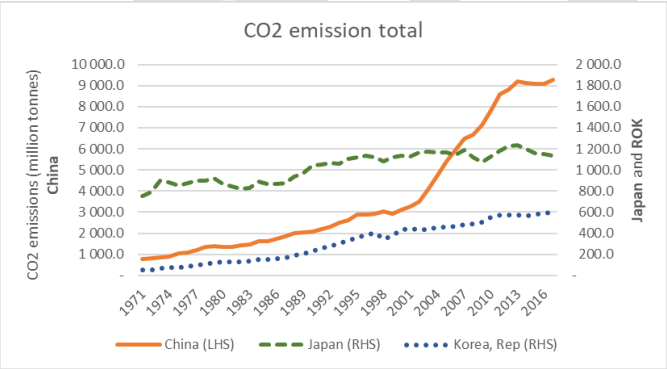


Figure 1a CO_2 emissions total

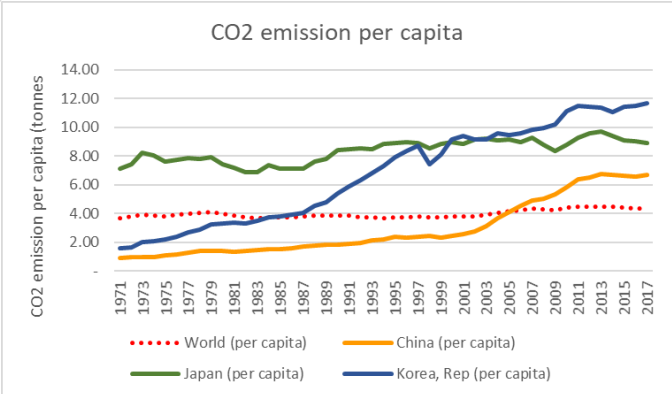
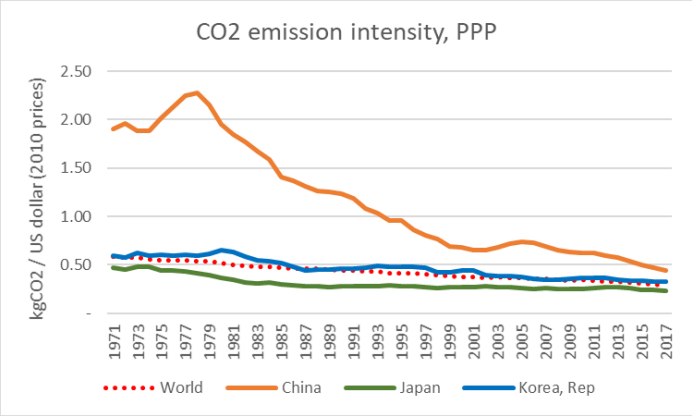


Figure 1b. CO_2 emissions per capita



(Data from International Energy Agency (2019), CO2 Emissions from Fuel Combustion). https://www.iea.org/statistics/co2emissions/)

Figure 1c. CO_2 emissions / GDP using purchasing power parities

Figure 1 CO2 Emissions for China, Japan, and Republic of Korea 1971-2017

Demographics

China

China is the most populous country with 1.39 billion, or *** % in the world total population as of (year). The average annual population growth rate is 0.51% (year) and expected to slow down further with a decreasing fertility rate (population forecast data??). The total population may peak at around 2030 at a level of 1.5 billion, after which it is likely to experience a slow decline.

Urbanization and an increasingly aging population will have a significant impact on consumption and behavior patterns, which in turn will shape energy consumption and carbon emissions. As the figure 3 shows, with the fast urbanization since 1980s, urban population size surpassed its rural population size by 2011. As urban energy consumption (per capita??) is consistently higher than rural energy consumption, China's continuing urbanization is expected to drive up carbon emissions. The dependency ratio of China's elderly population (aged 65+) increased by almost 4% between 2005 and 2017, while the size of the working population (aged 15-64) peaked in 2011 and has since begun to decline.

At this juncture, the impact of these age structure changes on carbon emissions is not clear. Typically, working urban people have higher energy consumption, with commensurate carbon emissions. However, this could be offset by the lower energy consumption habits of a growing elderly population, who tend to be more sedentary, thereby bringing down their carbon footprint.

Japan

The overall population of Japan doubled over a 100-year period, from a 1920 base year population of around 56 million. However, the population peaked in 2010 at 128 million, after which it has continued to decline. Japan is experiencing declining birthrates and an aging population. When Japan's population is divided into three groups (14 and under, 15-64, and 65 and older), the population aged 65 and older has increased from 10% over the past 30 years to 26%, and in 2007, it overtook the proportion of the population aged 14 and

under. Meanwhile, the proportion of the population aged 15 and under decreased from 22% to around 13%. The urbanization rate in Japan passed 90% in 2009. Compared to developing countries, Japan's potential for urbanization is limited.

Republic of Korea

The population of Republic of Korea doubled over the last sixty-year period, from around 25 million in 1960 to approximately 51.5 million people today. In 2016, the annual population growth showed a 0.45% increase from 2015. This shows that the emissions-driving effect from population growth is not as great as other factors (e.g. economic growth driven by the expansion of international trade in energy intensive manufactured goods). The share of the population aged over 65 years represented about 13.4% of the total population in 2016, which was almost four times higher than that of 1960 (3.4%). As in Japan, declining birth rates and population growth (from 2.91% in 1960 to 0.45% in 2016) together with an aging population have become policy challenges. In 2015, more than 81.5% of the total population lived in urban areas, and less that one fifth of the total population resided in semi-urban and rural areas. The urban population in 2015 was 41.7 million, almost six times higher than in 1960.

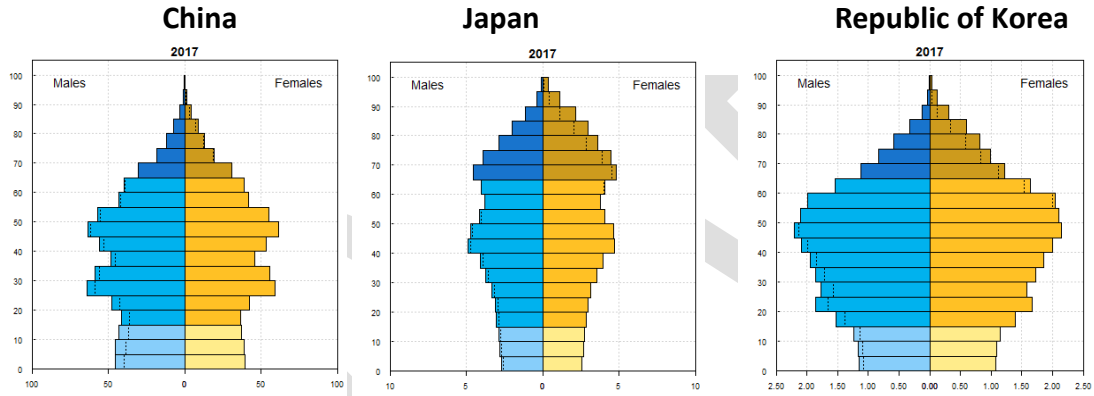


Figure 2: Population Pyramids of China, Japan , and Republic of Korea, 2017 (UNDESA, 2019)

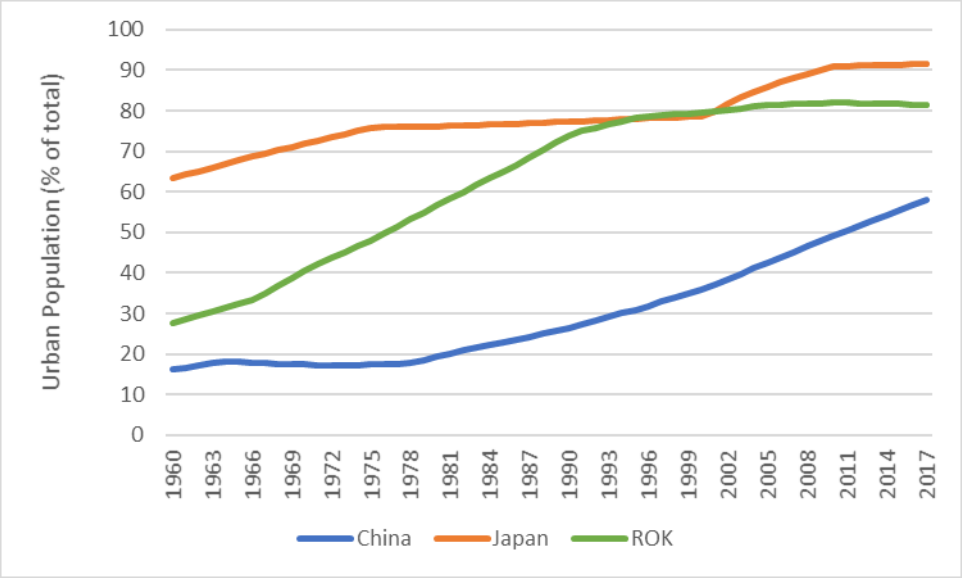


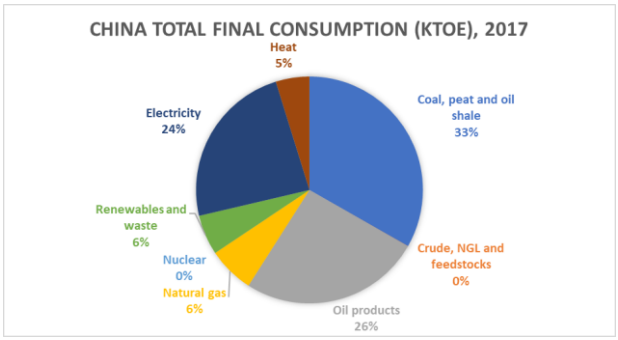
Figure 3. Urban population percentages in China, Japan, and Republic of Korea (World Bank, 2019)

Energy Structure and Consumption Patterns

China

China is the largest consumer of energy, with a share of about one fifth of the world energy supply. Total energy consumption almost tripled from 1990 to 2017. While the share of coal in total final consumption from 47% to 33% during the same period reflecting increased share of electricity, the electricity is predominantly generated by coal. Thus, the share of coal in total primary energy supply remain over 60%, though with declining trend since 2011. Nonetheless, China is undergoing the largest build out of wind power, hydropower, solar PV and nuclear power. One-quarter of the electricity generated in 2017 by renewable sources such as wind, hydro and solar, is produced by China.

China's industry sector is the largest consumer of energy. However, this share has been decreasing since 2010 from almost 60% to 49% in 2017. China's industrial structure is gradually shifting from energy-and resources-intensive to high productivity and incorporating high technology industries. China's transportation energy consumption is low relative to Japan and Republic of Korea. However, mobility and freight activity are rapidly increasing due to rising living standards, continued industrialization, and ongoing urbanization. Transport's share of final energy consumption was 15.6% in 2017, compared to 10.7% in 2000 or 4.6% in 1990. China's residential and commercial buildings accounted for around 21% of total final energy consumption in 2015, a growth of 6% from 2010. This is driven by urbanization and growing commercial and personal income. The "locking in" of high-carbon land use patterns is a common phenomenon. High-carbon land use is characterized by superblocks and single-use development.



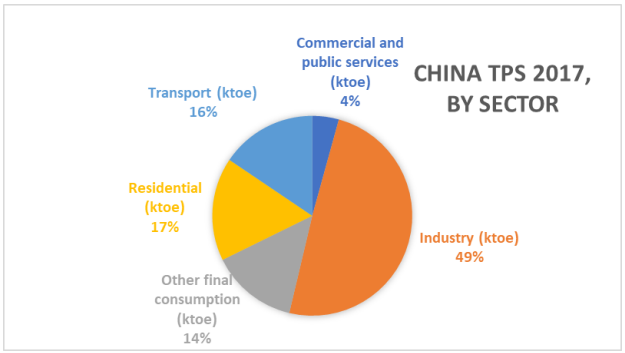


Figure 4. China 2017 total final consumption by source in ktoe and primary energy consumption by main sector (IEA, 2019)

Japan

Energy demand in Japan has rapidly increased since the 1960s, growing over three times in half a century. Japan's degree of dependence on oil reached 75.5% of domestic supply of primary energy in 1973. However, since the oil shock of 1973, Japan has sought to reduce its dependence on oil by promoting the introduction of nuclear power, natural gas, and coal. The share of oil in domestic primary energy supply dropped sharply to 40.3% in fiscal 2010 with an increase in the proportion of alternatives such as coal (22.7%), natural gas (18.2%), and nuclear power (11.2%). However, with the Great East Japan Earthquake in 2011 and the subsequent shutdown of nuclear power plants in the country, the proportion of fossil fuels increased and the proportion of oil that had been moving on a downward trend in recent years rose to 44.5% in fiscal year 2012 (Japan Ministry of Economy, Trade, and Industry, 2018). Between 1965 and 2016, the business sector ranked highest in energy consumption with a 6.37-time increase, followed by the residential sector at 4.28 times and the transport sector at 3.92 times. Growth in the industrial sector has been the lowest, stalling at only 2.07 times. Advances in energy conservation occurred mainly in the manufacturing industry following the first oil shock. However, the proliferation of energy-use devices and automobiles in the residential and transport sectors resulted in a relatively large increase in these sectors (Japan Ministry of Economy, Trade, and Industry, 2018).

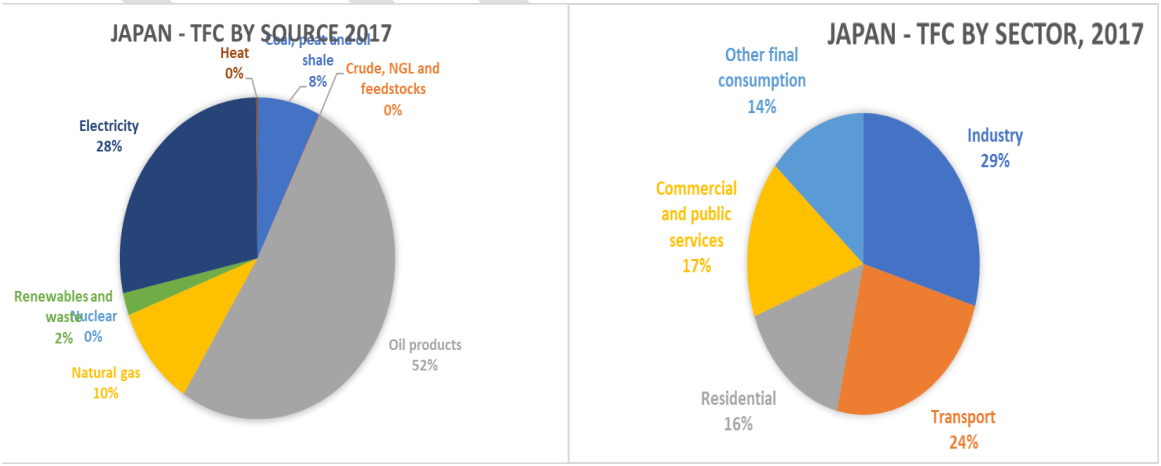


Figure 5. Japan 2017 total final consumption by source in ktoe and primary energy

Republic of Korea

Energy demand in Republic of Korea increased rapidly between 1981 and 1997, before the Asian financial crisis, led by a large demand for oil. After the crisis, natural gas and renewable energy consumption rose more rapidly than oil and coal. Total energy consumption in 2016 was 225.2 million TOE, of which oil represented 50.8% with 114.3 million TOE. Coal represented 32.3 million TOE, followed by natural gas with 22.2 million TOE. The annual energy demand growth rate in 2016 was 3%, with a decreasing growth rate trend in the last 35 years. Domestic primary energy production amounted to 50.1 million TOE and imported primary energy was about 321.9 million TOE in 2016. The industry and transportation sectors led final energy consumption growth between 2001 and 2017. In 2016, industry consumed 61.2% of total primary energy consumption. This was followed by transportation at 18.8%, the residential sector at 9.6% of total primary energy consumption, and the public sector at 7.6%.

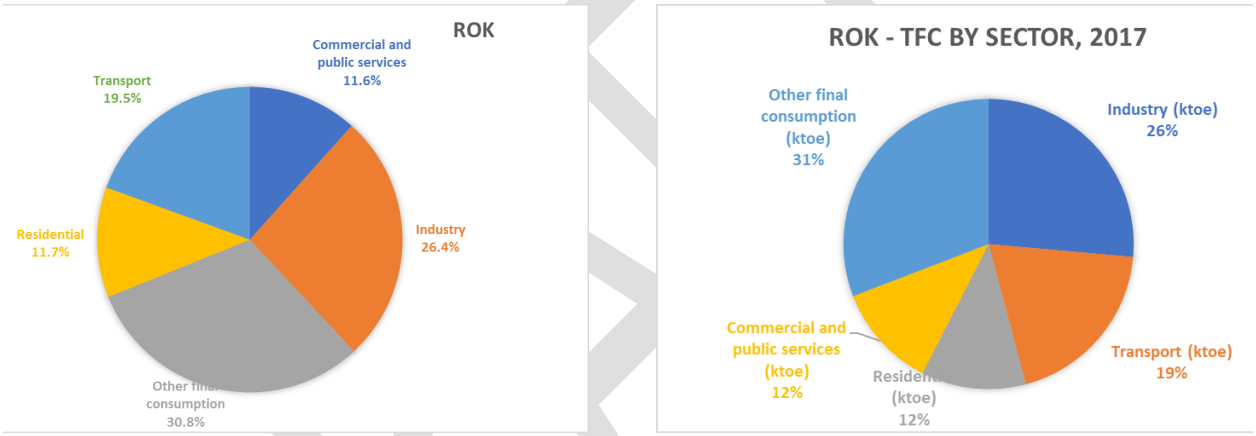


Figure 6. Republic of Korea 2017 total final consumption by source in ktoe and primary energy consumption by main sector (IEA, 2019)

Economic Structure and Strategy

China

China's economy, the world's second largest, is on a track of long-term growth. This growth has shown a modest slowdown since 2011, following an over 20-year run of high growth. Facing international economic and political instability and domestic environmental problems, China is shifting from investment-, labor- and resources-intensive, export-oriented growth to capital- and technology-intensive export and domestic demand-driven growth. This economic transformation is likely to exert downward pressure on carbon emissions. China has entered the ranks of "upper middle-income" countries, as defined by the World Bank. GDP per capita steadily increased from USD 195 in 1980 to USD 8,827 in 2017, with an average annual growth rate of 8.56%. This increasing wealth is driving up personal consumption, which is in turn enlarging the carbon footprint of the average Chinese citizen.

Increasing demand from Chinese households is driving up energy consumption and CO_2 emissions. China's household final consumption expenditure per capita increased from USD

1,874 in 2013 to USD 2,598 in 2017, with urban household final consumption expenditure per capita almost 2.4 times greater than the level of rural households during this period. Disposable income per capita in China's most affluent cities is still far lower than the level of other major metropolises. One exception, however, is in durable goods ownership. China's wealthiest cities show rates of durable goods ownership levels similar to Tokyo.

Japan

Japan's GDP passed USD 5 trillion in 1995, since which is has remained flat through 2007. However, as a result of the global financial crisis in 2008 and the Great East Japan Earthquake in 2011, the number of fiscal years when the GDP has fallen below USD 5 trillion has increased. Since 2013, GDP has made a comeback to the USD 5 trillion mark, recording a figure of USD 5.15 trillion - for the first time in 18 years in 2015. The average GDP growth rate between 1989 and 2015 was around 1%. Between 1995 and 2015, there has been only one time that the GDP growth rate has exceeded 3% from the previous year. Japan's economy has entered a period of low growth, so it is unlikely that there will be a significant increase in emissions resulting from economic growth. Current emission patterns suggest Japan has been decoupling economic growth from CO_2 emissions.

There have been no major changes in the proportion of Japan's GDP by industry over the past 25 years. Between 1989 and 2008, the proportion of the tertiary industry rose gradually, while the proportion of the secondary industry decreased. Since 2005, the tertiary industry has maintained nearly a 1.1% increase. In each year of the global financial crisis of 2008 and the earthquake disaster of 2011, secondary industry has seen a decline in the proportion of GDP. Since 2013, the proportion of secondary industry has continued to rise moderately. GHG emission reductions in the industrial sector since 2013 show that the decoupling between GHG emissions and GDP is already in progress.

Republic of Korea

Starting from USD 8.9 billion in 1970, Republic of Korea's GDP reached USD 1.42 trillion in 2016. During the same period, the average annual real growth rated declined from 10% to 2.9%. Rapid economic growth, with an annual average growth between 6~14%, characterized the export oriented massive industrialization period up to the year 2000. Since 2000, the economy of the Republic of Korea has entered a period of low growth with its annual growth rate continuously decreasing to a less than 3% average annual growth rate in recent years. Together with stagnant population growth, this slowdown of national economic growth has become one of the main drivers of national GHG emission stabilization.

The service sector represented the largest area of economic activity in ROK's economy in 2016. Services contributed USD 664 billion to ROK's GDP, followed by the manufacturing sector with USD 353.6 billion. Agriculture and fishery together amounted to USD 23.4 billion, representing less than 1.9% of GDP. The manufacturing and services sectors in 1960 marked USD 991 million and 13.7 billion respectively. ROK economic growth has been led by the rapid expansion of the manufacturing sector since 1970.

2. Low Carbon Policy in China, Japan and Republic of Korea

This section provides a snapshot of the national and subnational low carbon policies of the three Northeast Asian countries of China, Japan and Republic of Korea, with comparative analysis of the low carbon city policies in each country.

A significant portion of the global urban population and emissions growth is projected to come from Asia in the coming years (WWF, 2010).[5] In North-East Asia, China will dominate urban emissions growth in the future, with Japan and ROK at a lesser extent. This variation in economic growth and urbanization rates, as well as in national political structures, leads to different national approaches to low carbon policy (Ying, 2013).

National Low Carbon Policies and Targets

China

Commitment in the global context
The core objective of China's overall low carbon effort is to decouple economic growth from CO_2 emissions. Under the Paris Agreement, China's Nationally-Determined Contribution (NDC) pledges to achieve a peak in CO_2 emissions by 2030 and make efforts to peak earlier, lower the carbon intensity of GDP by 60%-65% below 2005 levels by 2030, increase the share of non-fossil fuels of the total primary energy to around 20% by 2030, and increase its forest stock volume by 4.5 billion cubic meters compared to 2005 levels.

National policy for low carbon development
The Five-Year Plans (FYP) for Economic and Social Development are at the core of China's economic and development strategy and have a major impact on low carbon development efforts. They contain both binding and non-binding targets across a range of measures, including carbon emissions and energy use. Supporting the specific low carbon targets, such as those embodied in the NDC, China has developed a range of plans such as the "National Climate Change Plan (2014-2020)", "Work Plans for Controlling Greenhouse Gas Emissions" during the 12th FYP and the 13th FYP (Figure 7). These documents outline major tasks and sector-specific measures for low carbon development. China is in the process of developing its 14th FYP for 2021-2025.

[5] Asia includes 49 countries. The North-East Asian Subregional Programme for Environmental Cooperation (NEASPEC) includes China, Democratic People's Republic of Korea, Japan, Mongolia, Republic of Korea, and the Russian Federation. This study only examines the North-East Asian countries of China, Japan, and ROK.

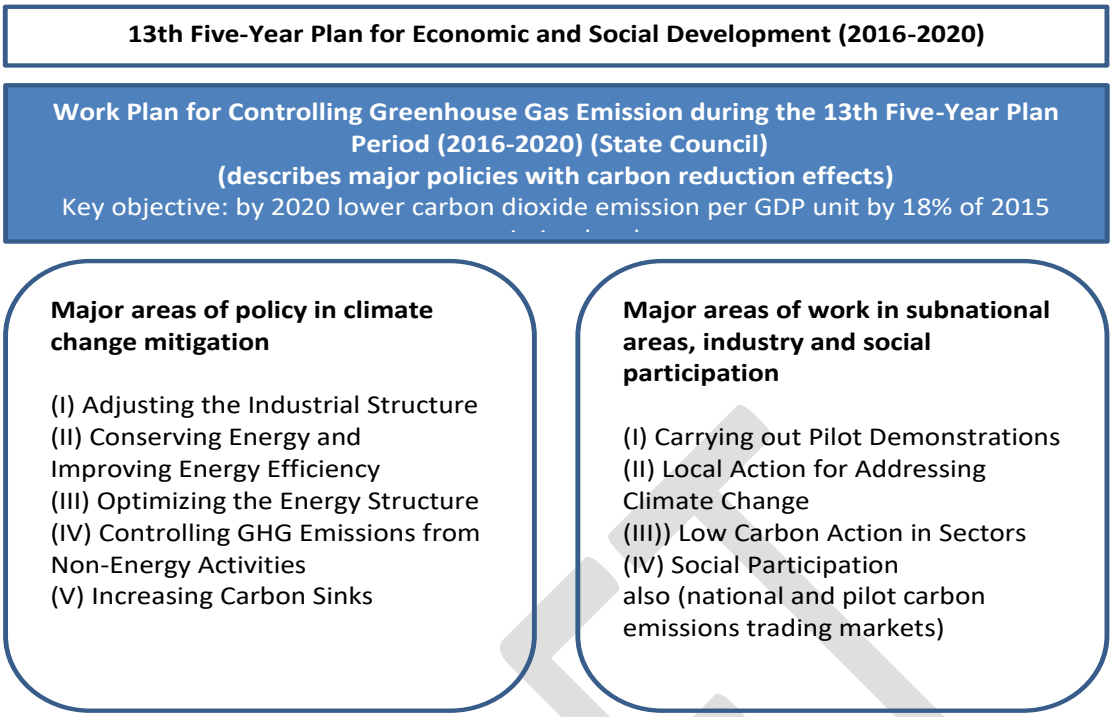


Figure 7. Framework for global warming countermeasures in China

Source: China's Policies and Actions for Addressing Climate Change, National Development and Reform Commission (2017)

Translating national target to local policy target

China has a Target Responsibility System (TRS) policy implementation mechanism that assigns national targets to local governments and requires the latter to be responsible for achieving the assigned target. China has been using this system for national low carbon development policy implementation. Currently there are two legally binding targets that relate to climate change and low carbon development in China's FYP. One is an energy intensity reduction target, and the other is a carbon intensity reduction target. To ensure these targets are achieved, China disaggregates them into different quotas for local governments. Achieving these targets is an important indicator for local government and cadre performance evaluation. This creates incentives for local government officials to prioritize energy and carbon intensity reduction in their local policy agendas.

Policy tools by the national government

China has also instituted economic incentives for low carbon development. To implement its carbon and energy intensity targets and sector-specific policies, the central government offers subsidies, tax breaks, and special funds. For example, China has a technological upgrading fund for the upgrading and transformation of traditional industry, and subsidies for the development and promotion of new-energy vehicles. Apart from these, the development of the emissions trading scheme (ETS) is a major market-based feature of China's low carbon strategy. China's ETS has been operating as a regional pilot program since 2013, covering five cities and two provinces. The pilots have generated know-how for the design and implementation of China's national ETS, which was launched in 2017 and is expected to begin fully operating with emissions trading in 2020.

Information measures are also an important part of China's low carbon policy
implementation. China has conducted GHG inventories at both national and subnational levels and conducted historical emissions data collection from key GHG emitting industries between 2013 and 2017. China also has a climate change statistical indicator system and a green development indicator system to assess green and low carbon development.

Japan

Commitment in the global context
To achieve the reduction targets set out in the Kyoto Protocol that was adopted in 1997, Japan enacted the "Act on Promotion of Global Warming Countermeasures" (Global Warming Act) in 1998, the following year. In 2018, Japan enacted the "Climate Change Adaptation Act". The Global Warming Act has been positioned as the basic law for climate change (mainly mitigation) measures and defines the responsibilities of the national and local governments, businesses and residents. The Global Warming Act was first enacted in 1998 and has been amended six times. The 2008 revision requires local governments over a certain size (prefectures and cities with a population of 200,000 or more) to formulate action plans to reduce greenhouse gases (GHGs) in line with the natural and social conditions of their area of jurisdiction[6].
National policies and targets
Japan's July 2015 Intended nationally determined contributions (INDC) to the United Nations includes a target of reducing GHG emissions by 26% by fiscal 2030 from fiscal 2013 levels. Achieving this target will require a significant GHG emissions reduction of about 40% in the residential and commercial sectors. In line with this, the national government clarified its policy to strengthen public awareness and amended the law in 2016 to promote measures to counter global warming in the region.

According to the "Plan for Global Warming Countermeasures" decided by the Cabinet in 2016, the Japanese government has introduced various policy packages, including voluntary, regulatory, economic, and information methods. These policies include 66 policy areas broken down into five sectors: (1) GHG emission reduction policies and measures, (2) development of civic movements, (3) measures taken by municipalities, (4) measures expected to be taken by businesses with particularly high levels of emissions, and (5) promoting the reduction of GHG emissions overseas, securing international collaborative opportunities, and promoting international cooperation (Figure 8).

[6] Local government action plans can be divided into two types: plans related to administrative business (hereinafter referred to as "local government operation plans") and plans concerning regional measures (hereinafter referred to as "area-wide plans"). There are also differences in the requirements for preparation according to population. Here, we are referring to area-wide plans. Details can be found in section 2.3 "City-level policy for low-carbon development".

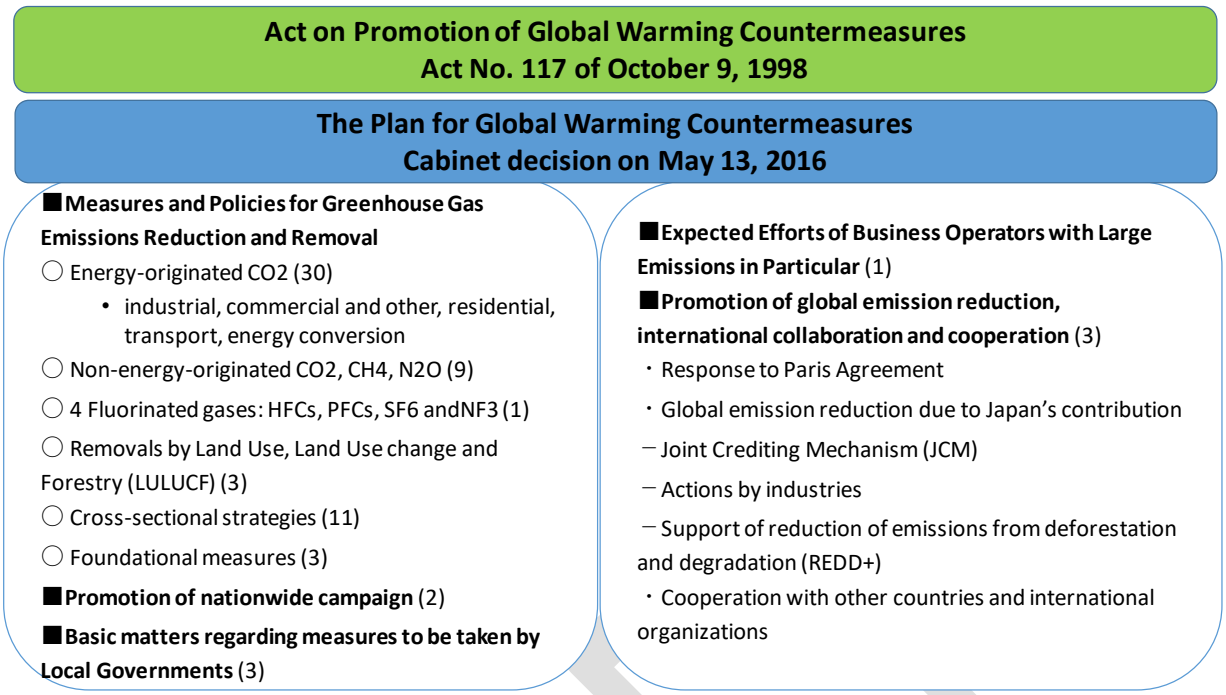


Figure 8. Framework for global warming countermeasures in Japan

Note: Numbers in brackets show the number of policy areas.
Source: Cabinet Decision. "The Plan for Global Warming Countermeasures", 2016

Overall, economic methods (subsidies and tax cuts) are the most widely used, while regulatory methods occupy a relatively small proportion in policy packages. For example, in GHG emission reduction policies and measures, there are 30 areas where countermeasures can be applied and 63 specific measures. However, only three regulatory systems are in place (i.e., compliance with energy conservation standards for new buildings, requirement to carry out energy management at factories and workplaces, and top-runner system).
MLIT's environment action plan (2008, latest revision 2017), issued following the government's Basic Environment Plan, outlines the Ministry's policies towards global warming, low carbon city planning etc.

Republic of Korea

Commitment in the global context
Under the Paris Agreement, Republic of Korea's NDC pledges to cut GHG emissions by 37% from a business-as-usual trajectory by 2030, which aims, along with the national emission roadmap, to provide businesses and entities with a clear signal toward a highly-efficient, low carbon society. The target was revised in 2018 to include a plan to peak national emissions around 2020 and reduce the scope of international offsets in achieving the target so that the domestic contribution must reach 32.5% (previously it was 25.7%) (Climate Action Tracker, n.d.).

National policies and targets
Republic of Korea's key policy for climate mitigation and low carbon development is the 2010 Framework Act on Low Carbon Green Growth (FALCGG), which is the cornerstone of

an innovative national development orientation based on low carbon and green technology for economic growth (KEI, 2019).

Box 2. Principles set by Framework Act on Low carbon Green Growth (FALCGG) to Approach to Low Carbon Development

1. Promotion of comprehensive strategy for national development, including the resolution of problems of climate change, energy, and resources, the expansion of growth engines, the enhancement of enterprises' competitiveness, the efficient utilization of national land, and the development of a comfortable environment;
2. Vitalization of market functions to the maximum and promotion of low carbon green growth initiated by the private sector;
3. Adoption of green technology and green industries as core engines for economic growth and establishment of a new economic system for creating and expanding new job opportunities;
4. Intensification of investment and support focused on green technology and green industries;
5. Enhancement of efficiency in the use of energy and resources in social and economic activities and facilitation of resources circulation;
6. Rearrangement of infrastructure, including national land and cities, buildings and transportation, road, ports and harbors, and waterworks and sewerage systems;
7. Efficient distribution of resources by reorganizing taxation and financial systems and encouraging changes in consumption patterns and lifestyles;
8. Mainstreaming low carbon, green growth with all citizens' participation and the cooperation of national agencies, local governments, enterprises, economic organizations, and non-governmental organizations;
9. Enhanced contribution to global low carbon, green growth by taking its responsibilities and roles as a member of international society

Source: KEI, 2019

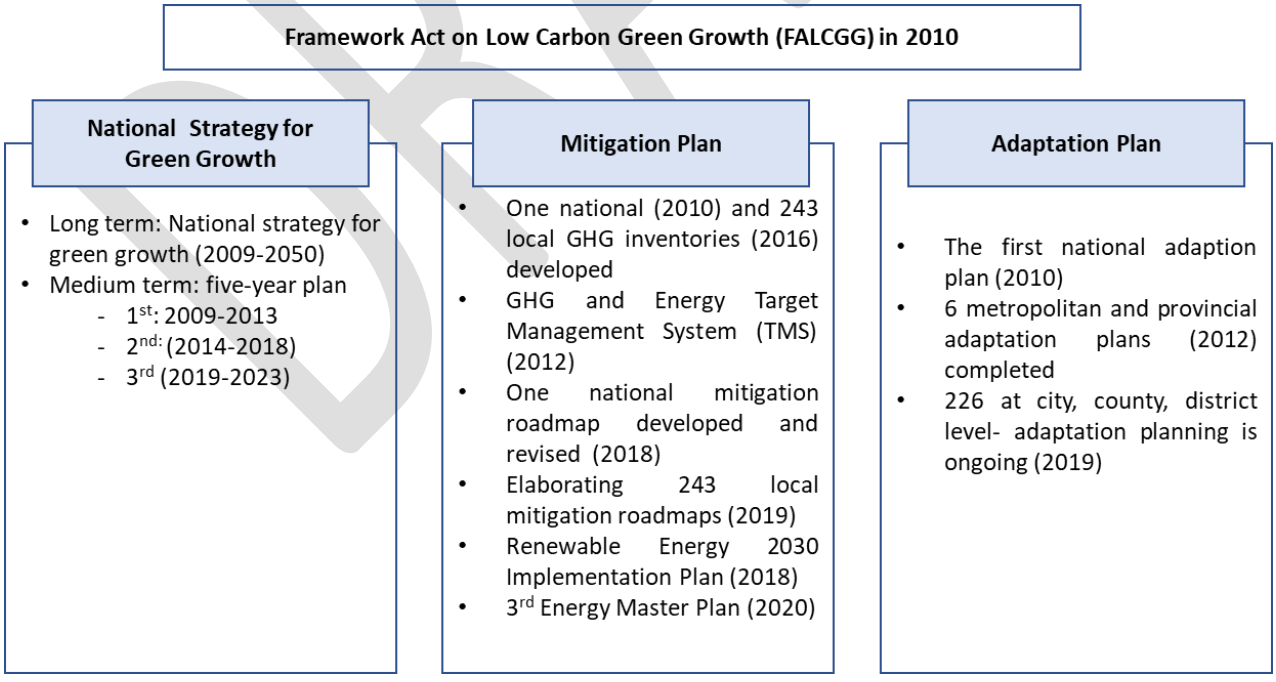


Figure 9. Framework for global warming countermeasures in Republic of Korea

Building on this, a sectoral emission roadmap was announced in July 2018 together with the "Renewable Energy 2030" implementation plan (issued by the Ministry of Trade, Industry

and Energy), which aims to increase the weight of renewable energy in the power sector from 7% to 20% by 2030. This energy transition toward eco-friendly power generation sources is expected to reduce 24 million tons of GHGs, reduce fine dust and air pollutants, and improve air quality. Republic of Korea's 3rd Energy Master Plan, which was approved by the State Council on 4 June 2019, lays out measures to reform energy taxation and incorporate environmental cost in power supply system. Guided by these national targets and the roadmap, local governments promote ambitious policies and actions to achieve climate resilient and sustainable communities.

Republic of Korea also operates a mandatory, nation-wide emissions trading scheme (ETS), which was launched in 2015. It was the first of its kind in Asia, covering 591 business entities of the country's largest emitters and 69% of total GHG emissions. It includes the direct emissions of six gases from the Kyoto Protocol and indirect emissions from electricity consumption. Participating entities are allowed to use international offsets for up to 5% of their obligations and the first regular emissions auctions took place in January 2019 (ICAP, 2019).

Institutional Frameworks and Governance Structures

China

In 2007, the State Council, China's highest government authority, set up the National Leading Group on Climate Change, Energy Saving and Pollution Reduction. This group has ministers or vice-ministers from more than 20 ministries or commissions as members, is headed by the Premier, and housed in the National Development and Reform Commission (NDRC) (Government of China, 2007). In 2008, the NDRC established the Department of Climate Change (DCC), which is the key government agency for low carbon development and in charge of developing and implementing climate change policies. As illustrated in Figure 10, the DCC was transferred from the NDRC to the Ministry of Ecological Environment (MEE) during the government restructuring of 2018. MEE and NDRC now are working together to run the daily work of the national leading group (Government of China, 2018), with MEE coordinating actions and policies that address air pollution and climate change.

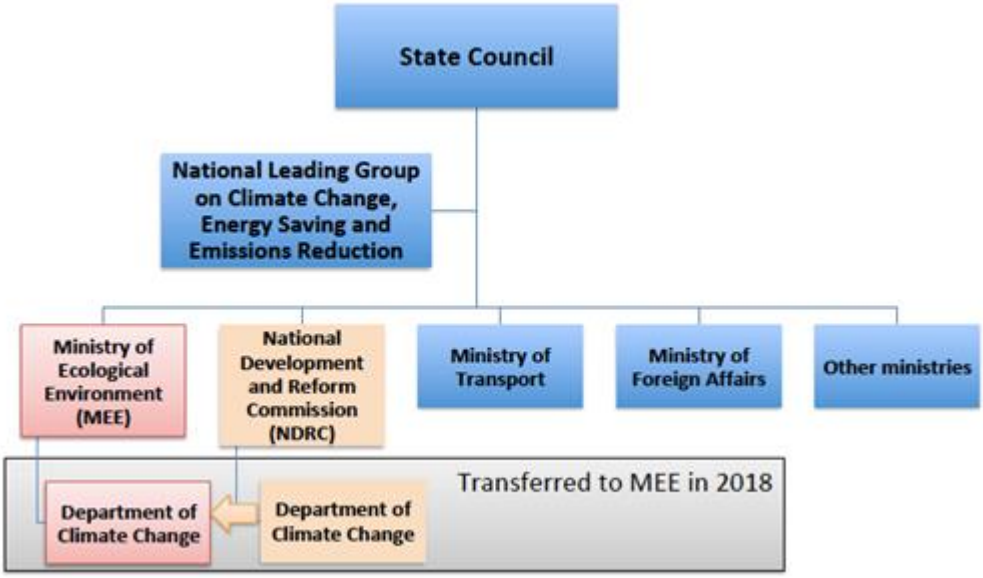


Figure 10. China's National Environmental Policy Administrative Structure (iGDP, 2019)

Interactions between National and Subnational Levels of Government

China operates as a unitary political system. Local governments usually implement decisions made by the central government and have political structures that mirror the central government. In China's multilevel government structure, authority is divided (i) vertically from the national to subnational levels in terms of functions, and (ii) horizontally among different government agencies within each territorial government (i.e. provincial government) (Lieberthal, 1997; Tsang & Kolk, 2010).

At each level of government, the provincial governor or mayor's office can issue orders and manage the work of government agencies within its jurisdiction. Therefore, local Ecological and Environmental Bureaus (EEBs) report to both local governments and higher-level EEBs. When priorities are in conflict, local interests are prioritized over functional interests, as the local government has a greater say on resources allocation under China's system of fiscal decentralization. Within this structure, local governments have the power and flexibility to develop and implement policies that serve local priorities. This makes it possible for them to explore unique, locally-appropriate low carbon actions.

Japan

The highest organ of state power and legislature in Japan is the bicameral Diet. It passes laws and elects the Prime Minister who then appoints Ministers of State to the cabinet (Government of Japan, 2007). The Ministry of the Environment (MoE) is the primary organ dealing with issues of environment and sustainability, including coordinating the state apparatus for environmental protection and enacting general environmental policies including for general pollution control and nature conservation. However, the overall stature of the Ministry of the Environment is comparatively weak and environmental policymaking is a collaborative process involving several other Ministries and supporting bodies. Importantly, the Ministry of International Trade and Industry (MITI), together with the MoE, is heavily involved in addressing Japan's industrial pollution (Ren, 2000).

A key governance dynamic in the development of low carbon policy is collaboration with industry. Rather than imposing strict regulations on industry, the policy approach in Japan has been one of close collaboration and negotiated agreements with industry to help them set their own sectoral targets for emissions reductions and other metrics of environmental performance (OECD, 2010). Formal, multi-stakeholder advisory groups called Shingikai (審議会) provide policy recommendations to the bureaucracy and Ministers while also serving as a venue for coordination and negotiation among the various interest groups. In the case of climate policy, and Japan's NDC development, MITI and MoE actively consulted three of their Shingikai, the Industrial Structure Council, the Advisory Committee for Natural Resources and Energy, and the Central Environmental Council (see Figure 11).

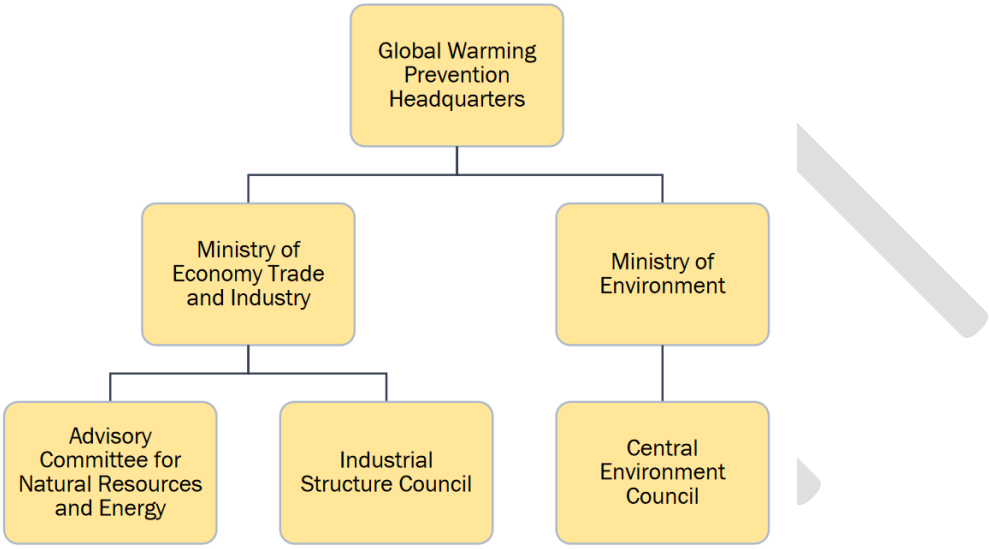


Figure 11. Administrative structure of Japan's climate policymaking (Sofer, 2016)

The former two are known to be more "business-friendly" while the latter are regarded as supportive of ambitious climate policies (Sofer, 2016). These advisory groups ultimately fed into the Global Warming Prevention Headquarters, a cabinet-level, interagency body charged with formulating the INDCs. Formally chaired by the Prime Minister and Chief Cabinet Secretary, in practice it is run by the METI and MOE ministers. This reflects the broader "consensus-based" decision making approach that predominates in Japan, where Shingikai and other core interest groups such as the Keidanren, which acts as a centralized singular voice for business interests, play a major role (Sofer, 2016).

Below the national government there are two main subnational tiers: 47 prefectures, within which there are 1742 municipalities. The national government is responsible for developing environmental policy and regulation, but local municipal governments tend to manage the implementation of local environmental efforts such as waste management. Prefectures and some larger municipal governments manage cross-jurisdictional issues such as industrial waste (UNCRD, 2014). Many local governments, including all cities, establish environment departments and can in theory develop their own ambitious local ordinances (Ogata, 2008). However, this is difficult in practice and rarely happens as local governments often depend significantly on financial support distributed by the national government. The national governments' strong agenda-setting role and use of subsidies and environmental bonds gives it a strong influence over the direction of local environmental policy (Ren, 2000).

Republic of Korea

Republic of Korea has a republican form of government in which the President is the Head of the State and the Prime Minister is the Head of Government. The powers of the government are divided among the Executive, Legislative and the Judiciary (UNDESA, 2017). In the national government, the Ministry of Environment, which exists under the office of the Prime Minister, is the primary body responsible for environmental protection and regulation. In 2008, the Korean Meteorological Administration became a subsidiary of the Ministry of Environment to facilitate the upstream climate change policy development focusing on impact assessment and relevant countermeasures. The Ministry of Environment enacts laws, establishes standards, and provides financial support for local governments' environmental management efforts (Government of Korea, 2018).

However, there are also climate and energy related environmental matters scattered across the work of and laws enforced by other ministries, which put in some cases challenges on clear responsibility governance avoiding unnecessary overlapping in function (Seol & Kim, 2018).

Table 2 Key policies with leading institutions

Central Government Level					
	Five-year plan of Green Growth	**Energy Master Plan**	**Master plan for Emissions Trading Scheme**	**Climate Change Adaptation Plan**	**Basic Plan for Climate Change Response**
Period and cycle	3rd (2019-2023) Every five years	3rd (2019～2040) every five years over a period of twenty years	1st (2015～2024) Every 5 and 10 years, linking medium-and long-term comprehensive plan	2nd (2016～2020) Every five years	1st (2017～2036) Every five years over a period of 20 years
Legal basis	Framework Act on Low Carbon, Green Growth (Article 9)	Framework Act on Low Carbon, Green Growth (Article 41)	Act on Allocation and Trading of Greenhouse Gas Emission Allowances (Article 4)	Framework Act on Low Carbon, Green Growth (Article 48)	Framework Act on Low Carbon, Green Growth (Article 40)
Institution	Office for government policy coordination	Ministry of Trade, Industry and Energy	Ministry of Economy and Finance	Ministry of Environment	Office for government policy coordination
Local Government Level					
Local plan	Local green growth plan	Local Energy Plan	N/A	Local Climate Change Response Plan	Local Climate Change Response Comprehensive plan
Period	Every 5 years	Every 5 years	N/A	Every 5 years	Every 5 years

Contents	GHG Reduction/ Green Industry	Energy Efficiency/Demand/ Renewable Energy	N/A	Impact and vulnerability assessment	GHG Reduction/ Adaptation

The national government exists two tiers of local government. The upper tier includes Seoul Special City (with the status of a capital city), six metropolitan cities (Busan, Daegu, Incheon, Gwangju, Daejeon, and Ulsan) and nine provinces (Do). The lower tier comprises 230 bodies: 75 cities (called Si), 86 counties (Gun, rural areas) and 69 autonomous districts (Gu, urban areas which exist only in the metropolitan cities and Seoul) (Kamal-Chaoui, Grazi, Joo, & Plouin, 2011). City governments carry out functions delegated by the central government, manage public facilities, collect local taxes, and provide a range of services to residents. Overall, however, municipal governments, including the metropolitan cities, depend heavily on the central government for budgetary support and largely act to implement a centrally determined agenda. Provincial governments serve as intermediaries between the central and municipal governments (UNDESA, 2017).

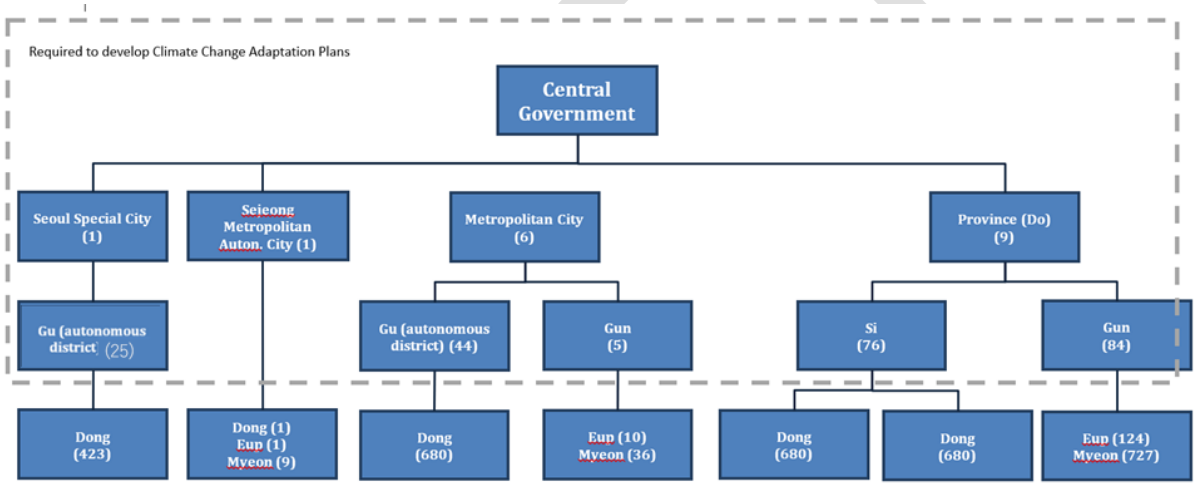


Figure 12 Central and Local Government Structure of Korean Administrative Governance

Another key structural feature in relation to low carbon development is the Committee on Green Growth, which is in charge of developing the National Strategy for Low Carbon, Green Growth (KEI, 2019). This includes reviewing the national five-year plans for low carbon, green growth. Under this framework, the issue of climate change in ROK is considered as a part of much broader national development policy agenda. The current National Committee on Green Growth deals with not only climate and environment related national agenda but also works on the economic growth issues under changed socio-economic trends covering national demographic and international market conditions.

The Committee comprises public officials and experts commissioned by the government. It is co-chaired by the Prime Minister and a commissioned civil expert and as of September 2019 included the 15 Ministers of Strategy and Finance; Science and ICT; Education, Foreign Affairs; the Interior and Safety; Culture, Sports and Tourism; Agriculture, Food and Rural Affairs; Trade, Industry and Energy; Health and Welfare; Environment; Gender Equality and Family; Land, Infrastructure and Transport; Oceans and Fisheries; SMEs and Startups; and Office for Government Policy Coordination; the two Chairmen of the Korea Communications and Commission and Financial Services Commission, and 25 experts from research

institutes, academia, NGOs, and business sector (Figure 13) . The Committee plays an important role in coordinating national and local low carbon development efforts. To help align with it, city and provincial governments also have local committees on green growth that fall under mayoral/gubernatorial supervision (UNESCAP, n.d.).

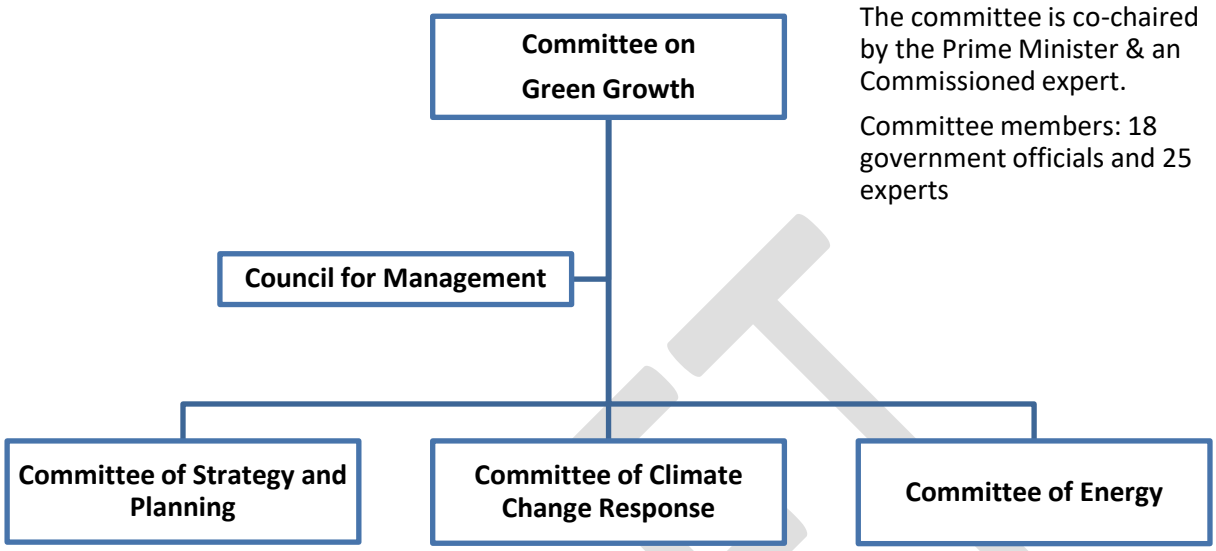


Figure 13. Central and Local Government Structure of Korean Administrative Governance

Low Carbon City Policies and Actions

Low carbon city policies and actions in China, Japan, and Republic of Korea vary based on the conditions across each country. These policies include both of those at the national level that specifically target cities, and those that are devised and implemented directly at the subnational level.

China

China's low carbon development planning is largely top down, with the most important targets being set in the five-year plans and passed down to cities and local governments through the Target Responsibility System (TRS). In some cases, the central government makes funding available to meet such goals, either through grants or preferential financing from the China Development Bank and other policy banks (Sandalow, 2018).

Policies in pilot cities - Low Carbon Pilot Cities
In addition to this general direction and support, China's flagship low carbon city policy is the creation of "Low Carbon Pilot Cities, launched by the National Development Reform Commission (NDRC) in 2010. As of 2018, NDRC has announced **three batches** of low carbon pilots, which now total 81 cities and 6 provinces. Under this program, all pilot cities are required to:

- Draft low carbon development plans and integrate climate change into local five-year plans

- Use a target responsibility system for GHGs emissions control and explore other complementary policies, including market-based mechanisms for policy implementation.
- Support low carbon industrial development
- Conduct a GHG inventory and build a GHG data management system.
- Promote green and low carbon lifestyles through public awareness raising (iGDP, 2019)

In addition to these universal pilot responsibilities, the **second batch** of pilots, launched in 2012, are required to conduct an evaluation on their work on GHG emissions reduction in relation to the target responsibility system. The **third batch**, launched in 2017, is required to develop a carbon peaking target in their low carbon plans and to explore low carbon innovations for different sectors. The pilot cities themselves are selected "based on criteria: local government leaders' awareness of low carbon development, application enthusiasm, accumulation of low carbon development experiences, regional balances, and potential to be good examples" (Wang, Song, He, & Qi, 2015 p. 82)

The pilots span a wide range of development profiles and are given latitude to develop plans that are appropriate under local conditions. The national government does, however, provide some general guidance that low carbon development plans should

- Calculate GHG emissions data
- Identify future emissions pathways
- Set emissions reduction targets and allocate targets to specific sectors
- Identify key technologies for low carbon development
- Develop low carbon policies and measures (NEASPEC, 2019a)

Figure 14 depicts how the Low Carbon City Pilots (LCCPs) interact with the Target Responsibility System (TRS).

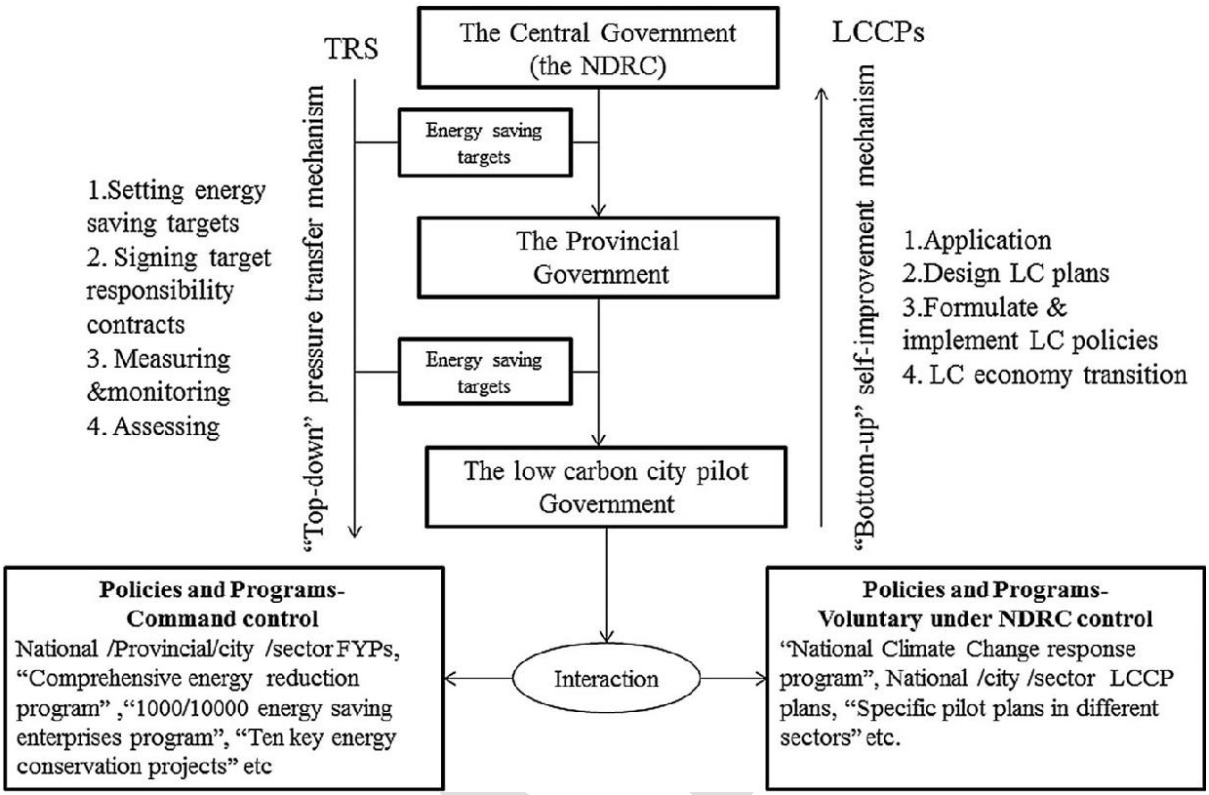


Figure 14. Interaction between China's Low Carbon City Pilots and Target Responsibility System (Wang et al. (2015))

While the low carbon cities pilot program is the flagship for promoting low carbon cities, China operates a number of other sustainability-related pilot programs that many of the low carbon pilots participate in concurrently. This broader ecosystem of pilot programs is discussed further in the next chapter.

China's Low Carbon Cities Pilotis (LCCPs) (and other cities) employ a range of strategies at the city level to advance low carbon development. They also often set their own, more ambitious sustainability targets. For example, while the national carbon intensity reduction target for 2020 is 40-45%, most of the first and second batch of low carbon pilot cities have targets above these national targets, some as high as 60%, as Wang et al. (2015) highlights. As Chinese cities pursue these targets, they must develop policies and actions that are appropriate for their geography, size, resource endowment, and levels of economic development. All of these factors vary greatly between cities. Their low carbon approaches may be broadly categorized as follows, (see the country study on China's low carbon city NEASPEC (2019a) for detail)

Post-industrialized cities: With a high proportion of urban residents and service-oriented economies, high carbon emissions come from the transport and building sectors. These cities often focus on the creation of new low carbon economic systems and consumption models.

Example: energy saving and green building development and promotion of electric vehicles (EVs) in public transportation in Shenzhen[7].

Transitional cities: While transitioning from heavy industry and manufacturing to a service-oriented economy, heavy industries still play an important role in these cities. These cites often pursue a low carbon path with accelerated technological innovation and upgrading of traditional industries.
Example: Shijianzhuang (capital city of Hebei province)'s Regulation for Promoting Low-carbon Development with specific measures for low-carbon development including those on energy supply and industry upgrading[8]; Plan on Structural Adjustment of Major Industries and Sectors 2017-2019, aiming to cut energy-intensive production capacity.

Industrializing cities: With limited economic development and relatively low urbanization rates, industrialization is still a priority on the local policy agenda in these cities. These cities look to integrate low carbon concepts into their social and economic plans, urban planning and infrastructure build-out, focusing on buildings and transportation as well as on decarbonizing their agricultural sector.
Example: Ganzhou city's sector-specific measures for low-carbon development covering industry, energy supply, building and transportation; application of biogas in the agricultural industry and the promotion of advanced agricultural technologies[9]

Specific policies being undertaken by China's LCCPs includes

Control measures such as
- Eliminating outdated production
- Prohibiting of coal use in city centers
- Establishing emission control standards for motor vehicles
- Eliminating high-emission vehicles

Economic incentives such as
- Removing fossil fuel subsidies
- Offering interest-subsidized loans for special energy-saving programs
- Developing carbon trading systems
- Creating tax incentives
- Pursuing ecological compensation

Pursuing low carbon paths
- Developing green buildings
- Targeting government procurement
- Initiating low carbon transportation or industry pilots
- Developing carbon monitoring systems

(Modified from Wang et al. (2015))

[7] Shenzhen Development and Reform Commission. (2013). Shenzhen's Medium and long-term planning for low carbon development (2011-2020). Retrieved from http://www.sz.gov.cn/szfgw/xxgk/ghjh/zxgh/201310/t20131016_2223234.htm

[8] Shijiazhuang Municipal Government. (2017). Shijiazhuang Low-carbon Promotion Regulation. Retrieved from http://qhs.ndrc.gov.cn/dtjj/201703/t20170328_842412.html

[9] Ganzhou Municipal Government. (2016). Ganzhou Municipal Government's Opinion on Low-carbon Development. Retrieved from http://www.gzsdpc.gov.cn/n2340/n2349/n2928/c178277/content.html

As shown in Figure 15, a low carbon pilot city organizes a leading group for municipal low carbon development headed by the mayor and consists of directors of key governmental agencies. Up to 2018, climate change and low carbon policy issues are handled by the NDRC at the national level. Thus, at the local level, the municipal development and reform commissions (DRC) were also responsible for low carbon policy issues, as well as the administration of the local leading group for low carbon development. With the latest government reshuffle, municipal EEBs have become in charge of climate policy at the city level. While the final impacts of the government reshuffle at the local level remain to be seen, the EEB is likely to inherit the administration of the low carbon leading group in the LCCPs.

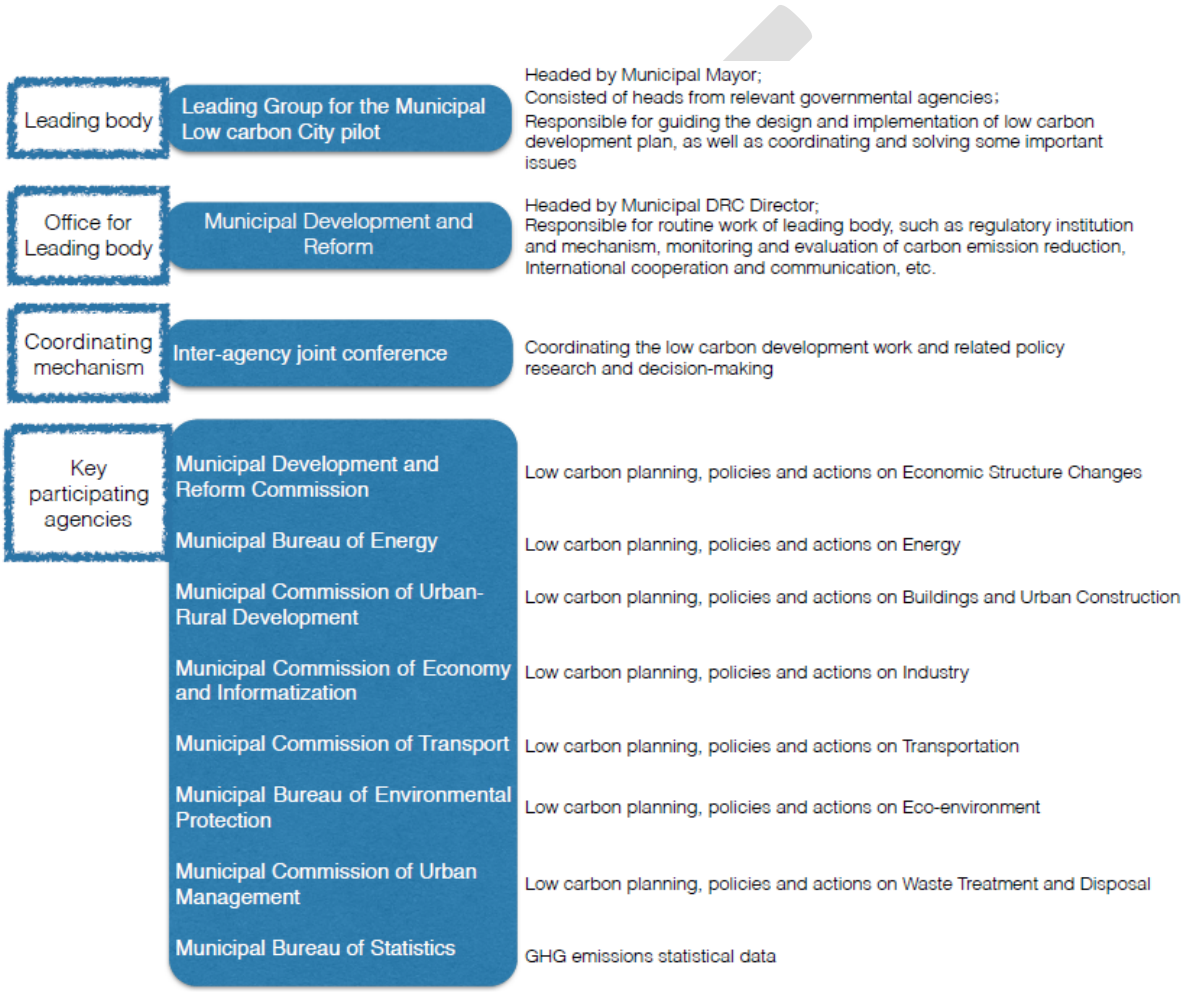


Figure 15. China's Low Carbon Pilot City Administrative Structure (iGDP, 2019)

Japan

Legal/regulatory aspect

While no legal system exist in Japan that binds local governments to create low-carbon cities, 2008 amendment of 'Global Warming Act' (first enacted in 1998) requires local governments (prefectures and municipalities) to develop "local government implementation plans".

The consequent Low Carbon City Act (Eco-City Act)[10], enacted in 2012, also requires the formulation of low carbon city development plans[11]. The Act aims to promote cross-sectoral emission reductions, providing tax breaks for certified energy efficient buildings. It helps cities overcome legal and jurisdictional constraints to creating low carbon city plans. The Eco-City Act stipulates that municipalities can formulate "plans to develop low-carbon cities" either alone or jointly, and plans can be formulated together with "local government action plans" based on the Global Warming Act.

The plans for cities with populations over 1,700 must guide action towards reducing GHG emissions generated in the process of administrative activities and projects implemented by the local governments. Local governments with populations over 200,000 (47 prefecture-level and 68 city-level governments), however, must produce "area wide plans" for reducing GHG emission in their entire jurisdiction. Plan may include promotion of

- use of renewable energy
- use of products and services with low GHG emissions and GHG emission control activities by businesses and residents
- consolidation of urban functions and convenience of public transportation facilities
- conservation and extension of green spaces and urban environment for controlling GHG emissions
- circular economy (IGES, 2019)

To promote low-carbon development, local governments need to use various legal systems (i.e., deregulation systems) and national support policies (i.e., subsidy systems).

Manuals and online platform

The Japanese government also supports cities as they develop their implementation plans. Based on surveys that identified a lack of manpower and expertise as the key barriers, the Japanese Ministry of the Environment has established a platform to support their formulation. It provides manuals and advice on the process for creating plans; calculation and verification tools; databases that are useful in the development of local government plans; information on relevant laws and standards; relevant national subsidy policies; case studies that can serve as references; and links to the more than 1,700 plans that have been published by local governments around the country (IGES, 2019).

Figure 16 provides a schematic view of Japan's climate change policy and the place of cities within it.

[10] http://www.mlit.go.jp/toshi/city_plan/eco-city.html

[11] Ministry of Land, Infrastructure, Transport and Tourism "Low Carbon City Development" https://www.mlit.go.jp/toshi/city_plan/eco-city.html

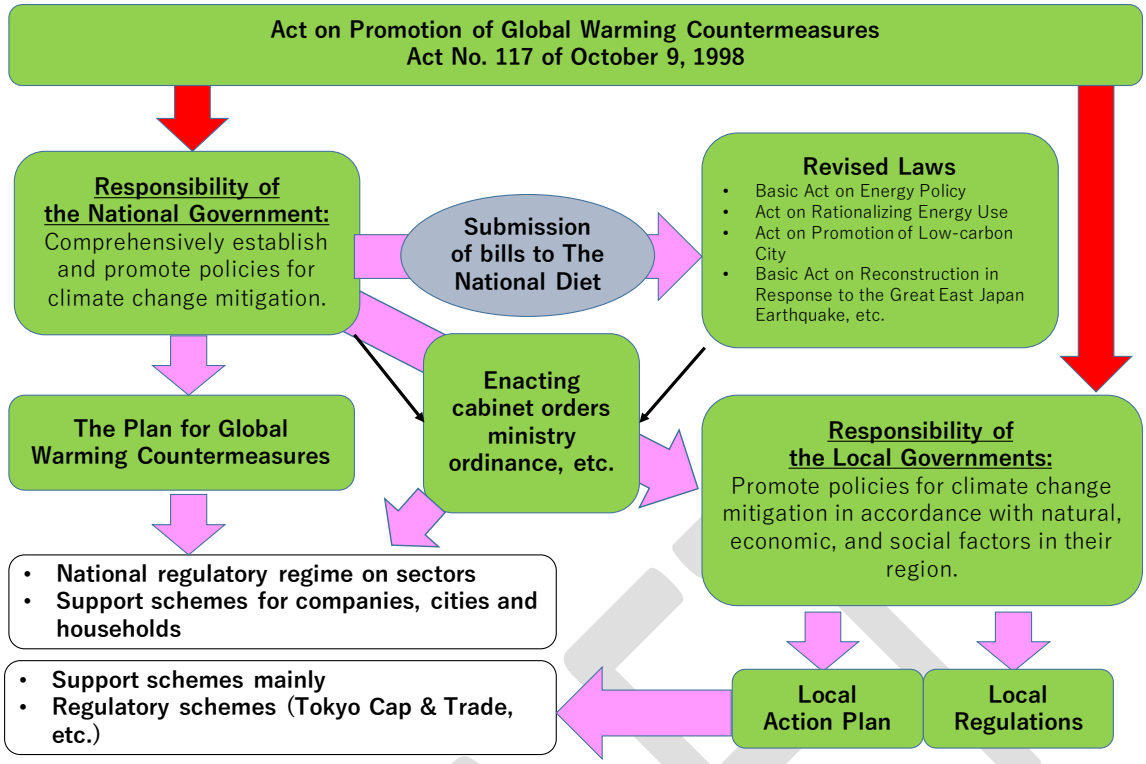


Figure 16. Japan Climate Change Policy Framework (IGES, 2019)

Model city development

In addition to this general support for cities to develop their low carbon plans, Japan also promotes low carbon city development through a set of certification programs, including the Eco model city, Future City, SDG Future City, and Local Government SDGs Model Programme. These are systems established by the national government where local governments formulate plans to create model cities that take regional characteristics into account according to concepts and evaluation criteria presented by the national government. The Eco-Model City project is for cities that have been selected by the Cabinet Office as environmental-model cities that are taking ambitious and pioneering actions to create a low carbon society, in order to provide a concrete, easy-to-understand image of the type of low carbon society Japan is aiming to create in the future. Between 2008 and the end of 2018, a total of 30 municipalities have been certified (IGES, 2019).

The Future City Initiative builds on this and selects among Eco-Model Cities for unique success stories in the areas of technology, socio-economic systems, services, business models and urban planning concerning responses to the environment and super-aging issues. Future cities are eligible for support from the national government in the form of consolidated budgets, regulations, systems, and tax reforms. Between 2011 and 2018, 11 cities were certified as Future Cities (IGES, 2019).

In 2018, the Cabinet Office further developed the “Future City Initiative”, launching the “SDGs Future Cities” and “Local Government SDGs Model Programme”, incorporating newly adopted SDGs methods. By the end of 2018, 29 cities had been selected as SDGs Future Cities, and of those cities, ten that had particularly advanced initiatives were selected as “Local Government SDGs Model Cities”, receiving a subsidy of a maximum of JPY 40 million (Government of Japan, 2018).

The national government has established an online platform for these types of proposed model projects and publishes information on the results of project selection, contents of projects, and related support. In addition, certified cities often have a relative advantage in accessing broader government funding for low carbon activities provided by various government Ministries.

Cities in Japan have made a range of efforts to follow through on these national directions at the city-level, as well as taking initiative themselves. Under the Global Warming Act, as of end of 2017, 84% of all local governments in Japan, had prepared local government operation plans and all 47 prefectures and 68 cities required to create area-wide plans had done so. In addition, 36 smaller local governments that were not required to prepare such had also voluntarily prepared action plans (IGES, 2019). This activity is further illustrated in Figure 17.

Local Government Operation Plan
All local governments are required to formulate, in line with the National Plan against Global Warming (May 2016), their own action plans for GHGs concerning the local conditions.

Area-wide Plan
Prefectures, and cities with more than 200K population are required to formulate respective area-wide plans, which include 4 categories.
- Renewable energy facilities
- Energy saving efforts by business and citizens
- Low-carbon transportation systems, urban green and forest management
- Circulation-oriented society

The number of local action plans (2017)

Type of Local Governments	Total	Local Government Operation Plan	Area-wide Plan
Prefectures	47	47(100%)	47(100%)
Cities (>500K population)	20	20(100%)	20(100%)
Cities (>300K)	48	48(100%)	48(100%)
Cities (>200K)	36	36（100%）	36(100%)
Other Municipalities (< 200K)	1,637	1,349（82.4%）	343(21.0%)
Total	1,788	1,500 (83.9%)	494 (27.6%)

Area-wide plan implementation rate (2017)

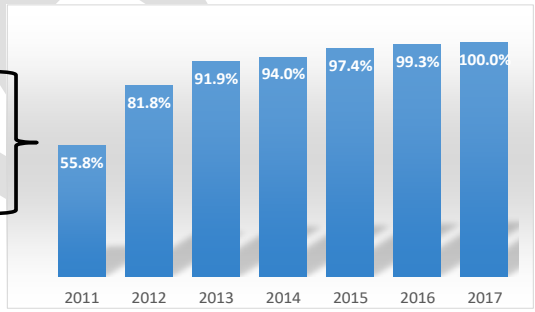


Figure 17. Implementation status of action plan formulation in local governments

Source: Act on Promotion of Global Warming Countermeasures (Legal framework); Ministry of the Environment. "Survey on the state of legal enforcement of the promotion of global warming countermeasures by local governments: Report on study results (Revised version)", September 2018 (Action plan formulation status).
Note: Prefectures consist of smaller units of local administrations (815 cities, 743 towns and 183 villages), and geographical coverage of the local administrations can overlap (e.g., township < city < prefecture)[12].

Deregulation

While most cities in Japan are limited in their capacities, some larger cities have taken the initiative to lead ambitious climate action. This includes Tokyo developing the world's first municipal ETS, which is discussed in the best practices section, and Yokohama committing to become carbon neutral by 2050 as part of the CNCA, putting itself on par with the most ambitious cities in the world regarding low carbon development. Cities in Japan also manage

[12] Japan Agency for Local Authority Information Systems, https://www.j-lis.go.jp/spd/code-address/kenbetsu-inspection/cms_11914151.html accessed on 13 June 2019

some other national schemes such as a certification scheme for low carbon buildings that offers preferential tax treatment as an incentive.

Republic of Korea

Legal/regulatory aspect

In the Republic of Korea, one of the Framework Act on Low Carbon Green Growth (FALCGG)'s basic principles is mainstreaming low carbon, green growth with all citizens' participation and the cooperation of national agencies, local governments, enterprises, economic organizations, and non-governmental organizations. The act encourages local governments, including cities, to formulate and execute low carbon development plans, including through the establishment of GHG inventories.

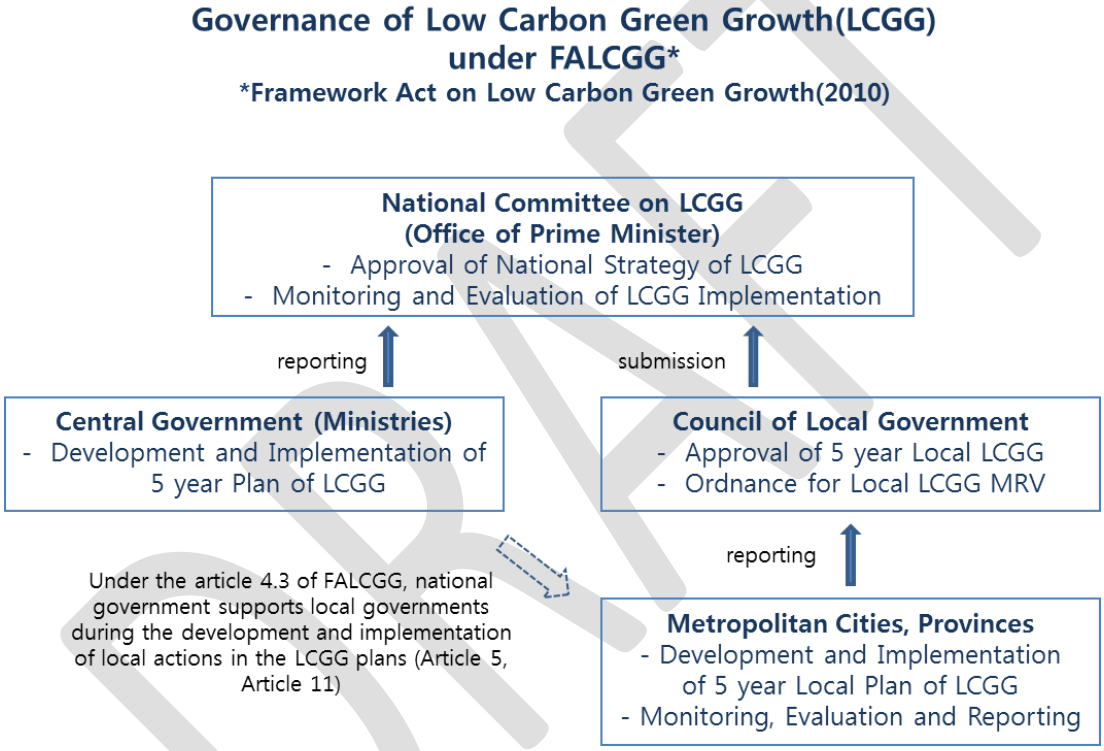


Figure 18. Legal Base of Low Carbon Green Growth of Korea since 2010

Currently, diverse promotional measures for the development of Climate Change Action Plan at city level are delivered by Korea Environment Corporation (KECO) in mitigation side and by Korea Adaptation Center for Climate Change (KACCC) in adaptation side. Figure 18 shows the overall structure of local climate action planning in Republic of Korea. Currently, the development of Local GHG Inventory and Low Carbon Road Map is not mandatory but recommended and supported by the Ministry of Environment. KECO is tasked with providing capacity building activities for the officials in local governments. With support from the central government, most Korean local governments at different level of Korean local administrative governance system have already developed or are developing their own climate action plans. However, the level of detail is different from city to city.

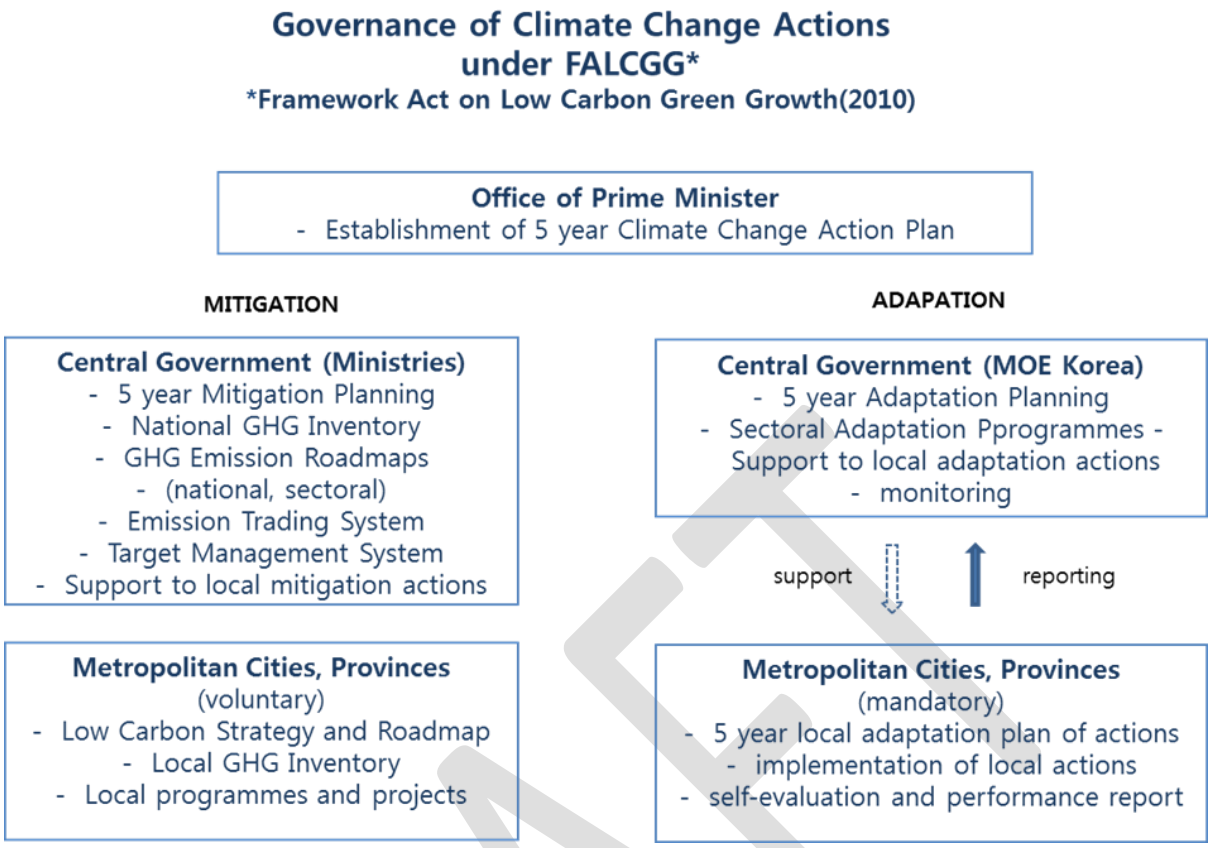


Figure 19. National and Sub-national Policy Framework of Climate Change Actions in Korea

Local climate action plans follow the basic structure of the national strategy of low carbon green growth in their principles and sectoral policy components while considering local socio-economic circumstances and characteristics (KEI, 2019). While the LCGG act does not specify exactly what actions cities should take, it contains principles for local government plans, including:

- Promoting the reduction of greenhouse gases efficiently and systematically by introducing a cost-effective, reasonable regulation system based on pricing functions and market system;
- Developing and utilizing advanced technology such as for information and communications, nanotechnology, and biotechnology, to reduce greenhouse gases drastically;
- Enabling emissions reductions through clarifying rights and obligations in connection with GHG and allowing transactions of such rights and obligations in the market (KEI, 2019)

Financial and human capacity aspects

Central government's financial support to local climate actions proves crucial in Korea, as it provides a substantial political motive for the locally elected city mayors and council members to move onto more ambitious local climate change targets in mitigation and adaptation. In practice, the low carbon city pilot program supported by central government leads the strategic local vision of more climate resilient urban development goals in the cities following and benchmarking the pilot cities.

Regardless of the central government's financial support to the local climate actions, the lack of the capacity of the local government in implementation of climate change policy and its action plans comes as the most important challenge for the success of the national-local climate change coordination.

Measures taken at local level

Some of the major low carbon development efforts at the subnational level in the Republic of Korea come through urban planning at the city level. Many provincial and metropolitan city governments focus on improving local and regional transportation networks. Kamal-Chaoui et al. (2011) note that Daegu, Daejeon, Gyeonggi-do, Jeollanam-do, Gyeongsangbuk-do and Jeju all included specific transportation measures in their local action plans. Gyeongsangbuk-do, is planning to build a hydrogen highway along the eastern coast of the Republic of Korea. Seoul has stood out in its green retrofitting efforts and Green Architecture Standard, which is equivalent to the international LEED standard, and a prerequisite for all new public buildings (Kamal-Chaoui et al., 2011).

Innovative scheme

The cities in the Republic of Korea have limited fiscal autonomy. This hampers their ability to initiate large and expensive low carbon strategies on their own. Many cities have responded to this with innovative efforts to promote voluntary climate action by citizens and industries in their jurisdiction. For example, both Changwon-si and Seoul have developed programs where citizens receive "millage points" for reducing emissions from their daily activities such as energy use. These millage points can then be redeemed for vouchers (Kamal-Chaoui et al., 2011).

Pilot LCC programmes by various national agencies

Different agencies of the government of the Republic of Korea have also launched pilot programs to promote low carbon cities, including: the EcoRich City Competition project (Presidential Committee on Green Growth), the Climate Change Adaptation Model City Project (Ministry of Environment), the Green City Project (Ministry of Environment), Eco City Project (Ministry of Environment), Low carbon, Green Village Project (a joint project involving six ministries), and guidelines for low carbon, green cities (Ministry for Land, Transportation and Maritime Affairs). "These projects aim to encourage locally tailored climate change actions and can be a useful tool for testing innovative urban planning strategies and green technological development, such as smart grids" (Kamal-Chaoui et al., 2011, p. 54).

Knowledge and information support

Being equipped with well elaborated and science based local policy supporting tools becomes priority in efficient and effective local climate actions. Even if the local climate action planning in mitigation and local GHG mitigation targeting is voluntary in its nature at the moment, the plan has more or less a comprehensive set of policy measures and monitoring system based on local GHG inventory guidelines provided by the Korean Environment Corporation (KECO) in charge of supporting local government in mitigation actions. In Korea national GHG inventory is maintained by specialized research institute established in 2010 under the Ministry of Environment. In the case of local GHG inventory at city level, KECO provides local GHG guidelines and a series of capacity building program for

the voluntary use of local government officers at city and provincial level. Recently KECO revised its local GHG guidelines to improve its compatibility with common reporting format used by most city network on local climate action, such as GCoM and CDP.

Key Sectoral Carbon Reduction Policies

This section summarizes the key sectoral carbon reduction policies and measure by country. The sectors reviewed are energy, industry, buildings, and transportation.

China

Energy

China's low-carbon development policies in the energy sector focus on optimization of energy structure and energy efficiency improvement.

National policies and guidelines: To decarbonize its energy sector, China has been working on transforming its energy structure by promoting coal consumption control and the clean utilization of fossil fuels, and the development of renewable energy. The *Energy Development Strategy Action Plan* (2010-2020), issued by the State Council, sets measures to reduce coal consumption. The *Natural Gas Development Plan* and the *Development Plan for Shale Gas* guides the exploration of low-emission fossil fuels, while the *Opinions on Promoting Safe, Green Exploration of Coal and Efficient, Clean Utilization of Coal*, and *the Action Plan for Clean and Efficient Use of Coal (2015-2020)* is designed to help clean up China's use of coal. The National Energy Administration (NEA) has developed a range of development plans and special plans to support renewable energy development, including hydropower, wind, solar and biomass. In 2016, the Ministry of Finance (MOF), the NDRC and the NEA developed the *Interim Measures on the Management of Collection and Utilization of the Renewable Energy Development Fund* and *the Interim Measures on the Management of the Additional Renewable Energy Surcharge Fund*.[13] These policies provide financial support for renewable energy installation.

China is improving energy efficiency by setting energy efficiency standards/labels and developing energy-efficient technologies. Since 2012, the NDRC has been working with the Standardization Administration to develop the "One Hundred Energy Efficiency Standard Promotion Program". Under this program, more than 100 energy-saving standards have been released. In addition, NDRC, together with other government agencies, has developed policies for energy saving labelling and certification, such as the "Certification Rules of Energy Management System" and the "Management Measures for Certification of Energy-saving and Low-carbon Products". NDRC has also issued several batches of the Catalogue on the Promotion of National Key Energy Saving Technologies, which lists a wide range of key

[13] National Development and Reform Commission. (2016). China's Policies and Actions for Addressing Climate Change 2016. Retrieved from http://www.greengrowthknowledge.org/sites/default/files/downloads/policy-database/CHINA%29%20China%27s%20Policies%20and%20Actions%20for%20Addressing%20Climate%20Change%20%282016%29.pdf

energy-saving and low-carbon technologies that can be used in different industries. By 2017, it had published 260 key energy saving technologies in 13 industries.[14]

Industry

China has issued a set of policies and measures to support the de-carbonization of the industry sector, aiming to optimize its industrial structure by upgrading traditional industries, developing strategic emerging industries and service industries, and cutting backward capacity.

Upgrading traditional industries: The Guideline Catalogue for Industrial Restructuring, issued by National Development and Reform Commission (NDRC) in 2011 and revised in 2013, emphasizes that China would take a strategic direction toward energy saving and emissions reduction in the industry sector[15]. On the other hand, the *Plan for Industrial Transformation and Upgrading (2011-2015)* and the *Special Action Plan on Green Industrial Development*, issued by NDRC, Ministry of Industry and Information Technology (MIIT) and other government agencies, promote the upgrade of key traditional industries. The State Council's "Made in China 2025" includes major tasks to promote energy efficiency and the green transformation of the industry sector.[16]

Developing strategic emerging industries and service industries: The State Council issued the *12th FYP Development Plan on National Strategic Emerging Industries* in 2012. It also released, in 2013, the *Opinion on Accelerating the Development of Energy-Saving, Environment-Protecting Industries*, which places an emphasis on the development of energy-saving and environmental protection technologies. The *12th FYP on the Development of the Service Industry* sets out a comprehensive framework to increase the share and quality of service industry with policy and institutional supports.

Reduce backward production capacity: The State Council issued the Opinions on Curbing Overcapacity and Redundant Construction in Some Industries and Guiding the Sound Development of Industries in 2011. The *Guidelines to Solving Serious Production Overcapacity*, released in 2013, include set of measures to address overcapacity, such as improving production quality and controlling the growth of new projects.

Buildings

China's low-carbon development in the building sector is centered on promoting building energy efficiency and developing green buildings. Different government agencies have also adopted a set of policies to support building de-carbonization.

The *Special Plan for Conserving Energy in the Building Sector During the 12th FYP,* issued by MOHURD, aims to improve energy efficiency and the use of renewable energy in building sector. China also revised its *Public Building Energy Efficiency Design Standards* and requires

[14] Ministry of Ecology and Environment. (2018). China's Policies and Actions for Addressing Climate Change 2018. Retrieved from http://english.mee.gov.cn/News_service/news_release/201812/P020181203536441502157.pdf

[15] National Development and Reform Commission. (2013). China's Policies and Actions for Addressing Climate Change 2013. Retrieved from http://en.ndrc.gov.cn/newsrelease/201311/P020131108611533042884.pdf

[16] The National Development and Reform Commission. (2015). China's Policies and Actions for Addressing Climate Change 2015. Retrieved from http://www.cma.gov.cn/en2014/climate/featutes/201511/P020151120633951236905.pdf

all newly-built urban buildings to adopt mandatory energy efficiency standards. In addition, China has a "Top Runner" Energy Efficiency Program to identify and promote energy efficiency products, which covers refrigerators, TVs and air conditioners.

The *Green Building Action Plan*, issued by the NDRC and MOHURD in 2013, provides a set of targets and measures to promote green building standards, retrofit existing buildings and encourage the use of green building materials. In 2015, MOHURD published a new *Green Building Evaluation Standards* that contains stricter requirements on green buildings and sets additional scores for green building technological advancement. In 2017, the Ministry of Housing and Urban-Rural Development (MOHURD) issued the S*pecial Plan for Scientific and Technological Innovation in Housing and Urban-Rural Development during the 13th FYP* to further the development of green buildings with an emphasis on building technology.

Transportation

China has also adopted a set of low-carbon policies in the transportation sector, particularly in the promotion of public transportation and new energy vehicles, to reduce carbon emissions and increase energy efficiency.

The *Guidance on Prioritizing the Development of Public Transportation*, issued by the State Council in 2012, sets a comprehensive framework to promote the development of public transportation. It identifies several priorities, including infrastructure construction, land use and planning for public transportation (the design of bus-only land and busways) and smart transportation development. The NDRC's *13th Urban Public Transportation Development Plan* also encourages actions such as developing non-motorized transport (public bike-only lane, public bike sharing system). In 2017, the Ministry of Transportation (MOT) issued the *Implementation Plan for the Promotion of Ecological Civilization in Transport* and the *Opinions on Comprehensively and Profoundly Promoting the Development of Green Transport*, setting the goals and key tasks for the development of green transport.

The *Energy-saving and New Energy Automobile Industry Development Plan*, released by the State Council in 2012, provides policy support for new energy vehicles. It aims to put China's automobile industry on long-term path toward the development of pure electric vehicles, making the industrialization of pure electric vehicles and plug-in hybrid vehicles as priorities. Meanwhile, MOF's *Notice on Preferential Vehicle and Vessel Tax Policies for Energy-Saving and New Energy Vehicles and Vessels* provides financial support such as subsidies and tax breaks for new energy vehicles.

Japan

Energy

In recent years, the quantity of power generation installations for renewable energy and the volume of power generated has rapidly expanded in Japan. The ***Plan for Global Warming Countermeasures*** has set the renewable energy generation target to 2030 to between 236.6 billion kWh and 251.5 billion kWh. If achieved, the proportion of renewable energy in the total amount of power generated will expand to around 22% to 24% with an expected CO_2 reduction effect of 160 to 170 million tons (Figure 20).

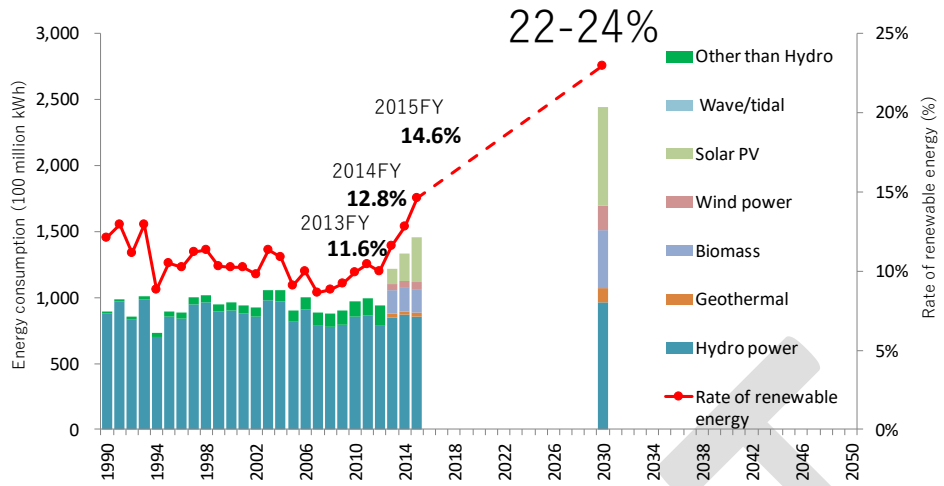


Figure 20. Long-term supply outlook FY 2030

Source: Ministry of the Environment and Agency for Natural Resources and Energy

Industry

Measures to address climate change in the industrial sector focus on the "***Act on Rationalizing Energy Use***" (hereinafter referred to as the "Energy Conservation Act"), an energy conservation policy enacted in 1979 following the two oil crises in 1970s. Under the Energy Conservation Act (latest revision in 2018) mostly administered by the Ministry of Economy, Trade and Industry (METI), factories and business establishments with an annual energy consumption (crude oil equivalent) of 1500kℓ or more are subject to the regulation.

These regulated businesses are required to notify authorities about the status of energy use, appoint an energy management supervisor/management plan promotion supervisor and notify authorities, and submit periodic reports on energy conservation actions and medium- to long-term plans (three- to ten-year periods). The business operators that are subject to this act are also required to reduce annual energy consumption intensity by 1% or more on average in the medium to long term. The government can exercise its authority, such as by offering guidance and advice, conducting on-site inspections, and providing instructions on the submission of improvement plans, in line with the state of energy conservation actions implemented by business operators. If businesses do not comply with these administrative instructions, punitive measures may be taken, such as disclosing their violation, ordering improvements, or imposing fines.

A benchmarking system by sector has been introduced for 11 industries, such as steel manufacturing, cement production, power supply industries, and convenience stores. It is the standards for energy conservation set at the level that are met only by top 10% to 20% of all businesses (top-runner approach[17]) in each industry. Business operators in the respective industry/area must achieve the standard (level higher than the standard level, plus standard deviation) in the medium to long-term. As of 2018, the benchmark system

[17] The "top-runner" (highest standard achieved) approach compares with minimum standard (such as Minimum Energy Performace Standard) and average standard approach. (Reference. Agency for Natural Sources and Energy, METI, https://www.enecho.meti.go.jp/category/saving_and_new/saving/data/toprunner2015j.pdf in Japanese).

was aimed to cover 70% of energy consumption in all industries.[18] While business entities in these sectors are not legally obliged to achieve those benchmarks, they are required to prepare reports each year on benchmark improvements that will be submitted to the national governments, which can provide guidance on business activities.

In addition, the "top-runner" system is also applied for 31 types of household equipment and facilities energy-saving equipment. such as transformers, lighting fixtures, and automobiles, refrigerators. According to estimates, the coverage rate for target equipment in top-runner companies is about 70% of household energy consumption.[19] This system sets energy saving standard at the best energy-saving performance of the products available in the market at the time of standard setting and encourages manufacturers to improve the energy-saving performance of the products in the mid-term (3-10 years), such as through capital investment and product development.
If the energy efficiency is considered remarkably low against the standard and require improvement, the Minister of Economy, Trade and Industry (in cases involving cars, the Minister of Economy, Trade and Industry and the Minister of Land, Infrastructure, Transport and Tourism) issue recommendations to the manufacturer in question. If the manufacturer does not comply with the set recommendations, measures will be taken such as the public announcement of violations, orders and penalties (fines).[20]

Buildings
Global warming measures in the construction sector have been developed mainly on energy conservation measures using the "Energy Conservation Act" and the "Act on Improving the Energy Consumption Performance of Buildings" (hereinafter referred to as the "Building Energy Conservation Act") as the main rationale. Regulations of energy conservation for buildings (both for business and housing) were transferred to the Building Energy Conservation Act enacted on April 1, 2017, administered by the Ministry of Land, Infrastructure, Transport and Tourism (MLIT).

Under the Building Energy Conservation Act, non-residential building owners must comply with building energy conservation standards set by the national government when constructing new or renovating non-residential buildings that are 2,000m^2 or more. Buildings that do not meet energy conservation standards cannot acquire building certification. (Table 3).

Measures to improve the energy-saving performance of new residential buildings by commercial agents below 300m^2 are implemented through the top-runner system while improvement of energy-saving performance of existing buildings are encouraged through facility equipment (lighting, water heaters, elevators, etc.) and materials (insulation, etc.)

[18] Ministry of Economy, Trade and Industry. "Trends in Energy Conservation Measures", 2017. http://www.enecho.meti.go.jp/category/saving_and_new/saving/pdf/2017_02_shoueneseisaku.pdf
[19] Ministry of Economy, Trade and Industry. "Trends in Energy Conservation Measures", 2018. https://www.kansai.meti.go.jp/3-9enetai/downloadfiles/2018/20190212sesakusetumei.pdf
[20] Agency for Natural Resources and Energy, Ministry of Economy, Trade and Industry. "Search Q&A to Support Energy Savings by Companies". https://wwws.meti.go.jp/enecho/saveenergy2/enterprise/faq/qa01.html

This system includes some financial incentive schemes (tax, subsidies) as well as voluntary schemes such as labelling for energy efficient buildings and regulation related to permission for maximum floor space per unit of land.

Table 3 Act on the Improvement of Energy Consumption Performance of Buildings

Act on the Improvement of Energy Consumption Performance of Buildings		
(for new construction)	**Non-residential building**	**Residential building**
Large-scale buildings (above 2,000m^2)	Mandatory compliance Mandatory compliance/evaluation for compliance of newly constructed building energy efficiency performance standards (energy efficiency standards)	Mandatory notification Mandatory notification to administrative agencies with jurisdiction of plan for new construction/extension/renovations (Instruction / orders for non-compliance) Instructions/orders issued when deemed necessary without compliance with standards.
Medium-scale buildings (300 to 2,000m^2)	Mandatory notification (Instruction / orders for non-compliance)	
Small-scale buildings (below 300m^2)	Reasonable endeavour (for improvement of energy consumption performance)	Reasonable endeavour -Housing top-runner (standard) Recommendations /orders issued when deemed necessary

(reference: MILT https://www.mlit.go.jp/common/001223580.pdf and https://www.mlit.go.jp/common/001134876.pdf)

Transportation

The Energy Conservation Act requires that transportation companies with a transport capacity over a certain level (300 railcars, 200 trucks, 200 buses, 350 taxis, 20,000-tonne ships (total vessel capacity), and 9,000-tonne aircraft (maximum takeoff weight)) submit periodic reports on transportation capacity, energy conservation efforts as well as medium- and long-term plans for improvement of energy efficiency.

Business operators that are subject to this act are also required to reduce energy consumption intensity by 1% or more on average over the medium to long term.
In addition to the above, shippers who use transportation companies to transport cargo more than 30,000 ton-kilometers (weight x distance) per annum are also subject to regulations and are required to submit periodic reports on the status of energy use and planning documents on energy conservation efforts.

Based on the contents of periodic reports submitted by specified transportation companies and target shippers, the national government may collect reports or carry out on-site inspections to confirm compliance with assessment standards and changes in energy consumption intensity. In some cases, the national government may also submit recommendations, publications, or orders if they recognize that there are significant insufficiencies in the rational use of energy in light of assessment criteria.

Republic of Korea

Energy

Energy Master Plan: In developing and implementing national energy policies and plans, the Energy Committee, established in 2006, elaborated the First Energy Master Plan for 2008-2030 on August 2008.Later the 5 year planning process of Energy Master Plan was integrated into the National Strategy for Low Carbon Green Growth (LCGG), pursuant to the Article 40 of the Framework Act on Low carbon Green Growth (FALCGG) adopted on January 2010. The Energy Master Plan is a comprehensive plan that covers all energy sectors for 20 years of planning period, and systematically links and coordinates energy related sub-plans from a macro perspective (MOTIE, 2014). The Plan is amended every five years. The drafted initial plan and the amendment to the existing plan are presented to the Energy Committee under Article 9 of the Energy Act and then to the National Committee on Green Growth and the State Council consecutively for deliberation.

GHGs and Energy Target Management System*:* To cope with the global climate change and energy challenges, the central government has established and operated a system of GHGs and energy target management since 2009 based on the articles 42 of FALCGG on medium and long-term targets and the goals in greenhouse gases reduction, energy saving and efficiency, self-sufficiency in energy, and supply of new and renewable energy.[21]

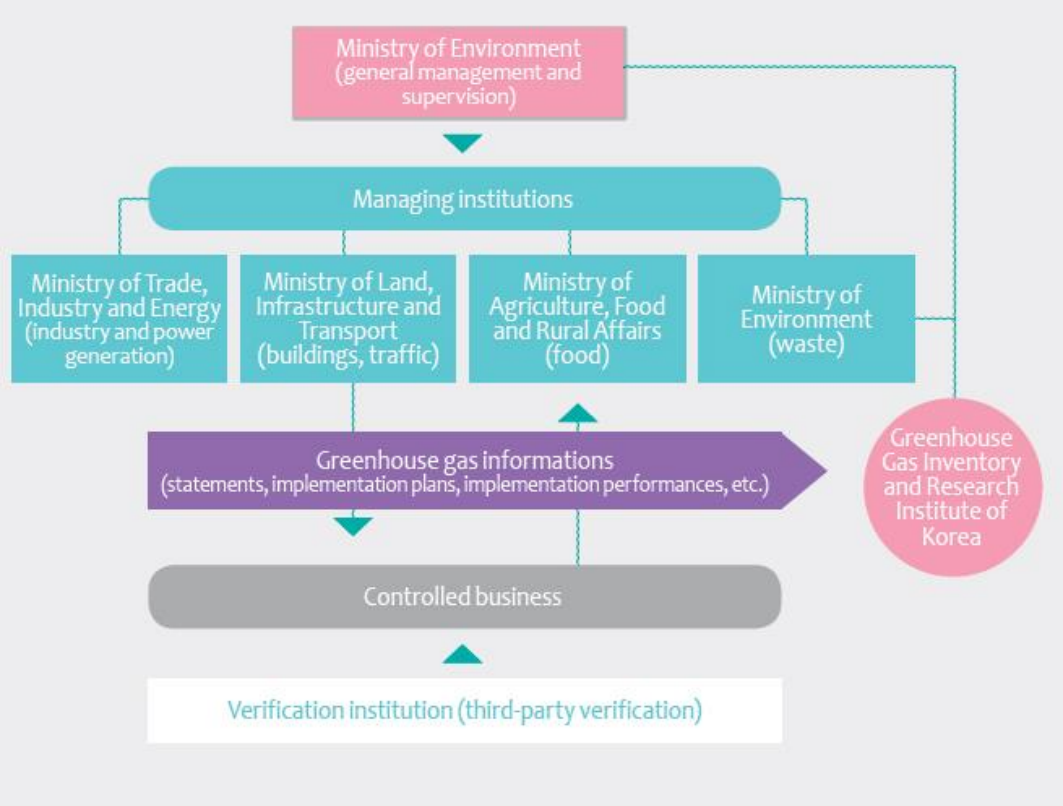


Figure 21. Operation of the Greenhouse Gas Target Management System

Source: Ministry of Environment, Republic of Korea

21 https://www.greencompany.or.kr:447/eng/introduce/system.aspx

As shown in Figure 21, the Ministry of Environment is in charge of the overarching framework of the GHG Target Management System, coordinating line ministries. The Ministry of Environment sets standards, drafts guidelines, and manages verifying agencies. Engaged ministries select entities to be subjected to the System per sector, sets targets based on negotiations and evaluate performance records. For that purpose, the government established the Greenhouse Gas Inventory and Research Institute (GIR) in 2010. The key function of GIR is to support establishment of the national/sectoral GHG reduction target, to manage national GHG inventory Measurement, Reporting and Verification (MRV) system and to operate the National Greenhouse Gas Management System (NGMS). GIR supports also the operation of Greenhouse Gas and Energy Target Management System (TMS) and Emissions Trading System (ETS).

The central government designates business entities that emit greenhouse gas and consume energy in large volumes as controlled entities, imposes greenhouse gas emission and fossil energy consumption targets, and manages and supports them performance check. When a controlled business reports its previous emissions to the managing institution of each sector, the managing institution sets greenhouse gas emission goals for each industry, which then submit an implementation plan to achieve the goals. In the following year, the controlled business submits a statement specifying its emissions and energy consumption together with an implementation performance report after third-party verification. The statement and implementation performance are confirmed by the managing institution of each sector, then submitted to GIR. Correction notices and other such measures are used to address any business that fails to reach its goals or does not meet measurement, reporting, and verification (MRV) requirements (MOE).

Central administrative agencies, local governments, public institutions, other parts of the public sector are also subject to the greenhouse gas target management system in addition to industrial sectors. The aim is to encourage private sector participation to reach national greenhouse gas reduction goals based on public sector participation and leadership.

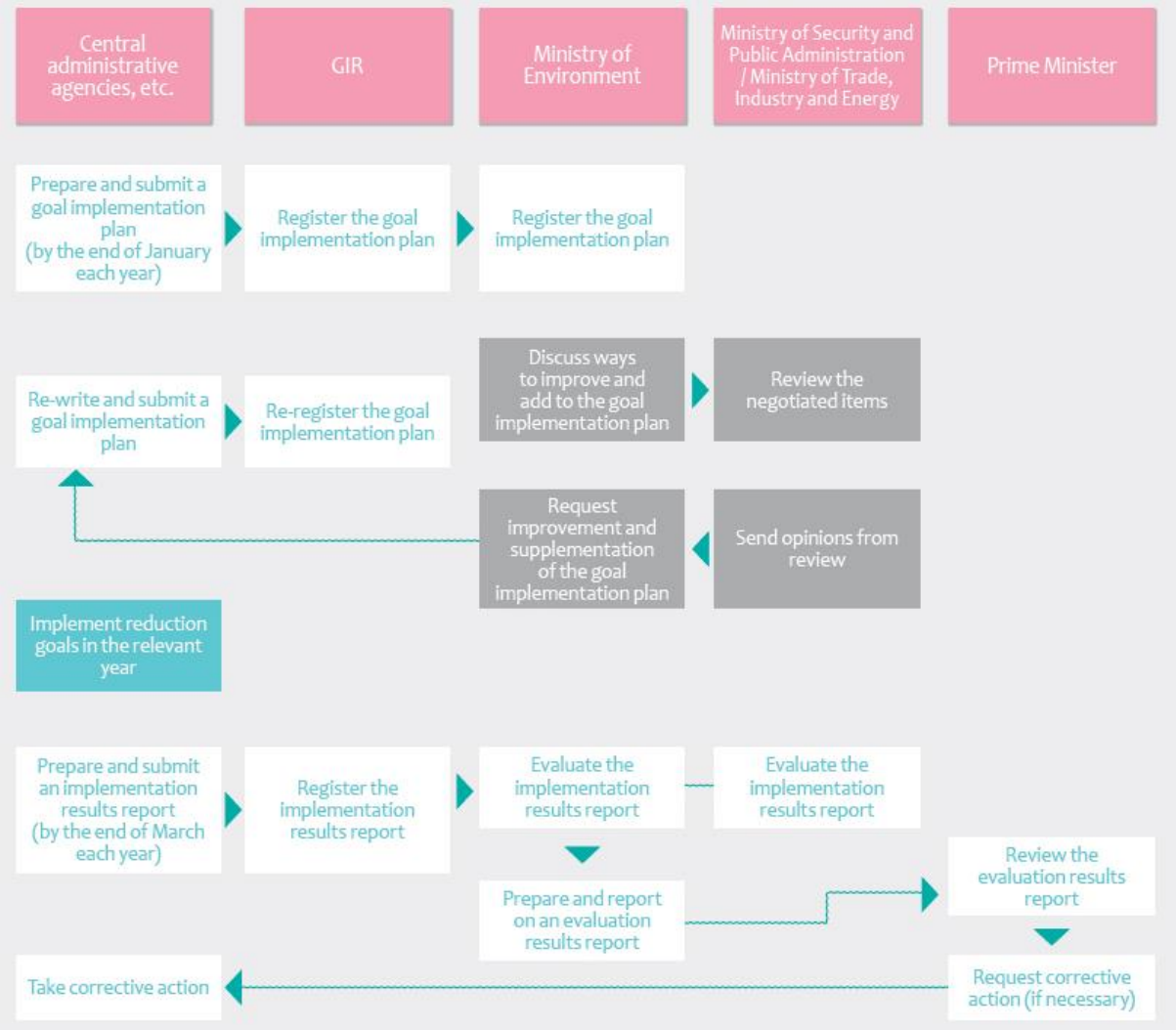


Figure 22. Operation of the Greenhouse Gas and Energy Target Management System in the Public Sector

Source: Ministry of Environment, Republic of Korea

The target management system applies to 590 institutions as of 2019, including central administrative agencies, local governments, public institutions, regional public corporations, national and public universities, and national university hospitals. These institutions are required to carry out target management regarding the buildings and vehicles that they own or use.

The Ministry of Environment subsidizes the Green Rooftop Project to support greenhouse gas reduction activities by local governments. It also offers on-site reduction technology diagnosis and customized consultation to suit the circumstances of each institution by operating a “Public Greenhouse Gas Reduction Technical Support Team” (since 2012) to manage reduction and provide greater support for vulnerable institutions. It is making a variety of efforts to encourage reduction activities in public institutions by organizing the “Public Sector Greenhouse Gas Target Management Performance Report Presentation” to award institutions that have been exceptionally successful in reduction activities, recognize exemplary cases, and gather suggestions (MOE, ROK).

Emission trading system*:* As a part of national GHGs management system, the government also introduced an emission trading system providing a market based GHGs reduction measure to accomplish the national target of greenhouse gases reduction. The method of allocation of the allowable quantity of emission, the methods of registration and management, and the establishment and operation of an exchange for implementing the system is taken in charge of GIR. Currently, the Korean ETS covers up to 70% of national GHG emissions, and the contribution of national reduction target is expected to expand as the three-year target setting and implementation phase continues.

Industry

Green Industry and Technology in Circular Economy
In accordance with the Article 22 of the FALCGG which defines basic low carbon principles for industrial sector, the government considers the following measures for:

i) the gradual conversion of the conventional, industrial structure into a green industrial structure;
ii) the targets for the medium and long-term and for each phase for facilitating green industries and the strategy for the facilitation;
iii) the fostering of, and support for, green industries for new growth engines;
iv) the conversion of existing, national infrastructure, including electric, information and telecommunications, and traffic systems, into an environmentally friendly structure; the industry of advisory services for green management;
v) the training of human resources for green industries and the creation of job opportunities;
vi) other matters concerning the facilitation of green economy and green industries.

In a broader context of low carbon development strategy, the government adopted a resource circular policy direction. By saving and using resources efficiently, resource circular policy measures are expected to contribute the GHGs emissions from industrial activities. The resources circulation industry policy covers the following areas:

i) Establishment of targets of facilitating the resources circulation and improving the productivity of resources; Supply and management of resources;
ii) Control of the use of substances hazardous or hard to re-manufacture or recycle;
iii) Control of the generation of wastes and conversion of wastes into resources through re-manufacturing or recycling;
iv) Collection and utilization of biomass, such as wood, plants, and agricultural produce, that may be used as resources for energy;
v) Development of technology related to resources circulation and fostering of the industry therefor;
vi) Matters concerning education, training, and fostering of human resources to improve the productivity of resources.

The government promotes green management practices by providing support and incentives aiming the adoption of environmentally friendly production system, which brings efficient use of energy and resources as well as reduced emission of greenhouse gases. Additional support from the government, especially in favour of small and medium sized

enterprises, was given to the R&D and commercialization of green technologies; diffusion and utilization of ICT regarding energy saving and efficiency for GHGs reduction; accelerated mobilization of public and private financial resources for green investment in terms of preferential tax system, interest rate, and subsidies. Provision of green technology and industry certificate and standard follows to the support and incentive system. Development of green technology and green Industry complexes as a part of balanced regional development programmes, policy measures promoting efficient mobility and conversion of human resources in green industry sector are among other complementary low carbon development policy measures.

In agriculture and fishery sector, the government promotes energy efficient production technologies in favour of renewable and bio-energy sources by minimizes the use of chemical fertilizers, materials, and agrochemicals to the greatest extent. The government also increases carbon sinks by preserving and developing farmland and developing sea groves (referring to communities of seaweeds, such as Gelidium amansii, to be developed in seawater to absorb greenhouse gases in the atmosphere). The expansion of carbon sinks is implemented substantially through conservation and development of forests and facilitate the utilization of biomass in forests. The government establishes and implements measures that raise self-sufficiency in food through the improvement of new varieties that can cope with climate change positively.

Buildings

In the building sector, the government introduced green building certification system based on the energy efficiency standard. It aims to improve and expand energy efficiency and renewable energy share in building sector. The government sets and manages medium and long-term goal energy efficiency standards and reviews periodically the goals to meet with the standards prescribed by Presidential Decree to reduce the consumption of energy and the emission of greenhouse gases in buildings.

Green building system sets different measures and standards for each life cycle stage of building, designing, construction, maintenance, renovation and dismantling. These measures and standards contribute to the reduction of GHG emission from building sectors by enhancing the energy efficient design standards and construction procedures which result in minimization of energy consumption and GHG emission in the entire building life cycle. For the buildings of central administrative agencies, local governments, public institutions, educational institutions, the Government may ask the installation and management of intelligent meters for controlling and reducing consumption of energy such as power consumption, etc. in newly constructed or renovated buildings. The government expects a leading role of public sector in transition toward green buildings.

Article 25 of the Energy Use Rationalization Act assures the government to implement energy inspections on energy saving programs of existing buildings to monitor and assess the performance in GHG reduction. Energy inspection contributes to the conversion of existing building stock toward green buildings. The government also endeavor to increase or supply green buildings through the new city development project as well as re-habilitation projects of old urban center as a part of smart energy efficient urban planning policy. For

that purpose, the Government may provide financial support, tax abatement or exemption, and other measures as prescribed by Presidential Decree.

Transportation

The Government sets and manages goals for the reduction of greenhouse gases in the traffic sector to reduce GHG emission and improve energy efficiency. The medium and long-term goals, phased and renewed periodically, cover the improved share of public urban traffic and railroad transportation to establish low-carbon traffic systems minimizing energy consumption and GHG emission. The investment into railroads expands continuously to build the massive national infrastructure of main national transportation networks. In urban traffic, the city governments expand the means of public transportation, such as buses, subways, light rail transit systems. and encourage the use of bicycles and other low carbon personal mobile equipments.

In supply side, the government takes diverse policy measures requiring automobile manufactures to meet with the GHG emission standards compatible with those of international market. For that purpose, the government introduced two standard systems: a standard for the average energy consumption efficiency and a standard for GHG emission allowance. The former standard aims to promote energy saving by improving average energy consumption efficiency of automobiles. The standard for GHG emission allowance is expected to improve atmospheric air quality by reducing exhaust gases and greenhouse gases from automobiles.

With a view to avoiding double overlapping burden to automobile industry, the government allows auto makers and importers to choose one of the two standards. To reduce the burden of strict regulation compliance, the government is providing financial support for early adapters in green cars, while imposing a charge for automobiles emitting more greenhouse gases. In addition, the government enhance the support schemes for research and development, manufacturing and distribution of low-carbon, high-efficiency transportation means, such as hybrid vehicles and fuel cell electric vehicles.

The government also promotes urban traffic demand management system to improve the GHG emission, air quality and social costs incurred by traffic congestion. To reduce traffic congestion in the Seoul Metropolitan Area, the local government introduces a traffic congestion and inducement charges, BRT system, vehicle free zones, low-pollution car incentives, and intelligent traffic information systems.

3. Comparative Analysis of Low Carbon City Policy

While there are certain limitation in direct comparison of experiences among the three countries due to contextual variations[i], low carbon city policies are considered here in two types: nationally driven policy, that coming from national governments; and locally driven policy, that coming from local governments, such as cities, themselves. Regarding nationally driven policies, this report focuses on three broad categories: how cities generally fit into national climate policy, support mechanisms for low carbon city development, and pilot and certification schemes. In considering subnational policy, it considers variation in the activity and ambition of cities in China, Japan, and ROK along with their use of three broad policy approaches: voluntary, market-economic, and command-and-control tools.

Governance and Institutional Structure

A key point of comparison among cities in the three countries is their fiscal and policy autonomy. As discussed, the political system in China is highly decentralized with much of the business of government delegated to subnational levels, which account for about 80% of public expenditure. They are responsible for providing public services, enforcing laws and regulations, and implementing national legislation (Hart, 2019; Kostka & Nahm, 2017). Compared to their counterparts in Japan and ROK, where the structure of governance affords them much less financial and regulatory control, many Chinese cities have the autonomy and capacity to play very direct roles in both envisioning and implementing low carbon development. At the same time, due to China's top-down planning approach that sees local governments being assigned specific targets for a range of low carbon development indicators, the political room for independent policy innovation on the part of cities is somewhat limited. Japanese and ROK cities, by and large, rely significantly on central government direction and resources. There are some exceptions to this among Japan and ROK's large prefectural-level and municipal cities, however, such as Tokyo and Seoul, for example, with the latter having 89% fiscal autonomy (compared to only 50-70% for other major cities and even less for smaller ones in ROK) (J.-S. Lee & Kim, 2016).

Despite having less financial autonomy, however, ROK, and particularly Japanese cities have more institutional political leeway in driving their low carbon development. Unlike Chinese cities, those in ROK and Japan do not have sectoral targets handed down to them from the national government. Although in practice ROK cities tend to adopt targets that mirror the national ones, Japanese cities show great variation in terms of the target development, suggesting a greater degree of institutional leeway.

Institutional aspects

From the perspective of institutional setup, Korean practices are more similar to those of China, which puts the Premier at the head of climate change and national development agenda through NDRC. It seems that China and Korea take more integrated and centrally coordinated approach in mainstreaming climate change issues into a main stream of national development strategy. In the background of these centrally coordinated climate change approaches are the unitary political system of China and the republic presidential system of Korea.

These approaches result in the central government's direct support to the local climate change mitigation and adaptation efforts in both countries through central government budget financing for local climate actions

Incentive structures

The different political systems in each country also create interesting variation in incentive structures for city officials. In China, political appointments are made top-down by the central government, meaning officials are incentivized to reach targets and perform to the metrics of the administrative hierarchy. In contrast, Japanese and ROK cities are subject to local public electoral processes. The effect of such a difference depends on the political climate and government objectives at any time. For example, in a situation where local communities have a strong desire for climate action, but top-down government priorities lie elsewhere, incentives to pursue low carbon development would be greater in governance structures such as Japan and ROK's compared to those like China's. In contrast, in the reverse situation, the incentives would be stronger in China as officials are not subject to the immediate demands of public electoral pressure.

Distribution of authority

The distribution of authority and inclusiveness regarding low carbon policy development also varies across the three countries. In China, although the NDRC will continue to play dominant role in overall economic planning, the transfer of the climate change department to the newly formed MEE looks set to give low carbon development efforts a new level of integration and coordination with other environmental policies. In Japan and ROK, the Ministries of Environment have already been playing the central role in devising climate and low carbon policy, although some overlap with other ministries still occurs.

Stakeholder engagement

Japan and ROK have institutionalized public mechanisms for stakeholder engagement into the development of low carbon policy. In Japan, corporate groups and organizations, such as federations, play an important role in the policy implementation process. These corporate groups help set and review the mid-term goals of the country and contribute to related policy planning processes through setting and implementing voluntary mid-term reduction targets. In ROK, the multi-stakeholder Presidential Committee on Low Carbon Green Growth plays a key role in guiding the country's low carbon development. China also consults with stakeholders from industry and non-profit policy research organizations, but these consultation practices tend to be low-profile. In addition, China solicits expert counsel from abroad at both the local and national levels. The China Council for International Cooperation on Environment and Development is an example of a formal organization that is designed to gather input into China's environmental policy broadly.

National-Level Low Carbon City Policy

National governments can play a key role in shaping the development of low carbon cities. China, Japan, and ROK have all developed national policy directed towards this end, with variation across a range of dimensions.

The Role of Cities in National Climate Policy Frameworks

Cities occupy a different place in the national climate policy frameworks of China, Japan, and ROK. Japan and ROK both have flagship national climate change laws that carve out responsibility for cities to develop their own low carbon/climate mitigation plans, either directly or through the concerned line ministries. China, in contrast, has a flagship climate policy program specifically about cities: the low carbon cities pilot program. The use of a pilot program approach rather than more blanket approach, such as Japan and ROK's, reflects a longstanding policymaking tradition in China. Given the large number and wide diversity of local conditions in Chinese cities, developing effective blanket policies is challenging. Pilot programs are designed to generate lessons and information that can later feed into the development of broader national policies. At the same time, China's pilot approach should not be seen as necessarily "narrower" than Japan and ROK's approach. The number of cities participating in the pilot program (81) is, in fact, greater than the number of Japanese cities required to create area plans (68).

Japan and ROK's climate law frameworks are similar in that they encourage cities to produce local climate action plans but differ in terms of their stringency. In Japan, it is mandatory for cities to produce the type of plan appropriate for their size ("local government implementation plans" or "area plans" as discussed above). In ROK, on the other hand, creating local adaptation plans is mandatory under the FALCGG but mitigation plans remain voluntary (KEI, 2019). In China, participation in the pilot cities program is also voluntary in that cities have to put themselves forward to be selected.

The overall frameworks for encouraging low carbon cities can also be compared in terms of their "depth". Japan's "Global Warming Acts" outlines broad areas that cities should focus on (e.g. promoting renewable energy, sustainable lifestyles, and low carbon transport) but provides few specifics for how this should look. The 2016 revision to the Act did, however, clarify that cities must work towards consolidated urban forms due to pressures of an ageing and decreasing population. ROK's guidance for city plans, which are already voluntary, appears to be even less detailed. In China, although a large part of the pilot program's *raison d'etre* is to allow cities to develop policies and plans based on their unique circumstances, a number of specific requirements are still given that go further than those stipulated for Japanese and ROK cities. For example, China's pilot cities are required to create GHG inventories, model emissions pathways, create sectoral targets based on the TRS, and, for the third batch, stipulate specific target years for carbon peaking.

Support Mechanisms for Cities

As well as broad frameworks to encourage cities towards low carbon development, China, Japan, and ROK also provide different kinds of support to enable cities in doing so. In China, the government has developed a guideline for provincial and municipal governments to conduct GHG inventories. The national government also provides additional financial support for low carbon city development through grants and preferential financing, but these are for efforts towards achieving centrally mandated Five-Year Plan targets, rather than initiatives emerging from being a low carbon pilot city (Sandalow, 2018). As described above, the "Low Carbon City Act" gives more flexibility to the municipalities to develop

cross-sectoral low carbon city plans. In addition, Japan's Ministry of the Environment operates a platform to support cities in formulating their plans based upon a survey of the key challenges they face in doing so. It provides a range of manuals and tools for city officials, including example plans. In ROK, the Ministry of Environment supports the development of local GHG inventories and low carbon road maps, while the ROK Environment Corporation is in charge of providing capacity building activities for the officials in local governments.

Model City Schemes

Model city schemes are commonly used policy tools that encourage voluntary action and provide frameworks to scale up and learn from the results. As mentioned, China regularly uses pilot programs as part of national policy development and its low carbon cities pilot program is its flagship policy for promoting low carbon cities. In addition to this program, China operates a large number of other sustainability-related pilot programs that many low carbon pilot cities participate in concurrently. Table xx provides a list of these programs.

Table 4. Low Carbon Development Pilots Programs in China (iGDP, 2018)

Carbon Emission Permit Trading Pilot	Demonstration Work for Financial Policies for Energy Conservation and Emission Reduction
Green Finance Pilot Zone	New Energy Demonstration City
Green Industrial Transformation Development Pilot	National Low Carbon Industrial Park Pilot
Concentrated Solar PV Demonstration Area	New Energy Vehicles Promotion and Application Pilot
Green Circular and Low Carbon Transportation Pilot	Transit Metropolis Pilot
Demonstration Projects of Urban Walking and Bicycle Traffic System	National Green Ecological Demonstration Area
Low carbon Community Pilot	City Betterment and Ecological Restoration Pilot
Alliance of Peaking Pioneer Cities	Demonstration Projects Using Renewable Energy in Buildings
Comprehensive Pilot Projects on New-Type Urbanization	National Ecological Civilization Demonstration Area
National Smart-City Pilot	Sponge City Pilot
Kitchen Waste Resource Utilization Technologies and Harmless Treatment Construction Pilot	Domestic Waste Classification Pilot

These programs are operated by a number of different ministries, including the MEE, NDRC, MOHURD, NEA, MIIT, and MOT (iGDP, 2016). There appears to be significant overlap between the objectives of these programs. Khanna, Fridley, & Hong (2014) argue that this can create administrative confusion and burden that hampers their effective implementation. Similar issues have been identified in ROK, where, although there are

fewer pilot initiatives than in China, there are still several ones with very similar aims operated by different government authorities. This has at times led to conflict among the managing ministries, redundancies, and inefficiencies in expenditure and implementation (Kamal-Choui et al. 2011). However, the range of pilot programs in China may offer greater flexibility to cities as they try to pursue locally-appropriate low carbon development (Khanna et al. 2014).

Unlike in China and ROK, Japan's multiple model city certification schemes are hierarchically ordered and managed by the same authorities. The "Eco-Model City" initiative is the primary program through which cities can apply to be officially recognized for their low carbon development efforts. More ambitious action can lead Eco-Model Cities to be progressively recognized as "Future Cities", and by alignment with SDGs as "Local Government SDG Model Cities. The schemes are jointly organized by the Ministry of Environment (MoE) and Ministry of Economy, Trade, and Industry (METI) rather than siloed across different parts of the government (Van Berkel, Fujita, Hashimoto, & Geng, 2009). Fewer in number, the Japanese and ROK model city programs are also broader than those in China, encompassing future-oriented issues that are not directly related to low carbon development, such as super-aging populations and disaster-responsiveness (IGES, 2019; Kamal-Chaoui et al., 2011).

One important similarity across the pilot schemes in all three countries is that they tend not to impose rigid requirements on cities, such as setting specific emission reduction targets. This differs from many of the major transnational city networks, such as C40, which requires members to make a plan by 2020 to align with the Paris Agreement by reaching zero emissions soon after 2050, or Carbon Neutral Cities Alliance (CNCA), which requires cities to commit to reducing GHG emissions by at least 80% by 2050.

Local-Level Low Carbon City Policy

Cities in China, Japan, and ROK also take the initiative themselves in pursuing low carbon city development. Some of this is directly in response to national efforts to promote it, while other manifestations reflect independent leadership emerging at the city level.

Targets and Ambition

An objective overall comparison of the ambition of low carbon development plans in China, Japan, and ROK is difficult due to the variation in development profiles and metrics used for target setting in each country. Chinese pilot cities, many of which are significantly different from those in Japan and Republic of Korea because they are rapidly growing or industrializing, have targets to peak carbon emissions between 2020-2030. In Republic of Korea, most major cities aim to align with the national target of reducing emissions by 30% below business-as-usual projections by 2020 (Kamal-Chaoui et al., 2011). Japanese cities, in contrast, adopt absolute emission reduction targets which, as of 2012, have an estimated average mitigation target for 2020 and/or 2030 of 19 percent compared to base years of FY2008-10 (Kuramochi, 2014). On a nominal level, absolute emission reduction targets are

the most ambitious type of target as they exclude the possibility of growth of emissions and have a more objective measurement standard.[22]

The choice of target and target type, however, is often heavily influenced by standards set at the national level. Table 3 compares the city targets just mentioned and the relevant respective national mitigation targets in each country.

Table 5. Target Setting in China, Japan, and the Republic of Korea 4. Target Setting in China, Japan, and the Republic of Korea

	China	**Japan**	**Republic of Korea**
City targets	Emissions peaking between 2020-2030	Estimated average of 19% reduction by 2020/2030 (FY2008-10 baseline years) as of 2012[23]	30% below BAU by 2020
National targets	Emissions peaking by 2030	25% reduction by 2020 (1990 baseline year)[24]	30% below BAU by 2020
(Potential) emissions reduction burden of cities	36 cities and 6 provinces account for 54% of CO_2 emissions (2013)	Area-wide city plans cover 65% of CO_2 emissions (2018)	26% of national emissions in 2020 to fall under the mitigation jurisdiction of local governments.

Source:

In China, the low carbon pilot cities have targets that are expected to lead in the fulfilment of the national target. These cities have targets that are at least as ambitious as the national target and generally significantly more ambitious. In the Republic of Korea, where there is also a top-down approach to low carbon development and cities have limited fiscal independence, most cities have adopted the national target as their own. In Japan, in contrast, the mitigation targets of cities are generally less ambitious than those of the national government, which may reflect the country's comparatively more bottom-up political system combined with limited city capacity while sectoral policies on low carbon and energy efficiencies include regulatory measures concerning low carbon development of cities, such as building standard and transportation.

In terms of the overall emissions burden shouldered by cities, it is a shared challenge in each country that a significant amount of national emissions come from urban areas. China's first

[22] There is a movement towards China developing absolute emission reduction targets in the future, which would open doors towards more effectively comparing them with those of other countries. Hu (Forthcoming) provides commentary on how this could be included as part of the 14th Five-Year Plan.
[23] Kuramochi, 2014
[24] This is the target set at COP15 in 2009. It was updated in 2013 due to the Great East Japan Earthquake to a 5-9% target reduction. The 2009 target is used for this comparison because the data presented for the city-level targets is from the time during which this was still the target.

and second batches of low carbon pilots already accounted for 54% of national emissions in 2013 (iGDP, 2015), a number that has surely risen with the introduction of the third batch that nearly doubled the total number of pilots. Similarly, the area-wide plans of Japan's larger cities cover approximately 65% of national emissions as of 2018 (IGES, 2019). While equivalent data is not available for ROK, estimates have predicted that 26% of national emissions in 2020 will fall specifically under local government jurisdiction to mitigate (KEI, 2019).

While comparing cities generally across countries is difficult, the preponderance of specific, high-ambition cities can be examined by identifying the few that have set long-term targets for carbon neutrality or close to it. In Japan, Yokohama and Tokyo both have goals to have net-zero emissions in 2050, while in the Republic of Korea, Gwangju has done the same. No Chinese cities have yet committed to such ambitious targets but the 13 Chinese cities that are members of C40 will be required to do so by 2020 as part of continued membership. In the Republic of Korea, Seoul will face similar expectations as a member of C40.

A major way in which cities advance low carbon development is through participation in relevant transnational city networks (TCNs). These often provide political, technical, and sometimes financial support for city governments. As Table 1 in the introduction showed, China, Japan, and ROK's participation in the major climate change related TCNs varies significantly. Chinese cities participate heavily in C40 and UCLC WC, while Japanese and ROK cities concentrate their participation in ICLEI and CoM. The variation in C40 participation can largely be accounted for by size, with China having a large number of "megacities" (the focus of C40) while Japan and ROK have very few. Overall, however, Republic of Korea and Japanese cities appear to be more active in TCNs. Considering in detail the reasons for and ramifications of this variation would be a useful line of future research.

Overall, it appears that Japanese cities are pursuing the most nominally ambitious agenda due to their focus on overall emissions reductions while, considering respective national contexts, China's low carbon pilot cities are the most ambitions compared to their national government. The individually most ambitious cities are located in Japan and Republic of Korea and cities from these countries are the most active in TCNs.

Policy Approaches

Cities in China, Japan, and the Republic of Korea take different approaches to promoting low carbon development, often in ways that reflect their varied administrative-authority structures described above. Three broad categories of tools that cities employ include voluntary approaches, those that focus on encouraging self-driven action by other actors; market-economic approaches, those that use investments and economic incentives to drive action; and command-and-control approaches, those that compel action through regulatory authority. This section compares how these different approaches have been taken by cities in China, Japan, and the Republic of Korea.

One of the keys to understanding the variation in policy approaches among cities in China, Japan, and Republic of Korea is the administrative authority and powers that city

governments wield. The extent of devolution to city-level governance shapes the potential balance between top-down and bottom-up city climate action and where barriers to policy design, implementation, and monitoring may occur, with all these potentially varying across sectors in line with how power is devolved. This is also a key finding from C40's 'Powering Climate Action' report. Which presented a typology of six urban governance structures that reflect variation in the breadth and depth of city government powers and authorities. This is replicated here in Figure 18.

Figure 23. Typology of Urban Governance Structures (Arup & C40 Cities, 2015)

Cities bring together different combinations of these characteristics. Furthermore, definitions and administration of cities and local governments differs in all countries. Nonetheless, this framework provides a useful rubric for considering the different ways in which cities do, or could, pursue low carbon development on their own initiative.

In Chinese cities, where local authorities are dominant with their strong fiscal capacities, and top-down decision-making processes, command-and-control approaches are the primary ones used foster low carbon development (Liu, Matsuno, Zhang, Liu, & Young, 2013). Nonetheless, while voluntary approaches tend not to be dominant among China's LCCP's, a range of them are deployed including low carbon transportation and industry park pilot projects, promoting zero-carbon buildings, and developing carbon monitoring tools (Wang et al. 2015)

In contrast, cities in Japan and Republic of Korea rely significantly on voluntary approaches due to their limited fiscal and regulatory authority. In Japan, as at the national level, local governments engage heavily with industry when considering their own low carbon policy as well as to support and encourage voluntary emission reduction efforts across sectors. Japan's Global Warming Act also stipulates that local governments promote emission

reduction activities by businesses and residents, including through the use of low GHG products and services (IGES, 2019). In cities of the Republic of Korea, the "Green Start Movement" is a good example of this. Supported by local governments, it is a network of local multi-stakeholder groups that promote low carbon lifestyles through green education and awareness raising (Kamal-Chaoui et al., 2011). Due to their low cost, voluntary approaches are common for cities in all three countries. As such, they also are relatively more prominent in the overall suite of approaches taken in the cities of Japan and the Republic of Korea, which have generally less policy and fiscal autonomy than major Chinese cities.

As mentioned, there are key exceptions to this difference in autonomy, however, most notably Seoul in the Republic of Korea and Tokyo and Yokohama in Japan. Due to their economic and political prominence, these mega-cities are able to deliver more comprehensively promote low carbon activity in their jurisdictions. Seoul stands out in the Republic of Korea as it is a special administrative municipality as the capital and enjoys exceptionally high fiscal autonomy, allowing it to develop and pursue its own initiatives in ways that most cities of the Republic of Korea cannot (J.-S. Lee & Kim, 2016). Yokohama and Tokyo similarly stand out in Japan, with the former being the only member among the three countries of the high-ambition Carbon Neutral Cities Alliance and Tokyo being the first city in the world to develop a metropolitan ETS.

Overall, however, the greater decentralization of authority to Chinese cities has also facilitated their greater use of market-economic approaches. While command-and-control approaches, as mentioned, predominate, some of China's LCCPs also invest significantly into clean energy development, subsidized loans, and other subsidies (Wang et al., 2015). Most cities of Japan and the Republic of Korea lack of the capacity and fiscal autonomy to do this at scale, but some have developed interesting incentive programs based on "points" and certification schemes that promote business and household emission reductions. Perhaps the most prominent market-based instrument is the development of an ETS, and while they are most commonly created at the national-level, both Tokyo and Chinese LCCPs have developed them at the municipal level. While Tokyo was the world-leader in this regard, it remains the only one in Japan, with an ETS not having emerged at the national level. Seven of China's LCCPs have piloted an ETS and, unlike for Tokyo, these are actively part of a central government scheme to develop an integrated national ETS. No cities in the Republic of Korea operate an ETS as a national system has been in place since 2015.

4. Good Practices

Overview

This section takes a close look at good practices in low carbon city policy at the local and project level in fifteen brief case studies. The case studies, arranged by country, highlight three aspects of low carbon practice: effectiveness and efficiency, sustainability and transferability (the relevance of the policy or practice to other cities). The case studies also provide illustrations of the use or appearance of the local low carbon policy approaches and features described in the preceding section of this report: level of ambition and leadership, the promotion of voluntary participation in low carbon city programs or campaigns, the provision market-economic incentives for carbon reducing activity, and the use of the command-and-control tools under the legal authority of local governments. The table below organizes fifteen good practice case studies against these four analytic dimensions. While most of the case studies provide illustrations of all four analytic dimensions, some provide powerful examples of one particular approach.

Table 6 Case studies by Local-level Low Carbon City Policies and Approaches

	Ambition and Leadership	**Command-and-control Tools**	**Voluntary Tools and Stakeholder Engagement**	**Market-economic Tools**
China	1. Zhenjiang Carbon Emission Management Cloud Platform (pioneer) 3. Large-scale Existing Public Buildings Renovation in Changning District, Shanghai (local government leadership)	4. Turpan New Energy Demonstration Zone – (new energy demonstration site) 5. Guangzhou Bus Rapid Transit	2. Qinghuangdao Energy Efficiency Building Projects (stakeholder engagement)	6. Shenzhen ETS Pilot Program
Japan	2. Power systems: Miyama Smart Community (provides a model for other cities)	3. Transportation: Toyama Compact City 5. Kitakyushu Eco-town – Waste Management	1. Smart community: Yokohama Smart City Project (YSCP) (local stakeholder engagement)	4. Tokyo Cap & Trade
Republic of Korea	2. Jeju Province - from World Environmental Hub to Carbon Free Island (global ambition)	1. Gwangju Metropolitan City - Urban Carbon Management System (official city-wide effort)	3. Suwon City - Transportation (community based public participation)	4. Gwangju Metropolitan City - Financial Incentives for Low Carbon Lifestyle

Ambition and Leadership

In China, Japan, and the Republic of Korea municipal policymakers often have the authority and drive to exceed the ambitions of national governments. In China, low carbon pilot cities are expected to lead in the fulfilment of national mitigation or energy-related targets. Chinese cities in the national low carbon pilot program are also encouraged to show

leadership and serve as exemplars of effective or innovative practices. The Carbon Emission Management Cloud Platform developed in the city of Zhenjiang is an example of leadership in local-level emissions management in China. One of China's earliest efforts at robust CO_2 emissions management, it has pioneered the application of cloud computing, geographic information systems, and AI, as well as visualizations of carbon emissions data. However, in Japan, the mitigation targets of cities are generally less ambitious than those of the national government, which is reflective of the country's comparatively bottom-up political system in combination with limited city capacity. In the Republic of Korea, regardless of top-down approach to low carbon development, most cities managed to adopt a local mitigation target corresponding to the national target, due to the limited local fiscal resources.

Selected cities in both Japan and the Republic of Korea have undertaken ambitious projects to refashion large parts of their energy and industrial sectors, or transportation infrastructure, in a conscious effort to become champions of progressive energy and climate policy. In Japan, Miyama Smart Community has developed a system to produce and sell renewable energy in a manner that allows revenues to be cycled back into social support services that counteract population decline, the relocation of younger generations to other areas, and the shrinking of the local economy. Miyama is providing an innovative model for other communities that are looking for ways to address climate change and local social challenges at the same time. In the Republic of Korea, Jeju Province has embarked on a multi-year, province-wide effort to transform itself into a global hub for environmental protection and a carbon-free island. The province aims to become a global paragon of livability, where environmental protection, economic vitality, and personal well-being are in harmony.

Command-and-control Tools

In Chinese cities, where local authorities have strong fiscal capacities and relatively top-heavy decision-making processes, low carbon development is often driven by command-and-control approaches. The Turpan New Energy Demonstration Zone and Guangzhou Bus Rapid Transit case studies illustrate the use by local municipal authorities of their wide powers to reshape major features of the local urban landscape.

Command-and-control measures are also used in Japan and the Republic of Korea in the construction of ambitious, large scale carbon-reduction schemes, as noted above. In Japan, the Toyama Compact City and Kitakyushu Eco-town case studies are examples of comparable large-scale transformations efforts by local governments to reshape their cities.

In the Republic of Korea, the development of the ICT based Urban Carbon Management System in Gwangju is city-wide effort focusing on enhanced science-policy interface. The city of Gwangju signed the first agreement with the Ministry of Environment to undertake ambitious climate actions. Gwangju currently has 74 project-level low carbon initiatives in four sectors, including the development of city level micro climate change impact assessment tools.

Voluntary Tools and Stakeholder Engagement

Cities in Japan and the Republic of Korea rely significantly on voluntary approaches due to their limited fiscal and regulatory authority, as well as their relatively pronounced bottom-

up government structures. In Japan, local governments engage heavily with industry as they develop low carbon policy to support and encourage voluntary emission reduction efforts across sectors. The Yokohama Smart City Project provides a good example of strong stakeholder engagement and the encouragement of voluntary participation and support for ambitious carbon reduction schemes. Its goal is to take the lead in establishing the world's best smart city model. To do this, the city established the Yokohama Smart Business Association, a new public-private collaborative council. This ensures the cooperation of companies and demonstrates to the private sector that taking local action will lead to business opportunities both in Japan and overseas.

This sort of stakeholder engagement is also evident in the case study of the city of Suwon in the Republic of Korea. Suwon, which aims to become the 'Environment Capital of Republic of Korea', has invited community based public participation in support of evidence-based climate policy and measures. It launched a special committee on climate change and organized a series of town hall meetings to review different GHG reduction scenarios by 2030. The outcomes of these meetings and public consultations resulted in a 2030 GHG reduction target 40% lower than the emission level in 2005**.** In China, the success of the Energy Efficiency Building Project in Qinghuangdao also depended on stakeholder engagement. A key project success factor was the inclusion of central and local authorities, science and technology supporting agencies, real estate developers, and constructive cooperation between Chinese and German technical experts.

Market-economic Tools

Perhaps the most prominent market-based instrument is the development of emissions trading systems. While they are most commonly created at the national-level, both Tokyo and Chinese LCCPs have developed them at the municipal level. Tokyo's ETS is the world's first urban cap and trade system for the industrial and business sectors, where CO_2 emissions from these sectors account for about half of the metropolitan area's emissions. In China, although Shenzhen only accounts for a small proportion of total carbon emissions in the country, the local ETS far exceeded the 21% reduction target set by the central government for Shenzhen during the Twelfth Five-Year Plan period, the local ETS managers are now serving a leading advisory role in the development of the national carbon market. In the Republic of Korea, the city of Gwangju collaborated with the Ministry of Environment to launch the Carbon Bank Program, which provides subscribers with carbon points to promote low carbon lifestyle in consumption of energy and water services.

Sectoral Relevance

The case studies below also provide examples of good practices within sectors. The table below arranges the case studies by the country and sector.

Table 7. Case Studies by Country and Sector

	China	Japan	Republic of Korea
Market mechanisms	Shenzhen Emissions Trading Pilot	Tokyo Cap & Trade	
Buildings	(1) Qinghuangdao Energy Efficient Buildings (2) Shanghai retrofitting buildings for energy efficiency		
Power systems	Turpan Solar Energy	Miyama Smart Community	Jeju Province Carbon Free Power System
Transport	Guangzhou Bus Rapid Transit	Toyama Compact City	Suwon City - Transportation
Carbon Management	Zhenjiang Management System Innovation		Gwangju Metropolitan City Urban Carbon Management System
Smart Communities		Yokohama Smart City Project	
Waste Management		Kitakyushu Eco-town	
Public Participation			Gwangju Metropolitan City Financial Incentives for Low Carbon Lifestyle

China

China has adopted a wide range of policies to encourage local actions on low carbon development. This section selects cases that reflect local low carbon development experiences in different sectors, different regions, and at different scales. In terms of city type, they cover practices implemented by megacities, mid-sized cities, and districts and communities. In terms of low carbon actions, they cover low carbon management systems, key policies, and sector-specific actions in energy, buildings and urban transport. Each case contains background information, key features, and valuable experiences.

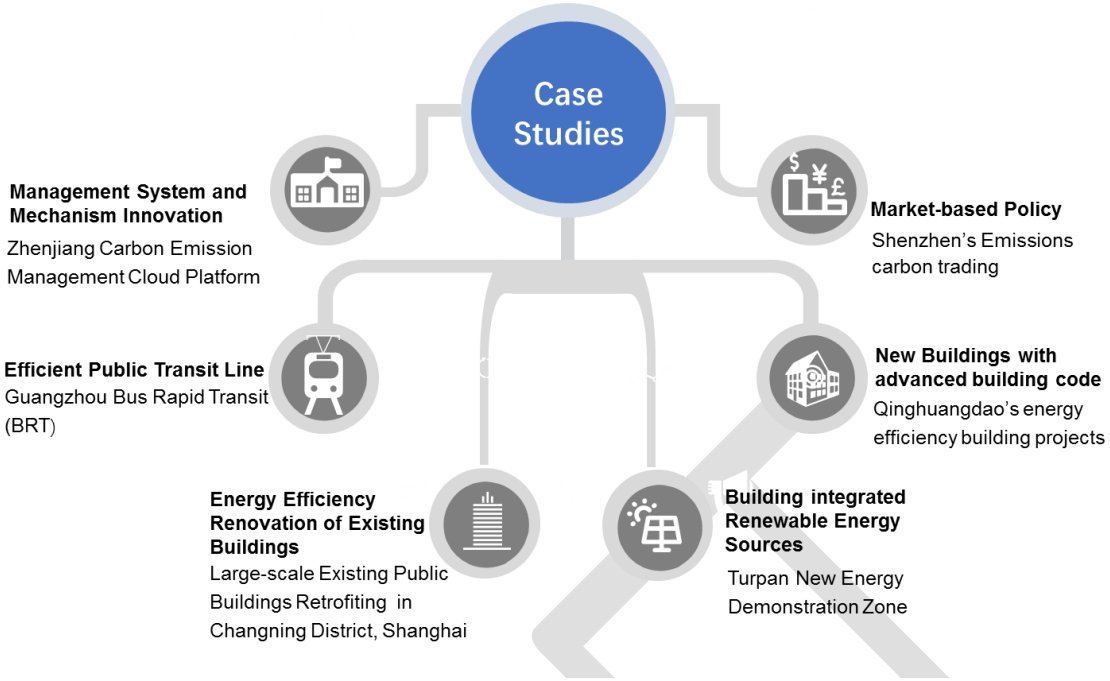


Figure 24. Chinese Best Practice Case Studies (iGDP, 2019)

Management System Innovation: Zhenjiang Carbon Emission Management Cloud Platform

Developing a city greenhouse gas emission statistics accounting system, a monitoring and evaluation system, and capacity building mechanism have been key challenges faced by China's cities at the initial stage of developing a low carbon pilot. The city of Zhenjiang took the lead in this area. In 2013, it launched a carbon emission accounting and management system platform that integrates data collection, accounting, and management systems. This platform is the core and foundation of Zhenjiang's urban carbon management system. It provides a visual display of carbon emissions data on a user-friendly map. The scope of data collection includes economy-wide total carbon emissions, carbon emissions from industrial processes, carbon emissions from energy sources, carbon emissions from waste, and carbon sinks. Intelligent carbon emission data collection and analysis systems provide data for pilot administrators to make low carbon development decisions.

Figure 25. Zhenjiang Low Carbon City Management Cloud Platform

Effectiveness and Efficiency
This system was developed as an early entrant in the field of CO_2 emissions management, using new information and internet technologies such as cloud computing, geographic information systems, and AI. It is now recognized as a pioneer in China in the promotion of scientific, digitized and visualized carbon emission data management.

The system consolidates GHG emissions data from various urban management agencies and multiple sectors, including land use, environmental protection, resource management, industry, energy conservation, emission reduction, and carbon reduction, among others. In terms of management levels, it covers city-level, district (county) level, industry level, enterprise-level, and project-level data. In terms of time span, the system includes historical data, current data and future projections. The Carbon Emission Management Cloud Platform is based on real-time data collection of energy consumption and industrial production processes related to carbon emissions, and 48 key enterprises with annual greenhouse gas emissions of more than 25,000 tons of CO_2e are included in the platform. The emissions from these enterprises account for 66% of the city's total emissions

Through three systems of collection, aggregation, accounting and management, the platform can visually display the city's carbon emissions and provide scientific support for status assessment, trajectory forecasting, reduction potential analysis, target setting and performance tracking.

Sustainability
Local government has provided funding and institutional support to establish and maintain the platform's construction and operation and has established a leading group on low carbon city construction led by the city mayor. This group is responsible for coordinating the development of low carbon work in various fields, coordinating and solving major problems encountered in the construction of low carbon cities, and carrying out the monitor and evaluation on situation of low carbon cities construction. The Zhenjiang Carbon Emission Management Cloud Platform is the key tool used by the group to implement improved management and scientific decision making for carbon emissions control.

Transferability
Following Zhenjiang case, other low carbon pilot cities in China have also established on-line carbon management platforms, including Wuhan, Shenzhen and Lanzhou. The Zhenjiang Carbon Emission Management Cloud Platform has established a benchmark for low carbon pilot cities across the nation by using information technology to improve low carbon management.

Ultra-Low Energy Consumption Buildings: Qinghuangdao's Energy Efficiency Building Projects

At present, China's passive low-energy consumption buildings are still in the demonstration stage. Compared with developed countries, China still has a big gap in this field. It currently largely lacks a comprehensive standards and policy system, low professional capacity, and mechanisms to incentive and absorb technological innovations.

Qinhuangdao is in Hebei Province, northeastern China, facing Bohai Bay. It has a warm to temperate semi-humid monsoon climate, with annual temperature variation between -9 °C and 29 °C. The population of Qinhuangdao is about 3.11 million, and the per capita GDP is 48539 yuan.

Nine demonstration buildings (with a total area of 80,344 square meters) are located in Zone C of Qinhuangdao's "Zai Shui Yi Fang" residential area. These buildings are the first China-Germany passive building and ultra-low energy building demonstration projects (highlighted in red part in the picture). In October 2013, Building C15 (6,467 square meters of building area) became the first ultra-low energy consumption building in China, as determined by the German Energy Agency.

Effectiveness and Efficiency

The pilot is designed to deliver a comfortable indoor environment at an acceptable cost. The building can keep a room temperature of 22-25 degrees Celsius throughout the year, has a comfortable level of indoor humidity of 40%-60%, and a low carbon dioxide concentration of less than 1000ppm. Compared with buildings conforming to local building codes, the additional construction and installation costs for Building C15 amounted to 577 yuan/m2 (including heat recovery system with new wind health function, external thermal insulation thickening system, improved door and window quality). However, C15's heating and cooling costs were reduced. In addition, the ultra-low energy building reduces the demand for connections to traditional central heating systems in urban areas.

Table 8. Cost Comparison of ultra-low energy buildings and buildings conforming to 75% local building codes

	C15 ultra-low energy building	75% energy efficient building	Additional cost
1 Construction and installation cost			
1.1 Construction and installation cost （yuan/m2）	2451	1749.9	701.1
1.2 Cost for Connecting to district heating pipe network yuan/m2）	0	124	-124
Total（yuan /m2）	2451	1873.9	577.1
2 Maintaining and operating cost	Saving cost of C15 building ultra-low energy building, compared to ordinary residential building		note
Saving heating cost （yuan/m2/day）	0.02-0.01		Heating costs for ultra-low energy building: 0.52 yuan / kWh; Central district heating costs: 0.24 yuan / m2 / day Ordinary residential cooling hours: 5h / day
Saving cooling cost （yuan/m2/day）	0.02-0.04		

Sustainability
The key element in the success of Qinhuangdao' ultra-low energy consumption buildings has been stakeholder engagement, including central and local authorities, science and technology supporting agencies, the real estate developer and cooperation relationship between Chinese and German experts.

Transferability
Qinghuagndao's "Zai Shui Yi Fang" ultra-low-energy consumption building project has served its intended demonstration effect. The high-energy efficiency level of the new buildings and the method for constructing them in Hebei Province have led to the improvement of energy efficiency standards in Hebei Province as a whole. In May 2017, Hebei Province issued a new regulation for new residential buildings to fully implement 75% of local building codes, and to have all commercial and residential buildings fully implement the green building standards. The demonstration project also introduced the "Energy Efficiency Building Code for Passive and Ultra-Low Energy Consumption Residential Buildings" to Hebei Province. This is the first building code for passive and ultra-low energy consumption building standard in China, providing a reference for similar standards in other climate zones.

Qianghuangdao's ultra-low energy consumption building demonstration has proved that it is feasible to promote passive and ultra-low energy consumption buildings under China's existing conditions. It shows that ultra-low energy consumption buildings can improve indoor living environments while significantly reducing a building's energy consumption using affordable technology.

Large-scale Existing Public Buildings Renovation in Changning District, Shanghai
China has more floor space that North America and Western Europe combined. Most of these structures are energy-inefficient, offering tremendous potential for carbon reductions. Districts where large-scale public buildings are highly concentrated lack baselines for building renovation, binding controls, as well as incentives for energy efficiency upgrades.

In May 2010, the Shanghai Municipal Development and Reform Commission selected eight districts as the first low carbon development practice zones, including the Changning Hongqiao Business District. Changning Hongqiao Business District is located in the west of Shanghai and covers an area of 3.15 km^2. Hongqiao Economic and Technological Development Zone is its core area, featuring space for exhibitions, offices, dining and shopping. Tertiary industry accounts for more than 97% of the total GDP of the district. Changning District has a public buildings stock of three million square meters and residential building stock of 3.8 million square meters.

Effectiveness and Efficiency
On March 21, 2013, the World Bank and Global Environment Facility (GEF) provided a loan and grant for green low carbon development in Changning Hongqiao Business District. This project aimed to facilitate energy-saving retrofitting of existing public buildings (hotels, shopping malls and commercial buildings, through the comprehensive energy-saving renovation of building envelope structures, lighting and air-conditioning systems. Since

2013, Changning District has carried out energy-saving renovation in 38 existing public buildings, covering a building area of about 240,000 square meters with energy saving of 8404 tce and carbon dioxide reductions of over twenty thousand tons.

Sustainability
The low carbon building renovation in Changning District introduced GEF grants and World Bank loans through international cooperation, which made up for the shortage of local low carbon city funds and introduced a set of international advanced project management methods and mechanisms, including a contracted energy management financing model. The municipal and district governments provided strong leadership and supporting polices for the implementation of the project.

Transferability
The project yielded new tools that can be applied in other districts. These included the establishment of a transparent, real-time data monitoring platform for building energy consumption, providing publicly available data and information for determining energy saving potential and an abatement cost curve, as well as monitoring and verifying the effectiveness of energy saving efforts. The development of an abatement cost curve provided an analytical basis for setting and allocating targets for carbon reductions, heling to shape measures and investment decisions required to achieve reduction targets. With these features, Changning district provided a demonstration for other cities in China in the selection, supervision, and financing of innovative low carbon, energy-saving renovations of existing public buildings.

Turpan New Energy Demonstration Zone – Solar Energy Utilization Project

The city of Turpan is located in the central and eastern part of China's Xinjiang Autonomous Region, with a total population of 270,000 and a per capita GDP of 41,681 yuan ($637.84). Turpan has a typical continental warm temperate desert climate with abundant sunshine and extreme dryness, with 3200 hours of annual sunshine, 5300 °C of annual accumulated temperature, and abundant solar thermal resources. The annual average temperature is 14 °C, and high temperatures of up to 47.8 °C. The Turpan New Energy Demonstration Zone was approved by the Xinjiang Autonomous Region in 2004. It is located in the eastern part of Turpan, five kilometers from the historical center of the city. The total land area is 8.81 km^2 and the planned permanent population was 60,000 people at the creation of the demonstration zone.

The new energy demonstration zone aims to provide solar energy for the new district and to integrate climate, urban planning, green buildings, smart microgrid management and green transportation during this process. Solar thermal and ground source heat pumps are supplied to a whole building to meet heating and cooling needs; unified management is employed in the solar photovoltaic power generation, and household metering methods are used to meet resident electricity demand.

Table 9. Turpan new energy demonstration zone basic information

Location	Eastern part of Turpan, Xinjiang Autonomous Region	Population	60,000
Built-up Area （km^2）	8.81	Starting time	2008 (planning)
Area（km^2）	30		2010 (construction)
Funding sources	Government subsidies, corporate subsidies and self-financing, bank loans	Ending time	2020
Key Functions	International New Energy Technology Exchange and Exhibition Center, National New Energy Technology Research and Development Integration Demonstration Zone, Regional Public Management Service Center and Science and Technology Tourism Service Center, Sustainable Development Ecological Habitable New City.		

Effectiveness and Efficiency

By 2015, the first phase of the residential area in the demonstration area had been built, with 890,400 square meters of buildings, providing residents with comfortable indoor living conditions in Turpan's cold winters and hot summers. By 2015, the installed capacity of solar photovoltaics on the roof in the first phase of the demonstration area reached 8.7MW, with 293 residential buildings and a roof area of 61216.65m^2. The annual power generation in 2014 and 2015 was 7.298 million kWh and 10.1828 million kWh.

The annual average power generation of photovoltaics in the demonstration area was about 1.47 times of the annual electricity consumption in the first phase of the residential area, reducing carbon emissions by 16,197 tons. Five heat pump units were also put into operation, with a maximum application area of 900,000 m^2. At maximum effectiveness, the ground source heat pump system in the demonstration area can replace 28,000 tons of standard coal per year, which is equivalent to reducing carbon emissions by 69,997 tons.

Sustainability

The construction of the Demonstration Zone started in 2010, positioning itself as a model of harmonious ecological urban-rural integration, with a core mission of providing solutions to micro power grid key technology challenges. The Demonstration Zone is currently the largest and most comprehensive application of solar energy utilization in China. In 2014, it was included as one of the first batch of China's national new energy demonstration cities.

Transferability

The lessons-learned in the Demonstration Zone can be applied in urban multi-story residential districts and small- or medium-sized cities. Turpan offers an example of how to achieve the maximization of the use of solar energy resources using a smart micro-grid system. This project integrates meteorological observation technology into the smart dispatch of micro-grid to predict the power supply capacity of solar energy resources and ensure the safety of residential electricity and large power grids. It also uses green bus charging and energy storage systems to reduce the impact of photovoltaic power generation systems on large power grids, and a system of landscape pools to create a green and livable living environment for residents.

Guangzhou Bus Rapid Transit

Located in southern China, Guangzhou is the capital city of Guangdong Province. Guangzhou is China's third largest city after Beijing and Shanghai, with a population of over 14 million and an urbanization rate over 86%. With high population density and limited road space resources, Guangzhou is prioritizing the development of urban rail systems with low energy consumption and pollution emissions, and optimal space resources per capita**.** Bus rapid transit (BRT) is a new public transportation solution that has been successfully adopted in other countries. It features low development cost, large traffic volume and low pollution.

Guangzhou's BRT was officially put into operation in February 2010. The total length is 22.5 km, along the east-west layout of Zhongshan Road, from Guangzhou Avenue in Tianhe District to Xiayuan in Huangpu District. Its 26 central side platforms are one of the main east-west passenger flow corridors in Tianhe District.

Figure 26. Guangzhou BRT

Source: http://www.itdp-china.org/brt/city/?city_id=15&city_name=%E5%B9%BF%E5%B7%9E&lang=0

Effectiveness and Efficiency
Guangzhou BRT has shown innovation in its use of "special corridor + flexible line" operation mode, which effectively integrates the BRT trunk line with more than 80 bus lines. It can increase the average speed of the bus from 15 km to 18 km per hour. Because of the separation of bus lanes and regular vehicle lane on Zhongshan Avenue, the traffic congestion has been largely reduced.

The Guangzhou BRT system links with subway, bicycle and walking systems to maximize connectivity. It is the first BRT system in China to be assessed as a "gold standard" by ITDP (Institute for Transportation & Development Policy), and won the 2011 World Sustainable Transportation Award and the 2012 United Nations Climate Change "Beacon" award (ITDP, 2014).

The Guangzhou BRT has played an important role in mitigating traffic congestion. As the largest express bus transportation system in Asia, Guangzhou BRT has an average operating speed of 23 km/h, which is 84% faster than conventional bus lines, with an average daily capacity of 850,000 passengers.

In addition, Guangzhou BRT has become the city's public exchange hub, integrating existing resources and technology, improving the operational services and operational efficiency of public transportation, and changing the travel mode of BRT passengers, such as travel intensity and total volume, non-commuting travel. It has made public mobility travel mainstream. The BRT system is reducing carbon emissions in Guangzhou by at least 86,000 tons each year.

Sustainability
Guangzhou BRT is the first system in China that belongs to multiple bus carriers. All BRT lines are operated by three carrier groups consisting of seven bus operating companies. This mode allows the government to guarantee a high standard of service quality. The public transportation information system in Guangzhou has integrated into and accessed to the intelligent public transportation system of all bus companies in the city.

Transferability
Guangzhou BRT's success can be contributed to several key components, including successful planning and design all key stages, political supports from the Guangzhou municipal government and related departments, and the adoption of advanced technical standards. Similar systems can be adopted in large and medium-sized cities with large population density, small urban space and traffic congestion. Guangzhou BRT has become the most successful BRT project in China. It's China's first closed corridor + flexible line" in China, and even the first system in Asia to achieve the passenger transport capacity of the subway.

Market-based Mechanisms: Shenzhen ETS Pilot Program

As one of China's first seven carbon trading pilots selected by the National Development and Reform Commission, Shenzhen took the lead in launching an ETS on June 18, 2013. The Shenzhen pilot ETS now covers 636 key industrial enterprises and 197 large public buildings.

Its trading volume is currently at the top of the seven pilot exchanges. Compared with other pilot cities in China, the proportion of heavy industry in Shenzhen's industrial structure is small. But while Shenzhen's ETS-covered carbon emission is small, it has the highest turnover rate due to its mature carbon market mechanism (Yang, 2017).

Effectiveness and Efficiency
Although the total carbon emissions in Shenzhen only account for a very small proportion of the total carbon emissions in the country, Shenzhen ETS Pilot Program is demonstrating the role of market mechanisms in reducing greenhouse gas emissions. Absolute carbon emissions under the ETS in 2015 decreased by 5.31 million tons compared with 2010, far exceeding the 21% reduction target set by the central government for Shenzhen during the "Twelfth Five-Year Plan" period. At the same time, the industrial added value of the ETS covered industries in 2015 increased by 148.4 billion yuan compared with 2010.

Sustainability
Shenzhen's has built sound fundamentals for ETS operation, such as legislation and an measurement, reporting, and verification (MRV) system, with legislative principles and institutional design based on local conditions. Shenzhen has successively promulgated the "Provisional Regulations on Carbon Emission Management", "Interim Measures for the Trading of Carbon Emission Rights" and other regulations. It has also implemented precise monitoring and strict verification for the ETS covered industries and helped them actively carry out energy conservation and emission reduction. In addition, Shenzhen actively explores carbon finance innovations, such as carbon bonds, carbon funds, and cross-border repurchase financing of carbon assets to introduce more social capital into the green finance sector.

Transferability
Shenzhen's ETS Pilot Program is providing useful lessons-learned for other cities as well as China's national carbon emission trading system. In contrast to other pilots, the Shenzhen ETS not only includes direct sources of CO_2 emissions, but also incorporates a large number of relatively small indirect sources. It has accumulated a large amount of practical experience on how to define organizational boundaries, identify emission sources, and guarantee the reliability of data acquisition in enterprise carbon emission verification. With the launch of China's national carbon market in 2017, Shenzhen ETS managers are now serving a leading role in improving the national carbon market policy system, infrastructure construction and stakeholder capacity building.

Japan
Partnerships between local governments, businesses and residents are fundamental to the development of low carbon cities in Japan. To formulate effective approaches while maintaining partnerships, it is important to clarify and share with stakeholders information that can contribute to the low carbon development of cities as a result of linking the co-benefits obtained by creating low carbon cities and those earned through the implementation of other measures with GHG emissions (Figure 23).

This section focuses on five cities (Tokyo, Yokohama, Toyama, Kitakyushu and Miyama) that are developing specific initiatives that will result in the low carbon development of the city

(Figure 24). Low carbon cities can be created not only in mega-cities, but even by cities with only a few thousand residents by leveraging the enthusiasm and ingenuity of people taking charge, together with the use of national support systems.

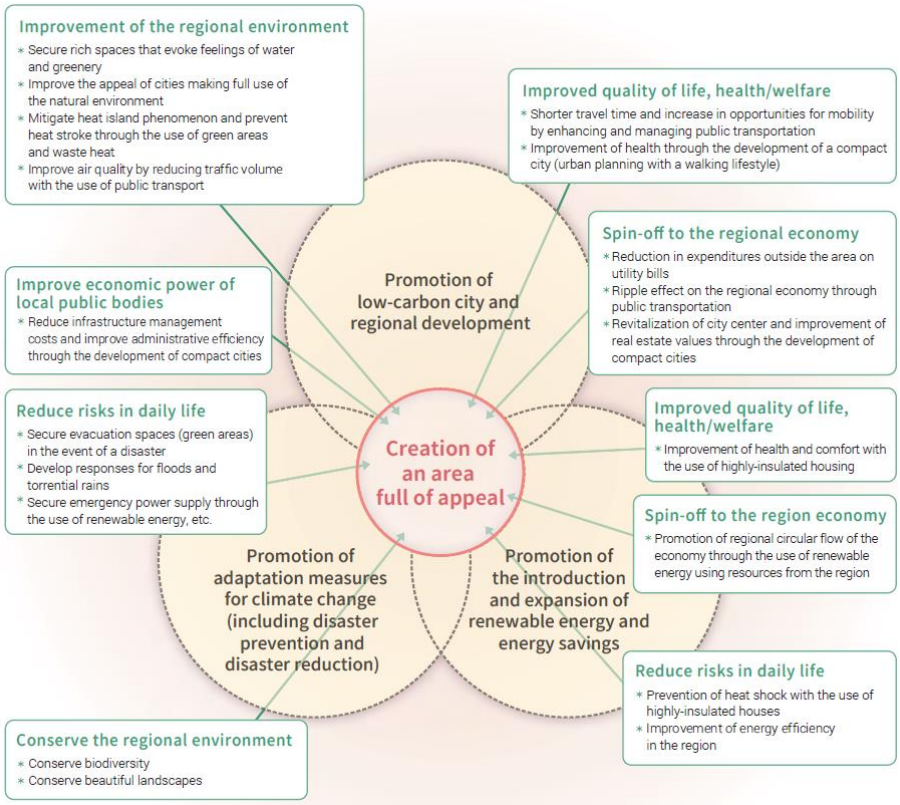


Figure 27. Examples of co-benefits from global warming countermeasures

Source: Ministry of the Environment, Japan "Low-carbon City Profile – Climate Change Actions by Asian Cities in the City-to-City Collaboration Programme" March 2018. (https://pub.iges.or.jp/pub/low-carbon-city-profile-climate-change-actions)

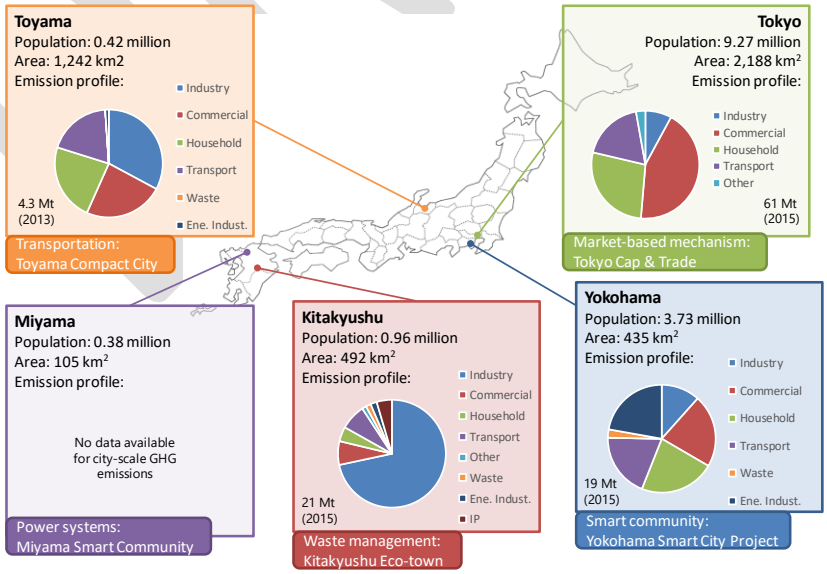


Figure 28. Basic information on the five cities introduced in this section

Source: Created by authors

Smart Community: Yokohama Smart City Project

The new growth strategy formulated by the Japanese government in June 2010 includes a policy to promote action to achieve the development and overseas expansion of a Japanese-style smart grid. Yokohama City implemented the "Yokohama Smart City Project (YSCP)" at the demonstration stage as one of a number of "Next-Generation Energy and Social System Demonstration Projects" developed by the Ministry of Economy, Trade and Industry between fiscal 2010 and 2014. With a mission to take the lead in establishing the world's best smart city model in the state-of-the-art city of Yokohama with a population of 3.7 million and export Yokohama's solutions to cities overseas, Yokohama City has collaborated with 34 companies to implement 15 projects and verified the use of advanced technologies that have come close to the next step of being put to practical use in the real world. With the Great East Japan Earthquake that hit Japan in March 2011, peak shifts and peak cuts in electric power demand were also positioned as targets in the development and expansion of this demonstration project. Specifically, demonstrations were carried out on technologies and applications to encourage distributed electric power peaks, demand responses, and reductions in the total amount of electricity consumed by utilising local energy management systems centred on Community Energy Management System (CEMS) and visualising the situation of electric power use by customers. This provided feedback to various points, including policy planning by the national and municipal government, improvement of business technologies and systems, and energy-saving behaviour by residents. Since 2015, Yokohama City has moved from the demonstration stage to expansion taking full advantage of the technologies and knowledge developed through the YSCP. To accomplish this, the Yokohama Smart Business Association (YSBA), a new public-private collaborative council, was established and is taking steps with the aim of creating an energy-circulating city with superior disaster prevention capabilities, environmental performance and economic efficiency (City of Yokohama, 2017).

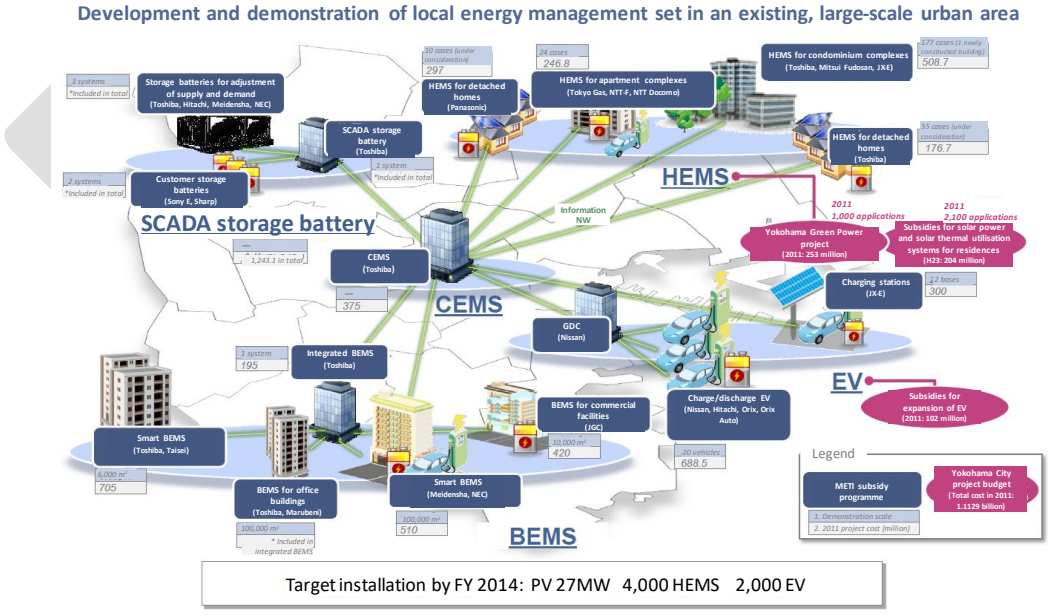


Figure 29. Overview of Yokohama Smart City Project (YSCP) (excerpt)

Note: HEMS – Home Energy Management Systems; BEMS – Building Energy Management Systems; CEMS – Community Energy Management Systems; FEMS – Factory Energy Management Systems; EV – Electric Vehicles, SCADA – Supervisory Control and Data Acquisition.

Source: Yokohama City, Yokohama Smart City Project （YSCP） General Meeting, March 24, 2015. (Partial modification) (https://www.city.yokohama.lg.jp/kurashi/machizukuri-kankyo/ondanka/etc/yscp/yscp02.files/0003_20190312.pdf)

Effectiveness and efficiency

Effects of reducing greenhouse gas emissions

Under the YSCP, 4,200 HEMS (4,000 projects), 37 MW of PV (27 MW), and 2,300 EV (2,000 vehicles) were introduced, which reduced 39,000 tonnes (30,000 tonnes) of CO_2 emissions, which exceeded the original targets shown in the parenthesis.

Activities and promotional system for the YSCP demonstration project

Although the demonstrations carried out under the YSCP are diverse, major projects include the following: large-scale demonstration on energy-saving behaviour with the participation of about 3,500 households that introduced Home Energy Management System (HEMS), demonstration on the optimal use of energy at the local level with the management of business and commercial buildings, and demonstration of charging/discharging EV systems using EV as a form of social infrastructure capable of storing electric power, among others. These demonstrations clarified pricing and incentives for electric power that would be effective in encouraging peak cuts and peak shifts in electric power use in the city area and led to the design of a system for a power consumption trade market in Japan.

YSCP is a project carried out between the government and companies that are interested in developing a Japanese-style smart grid. The national government provided 60% of the total investment (about JPY 13 billion), with the private sector responsible for the remaining 40%. The local government did not make a direct investment but instead opted to provide support from the side lines by playing the role of liaison and connecting stakeholders in the project. The Climate Change Policy Headquarters in Yokohama City exists as an organisation that manages actions related to climate change across departments. The project promotion section within this headquarters, which has a number of opportunities to consult with the private sector, is in charge of the YSCP and is characterised by the diverse number of personnel who work there that have a wide base of knowledge in various areas, including civil engineering, electric power, and machinery.

Development from YSCP demonstration stage

Yokohama City, which experienced a paralysis in its administrative functions as a result of power outages from the impacts of the Great East Japan Earthquake, has applied the knowledge gained through the YSCP in the reconstruction of the city's Minami Ward Office. Specifically, Yokohama City has introduced the latest co-generation systems, secured an energy cooperation network at the municipal centre hospital and Minami Civil Engineering Office, which are located adjacent to the city office, and strengthened energy security in the city office by creating a system to collectively manage energy in both facilities using BEMS. In addition to this, a project aiming to improve disaster prevention capabilities in the area and set up a virtual power plant (VPP)[25] in local elementary and junior high schools is also being developed through public-private cooperation.

[25] This is a mechanism for the remote and integrated control of EVs, storage batteries and power generation equipment in buildings and households and is used to adjust electric power supply and demand by functioning as a single power station. Yokohama City's VPP project involves the installation of storage battery facilities by electric power providers in elementary and junior high schools in the city that have been designated as local disaster preparation bases. The city aims to develop actions to use the VPP to adjust supply and demand for electric power during normal times and as a source of power for disaster prevention during emergencies that may arise during a power outage.

Sustainability

Yokohama City's policies, which aim at a "Zero Carbon Yokohama", are included in the city's four-year interim plan (2018-2021), which was announced in October 2018, and the Yokohama City Action Plan for Global Warming Countermeasures. The low carbon development of cities is also an important part of city planning. YSCP has been positioned as a key measure to achieve low carbon development and is supported by policy. Yokohama Smart Business Association (YSBA) was launched in 2015 as an organisation promoting initiatives to implement the YSCP. As of April 2018, YSBA includes the participation of 17 private companies and Yokohama City.

Transferability

In order to ensure that a project is feasible, it is necessary to consider who and how it will be organised at the planning stage. Even before the start of the national government's project, the YSCP was already an idea that had been exchanged in both the public and private sectors. In addition to device and system companies, electric power and gas supply companies were also included as energy supply companies to implement the project, which can be said to have made it possible for the project to develop further after implementation. The VPP developed by Yokohama City has been the focus of intense interest by other municipalities and the provision of information on appropriate know-how and acting as an intermediary for YSBA companies has resulted in the creation of business opportunities for local companies. Yokohama City, which is actively engaged in the development of international environmental cooperation, is also promoting activities to disseminate information through the organisation of the Asia Smart City Conference and transfer the technologies and environmental management know-how developed in the city as a package in cooperation with cities, such as Bangkok and Batam.

Conclusion

Clearly, as Yokohama City is working on achieving its "Zero Carbon Yokohama" plan as the direction it is taking in city development and has established the Climate Change Policy Headquarters, the city is taking positive steps to promote actions to decarbonise. Public-private cooperation is essential as an approach to achieve decarbonisation. To achieve this, Yokohama City is ensuring the cooperation of companies that will work together by displaying a proactive attitude to developing cutting-edge initiatives and demonstrating to the private sector that taking local action will lead to business opportunities both in Japan and overseas. An organisation within the city government has been established as an administrative body to put out feelers for trends in both Japan and overseas for this purpose. With a positive attitude, Yokohama will be able to develop initiatives that can both simultaneously achieve the creation of a city that is both liveable and decarbonised.

Power systems: Miyama Smart Community

As the amount of renewable energy originating in municipalities increases, the concept of distributed energy becomes more common, and the market for retail electricity sales opens up, municipalities in Japan are investing in electric power companies and rapidly expanding movements to promote the local production and local consumption of renewable energy (Tominaga & Hayashi, 2018). One such company, Miyama Smart Energy (Miyama SE),

founded in March 2015 with investment from Miyama City[26], has become known as the first company to offer low-voltage electricity for sale and purchase to households (electric power retail, purchase of excess solar power). Miyama City, through Miyama SE, has developed a business model of economic cycle which realizes a smart community, by promoting the local production and consumption of energy and thus retaining the cash flow from electricity consumption within the city, as well as providing comprehensive support services using IT. As a result, the city is developing services aimed to respond to local issues caused by population decline, relocation of younger generations to other areas, and the shrinking of the local economy, as well as the revitalisation of the local economy and creation of regional employment. Miyama's efforts have been widely recognised in Japan, including the city's distinction of being selected for the Good Design Gold Award in 2015. There are a number of local governments that have a strong interest in investing in new forms of electric power from the perspective of securing financial resources for resident services, and the knowledge and systems in Miyama are being spread through collaboration between municipalities.

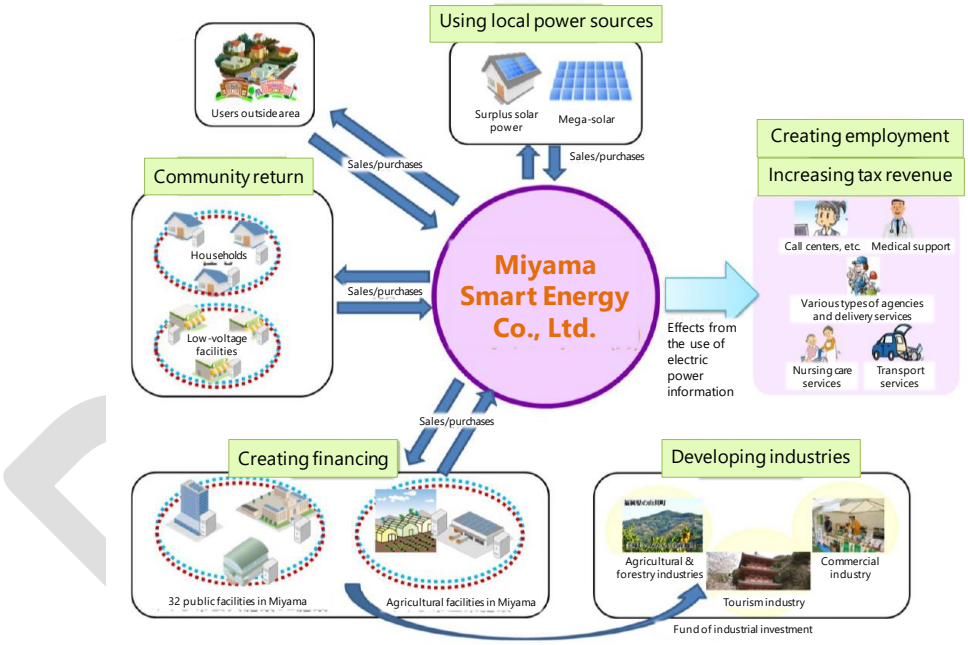


Figure 30. Business model for the circular flow of the economic system in Miyama City

Source: Miayam Smart Energy Co., Ltd. https://www.ider-project.jp/stage2/feature/00000178/file03.pdf

Effectiveness and efficiency

Effects of reducing greenhouse gas emissions

The measures by Miyama City are implemented as policies aiming to achieve economic independence, boost local employment and offer stability for people settling in the area. Low carbon development of the region is not positioned as a primary objective. However, since activities are being carried out using renewable energy as the community's power

[26] Total investment was JPY 20 mill. The Miyama city government covered 55% (11 mill.), 40% from local businesses (8 mill.) and 5% was from a local bank (1 mill.).

source, they have, as a result, led to the low carbon development of the area. In fact, according to the state of CO_2 emissions from city-affiliated facilities in Miyama City, emissions of about 11,000 tonnes of CO_2 in 2005 were already suppressed to 9,264 tonnes by 2015 as a result of promoting energy-saving activities (Miyama City, 2009). In 2016, the year after Miyama SE was established, emissions were estimated to have reduced further to 7,826 tonnes, which is about a 30% reduction from 2005 levels (Miyama City, 2017).[27][28]

Local production and local consumption of energy

Looking at the composition of the city's power supply from Miyama SE as a microcosm of the state of energy produced in the area, renewable energy makes up 20% of the total, with the remainder procured from a major power company. Miyama City demonstrates a diffusion rate of 10.8% for solar power generation, which exceeds the nationwide average of 6.6% because of the city's abundance of sunshine due to its location. Renewable energy is derived from mega-solar projects in which the city has invested and surplus solar power from households.

The total amount of power contracted from Miyama SE (as of the end of April 2018) in terms of the state of energy consumption (power consumption) in the city it is 54,000 kW. With the success of the project relying on the strategic prioritisation of securing large-scale customers to stabilise business activities, contracts were signed with about 400 high-voltage customers (36 city-related facilities, public facilities in neighbouring municipalities, private facilities). Although Miyama SE supplies power to approximately 4,000 low-voltage customers (households), due to discrepancies in the total number of households in Miyama City (about 14,000 households), it is also necessary to develop a new small retail customer base in the future in order to achieve the local production and local consumption of energy in the true sense of the word.

Response to local challenges

The launch of Miyama SE to promote the local production and local consumption of energy and develop resident services using IT has created about 50 new jobs (NHK Television, 2018) and is leading to the development of new industries. Miyama City has also developed resident services through Miyama SE, including online shopping and miscellaneous services, elderly monitoring services using HEMS, dissemination of governmental information, and the management of Sakura Terrace, which is a community space used in combination with restaurants that source local ingredients. All of these services is a return of the profits obtained through electricity sales back to the residents, which can be regarded as a unique service available only from local government investment in new power. In addition, an inbound effect can be achieved with a number of visitors coming from all over the country, which leads to revitalising the local economy (Miyama City, 2016).

[27] Miyama City "Efforts of Miyama City for local energy production and consumption and smart community" Dec. 22, 2017.

[28] In "Methods of handing FIT electricity in calculating actual emission factors" (June 27, 2016) from the secretariat of the study group on calculation methods for emission factors by business based on the Global Warming Act, the characteristics and advantages of not discharging CO_2 from electricity (FIT electricity) are said to be thinly and widely attributable to all customers who bear costs with the receipt of subsidies from the Feed-in Tariff (FIT) system. According to this policy, Miyama City cannot appeal the CO_2 emission reduction effects shown here. However, in this report, it should be noted that this is indicated as a reference value, taking into consideration that Miyama City has its own subsidy menu for spreading renewable energy power sources and is committed to achieving this project, including securing connection access points.

Sustainability

In order to ensure sustainability, it is essential to stabilise business activities and foster understanding of the stakeholders in the city. In order for business activities to be stable, power sources and suppliers must be secured but it is also necessary to embody or personify the idea of the local production and local consumption of energy. Although it is difficult to create new renewable energy power sources in the area due to decreasing subsidies for solar power generation and system constraints [29], Miyama City intends to strengthen the wide-area purchase of photovoltaic power generated in households, including those in neighbouring municipalities to secure power sources for Miyama SE, in addition to those renewable energy power sources that have already been secured.

Suppliers of electric power may lose out on contracts to less expensive electric power suppliers, especially with companies. Continuous contracts are fixed by getting approval on the philosophy of regional creation and regional circulation. Although nearly 70% of residents are aware of the smart community activities with regard to power supply to homes, this knowledge is not sufficiently linked to changeovers in electric power supply contracts and new methods must be developed for this demographic.

As part of efforts to promote understanding by stakeholders, Miyama City encourages younger people to learn about sustainable, bottom-up community development activities and is developing classes for elementary and junior high school students in the city with the purpose of deepening their attachment to their hometown.

Transferability

Miyama City's activities made significant progress because there were human resources who foresaw that the municipality could sell electric power at retail prices as Feed-in-tariff (FIT) was introduced, there was leadership by the mayor who had a significant interest in regional circular economy, and activities could be promoted making use of a menu of support from the national government. In the electric power retail industry where it is difficult to gain an edge in terms of price and quality, in particular, the "early bird catches the worm" mentality is strong in terms of the development of power supply and a customer base. The fact that Miyama City was able to work quickly on a timely basis to successfully develop this project is a major factor in its success.

In Japan, there are about 100 municipality that have a strong interest in investing in new forms of electric power from the perspective of securing financial resources for resident services. For these municipalities, consulting services may be available through Miyama Power HD Co., Ltd., one of Miyama SE's investors. Since the start of cooperation with Ichikikushikino City and Kimotsuki Town in Kagoshima Prefecture in March 2016, Miyama City has also established new agreements with several municipalities in the Kyushu, Kanto and Tohoku regions to provide know-how on the electric power business and transfer the

[29] There are power system constraints in terms of capacity and fluctuation. For example, where there is rich with photovoltaic power like Kyushu island, renewable energy output may be limited on a warm sunny day with low energy consumption in order to avoid imbalance of electricity demand and supply, which may cause blackout whole island at a worst case. This is regarded as business risk.

experience of the development of new electric power with investment from local governments.

A prerequisite to transferring the experience in developing new electric power sources with investment from local governments is ensuring a sense of scale to secure business profitability of the power business and to also secure connection access, in addition to power supply, to secure connection to grid power in Japan, where power system constraints are apprarent.

Conclusion
Miyama City has achieved the circulation of energy and biomass in the area by connecting existing resources as points centred in the city by lines with electric power and IT. The city is working to improve services to its residents by improving tenacity with secure renewable energy sources in the city and controlling the flow of financial resources out of the area. Even in regional cities with populations of 30,000, this is a good example of being able to create a low carbon, sustainable and liveable smart community using bold ideas and ingenuity. These activities have now moved past the early days and entered a period of growth with further developments expected in the future.

Transportation: Toyama Compact City

Overview
Toyama City's Compact City policy has been advocated by the mayor of the city as a solution to various urban challenges, including concerns over the anticipated increase in administrative costs due to falling birth rates and aging demographics, population decline, and the low density of the urban area, the fact that the city has become a difficult place for people to live without a car due to the deterioration of public transportation because of the excessive dependence on private vehicles, and rising CO_2 emissions due to the city's sprawling urban structure (Toyama City, 2018)**.** Toyama City is aiming to achieve an urban structure (multipolar compact city) of "dumplings and skewers" that not only connects the city centre using public transportation, but also focuses on local and citywide compact urban development. With permission granted to the Hokuriku shinkansen line project in 2001, Toyama introduced Japan's first full-scale LRT built by the public sector and operated by the private sector and developed the Portram, which runs northward from Toyama Station, and the Centram, which loops around the city centre on the southside of the station. The city improved mobility by linking these two lines and connecting urban and suburban trains. Together with improvements to the public transportation network, the city also integrated measures to revitalise regional bases along the railroad tracks to encourage people to move to those areas.[30] By implementing measures to enhance infrastructure and facilitate methods to encourage changes in public awareness and lifestyles, Toyama City is

[30] Assistance for business operators constructing apartment buildings in a common residential area along a public transportation line (subsidies for construction costs of apartment building (JPY 1 million/unit), assistance for construction costs for high-quality rental homes (JPY 1.2 million/unit), assistance for residents purchasing detached homes or apartments (subsidy for loans for the purchase of detached homes or apartments (JPY 500,000/unit), subsidies for rent with relocation to city centres (JPY 10,000/month, 3 years), subsidies for renovations (JPY 300,000/unit)) (Yoneyama, 2017).

moving closer to the type of town development where people can live slow, steady lives on foot.

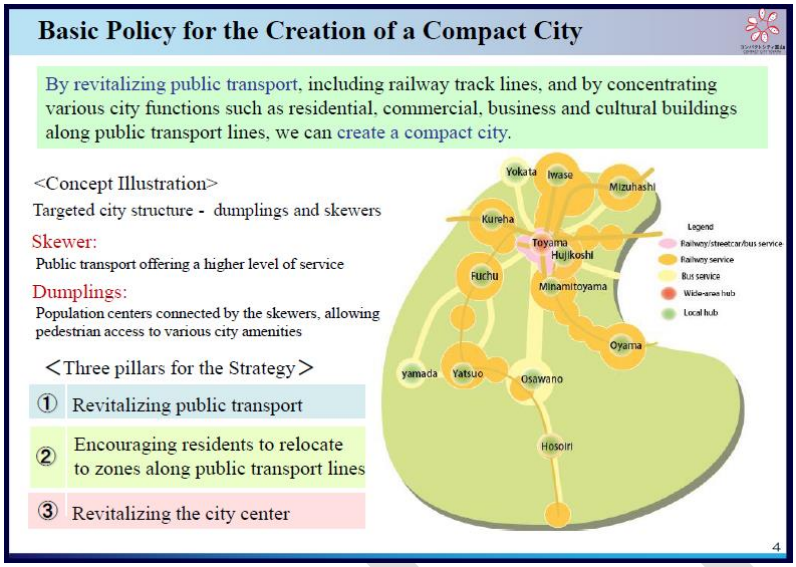


Figure 31. Toyama's basic policy for the creation of a compact city
Source: Toyama City

Effectiveness and efficiency

Effects of reducing greenhouse gas emissions
Toyama City has promoted low carbon city development under two of the Cabinet Office's programmes, the Eco-Model City programme (selected in 2008) and the Future City programme (selected in 2011). The basic policies stated as part of this initiative include promoting the revitalisation of public transportation, promoting the concentration of urban functions in the city centre and along public transportation lines, and promoting eco-lifestyles combined with compact urban development and eco-activities by companies. Included in these policies are the development of an LRT network, shift from the use of automobiles to public transport, expanded use of small-scale hydroelectric power, and the promotion of activities with residents, companies, and the government working together as "Team Toyama". Although the volume of CO_2 emissions in Toyama City rose by about 16% between 1990 and 2005 (Toyama City, 2012), as a result of the promotion of these activities, the city was able to steadily promote low carbon development in the city with the achievement of an 8.9% decrease in emissions in 2014 (3.9 million tonnes) from 2005 levels (4.2 million tonnes) (Mori, 2018).

Effects of compact city policies
The Compact City policy aims to create a positive cycle that will lead to the revitalisation of the city, increase tax revenue, and improve the name recognition of Toyama, while also advancing low carbon development by promoting the development of a walkable, liveable city. For this reason, Toyama is engaged in improving public transport, such as the LRT, promoting the construction of housing along public transportation lines, and revitalising the city centre, which offers certain positive effects. For example, the number of riders on public transportation has risen through the development of the LRT and the mobility of the elderly during the daytime, in particular, is improving (Morotomi, 2018). The proportion of

residents living in areas with convenient public transportation has increased from 28% (2005) to 37% (2017). Looking at economic effects, land prices around Toyama Station and the loop line have risen 3-5% (compared to the average increase in land prices throughout the city is 0.2%). In addition to this, property taxes for the FY 2018 budget and tax revenue for city planning taxes have increased by about 8% since fiscal 2014 (Morotomi, 2018). Property taxes and city planning taxes are core taxes that account for 47% of city tax revenue, so concentrated investment in central urban areas is rational and effective from the perspective of a return on taxes. In addition, the total value of urban redevelopment projects is JPY 81.88 billion, of which tax income is JPY 41.75 billion, which illustrates that public investment can succeed in triggering private investment (Toyama City, 2016). The population of Toyama is on a downward trend, just as is seen in Japan and Toyama Prefecture. However, a turning point occurred in 2010, when the number of people moving to Toyama City from outside the prefecture rose more than the number of people moving from Toyama city to other prefectures and the population's rate of decline showed a tendency to slow down compared with the rest of Toyama Prefecture. In this way, the anticipated effects are emerging with the simultaneous promotion of policies to develop infrastructure and revitalise the city.

Sustainability

The Compact City policy is being advocated under the strong leadership of the Mayor and is being promoted together with the Toyama City Master Plan and various other administrative plans. Toyama City is a model city that was selected under the national government's Future Cities Initiative and Local Government SDGs programmes, which also highlights the compact city policy as an essential point. In order to continue to promote policies such as these, it is important to build up achievements by deploying various initiatives in collaboration with stakeholders both inside and outside of Toyama under an unshakeable concept. Helping residents understand that improving the name recognition of the city by disseminating the outcomes of these initiatives to the outside world will lead to an improvement in their quality of life is also important to receiving support for policies.

It is also essential to improve governance. For example, in city hall, the Environmental Policy Division, which is responsible for the Eco-Model city programme and others, is building a collaborative framework that goes beyond barriers between departments, devising measures for low carbon development and creating indicator reports to raise the awareness of staff. On the private sector side, "Team Toyama", which was established by companies and organisations to promote global warming countermeasures in 2008, and the Platform of Environmental Citizenship Toyama, which was launched in 2018 to promote the SDGs, are carrying out educational activities in collaboration with the local government. In addition to this, Toyama is also developing a system to promote urban development in collaboration with academic institutions, such as Toyama University.

Transferability

International recognition of Toyama City's compact city planning and environmental measures has been significant. In addition to being selected as a city with advanced compact city policies by OECD, for the Sustainable Energy for All (SE4ALL) global initiative, and as one of the 100 Resilient Cities (100RC), Toyama City has also taken part in the World Bank's "City Partnership Program" and has disseminated information all around the world.

Toyama City is also making an effort to formulate intercity cooperation activities mainly with Southeast Asia to disseminate the strengths of local businesses in the city in an easy-to-understand way not only to the city's environmental administration, but to a wider audience as well. The local government and companies have teamed up together and are striving to gain local confidence by traveling directly to sites in an effort to expand overseas, which poses a high hurdle when it involves only the companies themselves. With city-to-city cooperation, these activities can also lead to the formation of concrete projects while also taking advantage of support from the national government.

Conclusion

Toyama City has promoted its Compact City policy to build up the creation of a walkable and liveable city. This is a fundamental policy for sustainable city planning, and by promoting this policy, the advantageous effects can be seen in all aspects of the environment, economy and society. Budgetary, human resource, and institutional support are needed when implementing various projects, but there are limits to what governments can do themselves. One of Toyama City's strong points is that by promoting the Compact City policy for so many years, it can be said to have given rise to the development of a mechanism that can make the maximum use of resources through cooperation among industries, academia, the government, and civic society. Toyama City, which was selected as an SDGs Future City in June 2018, will be undertaking an SDGs model project on "Expanding the compact city through the integration of the LRT network and autonomous energy management",[31] which is expected to further promote low carbon development in the city.

Market-based mechanism: Tokyo Cap & Trade

Tokyo is a large metropolis with a population of about 14 million and a level of GHG emissions that is on par with that of Austria and Greece. In recognition of how vital it is to develop major cities into low carbon societies as a measure to counter climate change, Tokyo set a target to reduce its GHG emissions by 25% by 2020 from 2000 levels in its urban strategy, "Tokyo's Big Change - The 10-Year Plan" (2006). In 2007, the metropolitan government announced the "Tokyo Climate Change Strategy", which outlined the basic policies for all stakeholders that required specific measures in order to create a new urban model that could respond to the risks of climate change. One of the policies, "impose the obligation to reduce total emissions on large CO_2-emitting business establishments and institute an emissions trading system", has been shaped into the Tokyo Cap & Trade (Tokyo C&T). This became the world's first urban cap and trade system for the industrial and business sectors based on the features of Tokyo, in that CO_2 emissions from these sectors account for about half of the metropolitan area's emissions (Tokyo Metropolitan Government, 2018). Prior to that, Tokyo introduced the "Global Warming Countermeasures Planning System" based on the Ordinance to Improve the Urban Environment and Protect the Health of Citizens (Environment and Health Ordinance) and had promoted voluntary initiatives by business operators since 2002. However, the Environment and Health Ordinance was revised in 2008 because significant effects were not seen, and an obligatory system was introduced. As a result, owners of target business establishments are required

[31] Local Government SDGs website

to reduce CO_2 emissions as prescribed during the reduction plan period and improve implementation systems within the company. By purchasing credits[32] created through voluntary initiatives or by others, business owners needed to fulfil their reduction obligation.[33] Since this system started, large-scale business establishments have achieved significant emission reductions of 26% by 2016 compared to the base year. This has also simultaneously resulted in the desired effect of achieving the creation of a low carbon society, such as raising awareness in businesses about energy conservation and improving energy management capacity. Tokyo has already started to consider systems for the third planning period (2020 to 2024) as a new stage to promote initiatives with the aim of achieving the 2030 target and focusing on the creation of a decarbonised society post-2030 and is moving forward in promoting low carbon development through intensive energy savings.

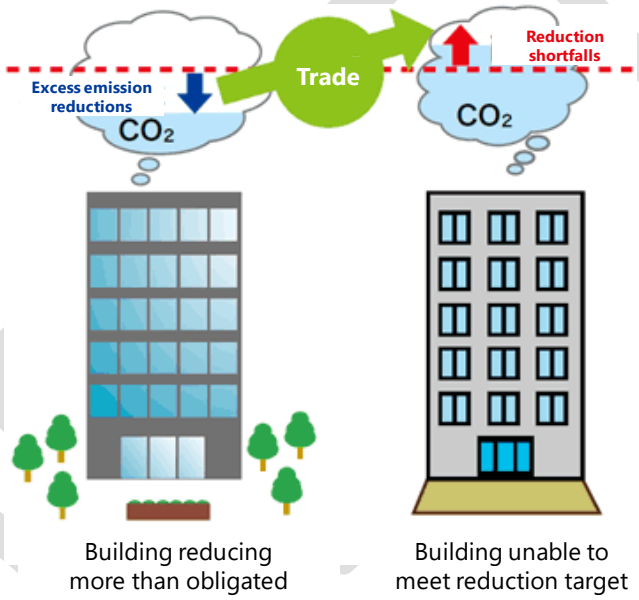


Figure 32. Illustration of emissions trading in Tokyo
Source: Tokyo Metropolitan Government

Effectiveness and efficiency

Effects of reducing greenhouse gas emissions

Caps under the Tokyo C&T are set by back-casting from the 2020 target. Caps are set at 8% or 6% in the first commitment period and 17% or 15% in the second commitment period. As a result of a sincere effort to conserve energy in the workplace, Tokyo achieved a 25% reduction in base year emissions (1,650 tonnes) in 2014, the final year of the first planning period. Ninety-one percent of business establishments (1,262 businesses) implement their own energy conservation measures, with the remaining 9% (124 businesses) fulfilling their obligation through emissions trading.

[32] There are five different types of credits permitted by the Tokyo Metropolitan Government: excess emission credits, small and mid-sized facility credits in Tokyo, renewable energy credits, outside Tokyo credits, and Saitama credits.

[33] If reduction targets cannot be achieved, a reduction of 1.3 times the shortage will be added to the next reduction target. In the event that there is a violation of these orders, the business operator shall pay a fine (up to JPY 500,000) and the details of the violation shall be made public.

Under this system, results have been achieved by promoting energy conservation activities by business operators and updating facility and equipment to be more energy efficient coupled with an even more ingrained awareness about energy efficiency as a result of the 2011 Great East Japan Earthquake. Results continued to be steadily stockpiled and in 2016, the second year of the second commitment period, Tokyo achieved a 26% reduction compared to the base year. It is expected that nearly 80% of businesses will be able to achieve their obligations through their own energy conservation measures.

Both the total amount of emissions reduced and the CO_2 emission intensity per total area of the business establishment are falling. The standard unit for office use in 2014 has decreased by 30% from the base year. In a comparison of the final amount of energy that depicts the same trends as CO_2 emissions between the national and metropolitan industrial and commercial sectors, although both are on a continuous downward trend, the effectiveness of the system can be seen with confirmation that the level of reduction at the Tokyo metropolitan level is equivalent to twice that of the nationwide level when viewed from the time that the Tokyo C&T has been implemented (Tokyo Metropolitan Government, 2018). Although there are concerns about the possibility that Tokyo's economic vitality could be undermined by putting a cap on the CO_2 emissions of companies issued before the system was implemented, decoupling is moving forward in which final energy consumption in Tokyo is decreasing while gross production in the metropolitan area continues on an upward trend, demonstrating that this fear is proving unfounded.

Secondary effects from Cap & Trade

There has been a change in the perception that the design and implementation of the Tokyo C&T system has been guided not only by regulations, but also by the public and private sectors working together, rather than the traditional way of the government leading and the private sector following. For example, the system has been revised to be more effective based on feedback from business operators, including improvements from a mechanism in which only the owner of the tenant building takes responsibility to one in which the cooperation of tenant business operators is obtained, as well as the provision of incentives to reduce the reduction obligation by certifying businesses with particularly successful systems, facilities and operations as top-level companies**.** The "Tokyo★Energy-Saving Chart" has also been created based on the Global Warming Countermeasures Implementation Plan submitted by large-scale businesses. This chart contains information, such as CO_2 and energy emission sources of certain businesses and workplaces with similar applications located in Tokyo, as well as the status of the introduction of energy-efficient equipment. It is intended to allow for an understanding of where the company is positioned to be used to further promote energy conservation activities based on the state of the initiatives of other companies. The use of such detailed data makes it possible to carry out consultations with companies. With increasing opportunities to communicate with businesses, there were movements seen in the metropolitan government to strengthen the system, such as by gathering together engineering professional staff with specialised knowledge on electric power and machinery from other departments in the Global Environment and Energy Department in Tokyo Metropolitan Government's Bureau of the Environment, under which jurisdiction the Tokyo C&T falls.

This system is leading to increased awareness of employees on energy conservation, including top management in companies, as well as improved capacity to manage both the

environment and energy. In the developer industry, movements are being seen to recognise business operators with higher skills in energy management. In response to growing demand for energy-efficient equipment, the perspective of energy conservation has been actively incorporated into product development. The experience of addressing energy conservation, which leads to power savings and also offers economic benefits is designed to create a positive cycle in which global warming countermeasures can be promoted from a management perspective.

Sustainability
This system is implemented under the Environment and Health Ordinance. Reduction targets are periodically raised and measures to achieve obligations are reviewed based on international trends to develop business activities. In order to continue with these efforts, the operation must be managed in a stable and steady manner. With the operation of the system to date, the organisation within the metropolitan government has been improved, including the assignment of necessary personnel in responsible sections and increasing the number of staff. Since there are also a number of opportunities to discuss countermeasures with businesses, there is intense focus on human resources development for new staff, such as courses for energy managers and the conduct of energy-saving diagnoses on site. In this way, Tokyo is ensuring that activities are sustainable, while also strengthening governance within the metropolitan government.

Transferability
This system targets companies that are sources of large-scale emissions. One reason that this system has been accepted by companies is that policy packages for all stakeholders were developed in 2007 and as part of that process, the metropolitan government obtained the understanding of companies. Promoting policies in such a way as to eliminate a sense of unfairness can be identified as an important perspective for transferability. It is also important to build a mechanism that can compile data because it is impossible to ensure the effectiveness of the system without accurate and complete information. For this purpose, it is necessary to reach a common understanding between companies and the government and to tenaciously promote continuous dialogue to build trust. This system is also being carried out over a wide area in cooperation with Saitama Prefecture.

Tokyo C&T is renowned globally as an effective system that leads to a reduction in GHG emissions. Tokyo is developing information dissemination and cooperation activities through The Large Cities Climate Leadership Group (C40) and the International Carbon Action Partnership (ICAP).

Conclusion
The Tokyo Metropolitan Government recognises that it is the mission of large cities to contribute to the protection of the global environment as well as protect the living environment of its residents. Tokyo is developing various actions under the various policy packages shown in 2007. Tokyo C&T, which was introduced as one of those efforts, was originally designed to ensure effectiveness based on the local situation, and in fact encourages business establishments in Tokyo to significantly reduce emissions. Even with events that had a major impact on the awareness of residents on energy conservation, such as the Great East Japan Earthquake that occurred just after the launch of this system and

the resulting power failures, they can be said to have subsequently legitimised the energy conservation behaviours of businesses and made it easier to promote initiatives that can lead to a reduction in emissions.

Waste management: Kitakyushu Eco-town

With the waste disposal problems that emerged in the 1980s and the persistent economic downturn that Japan faced after the collapse of the bubble economy, the Eco-Town Project[34] was launched to achieve the concept of "zero emissions"[35] proposed by the United Nations and promote industrial and regional revitalisation through recycling. Kitakyushu Eco-Town was one of the first regions to be approved with the start of the project in 1997. A driver of economic growth in Japan, Kitakyushu City is known in throughout the country and overseas for its experience with debilitating pollution in the 1960s and its success in overcoming this challenge in collaboration with industries, the government, academia and civic society to become a city that has achieved environmentally-friendly economic growth (green growth). Kitakyushu Eco-Town is the concentration and development of companies and practical research facilities in the recycling industry located on idle land (about 2,000 ha) in the Hibikinada district[36] that has been developed as an industrial estate, in response to the arrival of a resource-recycling society that takes regional characteristics into account, such as the well-developed industrial infrastructure in the city, network of industries, government, academia and civic society formed through its experience in overcoming pollution, and the competitive edge afforded by the Hibikinada district.[37]

Kitakyushu City offers subsidies for business feasibility studies and the development of technology and provides a one-stop service for various administrative procedures in line with each stage in comprehensive development, from basic research and development of technologies to business development. About 20 years have passed since the start of the project, with the injection of JPY 78 billion in direct investment, 26 companies developing 27 projects, and the employment of about 1,000 people. In line with its original target, Kitakyushu Eco-Town has been confirmed to have had an economic effect through the promotion of the environmental industry. Studies are being carried out on the development of next-generation circulation industries, establishment of a regional resource circulation zone, and the sophistication of existing material circulation industries in order to determine that Kitakyushu Eco-Town is fulfilling its role as a form of social infrastructure for sustainable development in Kitakyushu City.

[34] In this project, the Ministry of the Environment and Ministry of Economy, Trade and Industry approved the Eco-Town plans formulated by municipalities and provided support for hard infrastructure projects (development of cutting-edge recycling facilities, development of R&D bases, etc.) and soft infrastructure projects (dissemination and development, provision of information, etc.). By 2005, 26 areas had been approved as Eco-Towns.

[35] Concept proposed by the United Nations in 1994 aiming at reducing all waste to zero through the mutual use of resources.

[36] The Hibikinada district is regarded as an advantage because of its vast area, a completed final disposal site, proximity to industrial concentrated areas and consumption areas, and well-developed logistical infrastructure.

[37] Kitakyushu Eco-Town became the first area approved together with Gifu Prefecture, Iida City in Nagano Prefecture, and Kawasaki City in the first round of approvals in 1997.

Figure 33. Panoramic views of Kitakyushu Eco-town
Source: Kitakyushu City

Effectiveness and efficiency

Effects of reducing greenhouse gas emissions
Kitakyushu has carried out studies on the effects of reducing CO_2 emissions in Kitakyushu Eco-Town (effects from reducing impacts on the environment) every five years since 2005. In FY 2016, 433,000 tonnes of CO_2 emissions were reduced as a result of the business activities of tenant companies in Eco-Town (22 projects).[38] Looking at the breakdown, although 70,000 tonnes of CO_2 were emitted through the recycling process, the CO_2 reduction effect from recycling (503,000 tonnes) exceeds this figure significantly. These emission reductions have been made possible as a result of mutual collaboration among tenant companies. The effects from reducing emissions have grown each year from 304,000 tonnes (21 projects) in fiscal 2005 to 400,000 tonnes (22 projects) in fiscal 2010 and can be cited as having contributed to the low carbon development of Kitakyushu.

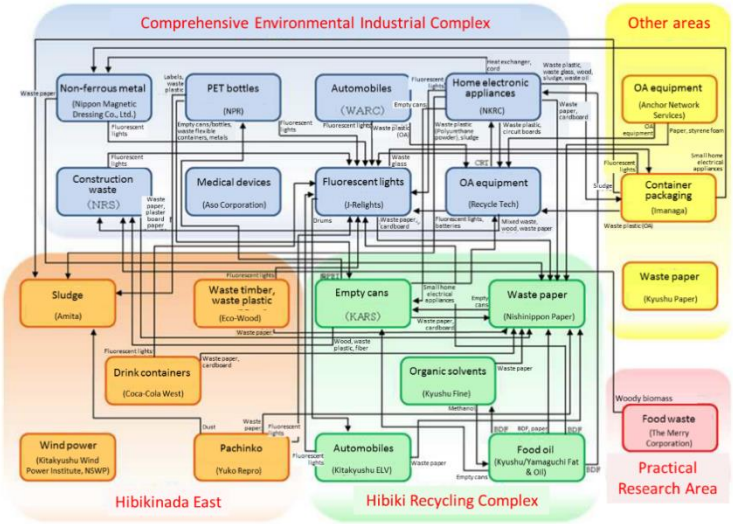


Figure 30 Voluntary, mutual resource recycling between companies in Eco-Town
(Japan Ministry of Environment, 2018b)

[38] Kitakyushu City homepage. "Effects of reducing greenhouse gas emissions through the Kitakyushu Eco-Town Project"

Effects from promoting environmental industries

Since Nishinippon PET Recycling (NPR) started operations in July 1998, although the number of companies in Kitakyushu Eco-Town has seen a slight increase and decrease over the years, overall the number of tenants has been rising steadily. As of August 2018, 26 companies are currently developing 27 business activities and employ 1,046 people. Of direct investment in Kitakyushu Eco-Town (total JPY 78 billion), only JPY 20.3 billion is from the national government with more than three times that from private investment. A large number of visitors from both Japan and abroad also make their way to Kitakyushu Eco-Town. Each year, about 100,000 visitors come to Kitakyushu Eco-Town, with a cumulative total of 1.54 million to date (Japan Ministry of Environment, 2018a). This has also contributed to the inbound effect and enhanced the name recognition of Kitakyushu City and the companies located here.

Features of Kitakyushu Eco-Town and implementation measures

Some of the distinguishing features of Kitakyushu Eco-Town include the (1) establishment of a social system to set up recycling businesses, (2) comprehensive development of basic research, technological development, and commercialisation, (3) wide-area acceptance of waste, and (4) role as a base for information disclosure and environmental learning. Although recycling businesses themselves can be promoted by the private sector, support from the government is indispensable for the development of systems to gather together recycling resources, establish a sound market for recycled products, support the development of technologies to cope with changes in waste disposal targets and needs of the times, and risk communication to gain understanding from residents. Kitakyushu City has appointed staff in the Environmental Bureau and provides one-stop services in collaboration with relevant departments within the administration.

Sustainability

Kitakyushu Eco-Town is a form of social infrastructure that advocates the city's goal of positioning itself as a "World Capital of Sustainable Development" and is promoted as a city policy. However, the continuity of business activities themselves by tenant companies is dependent on social factors. Products that are on the market today may not exist in the future and those that do not fit social conditions cannot be developed into a business even with the best of technology. It is also difficult to secure human resources. It is foreseeable that as markets die out, new products that must be recycled and new recycling technology based on market needs may be required. The tenant companies in Eco-Town themselves are also considering such challenges and the local government is providing the necessary support to respond to requests by these companies. It can be said that securing the sustainability of Eco-Towns is regeneration, or repeatedly replacing the old with the new. It is also indispensable to promote the understanding of residents to ensure the continuity of business activities. With the Eco-Town Center at the very core of the area and tenant companies required to open up their sites to the public, Eco-Town is actively disseminating information and promoting environmental learning, which offers a sense of peace of mind for residents. Kitakyushu City also provides support for publicity with the selection and exhibition of environmentally-friendly products, technologies and industrial activities as "Kitakyushu Eco-Premium" at Eco-Town. As residents have an actual look at the site of Eco-Town and recycled products, a positive cycle is created, which also leads to raising awareness on separating waste.

Transferability

There are many local governments that are interested in Kitakyushu Eco-Town. Coupled with the fact that Kitakyushu City is actively engaged in international environmental cooperation activities, feasibility studies on the construction of Eco-Towns are being carried out mostly in East and Southeast Asia. While it is natural that political support at the local level from national and local governments is needed, it is also necessary to create laws to boost recycling rates, improve residents' awareness on separating waste, develop collection systems for separated waste, concentrate technologies, find operators who accept recycled materials, and develop a market where these recycled materials can be used in order to establish recycling businesses themselves. To transfer the experience of Eco-Towns to other municipalities, it is necessary to develop not only recycling technologies and environmental management know-how, but also include environmental education as a set, in order to improve the awareness of companies and residents. With the limitations in administrative budgets, it is important that this be promoted by the private sector. There are a number of cities that are concerned about an increase in the amount of waste and pressure on landfills that goes hand-in-hand with rapid economic development and urbanisation, so demand for the transfer of recycling projects will continue in the future.

Conclusion

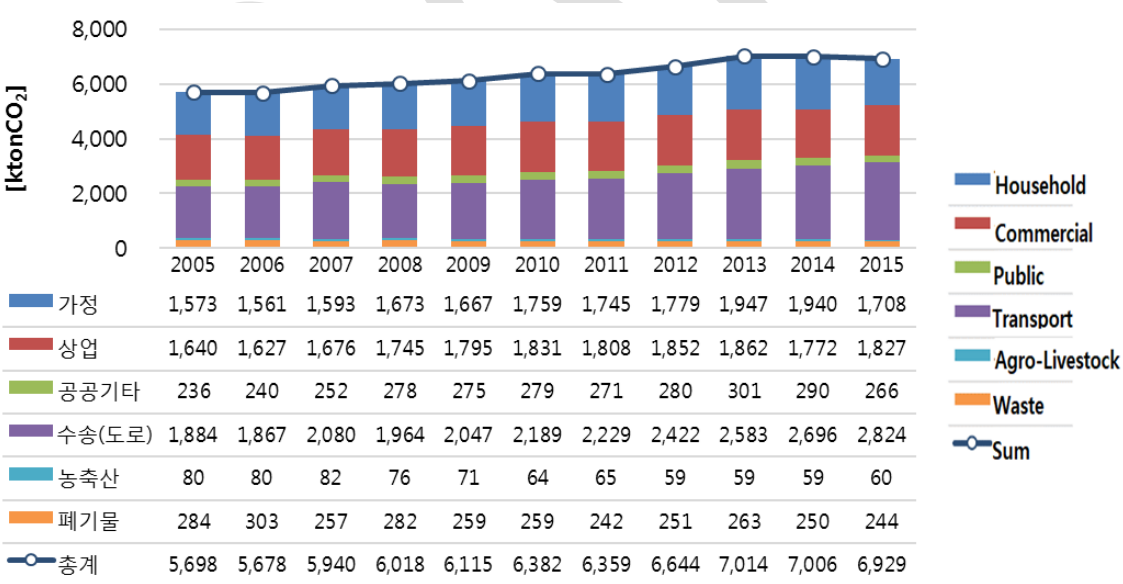
Kitakyushu Eco-Town is a project that was originally launched with resource recycling and industrial promotion in mind. It is now clear that mutual collaboration between companies contributes to low carbon development. With Kitakyushu Eco-Town positioned as a major project in the city's new growth strategy, Kitakyushu City is engaged in the promotion of regional energy bases around the Hibikinada district. Of these projects, the promotion of low carbon development in the region is expected to be promoted through the expanded application of solar panels and offshore wind power. Kitakyushu Eco-Town will continue to contribute to the creation of low carbon, sustainable city as a way to support such industries.

Republic of Korea

As described above, the government of the Republic of Korea provides robust support and incentives for local governments' climate action for a successful implementation of the local NDCs. Climate action at local level is mostly taken up by the public sector, which covers wide-ranging sectors including buildings, transportation, waste management, and renewable energy.

Gwangju Metropolitan City: ICT based Urban Carbon Management System

The Gwangju Metropolitan City, having 1.5 million population in 5 districts, signed the 'Agreement on the Climate Change Model City' with the Ministry of Environment in 2008, the ever first agreement between the central government and the said local municipality. Since then, Gwangju has enacted an ordinance of climate change, which provides a legal base of climate change policy and actions at municipal level. The department of climate change was established in 2009 to implement the 'low carbon model city plan'. The GHG reduction target stipulated in the plan was achieved (10% reduction from 2005 emission level by 2015). Even though the emission reduction was still on the rise, annual increase of emission has slowed down since 2010 despite of the local economic growth, which shows a decoupling trend entering 2015.



	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
가정	1,573	1,561	1,593	1,673	1,667	1,759	1,745	1,779	1,947	1,940	1,708
상업	1,640	1,627	1,676	1,745	1,795	1,831	1,808	1,852	1,862	1,772	1,827
공공기타	236	240	252	278	275	279	271	280	301	290	266
수송(도로)	1,884	1,867	2,080	1,964	2,047	2,189	2,229	2,422	2,583	2,696	2,824
농축산	80	80	82	76	71	64	65	59	59	59	60
폐기물	284	303	257	282	259	259	242	251	263	250	244
총계	5,698	5,678	5,940	6,018	6,115	6,382	6,359	6,644	7,014	7,006	6,929

Figure 34. Sectoral GHG emission in Gwangju (2005-2015)

Net GHG Emissions of Gwangju increased from 5.7 (2005) to 6.9 million-ton CO_2eq (2015) of which transportation as a single sector accounted for the biggest share (39%). Buildings in household, commercial, and public sector represent 53% of the total municipal GHG emissions. Emissions increased continuously during 2005~2013, then remained stable after 2013 till 2015.

Following the INDC announced in 2015, Gwangju renewed its mitigation goal: 30% reduction by 2020 and 40% by 2030 from BAU. It aims to be a carbon neutral city by 2050 as a long-term goal. For the fiscal year of 2018, a total of 13 billion US dollars are allocated to local actions categorized into the following 4 sectors: Mitigation (6.7 billion USD), Offset (3.9 billion USD), Adaptation (25 million USD) and Adoption of Green Life Style (37 million USD).

Effectiveness and Efficiency

The Gwangju Ordinance of Climate Change Response and Gwangju Ordinance of Low Carbon Green Growth and Sustainable Development adopted in 2009 provides e legal frameworks for climate change adaptation and mitigation at municipal level. The implementation of plan and programmes is reviewed by the Citizen Council for Climate Change Response, which comprises of about 30 experts and major stakeholder representatives. In the administration side, the Climate and Air Department in the Environment Ecology Bureau is in charge of ensuring the effective implementation. Each department of the city government submits every year the implementation schedule of climate action plan with estimated emission reduction report from individual project implemented. The individual project covers GHG Reduction, GHG Offset, Climate Change Adaptation and Green Lifestyle Promotion. The evaluation of project implementation is conducted twice a year by the Citizen Council, specifically examining the Performance Analysis of the estimated net GHG emissions offset compared to the analysis reported from the year. The estimation and analysis by each of 5 districts is supported by local GHG inventory system.

Gwangju currently has a total of 74 low carbon initiatives including 55 GHG reduction projects covering Carbon Bank, Collective Energy, Electric Cars, NOx Reduction, LED, etc.; 6 Carbon offset projects affiliated with the Carbon Neutral Program on Environment Infra, Emission Trade, Parks for carbon sink, etc.; 4 Climate change adaptation projects focusing on the Vulnerability in Forest, Monitoring on Illness, Prevention of Infection, etc.; and 9 Green Life projects in Low Carbon Apartments, Water saving, Local Food, Green Goods, etc. The budget allocation for the implementation of the abovementioned projects for five fiscal years from 2016 to 2020 totaled about 13 billion US dollars in 2018: 6.7 billion USD(Reduction), 3.9 billion USD (Offset), 25 million USD (Adaptation), 37 million USD (Green Life).

Various projects have been implemented since 2008 to meet Gwangju's 2020 GHG reduction target. As of 2015, 0.697 million ton of CO_2eq was reduced through these projects, which means that Gwangju achieved its 2020 reduction target (0.665 million ton CO2eq).

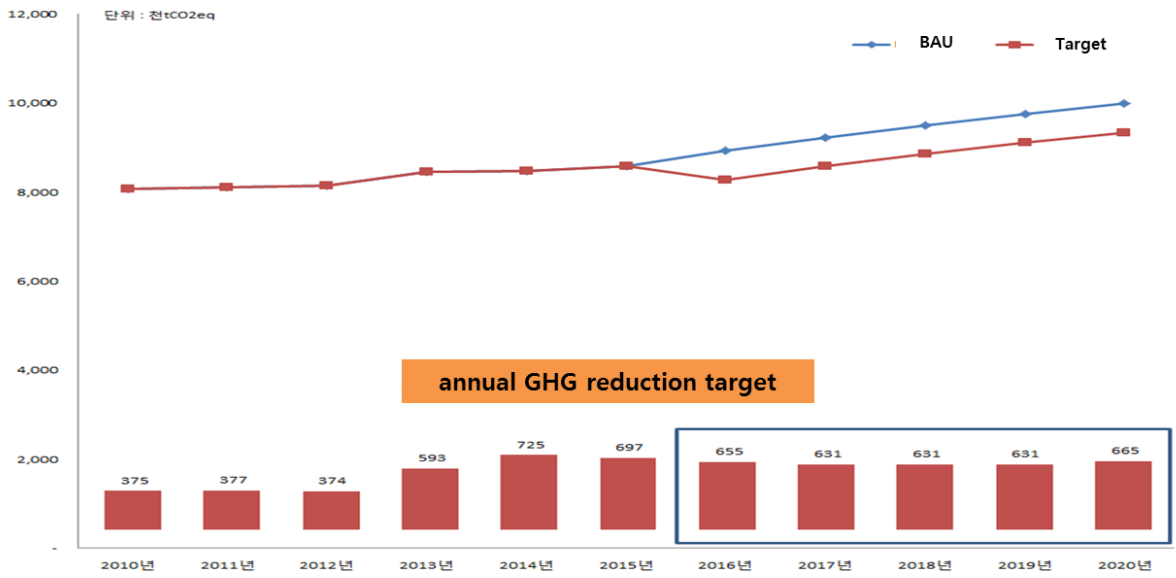


Figure 35. Annual GHG Reduction Target

Sustainability

The climate change actions of Gwangju are supported by the ICT based on-line Urban Carbon Management System linked with the GHG Projection and Diagnostics (GPD) Program for monitoring, reporting and verifying the effects of GHG emission and low carbon policies.

Pioneering low carbon policies and practices since 2010, Gwangju developed a GHG inventory tool named as GHG Projection and Diagnostics Program(GPD) integrating sectoral inventory, emission parameters, emission calculation and estimation formula.., The GPD aims to be the universal inventory system for the policy and programme based Clean Development Mechanism (CDM) projects.

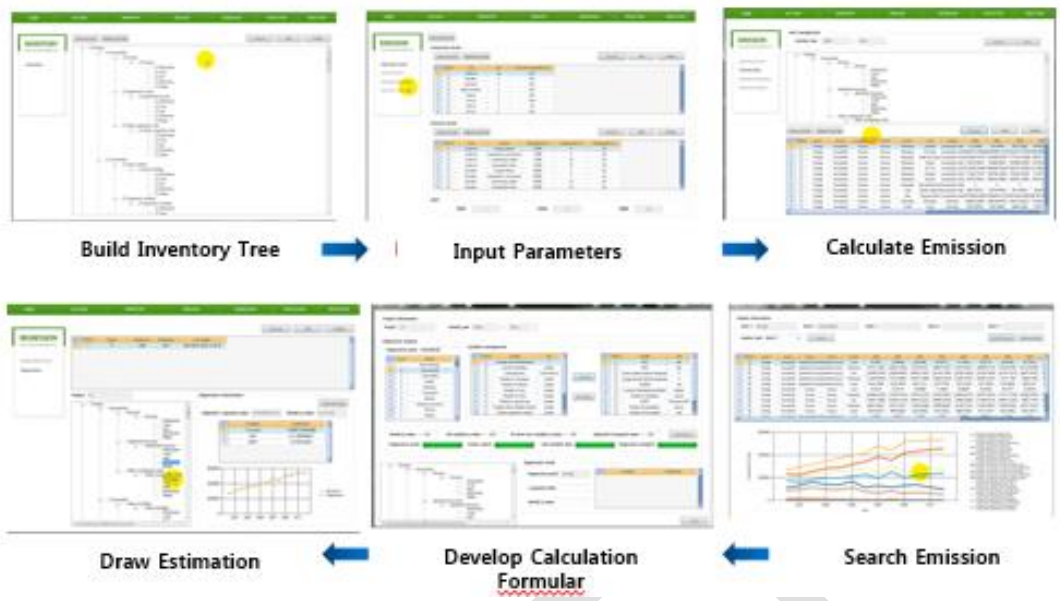


Figure 36. Graphic User Interface of GPD for Local GHG Inventory of Gwangju, ICEC (2018)

Later, the GPD established an integrated GIS- based policy making tool named the Urban Carbon Management System (UCMS) for municipal planning of buildings, urban transport and green space infrastructure. UCMS allows the local government officers to adopt a science-based climate change policy development. Inventory categories are detailed to fit for urban planning by lot and block. Emission resources and energy source are linked to the individual building information (with GIS spatial data. Sectoral emission factors and estimation algorithms are integrated into a city level carbon evaluation system.

Figure 37. Urban Carbon Management System of Gwangju (ICEC, 2018)

Transferability

Providing GHG monitoring and evaluation tools for sectors related to building, transportation and green area help officers of districts and members in primary levels of administration to make policy decisions regarding carbon management projects under their management. The system contributes to the development of policies and initiatives specifically tailored to each city district with different socio-economic characteristics by providing relevant background information on the linkages between socio-economy, environment and climate change for policy making process.

Currently, Gwangju is developing a local climate change and environment impact assessment model to complete a comprehensive set of science-based climate change policy development tools, covering climate change impact and vulnerability assessment, local GHG inventory in GPD, and integrated Urban Carbon Management System.

Starting from the establishment of specialized policy supporting think-tank for climate change and environment, the International Climate and Environment Center (ICEC) in 2010, Gwangju has been promoting the dissemination of science based carbon management tools for the member cities of the Urban Environment Accords (UEA), of which the city provides a secretariat service by organizing biennial mayors summit and implementing inter-city cooperation projects adopted by annual executive committee meeting of the UEA.

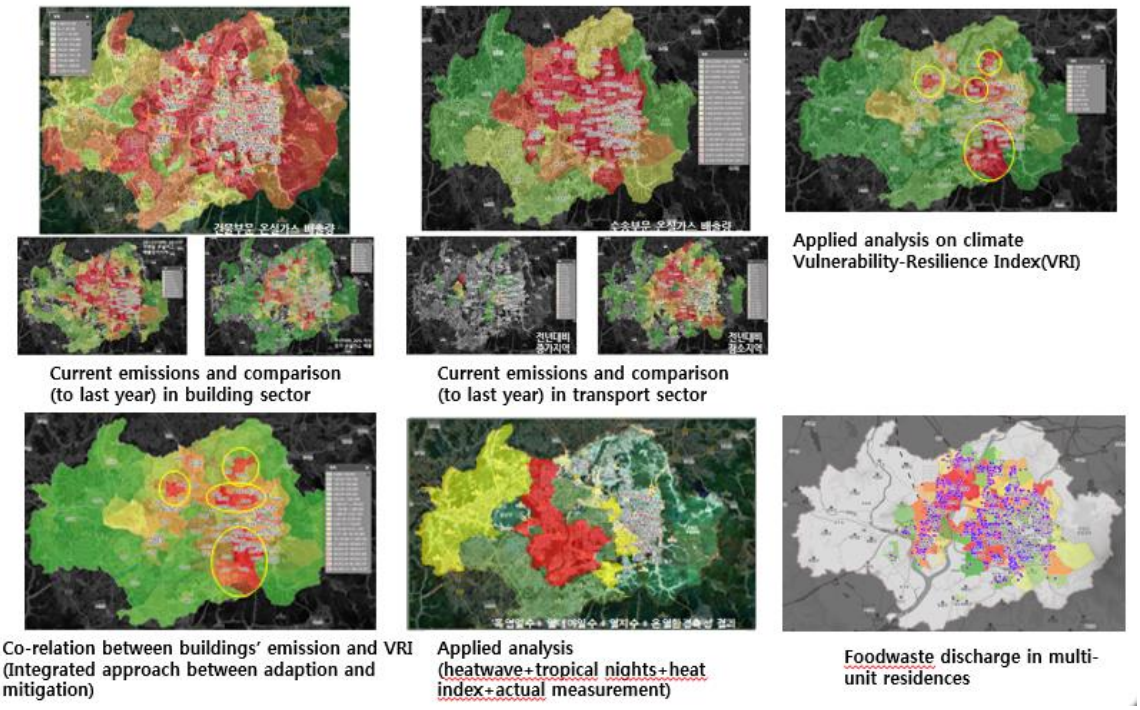


Figure 38. Use of Urban Carbon Management System in Gwangju Urban Carbon Planning

Jeju Province: Carbon Free Power System with Electric Vehicles, Renewable Energy, and Smart Grid

Jeju Special Self-Governing Province is, one of the 9 provinces of the Republic of Korea with the total surface area of 1,850km^2 administration which encompasses 1.85% of the national territory. As of July 2019, 695 thousand people reside in the province.

Jeju was designated as a free international province by the national government in 2002 and became a self-governing province in July 2006. It is an island located in the southeast of the Korean peninsula, an important point to connect key cities in East Asia. The average temperature of the city has steadily increased since 1930s. According to the RCP 8.5 scenario of IPCC, the annual average temperature on the Jeju Island is projected to increase by 3.2 degrees Celsius by between 2000s and 2090s.

The Net GHG emission of Jeju in 2013 was 3.530 million tCO_2eq which accounted for 0.7% of national emissions. Indirect emissions from electricity generation and waste, and energy sector (fuel combustion, fugitive emission) attributed to 97.3% of the total emissions. As of 2014, emissionsfrom petroleum has contributed to the second biggest proportion (74.1%) of national emissions, since Jeju lacks an island-wide network of LNG pipelines. The limited pipelines tend to increase the use of petroleum for residential heating. Emissions in Jeju are projected to rise steadily, up to 5.67 million tCO2eq in 2030; the forecasted number is equivalent to an increase of 59.1% compared to the 2005 levels.

Jeju set up two climate resilience plans titled 'the World Environmental Hub' and 'the Carbon Free Island'. 'The World Environmental Hub' plan aims to make Jeju a global livable city with environment, economy and society in harmony (SEE Harmonized Jeju). To achieve each goal in these 3 sectors, Jeju drew 8 key strategies and 30 projects and implement them by analyzing city's characteristics and reviewing related policies from eco-friendly cities around the world. In addition, Jeju announced 'Carbon Free Island 2030' plan in 2012 and roll out policies and make investments to make the city carbon-zero. As its results, the share of renewable energy in Jeju rose from 5.00% in 2011 to 13.61% in 2017 (national average : 8.07%), and the number of electric vehicles reached 11,287 (as of June 2018, which accounts for 30.6% of the electric vehicles in entire nation, and 2.3% of entire vehicles in Jeju.) Also, AMI (Advanced Metering Infrastructure) is equipped to 49.1% of households (192,335 out of 391,623).

The Jeju government has made numerous endeavors to make the island carbon free by 2030 including building renewable energy infrastructure, replacing gas-fueled vehicles with electric counterparts and improving energy efficiency in public buildings. Jeju earned the honorable recognition of being an eco-model city for environment education and climate change response as well as, smart grid demonstration complex, etc. Jeju hosted the 2012 IUCN World Conservation Congress to demonstrate its strong aspiration of becoming a World Environment Hub.

Under the 'Carbon Free Island (CFI)2030', Jeju set a target to cover 50% of energy consumption by 2020, and 100% by 2030 and making various and continuous efforts to supply renewable energy to the island. To achieve CFI, Jeju is building a transport

infrastructure assuring the conversion to 100% electric vehicles by 2030. To reduce the energy bill on the provincial budget for CFI, Jeju seeks to disperse the smart grid network across the island by 2030.

Following a benchmark analysis of eco-friendly cities around the world, detailed implementation programmes and projects for CFI 2030 were introduced in 2012 and the government rolled out policies and made investments to make the province carbon-zero island by 2030. At the moment, progresses in policy and action are based on 8 key strategies and 30 projects to implement in the light of local socio-economic and environmental characteristics. The Carbon Free Island 2030 project is expected to generate 50,000 jobs in green industries which will result in an increase in local income.

Effectiveness and Efficiency

Jeju CFI plan is progressing in 3 directions: renewable energy, electric vehicles and smart grid reducing GHGs emission and increasing energy efficiency. In order to establish efficient management of energy demand and economic and stable energy supply system, Jeju introduced basic energy ordinance of Jeju Special Self-Governing Province and developed recently its 5th Regional Energy Plan covering a period of 2018-2017 as well as whole area of Jeju Special Self-Governing Province. The plan detailed the background, characteristics and applicable scope of the plan, trend and prospect of regional energy supply and demand, measures to secure and supply regional energy in a stable manner, present measures for setting eco-friendly energy supply such as new & renewable energy and its usage, measures to rationalize energy usage and reduce the emission of greenhouse gas, and legal, institutional and administrative support measures and evaluation measures.
Renewable Energy Facility

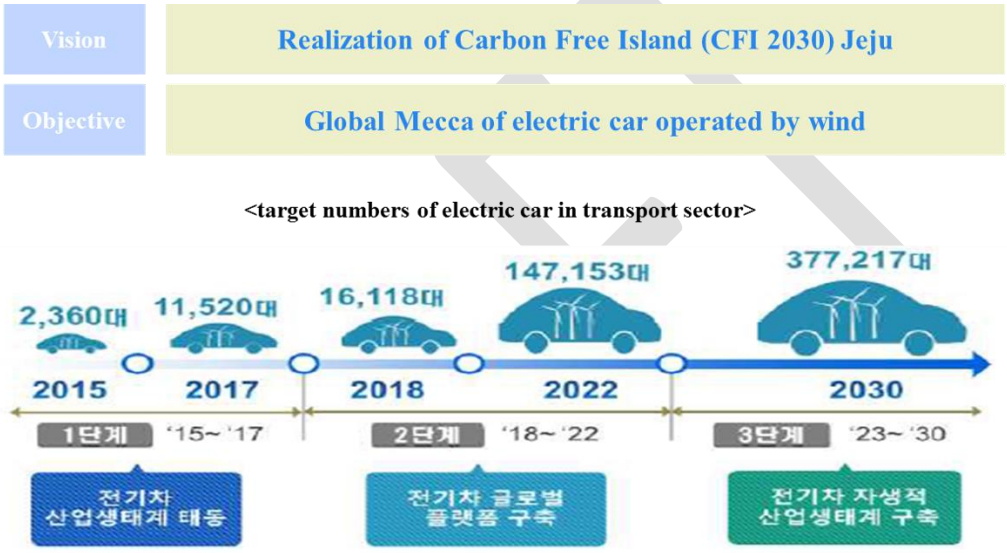
Starting with the operation of a 30 MW offshore wind power generation facility constructed in Hangyeong-myeon in September 2017, Jeju has issued the offshore wind power generation license of a 565 MW power generation facility in 3 district projects driven by the local government (Weoljeong-Hengwon, Handong-Pyeongdae, and Pyoseon) and 2 district projects (Daejeong and Hanrim) invested by private entities in 2017. In onshore wind power sector, the 25.2 MW wind power facility was built at an onshore area in the Soomang district of Seogwipo city at the end of 2017 and 2 MW facility in the Dongbok district in 2018.

For solar power generation side, the 47.5 MW facility work in 111 photovoltaic power generation sites was finished during 2016 and 2017. And the new 20 MW facility project was under preparation during the second half of 2017. To cope with the challenges prompted by the instability of the power grids from substantial renewable energy loads into the main grid, the government provided financial support to promote the installation of energy storage system (ESS).
As a result, the share of wind and solar renewable energy in the power sector in Jeju increased from 5.00% in 2011 to 13.61% in 2017, which exceeded the national average of 8.07%. The total of new and renewable energy distribution amounted to 753GWh including 55.2 MW of inland and offshore wind power turbine and 47.5MW of solar power system. The total represented nearly 14% (5,385 GWh) of the island's total electricity use.

The plan has set a mid-term goal of new and renewable energy share in total energy use up to 50% by 2020. This target is anticipated to be achieved with an increase in the capacities of wind power systems by additional 565MW wind power and 20MW solar power system.

Electric Vehicles

The number of electric vehicles reached 11,287 as of June 2018, which accounts for 30.6% of the electric vehicles in the Republic of Korea, and 2.3% of all vehicles in Jeju. In 2030, all vehicles in Jeju (estimated 377,217 units) will be electric with island wide charging infrastructure. Accompanied manufacturing and maintenance electric car services will be additional economic opportunities for Jeju (50,000 jobs by fostering and enhancing green industry).



Source: Jeju Special Self-Governing Province, revised mid-term and long-term master plan for expanding the distribution of electric cars and cultivating the industry (2018-2030) (March 2018)

Figure 39. Jeju Province: from World Environmental Hub to Carbon Free Island

Smart Grid

Smart grid is one of the essential components of CFI implementation. Based on the test bed experience of Carbon Zero Smart Grid in Gujwa-eup district (2,000 households) for 2009~2013, the local government designed a Jeju smart grid masterplan. Major energy and ICT companies including, KEPCO, LG Electronics, KT, and SK Telecom participated in this test bed project. The Smart grid master plan integrates various actors in the following fields: Smart consumers, Smart Transportation, Smart power network including smart power transmission, digital substation, and advanced metering system. 49.1% of households (192,335 out of 391,623) have recently been connected to the Advanced Metering Infrastructure (AMI Smart Grid) in the power sector for efficient power supply and demand management.

Figure 40. Figure 40: Jeju Global Eco-Platform with Smart Grid

To support smart consumers, Jeju introduced the optimal management system that enables consumers and power suppliers to exchange power supply and demand information in real-time through the electric power network. The Outage Management System (OMS) includes the advanced metering infrastructure (AMI), energy management system (EMS), and two-way communication technology.

To provide grid infrastructure for smart transportation, Jeju established a new business by conducting a series of demonstration projects aimed at developing advanced EV charging technologies for electric vehicles. The government financed the R&D programs to support the development of essential EV components which include the high-speed and low-speed charger, power network linkage technology (V2G), inverters and connectors. As a part of the new smart renewable energy solution, projects for improving efficiency and stability of energy storage equipment are introduced along with the preferential real-time fare system for new and renewable energy sources. The government has also provided substantial support in developing a micro grid technology, an energy saving technology, an electric power quality compensation technology, and a power network linkage technology. Fundamental researches promoted by the government focus on a wide scope of a smart power network including a smart power transmission, a digital power substation, and automation of distribution and management of irregular power supply and demand such as new & renewable energy and electric cars. The government has currently established infrastructures for 5 smart grid fields, verified 153 technologies, identified 9 business models, and promoted the commercialization of 6 business models.
Despite vigorous efforts to optimize the CFI 2030 goals, a variety of challenges still await. Most of them come from its tourism-driven economy, for which it matters to build infrastructure for electric vehicles in a timely manner, make transition to low carbon tourism, establish solid legal infrastructure for low carbon society, and make closer collaboration scheme with central government, etc.

Suwon City - Living-Lab for Low Carbon Transport

Suwon has 121km^2 administration territory and 1.24 million citizens as of 2017. About 40km to the south of capital city, its population keeps increasing and expanded urbanization is still going on to absorb the migration from the capital and surrounding semi-rural area.

The average temperature of the city has increased by 0.057°C every year in the last 37 years, the highest rate of warming was 19.2% in 2010. According to the long-term projections of climate change, the RCP 4.5 scenario assumes an increase of 2.3°C and the RCP 8.5 scenario about 5.5°C in the late 21st century (2071~2100). Also, the temperature difference of 3.2°C is anticipated of difference can be expected with and without proper reduction actions.

The net GHG emission of Suwon in 2017 was 5.749 million tCO_2eq, reduced by 1.4% compared to 2005 emission level. Following a short period of decreasing trend until 2014, the emission of Suwon has reversed again since 2015 due to the increase of the population. Nevertheless, per capita emission in 2017 was 4.63 tons, which reduced by 16.1% compared to the level of 2005. While the increase of net emissions is inevitable due to the increase of population, the emission per capita shows the positive outcomes of the efforts to reduce efforts. Emissions in the industry and household sectors shows decline, but emissions in the commercial and transportation is on the rise. Compared to 2005 sectoral profile, commercial and household played a role more important than industry.

In 2011, Suwon set its vision for low carbon green city as 'Environment Capital of Republic of Korea', which was driven by the community based public participation in support of the evidence-based climate policy and measures.

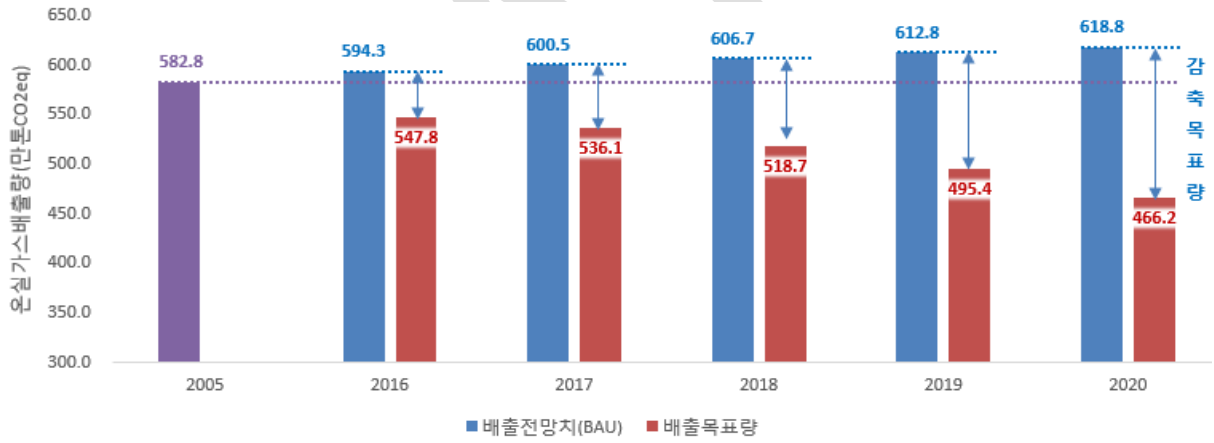


Figure 41. Low Carbon Roadmap of Suwon

Sustainability

In implementation, Suwon launched a special committee on climate change and organized a series of town hall meetings to review different GHG reduction scenarios by 2030. The outcomes of expert meetings and public consultations took the form of the 2030 GHG reduction target of 40% less than its historical emission level in 2005 (582.8 million tCO_2eq). As for the medium-term target, Suwon has adopted its target of a 20% cut from its historical emission in 2005, which limits its GHG emission around 466.2 million tCO_2eq.

A department of climate change response was established in 2012 and received a mandate to set up a series of policy programmes for climate change resilience. The department elaborated on the integrated GHG-energy management system and rolled out low carbon projects in fields of energy conversion, efficiency, and energy saving. The 58 low carbon projects in 9 sectors in Suwon started in 2012, which covered integrated GHGs management systems, the performance evaluation of individual projects and the verification of reduction

outcomes. Based on these practical experiences, Suwon has developed a comprehensive climate action plan including the detailed climate change adaptation plan as well as the comprehensive mitigation program (2014~2018) Suwon's experiences in low carbon climate resilient sustainable development could be characterized by two factors, a community driven public participation of local climate actions and a panoply of the integrated GHG management policies and measures.

Effectiveness and Efficiency

The quantitative and indirect qualitative analysis of Suwon's implementation of low carbon policies in 2017 showed that 59% of the annual mitigation target was accomplished. The city had substantial difficulties in meeting its reduction target in regard to a voluntary green lifestyle practice and a green transport system.

Table 10. Performance Evaluation of Suwon Low Carbon policies 2017

Category	Target	Reductions by Project			Achievement (%)
		Quantitative	Additional Reductions (Qualitative)	Total	
Total	643,827	333,327	47,556	380,883	59.2%
Green living practices	220,183	11,147	36,656	47,803	21.7%
Green transport system	146,371	15,740	-	15,740	10.8%
Expansion of Green Areas	96,447	96,709		96,709	100.3%
Energy Efficiency	10,965	10,509		10,509	95.8%
Renewable Energy	7,496	6,254		6,254	83.4%
Eco Friendly Buildings	94,114	107,340		107,340	114.1%
Efficient Resource Use	68,251	85,628	10,901	96,528	141.4%

Even if the Suwon's experience resulted in limited mitigation outcomes at the moment, the key characteristics of Suwon's decarbonization policies can be categorized into the following 4 points:

i) Suwon set up a local GHG reduction target higher than the national target, and established phase-by-phase evaluation/verification system to monitor achievement of reduction projects.

ii) The GHG reduction target in local energy plan was implemented through a wide participation of civil societies and citizens which facilitated further collaboration among major stakeholders including the city government, industry and business groups, thus transition to low carbon energy paradigm of the city.

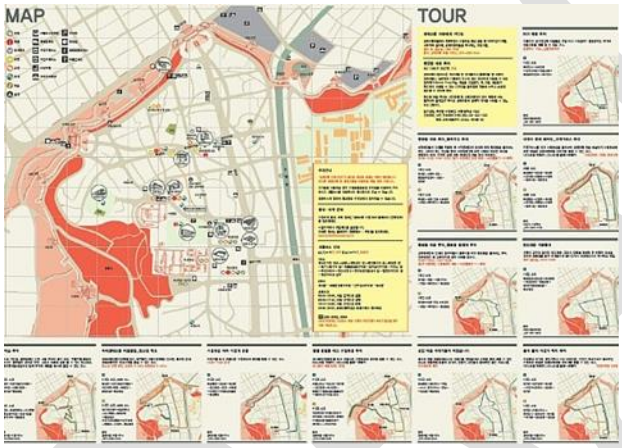
iii) Suwon experimented several living-lab type public participation projects. 'EcoMobility Suwon 2013' was held for a month, and its success led to the beginning of realization of green traffic system for the decarbonization of the city.

iv) With the different form of civil support, Suwon reduced its GHG emission by 1.1 million tons in cumulative terms for the first 3 years of implementation of its comprehensive low carbon plan: civil campaign, model city for environment education, hands-on exhibition for climate change education, etc.

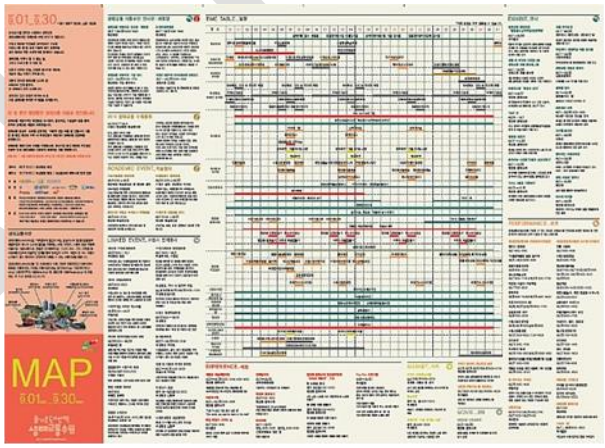
Suwon's pioneering decarbonization policies always undergo the internal and external civil consensus building process to ensure the transparency and responsibility of the project implementation and ownership by citizens. In this regard, assuring environment welfare and energy equity was also highly appreciated for the vulnerable cluster of people. The 'Solar power sharing projects' was promoted as one of the practical model cases connecting renewable energy with energy welfare.

Living-Lab for Low Carbon Transport: 'EcoMobility Suwon 2013'

As a part of 'EcoMobility Suwon 2013' program, Suwon city designated one of its sub-districts of 4,300 permanent residents as automobile free zone for a month (1-30 September 2013) and experimented carbon free and low carbon transportation equipment (bicycles, light electric vehicles, etc). It was the ever first sub-district level living lab for sustainable eco-mobility policy experimentation in real urban transport system. The programme was designed and developed by Suwon city, ICLEI, UNHABITAT and Kores Environment Institute.



Sub-district eco-mibility map 2013



Living lab programme, September 2013

Connection to the external traffic network

Public participation and outreach

Figure 42. Eco-mobility Living Lab Suwon 2013

During one month of the living lab, the city government, the resident representatives, public research institutes and civil society organizations organized several consultation meetings for monitoring and assessing the potential and enabling conditions of eco-mobility in a real-

life scale. More than 1,500 private cars were kept parked for the duration of the whole month, and the internal traffic was managed by 6 lines of electric buses that ran every 15 minutes. The local administration also provided the 24 hours emergency traffic services with electric shuttles always set ready to accommodate the urgent needs of the local residents. The city government collaborated with transportation-related businesses to ensure that the sub-district residents commute to work outside of the Eco-mobility zone. The city administration also provided 400 units of individual mobility tools like bicycles, electric motors, etc. Post services and police stations also used electric vehicles and light cargos. Throughout the duration of the project, the city observed a 2.3% reduction in car use and a staggering 16.3% increase in walking and an 8.4% in bicycling. The city also witnessed carbon emissions from vehicle travels decreasing by 21.1% (108.89 tons out of 516.34 tons). A total monthly reduction of 20.65 tons of CO_2 is anticipated if 4% of car commuters switch to emission-free mobility options.

The challenges mentioned by residents and visitors were readily taken into consideration to come up with pragmatic solutions. The results proved the important potential of community driven green traffic system at both sub district and district levels and the lessons learned from the program provides valuable inputs on the formulation of long-term goals for climate resilient and eco-friendly development of Suwon. If 38% of the residents voluntarily display their persistent efforts in adopting Ecomobility, the estimated total of 1,306.68 tons of CO_2 will be reduced annually. Such projected reduction in CO_2 is equivalent to planting 470,405 plants. If the program expands across the entire Suwon city, a drastic cut in emissions is forecasted. Suwon's experiment is still ongoing on to change the city's energy paradigm through with further collaboration with the city government and energy industries.

Gwangju Metropolitan City - Financial Incentives for Low Carbon Lifestyle

Gwangju promoted actively demand side carbon reduction policy encouraging low carbon lifestyle. Systematic education and citizen-led policy campaigns brings enhanced public awareness and participation. In collaboration with the Ministry of Environment, Gwangju introduced its very first Carbon Bank Program in 2008, which promoted low carbon consumption habits by granting the participants carbon points that have monetary value.

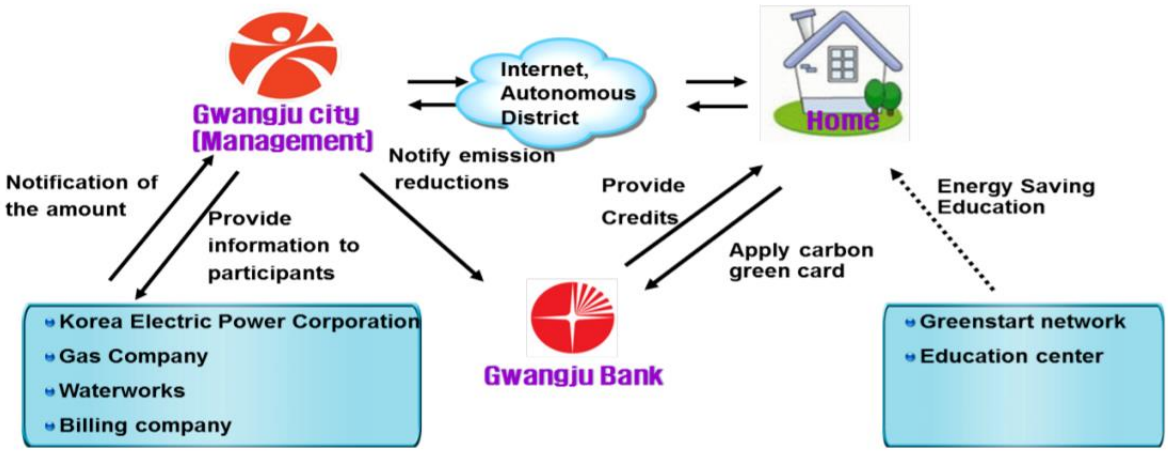


Figure 43. Carbon Banking System in Gwangju

Effectiveness and Efficiency

A household subscription to the carbon credit system, submitted to the district office of resident, is listed on the registry of carbon credits system managed by city administration. The city government send the registry notice to the electricity, water and gas providers as well as to the commercial bank, which issues a carbon point integrated credit card to the household subscriber. Every year, the electricity, water and gas providers monitor the net saving of electricity, water and gas consumption of the subscriber compared to the previous year consumption records, and then report the results to the city administration. After receiving the notice of saved amount of electricity, water and gas bills, the contracted bank gives a part of the saved bill to the subscriber as carbon points, which the household subscriber can use for shopping.

As of 2018, approximately 350,000 out of the total 580,000 Gwangju households have registered for the Carbon Bank System, ranking first amongst all metropolitan cities in the Republic of Korea for its membership rate exceeding over 50%. In early 2016, 48,000 homes attributed to reducing 55,000 tons of GHG emissions and received 300 million won worth of green points in return for their contributions towards sustainable livelihoods. The reduction of such staggering amounts of GHGs generated an equivalent effect of planting about 20.91 million pine trees. The city has assigned carbon coordinators to strategically assist households to achieve further energy reductions. Since 2014, the Gwangju Metropolitan government stimulated the participation of 27 major GHG-emitting facilities in lowering their carbon footprints by granting merit-based awards along with financial incentives. Despite the Carbon Bank System was primarily only applicable to individual households, the system has now been expanded to include non-residential, and private buildings. Up to now, in Gwangju, a total of 351,576 participated in the system including; individual households (84,001), apartments (266,804), commercial facilities (514) and the public sectors (257).

Sustainability and Transferability

Based on the experiment of Gwangju carbon credit system, the Ministry of Environment set a nationwide carbon credit system in 2014, which has a key role in GHG reduction at an individual household level. If a household managed to save 5~10% of their bill, its carbon credit point is equivalent to 155~17,500 Korean Won. If a household's bill saving goes beyond 10%, maximum carbon credit could go up to 70,000 Korean Won.

The nationwide expansion of the system has enabled many cities in different provinces such as Jeonju, Gumi, Jinju and so on to take bold initiatives in reducing their shares of GHG emissions. Gwangju is also reviewing the enactment of incentive plans for environmentally conscious drivers who travel less than the designated miles daily. Regardless of a steadily increasing number of participating populations, there are still unprecedented numbers of people unaware of the system being present. The active engagement of residents is vital to yield a systematic, accurate data on GHG emissions reduction trends. Gwangju should also ensure the visibility of reduction in GHG emissions. Nevertheless, it is an undeniable fact that the Carbon Bank system has constructed a fundamental mechanism for the Korean Ministry of Environment to spread the carbon point system both domestically and overseas.

The system is being acknowledged to serve as an excellent exemplary guide for a low carbon policy which all environmentally conscious nations should put into practice.

5. Challenges in low carbon city development

As highlighted in the comparative analysis and country studies above, the three countries in this study differ significantly in terms of the social, political, and economic backdrops against which low carbon city development is occurring. Even though there are many lessons that can be shared, it is important to recognize these contextual differences when considering how the challenges and recommendations presented in this section may inform new policy efforts going forward.

Common Challenges in Low Carbon City Development

Many of the challenges facing the three countries in this report are common between them. This reinforces the growing awareness that cities around the world can learn from each other, which serves as the foundation for the proliferation of transnational city networks.

Target Setting

Identifying the appropriate level of ambition is a major challenge for cities pursuing low carbon development strategies. In China, the low carbon pilot cities are expected to lead in the fulfilment of the national target. In ROK, which also has a top-down approach to low carbon development, most cities have adopted the national target as their own. In Japan, meanwhile, the mitigation targets of cities are generally less ambitious than those of the national government.

In general, however, most city targets (and national targets) fall short of the ambition required to meet internationally agreed upon objectives such as the goal of keeping global warming below 1.5 or 2 degrees, as enshrined in the Paris Agreement. To achieve low carbon development, cities face the challenge of not only building support for implementing existing plans or incremental improvements, but for far more ambitious plans that involve deep reductions, and eventually zero carbon transformations. No major cities have achieved such ambitious goals, so the challenge is amplified by the lack of clear models to follow. A small number of prominent international cities have made robust plans for carbon neutrality, including New York, London, and Paris, but all involve some long-term uncertainty regarding exactly how the goal will be achieved. In Northeast Asia, Jeju Special Self-Governing Province has a plan to become a 'Carbon Free Island' by 2030. Developing long term plans by 2020 that align with the Paris Agreement is a condition of C40 membership, which applies to cities in China, Japan, and ROK alike. Short-term goals may remain the immediately priority, but developing ambitious long-term goals remains a challenge for cities in Northeast Asia.

Support from National Governments

National governments can play a critical role in low carbon efforts at the local level. Although depending on the degree of autonomy of the local government support from a

national government is not strictly necessary[39], national governments shape the larger policy environment in which local governments operate. National governments can (i) provide policy coherence (particularly important in China where there are multiple pilot programs with overlapping mandates), (ii) help align national and local infrastructure and energy development plans, (iii) create market and financial regulations that affect investment decisions broadly, and (iv) provide funding and capacity building services for local efforts. National governments, of course, also provide leadership and serve as conduits of major international agreements and obligations (UNEP, 2018; OECD, 2014).

Because China's low carbon policy system is largely top-down, the recent institutional reform that moved the Department of Climate Change from the NDRC, China's influential economic planning agency, to China's new Ministry of Ecology and Environment, may destabilize the critical national level leadership behind the low carbon pilot program. A recent workshop for China's low carbon cities in Chengdu invited participants to discuss measures for carbon peaking at the municipal level, but its currently not clear what will come next for the low carbon pilot scheme as a whole. As described in the Japan-specific challenges section below, local government plan formulation rates are uneven and are not concentrated in the most important areas. The prefectures that have the highest rates of energy consumption do not currently have the highest rate of plan formulation. National level leadership could support local governments in developing low carbon plans and implementing them. In ROK, local governments are now updating their local GHG reduction roadmaps in response to the 2018 revision of ROK's national mitigation roadmap, which aims for a 37% GHG reduction from BAU 2030. The national government could use this opportunity apply lessons learned from municipal low carbon practices in the preceding years to these new plans.

Limited Capacity

Pursuing low carbon development involves new ideas, and often new resources. Harnessing these is a common challenge for cities who, apart from the largest and most wealthy, often lack capacity in terms of human, technical, and financial resources. In Japan, the national government's annual survey of local governments confirms this is the case. This study has found that more than 80% of local governments have indicated a lack of human resources as a challenge in formulating low carbon plans (see Japan section below). It also shows that a significant number of local governments, particularly for small urban authorities, lack a dedicated department for climate change issues (IGES, 2019). As discussed, cities in both Japan and ROK also generally have limited fiscal autonomy, which makes financial capacity a major challenge as low carbon strategies are often seen as an "additional" effort that must compete against existing priorities. Even in China, where cities have much greater fiscal autonomy, Wang et al. (2015) highlight that expertise and technical capacity regarding low carbon development strategies and policies is severely lacking, even in relatively large and wealthy LCCPs. It is because capacity is such a prevalent and important challenge for cities

[39] For example in the United States, local governments, state and municipal, have the authority to pursue ambitious carbon reduction goals and join transnational city networks

that the large, practice-orientated literature discussed in Section 1 has emerged and networks such as C40 dedicate significant resources toward technical support.[40]

Political and Economic Uncertainty

Lower economic activity could lead to lower carbon emissions, in particular in countries with economic activities closely related to carbon emission growth. However, economic downturns can also lead to a waning of support for environmental protection and emissions reductions. In this scenario, cities may find it especially challenging to advance a low carbon agenda and more work will be required to build broad-based support for costly carbon reduction initiatives. In the case of China, which faces the twin challenge of a protracted economic slowdown and continued urbanization, recessions in export markets could cause the relaxation of low carbon policy, including support for low carbon actions at the city level, in favor of economic stimulus, including the deeper entrenchment of fossil fuels for primary energy, motivated by an energy security imperative (iGDP, 2019). The on-going trade tensions between China and the USA also have global ramifications that will affect trade in green technologies.

Data Collection, Consistency, and International Coordination

Ensuring proper data collection is a common barrier for cities' low carbon development efforts as it is difficult to reduce carbon emissions without knowing their sources and impossible to measure progress without robust monitoring systems. At the same time, emissions and other data tracking at the city level tends to lag far behind that at the national level. China has recognized this and has made the development of GHG inventories and green indicators a priority for its LCCPs. Likewise, Japan's support for cities in developing their local climate plans contains a significant data component. ROK's FALCGG recommends the development of local GHG inventories but does not require them and while some larger cities have done so most have not, a trend that is mirrored in both Japan and China. The lack of consistent, reliable data on emissions and other dimensions of low carbon development in cities also frustrates research efforts that could support cities in their policy efforts. The 2018 Emissions Gap Report notes that lack of data transparency and common reporting standards are hampering efforts to coordinate actions at the national and subnational levels (UN, 2018).

Country-specific Challenges

China

Low carbon cities entered China's climate policy agenda in 2009, when the NDRC launched the low carbon pilot program. Over the past ten years, these low carbon pilots have developed carbon management platforms, target disaggregation systems, special low carbon funds, low carbon labelling programs, and other tools and mechanisms to drive down emissions. These advances provide a basis for the further integration of low carbon city policy into China's overall low carbon development policy framework. They also constitute a library of effective practices that can be shared with other Chinese cities, or with cities in other countries pursuing sustainable and low-emission economic development.

[40] C40, for example, employs "city advisors" to be embedded in and work directly with the staff and officials of member cities.

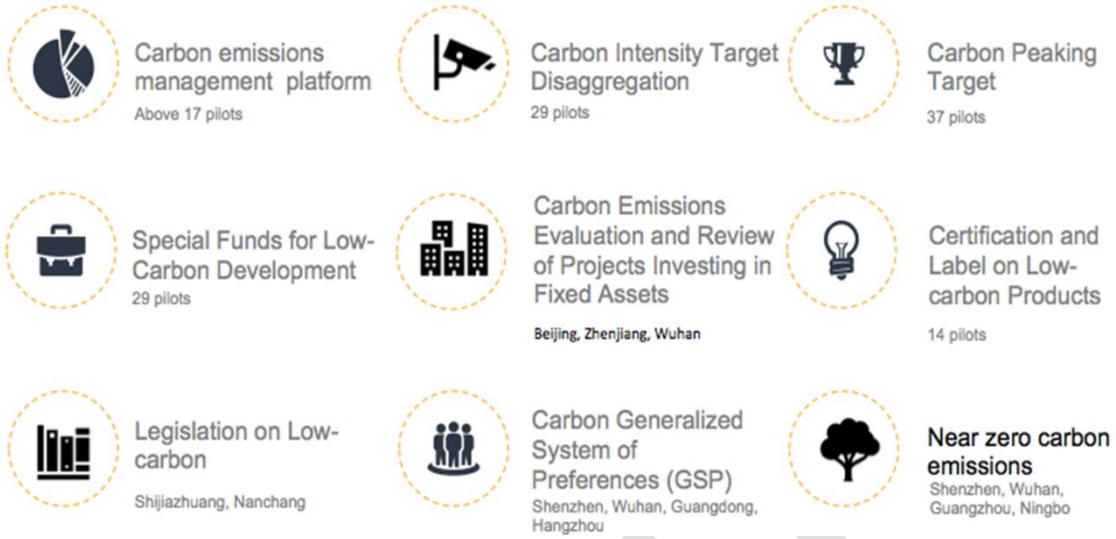


Figure 44. Summary of accomplishments in China's low carbon pilots
Source: Hu, et al. 2018

Box 3. Low-Carbon and Green Index for Cities

According to iGDP's Low-Carbon and Green Index for Cities research report (LOGIC), which measured green and low carbon progress in China's cities between 2010 and 2015, China's cities have been getting greener overall and low carbon pilot cities have shown particularly strong gains. The average overall LOGIC index score for China's low carbon pilot cities was 47.0, compared to an average of 42.9 for non-pilot cities. The pilot cities also saw a quicker increase in their scores over the study period – for the overall index score, as well as in most of the individual index categories/sub-categories.

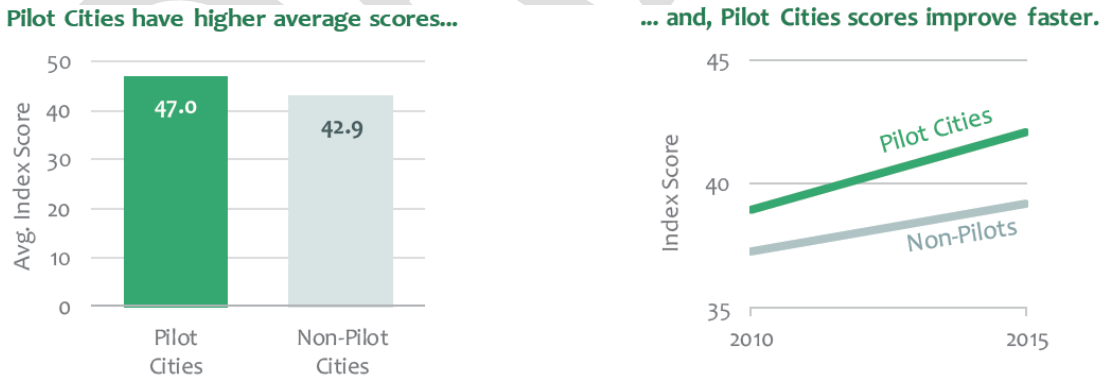


Figure 45: Low carbon pilot cities compared to non-pilot cities in LOGIC framework
Source: Hu, et al. 2018

These early accomplishments notwithstanding, China's low carbon pilot cities, low carbon pilot program, and other efforts to achieve sustainable urban development will likely need to overcome a series of challenges in the years ahead.

Sustaining momentum after institutional reforms

Ministry of Ecology and Environment (MEE)'s low carbon pilot program requires sustained, long-term guidance and support. There is a risk that this guidance and support will be undermined by China's recent institutional reforms. The transfer of the Department of Climate Change from the NDRC, China's influential economic planning agency, to China's new Ministry of Ecology and Environment may result in a weakening of the pilot program. This could happen if the MEE is not continually strengthened vis-à-vis other ministries and local municipal authorities, or if the program loses prominence relative to other MEE initiatives. One putative advantage of the transfer of the low carbon pilots program to MEE is that climate and environmental policy are now governed by the same ministry. In the long term, this may lead to improvements in the urban carbon emission measurement, reporting, and verification (MRV) system, bringing it up to par with China's rapidly improving MRV systems for other pollutants. In the near term, however, the administrators of China's low carbon pilot program will have to navigate a potentially awkward transfer of authority and personnel, fitting a complex program into a new ministry that will be looking to find a foothold in China's complex institutional landscape.

Competing policy priorities at the local level and unstable local leadership

The policy priority for China's local governments remains economic development. This focus on economic performance is reinforced by a government personnel management system in China that, despite recent reforms, remains biased toward good performance against economic indicators. Moreover, China's government personnel management system involves regular transfers and rotations (including the mayor of cities), creating the potential for loss of leadership, momentum, and policy expertise in low carbon initiatives (Hart, et al. 2018).

International experience shows that commitment by city mayors and other leaders is crucial, because low-carbon development involves nearly all city operations. City low-carbon development and sustainability efforts must be integrated with regular city planning efforts to be effective. In addition, a strong administrative team is needed, including managers, dedicated staff, community support groups (with active public participation), and knowledge partners (universities and research institutes). In most cities, local government officials regard economy growth as their major priority, which affects their personal careers. Low-carbon development is treated as the lower priority unless it can promote a growth in the economy (Council of Scientific Research on China's City, 2009; Qi, 2014). Without strong support from the mayor, ministries such as the NDRC and the Ministry of Industry and Information Technology (MIIT) find it difficult to coordinate their operations or share information.

Uncertainty surrounding China's future economic growth rate

China has entered a new economic normal in which the economic growth rate of many cities has slowed down. For many Chinese low carbon pilot cities, industrial restructuring or improvements in industrial energy efficiency are key means of lowering emissions (Oshita, et al. 2015). This movement away from energy-intensive industry is contingent on the existence of alternative sources of economic growth and employment. China's general economic slowdown may tempt pilot administrators to relax these critical industry-focused emissions reduction efforts.

Improving Monitoring, Reporting and Verification

China's low carbon pilot cities do not currently belong to a universal or integrated system to gather or publish city-level GHG data. These systems, when they are developed, will need to be able to capture changes in emission trends driven by China's ongoing rapid urbanization and economic transformation, and will also have to be consistent with international methodologies for Chinese climate policymakers to be able to speak a common language with their international counterparts. Strong systems for monitoring emissions are also often missing (Hart, et al. 2018).

Demographic Challenges

China faces a demographic challenge that combines ongoing waves of urbanization, rising consumer wealth, and a projected turning point toward an aging population at around the year 2030. Consumer behavior driven by rising wealth has led to growing GHG emissions per capita due to increased use of private cars, washers/dryers, air conditioning and greater meat consumption. The carbon footprint from households increased by 19% in the five years between 2007 and 2012, with a majority of the increase driven by consumption by prosperous urban denizens (Wiedenhofer et al., 2017). While Chinese cities are still adjusting to and learning how to implement low carbon strategies, the pressure from growing consumption is immediate, making avoiding traditional, more-polluting development strategies a serious challenge. They must overcome the challenge of creating low carbon development pathways that simultaneously meet the needs of growing numbers of residents who are consuming greater amounts of carbon-costly good and services. China is also expected to encounter challenges associated with an aging population. Its population is expected to peak at around the year 2030, after which policymakers will have to contend with a rising proportion of elderly citizens and a potential slowing of economic growth.

Making low carbon cities "smart" by assimilating emerging technologies

New digital tools and technologies– mobile payment, artificial intelligence, big data – are quickly reshaping the business landscape, consumption patterns, and overall lifestyles in China's cities. Low carbon pilot administrators, who are already hobbled by a lack of technical capacity, will need to raise their technical literacy to take advantage of the potential new efficiencies afforded by these new tools and technologies. "Smart Cities" are now an active area of policy and research in China. The Ministry of Housing and Urban-Rural Development has managed a national smart cities pilot project since 2013 (Yuanping, et al. 2019). Finding synergies between China's smart city and low carbon pilot programs will require capacity building, coordination between policymakers working in different ministries, and consultations with experts in new technologies from academia and the private sector.

Japan

Since the enactment of the Global Warming Act in 1998, the Japanese government has been promoting the establishment of systems to encourage industries, local governments and the public to work together to reduce GHG emissions. In particular, local governments are being requested to formulate and implement action plans and urged to carry out policy planning that can simultaneously solve socio-economic issues in the region as well as reduce GHG emissions. Support measures are needed, as mentioned above. Although GHG emissions

have been decreasing since 2013, this decline is not significant enough to reach the target of a 26% reduction by 2030.

Although local governments are the drivers in the creation of low-carbon cities, the following issues have been identified after looking at the results of surveys by the Ministry of the Environment on the state of local government action plans.

Disparities in the introduction rate of action plans in the region

There are wide variations across the prefectures in formulating action plans at sub-prefectural level, although the number of the local governments in each prefectures also varies. Figure 46 compares the share of local governments which formulated action plans in each prefecture (excluding prefecture governments and prefectural capital cities) and each prefecture's share of national energy consumption. For example, in Miyagi Prefecture, only 2.9% of the local governments formulated action plan, compared to 60% in Kyoto Prefecture.

In addition, a comparison of formulation of action plans with the share of energy consumption in each prefecture indicates that there is no clear link between the two. In other words, even though the local energy consumption rate in Kyoto Prefecture is only 1.19%, the formulation rate for its area-wide plan is 60%, while Osaka Prefecture, which has a local energy consumption rate of 5.83% that exceeds the national average, has a formulation rate of only 9.4%. By all rights, it is preferable that the formulation ratio for area-wide plans would be higher in areas with higher rates of energy consumption, but at present, there does not seem to be any correlation between these two points.

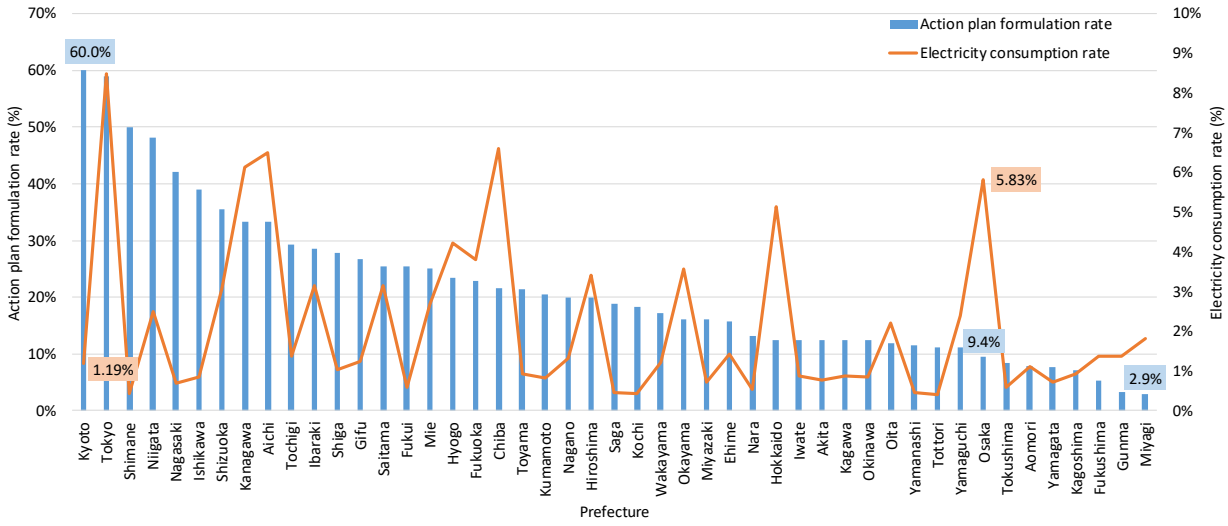


Figure 45. Action plan formulation rates and electricity consumption rates by prefecture, 2018

Source: Ministry of the Environment, Japan. "Survey on the state of legal enforcement of the promotion of global warming countermeasures by local governments: Report on study results (Revised version)", September 2018 (Action plan formulation rates); Agency for Natural Resources and Energy (Electricity consumption rates).

Lack of dedicated departments / human resources in the local governments

By law, local governments in Japan are required to formulate action plans. However, depending on the population size of the more than 1,700 municipalities and their level of socio-economic development, their capability to develop plans and the challenges they face also differ. Each year, the Japanese government conducts a questionnaire survey of all local governments to review the status of formulating plans and the issues they face. According to the latest survey, more than 80% of local governments have indicated a lack of human resources as a challenge in formulating action plans.
It is also reflected in the survey results that the smaller the population, more likely their local local governments have no departments in charge of climate change policy. (Table 10 or "Box")

The absence or limited capacity of the dedicated department for the climate change policy is likely reflected in the other challenges identified in the survey, such as lack of expert knowledge and difficulty evaluating the effects of policies and measures (see Box).

Box4. Survey on the local government responses to the climate change policy

Table 11. Number of local governments with departments in charge of climate change policy

Type	Number of population	Department in charge of climate change policy		
		Have	None	
Prefectures		47	0	
Ordinance-Designated cities		20	0	
Core cities		48	0	
Special case cities		36	0	
Cities, Towns and Villages	100,000 or more	180	3	1.7%
	30,000 - 99,999	481	19	4.0%
	10,000 - 2,9999	422	26	6.2%
	10,000 or less	415	91	21.9%

Source: Ministry of the Environment. "Survey on the state of legal enforcement of the promotion of global warming countermeasures by local governments: Report on study results (Revised version)", September 2018.

Figure 47 shows the number of staff in charge of climate change policies divided into four groups and the number of local governments who have assigned a corresponding number of staff. Just as we can see from the figure, the number of staff in charge in 58.3% of local governments is four or less. Even at the prefectural level, more than half of local governments responded that the number of staff in charge of climate change policy is 10 or less.

Type	Number of population	Nunber of officials in the Department in charge of climate change policy				
		4 or less	5 ~ 9	10 ~ 24	25 ~49	50 or more
Prefectures		4	23	16	3	1
Ordinance-Designated cities		2	8	3	7	0
Core cities		11	23	14	0	0
Special case cities		12	16	7	1	0
Cities, Towns and Villages	100,000 or more	80	66	33	1	0
	30,000 - 99,999	260	182	37	2	0
	10,000 - 2,9999	296	105	20	1	0
	10,000 or less	297	88	30	0	0

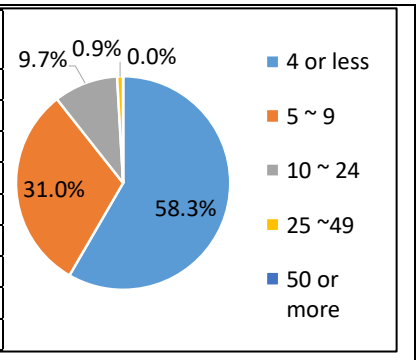


Figure 47: Number of staff in charge of climate change policy
Source: Ministry of the Environment. “Survey on the state of legal enforcement of the promotion of global warming countermeasures by local governments: Report on study results (Revised version)”, September 2018.

Other issues clarified in the above questionnaire survey include a lack of expert knowledge on climate change measures (60%), inadequate financial resources (44%), and difficulty in evaluating the effects of policies and measures (36%).

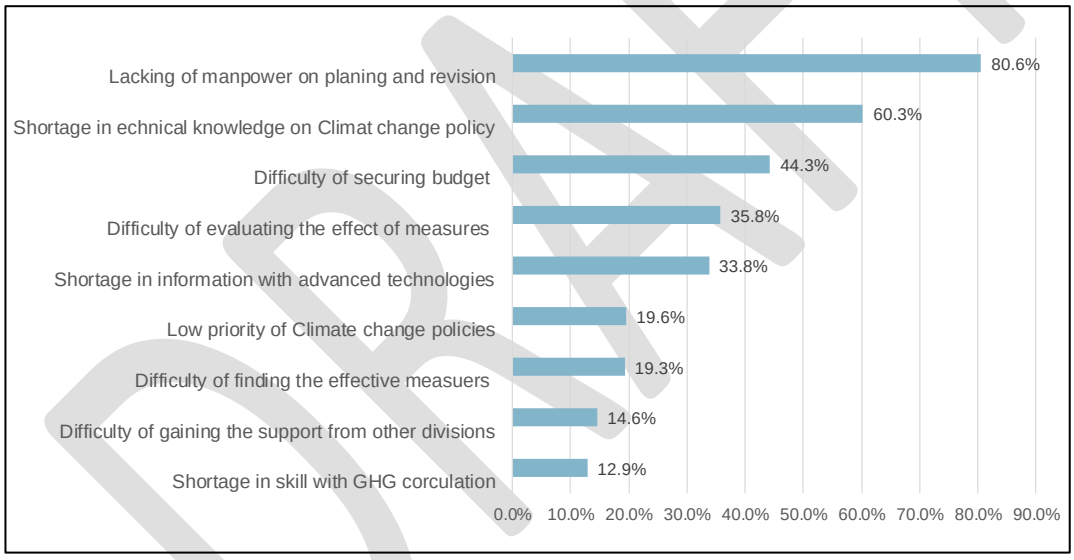


Figure 48: Reasons why the area wide plan is not yet formulated (extract the top 9 items)
Source: Ministry of the Environment. “Survey on the state of legal enforcement of the promotion of global warming countermeasures by local governments: Report on study results (Revised version)”, September 2018.

Constraints of financial resources and measures at local level

The reduction targets of local governments cannot be achieved without financial measures. However, it is difficult to obtain the support of local councils/assemblies solely based on the target of reducing CO_2 emissions. It is important for the national government to increase the level of support to local governments, but the decisive moment will come when we

determine how to connect the reduction of CO_2 emissions to local issues. While it is important for the national government to increase support to local governments, the decisive moment will come when we figure out how to simultaneously combine GHG emission reductions with solutions for local issues and are able to involve stakeholders that implement projects for this purpose, as well as entities that implement programs so that they can obtain funding from support offered by the national government. The cities in the innovative cases presented in the the case studies (Chapter 4) showcase such examples. However, such initiatives tend to be hampered, especially in smaller municipalities, both in terms of human resources and a lack of expertise. For such small local governments, it will be necessary to identify and provide examples of actions that can be promoted using systems that allow external experts, in some cases, to take part in cooperation with local residents.

Republic of Korea

Following the 2018 revision of the national mitigation roadmap of the Republic of Korea, which outlines the measures that will be taken to NDC 2030 targeting 37% GHG cut down from BAU 2030, cities in the Republic of Korea are revising existing local GHG reduction roadmaps.

The mitigation from local climate action was estimated approximately about 25.7% of national business usual GHG emission level in 2020 (776.1 million ton of CO_2 equivalent). The government planned that 499 million ton (64.3% of national emission) could go under control of national carbon management system (NCMS) composed of energy and GHG target management and GHG emission trading for heavy emitters in industry and other sector except households. Emission outside of national control (EONC) was about 35.7% of national emission and that part was concentrated on households, transportation and commercial and public sectors. It was estimated that about 72% of EONC falls on the local government's mitigation actions.

Conformity of local GHG inventories to the national GHG monitoring system

Achieving national target of GHG mitigation requires a coordinated monitoring, reporting and verification system between central and local governments. For that purpose, the Ministry of Environment supports the development of local GHG inventory system and annual statistical report of local GHG emission on a voluntary base. In the beginning, the central government proposed to use the national GHG inventory guidelines following the IPCC guidelines. Since 2006, the government has promoted a local GHG inventory system based on locally adapted indicators. The local GHG inventory guidelines is provided by the Korea Environment Cooperation with a mandate of Ministry of Environment.

This change results in substantial challenges on the implementation of national mitigation target in collaboration with local authorities. At the moment, the national GHG emission outside of the central government control is not well attributed to each of the local authority's administrative territory. Top down allocation of the national GHG emissions does not correspond to the bottom up compilation of local GHG inventories in some cases. This may come from the fact that local GHG inventory guidelines adapted from the national one does not provide in some cases sufficient details more appropriate to the local context of GHG emission depending on different socio-economic drivers. In addition, the central-local

coordination in GHG emission control is greatly challenged by the fact that current local GHG inventories do not cover all the local administrative units from province to city and county as well as from metropolitan cities to district.

Limit in local fiscality financing climate actions

The challenges faced by each local government are different depending on the level of fiscal autonomy of local budget and policy priority depending on the socio-economic context of regional development. Among them, it comes first budget matching principle which requires a mobilization of local budget resources matching the central government transfer to finance the implementation of major program and projects in the local climate action plan. Without substantial engagement of local authorities, cities in climate action could not meet with the local priority of climate actions which may fall outside of national priority. This calls for innovations in green financing mechanisms, including market incentives for PPP in line with the national low carbon development policy framework.

Voluntary aspect of GHG inventory and mitigation roadmap development

The development of local GHG inventory and mitigation roadmap is not mandatory in legal terms, nevertheless local adaptation planning is required by the law. The State encourages and supports also local governments' implementation of local low carbon green growth strategy. At sub-national level, each local government, taking into account the local geo-economic and social characteristics, formulates and execute the LCGG plans and projects within its jurisdiction and takes necessary measures for encouraging activities of business entities, residents, and non-governmental organizations. ROK should consider whether to make mitigation roadmaps mandatory and offer support for this effort.

Continuous support from local institutes specialized in climate change policy

Climate action at local level is mostly taken up by the public authority not always well equipped with rigorous expertise in science and evidence-based policy development and implementation. Moreover, climate policy covers wide-range of sectoral urban policies which requires elaborated coordination among different department in charge of buildings, transportation, waste management as well as transformation of local energy system toward low carbon clean energy sources.

As it is in the case of Gwangju Metropolitan city, some cities are supported by specialized climate change expert group working on local climate change policy. But most district and county level authorities do not have that kind of technical support assuring a stable implementation condition of locally appropriate climate actions. The central and higher level of local governments need to enhance the local policy support infrastructure by enhancing institutionalization of local expertise linked to the national climate change think tank already installed at central government level.

Outreaching efforts for global sharing of local experiences

Spreading good practices will also be a challenge. Gwangju's 'Agreement on the Climate Change Model City' with the Ministry of Environment in 2008, and the city now promotes its inventory and carbon management tools as a member of the nation's Urban Environment Accords, for which serves as the secretariat. ROK should challenge itself to ensure that these tools find widespread use. The city of Suwon is actively involved in international

cooperation by registering and sharing their actions for climate change response, GHG inventory, and reduction targets by uploading them to ICLEI's Carbonn Cities Climate Registry (cCR) and CDP (Carbon Disclosure Project). Encouraging other cities to follow suit will also be a challenge.

6. Conclusion

Promoting low carbon city development is simultaneously urgent and challenging. This report has provided an analysis of the structure and status of low carbon city policy and action in China, Japan, and ROK, and has outlined the key challenges each country is facing as it pushes these efforts forward. While the national circumstances in each country vary, some common ways forward can be recommended. This section offers general recommendations in view of differing national circumstances.

Recommendations

Link to Co-benefits

Gathering support for low carbon city policy is challenging…
Effective, ambitious low carbon city policy will lead to significant changes to how cities are built, and how people travel, consume, and manage their waste within them. Implementing such policies, whether at the national or subnational level, will therefore require building broad coalitions of support among all stakeholders. Gathering support for administratively complex and financially burdensome carbon reduction policies can be challenging when framed purely in terms of reducing GHG emissions. The threat of climate change often appears distant and the size of the emissions reductions from any one city may seem insignificant compared to the scale of the challenge.

Co-benefits of GHG emission reduction may gather more support…
One way to overcome this is by drawing clear links between low carbon city policies and benefits beyond GHG mitigation. A policy or action that also delivers the co-benefit of reducing traffic or energy consumption, or improves air quality or urban livability, is more likely to receive widespread support than one that only reduces GHG emissions. The co-benefits of low carbon development are many and rest on a robust body of evidence. For example, investments in low carbon public transport reduce GHG emissions from cars but also improve economic productivity through reduced congestion, reduce air pollution, and often reduce health costs through fewer accidents (Kwan & Hashim, 2016). Raising the sustainability standards of buildings not only reduces their GHG emissions but lowers energy bills and improves indoor comfort and productivity (WGBC, n.d.).

…possibly connecting with wider range of funding sources
Emphasizing the co-benefits of low carbon policies can also help cities overcome financial and capacity constraints by helping them connect to a wider range of funding sources. For example, there may be funding streams available for health or air quality rather than emissions reductions; a co-benefits approach can effectively integrate these and make such funding relevant and accessible.

Cities can also embrace low carbon development in their urban policies
Co-benefits, moreover, can be pursued in a two-way fashion. Low carbon city administrators can support environmental and urban livability policies for their direct benefits and assimilate their indirect carbon reduction effects into low carbon plans and assessments.

Improve Data Collection and Create Common Metrics

The ability to track, analyze, and support the enhancement of low carbon city policies and actions is dependent on the quality and availability of relevant data. This report has made some initial, broad comparisons of low carbon city development in China, Japan, and the Republic of Korea, but the depth of analysis is restricted by the amount of accessible data. Perhaps most importantly, the lack of data over time on city-level GHG emissions makes measuring or comparing the effectiveness of low carbon city policies and actions exceedingly difficult. Similar issues exist regarding tracking non-state and subnational climate action and low carbon development efforts in all regions of the world (UNEP, 2018).

Consistent measurement methodologies
Being able to track the impacts of low carbon city policy is crucial to ensuring their effective implementation and helping share the benefits of such policy to encourage action on a wider scale. Converging on consistent methodologies is an important step for quantifying subnational and non-state climate action (Hsu et al. (2019). This is echoed by UNEP's 2018 Emissions Gap report, which called for common principles to be adopted for measuring subnational climate action that "include clear and quantifiable targets based on relevant benchmarks, technical capacity of the actors, availability off financial incentives and the presence of regulatory support" (UNEP, 2018). National governments should look to encourage such alignments domestically and regional organizations should do so transnationally.

Financial support essential for the long-term benefits
Technical capacity and financial support will need to be increased to produce more consistent and higher quality data, but the benefits of doing so would be large. It would allow best practices to be identified and shared in a more rigorous, outcomes-orientated manner; create a stronger baseline for implementation and enforcement; and facilitate deeper research into the institutional, social, and economic factors shaping low carbon city development, such as those touched upon on this report.

Strengthen Regional Networks of Support with Targeted Policy Advice
This report shows that cities in the three North-East Asia countries of China, Japan and the Republic of Korea have each amassed a great deal of experience in low carbon city policy at both national and subnational levels. Policymakers and policy experts at the national and municipal levels of these countries are also active in a wide variety of international collaborative projects and networks. Currently missing, however, are mechanisms or institutions for the countries of North-East Asia to offer support to each other at a scale that is proportional to the climate challenge. NEASPEC's North-East Asia Low Carbon City Platform is a step in this direction. ICLEI East Asia provides excellent technical and capacity building services to its network participants but operates on membership model and has a mission that includes but goes beyond low carbon city policy.

To draw maximal value from the national, sectoral and municipal good practices in low carbon city policy from this region, future projects should address the development of a tools, mechanisms, or platforms that facilitate the transmission of know-how across national boundaries.

This know-how should also be channeled in the right direction and should address the specific challenges of the country or local government receiving support. China, Japan and ROK have diverse emission driver profiles, levels of economic development, and institutional structures and policy frameworks, and this diversity is greater at the municipal level. These differences make it a challenge to identify the specific features of national, subnational or sectoral low carbon city policy that are truly relevant in other contexts. Japan and Korea's responses to the emissions effects of aging populations may be instructive for China, which is expected to experience a similar demographic transition in the coming decades. China's efforts to introduce low carbon practices in a period of rapid economic development and urbanization could prove useful to other countries in North-East Asia looking for ways to strike a balance between economic and environmental policy priorities. Moving beyond North-East Asia, cases of successful carbon reduction efforts under conditions of rapid economic growth in China could also be exported to developing economies under the Belt and Road initiative. But these observations are of surface characteristics. Matching the demand for targeted policy advice with the right experts or lessons-learned will require deep dives into local conditions. As this report shows, low carbon city policy is not one-size fits all.

References

Akagi, J. (2018). *Low Carbon City Profile: Climate Change Actions by Asian Cities in the City-to-City Collaboration Programme*. Retrieved from IGES website: https://pub.iges.or.jp/pub/low-carbon-city-profile-climate-change-actions

Arup, & C40 Cities. (2015). *Powering Climate Action: Cities as Global Changemakers Executive Summary*. Retrieved from https://www.c40.org/researches/executive-summary-powering-climate-action

Bansard, J. S., Pattberg, P. H., & Widerberg, O. (2017). Cities to the rescue? Assessing the performance of transnational municipal networks in global climate governance. *International Environmental Agreements: Politics, Law and Economics*, *17*(2), 229–246.

Betsill, M., & Bulkeley, H. (2006). Cities and the multilevel governance of global climate change. *Global Governance: A Review of Multilateralism and International Organizations*, *12*(2), 141–159.

Bulkeley, H. (2010). Cities and the Governing of Climate Change. *Annual Review of Environment and Resources*, *35*(1), 229–253. https://doi.org/10.1146/annurev-environ-072809-101747

Bulkeley, H., Andonova, L., Betsill, M. M., Compagnon, D., Hale, T., Hoffmann, M. J., … VanDeveer, S. D. (2014). *Transnational climate change governance*. Cambridge: Cambridge University Press.

C40 Cities. (2012). C40 Cities: Why Cities are the Solution to Global Climate Change. Retrieved 20 June 2019, from https://www.c40.org/ending-climate-change-begins-in-the-city

C40 Cities, & McKinsey Center for Business and Environment. (2017). *Focused acceleration: A strategic approach to climate action in cities 2030*. Retrieved from https://www.c40.org/researches/mckinsey-center-for-business-and-environment

C40 Cities, & Tokyo Metropolitan Government. (2015). *Urban Efficiency: A global survey of building energy efficiency policies in cities*. Retrieved from www.kankyo.metro.tokyo.jp/en/int/c40/c40_pse_r.files/kankyo4710.pdf

Castán Broto, V., & Bulkeley, H. (2013). A survey of urban climate change experiments in 100 cities. *Global Environmental Change*, *23*(1), 92–102. https://doi.org/10.1016/j.gloenvcha.2012.07.005

City of Yokohama. (2017). *Yokohama City Action Plan for Global Warming Countermeasures*. Retrieved from

http://www.kankyo.metro.tokyo.jp/en/climate/cap_and_trade/icap_tokyo_2017.files/170614icapsymposium_session3_yokohama_ci.pdf

Climate Action Tracker. (n.d.). South Korea. Retrieved 13 June 2019, from Climate Action Tracker website: https://climateactiontracker.org/countries/south-korea/

Collier, D. (1991). The Comparative Method: Two Decades of Change. In D. Rustow & K. Erickson (Eds.), *Comparative Political Dynamics: Global Research Perspectives*. Retrieved from https://cloudfront.escholarship.org/dist/prd/content/qt53f5g5rp/qt53f5g5rp.pdf

Dhakal, S., & Ruth, M. (Eds.). (2017). *Creating low carbon cities*. Cham, Switzerland: Springer.

Fuhr, H., Hickmann, T., & Kern, K. (2018). The role of cities in multi-level climate governance: Local climate policies and the 1.5 °C target. *Current Opinion in Environmental Sustainability*, *30*, 1–6. https://doi.org/10.1016/j.cosust.2017.10.006

Gopinath, G. (2019). The Global Economy: A Delicate Moment. Retrieved 18 June 2019, from IMF Blog website: https://blogs.imf.org/2019/04/09/the-global-economy-a-delicate-moment/

Gouldson, A., Sudmant, A., Khreis, H., & Papargyropoulou, E. (2018). The Economic and Social Benefits of Low-Carbon Cities: A Systematic Review of the Evidence. *Coalition for Urban Transitions*. Retrieved from http://newclimateeconomy.net/content/cities-working-papers

Government of China. (2007). The State Council Circular regarding the establishment of the National Leading Group on Climate Change, Energy Saving And Pollution Reduction. Retrieved 7 May 2019, from http://www.ccchina.org.cn/Detail.aspx?newsId=28014&TId=60

Government of China. (2017). National Development and Reform Commission, China's Policies and Actions for Addressing Climate Change. Retrieved 12 August 2019, from http://en.ndrc.gov.cn/newsrelease/201711/P020171108521968689324.pdf

Government of China. (2018). The General Office of the State Council on adjusting the national response to climate change and Notice of the members of the leading group for energy conservation and emission reduction work State Office issued [2018] No. 66. Retrieved 7 May 2019, from http://www.gov.cn/zhengce/content/2018-08/02/content_5311304.htm

Government of Japan. (2007). Fundamental Structure of the Government of Japan. Retrieved 24 May 2019, from https://japan.kantei.go.jp/constitution_and_government_of_japan/fundamental_e.html

Government of Japan. (2018). Local Government SDGs. Retrieved 26 April 2019, from http://future-city.jp/sdgs/

Government of Korea. (2018). About Us. Retrieved 28 May 2019, from Ministry of Environment website: http://eng.me.go.kr/eng/web/index.do?menuId=6

Hart, C., Zhu, J., Ying, J. 2018. Mapping China's Climate and Energy Policies. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/786518/China_Climate_Map_Public_Secured_2019-3-1.pdf

Hart, C. A. (2019). *Implementing the Paris Agreement in the People's Republic of China*. 44.

Homsy, G. C., & Warner, M. E. (2015). Cities and Sustainability: Polycentric Action and Multilevel Governance. *Urban Affairs Review*, *51*(1), 46–73. https://doi.org/10.1177/1078087414530545

Hoornweg, D. (2012). Cities and climate change: An urgent agenda. In A. Baeumler, E. Ijjasz-Vasques, & S. Mehndiratta (Eds.), *Sustainable Low-Carbon City Development in China*. World Bank.

Hsu, A., Weinfurter, A. J., & Xu, K. (2017). Aligning subnational climate actions for the new post-Paris climate regime. *Climatic Change*, *142*(3–4), 419–432. https://doi.org/10.1007/s10584-017-1957-5

Hu, M., Yang, L., Cannan, A., Zhang, J., Ohshita, S., Chen, M., … Zhou, N. (2018). *Progress and Prospects: China's Cities Transitioning toward Energy Sustainability, and Pursuing Early Peaking of Carbon Emissions*. Retrieved from http://logic.igdp.cn/report.pdf

Hu, M. (Forthcoming). *Accelerating the transition from carbon emission intensity control to total control , leading the transformation of high-quality green development*. iGDP.

ICAP. (2019). *Korea Emissions Trading Scheme*. Retrieved from International Carbon Action Partnership website: https://icapcarbonaction.com/en/?option=com_etsmap&task=export&format=pdf&layout=list&systems%5B%5D=47

IEA. (2019). World Energy Balances. Retrieved 20 June 2019, from International Energy Agency website: https://www.iea.org/statistics/balances/

iGDP. (2015). *Low Carbon Cities in China: National Policies and City Action Factsheets*. Retrieved from http://www.efchina.org/Attachments/Report/report-cemp-20151020/iGDP_CityPolicyFactsheet_EN.pdf

iGDP. (2016). *Low-Carbon Cities in China: Alliance of Peaking Pioneer Cities Action Factsheet*.

iGDP. (2018). *Fact Sheet: China's Low-Carbon Cities Participation in Other Pilot Programs*. Retrieved from http://new.igdp.cn/wp-content/uploads/2018/07/2018-06-27-IGDP-

Fact-Sheet-EN-China%E2%80%99s-Low-Carbon-Cities-Participation-in-Other-Pilot-Programs.pdf

iGDP. (2019). *Low Carbon Policy in China: China Country Report (ESCAP commissioned background study)*.

IGES. (2019). *Low Carbon Policy in Japan: Japan Country Report (ESCAP commissioned background study)*.

Innovation Network for Communities, & CNCA. (2018). *Long-Term Deep Carbon Reduction Planning*. Retrieved from https://carbonneutralcities.org/wp-content/uploads/2018/04/CNCA-Framework-for-Long-Term-Deep-Carbon-Reduction-Planning.pdf

ITDP. (2014). BRT Database: Guangzhou. Retrieved 20 June 2019, from Institute for Transport and Development POlicy website: http://www.itdp-china.org/brt/city/?city_id=15&city_name=%E5%B9%BF%E5%B7%9E&lang=0

Japan Ministry of Economy, Trade, and Industry. (2018). Energy White Paper. Retrieved 20 June 2019, from Agency for Natural Resources and Energy website: https://www.enecho.meti.go.jp/about/whitepaper/2018html/2-1-1.html

Japan Ministry of Environment. (2011). Greenhouse Gas Emissions (Fixed Values) in FY 2009 (Information). Retrieved 20 June 2019, from Ministry of Environment website: https://www.env.go.jp/press/13722.html

Japan Ministry of Environment. (2014). Greenhouse Gas Emissions (Final Estimates) in FY 2014. Retrieved 20 June 2019, from Ministry of Environment website: https://www.env.go.jp/press/102377.html

Japan Ministry of Environment. (2018a). *History and development of Eco-Towns*.

Japan Ministry of Environment. (2018b). *Manufacturing and recycling network meeting for industries and regional symbiosis* (No. Document 4: Eco-Town Policies: A look back over 20 years.).

Japan Ministry of Environment. (2019). *Greenhouse Gas Emissions (Final Estimates) in FY 2017 (Information*. Retrieved from https://www.env.go.jp/earth/ondanka/ghg-mrv/sokuhou_zentaizu_2017.pdf

Kamal-Chaoui, L., Grazi, F., Joo, J., & Plouin, M. (2011). *The Implementation of the Korean Green Growth Strategy in Urban Areas* (OECD Regional Development Working Papers No. 2011/02). https://doi.org/10.1787/5kg8bf4l4lvg-en

KEI. (2019). *Low Carbon Policy in Korea: South Korea Country Report*.

Khanna, N., Fridley, D., & Hong, L. (2014). China's pilot low-carbon city initiative: A comparative assessment of national goals and local plans. *Sustainable Cities and Society*, *12*, 110–121. https://doi.org/10.1016/j.scs.2014.03.005

Kostka, G., & Nahm, J. (2017). Central–Local Relations: Recentralization and Environmental Governance in China. *The China Quarterly*, *231*, 567–582. https://doi.org/10.1017/S0305741017001011

Kuramochi, T. (2014). *GHG MITIGATION IN JAPAN: AN OVERVIEW OF THE CURRENT POLICY LANDSCAPE* (p. 40).

Lee, J.-S., & Kim, J. (2016). South Korea's urban green energy strategies: Policy framework and local responses under the green growth. *Cities*, *54*, 20–27. https://doi.org/10.1016/j.cities.2015.10.011

Lee, T., & Jung, H. Y. (2018). Mapping city-to-city networks for climate change action: Geographic bases, link modalities, functions, and activity. *Journal of Cleaner Production*, *182*, 96–104.

Lieberthal, K. (1997). *China's governing system and its impact on environmental policy implementation* [China Environment Series]. Retrieved from Wilson Center website: https://www.wilsoncenter.org/sites/default/files/CES%201%20Part%202.pdf

Liu, L., Matsuno, S., Zhang, B., Liu, B., & Young, O. (2013). Local Governance on Climate Mitigation: A Comparative Study of China and Japan. *Environment and Planning C: Government and Policy*, *31*(3), 475–489. https://doi.org/10.1068/c11246

Mahoney, J. (2007). Qualitative Methodology and Comparative Politics. *Comparative Political Studies*, *40*(2), 122–144. https://doi.org/10.1177/0010414006296345

Miyama City. (2009). *Global Warming Countermeasures Action Plan*.

Miyama City. (2016). *Realization of Smart Community Miyama*.

Miyama City. (2017). *Efforts of Miyama City for local energy production and consumption and smart community*.

Mori, M. (2018, November). *Initiatives of Eco-Model City Toyama: CO2 emission reductions through a compact city strategy*. Presented at the Open Seminar on "Initiatives to Create a Low carbon Society in Collaboration with the National Government, Toyama City.

Morotomi, T. (2018). *Easy Economics: Thinking about Compact Cities* [Nihon Keizai Shimbun, morning edition,].

NHK Television. (2018, June 28). *Revitalise towns with the local production and local consumption of electricity*. News Shibu 5.

Niederhafner, S. (2013). Comparing functions of transnational city networks in Europe and Asia. *Asia Europe Journal*, *11*(4), 377–396. https://doi.org/10.1007/s10308-013-0365-3

NRDC. (2017). *The road from Paris: Japan's progress toward its climate pledge.* [Data set]. https://doi.org/10.1163/9789004322714_cclc_2017-0016-022

OECD. (2010). *OECD Environmental Performance Reviews: Japan 2010*. Retrieved from https://read.oecd-ilibrary.org/environment/oecd-environmental-performance-reviews-japan-2010_9789264087873-en

OECD, & Bloomberg Philanthropies. (2014). *Cities and Climate Change: National Governments Enabling Local Action.* Retrieved from https://www.oecd.org/env/cc/Cities-and-climate-change-2014-Policy-Perspectives-Final-web.pdf

Ogata, T. (2008). *Environmental Administration in Japan and the Role of Local Governments*. Council of Local Authorities for International Relations.

Ohshita, S.B., L. Price, N. Zhou, N. Khanna, D. Fridley, and X. Liu. 2015. The role of Chinese cities in greenhouse gas emission reduction. https://www.osti.gov/servlets/purl/1237337

Rauland, V., & Newman, P. (2015). *Decarbonising cities: Mainstreaming low carbon urban development*. Cham: Springer.

Ren, Y. (2000). Japanese Approaches to Environmental Management: Structural and Institutional Features. *International Review for Environmentla Strategies*, *1*(1), 79–96.

RMI. (2017). *City Peaking Decarboniation Handbook*. Retrieved from Rocky Mountain Institute website: https://rmi.org/wp-content/uploads/2017/12/RMI_City_Peaking_Decarbonization_Handbook.pdf

Sandalow, D. (2018). *Guide to Chinese Climate Policy*.

Scholz, S., Rescalvo, M., Sugar, L., Lasa, M., D'Silva, N., Barrios, R., & Mata, J. (2014). *The low carbon city development program (LCCDP) guidebook : a systems approach to low carbon development in cities*. Washington, D.C.: World Bank.

Seol, T. K., & Kim, S. (2018). Korea Environment. Retrieved 28 May 2019, from Getting The Deal Through website: https://gettingthedealthrough.com/

Sofer, K. (2016). *Climate Politics in Japan*. Sasakawa USA.

Steger, I. (2017). South Korea is aging faster than any other developed country. Retrieved 19 June 2019, from Quartz website: https://qz.com/1066613/south-korea-demographic-time-bomb-its-aging-faster-than-any-other-developed-country-with-lowest-birth-rate-of-oecd-countries/

The Shift Project. (2019). The Shift Project Data Portal. Retrieved 20 June 2019, from http://www.tsp-data-portal.org/

Tokyo Metropolitan Government. (2018, March). *Overview of Tokyo Cap & Trade". First review meeting on technical matters on the implementation of the reduction obligation*.

Tominaga, S., & Hayashi, S. (2018). *Efforts on local production and consumption of renewable energy by local governments – Review of achievement and challenges so far for expanding the initiatives* [IGES Issue Brief September 2018].

Toyama City. (2012). *Construction of Toyama style urban management with compact city strategy -Towards sustainable and value creating city filled with social capital*.

Toyama City. (2016). *Members of the Japanese Communist Party. Urban area redevelopment projects in Toyama City*.

Toyama City. (2018). *Outline of the Urban Improvement Project, Toyama*.

Tsang, S., & Kolk, A. (2010). The evolution of Chinese policies and governance structures on environment, energy and climate. *Environmental Policy and Governance*, *20*(3), 180–196.

UNCRD. (2014). *Japanese Administrative System*. Presented at the UNCRD/AIT-VN Training Course on Management and Administration of Local Government Institutions for Bangladesh, Aichi, Japan. Retrieved from http://www.uncrd.or.jp/content/documents/1739Bangla%20Tra%202013_P1_Japanese%20Administrative%20System.pdf

UNDESA. (2017). *Republic of Korea: Public Administration Country Profile*. Retrieved from Division for Public Administration and Development Management website: http://unpan1.un.org/intradoc/groups/public/documents/un/unpan023315.pdf

UNDESA. (2018). *World Urbanization Prospects: The 2018 Revision: Key Facts*. Retrieved from Population Division website: https://population.un.org/wup/Publications/Files/WUP2018-KeyFacts.pdf

UNDP. (n.d.). *Defining a Sustainable Vision for The Future: Low Emission Development Strategies*. Retrieved from Low Emissions Capacity Building Programme website: http://www.lowemissiondevelopment.org/lecbp/docs/LECB_Thematic_Fact_Sheet_LEDs_FNL.pdf

UNEP. (2018). Emissions Gap Report 2018. Retrieved 20 June 2019, from UN Environment Programme website: http://www.unenvironment.org/resources/emissions-gap-report-2018

UNESCAP. (n.d.). *Case Study: Republic of Korea's Presidential Committee on Green Growth*. Retrieved from https://www.unescap.org/sites/default/files/36.%20CS-Republic-of-Korea-Presidential-Committee-on-Green-Growth.pdf

Van Berkel, R., Fujita, T., Hashimoto, S., & Geng, Y. (2009). Industrial and urban symbiosis in Japan: Analysis of the Eco-Town program 1997–2006. *Journal of Environmental Management*, *90*(3), 1544–1556. https://doi.org/10.1016/j.jenvman.2008.11.010

van der Ven, H., Bernstein, S., & Hoffmann, M. (2016). Valuing the Contributions of Nonstate and Subnational Actors to Climate Governance. *Global Environmental Politics*, *17*(1), 1–20. https://doi.org/10.1162/GLEP_a_00387

Wang, Y., Song, Q., He, J., & Qi, Y. (2015). Developing low-carbon cities through pilots. *Climate Policy*, *15*(sup1), S81–S103. https://doi.org/10.1080/14693062.2015.1050347

Westman, L., & Broto, V. C. (2018). Climate governance through partnerships: A study of 150 urban initiatives in China. *Global Environmental Change*, *50*, 212–221. https://doi.org/10.1016/j.gloenvcha.2018.04.008

Wiedenhofer, D., Guan, D., Liu, Z., Meng, J., Zhang, N., & Wei, Y.-M. (2017). Unequal household carbon footprints in China. *Nature Climate Change*, *7*(1), 75.

World Bank. (2019). World Bank Data. Retrieved 30 May 2019, from https://data.worldbank.org

WWF. (2010). *Reinventing the City*. Retrieved from http://assets.panda.org/downloads/wwf_reinventing_the_city_final_3_low_resolution.pdf

Yang, Y. (2017). Carbon Trading: "Shenzhen Model". Retrieved 20 June 2019, from http://www.tanpaifang.com/tanjiaoyi/2017/0620/59754.html

Ying, Q. (2013). *North-East Asian Cities: Moving Towards Low Carbon, Green Cities* [NEASPEC Working Paper]. UNESCAP.

Yoneyama, H. (2017). *Strategies of Scaled-down City Planning* (No. 444). Retrieved from Fujitsu Research Institute website: https://www.fujitsu.com/jp/group/fri/en/economic/publications/report/2017/report-444.html

Yuanping W., Hong R., Liang D., Hung-Suck P., Yuepeng Z., Yanwei X. Smart solutions shape for sustainable low-carbon future: A review on smart cities and industrial parks in China. Technological Forecasting & Social Change 144 (2019) 103–117

[i] Comparative analyses needs to strike a balance between systematic, large-N statistical analysis that identify generalizable trends or conclusions, and individual case studies that leverage the rich insights that can be drawn from close analysis of a single observation (Collier, 1991). The experiences of low carbon city development in the three countries vary reflecting their distinct histories, political systems, and socio-economic profiles. Due to such contextual variation, cross-case analysis attempted in this report is mostly drawn from similarities or differences among key variables to try and isolate causal effects (Mahoney, 2007). While not taking a specifically causal comparative approach, this section nonetheless draws on academic principles of comparative analysis and brings structure to bear upon the accounts of low carbon city development in China, Japan, and ROK described in the previous sections.