



A COMPARATIVE INFRASTRUCTURE DEVELOPMENT ASSESSMENT OF THE REPUBLIC OF KOREA AND THE KINGDOM OF THAILAND

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Foreword

Physical infrastructure plays a central role in economic growth, poverty reduction, and in the achievement of the Millennium Development Goals. According to the Asian Development Bank (ADB), the availability of basic infrastructure remains below minimally acceptable levels in most of Asia and the Pacific. An ADB study estimated that an investment of \$8 trillion over 2010–2020 would be required to update the region's energy, roads, water, and other infrastructure. Accordingly, as of 2011, more than one-half of ADB's lending has gone to infrastructure.

This study presents the outcome of a comparative assessment of the Republic of Korea and Thailand concerning their respective levels of infrastructure development for the period 2009–2010, with updates to 2013. The Republic of Korea and Thailand have both achieved rapid economic growth, reduced poverty, and made significant strides toward achieving the Millennium Development Goals, propelled largely by their investments in infrastructure. This drive was supported by strong longer-term planning, strategic frameworks, and far-reaching policy and institutional reforms. It is hoped that this study will help improve the understanding of the enabling environment necessary to enhance the provision of infrastructure.

As this study details, a unified approach toward achieving common objectives among all stakeholders and decision makers is critical for the successful implementation of a major infrastructure development program. Further, sufficient resources must be allocated for financing infrastructure investments. Infrastructure here covers (i) energy, (ii) transport, and (iii) water and sanitation. Experience in the Republic of Korea and Thailand suggests that infrastructure development must address the issues of intermodal balance in transport, regional and subregional connectivity, inclusive growth, energy use efficiency, water use efficiency, the water–energy–environment–food security nexus, and climate change. Infrastructure development must be approached in a way that will strike a balance among transport, energy, and water; and a balance within each sector (e.g., among modes of transport, between renewable and nonrenewable energy; and, with regard to water, between supply and demand, also quality and quantity).

The experience of the Republic of Korea demonstrates that a clear industrial policy can drive infrastructure policy. Infrastructure development is the means by which the country has built competitive industries for the global economy. In addition, the government, state-owned enterprises, and the private sector must coordinate with and complement one another to achieve maximum growth sustainably.



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Chong Chi Nai
Director, Energy Division
Southeast Asia Department

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Executive Summary

The economies of both the Republic of Korea and Thailand grew at impressive rates throughout the 1990s and 2000s. The Republic of Korea has experienced more rapid and intensive industrialization, while in Thailand the agriculture sector remains larger than manufacturing, which is concentrated in the Bangkok region. A combination of intensive investment in infrastructure, information and communication technology (ICT), and in human skills has been extraordinarily effective in growing the economy of the Republic of Korea. Meanwhile, in Thailand, the public sector undertook large investments in infrastructure in the 1990s and 2000s, but several issues emerged, among them numerous project delays. Further, the expressways and metro in Bangkok have contributed to a concentration of productive resources in and around the city, accentuating Thailand's regional imbalance in economic development.

In developing transport infrastructure, the Republic of Korea has been more focused and strategic than Thailand, where competitiveness is only one of several factors in determining investments. The Republic of Korea built expressways as major arteries (complemented by national highways) to connect cities, ports, and industrial complexes with high-quality direct links to reduce the logistics costs of exporting and importing. Thailand has instead used highways to achieve the broader objective of improved mobility and connectivity for all.

It is also clear that the rapid and pervasive application of ICT in other productive sectors in the Republic of Korea has improved competitiveness by reducing costs and enhancing efficiency. Energy sector investments in both countries have undoubtedly contributed to competitiveness by providing the electricity needed for production, services, and transport. Water supplies for manufacturing have also contributed directly to industrial growth in both countries.

During the 1990s and 2000s, the major share of infrastructure investment in the Republic of Korea and Thailand has been financed by the governments, directly or through state-owned enterprises (SOEs). Along with these public sources of finance, there has been a substantial amount of financing provided by private businesses. Most of the private investment in infrastructure has been through public–private partnerships (PPPs). The Republic of Korea has used PPPs for infrastructure investments in a wider range of sectors, and much more frequently, than has Thailand. While the Republic of Korea's promotion of PPPs has added substantially to public financing for infrastructure investment, it is difficult to establish the long-term cost to the government of the funds and risk sharing with which it has supported them.

During the 1990s and 2000s, as the economies of the Republic of Korea and Thailand developed, the patterns of demand for infrastructure changed, and so did the linkages between infrastructure and further economic growth. Political attitudes changed as well, influencing infrastructure investment by emphasizing social inclusion, private sector participation, and environmental sustainability. At the same time, the international context changed, increasing the prices and supply risks of fossil fuels and expanding public awareness of climate change induced by greenhouse gas emissions. Accordingly, there have been successive adaptations in the forms of infrastructure investment, in the policies underlying these investments, and in the pricing of infrastructure services. The situation is a dynamic one in both countries, and further changes are probable from 2010 onward. Ministers and their advisors will need to find the best courses of action to take in public policy, accepting political constraints but also offering leadership.

The governments of the Republic of Korea and Thailand recognize the importance of coordination, in planning and implementation, among the agencies responsible for infrastructure within and across sectors. However, their experiences have shown how difficult it is to utilize the agencies' specialized knowledge of their respective subsectors and, at the same time, maintain close and efficient interagency coordination. In general, interagency coordination must be prioritized because the setting of infrastructure investment priorities by a central authority is necessary to obtain the greatest benefit for given amounts of investment and to minimize waste. When it comes to coordinating within and among infrastructure sectors, the Republic of Korea has generally been more successful than Thailand. A related lesson is that it is preferable for each sector (such as energy) to have a single technical and economic regulator, rather than specialized regulators for each subsector (such as electricity, oil and gas, and nuclear energy).

The ICT sectors in the Republic of Korea and Thailand are unique in their high proportion of infrastructure investment from private companies. Both governments have played crucial roles in making policy, providing basic infrastructure, developing markets through their own demand, and regulating the industry, but they have not found it necessary to make the bulk of the investments. This has been the case, though to a lesser extent, in the downstream segments of the oil and gas industries in both countries (i.e., refining, distribution, and product sales). But the most appropriate mix of public and private finance and ownership of infrastructure is specific to each industry subsector, and dependent on the market structure chosen as the policy objective.

Further, active management of existing infrastructure assets—in terms of maintenance and utilization efficiency—is essential, but usually not given as much attention by the governments as new investment projects. The Republic of Korea has, in general, been more attentive to existing assets than have Thailand and most other middle-income countries of Asia.

This knowledge product offers recommendations regarding infrastructure development, both of a general nature and others specific to sectors in the Republic of Korea or Thailand.

Abbreviations

ADB	– Asian Development Bank
EGAT	– Electricity Generating Authority of Thailand
GDP	– gross domestic product
ICT	– information and communication technology
K-water	– Korea Water Resources Corporation
KEPCO	– Korea Electric Power Corporation
km	– kilometer
KOREC	– Korea Electricity Regulatory Commission
MRT	– mass rapid transit
OECD	– Organisation for Economic Co-operation and Development
OPEC	– Organization of the Petroleum Exporting Countries
PPP	– public–private partnership
R&D	– research and development
SOE	– state-owned enterprise



I. Infrastructure in the Republic of Korea and Thailand

A. Overview

The Republic of Korea and Thailand have achieved rapid economic growth, reduced their poverty rates, and made significant strides toward achieving the Millennium Development Goals, propelled largely by their investments in infrastructure. Conducted under a technical assistance from the Asian Development Bank (ADB), this study included an in-depth field review of infrastructure-investment-led growth in the Republic of Korea and Thailand, with the objective of gaining a better understanding of the enabling environment necessary to enhance such investment and concomitant growth (ADB 2010).¹ It examined the relationship among overall planning and strategy development, sector planning, fiscal planning, and infrastructure spending in both countries. It also reviewed (i) the impact of urban infrastructure development, (ii) the role of local and central government in infrastructure provision, (iii) the participation of private local and foreign investors, and (iv) the financing of infrastructure development. The study also explored the reasons why the Republic of Korea achieved the status of a developed country while Thailand was merely upgraded from a lower-middle-income to a higher-middle-income economy, a status it still had as of 2011. Given these developments, the question is what lessons can the Republic of Korea and Thailand learn from each other's experiences.

In geographical terms, the Republic of Korea and Thailand are starkly different. In land area, Thailand is five times the size of the Republic of Korea, and it has far more cropland (Table 1). Thailand's population is 34% larger, with a much lower population density: only about one-third live in urban areas, compared with more than four-fifths of the population in the Republic of Korea. Situated well north of Thailand, the Republic of Korea has long, severe winters, during which there is a large demand for space heating. In addition, the rivers in the Republic of Korea are not suitable for navigation, whereas those in Thailand are.

Thailand's economy has grown at an impressive rate, averaging over 7% annually from the 1960s to the mid-1990s, reflecting an expansion in both industry and agriculture. This was achieved through an emphasis on exports, infrastructure investments, conducive policies and institutions, and sound

¹ This study was conducted in 2009–2010, with figures updated through to 2013 following workshops in Bangkok in 2011 and Seoul in 2012; and provision of 2013 data by government and private institutions. "Infrastructure" as used in this study covers transport, information and communication technology, energy, and water and sanitation.



Table 1 Physical Indicators, Republic of Korea and Thailand, 2011

	Republic of Korea	Thailand
Land area (square kilometers)	97,100	510,890
Permanent cropland (% of land area)	2.1	8.8
Population (million)	49.8	66.6
Population density (people per square kilometers of land area)	512.7	130.3
Urban population (% of total)	83.2	34.1
Population growth (annual %)	0.7	0.3

Source: World Bank. 2011.

macroeconomic management. However, a severe downturn occurred during the 1997–1998 Asian crisis, when over 2 million people were laid off in Bangkok alone. During the Eighth Five-Year Plan² (1997–2001), the economy contracted from 1997 to 1998, and then recovered weakly from 1999 to 2001, with annual growth averaging 4.2%. Then the economy bounced back, with a growth rate averaging close to 6.0% annually during the Ninth Plan, 2002–2006. In 2008 and 2009, Thailand faced the global financial crisis, during which export demand contracted and domestic political turmoil occurred. In late 2011, floods covered a large portion of the country, taking lives, destroying physical capital, and halting production. In 2009, the economy shrank by more than 2.0%, then recovered in 2010, growing by 7.5%. Data from ADB’s Statistical Database System (ADB 2011) and the World Development Indicators database (World Bank 2011) show that in 2011, the economy showed virtually no growth at all, but it recovered again in 2012, registering a growth of 6.4% for that year.³

Large public sector investments in infrastructure have been undertaken since the 1990s in Thailand, and 5-year plans have frequently included the goal of extending roads and other infrastructure to promote development throughout the country. But various factors have hindered the achievement of this goal, such as changes in priorities regarding the types of infrastructure to be developed; delays in project execution; and variations in the efficiency with which infrastructure, once built, has been managed. In addition, the expressways and metro system in Bangkok have helped it grow into a megacity, but have also led to a concentration of productive resources in the metropolitan area, exacerbating Thailand’s regional imbalance in economic development.

Since the Eighth Five-Year Plan, the government has embraced the concept of the “sufficiency economy,” a holistic, people-centered approach to development that seeks growth and modernization

² These plans are 5-year plans, with the first one covering the period 1961–1966. The plans outline the government’s commitment to fulfilling the country’s social development and national development needs for the next 5 years. In the eighth plan, the government prioritized human development and the replacement of top-down administration with bottom-up processes.

³ Changes in Thailand’s system of national accounts delayed the generation of ADB figures for 2011 comparable to those for previous years. In the World Bank’s World Development Indicators, Thailand’s annual gross domestic product (GDP) growth was given as 7.8% in 2010, 0.1% in 2011, and 6.4% in 2012.

while preserving self-reliance, the environment, social harmony, and family values.⁴ The Eleventh Plan, 2012–2016 includes the aim of economic resilience, which is reflected in its pursuit of food and energy security; a wider geographical spread of investments; and higher-quality infrastructure services, including better logistics management.

The Republic of Korea's economy has been one of the fastest growing in the world. The country industrialized rapidly, to the extent that manufacturing represents over 35% of its gross domestic product (GDP); and open commercial policies have boosted trade volumes to 80%–90% of GDP. The country had an average annual growth rate of over 8% before it was hit by the 1997–1998 Asian crisis, but the government's response included both stabilization and far-reaching reform measures. Thus, the Republic of Korea transformed itself from a poor developing country in the 1950s to an economy with a GDP per capita of \$30,722 in 2012.⁵ After the global financial crisis, prudent economic management and effective stimulus policies restored GDP growth to 6.3% in 2010, although it has been more modest since then.⁶

The Republic of Korea has succeeded more in terms of GDP growth than many other middle-income countries in Asia, including Indonesia, Malaysia, the Philippines, and Thailand. The country's high ratio of investment to GDP, including investment in physical infrastructure, has been a key factor.⁷ The Republic of Korea has also made concerted investments in information and communication technology (ICT) and in education and skills upgrading.

The Republic of Korea's industrialization for export focused first, in the 1960s, on light labor-intensive manufacturing (e.g., textiles); in the late 1960s and 1970s, on heavy and chemical industries (e.g., oil refining, fertilizers, other chemicals, cement, iron and steel, and machinery); in the 1980s and 1990s, on technology-intensive industries, such as electronics (e.g., televisions and video cassette recorders), semiconductors, automobiles, and other precision machinery; and in the late 1990s and 2000s, on even more technology-intensive goods and services (e.g., bioengineering, microelectronics, fine chemistry, and aerospace). The Republic of Korea has also been dedicated to the development of green technologies, renewable energies, the efficient use of resources and materials, sustainable transport, green buildings, and ecosystem restoration. At all stages, the country's industrialization has been based on the adaptation of modern technologies through research and development (R&D), and on a continuous improvement of labor productivity through vocational education and technical training. It has therefore given a prominent place to investment in ICT infrastructure and to ICT applications for other infrastructure services.

⁴ This philosophy calls for balance at all levels, from family to national. On the national level, it refers to good governance. For the private sector, it means reliance on local materials and wisdom, and the cost-effective production of eco-friendly products. For agriculture, it means the application of King Bhumibol Adulyadej's "New Theory" to generate sufficient incomes for farmers. On the community level, it encourages popular participation; while in families, it implies improved relationships, and income and housing security. See Government of Thailand (2010b).

⁵ This is in terms of purchasing power parity, in current US dollars (see World Bank 2011).

⁶ The World Development Indicators gives the Republic of Korea's annual GDP growth as 3.7% in 2011 and 2.0% in 2012.

⁷ According to ADB's Statistical Database System, gross domestic capital formation averaged 30.8% of GDP from 1994 to 2011. Unfortunately, there is no published series of figures for investment in infrastructure.

The Republic of Korea's successive governments have led its economic development, and infrastructure investment, through consecutive 5-year plans. Every plan was a foundation for the next; and the country moved through stages of industrialization, each one focusing on the types and locations of infrastructure needed. For example, the Ten-Year Comprehensive National Physical Plan, 1972 included the development of major industrial estates, new deep-water harbors along the southeastern coast, and new ports in Incheon and Busan. The private sector has cooperated actively with the 5-year plans, particularly through the *chaebols* (large conglomerate firms, originally family-controlled, characterized by strong ties with government agencies).

In August 2008, then President Lee Myung-bak proclaimed “Low Carbon, Green Growth” as the Republic of Korea's new national vision. The government formed an interministerial committee on the United Nations Framework Convention on Climate Change, headed by the prime minister; and for 4 years conducted the Presidential Commission on Green Growth, which promoted eco-friendly growth engines for the economy, until its responsibilities were absorbed by various ministries. The Republic of Korea became the first country in the world to legislate for green growth when its Framework Act on Low Carbon, Green Growth went into force in April 2010. This framework includes a mandate for establishing a national inventory of greenhouse gas emissions, a target of reducing the country's emissions in 2020 by 30% (compared with a business-as-usual scenario), and a requirement for the government to develop a system of emissions trading. It also includes a 5-year commitment to invest 2% of GDP each year in areas such as green technologies, resource and material use efficiency, renewable energies, sustainable transport, green buildings, and ecosystem restoration.

B. Transport

Improvements in a country's transport infrastructure will help facilitate domestic and international commerce. Therefore, the construction of infrastructure will contribute to output and income (as measured in GDP) not only immediately, as the infrastructure is being built, but also subsequently, throughout its lifetime of use. Efforts to measure these contributions in the Republic of Korea and Thailand have indicated (subject to methodological differences) that the contributions of transport investment to growth have been greater in the Republic of Korea than in Thailand. In both countries, the expansion of highways to serve cities and seaports has been accompanied by the building or paving of rural roads as feeders for the highway system, and by the construction of new urban roads as towns and cities grew.

Since 1980, the Republic of Korea has developed all forms of transport infrastructure. It has more than 3,000 kilometers (km) of expressways linking its cities, industrial zones, and seaports. The government continued to develop railways through the 1980s, 1990s, and 2000s, complementing the growth of highway transport. City subway systems and high-speed passenger services on intercity routes have also maintained rail's share of passenger traffic (Table 2).

Table 2 Transport Indicators, Republic of Korea and Thailand, 2011

	Republic of Korea	Thailand
Road density (km of road per 100 square km of land area)	1,053 ^a	352 ^b
Motor vehicles (per 1,000 people)	363 ^c	157 ^c
Road sector energy consumption (% of total energy consumption)	11.4 ^c	16.5 ^c
Road sector energy consumption per capita (kg of oil equivalent)	575.6 ^c	291.0 ^c
Rail lines (total route, km)	3,379	4,429
Railways, goods transported (million ton-km)	9,996	2,455
Railways, passengers carried (million passenger-km)	21,603	7,504
Carbon dioxide emissions from transport (% of total fuel combustion)	15.4 ^c	22.3 ^c

kg = kilogram, km = kilometer.

^a 2007.

^b 2006.

^c 2010.

Source: World Bank. 2011.

Thailand built an impressive national road network within a relatively short period, and has developed large modern seaports and airports. But it has neither expanded nor modernized its rail network, and has developed its intermodal and logistics facilities only to a limited extent. Expressways in Thailand have mainly served to relieve traffic congestion within Bangkok. In the 2000s, domestic freight volumes grew only modestly, and there was little change in the shares of transport modes, with road transport continuing to dominate (except for international freight, with maritime transport used for about 90%). In Bangkok and its vicinity, according to data gathered by the Ministry of Transport in 2008, the shares of transport modes were van and private bus, 66%; bus, 23%; mass transit, 9%; and boat, 2% (see Termpittayapaisith 2009).

Bangkok's light-rail mass rapid transit (MRT) was introduced in the late 1990s, and expanded in the 2000s. Elsewhere, Thailand's railway operations have declined in efficiency and service standards, with aging tracks, signals, and rolling stock; declining punctuality; and a rising accident rate. However, a development plan approved in April 2010 promises modernizations such as the addition of high-speed trains and more multimodal facilities.

The dominance of roads in freight transport raises questions about efficiency, although recently rail's shares of budget allocations for transport have been significant in the Republic of Korea. A comparison of the unit costs of transport modes indicates a markedly higher cost of road transport in Thailand, and a lower cost of rail transport.⁸ Another comparison indicates that during

⁸ Data from the Government of Thailand (2010a and 2010c) and the Republic of Korea's Ministry of Land, Transport and Maritime Affairs as well as Korea Rail Corporation show that in US dollar equivalents, during the late 2000s, the cost per ton-kilometer (ton-km) of road transport was \$0.061 in Thailand, compared with \$0.036 in the Republic of Korea. Meanwhile, the cost per ton-km of rail transport was \$0.033 in Thailand, compared with \$0.042 in the Republic of Korea.

2000–2008, logistics costs were about one-third lower in the Republic of Korea than in Thailand. This probably reflects the Republic of Korea's greater geographical concentration of production, as well as its lower unit costs of road transport.

In both countries, transport accounts for 30% or more of overall energy use, reflecting the high energy intensity of road traffic, the dominant form of transport. However, in the Republic of Korea, there have recently been some changes in the mix of transport modes. In the 1990s and 2000s, passenger traffic by road declined by about one-quarter, while freight traffic by road grew 2.8 times. The decline in road passenger traffic was partly due to a near doubling of passenger traffic on railways, triggered by the introduction of high-speed intercity service and the expansion of urban subways. In contrast, freight traffic by rail declined by one-third during this period, mainly because of competition from road transport.⁹

Thailand's Suvarnabhumi Airport and the Republic of Korea's Incheon International Airport are frequently used transit points for long-haul flights. Airports relying on domestic traffic have fared indifferently in terms of both passenger and cargo movements, mainly because of competition from road transport and, in the Republic of Korea, from high-speed rail as well.

The development of seaports has played a critical role in both countries, as they have made large investments in establishing, expanding, and modernizing their port facilities. Both have recently focused on one principal deep-sea port, complemented by other seaports and river ports. Thailand has 1,750 km of navigable inland waterways, extensively used and with a potential for further development; the Republic of Korea has hardly any river or canal transport.

C. Information and Communication Technology

E-infrastructure is increasingly recognized as an important pillar of human development, and the Republic of Korea's early venture into this area has transformed it into one of the most ICT-integrated economies in the world, helping it to recover faster from the Asian financial crisis. It now boasts one of the world's most vibrant ICT industries, which provides infrastructure and ICT equipment for export and for the domestic market, including the government, businesses, and households; as well as services, including the development of software and content. Thailand has also seen substantial growth in its ICT exports, domestic market, and uses of ICT, although not as rapidly or on as large a scale as in the Republic of Korea (Table 3).

In both the Republic of Korea and Thailand, the adoption of cellular phones has been rapid. According to figures from the International Telecommunication Union, in the last few years the number of cellular phone subscriptions per capita in Thailand has overtaken those in the Republic of Korea (Table 4). Regarding the use of internet and fixed broadband connections,

⁹ Official communication, Ministry of Land, Transport and Maritime Affairs, Government of the Republic of Korea.

Table 3 Information and Communication Technology Goods and Service Exports, Republic of Korea and Thailand, Selected Years

	2000	2005	2010	2011	2012
Republic of Korea					
ICT goods exports (% of total goods exported)	34.5	30.0	21.4	18.0	...
ICT service exports (% of total service exports)	...	19.9	20.2	20.4	21.6
Thailand					
ICT goods exports (% of total goods exported)	28.7	23.4	18.9	15.6	...
ICT service exports (% of total service exports)	...	25.7	20.5	17.1	16.3

... = data not available, ICT = information and communication technology.

Source: World Bank. 2011.

Table 4 Cellular Phone Subscriptions per 100 Inhabitants, Republic of Korea and Thailand, Selected Years

	2000	2005	2010	2011	2012
Republic of Korea	58.3	81.5	105.4	108.5	110.4
Thailand	4.8	45.7	103.8	116.3	120.3

Source: International Telecommunication Union. 2012.

Table 5 Internet and Broadband Connections, Republic of Korea and Thailand, 2012

	Percentage of Individuals Using the Internet	Fixed (Wired) Broadband Subscriptions	
		Total (millions)	Per 100 Inhabitants
Republic of Korea	84.1	18.3	37.6
Thailand	26.5	4.4	6.2

Source: International Telecommunication Union. 2012.

the Republic of Korea is far ahead of Thailand (Table 5). Indeed, in its average speed of fixed broadband connections, the Republic of Korea was the world leader as of early 2012 (International Telecommunication Union 2013).

Progress in ICT in both countries has been accompanied by wide differences in usage based on age, income level, and region. In the Republic of Korea in 2008, internet usage differences were estimated as follows: (i) high-income, 87.4%; low-income, 52.8%; (ii) general population, 76.3%; rural areas, 33.4%; (iii) young (20s), 99.3%; over-50s, 34.1%; and (iv) nondisabled persons, 76.3%; disabled persons, 49.9% (Nam 2008). In Thailand in 2004, the rates of computer ownership, cellular phone use, and internet use were markedly lower in the central region and northeast (i.e., generally poorer areas) than in the country as a whole (Thuvasetthakul 2006).

D. Energy

Since the 1980s, Thailand's 5-year plans have combined the long-standing objective of energy system expansion by major state-owned enterprises (SOEs) with the additional goals of increased competition, more participation by the private sector, and environmental sustainability. Private sector investments have been sought, in particular, for electricity generation, oil refining, petrochemicals, and related industries. In addition, emphasis has been placed on developing domestic petroleum and coal resources, and on energy cooperation with neighboring countries. The Government of Thailand also promotes renewable energy resources, within constraints reflecting their much higher cost, for electricity generation, over fossil fuel resources (coal, oil, and gas). After its establishment in 2007, the Energy Regulatory Commission of Thailand instituted the Power Development Fund to finance subsidy programs for renewable energy projects.

The Republic of Korea has greatly expanded its energy sector to support industrial development and other forms of economic growth, but this has led to a heavy dependence on imported oil. For decades, the government has sought to reduce the share of oil in the country's total energy consumption, and to encourage energy efficiency and conservation. In the 2000s, its consumption of oil was held broadly constant, while consumption of liquefied natural gas and coal grew strongly (International Atomic Energy Agency 2011). Nevertheless, in 2011 oil still accounted for 38.2% of the Republic of Korea's primary energy consumption, with coal at 30.3%; liquefied natural gas, 16.8%; nuclear energy, 11.7%; and hydropower and other sources, 3.0% (Korea Energy Management Corporation 2011). The National Energy Basic Plan, 2008–2030 and the Five-Year Plan for Green Growth, 2009–2013 reflect the national vision of green growth and the commitment to spend 2% of GDP annually on green-growth programs.

Both countries rely heavily on fossil fuels, but Thailand has developed large amounts of its own oil and gas resources (Table 6). Its proportion of imported energy fell from 44% in 2005 to 39%–40% in 2008–2010, while the proportion for the Republic of Korea during the 2000s remained at or just above 80% (World Bank 2011). The Republic of Korea uses energy on a much larger scale than Thailand, and has remained much more reliant on energy imports. Further, the Republic of Korea uses nuclear reactors for a substantial amount (30% in 2010) of electricity generation (International Energy Agency 2012); while Thailand makes greater use of renewable energy sources—nearly 7% of electricity generation during 2006–2009 (World Bank 2011).

Table 6 Energy Indicators, Republic of Korea and Thailand, 2012

	Republic of Korea	Thailand
Energy production (mtoe)	44.9	530.4
Net imports (mtoe)	221.1	70.6
Electricity consumption (terawatt-hours)	481.5	155.1
Electricity consumption (kilowatt-hours) per capita	9,851	2,243

mtoe = million tons of oil equivalent.

Source: International Energy Agency. 2012.

In both countries, electricity consumption increased rapidly in the 1990s and 2000s. The rates of increase moderated in both countries in the 2000s, but more markedly in the Republic of Korea than in Thailand. Energy use in the Republic of Korea increased by 102% from 1990 to 2000, but by only 33% from 2000 to 2010, whereas in Thailand the corresponding increases were 73% and 62% (Table 7).

Table 7 Energy Use, Republic of Korea and Thailand, 1990–2010 (million tons of oil equivalent)

	1990	1995	2000	Ratio of 2000 to 1990 (%)	2005	2010	Ratio of 2010 to 2000 (%)
Republic of Korea	93.1	144.8	188.2	202	210.2	250.0	133
Thailand	41.9	61.9	72.3	173	99.2	117.4	162

Source: World Bank. 2011.

Given the increases in energy use in both countries through the 1990s and 2000s, and the high proportions of fossil fuels in their energy sources, it follows that emissions of carbon dioxide continued to grow (Table 8). In absolute and per capita terms, the Republic of Korea's carbon dioxide emission levels are much higher than Thailand's. In both countries, however, emission levels per capita were stable in 2007–2009.

Table 8 Carbon Dioxide Emissions, Republic of Korea and Thailand, 2005–2009

	2005	2006	2007	2008	2009
Republic of Korea					
Carbon dioxide emissions (thousand tons)	462,918	470,806	495,837	508,052	509,376
Carbon dioxide emissions (tons per capita)	9.6	9.7	10.2	10.4	10.4
Thailand					
Carbon dioxide emissions (thousand tons)	275,164	283,987	275,634	283,723	271,721
Carbon dioxide emissions (tons per capita)	4.1	4.2	4.1	4.2	4.0

Source: World Bank. 2011.

The Republic of Korea's ratio of GDP to energy use, after declining in the 1990s, rose steadily from 2000 to 2007, indicating an improvement in aggregate efficiency in the use of energy. Active government measures to promote efficient energy use played a large part, and the ratios remained relatively high through 2011 (Table 9). These measures include special tax treatment, low-interest loans for installing energy-saving facilities, regional energy planning, voluntary agreements with industry, development of energy-service companies, promotion of mass transit, fuel economy standards for motor vehicles, efficiency standards and labels for household appliances, and the

promotion of district heating. Through these measures, the government intends to reduce the energy intensity of aggregate output (measured in tons of oil equivalent per \$1,000 equivalent of GDP) from 0.317 in 2009 to 0.290 in 2013, and to 0.233 in 2020.

In Thailand, the ratio of GDP to energy use declined through the 1990s and early 2000s; and from 2002 to 2010, it remained around the same level, which was substantially lower than in the Republic of Korea (Table 9). However, the Energy Efficiency Development Plan, 2011–2030 was formulated with a target of reducing energy intensity 25% by 2030, from the level in 2005, the equivalent of reducing final energy consumption 20% by 2030. The Energy Conservation Promotion Act (No. 2) of 2007 authorizes regulations containing energy efficiency standards for factories, buildings, machinery, and equipment, as well as the operation of an energy conservation promotion fund.

Table 9 Gross Domestic Product per Unit of Energy Use, Republic of Korea and Thailand, Selected Years
(constant 2005 PPP dollars per kg of oil equivalent)

	1990	1995	2000	2002	2004	2006	2007	2008	2009	2010	2011
Republic of Korea	5.2	4.9	4.7	4.9	5.1	5.2	5.5	5.5	5.4	5.3	5.3
Thailand	5.5	4.8	4.8	4.5	4.4	4.6	4.7	4.7	4.6	4.5	4.5

kg = kilogram, PPP = purchasing power parity.

Source: World Bank. 2011.

In both countries, economic development has caused changes in the sector mix of energy use. Manufacturing, mining, other industries, and transport have increased their shares, with corresponding reductions in residential use. By the mid-2000s in Thailand, manufacturing and mining accounted for more than one-third of final energy consumption, and so did transport, with residential, commercial, and agricultural users accounting for the rest. By the late 2000s in the Republic of Korea, industry accounted for nearly 60% of final energy consumption, transport for about 20%, and residential and commercial users for about 20%.

Thailand's electricity supply system performs well by regional standards in terms of voltage fluctuations and frequency and duration of supply interruptions. There is a comfortable reserve margin (i.e., generation capacity in excess of maximum demand) of 15%. System losses, both technical and nontechnical, are less than 4% in the primarily urban franchise area, and less than 5% in the franchise area including rural communities. As for the Republic of Korea, while increasing its generation capacity in line with its rapid economic growth, it has improved supply reliability. Blackout time (total of blackouts of 5 minutes or more) was reduced from 21.6 minutes in 2000 to 18.6 minutes in 2005, and to 15.2 minutes in 2010.

E. Water and Sanitation

In the 1990s and 2000s, both governments made substantial investments to expand their water supply and wastewater treatment systems, in cooperation with local governments. In the Republic of Korea, investments were also made with the private sector through public–private partnerships (PPPs) in wastewater treatment. Water supply coverage in urban areas is nearly complete in the Republic of Korea and Thailand, while in rural areas coverage averaged 71% in the Republic of Korea and 97% in Thailand. Coverage of modern wastewater treatment is extensive in both countries, but the Thai system has many operational deficiencies.

In Thailand's development plans during the 1960s and 1970s, investments in water—both for irrigation in rice-growing areas and for domestic water supplies—were allocated large shares of government expenditure. Expansion of irrigation has continued, but since the 1980s it has been accompanied by a greater emphasis on rationalizing water allocation to help drain polluted water and prevent saline water intrusion in Bangkok.

Successive national plans have also included standards for water pricing, and have advocated integrated water resources management at the basin level, water use efficiency in agriculture, the polluter-pays principle,¹⁰ and private sector participation in local water supply. However, there have been difficulties in coordinating the more than 30 government agencies with responsibilities in the water sector; and decisions on the levying of sanitation fees have been left to local governments, many of which have not introduced or enforced them.

Thailand's agriculture sector is still the main user of water. The country has ceased being a primarily agricultural country, as its manufacturing and service industries have grown; in 2014 agriculture accounts for only about 10% of GDP. Yet because of extensive irrigation, the agriculture sector's share of water use is about 95%, while demand for water from other sectors and domestic users is increasing. Groundwater extraction is at levels that cause environmental problems, including land subsidence. Other water-related environmental issues are pollution from organic and factory waste, salinity, deforestation, soil erosion, and flooding.

There have been widely varying estimates of the efficiency of Thailand's irrigation system.¹¹ A study conducted in 1995–1998, covering the wet and dry seasons in two major basins, estimated that irrigation efficiency averaged 39% in the Chao Phraya irrigation area and 43% in the Mae Klong irrigation area. A government study during the dry season of 2009–2010 produced estimates of efficiency ranging from 50% to 75% for different regions of the country.¹²

¹⁰ This is a practice in which those who produce pollution are held responsible for bearing the costs of managing it so as to prevent damage to human health and the environment.

¹¹ Measures of irrigation efficiency refer to both system efficiency (i.e., how much of the water diverted at its source reaches the crops) and to application efficiency (i.e., how well the water that reaches crops corresponds to their requirements). Irrigation efficiency in the Asia and Pacific region is generally low, at about 30%.

¹² Official communication, Bureau of Hydrology and Water Management, Royal Irrigation Department, Government of Thailand.

The Republic of Korea's water quality management system developed in response to the stresses of economic development. In 1961, the government enacted the Water Supply Act, in 1963 the Pollution Prevention Act, and in 1966 the Sewerage Act. The institutions established under these laws to monitor and ensure compliance evolved into the Pollution Management Bureau and the National Institute of Environmental Research, which conducts research and analysis regarding water quality. The Environmental Protection Act of 1987 specifies water quality standards for each region.

No sewage treatment plants existed in the Republic of Korea prior to 1989, and in the 1980s problems associated with industrial and domestic wastewater became national issues, as accidents occurred and environmental conditions deteriorated. In 1989, in response to heavy metal pollution in the Nakdong River, the government initiated six major programs for water quality restoration, including the establishment of wastewater treatment plants.

The national utility, Korea Water Resources Corporation (K-water), has developed an effective nationwide system for managing water resources. A key part of the system is a set of special laws adopted in 1998 for the country's four main river basins. These laws promote cooperation with local governments; put controls on land use in waterside areas and upper limits on pollutants; and allow the taxation of downstream beneficiaries of upstream facilities, with the revenues supporting residents in watershed and waterside areas. Nevertheless, with water demand growing and the construction of large dams unlikely to proceed, the Republic of Korea faces challenges in balancing the supply of and demand for water.

The "Green Growth" approach, adopted by the Republic of Korea in 2008, focuses on the treatment of water to enhance its quality; the development of advanced water management technologies; installation of water control infrastructure to help prevent flooding; improvement of sewerage systems; and supplementary sources of water, such as rainwater, desalination, and the reuse of wastewater. The government has a range of targets for 2015, including the reduction of stream water intake to below 40%, the achievement of stream water quality of 60%, a water service ratio of 90%, sewerage system ratio of 90%, leakage ratio reduction to 10%, wastewater discharge reduction to 326 liters per person per day, and industrial water recycling rate increase to 60%.

The Republic of Korea's estimated irrigation efficiency of 65% indicates above-average performance. It uses auto-irrigation systems, with electronic measurement of soil moisture and irrigation flows, to ensure the accurate and uniform use of irrigation water, with low labor costs.

II. Institutional Arrangements

A. Transport

Overarching authority for transport policy and administration in Thailand lies with the Ministry of Transport, which oversees a set of subsector government agencies and SOEs. Regarding roads, the ministry's Department of Highways is responsible for the development and construction of intercity motorways and national highways, and for their maintenance and management. The Department of Rural Roads is responsible for the development, construction, maintenance, and management of rural roads. The Expressway Authority of Thailand is responsible for the development and regulation of Bangkok expressways, and shares the responsibility of operation with a concessionaire. The operation of some tollways is delegated to the private sector. Local roads are under the jurisdiction of local administrations. The Department of Land Transport oversees the regulation and monitoring of bus operators and vehicle safety.

The State Railway of Thailand is responsible, under the Ministry of Transport, for the development, construction, and operation of railways. Furthermore, the Department of Civil Aviation regulates air transport. Airports of Thailand is responsible for the construction, maintenance, and operation of major airports, while the Department of Civil Aviation fulfills these responsibilities for domestic airports.

The Marine Department is responsible for the regulation of inland and coastal waterways, seaports, and river ports. The Port Authority of Thailand, an SOE under the Ministry of Transport, is responsible for the construction, maintenance, and overall management of the five central and regional ports in Thailand—Bangkok, Chiang Khong, Chiang Saen, Laem Chabang, and Ranong. The Marine Department has similar responsibilities for the smaller ports, while the private sector operates several port facilities.

Generally, the government agencies in each subsector act as regulators, as well as manage the provision of necessary infrastructure. SOEs usually provide transport services, but in some subsectors they also provide infrastructure.

In the Republic of Korea, the Ministry of Land, Infrastructure and Transport has ultimate responsibility for all modes of transport. However, compared with those in Thailand, the SOEs here play a greater role in developing and building transport infrastructure—within the framework of government planning, policy, and budgeting—and in regulating operations. The main transport SOEs have been successfully corporatized. In many respects, they act like commercial entities, although with varying degrees of reliance on government subsidies.

Korea Expressway Corporation is responsible for the construction, maintenance, and operation of all expressways. The country's 18,000 km of provincial roads and 50,000 km of county and city roads are constructed and maintained by the Regional Construction and Management Administration.

Separate state agencies are responsible for the construction and operation of railways. Construction is managed by the Korea Railway Network Authority, while operation and maintenance are the responsibility of the Korea Rail Corporation (Korail). Korail is the older and larger enterprise, with 30,000 employees, compared with only 1,500 employees in the Korea Railway Network Authority. Coordination between them, notably over station area development, has proven difficult. Research is the responsibility of the Korea Railway Research Institute.

There are four subway operators in Seoul, including one private company, Seoul Metro Line 9 Corporation, a joint venture between Veolia Transportation and Hyundai Rotem. The other subway operators in Seoul are Korail and two more SOEs: Seoul Metro and Seoul Metropolitan Rapid Transit. In other cities, a single SOE operates the subway system.

An SOE, Incheon International Airport Corporation, is responsible for the airport's construction and operation, while other airports are under the control of another SOE, Korea Airports Corporation. SOEs are also responsible for the design, construction, and maintenance of major port infrastructure in the Republic of Korea.

B. Information and Communication Technology

In Thailand, the National Information Technology Committee and the National Electronics and Computer Technology Center develop and monitor ICT policy, while the Budget Bureau provides funds. Government ministries are the implementers, especially the Ministry of Information and Communication Technology and the Ministry of Science and Technology. The regulators are the National Telecommunications Commission and the National Broadcasting and Telecommunications Commission.

To make ICT a key driver of development, the Government of the Republic of Korea created the Ministry of Information and Communication in 1994 and designated the National Computerization Agency as the primary ICT policy and technical support agency in the country. Later, it formed the Informatization Promotion Committee (1996), chaired by the Prime Minister, and the Informatization Strategy Meeting (1998), chaired by the President. This high-level guidance has helped government agencies to harmonize their ICT strategies and policies.

C. Energy

Thailand's Ministry of Energy supervises all energy subsectors, which were previously the responsibility of different ministries. The Energy Policy and Planning Office, within the Ministry of Energy, oversees energy sector policy formulation and strategic planning. It also serves as the secretariat of the National Energy Policy Council, which is headed by the Prime Minister and includes ministerial representatives of other sectors, including transport, industry, and agriculture. A recently established department in the Ministry of Energy covers nuclear energy. The Department of Alternative Energy Development and Efficiency oversees new and renewable energy sources, energy efficiency, and conservation. The electricity distribution companies are under the administrative control of the Ministry of Interior, as they provide a social service.

The responsibility for regulating the energy sector in Thailand is divided between the Energy Regulatory Commission and Department of Energy Business. The Energy Regulatory Commission was established in 2007 with an extensive, diverse mandate covering the technical and economic regulation of the electricity and gas subsectors. However, its independence and institutional capacity are debatable. The Department of Energy Business oversees the technical regulation of the midstream and downstream parts of the oil subsector. It monitors and regulates quality and safety standards for compressed natural gas, liquefied petroleum gas, liquid fuels, and strategic petroleum reserves. The safety of radioactive waste material is regulated by the Office of Atoms for Peace, in the Ministry of Science and Technology, and by the Department of Medical Science, in the Ministry of Public Health, under the Thai Atomic Energy Commission. The Radioactive Waste Management Division, in the Office of Atoms for Peace, is the central radioactive waste management unit.

In the electricity subsector, the institutional structure reflects measures taken in the 1990s and early 2000s to introduce competition. Generation capacity is owned partly by the Electricity Generating Authority of Thailand (EGAT), and partly by two corporatized EGAT subsidiaries, private companies that were new entrants under build–own–operate schemes, independent power producers, small power producers, and very small power producers. EGAT remains the largest generator, with monopoly power in buying electricity from other generators for its transmission system, with the one exception that small and very small power producers are allowed by law to sell to customers directly connected to their power plants. There are two SOEs responsible for distribution, the Metropolitan Electricity Authority (for Bangkok and two nearby provinces) and the Provincial Electricity Authority (for other, mainly rural, areas). However, EGAT does sell a small part of its output (2%) directly to customers.

The Metropolitan Electricity Authority, EGAT, and the Provincial Electricity Authority are full SOEs. EGAT has two subsidiaries, the Electricity Generating Holding Public Company and Ratchaburi Electricity Generating Holding Company. While the Electricity Generating Holding Public Company is a publicly listed firm, with 25% of its shares held by EGAT and the rest by a range of investors, the Ratchaburi Electricity Generating Holding Company remains wholly owned

by EGAT. Despite the introduction of a range of other generators, including private companies, EGAT remains the dominant producer as well as the monopoly buyer for its transmission system. At the end of 2010, EGAT and its subsidiaries owned 49% of the country's electricity generation capacity, with independent power producers accounting for 39%, small power producers for 7%, and imports for 5%. An attempt to privatize EGAT was made in November 2005, but it led to a public outcry. The listing of its shares in the Stock Exchange of Thailand was suspended by the Supreme Administrative Court, and canceled in March 2006.

In the oil and gas subsector, the Department of Mineral Fuel grants oil and gas concessions. Both Thailand's PTT Global Chemical Public Company and multinational companies (including Chevron, ExxonMobil, and Unocal) are involved in oil and gas exploration and production, importing, oil refining, gas processing, oil product and gas storage, distribution, and retail. In recent years, however, poor profit margins have contributed to a gradual withdrawal of foreign private companies, including BP, Chevron, and Shell, from the downstream oil industry.

There are two main oil pipelines, both owned by the private sector. One of these pipelines, along the eastern seaboard, has fallen into disuse because of the lower cost of tanker transport. There is also a legal and regulatory framework for allowing third-party access to PTT's gas transmission system, so as to encourage private investment in production, but in practice PTT continues to hold a monopoly.

PTT has been corporatized, and about 32% of its shares have been sold to the public. The government holds 52% directly through the Ministry of Finance and a further 16% indirectly. The government also has a majority share in the Bangchak Petroleum Public Company, which owns about 10% of the country's oil refining capacity.

In the Republic of Korea, the Ministry of Knowledge Economy is the primary government agency for energy policy planning, including supervision of the industrial sector, climate change matters, and price controls. Environmental issues are coordinated with the Ministry of Environment. Under the guidance of the Ministry of Knowledge Economy, energy policies are implemented through the SOEs that dominate their respective subsectors.

The majority state-owned Korea Electric Power Corporation (KEPCO) is vertically integrated, still controls generation, and is the sole provider of transmission and distribution. As one reason for the reforms in the late 1990s and early 2000s was to introduce competition, KEPCO was corporatized, and shares were sold to the public, although the government retained a 50% holding. KEPCO's generation operations were divided into six subsidiaries. At the same time, the state-owned Korea Power Exchange was established to operate a wholesale electricity market. The six generation companies sell their output to this power pool, while KEPCO alone purchases electricity from the pool. The state-owned Korea Hydro and Nuclear Power Corporation owns and manages the nation's nuclear plants (which supply 40% of the country's electricity) and large hydroelectric dams.

The state-owned Korea National Oil Corporation is responsible for strategic oil reserves, and for the exploration, development, and production of oil. The natural gas sector is dominated, upstream and midstream, by the state-owned Korea Gas Corporation. The state-owned Korea Coal Corporation is responsible for developing the domestic coal industry, including the workforce and new technologies. It manages the importation of bituminous coal and domestic production of anthracite coal. The Korea National Oil Corporation, Korea Gas Corporation, and the state-owned Korea Resources Corporation implement the government's policy of developing overseas energy resources, including oil, gas, and bituminous coal.

As part of a liberalization program, the Republic of Korea established the Korea Electricity Regulatory Commission (KOREC) in 2001. KOREC is responsible for regulating generation (by independent power producers, generation companies, and the Korea Power Exchange), transmission, distribution, and overall industry functions. KOREC works under the authority of the Ministry of Knowledge Economy and shares some of the ministry's staff members, but this arrangement limits its independence. KOREC also conducts its own deliberations on such matters as licensing electricity companies. Final decisions are made by the Ministry of Knowledge Economy following the rulings or deliberations of KOREC, and normally does not overrule KOREC's decisions.

Responsibilities of KOREC include managing competition in the power sector. At the same time, the Fair Trade Commission is the Republic of Korea's anti-trust agency, responsible for monitoring monopoly problems and unfair business practices throughout the economy. In 2001, a memorandum of understanding between the Fair Trade Commission and KOREC established their respective roles, duties, and functions in the electricity industry. Further, the Korea Institute of Nuclear Safety is a specialized agency responsible for the technical regulation of the country's nuclear industry. There is no regulatory agency specifically for the gas and oil industry. As a result, the Korea Gas Corporation and Korea National Oil Corporation are largely self-regulated, under the guidance of the Ministry of Knowledge Economy.

The structural reforms of the power sector that were envisaged around 2000 have been suspended by the government. While it still plans to proceed with the privatization of five thermal generation companies, at the time of writing, there was still no timetable for doing so. The government also had no plans for the further privatization of KEPCO or for the privatization of Korea Hydro and Nuclear Power.

The natural gas industry has had no structural reform, as plans to split the Korea Gas Corporation into three companies have been postponed. While the Korea Gas Corporation manages supplies and operates the wholesale market, the retail market is made up of 32 city gas companies that have exclusive franchises within their respective regions. The central government, through the Ministry of Knowledge Economy and the Korea Gas Corporation, oversees the wholesale market, while local and provincial governments oversee the retail market (other than large consumers, including 10 power-generation companies that are supplied directly by the Korea Gas Corporation).

In the oil subsector, while the Korea National Oil Company dominates the upstream industry and owns the oil pipeline system without third-party access (except the Trans Korea Pipeline, for the United States armed forces), private companies are active in wholesale importing and most downstream areas. In the coal subsector, the Korea Coal Corporation runs three of the country's eight anthracite mines, and the remaining five are privately owned. Private companies, as well as KOREC, are involved in overseas projects producing bituminous coal. While the Korea District Heating Corporation remains the main supplier of combined heat and power, there are 21 companies providing combined heat and power overall. Only three of them are privately owned, however, so the government is working to diversify this market.

D. Water and Sanitation

In 2002, the Government of Thailand established the Ministry of Natural Resources and Environment, with several subordinate departments and agencies, including the Department of Water Resources. This department formulates policies and master plans; develops, conserves, and rehabilitates water resources; conducts research; and promotes public participation in water management. The Department of Water Resources has a total of 10 regional offices and operational units in each of Thailand's 75 provinces. The Metropolitan Waterworks Authority surveys water sources and provides water for Bangkok and for Nonthaburi and Samut Prakan provinces. The Provincial Waterworks Authority has similar responsibilities in the rest of the country, with 10 regional offices and 226 local offices covering all provinces. Both are SOEs. There is private participation in water provision at the local level, through service and management contracts, lease contracts, and build-own-operate-transfer and build-operate-transfer arrangements.

The Republic of Korea's water institutions include central ministries and departments for water management policy, supported by research institutions and executive agencies, and departments of local government responsible for implementation. Local governments may establish policies, subject to the central government's approval and certification. In parallel, the central government's Comprehensive Waste Management Plan allows local authorities to formulate and execute waste management policies, tailoring them to specific local conditions. Private companies account for the largest share of wastewater management (61%), followed by local governments (38%), and by the Korea Water Resources Corporation (K-water)(1%).

Several ministries have jurisdiction over water-related issues. The Ministry of Land, Infrastructure and Transport is responsible for the development of water resources, water resource management, dam construction, land acquisition, flood management, and river basin and river management programs. The Ministry of Environment is responsible for water supplies, sanitation and sewerage system operation, and water quality monitoring. The Ministry of Agriculture, Food and Rural Affairs is responsible for plans relating to water usage in rural areas; the development, management, and conservation of water for irrigation; the building and management of agricultural dams; and groundwater. The Ministry of Security and Public Administration oversees disaster management, flood response, and river management under the jurisdiction of local governments via the National Emergency Management Agency, which provides disaster relief.

E. Public–Private Partnerships

In Thailand, the State Enterprise Policy Office, a department of the Ministry of Finance that was established in 2002, promotes PPPs as part of its supervisory responsibilities. Individual SOEs seek to mobilize investment resources through PPPs, and the State Enterprise Policy Office is mandated to coordinate such efforts under the 1992 Royal Act on Private Participation in State Undertakings.

In the Republic of Korea, the Public and Private Infrastructure Investment Management Center was established under the PPP Act to provide comprehensive, professional support for the implementation of PPPs. Its mandates include *ex ante* evaluation of PPP project proposals, and provision of technical assistance during the negotiation and procurement processes of projects.¹³

¹³ The experience of public–private partnerships (PPPs) in the Republic of Korea was documented in this study under an ADB regional technical assistance project financed by the Republic of Korea e-Asia and Knowledge Partnership Fund (Kim et al. 2011).

III. Infrastructure and Competitiveness

The governments of both the Republic of Korea and Thailand view infrastructure investment as an important means of improving trade competitiveness. Competitiveness is defined as the ability of a firm or a nation to offer products and services that meet the quality standards of local and world markets at relatively low prices, and provide adequate returns on the resources employed or consumed in producing them. In economic terms, there are two sets of linkages. Most visibly, the quantity and quality of infrastructure influence competitiveness through their effects on production and logistics (including transport). Effective infrastructure investments thus increase productivity, enabling greater output from a given budget of inputs, or reducing the costs of inputs, logistics, or other services involved in production. These effects contribute directly to the competitiveness of all businesses or sectors served by the additional infrastructure. Investments in infrastructure can also have positive dynamic effects, particularly by helping to form clusters or corridors of industrial or service sector growth, either domestically or regionally.

Less visibly, the cost of infrastructure investment is borne somewhere in the economy, mostly through additional taxation or user charges through which governments, SOEs, or private operators finance their investments. In general, these add to the cost structures of both export and domestically oriented businesses. However, the financing of infrastructure is usually long-term, often involves domestic or foreign borrowing, and may have lagged effects on taxpayers and users. Consequently, it is generally difficult to trace the economic effects of infrastructure financing so as to compare them with the economic benefits of the infrastructure itself, except for a few cases in which there are clearly identified beneficiaries that also finance the infrastructure through user charges (e.g., project-financed improvements in seaports). Therefore, infrastructure investments designed to support particular industries, such as irrigation, are likely to improve the competitiveness of those industries, but with uncertain overall effects on national competitiveness when their financing is taken into account; and, while efficient infrastructure investments probably result in net gains to national competitiveness, inefficient investments might not do so.

The World Economic Forum's *Global Competitiveness Report 2010–2011* described infrastructure as the second pillar of a country's competitiveness (Schwab 2010, 4). The report pointed out several other elements that contribute to competitiveness and that should be made to reinforce each other, such as sound macroeconomic policies, stable political and legal institutions, sophistication of companies' operations and strategies, and the quality of the microeconomic business environment. The 2012–2013 report contains an index of the quality of overall infrastructure, in which the Republic of Korea ranked 22 among 144 countries, while Thailand ranked 49 (Schwab 2012, 221 and 345).



A. Transport

In developing transport infrastructure, the Republic of Korea has been more focused and strategic than Thailand, where competitiveness has been only one of several factors in determining investments. The Republic of Korea built expressways as major arteries (complemented by national highways) to connect cities, ports, and industrial complexes with high-quality direct links to reduce the logistics costs of exporting and importing. Thailand has instead used highways to achieve the broader objective of improved mobility and connectivity for all. For instance, rural roads were built as links to markets for the farm sector, which became a major source of exports.

Both countries are now seeking to make the most efficient use of their road and expressway networks, emphasizing “smart highway” traffic management.¹⁴ They are also pursuing intermodal balance, so that railways can play a larger role in hauling cargo, at a lower cost. There are indications that logistics costs have been decreasing since 2000 in both countries, with costs remaining lower in the Republic of Korea than in Thailand.

B. Information and Communication Technology

The rapid and pervasive application of ICT in other productive sectors in the Republic of Korea, more so than in Thailand, has improved competitiveness by reducing costs and enhancing efficiency. This is especially evident in ICT applications for managing road traffic, ports, railways, and mass rapid transit (MRT) passenger information. The Republic of Korea has also developed a marked competitive advantage in the production and assembly of ICT hardware, allowing it to export almost one-half of production. The contribution of ICT to economic growth has been estimated at 2.0 percentage points of 5.1% in 2006 and 1.6 percentage points of 5.0% (estimated) in 2007 (Nam 2008). In the aftermath of the global financial crisis, in the Republic of Korea, “the ICT industry has played a decisive role in the process of recovery from the economic crisis and of take-off to a new phase of development” (Lee, no date, 1).

The competitive strength of the ICT industry in the Republic of Korea was created by preferential access to finance and by public and private investment in research and development (R&D), which allowed firms to narrow the technology gap and develop state-of-the-art products, such as the world’s first 256-megabyte dynamic random access memory. The industry’s competitive strength is now supported by excellent broadband infrastructure; a large domestic consumer base providing an ideal testing site for technology innovations; continued government support; and close collaboration among industry, government, and universities in research. However, there are shortcomings associated with a bias toward large firms, corporate governance, a shortage of creative skills, dependence on a few products, and competition in saturated product markets. Thailand’s ICT industry has been less outstanding, but it has enjoyed healthy growth (Thuvasethakul 2006).

¹⁴ “Smart highway” is a concept that uses innovative technology to visually communicate dangerous road conditions and traffic pattern disruptions, thereby increasing road vehicle capacity and minimizing traffic congestion.

C. Energy

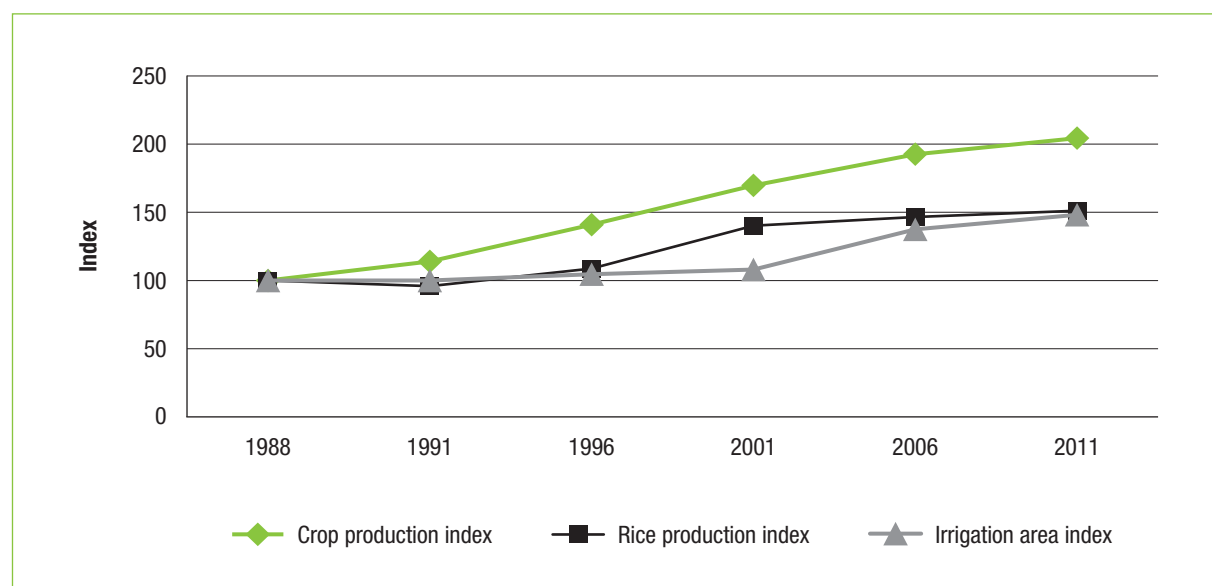
Energy sector investments in both the Republic of Korea and Thailand have undoubtedly contributed to competitiveness by providing the electricity needed for production, services, and transport.

D. Water and Sanitation

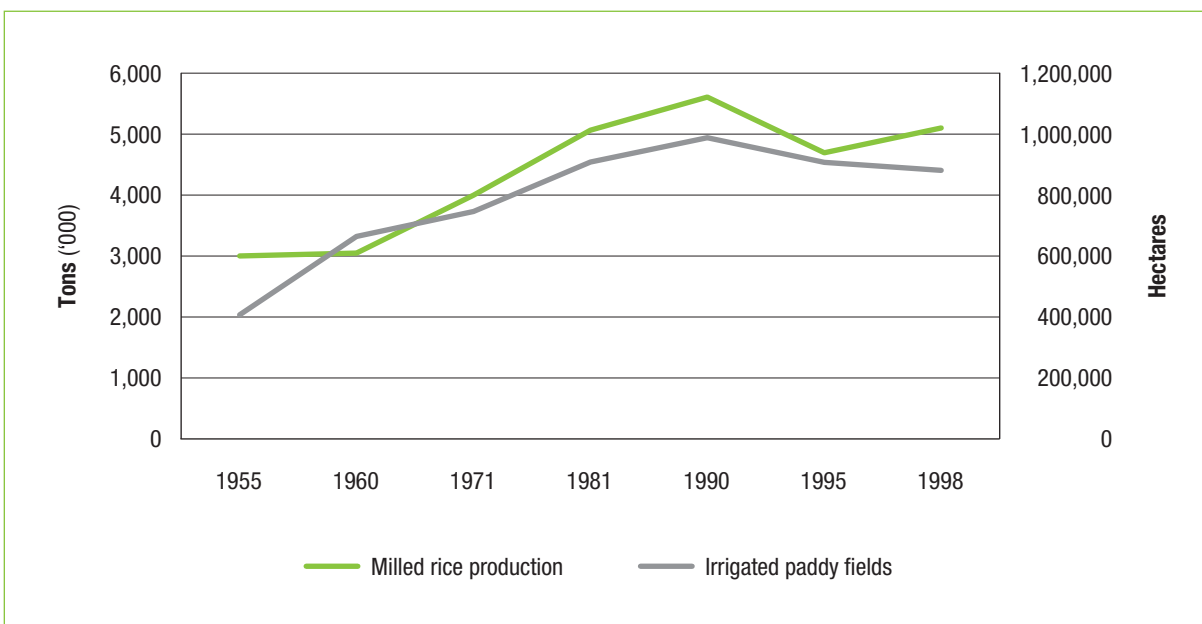
In manufacturing, good, stable water supplies have contributed directly to industrial growth in both countries; but in a broader sense, the improvement of water supplies has probably made greater contributions indirectly, by enabling a concentration of people in industrial areas and by reducing the toll of illnesses from unimproved water supplies.

In both countries, irrigation expansion has had a profound impact on rice production, in combination with other factors, including improvements in seed varieties, crop husbandry, fertilizers, and commercialization. Figure 1 compares indexes from 1988 to 2011 for Thailand's crop production, rice production, and total irrigated area. It shows that crop and rice production increased earlier than irrigated area. Figure 2 compares the Republic of Korea's rice production and area of irrigated paddy fields from 1955 to 1998. The earliest increases in irrigated area preceded the first increase in rice production, but later increases in the two variables were broadly in line. However, from 1995 to 1998, rice production rose despite a reduced irrigated area.

Figure 1 Crop Production, Rice Production, and Irrigated Area Indexes, Thailand, 1988–2011
(1988 = 100)



Sources: Bank of Thailand. 2011; Budhaka et al. 2002.

Figure 2 Irrigation and Rice Production, Republic of Korea, 1955–1998

Sources: For irrigation: Framji et al. 1982. For rice production: Index Mundi. 2011.

IV. Pricing of Infrastructure Services

A. Transport User Pricing

In the Republic of Korea and in Thailand, the setting of charges for users of transport infrastructure reflects a range of factors, and varies across subsectors. In both countries, it appears that expressway tolls recover at least a good part of the *operating* costs of public and private providers, but they vary in the amounts of *capital* costs, if any, that they recover. There are also instances of cross-subsidies and, in the Republic of Korea, of congestion charges. In some cases, urban MRT tolls are set at levels that recover operating costs; but in others, affordability for users is seen as vital, and government subsidies make up the rest of operators' costs. Indeed, it seems that few MRT tolls recover any of the providers' capital costs. Finally, for other types of transport, user charges generally recover the operating costs of public and private providers, but again, vary in the amounts of capital cost they recover, with the rest provided by government subsidies.

B. Energy User Pricing

1. Oil Product Pricing

Although oil product prices have been deregulated since 1991 in Thailand, the government intervenes through the Oil Fund, and through the marketing margin, to maintain prices it sees as appropriate.¹⁵ Retail prices of oil products comprise the ex-refinery price or cost, insurance, and freight price; excise duty; municipal taxes; Oil Fund levy or subsidy determined by the National Economic Advisory Council; value-added tax; and marketing margin. For some years, the prices of diesel fuel and liquefied petroleum gas (mainly a household cooking fuel) were subsidized by the Oil Fund. The government has also subsidized gasohol and biodiesel prices by requiring the contribution of less-than-standard quality fuels to the Oil Fund.

In the Republic of Korea, the domestic market in oil products has been liberalized since 1997. Prices are no longer regulated, and there is no overall subsidy associated with petroleum products. However, the prices of unleaded gasoline and diesel include taxes of around 50%, and the government has used these taxes to modify relative prices with a view to facilitating a transition to a less energy-

¹⁵ The Oil Fund was originally intended to help stabilize the domestic prices of oil-based fuels through transfers to and from the fund that would counteract fluctuations in the internationally determined prices of imported oil.



intensive economy. The prices of oil products in the Republic of Korea in the first quarter of 2012 were comparable to those in major countries of the Organisation for Economic Co-operation and Development (OECD) except the United States (International Energy Agency 2012, 42).

2. Natural Gas Pricing

The wholesale price of gas in Thailand is based on the pool price and gas transmission and distribution charges, which are regulated by the Energy Regulatory Commission. In accordance with government directives, to keep transport costs low, the price of compressed natural gas is subsidized by the main supplier, PTT. Gas prices in the Republic of Korea are set by the Korea Gas Corporation based on costs linked to the import prices of liquefied natural gas and on-costs, including import tariffs and levies, handling charges, a special excise tax, and a safety management fund contribution. Rates vary bimonthly for industrial customers, but are fixed annually for residential customers. This year-round constancy of residential gas prices increases supply costs because about four times more gas is used in winter than in summer, while producers of liquefied natural gas (the source of nearly all of the country's natural gas) have long-term contracts providing for a steady off-take. Prices of natural gas for industry and households in 2011 were comparable to those in the other major OECD countries except the United States (International Energy Agency 2012, 42).

3. Electricity Pricing

In Thailand's electricity subsector, tariffs along the supply chain (i.e., generation, transmission, and distribution) are regulated by the Energy Regulatory Commission. According to determinations by the commission, electricity prices are set at less than the marginal costs for four categories of consumers: agricultural users (for irrigation pumping), residential consumers (up to a usage threshold), government agencies, and nonprofit organizations. Electricity is thus free for about 25% of the 3 million consumers in the greater Bangkok distribution area, and for over 50% of the 15 million consumers in rural distribution areas, whose recorded usage is under the threshold (perhaps through the use of multiple accounts). These subsidies are funded mostly by cross-subsidies from other electricity consumers.

In the Republic of Korea, retail electricity rates are set by the Korea Electric Power Corporation (KEPCO), subject to approval by the Ministry of Knowledge Economy, on the basis of supply costs. But several usage categories have tariffs well below cost—agriculture, education, street lighting, and “midnight power service,”¹⁶ together with special groups such as war veterans and low-income customers. The International Energy Agency figure for the average price of electricity for households in the Republic of Korea in 2011 was significantly below those in the other major OECD countries, including the United States (International Energy Agency 2012, 43).¹⁷

¹⁶ These are customers who use electric appliances or equipment that store energy utilizing off-peak electricity (between 11 p.m. and 9 a.m.). The stored energy is then used at a time when convenient to the customer, generally for heating and cooling purposes.

¹⁷ No figure is provided for the average price of electricity for industry in the Republic of Korea.

KEPCO figures for tariffs in 2010 indicated an overall cost recovery rate of 94% (Korea Electric Power Corporation 2010).

In 2009, the average cost of electricity for users was about 20% higher in Thailand than in the Republic of Korea. One likely reason for the higher average prices in Thailand is that the contribution of coal, the cheapest fuel, to electricity generation is about 20%, significantly lower than in the Republic of Korea, where it is about 33%. Also, the Republic of Korea produces some 35% of its electricity in nuclear power plants, which have low operating costs. And regulated tariffs there recover only 90%–95% of supply costs, whereas in Thailand tariffs fully recover supply costs. In both countries, the state-owned supply companies—KEPCO and the Electricity Generating Authority of Thailand (EGAT)—are allowed to set the returns on their investments, so differences in these returns could be another contributing factor.

C. Water Use Pricing

There is insufficient information for a full picture of water supply pricing in Thailand. However, it is clear that weak enforcement of the polluter-pays law threatens the sustainability of wastewater management. The tariff expected to fund the local governments' management and expansion of wastewater treatment plants was, in the early 2010s, being implemented only in three municipalities, Patong, Pattaya, and Sansuk.

In the Republic of Korea, bulk water supply tariffs are set by the Korea Water Resources Corporation (K-water), with approval from the supervising Ministry of Strategy and Finance. In the late 2000s, K-water was charging municipalities ₩250 (\$0.23 based on a \$1 = ₩1,086 conversion as of August 2011) per cubic meter for bulk water which represented 80% of cost. At the local level, municipal suppliers set their tariffs with the approval of local councils. Different tariff rates are applied to raw, purified, and industrial water. Overall cost recovery is 70%–80%, and the gap is covered by the government.

V. Investments and Financing

Since 1994, in the Republic of Korea and Thailand, the largest share of infrastructure investment has been financed by the government, either directly or through state-owned enterprises (SOEs). Yet alongside government sources of finance—budget allocations; funds generated by SOEs; and borrowing from donors, suppliers, or capital markets—there have been substantial amounts of finance provided by private businesses.

Much of the finance for infrastructure investment in Thailand has come from government-supported borrowing, and much of the rest from the relevant SOEs. However, investment in highways (distinct from the expressways in and near Bangkok) has been undertaken directly by the Department of Highways. The totals for highway construction have varied considerably over time—large amounts in the late 1990s, a sharp reduction after the 1997–1998 Asian crisis, and a partial recovery from 2005 to 2010.

Bangkok's MRT has been financed partly by the government and partly by PPPs. For example, the underground Blue Line was constructed through a PPP in which the government financed the construction of the tunnel (costing the equivalent of about \$2 billion), while a private entity, Bangkok Metro Company, invested about \$350 million in rolling stock, with a 25-year concession as operator.

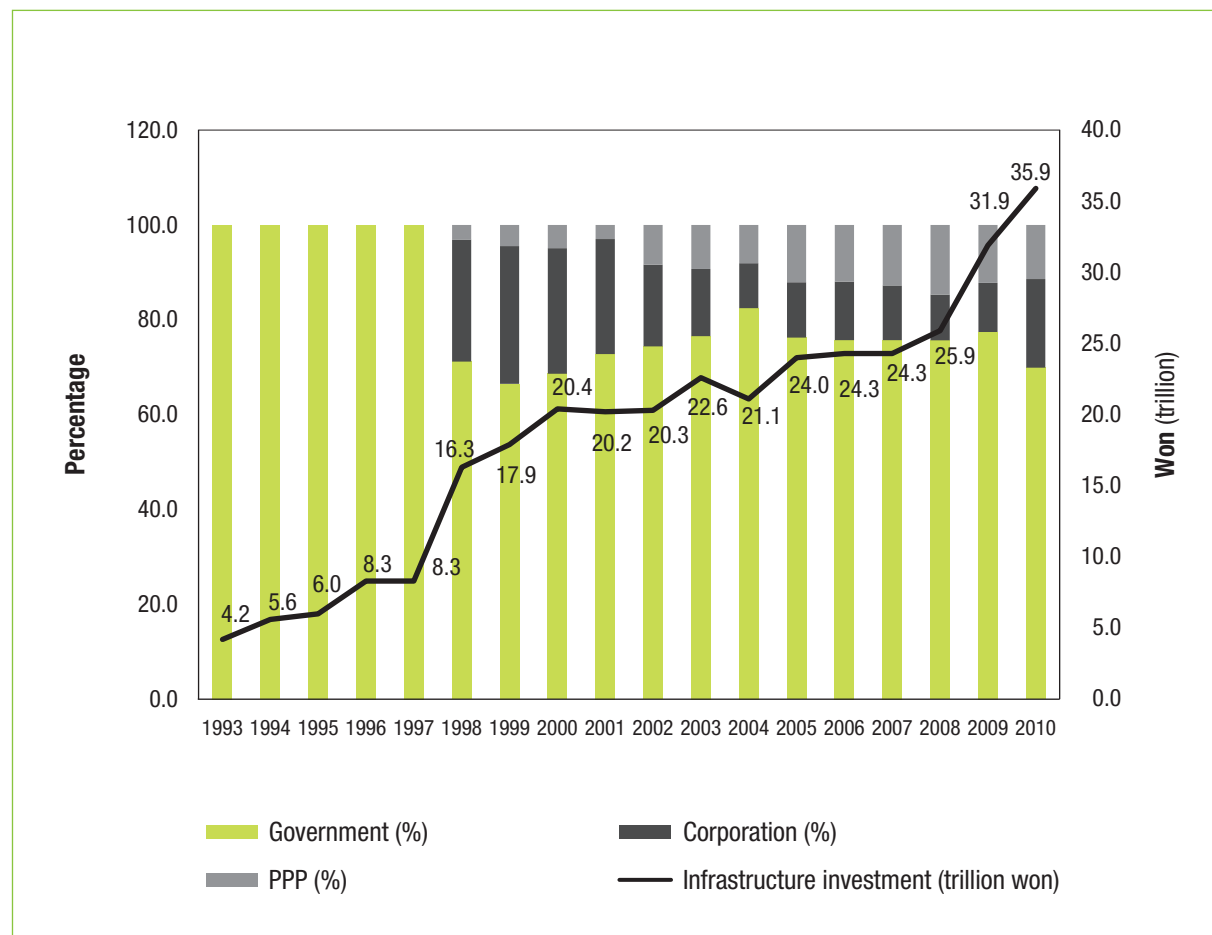
In infrastructure sectors other than transport, financing has been less reliant on public funds. The government has financed a large part of the electricity infrastructure by arranging and guaranteeing loans from such sources as Canada, Germany, Japan, OPEC, and the World Bank. In addition, the policy of seeking private investment in electricity generation has elicited large amounts of financing. SOEs have financed their investments partly with their own funds, as well as through government-guaranteed loans. SOE capacity to self-finance their investments, or to service loans for them, depends on their profitability. Current electricity tariffs are designed to ensure that SOEs can self-finance 25% of their investment projects. SOE investment burdens are also reduced by requirements for high-voltage customers to invest in their own substations (and be repaid through reduced charges) and for small customers to pay up front for metering.

In Thailand, most of the infrastructure for oil and gas exploration, production, importing, and distribution has been funded by the majority state-owned PTT and private operators, including Chevron. Further, investments in the country's infrastructure for water supplies and wastewater treatment have come largely from public funds, with a small private share from PPPs.



In the Republic of Korea, until 1997, the public budget was the sole financing source for the government's infrastructure investments. From 1998 onward, as part of the process of corporatizing SOEs and fostering private participation through PPPs, financing flows from those two sources have appeared alongside government funding, as shown in Figure 3.

Figure 3 Sources of Infrastructure Financing, Republic of Korea, 1993–2010



PPP = public–private partnership.

Note: \$1 = W1,086 as of August 2011.

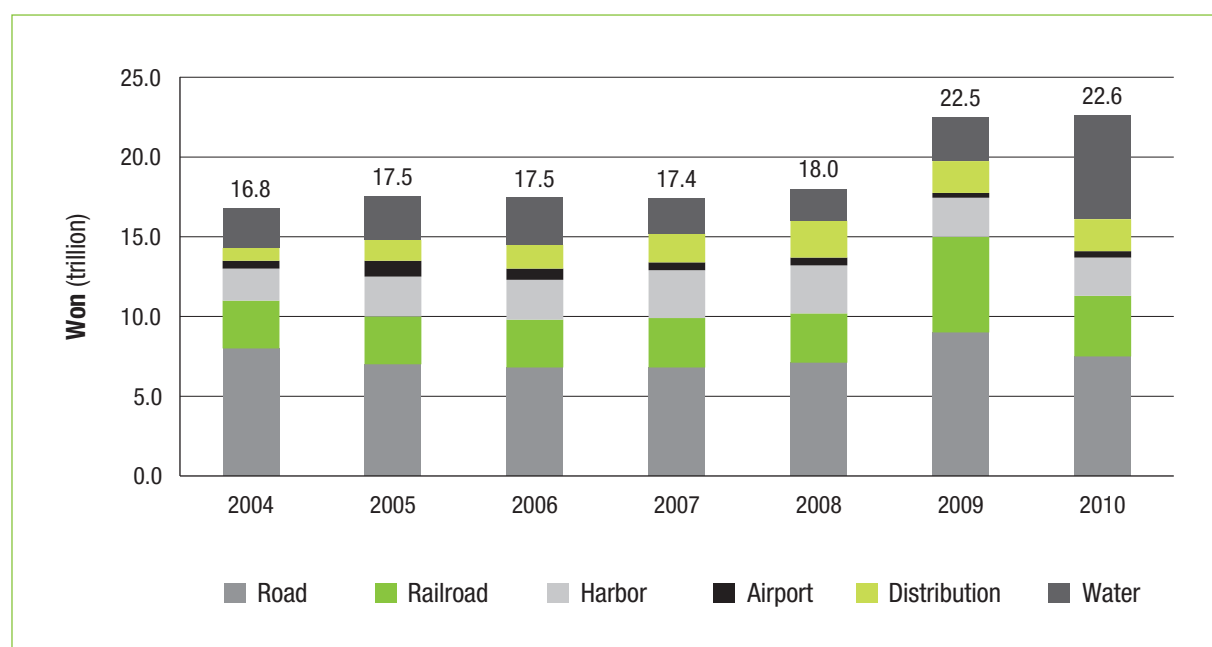
Source: Ministry of Strategy and Finance.

As soon as SOEs began to finance their infrastructure investments, in 1998, they did so in substantial amounts. However, from 2001 to 2004, these amounts declined in the aggregate, and only partly recovered in the late 2000s. Nearly all investments in the country's upstream and midstream energy infrastructure, apart from some private participation in electricity generation, have been made by SOEs. Funds for their investments in new capacity have come from their sales revenues, supplier credits, and bond issues in domestic and foreign financial markets.

In contrast, the private sector's share of investment financing for infrastructure gradually grew. According to information from the Ministry of Land, Transport and Maritime Affairs, private financing of transport infrastructure climbed slowly from the mid-1990s until 2005, when it was nearly 16% of the ministry's infrastructure budget, and remained at about that percentage until 2010.

The amounts allocated by the central government for infrastructure investment from 2004 to 2010 are shown in Figure 4. There was a marked increase in the total in 2009 and 2010, due in part to substantial increases in financing for the logistics and water sectors. However, a comparison of the figures for the central government with those for total infrastructure investment in the same period (Figure 3) shows that the central government's share had been steadily declining, from nearly 80% in 2004 to 63% in 2010.

Figure 4 Central Government Infrastructure Investment, Republic of Korea, 2004–2010



Note: \$1 = W1,086 as of August 2011.

Source: Ministry of Strategy and Finance.

While investment in the Republic of Korea's water infrastructure is financed mostly from the central government budget, it is supplemented in two ways: (i) K-water uses internal resources for the rehabilitation of its facilities, and borrows for investment in additional hydropower; and (ii) large municipalities finance their own requirements, although it is not clear how much investment in the aggregate this has involved.

A. Private Participation through Public–Private Partnerships

In both the Republic of Korea and Thailand, most of the private finance for infrastructure investments, except for bond issues by SOEs, has been introduced in the form of PPPs. These have been motivated in varying degrees by a desire to benefit from private sector expertise in addition to financial contributions. In Thailand, there have also been a few privatizations of state infrastructure enterprises, mostly in the period after the 1997–1998 Asian crisis.

Thailand has had PPPs in three transport subsectors, toll roads (expressways), MRT (urban light railways), and port facilities. These PPPs have been organized by the relevant SOEs, the Expressway Authority of Thailand, the Mass Rapid Transit Authority of Thailand, and the Port Authority of Thailand, except for two that were organized by government agencies (the Don Muang Tollway project under the Department of Highways and the BTS MRT project under the Bangkok Metropolitan Authority). The expressway and MRT PPPs have turned out to be successful, after facing financial difficulties in their early phases because of shortfalls in usage.

In the transport sector, the Government of Thailand has mostly opted for the build–transfer–operate model, but other types of PPP have been used as well. Since 1992, the Royal Act on Private Participation in State Undertaking has provided an enabling framework for private participation. However, private investors have proven unwilling to make large capital investments, such as constructing subway tunnels or acquiring large amounts of land, due to the perceived risks in the overall sector. Recently, in a further effort to increase private participation in infrastructure, Thailand worked with ADB on a draft PPP Promotion Act, addressing the limitations of the 1992 act and defining more clearly the roles and responsibilities of all parties.¹⁸ The preparation of this draft law included drawing on the Republic of Korea’s successful practices and PPP law, and suggesting an aggregate ceiling for national budget contributions.¹⁹

Moreover, in the energy sector, seven independent power producers have long-term power purchase agreements with EGAT. These agreements (except those with entities formed from EGAT itself) have increased generating capacity without requiring investment by EGAT.

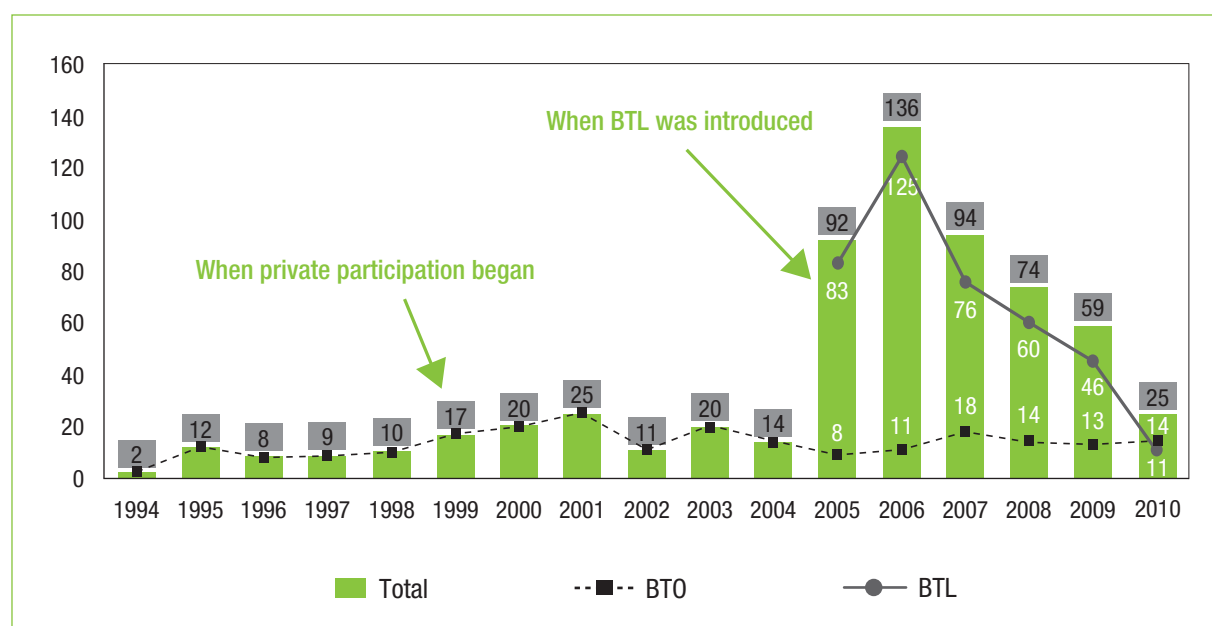
Finally, a small fraction—less than 1%—of the provision of raw water, water treatment, bulk transfers, and local distribution is handled by PPP arrangements in Thailand. For instance, the East Water Company was established to provide water facilities to the eastern seaboard. It was initially a subsidiary of the Provincial Waterworks Authority, but was subsequently partly privatized, with the state retaining a 44% shareholding.

¹⁸ The main problems of the 1992 act have been lack of clarity; time-consuming approval processes; lack of any provision for amending contracts; lack of a central agency responsible for administering its provisions; and lack of references to risk identification, allocation, and sharing.

¹⁹ The draft law includes the requirement that contingent liabilities be identified and reported to the Ministry of Finance.

The Republic of Korea has used PPPs for infrastructure investment in a wider range of sectors, and in much larger numbers, than has Thailand. The Republic of Korea's PPPs have been managed both by the central government and by local governments. More than one-half, by value, of the country's build-transfer-operate projects have been expressways. The number of PPPs increased in the late 1990s, when a framework was introduced for private companies to put forward proposals, and again in 2005, when the build-transfer-lease model was introduced. These increases in the quantity of new PPPs are shown in Figure 5.

Figure 5 Trends in the Number of Public-Private Partnership Projects, Republic of Korea, 1994–2010



BTL = build-transfer-lease, BTO = build-transfer-operate, PPP = public-private partnership.

Note: In 1999 (when private participation began), 17 cases were announced; in 2000, 20; and in 2001, 25 cases. In 2005 (when BTL was introduced), 92 cases were announced, while 136 were announced in 2006. Since 1997, the number of PPPs has fallen sharply.

Source: ADB estimates.

The legal and institutional framework for PPPs, which the Republic of Korea established in 1994, centers on projects identified and solicited by the government. It was made more comprehensive in the Private Investment Act of 1999, with provisions for improved investment selection processes and a range of financial incentives. While the 1999 law introduced provisions for unsolicited projects, some financial incentives were reserved for solicited projects.²⁰ Amendments to the

²⁰ A solicited project is one that the competent authority identifies as suitable for private investment, and for which it seeks a private partner through a request for proposals. An unsolicited project is one identified by a private entity submitting a project proposal, which the competent authority, after examination, designates as a PPP project.

PPP law in 2005 provided not only for build–transfer–lease schemes, but also for the expansion of facility types and for the diversification of investor profiles. After these successive changes, substantial financial incentives remain available for PPPs, though they are more generous for solicited (i.e., government-identified) projects than for unsolicited ones.

Road, seaport, and railway projects in the Republic of Korea have mostly been implemented on the build–transfer–operate model, while projects for schools, dormitories, and military housing are mostly build–transfer–lease.

The government substantially increased the coverage of sewage treatment facilities through several policy initiatives, including the allocation of liquor tax revenues to local governments and the acquisition of private capital through the Sanitation Facilities Private Investment Project. As a result, private companies own 61% of the country's sewage treatment facilities, followed by local governments (38%), and K-water (1%).

The Republic of Korea has substantially increased the public funds for infrastructure investment through its promotion of PPPs, but it is difficult to determine the long-term costs to the government of the financial incentives and risk sharing used to support the PPPs. There has been criticism of the fiscal burden involved in subsidizing PPPs, especially through the policy of minimum revenue guarantee. There has also been dissatisfaction among highway users over tolls that seem high and that differ from section to section.

B. Future Needs for Private Finance

The Republic of Korea and Thailand share with most other countries in the Asia and Pacific region the need to expand infrastructure to better accommodate rising urban populations; growing incomes; rapid industrialization; and the burgeoning demand for energy, water, and mobility. The regional total of these infrastructure gaps in the years leading up to 2020 was estimated at \$8 trillion (Asian Development Bank and ADB Institute 2009). Both countries face the daunting tasks of choosing and developing the soundest projects; finding appropriate resources; and building capacity for design, delivery, and operation.

The case for increasing private participation in infrastructure is based on the contributions private companies can make to the quality and reliability of design, construction, operation, and maintenance, as well as on the desirability of increasing private financing. However, private investment flows will tend to be directed toward infrastructure sectors and projects from which returns can be expected in the short or medium term, and with relatively low risk. In the past, private participation in infrastructure in developing countries has been overwhelmingly in telecommunications, and secondarily in electricity. In both the Republic of Korea and Thailand, financing will continue for substantial and, if possible, growing amounts of infrastructure through corporatized SOEs and PPPs, applied with the best methods learned from experience.

One key difference between the Republic of Korea and Thailand in the financing of infrastructure investment is the greater success of the Republic of Korea in instituting PPPs in a range of sectors. Further, in some of Thailand's early transport PPPs, the projected traffic and, hence, the expected revenue, failed to materialize. Thailand addressed this problem on a piecemeal basis. In contrast, the Republic of Korea addressed similar issues by providing a legal and systematic framework for the minimum revenue guarantee and other financial incentives. In addition, it appears that in several sectors, notably rail transport, water supply, and wastewater treatment, Thailand's SOEs recover a smaller portion of their costs through user charges, thus limiting their ability to help finance new investments.

VI. Lessons

This study was conducted in 2009–2010, and the infrastructure needs and performance of both countries have been constant up to 2013. With infrastructure being a long-term economic agenda, this section provides a retrospective on the experiences of the Republic of Korea and Thailand to set the stage for future directions and priorities.

1. Support for Growth, with Changing Priorities

Experience in both the Republic of Korea and Thailand since the 1990s suggests that economic growth was greatly assisted by extensive investments in infrastructure, mostly through government agencies or SOEs, which suited each country's development opportunities. In the 1990s and 2000s, every government strategy for supporting growth through infrastructure investment underwent substantial changes in priorities. As each economy developed, patterns of demand for infrastructure changed, as did the linkages between infrastructure and further economic growth. Political attitudes changed as well, influencing infrastructure investment by putting greater emphasis on social inclusion, private sector participation, and environmental sustainability. At the same time, the international context changed, increasing the prices and supply risks of fossil fuels and expanding the knowledge of climate change induced by greenhouse gas emissions.

Accordingly, in both the Republic of Korea and Thailand, there have been successive adaptations in forms of infrastructure investment, in policies underlying these investments, and in pricing of infrastructure services. The situation is a dynamic one in both countries, and further changes are probable from 2010 onward. Ministers and their advisers will need to find the best course in public policy, accepting political constraints but also offering leadership.

2. Green Agenda

Given the price and supply risks of fossil fuels, and the damaging effects of greenhouse gas emissions resulting from their use, the best policy approach would be to reduce use of fossil fuels through a range of mutually supportive measures, including: the application of information and communication technology (ICT) in the energy and transport sectors, replacement of broad subsidies with targeted and transparent ones, and a progressive resetting of user prices to better reflect environmental as well as supply costs (e.g., through emissions trading schemes).²¹ As part of this approach, the subsidization

²¹ The Republic of Korea enacted legislation in May 2012 providing for a greenhouse gas emissions trading system that was being formulated as of June 2013; and for an interim system of emission caps, which is currently in force (see Talberg and Swoboda 2013).



of renewable energy sources would be justified by the need to overcome initial cost and knowledge barriers. However, these subsidies must be carefully limited because of the competition among priorities for limited financial resources, and their effectiveness must be reassessed periodically.

Some subsidization of public passenger transport can also be justified, at least in the near term, while private and commercial vehicles are still using fossil fuels with pricing that does not fully reflect environmental costs. Public passenger transport, especially the MRT in cities and intercity rail, involves less fuel usage, pollution, and greenhouse gas emissions per passenger-km traveled, compared with private vehicles. In addition, drawing passengers away from private vehicle use will reduce road congestion, making freight transport more efficient.

In public passenger transport, subsidies will also have to be limited and periodically reassessed. Given that it would be better if infrastructure providers could finance their own investments, as well as operation and maintenance, cross-subsidization is generally a more attractive option than subsidization from government budgets.

3. Coordination

The governments of the Republic of Korea and Thailand recognize the importance of coordination, both in planning and implementation, among the agencies responsible for infrastructure within each sector and across sectors. However, the experiences of both countries have shown how difficult it is to utilize the agencies' specialized knowledge of their respective subsectors and, at the same time, maintain close and efficient interagency coordination. These difficulties have remained despite a variety of institutional arrangements.

In general, interagency coordination should be prioritized, as the setting of infrastructure investment priorities by a central authority is necessary in order to obtain the greatest benefit from given amounts of investment and to minimize waste. When it comes to coordinating within and among infrastructure sectors, the Republic of Korea has generally been more successful than Thailand. A related lesson is that it is preferable for each sector to have a single technical and economic regulator, rather than specialized regulators for each subsector.

The key government agencies—planning bodies, SOEs, and regulators—must have technical capacity, committed leadership, and political support. Otherwise, the infrastructure on which the government has spent large sums will not be operated or maintained efficiently. Thus, effective institutions are national assets, as much as the physical infrastructure they operate.

4. Sector Differences in the Public–Private Mix

The ICT sector is distinctive, in both the Republic of Korea and Thailand, in its high proportion of infrastructure investment from private companies. Both governments have played a crucial role in making policy, providing basic infrastructure, developing markets through their own demand, and regulating, but they have not had to make the bulk of investments. This has also been true,

though to a lesser extent, in the downstream segments (i.e., refining, distribution, and product sales) of the oil and gas industries in both countries. The key lesson here is that the most appropriate mix of public and private finance and ownership of infrastructure will be specific to each industry subsector, and dependent on the market structure chosen as the policy objective.

5. Active Management of Infrastructure Assets

Active management of existing infrastructure assets—in terms of maintenance and utilization efficiency—is essential, but not often given as much attention by the government as new investment projects. The Republic of Korea has, in general, been more attentive to existing assets than have Thailand and most other middle-income countries in Asia. But its agencies now face additional complex challenges, including how to incorporate new technologies on a modular basis and how to make responses to natural disasters and security threats more resilient. The Republic of Korea's further progress will likely offer useful models for Thailand and other countries in the region.

6. Financing of Infrastructure

Governments alone cannot bear the entire financial burden of infrastructure development. The effort to attract more private financing for infrastructure, on terms that are fiscally prudent for governments, leads to the same problem as the effort to make SOEs more capable of financing their own investments: how to apply cost recovery principles in all infrastructure sectors as much as possible, despite the political problems that may occur when the public reacts strongly against higher user charges.

A. Transport

In Thailand, the lack of integrated planning for the various modes of transport has led to an unbalanced development of its transport infrastructure, with regional and cross-sectoral inequalities. Consequently, the developmental impact of infrastructure investment has not been optimized. As in most other countries in the region, the primacy of roads in transport investment has led to environmental pollution and increased dependence on fossil fuels and energy imports.

It is clear that transport investments have contributed substantially to the expansion of production and trade, although the precise relationships are difficult to establish.²² Rural and provincial roads have helped link markets with production centers, thus contributing to the rapid commercial development of agriculture in Thailand. However, the infrastructure for some types of cross-border

²² Estache and Fay (2007) examined these relationships and concluded that, because of thresholds and network effects, the elasticity of output with respect to infrastructure is nonlinear; the effects of transport infrastructure on regional disparities are ambiguous; and more work is needed to understand the dynamic impacts of infrastructure investments.

trade, and for multimodal transit, has lagged behind that for other parts of the transport sector. One reason for this is the relative underdevelopment of Thailand's railways.

The transport sector in Thailand has great potential for improvement—especially in the use of PPPs (along with appropriate policy and regulatory reforms), the management of logistics, the application of ICT to transport, and in urban transport planning.

For the Republic of Korea, investment in a high-quality intercity expressway system, complemented by logistics centers in industrial cities, has provided substantial benefits by reducing travel times and costs, although these benefits have been partly offset by increases in traffic and congestion. The resulting reductions in logistics costs have enhanced the competitiveness of the Republic of Korea's tradable industries.

The Republic of Korea has also made substantial and appropriate investments in its railway network, seaports, and international airports. However, the country's transport sector development has been hindered by an imbalance in favor of roads over alternative modes, high levels of energy intensity, and unwarranted subsidies. Increasingly aware of environmental issues, the government has adopted a green agenda for infrastructure investment, and has changed its transport priorities. It is reallocating investment to the rail subsector in particular; and, in the road subsector, it is giving priority to consolidation and energy efficiency over new construction. It sees a major role for ICT in improving transport efficiency, for example through real-time traffic management on highways, cargo management in seaports, and the automation of railways.

B. Information and Communication Technology

In Thailand, the government contributed to ICT development not only through investments in e-infrastructure, but also through support for R&D, education and training, and efforts to expand broadband access to underserved areas.

Government leadership and support helped bring about the remarkable development of the Republic of Korea's ICT sector. This success is attributable in part to the country's high urban densities and the willingness of company heads to cooperate with the government in ICT industry development. However, ICT success is also due to effective government policies, such as using special incentive funds, fostering competition among service providers, helping to train a large and highly skilled workforce, and boosting demand for ICT in the government and education sectors.

C. Energy

Through a combination of the Ministry of Energy, other government agencies, SOEs, and private companies, the rapid growth in Thailand's energy requirements from the 1990s through the early 2010s has been successfully met. However, planning in the energy industry has not been proactive,

just focusing instead on accommodating the present pattern of demand, which is not the best approach to developing energy infrastructure. To meet the government's objective of promoting green energy, changes in the energy intensity and fuel mix of transport and industry can and should be implemented. The expected amount of additional electricity infrastructure needed in the near future means that more must be done to increase the financing capacity of the utility enterprises and to attract private investment in the energy industry.

The Republic of Korea's experience in energy has shown that rapid economic growth can be supported by centralized planning of energy supply and demand; that energy sources can be diversified, and emergency reserves established; and that R&D in technology, such as in nuclear safety, supply management, conservation, and time-of-use metering, can bring large benefits.

While the Republic of Korea has formulated clear policies promoting renewable energy sources and efficiency in energy use, its economy remains highly dependent on external sources of energy, and its major industries are energy intensive compared with those of most other countries. Therefore, major tasks lie ahead in the transition to a green, sustainable economy.

The government has decided to liberalize the market in oil products, and has ambitious plans for the reform of the electricity and gas subsectors. It has also set up an independent electricity market regulator. When the reforms are implemented, they can be expected to reinforce each other, bring numerous benefits, and provide positive lessons for other countries in the region.

D. Water and Sanitation

The first main lesson from Thailand's experience with water and sanitation is that infrastructure investments have suffered from reduced efficiency due to coordination issues. Over 30 government agencies are involved in the water sector, and the difficulty of coordinating them has been exacerbated by a range of laws that work at cross purposes. Local governments and communities also play major roles, according to the Decentralization Act of 1999 and the Constitution of 2007, but in many cases they lack the capacity to provide water services of adequate quality.

Thailand's practice of setting concessional prices (or zero prices) for segments of industry and agriculture has prevented SOEs and local governments from having enough funds to meet investment needs, or, in some areas, even to finance operation and maintenance. The second main lesson, therefore, is that water supply and wastewater management must be treated as businesses, in which minimizing losses and obtaining healthy financial returns are the keys to sustaining the wide delivery of high-quality services. This will involve reviewing all tariffs for water supply or wastewater management that represent less than full recovery of costs.

The Republic of Korea's experience in harnessing its limited water resources includes several examples of successful management, such as integrated water resource management in the five main river basins, with a system for inter-basin transfers when necessary; measures to improve supply quality through river basin units with centrally managed monitoring; charges enabling upstream residents to be compensated for the regulation of their use of water and watersheds; and central funding for wastewater management by local governments and local PPPs.

The Republic of Korea has advanced systems of monitoring and information management in the water sector. K-water has proprietary systems for remote data analysis, which enable it to identify problems such as leaks and suboptimal equipment. In addition, water conservation measures taken by the government have been successful, and consumption per capita has been declining. The management of agricultural demand for water, however, will require further adaptation, including the promotion of eco-friendly agriculture, improvement of irrigation efficiency, and reclamation of farmland. To encourage this adaptation, cost-based pricing of agricultural water will be crucial.

VII. Recommendations

A. General

In the Republic of Korea and Thailand, as in other countries of the region, development is best assisted by infrastructure investment that follows an integrated plan at the national level, supported by long-term sector master plans. The quality of such plans depends on whether they are based on thorough comparisons of the likely benefits of possible projects with respect to efficiency, productivity, and social and environmental objectives, compared with the likely costs. The practicality of the plans depends on whether they are consistent with medium-term fiscal strategies and annual budgets. Following the Republic of Korea's example, Thailand must form a comprehensive territory or land use plan aligned with the national infrastructure investment plan.

1. Spending Levels

It is difficult to assess from year to year what amounts of infrastructure spending will be optimal, either in the aggregate or as portions of government and SOE investment. Multilateral development banks recommend that at least 5%–6% of GDP be spent per year on infrastructure, but they acknowledge that individual cases will vary according to fiscal circumstances and indications obtained from cost–benefit analyses of major proposals.

2. Separation of Policy Making and Regulation

Several recommendations in this study addressed specifically to the Republic of Korea and Thailand are based on the assessment that both countries would benefit from a clearer separation of sector regulation from policy formulation and implementation, with more protection for the independence of regulatory authorities. The need for a separate, independent regulator is especially important when the implementing agency has responsibility for contracting.

3. Private Sector Participation

Similarly, in several infrastructure subsectors, both countries would benefit from more competition to drive improvements in service quality and efficiency. Furthermore, they would obtain more private financing for new investments if their policies and regulations provided a more reliable basis for private participation. This would involve the long-term ability of operators to set user charges that fully recover the costs of investment, operation, and maintenance. Alternatively, this could depend on well-specified, sustainable subsidies. Experience in both the Republic of Korea and Thailand has shown the importance of these changes for the financial viability of PPPs.



4. Cost–Benefit Analysis

Their experience with PPPs also suggests that, to obtain the most effective investments and protect the public from unduly high user charges, social cost–benefit analysis should be applied to all proposals, with assistance from national planning bodies.

B. Transport

In Thailand, the responsibility for planning lies with the National Economic and Social Development Board, which would benefit from greater use of analytical work, more rigorous prioritization, and stronger coordination with subsector agencies and SOEs. For the Bangkok Metropolitan Region, a planning authority is needed to cover both transport and land use. This authority must have the ability to integrate the planning of the transport network and public transport services with the planning of land use and other infrastructure. It would be most effective if the board had, in addition to a mandate to make plans, the power to approve all transport expenditures.

Governance of the transport sector could be improved by increasing the transparency and accountability of individual agencies and enterprises, and by separating regulation from policy making and operation. Ideally, there should be one regulatory agency for all modes of transport.

The usage of expressways and highways could be made more efficient through the (i) application of available technology in the form of electronic tolls for expressways, congestion charging, and ramp metering; and (ii) accelerated development of inland container depots and other intermodal facilities, with investment priorities determined through cost–benefit analysis.

Thailand has recognized the strong case for giving highest priority to upgrading and modernizing its railway system. Efficiency gains could be expected from the unbundling of the State Railway of Thailand and the introduction of competition in commercially viable segments. However, this is likely to be feasible only with a pricing regime based on the recovery of costs, including investment costs, or with specifications as to where cross-subsidies would be accepted or government subsidies provided. Other specific investments that deserve consideration are the restoration and expansion of Don Muang Airport, capacity expansion in the Port of Bangkok, and the establishment of a major port on the west coast.

In the Republic of Korea, the government should proceed with its plans and preparations for the expansion of private participation in transport infrastructure in areas where it can be expected to bring the benefits of competition or to augment public financing. The main areas in which the expansion of private participation seems feasible are seaports and the commercially viable parts of the rail system. While unbundling Korail operations is the obvious option, the advantages and disadvantages of the separation of track construction and maintenance from rail operations should be reviewed. In addition, the reported rises in road maintenance costs should be examined in light of the possibility of outsourcing road maintenance to private contractors on a trial basis.

The Republic of Korea is seeking to reduce the energy intensity of the transport system by promoting greater efficiency in the use of roads and by shifting investment priorities from road to rail, including MRT in cities. These policies would be assisted by the removal or narrowing of price subsidies so as to favor the use of diesel and liquefied petroleum gas as transport fuels, and by pricing that would more fully reflect the environmental externalities of fuel usage.

The associated inconvenience for passengers from transfer and waiting times in the MRT could be reduced if transfer centers were developed to offer more commercial, cultural, and business facilities.

Given the importance of PPPs in the country's highway and MRT systems, the policy framework for ensuring their financial attractiveness to operators, consistent with fiscal prudence on the part of the government, should be monitored and refined as necessary. During and after implementation, there should be greater transparency in the financial returns for PPP operators, the basis for user charges, and the costs involved for the government. Cost-benefit analysis should be applied again after project implementation. The government's readiness to have its PPP framework assessed and reported on by experts provides a valuable source of lessons, not only for the Republic of Korea but also for Thailand and other countries.

In other areas of transport infrastructure, the Republic of Korea is an innovator generating valuable lessons for other countries. One area is its use of intermodal transfer centers and logistics complexes near airports and seaports. Another is its use of ICT, as in the "Seoul Bus" smartphone application; and its "smart highways," with congestion charging, ramp metering, and radio frequency identification logistics. As with PPPs, these could be areas in which expert assessment of innovations would be useful for the Republic of Korea and for other countries.

C. Information and Communication Technology

For further development of Thailand's ICT industry, the current forms of government initiatives should be continued through the enabling and regulatory framework, education and training, and the government's own demand for ICT services.

To further develop the Republic of Korea's ICT sector, the current government initiatives should be continued, including refinement of the enabling and regulatory framework, the provision of education and training in ICT skills, and creative approaches to increasing the demand for ICT services. Given that broadband infrastructure is proving critical to ICT growth, support needs to be extended to even greater outreach. The digital divide could be reduced through measures such as targeted financial incentives for market expansion.

D. Energy

For better infrastructure planning in the energy sector, Thailand's Energy Policy and Planning Office plans should be based on more rigorous quantitative analysis. The plans for energy capacity need to be integrated into policies for energy-intensive sectors of the economy and for environmental protection; and subsectors must be more strongly coordinated within a sector master plan. Given these needs, it is encouraging that the Energy Policy and Planning Office has commissioned the Long-Range Energy Alternatives Planning model, a decision-making tool used in many countries to identify long-term options and to prepare national energy plans. The adequacy of inputs to the Energy Policy and Planning Office from other key government agencies, notably the ministries responsible for industry, transport, agriculture, and the environment, should be closely coordinated and monitored.

Capacity expansions in the energy sector, which are currently planned, will require bigger shares of financing both from the energy utilities' resources and private investors. The prospects of this happening would be increased if energy policies were more consistent; the Energy Regulatory Commission had more authority and independence; and opportunities were taken to unbundle the distribution of electricity, oil, and gas. This would require a reliable regime for third-party access to infrastructure, as well as pricing of electricity and oil products much closer to full cost recovery. The cornerstone of these reforms would be the replacement of the current broad subsidies for the consumption of petroleum products and electricity with closely targeted and transparently administered subsidies, sufficiently modest to be affordable in the long term, but consistent with the commercial viability of infrastructure businesses.

In its technical and economic regulations, the Energy Regulatory Commission should be more independent of the policy-making ministries, and have more authority over public sector entities. Under the relevant 2007 legislation, the Ministry of Energy still supervises the operation of the energy industry, but this responsibility would be better placed with the Energy Regulatory Commission, with its resources and technical capacity suitably strengthened.

Given the policy priority that the government attaches both to the security of energy sources and to environmental sustainability, several long-term interventions are appropriate, as long as they remain within the bounds of affordability, use market mechanisms whenever possible to encourage renewable forms of energy, increase investment in domestic and foreign sources of oil and gas, and include the development of domestic lignite sources.

Renewable forms of energy production should be encouraged through a more streamlined and transparent subsidy than exists at present, offered on a more selective basis, and supported by the continued provision of resources for R&D.

The development and use of lignite should also be encouraged in conjunction with "clean coal" measures to limit its environmentally damaging effects. This could best be achieved through the establishment of a regulator empowered to represent public interests and promote eco-friendly

technologies. Similarly, as the government proceeds with its plans to expand the development of nuclear generation plants, a regulator should be established with enough authority to assure the public that safe forms of production and disposal of spent fuel will be used.

There is scope for the government to develop a wholesale electricity market and foster competition among electricity generators in the Republic of Korea. This could be done by privatizing the five generation companies now owned by the Korea Electric Power Corporation. Third-party access to electricity transmission should also be considered to enable competition in distribution.

A framework for competition among electricity generators would be consistent with continued support for the development of renewable energy sources, through a limited and transparent subsidy arrangement as well as promotion of R&D. Within that same framework, the government's plan for expanding the development of nuclear power plants must carefully balance public opinion, the country's energy security, and the need to reduce carbon emissions. Plans for nuclear power plants will have to include substantial investments in safety and in the management of spent nuclear waste.

The current subsidies for producers and consumers of domestic coal need to be reviewed. Although domestic coal production contributes to the country's supply security, its place in the energy mix needs to be reassessed in light of the latest understanding of environmental costs and energy security options.

Several reforms could be undertaken in the oil and gas industries. While diversification of sources of supply is an important objective, it may be better to let private companies decide on which foreign upstream developments to invest in, as they have an incentive to seek supply security and to balance it appropriately against other commercial factors. Downstream, the scope for unbundling the operations of the Korea Gas Corporation must be assessed, especially with regard to distribution, before a regime for third-party access to gas pipelines can be developed. Further, it would be worthwhile to establish a fully independent regulator covering the oil and gas and electricity subsectors. While the conditions for competition currently exist in the market for oil products, they may need to be fostered and safeguarded through more active policing.

The scope of benefits resulting from greater competition will depend on the replacement of current subsidies for the consumption of natural gas, certain petroleum products (i.e., liquefied petroleum gas and diesel), and electricity (for industrial and agricultural uses) with closely targeted and transparently administered subsidies, preferably cross-subsidies within infrastructure businesses that are commercially viable overall. More efficient pricing, reflecting economic and environmental costs, would be greatly helped by extending the use of metering to vary prices according to the season and time of day, and to make the variations more visible to users.

E. Water and Sanitation

Water supply services in Thailand would be enhanced by (i) the passage of the proposed Water Resources Law and, on that basis, the development of a nationwide planning system; (ii) a strengthening of the powers and technical support of the National Water Management Committee, to help it oversee integrated nationwide water management and coordinate among different levels of government and their agencies; and (iii) the establishment of an independent regulator of water pricing with a mandate to promote cost recovery pricing. Further, wastewater management could be greatly improved by an extension of the polluter-pays principle to the domestic market, by stricter monitoring of wastewater disposal, and by better enforcement in the collection of user fees.

To address threats to water security, measures must be taken to develop new sources of water, expand the use of closed-loop systems and wastewater recycling, and increase public awareness of the need for water conservation. Special attention is needed for areas susceptible to flooding and rises in sea levels, and for areas where water quality is at risk.

In addition, strengthening links among national, regional, and local organizations would help them share best practices. Local governments need capacity building for their functions of water supply and wastewater management, and for their expected responsibilities under the decentralization programs of relevant government ministries and agencies.

There are promising developments in water quality management in the Republic of Korea, in particular the four special laws regarding the main river systems, and the application of ICT to the management of water supply and demand. At the same time, some parts of the policy framework require better implementation, such as the creation of community-based capacity to confront possible floods and droughts, especially the nonstructural aspects like insurance, forecasting, warnings, and evacuation drills; the management of water conflicts by clarifying water use rights and watershed protection responsibilities; and the maintenance of water quality by setting pollutant limits, controlling land use in upstream areas, and encouraging participation by local governments. With respect to the management of water conflicts and maintenance of water quality, the application of appropriate charges for water use and for pollution will be crucial for establishing adequate incentives for good water management.

Comparing the experiences of the Republic of Korea and Thailand in developing municipal water supply facilities could contribute to the improvement of municipal water supplies in both countries. It could be worthwhile for the Republic of Korea to develop joint pilot programs to improve water sector management. Further, because of the possibility of water shortages in Thailand (and other developing countries in the region), multilateral development banks should promote integrated water resource management, irrigation efficiency, and water conservation strategies. Given the experience and capability of the Republic of Korea in these areas, multilateral development banks should promote collaboration between enterprises in the two countries.

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A Comparative Infrastructure Development Assessment of the Republic of Korea and the Kingdom of Thailand

This publication is a comparative analysis of the provision of infrastructure in the Republic of Korea and the Kingdom of Thailand. It presents a comparative assessment of the two countries with the purpose of learning from the experience of others. Those interested in identifying the similarities and differences in infrastructure development between a developed country and a middle-income country may find this report helpful. It seeks to explain and interpret the outcomes in each country and their significance to current institutional arrangements.

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