

## Chapter 2

# ICT Investment and Energy Use in South Korea and Japan

The rapid innovation and diffusion of ICT over the past few decades have led to tremendous changes in the economy especially for the industrialized countries. The continuous decline in the price of ICT equipment and software led to increase in the ICT investment and diffusion. As a consequence, the industries have witnessed significant transformation in their production structure. The ICT has become a serious part of economy especially in the industrialized countries. Almost all firms and consumers use computers and Internet connection for economic purposes, such as providing consumers with a more diversified and customized products, improving product quality, and selling goods and services. With the ICT's great effects, it was possible for industries to enhance their interaction with each other aiming at streamlining their production process, lowering the transaction costs, and focusing on the productivity enhancing effects of ICT such as possible substitution between ICT and other input factors of production such as energy use. A worldwide trend is growing to reduce the main source of global warming the carbon dioxide (CO<sub>2</sub>) emissions. This movement trend may have negative effect on the economic growth due to restriction in the use of fossil fuels. As a result, different economic policies have been driven toward energy conservation without disrupting the economic growth. South Korea is a new industrialized economy that has taken advantage of technological development, thereby serving as an economic model for emerging economies. It enjoyed a high economic growth rate from the post-war period until 1997, in which its per capita GDP was about 10,000 USD. The South Korean economy has quickly recovered from the Asian Financial Crisis of the late 1990s, the ICT bubble of 2001, and the credit crunch of 2003. In contrast, Japan has suffered from an economic recession since the 1990s although the government has adopted different macroeconomic policies in order to stimulate the economy, and promoted deregulation and restructuring of industries. However, Japan is still considered as the world's fourth largest energy consumer. The environmental field considers efficient energy consumption as a top priority in terms of both resource conservation and combating climate change. In general, declining economic growth as a consequence of reduction in energy consumption is not acceptable. Therefore,

improving energy efficiency without impairing economic performance is important for every economy. The energy demand management or the so-called demand side management (DSM) is implemented in South Korea, targeting the energy sectors of electricity, gas, and heating. Different energy conservation programs have been promoted by South Korean government. For example, tax breaks, loan and subsidy programs, energy conservation technologies, various pilot projects, energy exhibition, and energy service companies program. An efficient use of energy is not only beneficial to the nation's economy but also important for conservation of natural environment. One of Japan's biggest achievements in the case of oil after the 1970's is in its energy efficiency. Almost no other country is as efficient as Japan in cutting energy consumption per unit of GDP. Currently Japan consumes only half of the energy unit of GDP than for example the European Union or the US do. This was also a great step towards the reduction of CO<sub>2</sub> emissions, since energy efficiency was placed the most on the transportation sector, heavily relying on oil.

## 2.1 Introduction

The rapid innovation and diffusion of Information and Communication Technology (ICT) over the past few decades has changed the economy especially in the industrialized countries. Modern economic activities have largely carried out using ICT features. Computer-integrated manufacturing systems are conducted in the industrial sectors to link design, production, and management aiming at efficient use of input factors of production (Khayyat et al. 2016).

The ICT has facilitated the provision of many services in terms of efficiency in time and resources allocation, management of inventories and human resources, accurate decision making based on up-to-date market data, effective control of supply chain, and many others (Bunse et al. 2011). Furthermore, with the ICT's great effects, it was possible for industries to enhance their interaction with each other aiming at streamlining their production process, lowering the transaction costs, and focusing on the productivity enhancing effects of ICT such as possible substitution between ICT and other input factors of production (Coad 2009; Mun and Nadiri 2002).

A worldwide trend is growing to reduce the main source of global warming the carbon dioxide (CO<sub>2</sub>) emissions. This movement trend may have negative impact on the economic growth due to restriction in the use of fossil fuels. As a result, different economic policies have been driven toward energy conservation without disrupting the economic growth. Many studies have investigated the causal relationship between energy consumption and economic growth (see for example: Oh and Lee 2004; Belke et al. 2011; Stern 2011; Fei et al. 2011; Hamit-Haggar 2012). The 1997 Kyoto protocol aims at industrialized economies that have signed the treaty to reduce their Greenhouse gases emissions, principally CO<sub>2</sub>, by around 5.2% below their 1990 levels over the next decade. The industrialized economies produce nearly 40% of the world's human generated CO<sub>2</sub> (Lee and Chang 2008).

South Korea is a new industrialized economy that has taken advantage of technological development, thereby serving as an economic model for emerging economies. It has enjoyed a high economic growth rate from the post-war period until 1997, in which its per capita GDP was 10,000 USD. The South Korean economy has quickly recovered from the Asian Financial Crisis of the late 1990s, the ICT bubble of 2001, and the credit crunch of 2003 (Oh et al. 2012; Borensztein and Lee 2000). South Korea was the first country to recover within a year from the Global Economic Crisis of 2007/08. In addition, through the conclusion of negotiations on a US–South Korea free trade agreement (FTA), and a potential Japan–South Korea FTA in the future, the liberalization of South Korean markets will continue (Fukao et al. 2009). South Korea has promoted the utilization of new and Renewable Energy (NRE) Development that was enacted in 1972 by taking a market-oriented approach. Since 2012, the Renewable Portfolio Standards (RPS) program has replaced the solar feed in tariff (FIT) program, which entered into implementation in 2002. While South Korea started to achieve tangible results from FITs, the government discontinued FITs due to the financial burden on the government (Chen et al. 2014).

In contrast, Japan has suffered from an economic recession since the 1990s although the government has adopted different macroeconomic policies in order to stimulate the economy, and promoted deregulation and restructuring of industries (EIA 2013a). However, Japan is still considered as the world's fourth largest energy consumer. The national energy policy of Japan has witnessed a radical change after the tsunami and nuclear disaster in 2011. The government has announced the end of the country's dependence on nuclear power and to further develop the technology to increase renewable energy generation to contribute to Japan's energy supply by at least 20% by 2020 (Chen et al. 2014).

## 2.2 ICT Investment

The rapid innovation and diffusion of ICT over the past few decades has caused tremendous changes in the economy especially to the industrialized countries. The continuous decline in the price of ICT equipment and software led to increase in the ICT investment and diffusion. As a consequence, industries have witnessed significant transformation in their production structure.

For the industrialized countries the ICT has become an essential part of their economy. Almost all firms and consumers use computers and Internet access for economic purposes, such as providing consumers with more diversified and customized products, improving product quality, and selling goods and services. Gaining access to ICT leads to higher rates of economic growth as ICT presumably has large positive spillover to other aspects of the economy, and lead to higher skill and education levels among the workforce (Khayyat 2010).

Competitiveness among industries in the new world of globalization is linked to the ability firms have to innovate and to how fast they can make this innovation

real. The intensity of market demand and competition forces organizations to continually search for improvement and offer better services. Thus, the ICT usability becomes a matter of concern for industries to survive. ICT has contributed to redesign, simplification and innovation in work processes, making industries more responsive and active in the implementation of innovations and their insertion in the global market (Khayyat 2010).

Since the 1980s, the ICT sector in many countries has witnessed an extraordinary expansion. The fast paced growth of ICT services can be explained by a number of factors such as price decline of ICT equipment, advancements in technology, market liberalization, and privatization. The output of the world's economy has also been growing at a faster rate during that period. In particular, many developing countries and transition economies have experienced rapid growth. Development in ICT is considered to be one of the driving forces of globalization and the rapid growth of the world's economy (GESI 2012).

As ICT becomes less expensive, more portable, better integrated and interconnected, and embedded in a wider variety of devices, new applications in these fields and whole new industries such as interactive multimedia systems for business, home entertainment, and communications purposes are likely to evolve and to have profound effects on industries' structures, employment, and economic growth. The magnitude of the investment in ICT in the past decade has prompted questions about payoff for both the nation and individual enterprises.

Because ICT is often used to automate processes (that is, to perform tasks that might otherwise require substantial human intervention), and because automation is popularly associated with efficiency and cost reduction, questions about payoff have usually centered on productivity, as the latter is a concept that relates the level of outputs to the level of inputs used in the production. In particular, some economic studies have suggested that the large investment in ICT by the service sector has not been associated with substantial gains in productivity as measured by national macroeconomic statistics (Khayyat 2010).

The ICT revolution of the mid-1990s is considered to be the main driver of the new global economy. Evidence shows that ICT has strong potential to continue to influence economic growth (Atkinson and McKay 2007; Takase and Murota 2004). ICT is considered a driving engine of green growth due to its effects on raising resource and energy efficiency (Ishida 2015). ICT offers various functionalities such as the direct substitution of virtual process for physical process, system monitoring using censoring tools, data transmission and processing, and driving and control of equipment. Through these functions ICT enhance the decoupling of economic activities from energy use (Schulte et al. 2014; Melville 2010).

### **2.2.1 South Korea**

According to the OECD report (OECD 2003), South Korea has built extensive broadband Internet networks and became one of the top leading countries in ICT

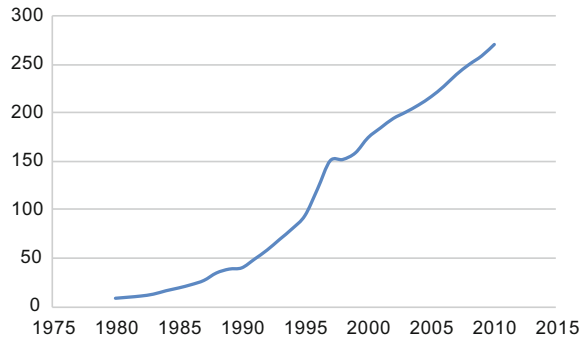
development. In the mid of 2002 South Korea had the world's highest rate of broadband access (19.1% per 100 inhabitants). This was nearly double the access rate of second ranked Canada (with 10.2% per 100 inhabitants). In promoting broadband and the Internet, the South Korean government enacted a series of demand magnification programs. Several programs were designed to facilitate Internet based education, computer use in schools, homes, to offer computer purchase assistance, and even to educate housewives, who tend to control household finances. Perhaps the most clever demand magnification policy was to deeply embed computer literacy in Korea's ultra-competitive university entrance exams, making a home PC a prerequisite for any serious education-minded parent, of which there is no shortage as evidenced by the extensive cram-school industry.

Over the past decade, the average GDP growth in South Korea was 8% and export share of ICT producing industries amounted to 35%. Although South Korea's growth rate decreased from 8 to 4% per year after the financial crises in the late 1990s, the leading export industries such as shipbuilding, automobile, steel products, and chemicals, the ICT producing industries such as semiconductors and mobile handset equipment have greatly strengthened their international competitiveness. In the absence of an underlying driving force that stimulates technological convergence and a productivity increase, such a position gain in international competitiveness might not have been realized during the mid-2000s when the South Korean won appreciated against the Japanese yen and US dollar threatening export markets.

The South Korean government recently began to acknowledge the importance of ICT diffusion and technological convergence (Park 2014). The government announced the "Future Strategy for IT Korea", which coordinates the ICT policy directives of the Ministry of Knowledge and Economics and Korea Communications Commission. It outlines a set of candidate industries that will benefit the most from technological convergence, emphasizing the role of the software industry as a vehicle for industrial competitiveness. The policy priority includes in addition to the mentioned above the security and speed of Internet service. The shift of the policy directive from the network infrastructure to the application of ICT, however, is likely to bring important changes in the regulatory regime of the network industry and requires a comprehensive assessment of the source and impact of technological convergence (Jung et al. 2013).

The ICT industry has grown rapidly during the last decade. According to the Organization for Economic Cooperation and Development (OECD), South Korea's trade surplus in the ICT sector is about 43.30 billion USD, which makes it the largest net exporter of ICT among the OECD member countries (OECD 2013). In 2007, South Korea has exported ICT goods that valued at 97.40 billion USD, while importing ICT products worth of 54.10 billion USD. On average, the trade surplus of the South Korean ICT sector has been growing by approximately 10% a year from 1996 to 2007 (OECD 2013). Many studies have explored the causes of this

**Fig. 2.1** Total industry ICT investment in South Korea (in trillions of Korean Won (KW)), 1980–2010



rapid growth in the South Korea's ICT industry (see for example: Lee et al. 2009; Hwang and Lee 2010; Kwon and Shepherd 2001; Shin and Park 2007; Choung et al. 2012, 2014).

The success in the development of the ICT sector and infrastructure could partly be attributed to policies and initiatives of South Korea that developed before and after the 1997 Economic Crisis. Since the mid-1990s, the South Korean government has established three master plans for the development of the information society: (i) the Informatization Promotion Act (1995) followed by the First Master Plan for Informatization Promotion (1996), (ii) Cyber Korea 21 (1998), and (iii) e-Korea Vision 2007 (Jung et al. 2013).

South Korea came one step closer to a knowledge-based society with the construction of an advanced information infrastructure, the introduction of various information systems in public services and in the private sector, as well as growth in the overall ICT industry (I. D. R. C. 2008). The development of ICT use in the South Korean industrial sectors for the years 1980–2010 is shown in Fig. 2.1. The figures are based on the aggregate level of ICT capital investment in the industrial sector.

The average annual growth rate of ICT investment was 12.8% for the period 1980–2010. Although the ICT investment showed steady growth until 1997, but dramatically decreased during 1998 due to the Asian Financial Crisis. However it has recovered rapidly to reach 27 trillion KW in 2010. The share of ICT investment from the total investment was 13% in 2010. The average share of ICT capital service from the total value added was 6.6% during 1980–2010. These figures indicate that South Korea has achieved considerable development in its economy from the share of ICT investment.

### 2.2.2 Japan

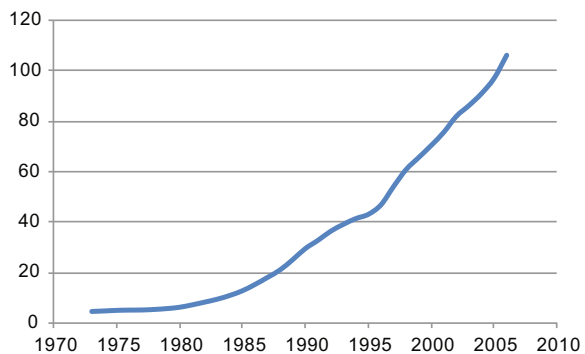
The broadband access rates in Japan are lower than those in South Korea. However, Japan ranks number 9 among the OECD economies with respect to broadband

access per 100 inhabitants. The Japanese government has made a sequence of national ICT policies. The first national ICT policy was released in year 2000 aiming at fostering an advanced ICT network society. The internet penetration rate in 1999 was 13.4% as low as Northern Europe and North American countries. As of 2001, the number of broadband subscribers in Japan was 737,000, behind the US and South Korea. At the time, introducing ICT into corporate management in Japan aimed at installing information technology devices and systems. The law was established because of a sense of urgency on the part of the government about Japan's slow start in the ICT revolution (ODA 2006).

The impact of the ICT industry's performance on Japan's economic growth is significant. The share of ICT industry in Japan's GDP has increased. The per-industry real GDP of the ICT industry in 2004 was US\$560 billion (accounting for 11.7% of Japan's real GDP. The percentage change of per-industry real GDP for the ICT industry was 9.21%. In other words, the ICT industry has contributed by 40% to the change in Japan's real GDP. In year 2004, the total investments in ICT in Japan were US\$150 billion (accounting for 21.5% of the total capital investments made by the private sector. The total ICT capital stock was US\$335 billion, comprising 3.0% of private capital stock. Considering that ICT capital stock comprises 2–3% of private capital stock, its effects on economic growth is significant (ODA 2006).

In Japan, the ICT as a leading factor in technological innovations has contributed significantly to productivity resulting from ICT diffusion in industries and business (Ishida 2015). The increase in total factor productivity (TFP) for the general ICT industry in Japan between 2000 and 2004 was 3.7%. It was 2.9% for electrical machines. The TFP was high for fields related to ICT. It is believed that growth in Japan's TFP is caused mainly by the ICT industry (ODA 2006). The development of ICT use in the Japanese industrial sectors for the years 1973–2006 is shown in Fig. 2.2. The figures are based on the aggregate level of ICT capital investment in the industrial sector.

**Fig. 2.2** Total industry ICT investment in Japan (in millions of Japanese Yen (JPY)), 1973–2006



## 2.3 Energy Use

### 2.3.1 South Korea

South Korea has no crude oil production and therefore is completely depending on its imports. South Korea is placed as the fifth country with the biggest import of crude oil worldwide with 2240 thousand barrels per day. As a consumer of crude oil South Korea is on place nine worldwide with 2301 thousand barrels per day (IEA 2011b).

Oil is still the dominant source of energy in South Korea and makes out around 40% of the Total Primary Energy Supply (TPES) (see Table 2.1), followed by coal with 28% and natural gas with 14%. According to the IEA (2011b), the outlook for the next twenty years in the TPES will be a gradual decrease in oil down to 35–31%, and a huge increase in nuclear energy, while natural gas will remain flat during the projection period.

The South Korean annual energy consumption growth has reached 4.9% in year 2009. The per capita consumption of energy in South Korea is about (5.0) toe in 2009, in which it accounted for more than twice of the world's average energy consumption.

There are three factors that justify the South Korea's high reliance on oil as an energy resource:

1. South Korea had started its economic and industrial development in periods where oil as a resource was plenty, which made energy intensive industries very lucrative ones.
2. The global oil prices were low and further declined during the 1980s and 1990s, which encouraged the South Korean government to deepen its reliance on imported oil as a main form of energy. Even though South Korea is in the transitioning steps towards a knowledge-intensive industrial structure, it started

**Table 2.1** South Korea key oil data. *Source* IEA (2011b)

|                          | 1985  | 1990   | 1995   | 2000   | 2005   | 2008   | 2009   | 2010   |
|--------------------------|-------|--------|--------|--------|--------|--------|--------|--------|
| Production (kb/d)        | –     | –      | –      | 13.0   | 9.8    | 14.2   | 19.0   | 20.9   |
| Demand (kd/d)            | 551.7 | 1048.3 | 2007.7 | 2135.3 | 2191.3 | 2142.3 | 2185.0 | 2248.6 |
| Motor gasoline           | 19.0  | 64.9   | 163.9  | 170.5  | 162.9  | 172.0  | 179.8  | 188.9  |
| Gas/Diesel/Oil           | 149.6 | 279.1  | 481.2  | 379.1  | 413.9  | 388.3  | 381.5  | 389.2  |
| Residual fuel oil        | 212.2 | 333.1  | 558.6  | 487.2  | 433.7  | 331.7  | 313.2  | 306.3  |
| Others                   | 170.9 | 371.1  | 804.1  | 1098.6 | 1180.9 | 1250.3 | 1310.5 | 1364.2 |
| Net imports (kd/d)       | 551.7 | 1048.3 | 2007.7 | 2122.3 | 2181.5 | 2128.1 | 2166.0 | 2227.7 |
| Import dependency (%)    | 100.0 | 100.0  | 100.0  | 99.4   | 99.6   | 99.3   | 99.1   | 99.1   |
| Refining capacity (kb/d) | 776   | 887    | 1170   | 2540   | 2577   | 2577   | 2607   | 2790   |
| Oil in TPES (%)          | 48.5  | 53.4   | 63.0   | 53.3   | 44.0   | 39.5   | 40.0   | –      |



out with a highly oil intensive industrial structure in steel, shipbuilding, petrochemical, and fertilizer industries, that are still an important factor in today's Korean economy (Borensztein and Lee 2000; Jung and Park 2000).

3. South Korea's oil demand also has risen rapidly due to its automotive revolution after the second oil shock in 1979–1980. Because of the economic success, the car and transport unit ownership that are highly dependent on oil have expanded drastically, in contrast to the mass-transit reliance of their Japanese neighbors (Oh et al. 2009).

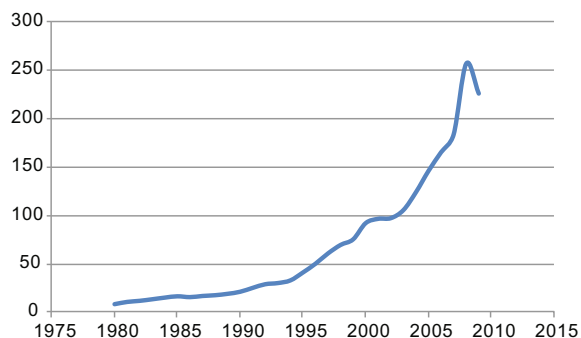
Furthermore, the rapid industrial development of South Korea in the twentieth century transformed its economy to a service based economy with an annual GDP growth of 2.9%. The electricity consumption share of total consumption of energy is rapidly growing. For example, the steel production is heavily depending on the electric arc furnaces and accounted for nearly 57% in 2009. The chemical sector is the largest energy consumer in the South Korean industrial sector, while the largest share of fuel mix in the industrial sector is represented by liquid fuel consumption for feedstock use (IEA 2011a). Figure 2.3 shows the development of energy use in the South Korean industrial sector for the period 1980–2010. The figures are based on the aggregate level of energy used in the industrial sectors.

### 2.3.2 Japan

Japan also relies heavily on oil imports. Japan is placed in the third worldwide on the list of the oil importing countries; with 4579 thousand barrels per day in 2012 due to almost no domestic natural resources. That is around 2300 thousand barrels more than South Korea. While South Korea ranks only on place nine in consumption, Japan is on the third place with a consumption of 4715 thousand barrels per day in 2012 (IEA 2013).

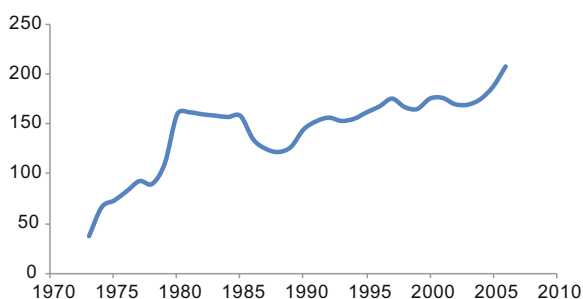
Even though Japan was one of the biggest user and producers of nuclear energy after the US and France before the Fukushima Daiichi nuclear power plant accident in March 2011, oil is still the biggest energy source in Japan. In 2011 oil made up

**Fig. 2.3** Total industry energy consumption in South Korea (in trillions of KW), 1980–2009



**Table 2.2** Japan Key Oil Data. *Source* IEA (2011b)

|                          | 1985  | 1990   | 1995   | 2000   | 2005   | 2008   | 2009    | 2010   |
|--------------------------|-------|--------|--------|--------|--------|--------|---------|--------|
| Production (kb/d)        | —     | —      | —      | 13.0   | 9.8    | 14.2   | 19.0    | 20.9   |
| Demand (kd/d)            | 551.7 | 1048.3 | 2007.7 | 2135.3 | 2191.3 | 2142.3 | 2185.0  | 2248.6 |
| Motor gasoline           | 19.0  | 64.9   | 163.9  | 170.5  | 162.9  | 172.0  | 179.8   | 188.9  |
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**Fig. 2.4** Total industry energy consumption in Japan (in millions of JPY), 1973–2007

to 45% of the TPES followed by coal with 23% and natural gas with 22% (see Table 2.2).

Japan was able to reduce its oil demand from 5.71 mb/d<sup>1</sup> in 1997 to 4.47 mb/d in 2010. However, its oil demand increased again to 4.48 mb/d in 2011 and 4.73 mb/d in 2012 due to the Great East Japan Earthquake with the nuclear power plant accident in March 2011 and its following effects where oil had to substitute for the loss of nuclear energy (IEA 2013).

Since the 1970's oil shocks, Japan demonstrated a threat towards energy security due to the heavy dependence on the Middle East oil supply. However projects to diversify the suppliers or find alternative energy resources have not been very fruitful so far and Japan is still relying on oil from the Middle East as a primary source, importing up to 82% of its complete crude oil imports from Saudi Arabia (33%), United Arab Emirates (23%), Qatar (10%), Iran (9%), and Kuwait (7%) in 2011. Only 4% of its crude oil imports are imported from Russia and 14% from the rest of the world (IEA 2013). Figure 2.4 shows the development of energy use in

<sup>1</sup>mb/d: million barrel per day.

the Japanese industrial sector for the period 1973–2007. The figures are based on the aggregate level of energy used in the industrial sectors.

## 2.4 Energy Efficiency

The environmental field considers efficiency in energy consumption as a top priority in terms of both resource conservation and combating climate change. In general, declining economic growth as a consequence of reduction in energy consumption is not acceptable. Therefore, improving energy efficiency without impairing economic performance is important for every economy (Honmaa and Hub 2014).

Since the first oil crisis in 1973, many industrialized economies have implemented different measures to improve energy efficiency. The European Council has announced the so called the 20/20/20 Goals. The aim is to reduce greenhouse gas emissions by 20% from 1990 levels by 2020, to increase energy efficiency to reduce EU energy consumption by 20% by 2020, and to ensure that 20% of all EU energy consumption comprises renewable energy by 2020 (Honmaa and Hub 2014).

The increase of energy efficiency in 20/20/20 goal seems to be the only item that will reduce GHG emissions, improve energy stability, reduce energy costs, and enhance economic competitiveness. It is important to note that improving energy efficiency can help to reduce GHGs and boost the share of renewable energy without new investment. One driver of improved energy efficiency in the industrial sector is technological change, which is critically affected by the political framework and stringent standards of carbon dioxide reduction. Thus, the importance of energy efficiency targets in policymaking cannot be overemphasized (Honmaa and Hub 2014).

### 2.4.1 South Korea

The South Korean annual energy consumption growth reached 4.9% in year 2009. The per capita consumption of energy in South Korea is about (5.0) toe in 2009,<sup>2</sup> in which it accounted for more than twice of the world's average energy consumption. Major energy sources include fuel oil, coal, nuclear energy, and Liquid Natural Gas (LNG). Although an increase in the use of renewable energy is expected, it will not contribute to the remarkable energy supply in the South Korean energy systems. This poor self-sufficiency is one of the most critical components of the national energy system that leaves South Korea vulnerable to future energy shocks. In this

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<sup>2</sup>toe: An acronym for ton of oil equivalent, it is used to measure energy consumption, an amount of energy released by burning one ton of crude oil, 1 toe = 39.68320 million Btu EIA. (2013b). *International energy statistics-units*. US Energy Information Administration (Online). Available: <http://www.eia.gov/cfapps/ipdbproject/docs/unitswithpetro.cfm> (Accessed May 13 2013).

light, the stable energy supply and conservation is vital to the nation's sustainable development (Lee et al. 2012).

Different energy conservation programs have been promoted by South Korean government. For example, tax breaks, loan and subsidy programs, energy conservation technologies, various pilot projects, energy exhibition, and energy service companies program. An efficient use of energy is not only beneficial to the nation's economy but also important for conservation of natural environment. The major share of this high rate of consumption in energy comes from the electricity, as its share from the final energy consumption has doubled from 12 to 23% by the year 2009 compared with a decade ago. In the industrial sector, the electricity share of the annual final energy consumption growth has reached more than 5.8% (International Energy Agency IEA 2011a).

The energy demand management or the so-called demand side management (DSM) is implemented in South Korea, targeting the energy sectors of electricity, gas, and heating. The Korea Electric Power Corporation (KEPCO) is responsible for the load management program and efficiency, and for the Variable Speed Drive (VSD) program, which aims at implementing high efficiency lighting. As part of the program, transformers are implemented and managed by the government (Lee et al. 2012).

The South Korean government has developed a set of five-year plan for rational utilization of energy since 1993. Hereafter, a basic national energy plan 2008–2030 was announced in an attempt to reduce the energy use intensity by the end of 2030, with up to (38.0) million toe, which corresponds to 46% of the actual energy consumed. Within the frame of the energy plan, the South Korean industrial sector will have to reduce its energy consumption as minimum as 44% (IEA 2009, 2011a).

### **2.4.2 Japan**

One of Japan's biggest achievements in the case of oil after the 1970's is in its energy efficiency. Almost no other country is as efficient as Japan in cutting energy consumption per unit of GDP. Currently Japan consumes only half of the energy unit of GDP than for example the European Union or the US do. This was also a great step towards the reduction of CO<sub>2</sub> emissions, since energy efficiency was placed the most on the transportation sector, heavily relying on oil. After 1970's the Japanese government raised special taxes to make automobile traveling more expensive, as well as raising expensive highway tolls and it is now relying heavily on public transport and mass transit, which leads to reduced oil consumption (Lipsky and Schipper 2013; Vivoda 2010).

Furthermore, Japan has fought its energy insecurities mainly in three dimensions: (i) Japan puts restrictions on oil use, especially in the transport sector, (ii) Japan positively supports alternative fuels, particularly nuclear and solar power, and (iii) The Japan's new energy efficiency policy (Mito 2014).

## 2.5 Summary

The rapid innovation and diffusion of ICT over the past few decades has changed the economy especially in the industrialized countries. The ICT has facilitated the provision of many services in terms of efficiency in time and resources allocation, management of inventories and human resources, accurate decision making based on up-to-date market data, effective control of supply chain, and many others.

The ICT has become a serious part of industrialized countries' economy. Almost all firms and consumers use computers and Internet connection for economic purposes, such as providing consumers with a more diversified and customized products, improving product quality, and selling goods and services.

ICT is considered a driving engine of green growth due to its effects on raising resource and energy efficiency. ICT offers various functionalities such as the direct substitution of virtual process for physical process, system monitoring using censoring tools, data transmission and processing, and driving and control of equipment. Through these functions ICT enhance the decoupling of economic activities from energy use.

The success in the development of the ICT sector and infrastructure could partly be attributed to policies and initiatives of South Korea that developed before and after the 1997 Economic Crisis. ICT investment has grown at a rapid rate in Japan since 1980.

A worldwide trend is growing to reduce the main sources of global warming the carbon dioxide (CO<sub>2</sub>) emissions. This movement trend may have negative impact on the economic growth due to restriction in the use of fossil fuels. The 1997 Kyoto protocol aims at industrialized economies that have signed the treaty to reducing their Greenhouse gases emissions, principally CO<sub>2</sub>, by around 5.2% below their 1990 levels over the next decade.

South Korea is a new industrialized economy that has taken advantage of technological development, thereby serving as an economic model for emerging economies. In contrast, Japan has suffered from an economic recession since the 1990s although the government has adopted different macroeconomic policies in order to stimulate the economy, and promoted deregulation and restructuring of industries.

Energy is one of the critical driving forces for human life. It provides heat, light, mobility, etc. South Korea's annual energy consumption growth reached 4.9% in the year 2009. The per capita consumption of energy in South Korea was about (5.0) toe in 2009, which accounted for more than twice of the world average.

South Korea imports more than 97% of its primary energy. Major energy sources include fuel oil, coal, nuclear energy, and LNG. Although an increase in the use of renewable energy is expected, it will not make a remarkable contribution to the energy supply in the South Korean energy systems. This lack of self-sufficiency is one of the most critical components of the national energy system that leave South Korea vulnerable to future energy shocks. In this light, the stable energy supply and conservation is vital to the nation's sustainable development.

The rapid industrialization and urbanization have resulted in a noticeable increase in the demand for energy, especially in the industrial sector. Although the policy of demand side management has been adopted in South Korea with targeted energy sectors, South Korea's annual energy consumption growth reached 4.9% in year 2009.

Japan relies also heavily on oil imports. Japan is placed in the third worldwide on the list of the oil importing countries; with 4579 thousand barrels per day in 2012 due to almost no domestic natural resources. That is around 2300 thousand barrels more than South Korea. While South Korea ranks only on place nine on consumption, Japan is on the third place with a consumption of 4715 thousand barrels per day in 2012.

Since the 1970's oil shocks, Japan demonstrated a threat towards energy security due to the heavy dependence on the Middle East oil supply. However projects to diversify the suppliers or find alternative energy resources have not been very fruitful so far and Japan is still relying on oil from the Middle East as a primary source.

The environmental field considers efficient energy consumption as a top priority in terms of both resource conservation and combating climate change. In general, declining economic growth as a consequence of reduction energy consumption is not acceptable. Therefore, improving energy efficiency without impairing economic performance is important for every economy.

The energy demand management or the so-called demand side management (DSM) is implemented in South Korea, targeting the energy sectors of electricity, gas, and heating. One of Japans biggest achievement in the case of oil after the 1970's is its energy efficiency. Almost no other country is as efficient as Japan in cutting energy consumption per unit of GDP. Currently Japan consumes only half of the energy unit of GDP than for example the European Union or the US do.

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Khayyat, N.T.

2017, XIII, 164 p. 11 illus., Hardcover

ISBN: 978-981-10-4755-8