CHAPTER 7

Historical Evaluation of Korean New and Renewable Energy Policy

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7.1 Introduction

The Republic of Korea is now facing grand energy transition as the new administration pursues the long-term phase-out of nuclear and coal, offset by the rapid deployment of renewables, which is unprecedented from the

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path-dependent energy policy history in Korea. The new administration announced in 2017 the Renewable Energy 3020 Implementation Plan (RE2030) whose principal goal is to supply 20% of electricity from renewable sources by 2030 (The Ministry of Trade, Industry and Energy 2017), and more recently in 2019 the 3rd National Energy Master Plan (3rd EMP) where the renewable share in power generation is upwardly targeted at 30% ~35% by 2040 (The Ministry of Trade, Industry and Energy 2019).

The proposed energy transition raises a heated debate. On the one hand, the plans were embraced as an appropriate policy response to ever-worsening local air pollution such as particulate matter, climate change as well as safety and radioactive waste issue of nuclear power generation. On the other hand, the plans were blamed for the reason that expanding renewable would not be economical and would undermine the domestic nuclear industry's foundation and its just-blossoming international competitiveness. Both sides, however, raise the same concern of whether the seemingly ambitious target is feasible in the suggested timeline given the laggard deployment of renewable energy throughout the past decade even with much energy and environmental policy attention and initiative to the low-carbon green growth and sustainable development.

In this context, this chapter articulates the Korean New and Renewable Energy Policy (the NRE policy), reviewing its historical development and background in terms of its objectives and instruments, evaluating its overall and program-specific performance, and identifying possible enabling factors and barriers to the effective implementation of the policy. This chapter also draws general lessons applicable to other countries in the burgeoning stage of renewable energy policy.

7.2 Overview of New and Renewable Energy

In the Korean energy policy arena, the terminology of new and renewable energy (NRE) has been more familiar and widely used than renewable energy (RE) up to recently. The "new" includes energy produced from unconventional technologies such as fuel cells, integrated gasification of combined cycle (IGCC). Even the "renewable" includes some energy sources such as waste, which is not commonly regarded as renewable sources.[1]

[1] According to the IEA standard, only 3% of electricity generation from waste in 2016 in Korea can be categorized as the renewable energy (http://www.koenergy.co.kr/news/articleView.html?idxno=104352).

NRE capacity for electricity generation is about 16 GW in 2017, accounting for 13% of the total power capacity. The NRE share in electricity generation is about 8% in 2017, which has been rising since the early 2010s. By the IEA standard the RE[2] capacity shrinks to 11.3 GW with its generation share to 3.5% in 2017. During the past 12 years, the NRE in the power sector grows at the annual rate of 10% (14% for RE only) for capacity and 12% (16% for RE only) for power generation, which has been mainly driven by solar PV, wind, and bioenergy.

According to the two latest energy plans mentioned above, the Korean government is targeting to deploy 36 GW of solar PV, in cumulative term, by 2030 and 113~118GW by 2040 and 17.7GW of wind by 2030 and 43GW by 2040. These deployment targets are about 20 folds increase for solar PV and 38 folds for wind in the next 23 years from the level in 2017.

NRE, in terms of primary energy supply, shows similar development patterns as in the electricity sector. As of the end of 2017, energy supplied by NRE sources totaled 16.45 Mtoe, accounting for 5.5% of the total primary energy supply, but the share shrinks to 2.2% if only renewable sources by the IEA standard is accounted. Waste was the dominant primary energy source over the past 15 years, and bioenergy, solar PV, and wind have been recently driving up the renewable primary energy.

The energy statistics show that the NRE in Korea began to grow since the early 2010s after long stagnation in previous decades as the NRE policy expanded in terms of breadth and depth. The recent growth is mostly driven by carbon-free renewable sources such as bioenergy, wind, and solar, with which the government is targeting to achieve its low-carbon energy transition.

7.3 Introduction of Korean NRE Policy

The Republic of Korea has implemented the NRE policy since the 1980s with its legal basis provided by the Alternative Energy Development Promotion Act of 1987, which was amended later to the Alternative Energy Development, Use and Dissemination Promotion Act in 1997, and to the New and Renewable Energy Development, Use, and Dissemination Promotion Act (the NRE Promotion Act, hereafter) in

[2] RE only includes solar PV, solar thermal, wind, hydro, marine, bioenergy, and geothermal in the following figures.

2004. The NRE Promotion Act legitimizes the NRE policy and attendant institutions and organizations, stipulating the process of designing, implementing, and executing the NRE policy.

7.3.1 Objectives and Targets of Korean NRE Policy

There are three primary objectives in the Korean NRE policy: economic development, energy security, and environmental sustainability. For these objectives, the NRE policy specifies two broad targets: (i) NRE technology development and (ii) NRE use and dissemination. Under each of the targets, various policy instruments are in place (Fig. 7.1).

The NRE policy aims to address the country's chronic energy security issues and global and domestic environmental change problems, while at the same time establishing the NRE industry as a national engine for economic growth.

When the policy was first introduced in 1984 under the Alternative Energy Development Promotion Act, the precursor of the NRE Promotion Act, the policy primarily concerned with the energy security issue as its single objective. With changes in domestic and global circumstances, the NRE policy later expanded its set of objectives to include economic

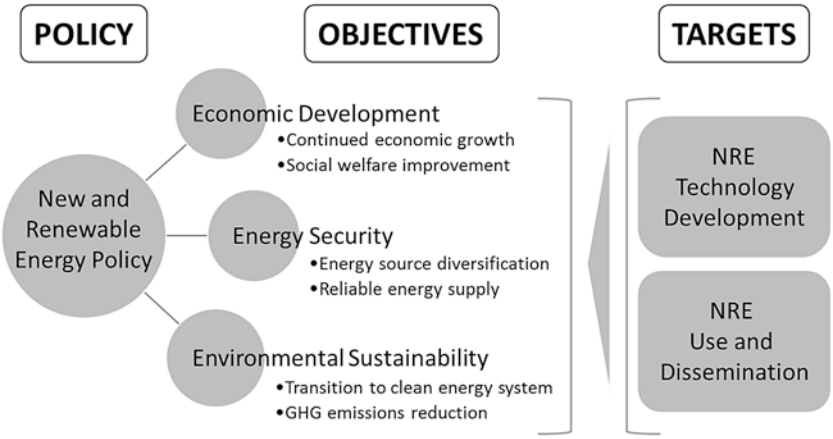

Fig. 7.1 Objectives and targets of the new and renewable energy policy in Korea. (Source: Author's description)

Table 7.1 Categorization of the NRE policy and its instruments

NRE research, development and demonstration (RD&D) programs			
Basic technology development	Source technology R&D program Strategic applied technology R&D program		Research & development
Technology commercialization	Commercializable technology R&D program Core technology R&D program		
Knowledge capability and infrastructures	Human resource development & international cooperation program Technology certification/ standardization/evaluation program		Research & development, information, and education
NRE use and dissemination programs			
Energy supply sector	Power producers policy (FIT/RPS)	Feed in tariff (FIT)[a] Renewable portfolio standards (RPS)	Economic incentives—Subsidy Regulatory standards with economic incentives—Marketable credits
	Transportation fuel policy (RFS)		Regulatory standards
Public and end use sector	Public buildings NRE adoption mandates		Regulatory requirements
	End user NRE dissemination policy (subsidy / rental program)		Economic incentives—Subsidy
	Municipal NRE dissemination policy (infrastructure development subsidy)		Economic incentives-subsidy

Source: Author's description

[a]Korean government replaced FIT to RPS in year 2012. There is no new FIT after 2012

development and environmental sustainability. The chronicle of the NRE policy is detailed in Section (4.1).

The NRE policy consists of many underlying programs and instruments prescribed for various sectors and stages, which can be broadly categorized into the research, development, and demonstration program (the RD&D Program) and the use and dissemination program. The overview of the NRE policy is given in Fig. 7.1 with its policy instruments described in Table 7.1.

7.3.2 Instruments of Renewable Energy Policy

Various policy instruments have been installed under the Korean NRE policy. The instruments can be divided into two broad groups, according to their target sectors and the stage along the process of NRE technology

innovation—the NRE Research, Development & Demonstration Program, and the NRE Use & Dissemination Programs. Each program category hosts a number of policy instruments and programs, addressing various actors and institutions involved in the system of NRE innovation—industry research centers, academia, public-funded research institutes, electric power producers and other private corporations, residential consumers, and municipal governments (Table 7.1). The policy instruments include research & development programs, information and education programs, regulatory mandates and standards, and market-based incentives for NRE technology development and dissemination. The existence of a suite of policy instruments is one of the crucial characteristics of the Korean NRE policy.

7.3.3 Governance Mechanisms of NRE Policy

The NRE Promotion Act requires the Ministry of Trade, Industry, and Energy (MOTIE) to establish the New & Renewable Energy Development, Use, and Dissemination Master Plan (the NRE Master Plan, in short) under the consultation of the NRE Policy Council. The council consists of twenty national experts appointed by the Ministry of Strategy and Finance (MOSF), the Ministry of Science, ICT and Future Planning (MSIP), the Ministry of Land, Infrastructure and Transport (MOLIT), the Ministry of Oceans and Fisheries (MOF), the Ministry of Environment (ME), and the Ministry of Agriculture, and Food and Rural Affairs (MAFRA). The NRE Policy council drafts the NRE Master Plan for the next ten years and beyond, taking into account the country's other national master plans and development plans. Then the MOTIE outlines yearly NRE Implementation Plan with the support from the ministers of other governmental bodies, designating the plan's execution branches under the Presidential Decree and securing program budgets from the central government.

Overall, the NRE Promotion Acts not only designates the MOTIE as the main executing body for the implementation of the NRE policy and but also requires the installation of responsible monitoring bodies and coordinating entities to ensure that the policy remains consistent with other national plans and roadmaps (Fig. 7.2).

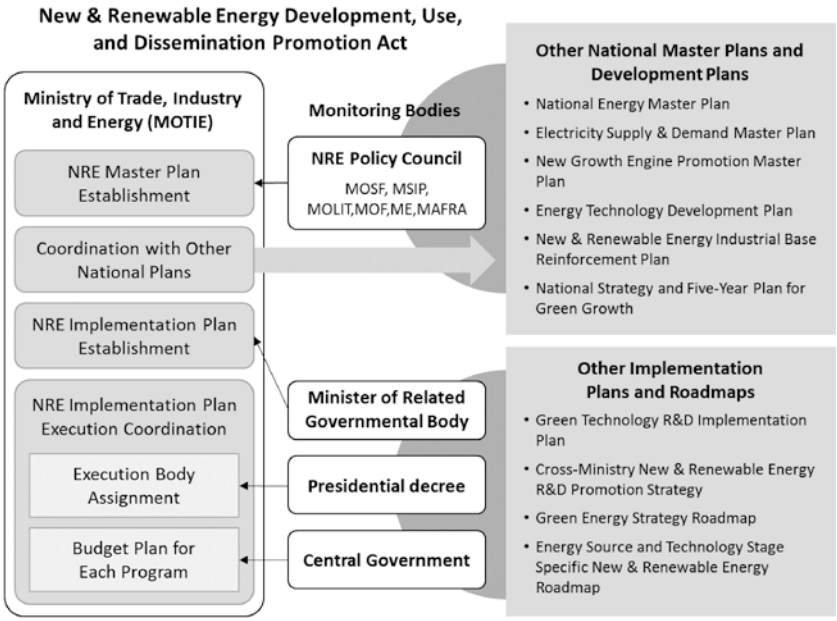

Fig. 7.2 Governance of the NRE policy. (Source: Author's description)

The New and Renewable Energy Center (NREC), an affiliate of KEMCO,[3] is held responsible for archiving NRE related data. The NREC conducts regular surveys, analyzing, managing, and disclosing national statistics and performances related to the NRE policy. There are two yearly statistical reports: the NRE Industry Statistics and the NRE Dissemination Statistics. The former contains the number of manufacturing companies in the NRE industry and their numbers of employment, sales, and exports. The latter provides detailed information on the demand for input resources and installed capacity for individual new and renewable energy technologies. In addition, the Korea Energy Agency publishes the NRE White Paper every other year, which contains descriptive information of NRE

[3] Korea Energy Management Corporation (KEMCO) is a government agency designated by the minister of MOTIE. The agency is responsible for implementing various energy conservation policies and energy efficiency improvement measures as well as climate change mitigation activities.

programs, performance statistics, and the specifications of individual NRE technologies.

7.3.4 NRE Policy and Finance

Among the NRE policy instruments, the NRE RD&D program has remained particularly intensive of financial resources with a varying degree of support to individual technology options. The NRE policy provides various financial supports for government R&D, private sector R&D, and use and dissemination projects. These program costs are sourced mainly from the Energy and Resources Industry Special Account and the Electric Power Industry Promotion Fund (installed in 1988).

Regarding the subsidy-based programs or public procurement programs under the NRE policy, those who receive subsidies or exclusive benefits are clear winners. In the case of RD&D programs, which often prescribe eligible institutions or consortiums in detail, the beneficiaries are very restricted. In other programs, the government often requires a particular minimum matching contribution from the potential beneficiaries. The level of contribution[4] varies by the type of NRE program and the characteristics of these beneficiaries. No apparent compensation mechanism for losers is currently in place under the NRE policy.

RD&D funding was allocated across various NRE technology options. The funding paid particular attention to the four flagship NRE technologies—integrated gasification combined cycle (IGCC), wind power, solar PV, and fuel cell—which were specified by the Green Energy Industry Development Strategy[5] pursuing the country's green transformation. The inclusion of IGCC and fuel cell, which are claimed as "new energy" but not regarded as renewable sources, is what distinguishes the Korean NRE policy from other countries' renewable energy policies. Wind power and solar PV technologies were chosen because, as compared to other options, these technologies were better positioned to be installed nationwide and also promoted for global business development. The funding for solar PV, wind, and bio has been gradually increasing since the mid-2000s, which

[4] The level of matching contribution ranges typically between 30–75%.

[5] On Aug. 15th, 2008, President Lee Myung-Bak announced a list of green energy technologies that the government plans to promote as an enabler of the country's green transformation.

coincides with the rapid deployment of these technologies since the early 2010s.

7.4 Evaluation of the Historical Development of the Korean NRE Policy

This section evaluates the historical development of the Korean NRE policy. It reviews the development of policy objectives and instruments while taking domestic and international environments into account. Then the section compares quantitative targets as specified in the NRE policy-related government plans with their actual performances. The section concludes with identifying possible enabling factors and barriers to the effective implementation of the policies.

7.4.1 Policy Objectives and Instruments

Over the last three decades, the Korean NRE policy has experienced several transitions in its legislation form, adapting and improving its objectives and policy instruments to accommodate the domestic and international needs. The current form of the Korean NRE policy objectives and targets highlight the country's ambition to solve pressing social issues while at the same time establishing a new growth engine based on the NRE sector. In other words, the NRE policy can be thought of as a reconciliation between the demand from the citizens and the international community for environmental and climate improvements and the country's ceaseless pursuit of global competitiveness, albeit the scarcity of its domestic natural resources.

7.4.1.1 Development of the Objectives of the Korean NRE Policy

The early stage of the NRE policy only took the passive path of addressing imminent concerns, such as energy security and air quality degradation. When the first form of the NRE policy was introduced in 1987 under the Alternative Energy Development Promotion Act, the attendant policy instruments focused mainly on the development of alternative energy sources as a means to diversify national energy supplies[6] thus to reduce the country's innate energy system vulnerability to external shocks,

[6] Alternative energy sources as stipulated by the legislation were solar energy, bioenergy, wind power, hydropower, fuel cell, energy from liquefied or gasified coal, energy from gas-

particularly to oil threats from geopolitically unstable nations. Not coincidentally, it was the time when the country barely survived after the two consecutive oil crisis in the 1970s[7] and went through a significant shift in the focus of national energy policy from its earlier petrolization strategy[8] (1960s to early 1970s) toward the promotion of energy security.

The NRE policy objectives and targets began to make their economic growth ambition clearer as of the late 1990s as the Alternative Energy Development & Promotion Act changed into the Alternative Energy Development, Use and Dissemination Promotion Act. The government was determined to promote the alternative energy industry as a significant strategic growth engine, establishing long-term policy objectives and enabling RD&D programs and instruments. Reflecting on the major shift in policy stance, the new Alternative Energy Development, Use and Dissemination Promotion Act started to pursue sustainable and sound economic growth by promoting the technology development, use, and diffusion of alternative energy sources. Unlike the energy security-oriented objectives under the old Alternative Energy Development & Promotion Act, the new act placed priorities on the promotion of the domestic NRE industry as a whole, seeking global business opportunities based on indigenous NRE technologies. It was also the time that environmental concerns, such as the abatement of air pollution and environmental protection, were gradually incorporated into its objectives.

ified heavy residual oil, marine energy, and energy from waste, not including oil, coal, nuclear power, and natural gas.

[7] On account of the state-driven industrialization policy, the country achieved a very rapid transition from primary industry-based economy to secondary industry-based economy—the share of manufacturing value-added in GNP increased from 11% in 1966 to 20% in 1973 with a 10.2% of an annual average rate of economic growth. Despite the 1973 oil crisis, the country was able to continue oil-based economic development, supporting the establishment of the heavy and chemical industry, which was energy-intensive. It was one of the reasons why the second oil crisis in 1979 resulted in minus growth, trade deficits, currency depreciation, and increased foreign debt. This dire situation continued until 1986, when the oil price war started to ameliorate the country's competitiveness. The Alternative Energy Development & Promotion Act was enacted then along with a series of policy instruments for energy security promotion.

[8] In 1966, the government introduced the petrolization strategy, based on the assessment that the coal-based energy development strategy was limited to support a major economic boost.

The country's strategic push for a particular sector like the NRE industry inherits its successful history of state-driven economic development.[9] The NRE industry was put forward as the government was compelled domestically to propose a new growth engine amid economic slowdown during the 2000s and globally to contribute to global environmental change, climate change in particular, as a responsible OECD nation. The country's growth model enabled by technological innovation capability and outstanding human resource base also made the emerging NRE industry an attractive strategic choice.

The Alternative Energy Development, Use and Dissemination Promotion Act has evolved into the New & Renewable Energy Development, Use, and Dissemination Promotion Act[10] in the mid-2000s. In fact, there was a considerable shift in the law's intent from the first alternative energy development and air pollution mitigation causes toward the purpose of "all-encompassing, environmentally friendly energy system transition." The shift suggests that the NRE policy started to assume a major responsible part in the establishment of the national energy policy, credibly and evidently demonstrating the government's determination to make the best use of the NRE industry as the country's new growth strategy. The NRE was no longer a mere response to energy security or domestic and international environmental concerns.

7.4.1.2 Development of the Instruments of the Korean NRE Policy

Along with the shift in the policy objectives, three significant changes were found in terms of the coverage of the policy's instruments and enabling schemes: (i) the consideration of the development and dissemination of fuller NRE technologies from its earlier single focus on the development of selected NRE technologies; (ii) fuller integration with other national

[9] The country strategically focused in the 1960s on export-oriented light industries and import-substituting industries (e.g., energy, fertilizer, cement), followed by the promotion of strategically focused industries (mechanical, steel manufacturing, chemical, shipbuilding, and electronics industries) in 1970s. In the 1990s, the country set the priorities of localizing 12 core industrial technologies, including aeronautical and semiconductor technologies, internationalizing research & development activities, and extending new technology investments overseas.

[10] The current NRE Development, Use & Dissemination Promotion Act stipulates that its purposes are (a1) energy source diversification, (a2) stable energy supplies (b1) environmentally-friendly transition of the national energy system (b2) reductions of greenhouse gas emissions (b3) environmental conservation, (c1) continued and strong economic development, and (c2) social welfare promotion.

energy policies and priorities; and (iii) the introduction of market elements. These changes in the policy instruments are embedded in the regularly drafted Alternative Energy Master Plan and the NRE Master Plan, which specify how the NRE policy would be implemented for the next ten years.

The 1st Alternative Energy Technology Development & Dissemination Master Plan (1997) was introduced along with the legislation of the Alternative Energy Development, Use and Dissemination Promotion Act. The master plan supported the use and dissemination of alternative energy and technology development. Several policy instruments, such as public procurement of alternative energy and subsidies for regional energy deployment, were implemented. The 1st Alternative Energy Master Plan and the following 2nd Master Plan (2003) both employed the select and concentration strategy and invested intensively on the three core technologies near commercialization, that is, solar PV, wind power, and fuel cell technologies, in an attempt to fast track the development of indigenous new and renewable technology systems (The Ministry of Trade, Industry, and Energy 2012).

By contrast, the 3rd NRE Technology Development & Dissemination Master Plan (2008) and the 4th NRE Master Plan (2014) as well extended the coverage to support a greater number of NRE technologies such as IGCC, addressing nearly full stages of the technology innovation process, ranging from R&D to demonstration, market formation, and diffusion (Grubler and Wilson 2014). The new NRE Master Plans provided various RD&D instruments, knowledge capability and infrastructure development programs, and dissemination programs, which would turn the NRE industry into the country's core growth engine. The R&D program under the new plans also set long-term, detailed implementation guidelines, such as strategic investments in technology commercialization, the establishment of local industrial infrastructures, and early achievement of economic feasibility by developing high efficiency and low-cost technologies. It was not until the new NRE Master Plan was introduced when the NRE policy began to be interconnected with the National Energy Master Plan.

The basic stance of the NRE policy, that of the dissemination program in particular, also experienced a major change as the NRE Master Plans substituted for the Alternative Energy Master Plans. First, the dissemination program for end-users has become increasingly responsive to market

needs[11] and regional idiosyncrasies.[12] For example, One Million Green Home Program, which is a successor of the earlier Solar PV Home Subsidy Program that subsidized PV installations only, extended its support to various NRE installations deemed suitable to regional and household characteristics. The program for public procurement also changed from its adoption mandates with limited coverage into a more stringent mandate with broader coverage.[13] The second meaningful change is that the new NRE Master Plan intends to promote program efficiency by leveraging market competition. The instruments brought by the 3rd and 4th NRE Master Plan would incentivize private enterprises to take a prominent role in the NRE dissemination. Instruments for electric power producers shifted from a subsidy-based approach (e.g., feed-in-tariff) to an approach that introduces market competition among renewable suppliers (e.g., renewable portfolio standards)[14] (Fig. 7.3).

7.4.2 Evaluation of Policy Performance

Although the Korean NRE policy articulates its objectives and targets, the performance of the policy has not been systematically evaluated for the respective indicators in any of the earlier reports. There could be two reasons for this absence; (i) the targets are continuously adjusted in accordance with the policy and its instruments development, and (ii) the

[11] The solar rental program enabled consumers to avoid the risk associated with large upfront costs, allowing them to adjust contract terms, such as rental rate, rental period, and renewables certification. In addition, consumers who chose to use government-hired contractors for installation were provided with access to public procurement projects delivered by those contractors.

[12] Over time, the municipalities became more involved in decision-making processes. The examples include participatory community projects, such as cooperative unions and projects that promote the development of customized business models.

[13] The earlier public procurement program covered new public buildings only. However, it later extended the coverage for addition and improvement of existing buildings, increasing the required share of new and renewable energy investments (Public Buildings NRE Adoption Mandate Standard Expansion 1 & 2). Recently, the program added the provision specifying a mandatory share of new and renewable energy use.

[14] It is also true that the financial burden to the Korean government is one of the important reasons for the shift. The Korean FIT support scheme on the NRE industry, particularly on the solar PV industry, has well exceeded the breakeven point for the investors, making the policy expensive and ineffective (Davis and Allen 2014). The introduction of the RPS scheme was considered to be appropriate for the Korean government to recover its financial efficiency of the overall NRE dissemination program.

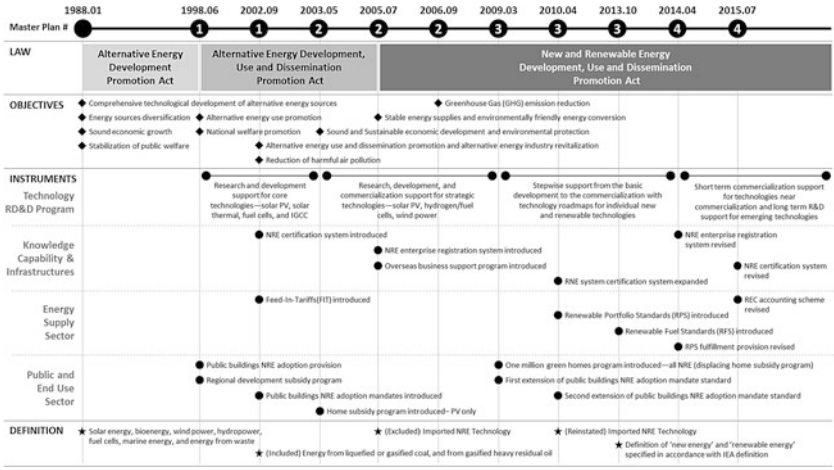

Fig. 7.3 Development of the Korean NRE policy legislation and instruments. (Source: Author's description)

statistics are reported in various formats and places depending upon the types of individual instruments and agencies held responsible.[15]

Perhaps as the most visible but controversial indicator of the policy effectiveness, the NRE primary energy supply targets in the series of NRE Master Plan are compared with their actual performances in Fig. 7.4. The targets set in the 2nd Master Plan were found to be overly ambitious so that the targets were adjusted downward in the 3rd and the 4th Master Plan considering the past deployment of NRE. It should be noted that the performance of NRE in terms of its share in the primary energy supply is reduced if only renewable sources are considered.

Figure 7.5 compares the installation targets for solar PV and wind power. As with primary supply targets, ambitious installation targets were adjusted downward in the following plans. The past installation performance is in line with the 3rd Master Plan, and, as of 2014, wind power deployment fell short of expectations, while solar PV deployment

[15] Although the rate of compliance with the RPS can be another indicator candidate for policy effectiveness, such statistics were not available. Quantification of the compliance rate also presents a major challenge because, due to confidentiality reasons, the fulfillment of the RPS is publicly reported only at the levels of aggregate REC [MWh] or generation capacity [MW] achieved, not at the level of individual power generation companies under the policy.

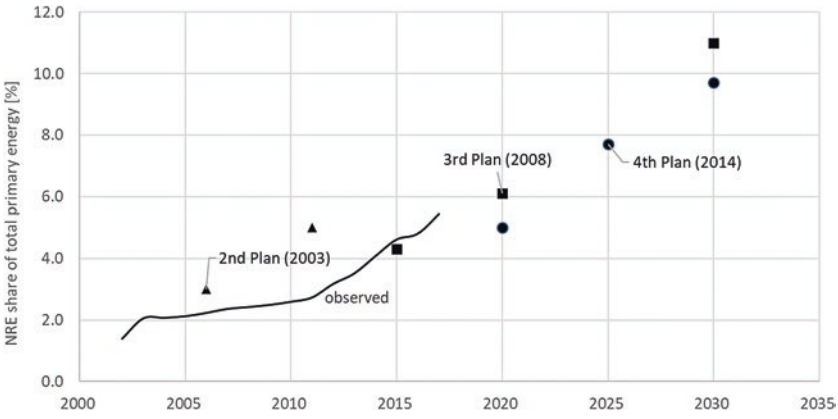

Fig. 7.4 NRE share target in the NRE master plans and real deployment. (Source: Author's analysis)

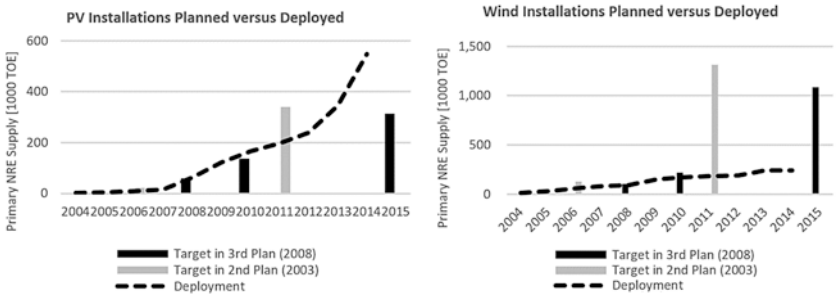

Fig. 7.5 Capacity installation target in the NRE master plans and real deployment. (Source: Author's analysis)

outperformed the target due to major cost reductions driven by fierce competition in the global PV market.

The economy-wide impact assessment of the NRE policy is not available, as the full benefit of the NRE policy will accrue over the next several decades. Nonetheless, it would be a good starting point to observe crude outcomes as expressed by some publicly available industry statistics, which would give a broad sense of how the policy has performed in response to various internal and external socio-economic and technological drivers and barriers. The NRE industry statistics such as the number of companies

and employees, and revenue witnesses that the industry has been growing since the early 2000s in terms of its size, revenue, and export and ramped up quickly until the year of 2011 when the global over-capacitation of solar module supply triggered by European economic stagnation resulted in fierce price competition worldwide and has been recovering since then. Solar PV is the main driving technology of the NRE industry growth followed by wind and bioenergy.

7.4.3 Enabling Factors for Policy Effectiveness

The first enabling condition for effective implementation of the Korean NRE policy was its system-wide policy coverage. The policy, in fact, covered nearly all stages of the energy technology innovation process—R&D, demonstration, market formation, and diffusion (Grubler and Wilson 2014). This is because the Korean government identified the NRE industry not only as one of its major growth engines but also as a means to address climate change and energy security, seriously committing financial resources for implementing innovation and dissemination programs for NRE technologies (The Ministry of Knowledge Economy 2011).

The country's commitment to the full coverage NRE policy is well demonstrated by how the policy was developed and updated. The Korean government periodically evaluates the performance of its public and private sector R&D program, modifying some of the instruments or even revising the overall NRE promotion strategy. For instance, the government's implementation plans for NRE RD&D were incorporated into various national plans, including the Green Energy Strategy Roadmap (2011), the Energy Technology Vision Roadmap (2013), the New & Renewable Energy Vitalization Plan (2013), the 2nd Energy Master Plan (2014), the 3rd Energy Technology Development Plan (2014), the 4th NRE Development, Use, and Dissemination Master Plan (2014), and the Energy Technology Development & Implementation Plan (2015). These individual plans were drafted in such a way that their underlying policy instruments and measures would deliver synergistic coupling with the NRE policy.

The usefulness of the system-wide coverage of the NRE policy is, to some extent, supported by several studies. The studies indicate that the subsidies made via the NRE Use & Dissemination Program, in combination with income growth, resulted in an increased demand for NRE systems, in which private-sector R&D induced by the NRE RD&D Program

played some modest part (Jeon 2007) . It was also indicated that the NRE RD&D Program, combined with industry-level experiences of NRE production, provided a positive influence on private-sector R&D activities (Lee and Noh 2009). The suggestion is that the system-wide approach taken by the NRE policy may have generated synergistic coupling between search processes in the upstream and downstream sectors.

The second related enabling condition for effectiveness would be the government's high-level RD&D guidance with detailed technology roadmaps, strengthened by the establishment of knowledge creation and management infrastructures. The government identified a set of NRE technologies to promote under its national technology innovation roadmaps, laying out associated NRE RD&D program with its enabling institutional arrangements specified.[16] It also delivered programs designed to help establish knowledge capability and infrastructures, with which the country's NRE innovation would be carried out effectively in accordance with other NRE policy instruments.[17]

The top-down, detailed RD&D guidance provided by the government would have the merit of (i) ensuring that the country's economic growth strategy is fully reflected in the RD&D program, (ii) facilitating the process of selecting beneficiaries of the program while reducing social costs associated with interest-group politics during its enactment and implementation, and (iii) allowing for parallel processing of multiple RD&D programs to serve technologies at different development stages (e.g., concurrent promotion of solar cells and balance-of-system development).

Nevertheless, caution has to be paid to the top-down approach, as it may present limited flexibility in adapting to rapidly changing market and technological environments. In this regard, the government required the related industry experts to participate in drafting NRE technology roadmap and attendant strategic plans, which in turn gave guidance to the industry stakeholders by keeping them from taking an irrelevant technology development path. Also, the government left room for possible revision of the roadmap by establishing multiple checkpoints and formal feedback loops to various stages of the NRE innovation process and also

[16] In Korea, basic technology development programs target industry-university-institution collaboration, whereas commercialization and core technology development programs are provided to firms or industry consortiums.

[17] For instance, standards for quality assurance and quality assessment in the NRE RD&D program, encourage firms to develop commercialization-stage technologies.

by monitoring global market and technology trends continually via expert consultation and international cooperation programs. Such a participatory process of developing the RD&D program and prompt, stage-wise evaluation, complemented with the country's relatively high innovation capability, suggests that the Korean NRE policy has what it takes to foster the effective implementation of the RD&D program.

The last enabler would be demand-pull from the public sector. The NRE policy's Use & Dissemination Program mandated government branches and related public institutions to purchase NRE technologies.[18] The state government also provided subsidies to municipal governments administering region-specific NRE dissemination programs. These public procurement programs helped create a foothold market, in which various NRE policy stakeholders, such as policy developers, technology providers, and end-users, could participate and learn from each other, resulting in the reinforcement of industry-wide knowledge capability.

With the public procurement, various NRE businesses engaging in technology development, sales, and installation and maintenance were able to enter and grow from the foothold market, not having to run the risk of failing to create a reliable consumer base. The government, as a purchaser, also benefitted from own experience of employing early-stage NRE systems, in terms of identifying potential room for improving various untested instruments of the NRE Use & Dissemination Program[19] and developing new instruments designed to build consumer trust, particularly in the early stage of technology development.[20] The state government and municipalities also learned from each other, sharing experiences gained from a variety of NRE projects implemented in various settings over the years, which in turn rapidly increased the government's capability of designing and administering the NRE program.

[18] The mandate also covered corporation established by the state, municipalities, public enterprises, government-funded institutes and businesses, subsidiaries of government-funded corporations, and special law corporations.

[19] The government, based on its program administration experience, used discretion in determining the share and delivery cost of NRE dissemination programs for private buildings and houses. Also, the government helped devise programs, such as solar PV rental program, which greatly reduced large up-front investment costs of NRE technology.

[20] Various trust-building programs, such as NRE quality certification, NRE technology standardization, NRE specialized company registration programs, were suggested and developed in this process.

7.4.4 Barriers to Policy Effectiveness

Not surprisingly, there have been several apparent barriers to the effective implementation of the Korean NRE policy. First, too much regulatory emphasis has been placed on the objective of economic development, not on energy security or environmental sustainability, even though all of the three objectives are stipulated in the NRE Promotion Act. Such an unbalanced pursuit of the three policy objectives is illustrated by indicators and measurements employed and reported by the government to monitor and evaluate the performance of the NRE policy. Presently, the performance indicators adopted and employed by the government for the NRE Use & Dissemination Program include NRE production, NRE installed capacity or use, NRE installation units per program expenditure,[21] and those for the NRE RD&D Program include the readiness level of NRE technology development, the number of NRE systems and products certified,[22] and the number of related corporations and institutions.[23] It is surprising that all of these performance indicators concern with the economic development objective, having little to do with the objectives of energy security and environmental sustainability. In particular, energy security and environment-related measurements, such as avoided air pollutants and greenhouse gas emissions,[24] energy self-sufficiency inducement, and changes in energy system stability and electric grid reliability, have rarely been used in monitoring or evaluation by the regulatory entities. Such unbalanced regulatory attention would make timely and proper revisions of the NRE policy increasingly difficult, imposing a serious barrier to the balanced achievement of the original set of objectives.

The lack of seriousness in pursuing the environmental objective in the Korean NRE policy is mainly because the Ministry of Trade, Industry, and

[21] For example, the NRE Use & Dissemination Program for buildings has so far produced the 43,142 toe of renewable energy between 1993 and 2014.

[22] The certification program has certified totals of 59 solar thermal models, 891 solar PV models, 161 geothermal models by 2013.

[23] The total number of 10,140 specialized NRE corporations have been registered under the NRE business certification program (as of September 2014).

[24] Among various end-user instruments under the NRE Use & Dissemination Program, only the housing NRE subsidy program reported the performance in terms of avoided CO_2 emissions. It reported that the total public investments of 671 billion KRW administered between 2004 and 2014 delivered a total of 171.8k solar-powered houses, 22.2k solar thermal houses, and 6.9k geothermal houses, generating 84,985 toe of NRE energy and abating 0.258 Mton of CO_2.

Energy is solely responsible for developing and administering the policy with no other government bodies, the Ministry of Environment, in particular, held primarily responsible. For example, the cross-ministry national GHG mitigation roadmap announced in 2014 did not report the estimated impact on GHG emissions of the policy's public buildings NRE adoption mandates, while the estimated impacts of other sectoral policies, such as Renewable Fuel Standards in the transportation sector, were provided. It suggests that cross-ministry communication and coordination in Korea with regard to the NRE policy remained mostly ineffective. Indeed, the absence of effective policy coordination between government bodies, aggravated by their different administrative jurisdiction, was found to be the main reason for the incompatibility of the Korean energy policy with other environmental or climate policy (Cho and Jean 2014).

The second barrier to effectiveness was the limited policy attention to turning developed NRE systems into real businesses, that is, bridging technology development with market formation. As described earlier, the NRE RD&D Program covers up to technology demonstration among various stages of technology innovation, while the NRE USE & Dissemination Program focuses on public-sector deployment. As a result, it was rare to see public-funded NRE systems near commercialization delivering profitable business cases (Lee and Noh 2009). This gap discouraged developers of basic- or commercialization-stage systems from staying their own boundaries, keeping them from engaging in business development or approaching to experienced business developers, especially when the market was highly uncertain (Lee 2013). It is thus suggested that the NRE policy should also focus on the missing but critically important part, business development, which provides social and environmental impacts, eventually serving the original objectives (Samsung Economic Research Institute 2008).

The third barrier would be the policy's uncoordinated pursuit of technology development versus technology dissemination. Most notably, the government rapidly expanded the size of the NRE Use and Dissemination Program even before indigenous technology systems were ready to be commercialized. This temporal mismatch allegedly made public and private sectors obliged to resort to imported core technology components, eventually impeding the development of a domestic industrial base (Samsung Economic Research Institute 2008). Previous studies point out that the NRE policy should adjust the targets and scope of the NRE Use and Dissemination Program, such that its original policy objectives (e.g.,

economic development) can be better served (Jeon 2007) while taking into account the characteristics and readiness of the technologies under consideration (Hyundai Economic Research Institute 2013). It was also suggested that the NRE policy should revise its RD&D program to reflect the realities and experiences of domestic dissemination (Lee 2013).

The last barrier to the effective implementation of the NRE policy relates to the country's limited resource endowment in terms of natural resource and consumer base. It can be argued that the policy's almost full coverage of NRE innovation stages, combined with formal feedback loops and multiple regulatory checkpoints, can create synergistic interactions between various developments made along the value chain, thereby making the innovation process better guided and more effective (Grubler and Wilson 2014). However, it should be noted that the country's small domestic market base *and* scarce resource base may not be able to keep up with the ambition of technology-based, export-driven economic growth. In other words, the country's innovation ecosystem presents a fairly week feedback loop from technology dissemination experiences to the public & private technology R&D. As such, some domestically developed NRE systems even fell short of their domestic economic feasibility criteria allegedly due to small domestic market demand and limited resource availability.

7.5 Summary and Lessons

The Korean new and renewable energy policy has been successful in establishing and institutionalizing NRE sectors as the nation's new economic growth engine and, albeit to a lesser degree, responding to the global pressure to combat climate change. The new and renewable energy policy is characterized by its all-encompassing coverage of the technology innovation process. Identifying global response to climate change as an economic growth opportunity, the Korean government has established, on the one hand, strategic roadmap and various supporting schemes for the research and development of new and renewable energy technologies. On the other hand, the nation pursued public procurement as the use and dissemination policy to create a scalable foothold market. The systematic policy approach to the development of new and renewable energy led to the pronounced expansion of the sector over the last decade, as indicated by authoritative national statistics.

Nevertheless, there are several hurdles to overcome. First, although the policy ostensibly has three grand objectives—economic development,

energy security, and environmental improvement—only the first economic development objective has been adequately pursued. The assessment of policy effectiveness has not been seriously conducted from the environment/climate perspective or the energy security perspective. This lopsided regulatory attention to the economic development objective resulted in virtually no policy evaluation commissioned by the government on environmental and energy security impacts. Furthermore, two critical chasms were found along the technology innovation process, which deterred the materialization of its full potential. Although the RD&D Program supported the development of technologies from the basic up to near commercialization stage, these technologies often went astray without profitable business cases. Also, in many cases, the use and dissemination program ramped up too rapidly for the RD&D program's indigenous technologies to catch up. This temporal discordance resulted in windfall profits for foreign technology vendors and investors.

We, however, believe that the rapid upscaling of renewable energy in Korea that is required to meet the INDC does not seem feasible by the economic development objective alone, let alone the energy security rationale. The so-far subdued environmental and climate objectives need to be fully reinstituted with strong and consistent political will at all levels of government, as evidenced by across-the-board enabling instruments, sending credible long-term signals to the market. Another important suggestion in the pursuit of the multifaceted objectives is that the effectiveness and performance of the newly instituted policy need to be evaluated regularly and objectively so that the possible trade-off between the objectives can be better understood in the national and regional context and thereby reflected in the revisions of policy instruments to come. The Korean experience of the new and renewable energy policy accounted for in this case study demonstrates both possibilities and obstacles to the grand policy transition.

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