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ADVANCED REVIEW

The rise and fall of green growth: Korea's energy sector experiment and its lessons for sustainable energy policy

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The idea of "green growth" has received international attention for more than a decade as a promising solution to a distinctly modern problem: a century of unparalleled increases in wealth based on equally unparalleled innovations in energy technology accompanied by global environmental threats such as climate change and persistent socioeconomic inequality. The green growth premise is that this problem can be solved without surrendering continued economic growth by a redirection of human effort to invent green energy technology, green energy markets, and green energy choice. Proponents have argued that green-energy based economic growth represents a paradigm shift bringing forth sustainable and equitable relations between environment, economy, and society. The paper reviews a decade of green energy growth strategies and practices. The Korean Green Growth Initiative (KGGI) is investigated as a case study of green energy growth operationalization. Korea's experiment was widely hailed by international bodies such as The Organization for Economic Cooperation and Development (OECD) and United Nations Department of Economic and Social Affairs (UNDESA) for its bold attempt at paradigm shift, with the hope that, if it succeeded, countries currently on the periphery of modern development would be able to overcome conditions of poverty, environmental degradation, and political dependency. But our analysis of the Korean case questions the idea and ideology of green energy growth, demonstrating instead that KGGI was quickly coopted by the paradigm it was supposed to supplant. In this respect, one contradiction in the strategy and practice of green energy growth has been its promise to change the trajectory of modern development without requiring serious changes in modern values and ideology.

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1 | INTRODUCTION

The article focuses on a modern contradiction: the ability to apparently cause rapid human development, especially in the form of economic growth; and, in the process of unparalled growth, an ability to cause environmental harm of a magnitude that threatens planet-scale health. Proposals to address this contradiction have been put forward under the general rubric of

"ecological modernization" (Dryzek, 2013; Jänicke & Jacob, 2005). "Green growth" (GG) is one of these and is the focus of this review (Jacobs, 2012; Jänicke, 2012; Lorek & Spangenberg, 2014).

We ask a specific question about GG: does it offer hope about our ability to live sustainably; or, is the practice of GG likely to leave us in the modern contradiction it intends to cure? The GG strategy pursued by a major architect of the proposal, South Korea, is examined as a means to review empirical evidence relevant to the question. Korean government reports, memoranda and announcements, as well as, press coverage, serve as secondary data. In-depth interviews with key government officials and business leaders were also conducted to understand whether Korean GG policy intended to achieve a paradigm shift in economy–environment interactions. Detailed information regarding the interviews are described in the case study section.

2 | OVERVIEW OF THE MODERN ENERGY PARADIGM

The modern energy system is characterized by centralized, large-scale power production based on complex technology. In the early phase of modernity (mainly 19th century), coal occupied the position of the principal energy source (Cottrell, 2009; Hall, Cleveland, & Kaufmann, 1986). At that time, coal was expensive and production facilities fueled by coal demanded costly investment. Market concentration and economies of scale came to be seen by proponents as essential to make modern energy prevail (Hughes, 1993; Messing, Friesema, & Morell, 1979). As a result, most European countries and the United States substantially subsidized rail transport to and from the mines while creating regulated markets in which electrical generation monopolies were assured a rate of return on their investments.

Mass production fueled by fossil fuels created great wealth. The fact that more people were earning incomes beyond those necessary to sustain life changed their mode of thinking and their manner of living. Soon, the experience that abundant energy sustained social improvement gave to rise a "more is better" ideology.

Fueled by abundant energy, the ideology of "more is better" flourished in the 20th century:

> The high-energy regime touched every aspect of daily life. It promised a future of miracle fabrics, inexpensive food, larger suburban houses, faster travel, cheaper fuels, and limitless growth (Nye, 1999 , p. 215)

New energy sources including petroleum, uranium, and natural gas flowed through the modern energy system and energy production facilities grew bigger and bigger. The production of power was isolated from homes and local work sites. Large-scale power plants supplanted the earlier pattern as every home, office building, shopping mall, and factory was connected to the new system via transmission lines. Large refinery plants supplied gasoline for automobiles while pipelines and wires networked the whole of society to modern energy (Messing et al., 1979; Nye, 1999).

The dominant energy sources in the past did not involve the systematic modification of nature. The premodern system relied on renewable energy sources, but they were part of nature. By contrast, modern energy systems often led to the exploitation of natural resources. As a result, nature became a managed and commodified subsystem of the human economy (Ellul, 1964; Escobar, 1999; Pattberg, 2007). The consequence is telling. Greenhouse gases engendered by the combustion of fuels are changing the air of the earth. Globally averaged, combined land and ocean surface temperatures rose 0.85°C during the period of 1880–2012 (Pachauri et al., 2014). Atmospheric chemistry dramatically changed and will continue to do so. In 2011, the concentrations of these greenhouse gases—carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) were 391 ppm, 1803 ppb, and 324 ppb, respectively (Stocker et al., 2013), exceeding the preindustrial levels by about 40, 150, and 20%, each (Stocker et al., 2013). The IPCC reports that it is "extremely likely that more than half of the observed increase in global average surface temperature" (Pachauri et al., 2014, p. 5) during the period of 1951 and 2010 was triggered by human impact.

As shown in Figure 1, the modern energy paradigm is characterized by three core values: continuous economic growth guided by the principle that "more is better," centralized, large-scale energy production to assure continuous increases in energy production, and human mastery of nature that can assure continuous extraction of (especially energy) resources.

However, success in all three has created the paradox of modernity. Our success is now the source of an epoch-scale environmental threat-climate change. How are we to undo this threat to our survival? One recently championed answer is "green growth" and, specifically, "green energy growth."

3 | SHIFTING TO A GREEN ENERGY GROWTH PARADIGM

In 1997, the World Commission on Environment and Development (WCED) of the United Nations (UN) launched the search for an international effort to address the conflict between the environment and development. In Our Common Future[1] (World Commission on Environment and Development, 1987), energy was identified as a key problem and a key tool to overcome

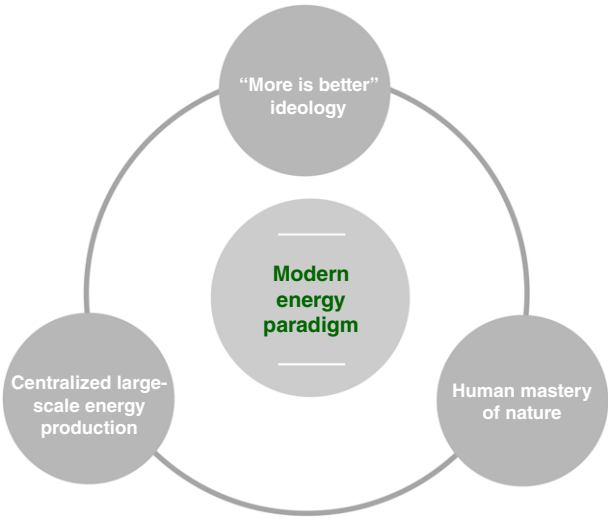

FIGURE 1 Modern energy paradigm

the modern contradiction. Energy efficiency and a reengineering of renewable energy options were stressed as the means to deliver the now-famous WCED ideal of sustainable development: "Development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development, 1987).

The sustainable development proposal of the WCED seemed promising but a hurdle remained. What should modern society do to address the third core value—economic growth? There was widespread sentiment that sustainable development could work especially for wealthy countries such as Germany, the Netherlands, Norway, and Sweden. They were in an economic position to adopt sustainability ideals. This bloc had successfully pushed an alternative energy pathway forward. This change was possible because these countries retained a large stockpile of technology, capital, and administrative structures, which are sufficient to enable nation states to lead development under a coalition of businesses, labor, and civil society (Gouldson & Murphy, 1997; Huber, 2008; Jänicke & Jacob, 2009). Despite struggles to implement an energy transition to renewables and efficiency, these energy options have become powerful market players with the demonstrated potential to create a new industry that actually contributes to economic growth during the transition (Jänicke, 2005, 2008).

But what about those countries with far less wealth; those who could not rely on already established economic success? This bloc argued from the outset that rapid economic growth was still very much needed. Representing the majority of the human population, Africa, Asia, and Latin America were not ready to join the parade in support of sustainable development (Lunb & Panda, 1994; Martínez-Alier, Pascual, Vivien, & Zaccai, 2010; McCright & Nichols Clark, 2006; Simon, 1989).

GG offered an apparent solution (Bina, 2013; Jacobs, 2012). Definitions of GG have always varied (Fay, 2012; OECD, 2009; UNEP, 2011), but a core proposition of GG is that a shift to "green" production and consumption could reduce ecological disruption and, at the same time, boost the economy by creating new industries and jobs. Proponents presented it as a paradigm shift in that changes in institutions and business practices along with investments in new technologies will engender new wealth and opportunities beyond the environmental benefits (Barbier, 2009; OECD, 2011b). Economic growth, which had so far eluded efforts spawned by the WCED doctrine of sustainable development was to be realized by GG.

GG was adopted as a consensus agenda of wealthy and developing countries. The UN and the Organization for Economic Cooperation and Development (OECD) led the process to institutionalize GG. Preceding the GG movement was the UN's Green Economy Initiative (GEI), which was launched in 2008 by the United Nations Environmental Programme (UNEP) and became one of the nine UN-wide Joint Crisis Initiatives administered by the UN System's Chief Executives Board. As a major UN-wide program, GEI includes cooperation from more than 20 UN agencies in supporting National and Regional strategies to "green" their economic development. This initiative has produced green development related research reports and has provided specific advisory services to countries regarding green economy development.[2] The OECD has been a global leader in GG research and policy development. During the years following 2013, the OECD issued over 60 publications incorporating strategies, indices, and policy recommendations for global GG initiatives.[3] The GG Knowledge Platform, which is a collaboration founded by the OECD with developing countries, the Global Green Growth Institute (GGGI), UNEP, and the World Bank, has spread the theories and practice of GG. The world's largest multilateral development banks, including the African Development Bank, Asian Development Bank, European Bank for Reconstruction and Development, Inter-American Development Bank, and the World Bank, pledged to actively support GG programs by using their financial and technical resources.[4] GG rose as a key agenda item for the G8 and G20. The Rio + 20 Summit, which was held as a follow-up to the Rio Earth

Summit of 1992, approved guidelines on green economy policies and stressed GG as a key means to achieve sustainable development.

Many countries rushed to introduce GG initiatives in order to overturn the economic recession of the 2006–2009 period (Kammen & Engel, 2009; Mathews, 2012; Mundaca & Richter, 2015). The American Recovery and Reinvestment Act (2009) embraced "clean energy" allocating toward its promotion USD 67–112 billion, which represented nearly 0.7% of GDP (Conley & Dupor, 2013; Mundaca & Richter, 2015). China committed to realizing a green economy, pledging in its 11th Five-Year Plan (2006–2010) to invest 1.33% of GDP by 2009 (OECD, 2018, April 18; Schmidt & Heilmann, 2010). The European Council adopted "20-20-20" targets in March 2007 (European Commission, 2018, April 23) aiming at a green economy through a 20% reduction in greenhouse gases emissions from the 1990 level, a 20% improvement in energy efficiency by 2020, and a 20% of renewable energy share in final energy supply. Under these targets, Directive 2009/28/EC imposed a binding commitment on the EU-27 as a whole to provide 20% of final energy consumption from renewables (Zoboli, Paleari, Speck, & Asquith, 2013).

The intent of the GGGI has been to catalyze the next step of transitioning the world's economies to green energy as the main driver of GG. Prevailing energy use patterns and supply systems are recognized as major sources of ecological destruction. The negative relation between energy and economy in modern development sparked calls for a paradigm change. For this reason, GG solutions to the modern energy-economy conflict are often also termed as Green Energy Growth (GEG) strategies. This article adopts this convention (OECD, 2011b). Figure 2 illustrates the link between the challenge of the modern development paradigm and the GEG solution. Figure 2 illustrates the link between the challenge of the modern development paradigm and the GEG solution.

4 | SOUTH KOREA'S GG INITIATIVE

4.1 | From Asian tiger to green pioneer

South Korea's role in the GG movement is interesting, given its experience after the 1953 Armistice that stopped the war on the peninsula. The country's economy was built from the ashes of civil war to produce the most rapid economic growth in modern history (until China's rise in the late 1990s) (Kong, 2013). Its politics, assisted by an alliance with the United States, both enabled and reinforced growth as the society's most important priority (Cotton, 1992; Park, 2003).

The energy system underpinning a politics, economics, and even the culture of "pali, pali[5]" was a key to the country's success. The growth of the Korean energy system from the 1950s to the beginning of the 21st century is an illustrative case of the "energy-civilization equation" (Basalla, 1979) that promotes the "more is better" ideology. In the 1950s, Korea was a poor country the majority of whose population did not benefit from the modern energy system. Severe energy poverty was regarded domestically as a key obstacle to the industrialization of the Korean economy (Yeo, 2015).

The Park, Jung-Hee Administration that initiated and led the country's economic development in the 1960s and 1970s made a major effort to secure reliable energy for industry. As a catch-up country with meager market share and weak technical infrastructure, cheap energy was believed to be a vital to creating price competitiveness of Korean products in the international market (Jung & Park, 2010; Kim, 2016; Kim & Ko, 2013; Lee, 2018; Yun, 2012). The government vigorously facilitated the building of large-scale energy facilities centered on oil refineries, coal, and nuclear power plants by authorizing massive

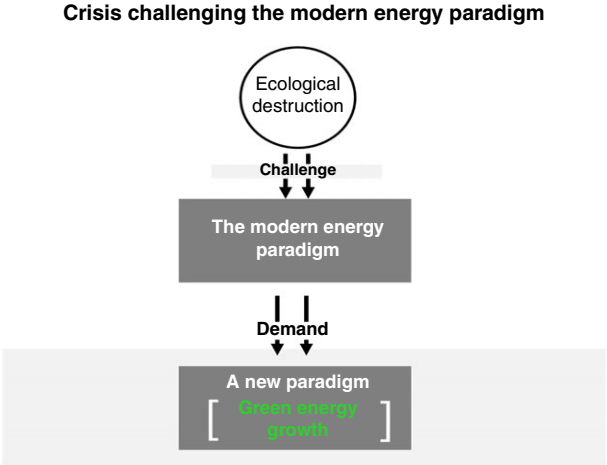

FIGURE 2 Perspective of paradigm shift of the GEG
Source: OECD (2011b).

finance measures including foreign loans, grants, and tax incentives (Boo, Kim, & Park, 2013; Yeo, 2015). The initial operation of nuclear power plants was an iconic event for the Korean energy system as this allowed for adequate supply of energy to the country's rapid economic development. Park, Jung-Hee expressed the start of Gori reactor #1, the first Korean nuclear power plant, as a symbol of the country's modernization and rebirth of the nation at the speech of the reactor's opening ceremony in July 20, 1978 (Lee, 2017, June 26). Also, a policy and regulatory framework enforced low electricity prices that made centralized energy appear to be "cheap" (Korea Institute of Public Finance, 2012; Park, 2011). In turn, this cheap energy strategy encouraged rapid growth in energy demand while preventing unsubsidized energy options from entering the market (Boo et al., 2013; Park, 2011; The Korean Government, 2008a; Yun, 2012). Under these circumstances, Korean energy-intensive development skyrocketed. Korea went from one of the lowest energy-using countries to rank as the eighth largest energy consumer in the world (in 2016, it used 288Mtoe) (Enerdata, 2017). In nuclear generation, it ranked fifth with 154.3 billion kWh in 2016 (NEI, 2018, May 16). The cheap energy price policy largely caused its high energy intensity (Jung & Park, 2010; Korea Environment Institute, 2013; The Korean Government, 2008a). On the eve of the adoption of GEG in 2009, the administered electricity price for industry users ranked as the lowest (2008) out of 34 OECD countries except Australia with 62.4 USD/MWh (compared to an OECD average of 107.4 USD/MWh) (OECD/IEA, 2017). Despite the country's heavy reliance on nuclear power, this low-price policy resulted in increased CO_2 emissions, 10.35 metric ton per capita, which saw Korea ranking 10th among OECD countries (2008).[6]

By the mid-1990s, however, the so-called miracle on the Han River was in trouble. High levels of national debt (accumulated by country's infrastructure to maintain export-led growth) companied with a regional, eventually, global economic recession, to derail the Korean growth machine(Kim, 1999). Its status as an Asian tiger was shaken, with the country experiencing rapid increases in unemployment, a shrinking economy, and creeping self-doubt about its future due to the financial crisis that brought forth the International Monetary Fund (IMF) bailout loan.

Neo-liberal policies focusing on opening the economy to the global market and reducing government intervention in markets were forced by IMF as conditions of the bailout (Feldstein, 1998). The international sanctions drove the Korean economy in a new and, for some, unwelcome direction. Job security weakened, which for many Korean industries that had followed the Japan model of lifetime guarantee of employment was unsettling (Lie, 1990; Yu & Rowley, 2009). Companies used to subsidies and forms of government protection lost their competitiveness. For a decade after the IMF crisis, the country's economy experienced compound difficulties resulting in ever-growing income gaps among classes and a shrinking middle class (Kim & Kim, 2013). Korean aspirations for a new economic engine that could restore the past glory of the tiger economy were very strong.

This background defines why South Korea would turn to GG. When the IMF insisted on "structural adjustment" of its economy as a precondition of loaning the country much needed capital (Kim, 2006), South Korea began an intensive search for an alternative. The new economy would restore international faith in the return of the society to elite status, and (perhaps most important) convince its citizens and businesses that growth would return as the ideal to guide the society's future.

GG could meet the demand of South Korea's people and its international partners—the new economic plan would be led by the country's much-admired infrastructure/construction sectors, and its previously proven ability to compete in high technology as well as industrial markets. Separately its approach from ones pursued by its regional competitors, South Korea would seek to be what it once was but to do so with a technology and policy strategy of "clean and green" development.

4.2 | South Korea's GG strategy

Among newly industrialized countries, Korea became a vocal champion of GG (Jones & Yoo, 2011; Sonnenschein & Mundaca, 2016). Its record of rapid economic development was applauded by development experts (Attar & Kazemi, 2017; Lucas Jr, 1993; Pack & Nelson, 1999; Stiglitz, 1996). The fact that many country leaders in Africa, Asia, and Latin America expressed their hope to emulate Korea's success, made its leadership of the GG movement particularly important (Asongu, 2017; Jwa, 2017; Schneidewind, Schneidewind, & Schneidewind, 2016).

The Korean Green Growth Initiative (KGGI) was designed by Korea's President, Lee Myung-Bak who served from 2008 to 2013. He declared a new development paradigm that would create a growth engine and job creation based on "green technology and clean energy" (The Korean Government, 2008b).With its creation of the KGGI, Korea became an enthusiastic supporter of GG domestically as well as internationally. The KGGI occupied the highest place on the national policy agenda and played a strategic role in steering national programs to promote the new approach. All ministries and local governments created GG promotion systems. Every ministry identified specific tasks for achieving goals published by the KGGI. For example, the Ministry of Strategy and Finance established a medium- and long-term development plan with GG as its goal and created budget plans to mobilize public funds to support the KGGI. The Ministry of Environment took responsibility for the introduction of a Korean emissions trading system (K-ETS). The Presidential Committee on Green Growth holistically steered GG policies and coordinated each ministry's implementation. Under a strong push by the President, the central government

allocated 3% of GDP to green initiatives between 2009 and 2012 (The Korea Presidential Committee on Green Growth, 2009, 2011a, 2011b, 2012).

Three factors interplayed in setting GG as the national policy agenda. First, GG would propel new development that could break the country out of its decade-long tepid economic performance (Jones & Yoo, 2011; Kim & Thurbon, 2015). Second, the transition to an economy founded on clean energy could be a useful alternative to the brown economy which suffered from resource price spikes. Energy price volatility is an especially serious risk to a country that imports 98% of its fuel (The Korea Presidential Committee on Green Growth, 2009; The Korean Government, 2008b). Third, the country was also searching for a vehicle that could establish an international presence for Korea (Han, 2015). Despite its rise to economic power in a very short time, Korea had little say in the international political arena. GG provided a perfect opportunity for Korea, in the midst of an international recession in 2007, to assert leadership that could appeal to domestic needs, leverage the country's reputation for fast economic development, and gain international, especially European, recognition as a leader in a new field.

President Lee quickly recognized the chance. The Korean government promoted GG by cooperating with international agencies such as the OECD, World Bank, UNDESA, and UNEP. It also initiated diverse cooperative programs with developing countries in order to spread GG. Aside from its "four rivers restoration" project around which arose a myriad of domestic disputes over whether it could be a green project in the true sense, the other three key polices of the KGGI—energy transitions, clean technology investment, and the K-ETS—were focused on a paradigm shift in development strategy.

In the Korean case, energy would be the key driver of GG (OECD, 2011b). Korea sought to replace the incumbent carbon and nuclear economy with a "green energy" version through a process of "creative destruction (Schumpeter, 1939)" in infrastructure, technologies, and policy arrangements. According to OECD (2011b), USD 270 trillion would be needed to be invested in the sector to meet energy demand over the next four decades. Proponents of GG saw this forecast as the opportunity to promote Korean construction and technology development in green energy.

GEG proponents depicted the strategy as a paradigm shift that is an inevitable outcome of the ecological crisis created by the conventional energy system. The scale and content of required change to avert further climate change is seen by many (Levin, Cashore, Bernstein, & Auld, 2012; Tompkins & Adger, 2005) as in direct conflict with the prevailing development paradigm. Many in the GG movement regarded and still regard the logic and reasonableness of GEG as a key asset. From 2009, the Korean government paid significant attention to planning for a new energy economy. A master plan for GG focused on the country's energy, aiming at decarbonization and energy security (The Korea Presidential Committee on Green Growth, 2009). The Korean energy strategy took detailed shape in the first national energy master plan (The Korean Government, 2008a) written to be completed by 2030. This plan identified five principles and their achievement indicators: (a) achieving energy independence; (b) transition to a low energy consumption society; (c) being a fossil-free society; (d) assuring energy welfare; and (e) creating new growth engines and jobs through green technology development.

4.3 | GEG principles

There is little doubt that the Korean GEG movement perceived itself as launching an energy paradigm shift. Reports and key policy plans of the Korean government announced this intent. Again, several related international agencies and research centers embraced the initiative as pledged to help the country to build a new order.

In-depth interviews with key people in the KGGI are cited to underscore the perceptions and beliefs of proponents and of those who were skeptical of the GEG ideal. All were promised anonymity. Interviews were conducted mainly in July and August 2014.[7] Among the 20 interviewees were 11 high-level government officials, with economic, energy and environmental affairs backgrounds. These individuals were deeply involved in the KGGI from 2008 to 2012. Three interviewees were professionals in the climate change and energy fields who worked for the Korean national research institutes. Two interviewees were representatives of Korean business associations and four were from the academia, who actively played advisory roles in government committees including the Presidential Committee on Green Growth.

Interviewees were recommended by senior government staffs who were consulted for this research. Staffs were asked to advise the authors who in government, business, and academia could furnish unbiased views about the GEG initiative. Interviews were conducted using an interview guide, but questioning was flexible and changed according to the interviewee's background, responsibility, and level of involvement in the KGGI.

As proponents of GEG argued, if GEG is a new paradigm, its principles have to break away from the key characteristics of the conventional energy paradigm. One major characteristic of the conventional energy system, the more is the better belief, has to be transformed to a focus on the importance of energy savings. The preponderance of centralized and large-scale energy system that enabled mass production and consumption of modernity and facilitated the complexity of energy technology also has to be altered into diversity in scale and location, especially, the decentralization of energy system. The main energy sources have to be moved from fossil fuels to renewables compatible with the environment. Energy equity is a value sought in the new paradigm contrast to the conventional paradigm in which political economic power mainly fell on the grip of

capitalists, bureaucrats, and experts. Lastly, a new paradigm has to establish green economy boosting green jobs for people. These principles are identified in the OECD publications and academic research (e.g., Burke & Stephens, 2018; Byrne & Toly, 2006; Byrne, Martinez, & Ruggero, 2009; Glover, 2006; OECD, 2011a; Schmalensee, 2012; Schulz & Bailey, 2014; Stirling, 2014; Weinrub & Giancatarino, 2015).

Table 1 shows GEG principles and their indicators for energy paradigm shift. Each is applied to the Korean case. Korea's actual value for each indicator in 2006 is provided and then the KGGI targets for 2030 are shown. A greens job indicator is available only from 2008 to 2015. A target for 2030 was not proposed by KGGI.

4.4 | Conflicts surrounding electricity price increases

The Korean government set an aggressive goal of reducing energy intensity by curbing demand. Energy intensity was 0.347 (TOE/USD 1,000) in 2006 and the target was to reduce it to 0.185 by 2030, a 46.7% improvement. This goal could be achieved only by a revolutionary change in the energy system where Korea would have to overcome the abundant energy or 'more is better' belief.

The government's will to overhaul the electricity price system would be essential to realize this change. The country's low electricity price was widely believed to be the main support of Korean industry's competitiveness (Kim, 2016; Kim & Ko, 2013; Lee, 2018; Yun, 2012). The Korean government had upheld low electricity price policy as a means to ensure government-led economic growth. Under this circumstance, its abandonment could bring about a transformation in the political–economic benefit distribution structure of the energy system and could trigger disputes and resistance from groups losing long-enjoyed subsidies. Thus, the electricity pricing policy became a heated battlefront between proponents of the existing paradigm and the GEG alternative.

The toughest resistance arose from inside the government "itself." The Ministry of Strategy and Finance (MOSF) was skeptical of raising electricity prices, even though it was deeply involved in the establishment of KGGI. As the "control tower" of Korean economic affairs, this ministry typically opposes high price schemes due to concerns over inflation (Jung & Park, 2010). The core ideology of the conventional energy paradigm found a powerful defender in MOSF. Byrne and Wang (2014) argued that a form of "dynamic conservatism" is often found in energy policy which forces proponents of change to deliver their ideas with the promise that they will not disturb the "steady state" of existing economic development. In a basic sense, MOSF has been the guardian of the "steady state" and would now play a key role in preventing the GEG strategy from realizing energy transformation.

The USD 10.3 billion of government subsidies in 2008 to KEPCO (the national electricity utility) and KOGAS (the national natural gas utility) provides a vivid demonstration of a compromise between the defender and reformer of electricity price. In that year, oil prices skyrocketed to USD 140 per barrel and utility prices had to be adjusted to reflect their impact on fuel markets, but the Korean government decided to offset the gap between costs and market prices with additional government subsidies. A government official from the Ministry of Trade, Industry, and Energy (MOTIE) conversant with the situation confirmed that there were conflicting views between the MOSF and the KGGI:

> We tried to discuss a rate increase with the Ministry of Strategy and Finance. But the ministry decided not to permit a rate increase. Instead, it chose an alternative option to offset possible deficits at KEPCO and KOGAS by

TABLE 1 Principles and indicators of Korean GEG

Principles	Indicators	Actual (2006)	Korean GEG targets (2030)
Energy saving	Energy intensity	0.347	0.185
Decentralized energy system	Nuclear share[a]	15.9%	27.8%
	Sites of utility-scale PV power plants[b]	3	N/A[c]
Transformation to renewable energy	Renewable share[d]	2.4%	11%
	Oil dependence	43.6%	33%
Energy equity	Energy poverty[e]	7.2%	0%
Green economy	Green jobs[f]	1.2% (2008)	N/A

Sources: The Korean Government (2008a, 2008c), K-indicator (2018, Oct. 2), MOTIE and KEEI (2017), and Yun and Park (2016).

[a] Nuclear share in total primary energy supply.

[b] Number of utility-scale PV power plants sites beyond 10 MW capacity.

[c] A formal target was not declared by KGGI. The basic plan on electricity demand and supply (2008–2022) announced by the Korean government demonstrates planned solar PV power plants coming in during the plan period by the total capacity not sites and their scales.

[d] Renewable energy share in total primary energy supply including hydro.

[e] Population eligible for energy voucher aid.

[f] Portion of employment in green industry = (employment in environmental industry + employment in renewable energy industry)/country's total employment.

> increasing the government budget. It pushed us to request a budget for the subsidy in the 2008 supplementary budget bill. We didn't like it, but we couldn't help but accept that decision.

This interviewee offered a strong objection to the decision:

> It can be compared to making a right turn signal using a left turn indicator. It was incoherent with Green Growth. The September 15 Blackout of 2011 was a result of the incoherent policy. The conditions for supply expansion policy were not favorable. In addition, demand-side management [programs] realized low performance because of the low electricity price mandated by the government. At every peak season, the nation had to draw electricity from the power emergency system due to shortages in power reserves.

Opposition from industry included highly energy intensive companies that contributed extensively to Korea's export sector whose businesses are very sensitive to electricity prices. As a high-level official in the Federation of Korean Industries observed:

> Businesses oppose raising electricity rates because it is costly. Industry rates are lower than those in the residential and commercial sector (though the general public benefits from growth attributed to expending industry). The cost to industry ultimately transfers to the consumer. However, [if government wants to increase the rate] first of all, the cost recovery rate of KEPCO has to be declared transparently. We don't trust the cost recovery rate that KEPCO receives. The electricity market is monopolized by KEPCO. Consumers cannot move to other choices. [And] KEPCO does not open their books for us to see its cost structure.

Because of the conflicting interests among diverse stakeholders, raising the electricity rate is and has always been a contentious issue. The belief in the "energy-civilization equation" dominates the industry mindset, making it difficult for the government to challenge it. In addition, opposition from the vested rights who had been the biggest beneficiaries were sturdy and effective.

Final energy consumption from 2008 to 2015 steadily increased as average consumption realized a 2.38% increase per year during the same period. The growth of average final consumption by industry grew faster, at 3.5%. The policy intervention of Korean GEG hardly produced a paradigm change. Government and industry appear to be as supportive of the energy-civilization equation as ever. One of the architects of the GEG strategy summed it up this way:

> We tried to place as a top priority of policy actions to normalize the electricity price in order to stimulate market change. 'No change' was the outcome of big fights with economic bureaucrats and industry. We lost.

4.5 | "Green Titans"[8] or a decentralized green energy system?

The emergence of renewable energy was a notable change in the Korean energy system by the time its GEG strategy was launched. Renewable energy gained recognition and elevated importance for the first time in the Korean energy development. The GEG strategy's top priority was to significantly increase the share of renewable energy in the national fuel mix for electricity generation because renewables offer a potential to lead to significant social change since their use can mean a major decentralization of the energy system and, importantly, its governance (Byrne & Toly, 2006; Glover, 2006; Goldemberg, Johansson, Reddy, & Williams, 1987; Goldthau, 2014; Khavul & Bruton, 2013; Lovins, 1979; Numminen & Lund, 2017; Zeschky, Widenmayer, & Gassmann, 2011). Glover (2006) observes that a social goal of renewable energy development lies in realizing autonomy for users and for communities who can tailor policies to local needs.

Renewable energy policy in Korea shifted to a Renewable Portfolio Standard (RPS) in 2011 with an intention to attract larger-scale projects in a short period. The GEG strategy sought large and quick additions of renewable capacity, hence the utility sector responded by promoting the development of mega-scale renewable energy projects. Significant growth was expected, particularly in wind and ocean power, through utility-scale wind farms and offshore sites. Tidal projects were conceived to provide the same level of power as existing fossil fuel or nuclear power plants. Through the RPS policy, third-party producers were guaranteed a large and fast-growing market whereas the utility sector was allowed to concentrate on MW-scale plants, a scale which it was not familiar with.

Few GEG planners raised objections regarding the biasness of large-scale plants. From their point of view, the size of plant had little relevance since the aim was fast growth in renewable energy generation to support conventional economic growth. The prospect that preference for "Green Titans" would leave the existing utility sector in the command of the country's greening of its energy system was not a worry. If the utility sector preferred large scale, the attitude of many proponents was in effect, "so be it."

Along with renewable energy, nuclear power gained strong support as the surest avenue toward decarbonization. The first National Energy Master plan targeted an increase in the nuclear share of power supply from 26% in 2006 to 41% in 2030. To meet the target, six new nuclear power plants had to be installed in addition to the 9 units that were already under construction at the time the plan was developed. The government also invested in nuclear R&D such as light water reactor, next-generation fast reactors, and even nuclear fusion which amounted to a budget of USD 7.7 billion during 2011 and 2013, representing 9.8% of the country's 18 green technologies R&D expenditure (Green Technology Center, 2014).

The main question was how a decentralized renewable energy system would coexist with centralized nuclear power; and tensions between energy savings and large-scale energy systems were not admitted. More specifically, how could energy intensity be sharply reduced while adding large amounts of generation capacity as required by the economics of nuclear power?

For renewables to prove their worth in leading to paradigm change, a different platform of embedded values regarding energy production and distribution systems is needed. Energy transition to an environment-friendly technology can, for example, reduce carbon emissions but such a reduction does not by itself alter energy demand (Byrne & Toly, 2006). As a result, the new energy strategy had to decide whether it would embrace the cheap energy principle of the conventional paradigm celebrating the economies of scale and technology innovation in pursuit of its ideology. Unless adherents found a social purpose in renewable energy design and governance that abandoned the ideology of the conventional paradigm, little more might result than a "green titans" scheme with solar, wind, and other sources simply inserted in the grid to retain the energy status quo (Byrne et al., 2009, p. 86).

4.6 | Increases in mega-scale renewable energy projects but a failure in achieving renewables targets

Many plans for large-scale green power plants were not realized. For example, the Gimcheon wind farm complex (97.5 MW) which was expected to come on line in 2013 was canceled in 2011 and the Garorim tidal power plant planned capacity of 520 MW planned for 2014 also faced the same fate. Significant conflicts of interest and civil resistance were the cause of cancellations in both cases. Despite the cancellations of utility-scale wind and marine power plans in Korea due to varied obstacles, solar power has grown. Utility-scale photovoltaic power stations which operated at three sites with 56.4 MW capacity in 2010 increased to eight sites with 135.7 MW capacity in 2013 and 320.7 MW capacity at 19 sites in 2016. However, the growth of utility-scale green power plants had little contribution to increases of the renewable energy share in the national energy mix. Renewable share in the country's primary energy rose from 2.40% in 2006 to 4.60% in 2016.

Unlike many cases in the world (such as France, Italy, Germany, Japan, and the United Kingdom) where Feed-in-Tariff (FIT) has shown a remarkable performance in boosting renewable energy penetration, its adoption did not lead to a significant change in the renewable share of Korea. This difference came from the small level of economic support to renewables under the Korean FIT. Notably, the Korean FIT was applied to 28% of total renewable energy generation by earmarking 6.6% of the Electrical Industry Foundation Fund, which is sourced by a power bill surcharge (KERI, 2010; MOTIE & KEEI, 2017). This contrasts with the practices of European countries and Japan. For instance, Germany and Japan levy a power tariff surcharge that is only dedicated to renewable energy FIT. France spent 85.4% of its CSPE (French electricity surcharge) to compensate the gap between renewable electricity in 2016 (Selectra, 2018, March 15; Couture & Gagnon, 2010; Sun & Nie, 2015). The full implementation of FIT that subsidizes all renewable energy projects coming in a year leads to increase in electricity tariff (DW, 2018, March 15; Craig, 2016, October 26; Bermudez, 2018; Renewable Energy Institute, 2017) in those countries.

Instead of implementing a more robust version of FIT, the Korean government installed an RPS system to facilitate fast growth and development of large-scale renewable energy plants. The background of the Korean government's shift from FIT policy to RPS raises doubts about government's seriousness in pursuing a transition to a renewable-centered energy system. The fear of rapidly raising the policy's costs won out over GEG principles. Revenue available from the Electrical Industry Foundation Fund amounted to USD 17.7 billion and the maximum expenditure for the FIT was only 18% of the revenue in 2011 (when the FIT subsidy size reached its peak before elimination) (The Korean Government, 2012). Thus, the government actually had sufficient funds to support the expansion of the FIT program if it had wanted to. However, the Fund's principal uses were: provision of compensation to communities living near and burdened by the operations and risks posed by the operation of large-scale power plants centered on nuclear, coal, and hydro power; support for R&D efforts (which involved the investigation of new nuclear plant designs in large portion); and support for pro-nuclear power plant advertising. These uses had a common entrenched interest—KEPCO, the majority of whose stock is shared by the government. The Korean government eventually directed these funds to be used to continue support for the conventional regime. That is, the Korean government, after announcing its GEG goals, decided not to reallocate financial resources served for safeguarding the prevailing "more is better ideology" in order to transform the energy sector.

4.7 | Neglected: Energy equity and green jobs

Core principles of the GG paradigm championed by the OECD and others are intended to guide policy to a different political economic structure. More people are supposed to get access to affordable energy and benefits from growth of the green energy sector and job creation and other benefits are intended to be shared broadly. In this sense, government in the pursuit of energy paradigm change has to put an emphasis on equitable distribution of benefits from the energy system revolution. In the Second Energy Master Plan of Korea, the Korean government set a target for energy poverty for 2030, but detailed programs for achieving the target were never outlined in the 5 Years Plan for GG. Actually, the portion of households eligible for energy vouchers continued to increase since 2006, realizing 7.2%, 9.6%, and 10.2% in 2006, 2011, and 2016, respectively (Yun & Park, 2016). This can be taken as recognition by the government of continuing energy inequality, but vouchers offer no guarantee of energy affordability, only an indication (for now) that the government recognizes the problem.

Green jobs created as outcomes of efforts from KGGI were not systematically tallied. If KGGI's goal of energy transformation were to be realized, significant increases would need to be achieved. However, expansion in jobs resulting from the rise of the green economy was meager. Employment in green industry rose from 1.2% in 2008 to 2.2% in 2015 out of the country's total employment.

The principles of energy equity and job creation were neglected in KGGI planning and as a result, no change (and even in a retreat in the case of energy affordability) resulted (Table 2).

The indicators analysis in Table 2 suggests that Korean GEG failed as a paradigm pioneer. Energy intensity, a proxy of "more is better ideology," was targeted to reduce by 2.5% per year upto 2030. However, its actual achivement was −0.9% per year by 2016, recording 0.315 (compared to 0.347 in 2006). This is much lower than the target. The Korean government's efforts in reshaping the power sector actually increased dependence on nuclear power and favored centralization of renewable energy in the hope of making it fit with the already existing system principles of a centralized and large-scale energy system. Even the government's support for an aggressive target for a rapid growth of the renewable share was not sufficient. Actually, the renewable energy share remains very small and there is no reduction in coal or oil dependence. Energy equity and green jobs were neglected. Figure 3 vividly demonstrates Korea's paradigm failure.

An analysis of policy actions reveals that the Korean "energy transition plan" was ignored by many of its own architects in favor of the status quo. When evidence of GEG commitment was necessary, the government backed green mega-machine development, which would be designed, built and operated by KEPCO and its subsidiaries. In the GEG transition, Korea's largest energy corporation would be the main agent of the GEG "paradigm shift," in effect pursuing "transition without change," a strategy coined by Byrne & Toly (2006, p. 22) in their investigation of how genuine energy change has often been derailed. The treatment of renewable energy in the Korea's GG era underscores a cone contradiction in its premise of creating a paradigm shift. "Green energy titans" do no seek to transform society–nature relationship, that is, mastery of nature by human society. The decision structure of the conventional energy system remains intact, no institutional overhaul occurs, and no change in ideology results. The production of energy is still centralized , "more energy is better" continues as an ideal, and energy governance is in the hands of the very instututions that guided modenization into the climate change crisis. Energy equity and green jobs had little attentions. They were believed as the outcomes of trickle down effect that conventional market liberal econmists have believed.

Paradigm shift was supposed to yield a different outcome. The energy system was supposed to be rebuilt to focus on socially valuable ends such as local development, equitable distribution of economic benefits, and governance based on democratic involvement of citizens rather than simply consumers (Beermann & Tews, 2017; Bulkeley & Fuller, 2012; Byrne et al., 2009; Byrne & Taminiau, 2016; Byrne & Toly, 2006; Cities, 2016; Dobbs, Wheldon, & Sharma, 2016; Glover, 2006; Goldemberg et al., 1987; Goldthau, 2014; Koirala, Koliou, Friege, Hakvoort, & Herder, 2016; Numminen & Lund, 2017; Ostrom, 2010; Piggot, 2018; Späth & Rohracher, 2010; Zeschky et al., 2011).

TABLE 2 Scorecard on Korean GEG efforts

Principles	Indicators	Actual (2006)	Korean GEG targets (2030)	Actual (2016)
Energy saving	Energy intensity	0.347	0.185	5.3%
Decentralized energy system	Nuclear share	15.9%	27.8%	11.6%
	Sites of utility-scale PV power plants	3	N/A	19
Transformation to renewable energy	Renewable share	2.4%	11%	4.6%
	Oil dependence	43.6%	33%	40.1%
Energy equity	Energy poverty	7.2%	0%	10.2%
Green economy	Green jobs	1.2% (2008)	N/A	2.2% (2015)

Sources: The Korean Government (2008a), Green Technology Center (2015), MOTIE and KEEI (2017), and Yun and Park (2016).

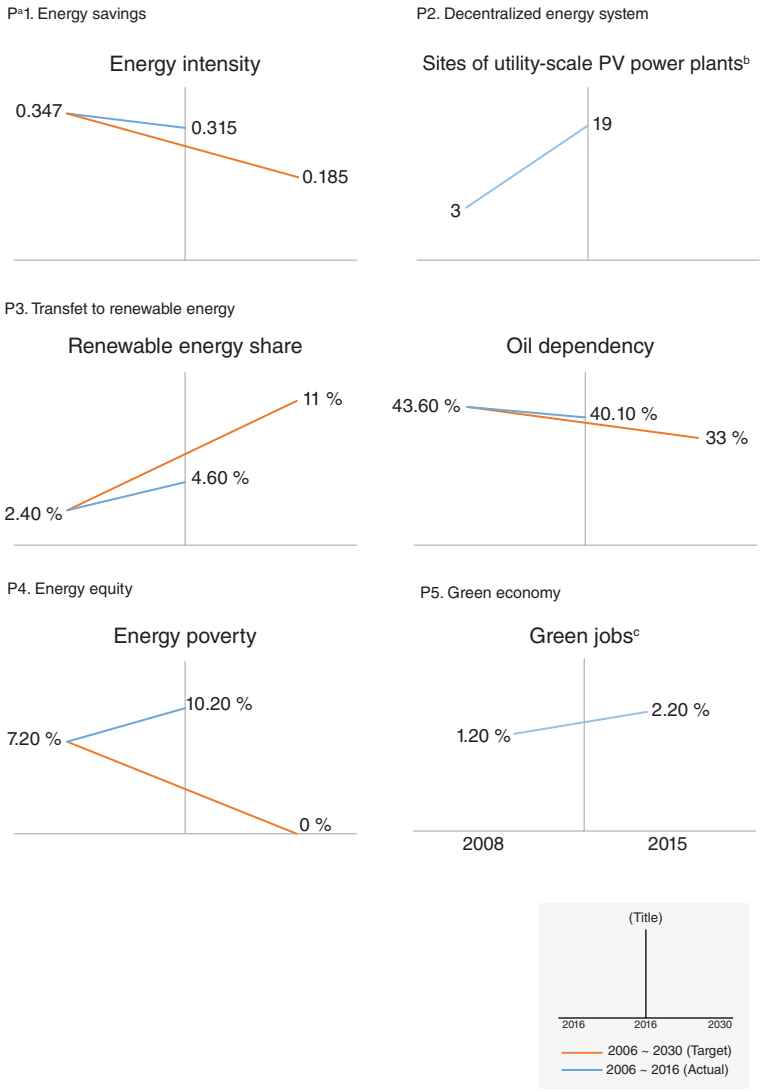

FIGURE 3 Achievement of major targets of Korean GEG

Notes: [a]P means a principle of GEG, [b]2030 targets for "sites of utility-scale PV power Plants" and "green jobs" were not proposed in the Korean GEG. [c]A green job indicator is available only from 2008 to 2015.

The GEG strategy, at most, offered a measure of decarbonization, but only by supporting green "tycoons" (Byrne & Toly, 2006). How large wind machines installed on mountain tops and valleys, barren fields, and deserts covered with solar panels are indicators of significant change in social values, a core requirement of paradigm shift? Far from being "incommensurable," (Kuhn, 1963) the conventional energy paradigm and GEG appear to be complementary. The reduction in carbon is registered as change in atmospheric chemistry, but not social direction. In this change, the prospect of human conflict with healthy ecosystems continues. More consumption, because it is based on green energy, is enabled. As a result, decarbonization associated with large-scale renewable energy might only be temporary because carbon sinks are converted to consumption/production sites and the paramount goal of growth once more pushes society to a new crisis.

5 | LESSONS FROM THE KGGI

Using Kuhn's approach (Khalil, 1987; Morgan, 1980; Willmott, 1993), an authentic paradigm shift of the energy system depends on changing the embedded values within institutions, policies, practices, and acutal projects in the field. Without a change in values and beliefs, the power of the existing paradigm is not put at risk (McDonagh, 1976; Willmott, 1993). In this case, GEG is little more than a failed dream. Two beliefs of the conventional paradigm proved to be its undoing; the "more is better" ideology regarding energy consumption, and the technological optimism of large-scale system managed by experts.

Architects and policy promoters of GEG believed in both values, leading the initiative to look for ways to reproduce the conventional energy system with different energy sources. When interests between the old and "new" approaches conflicted,

Korea's economic development strategy planners prevailed in apposing electricity price increases. Concerns over inflation and belief that higher prices would harm economic performance led the bureaucratic layer of the government to resisit implementation of GEG programs and policies. Similarly, when it came to procure renewable energy, the managers of the sector in the Ministry of Trade, Industy, and Energy (MOTIE) looked for "plug-in-pay" solutions. Renewable energy projects had to be large and had to meet the system goals of the national utility. GEG's proponents either spectated while renewable programs and policies were designed to fulfill centralism and giantism principles; or, in some cases GEG advocates actually supported their cooptation. As Kuhn (1963) noted in the case of paradigm conflicts in science, proposals for significant change in thinking are prequently coopted by guradians of paradigm; or, proponents stand aside in the belief that an incremental process will prevail and eventually improve science. Why fight over fundamentals when victories of a more modest kind are possible, and can lead to cumulative, and eventally change?

Conflicts that come from interwined interests of politics and economy often stymie paradigm change in social contexts (Antman et al., 2016; Flyvbjerg, 1998; Glover, 2006; Hendriks, 2008). In the Korean GEG case, proposed changes in institutions and policies, and the reallocation of resources, for a paradigm shift brought forth intense resistance from entities who had received a large share of benefits from the conventional paradigm over several decades (notably, large manufacturers). Their powerful position in society meant their voice to safeguard the status quo could be believed by many leaders who had initiated transformation policies without extensive efforts to attract societal support. Kuhn argued that support by members of a scientific community would be decisive. Social reserchers have found similarly, that support by key social and economic interests are key to policy success (Argyrous, 1992; Dolfsma & Welch, 2009; McDonagh, 1976; Moss, 2013). Without community support, leaders of efforts to make significant change can end up leading a movement to nowhere. In the case of efforts to evoke change in a political ecnonomy, support from grassroots groups, local and central government bureaucrats, and especially support from system critics are essential. Yet, GEG leaders paid little attention to this need, in the end, appearing to assume that a shift in paradigm was inevitable.

After defeats in policy, planning, and implementation efforts, the Korean GEG leadership adopted a compromise—a pact to promote green energy in a manner that could gain the support of the defenders of the conventional energy system—namely, a form of "green energy abundance." Their efforts were successful to some extent, but did not inspire a transiton in the modern system. Rather, they mostly changed the focus and definition of a "green" paradigm: remedies were adopted that might change the rate of CO_2 emissions and the type of energy technologies on which society would depend but a socioeconomic order based on ideals of abundance, centralization, and technological optimism would be retained, and the premise that urgent societal transformation would be needed was dropped. "Green" and "growth" were pursued in the belief that a complementary strategy of eco-modernization would address social and enviromental problems associated with the energy system—the equivalent of a normal science victory (Glover, 2006).

For those intending to encourage energy transformation, there are lessons from the Korean case. First, energy transformation is not a contest over the chemestry of the atmosphere but over values, ideas and ideology. Second, if energy transformation is actually going to lead to a change in energy–scociety relations and the political economy that underpins them, a clear alternative to energy centralism, technological optimism, and paraphrasing Daly, the "angelizing" of abundance (Daly, 1991, p. 119) is needed. Recent research on polycentric energy change (Abbott, 2014; Blok, Höhne, Van der Leun, & Harrison, 2012; Taminiau, 2015, chap. 4 and 5), the "unburnable fuels" movement (Ayling & Gunningham, 2017; Bratman, Brunette, Shelly, & Nicholson, 2016; Jakob & Hilaire, 2015; Piggot, 2018), efforts to contest the energy commodity economy with commons strategies (Byrne & Taminiau, 2016; Byrne, Taminiau, Kim, Lee, & Seo, 2017; Byrne, Taminiau, Kim, Seo, & Lee, 2016; Saunders, Gross, & Wade, 2012), and so on, point to the importance of civil society agency to produce meaningful energy change. Grassroots groups need to be understood as key drivers and defenders of transformation long after political campaigns wane. Ideas for changing energy–society relations have not often pursued models for effecting change in these ways. Too often, political rhetorics like "green growth" and "100% renewable energy cities" have been embraced, perhaps in the hope that they could at least be instrumental in stirring deeper change. Perhaps the most important lesson from the Korean GEG experience is that change cannot and will not happen without fundamental changes in embedded belief of "the more energy is the better" and necessary changes in the main drivers of energy system.

CONFLICT OF INTEREST

The authors have declared no conflicts of interest for this article.

ENDNOTES

[1]Our Common Future is also called the Brundtland report, which was created by the Brundtland Commission. The full report is available at the UN's sustainable development knowledge platform.

[2]Retrieved from http://www.unsystem.org/content/unep-led-green-economy-initiative.

[3]Retrieved from https://www.oecd-ilibrary.org/.

[4]Retrieved from http://www.greengrowthknowledge.org/, http://3gf.dk/en, http://www.ebrd.com/cs/satellite?c=Content&cid=1395250237163&d=Mobile&pagename=EBRD%2FContent%2FContentLayout, https://www.adb.org/features/12-things-know-2012-green-growth.

[5]"Pali-pali culture" means a faster manner appearing in every aspects of Korean life from food preparation and delivery to infrastructure construction and business practice.

[6]Retrieved from https://Data.worldbank.org/indicator/EN.ATM.CO2E.PC?end=2008&start=1998&year_high_desc=false.

[7]Interviews were conducted for the doctoral dissertation of one of the authors of this paper (Dr. Ha).

[8]Byrne et al. (2009) used the concept "Green Titan" to symbolize renewable energy projects repeating conventional large-scale and centralized energy projects.

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REFERENCES

Abbott, K. W. (2014). Strengthening the transnational regime complex for climate change. *Transnational Environmental Law*, *3*(1), 57–88.

Antman, A., Brubæk, S., Andersen, B. H., Lindqvist, K., Markus-Johansson, M., Sørensen, J., … Teerikangas, J. (2016). *Nordic agriculture air and climate*. Copenhagen: Nordic Council of Ministers.

Argyrous, G. (1992). Kuhn's paradigms and neoclassical economics. *Economics and Philosophy*, *8*(2), 231–248.

Asongu, S. A. (2017). Knowledge economy gaps, policy syndromes, and catch-up strategies: Fresh South Korean lessons to Africa. *Journal of the Knowledge Economy*, *8*(1), 211–253.

Attar, S., & Kazemi, H. (2017). Economic policy and developmental regulation in South Korea. *European Journal of East Asian Studies*, *16*(1), 67–85.

Ayling, J., & Gunningham, N. (2017). Non-state governance and climate policy: The fossil fuel divestment movement. *Climate Policy*, *17*(2), 131–149.

Barbier, E. B. (2009). *A global green new deal: Final report.* Towards a Green Economy.

Basalla, G. (1979). Energy and civilization. *EPRI Journal*, *4*(6), 20–25.

Beermann, J., & Tews, K. (2017). Decentralised laboratories in the German energy transition. Why local renewable energy initiatives must reinvent themselves. *Journal of Cleaner Production*, *169*, 125–134.

Bermudez, V. (2018). Japan, the new "El dorado" of solar PV? *Journal of Renewable and Sustainable Energy*, *10*(2), 020401.

Bina, O. (2013). The green economy and sustainable development: An uneasy balance? *Environment and Planning. C, Government & Policy*, *31*(6), 1023–1047.

Blok, K., Höhne, N., Van der Leun, K., & Harrison, N. (2012). Bridging the greenhouse-gas emissions gap. *Nature Climate Change*, *2*(7), 471–474.

Boo, K., Kim, H., & Park, J. (Eds.). (2013). *Energy policies*. Seoul: Korea Development Institute.

Bratman, E., Brunette, K., Shelly, D. C., & Nicholson, S. (2016). Justice is the goal: Divestment as climate change resistance. *Journal of Environmental Studies and Sciences*, *6*(4), 677–690.

Bulkeley, H., & Fuller, S. (2012). *Low carbon communities and social justice*. York, England: JRF.

Burke, M. J., & Stephens, J. C. (2018). Political power and renewable energy futures: A critical review. *Energy Research & Social Science*, *35*, 78–93.

Byrne, J., Martinez, C., & Ruggero, C. (2009). Relocating energy in the social commons: Ideas for a sustainable energy utility. *Bulletin of Science, Technology & Society*, *29*(2), 81–94.

Byrne, J., & Taminiau, J. (2016). A review of sustainable energy utility and energy service utility concepts and applications: Realizing ecological and social sustainability with a community utility. *WIREs Energy and Environment*, *5*(2), 136–154.

Byrne, J., Taminiau, J., Kim, K. N., Lee, J., & Seo, J. (2017). Multivariate analysis of solar city economics: Impact of energy prices, policy, finance, and cost on urban photovoltaic power plant implementation. *WIREs Energy and Environment*, *6*(4), e241.

Byrne, J., Taminiau, J., Kim, K. N., Seo, J., & Lee, J. (2016). A solar city strategy applied to six municipalities: Integrating market, finance, and policy factors for infrastructure-scale photovoltaic development in Amsterdam, London, Munich, New York, Seoul, and Tokyo. *WIREs Energy and Environment*, *5*(1), 68–88.

Byrne, J., & Toly, N. (2006). Energy as a social project: Recovering a discourse. In J. Byrne, N. Toly, & L. Glover (Eds.), *Transforming power: Energy, environment and society in conflict* (pp. 1–32). New York, NY: Routledge.

Byrne, J., & Wang, Y. (2014). *Green energy economies: The search for clean and renewable energy*. New Brunswick, New Jersey: Transaction Publishers.

Cities, E. (2016). *"Think local first": From pipe dreams to local means. A guidance paper to assist member states within the energy union governance process*. Retrieved from http://www.energy-cities.eu/spip.php?page=search&id_rubrique=&q=%E2%80%9CTHINK+LOCAL+FIRST%E2%80%9D%3A&ok.x=22&ok.y=17

Conley, T. G., & Dupor, B. (2013). The American recovery and reinvestment act: Solely a government jobs program? *Journal of Monetary Economics*, *60*(5), 535–549.

Cotton, J. (1992). Understanding the state in South Korea: Bureaucratic-authoritarian or state autonomy theory? *Comparative Political Studies*, *24*(4), 512–531.

Cottrell, F. (2009). *Energy & society: The relation between energy, social change, and economic development*. Bloomington, IN: Author House.

Couture, T., & Gagnon, Y. (2010). An analysis of feed-in tariff remuneration models: Implications for renewable energy investment. *Energy Policy*, *38*(2), 955–965.

Craig, M. (2016). *German renewable power surcharge increases by 8 percent. Renewable energy world.* Retrieved from https://www.renewableenergyworld.com/articles/2016/10/german-renewable-power-surcharge-increases-by-8-percent.html

Daly, H. E. (1991). *Steady-state economics: With new essays*. Washington DC: Island Press.

Dobbs, E., Wheldon, A., & Sharma, C. (2016). 15 years of development in access to off-grid renewable electricity: Insights from the Ashden awards. *Field Actions Science Reports. The Journal of Field Actions*, *15*(4), 150–159.

Dolfsma, W., & Welch, P. J. (2009). Paradigms and novelty in economics: The history of economic thought as a source of enlightenment. *American Journal of Economics and Sociology*, *68*(5), 1085–1106.

Dryzek, J. S. (2013). *The politics of the earth: Environmental discourses*. Oxford: Oxford University press.

DW. (2018). *German green energy surcharge rises to record.* Retrieved from https://www.dw.com/en/german-green-energy-surcharge-rises-to-record/a-36040052

Ellul, J. (1964). *The technological society*. New York, NY: Vintage Books.

Enerdata. (2017). *Global energy statistical yearbook 2017*. Enerdata. Retrieved from https://www.enerdata.net/publications/world-energy-statistics-supply-and-demand.html

Escobar, A. (1999). After nature: Steps to an antiessentialist political ecology. *Current Anthropology*, *40*(1), 1–30.

European Commission. (2018). *2020 climate & energy package.* Retrieved from https://ec.europa.eu/clima/policies/strategies/2020_en

Fay, M. (2012). *Inclusive green growth: The pathway to sustainable development*. Washington, DC: World Bank Publications.

Feldstein, M. (1998). Refocusing the IMF. *Foreign Affairs-New York*, *77*, 20–33.

Flyvbjerg, B. (1998). *Rationality and power: Democracy in practice*. Chicago, IL: University of Chicago Press.

Glover, L. (2006). From love-ins to logos: Charting the demise of renewable energy as a social movement. In J. Byrne, N. Toly, & L. Glover (Eds.), *Transforming power: Energy, environment, and Society in Conflict* (p. 247). New York, NY: Routledge.

Goldemberg, J., Johansson, T. B., Reddy, A. K., & Williams, R. H. (1987). *Energy for a sustainable world*. Washington DC: World Resources Institute.

Goldthau, A. (2014). Rethinking the governance of energy infrastructure: Scale, decentralization and polycentrism. *Energy Research & Social Science*, *1*, 134–140.

Gouldson, A., & Murphy, J. (1997). Ecological modernisation: Restructuring industrial economies. *The Political Quarterly*, *68*(B), 74–86.

Green Technology Center. (2014). *Statistics yearbook 2013 of green technology R&D*. Seoul: Green Technology Center.

Green Technology Center. (2015). *Green technology development level 2015*. Seoul: Green Technology Center.

Hall, C. A., Cleveland, C. J., & Kaufmann, R. K. (1986). *Energy and resource quality: The ecology of the economic process*. Niwot, Colo: University Press of Colorado.

Han, H. (2015). Korea's pursuit of low-carbon green growth: A middle-power state's dream of becoming a green pioneer. *The Pacific Review*, *28*(5), 731–754.

Hendriks, C. M. (2008). On inclusion and network governance: The democratic disconnect of Dutch energy transitions. *Public Administration*, *86*(4), 1009–1031.

Huber, J. (2008). Pioneer countries and the global diffusion of environmental innovations: Theses from the viewpoint of ecological modernisation theory. *Global Environmental Change*, *18*(3), 360–367.

Hughes, T. P. (1993). *Networks of power: Electrification in Western society, 1880–1930*. Baltimore: JHU Press.

Jacobs, M. (2012). *Green growth: Economic theory and political discourse* (Centre for Climate Change Economics and Policy Working Paper No. 108).

Jakob, M., & Hilaire, J. (2015). Climate science: Unburnable fossil-fuel reserves. *Nature*, *517*(7533), 150–151.

Jänicke, M. (2005). Trend-setters in environmental policy: The character and role of pioneer countries. *European Environment*, *15*(2), 129–142.

Jänicke, M. (2008). Ecological modernisation: New perspectives. *Journal of Cleaner Production*, *16*(5), 557–565.

Jänicke, M. (2012). "Green growth": From a growing eco-industry to economic sustainability. *Energy Policy*, *48*, 13–21.

Jänicke, M., & Jacob, K. (2005). Ecological modernisation and the creation of lead markets. Towards environmental innovation systems. In M. Weber & J. Hemmelskamp (Eds.), *Towards environmental innovation systems* (pp. 175–193). Berlin, Germany: Springer.

Jänicke, M., & Jacob, K. (2009). *A third industrial revolution? Solutions to the crisis of resource-intensive growth*. Berlin, Germany: FFU.

Jones, R. S., & Yoo, B. (2011). *Korea's green growth strategy: Mitigating climate change and developing new growth engines* (OECD Economics Department Working Paper No. 18151973).

Jung, H., & Park, K. (2010). *A comprehensive study on building a market-friendly energy price system*. Seoul: Korea Energy Economic Institute.

Jwa, S. (2017). Reproducibility of the Korean economic miracle. In *The rise and fall of Korea's economic development* (pp. 129–133). Cham, Switzerland: Springer.

Kammen, D. M., & Engel, D. (2009). *Green jobs and the clean energy economy*. Copenhagen: Copenhagen Climate Council.

KERI. (2010). *Amendment of the Korean feed-in-tariffs in 2011*. Changwon, Korea: KERI.

Khalil, E. (1987). Kuhn, Lakatos, and the history of economic thought. *International Journal of Social Economics*, *14*(3/4/5), 118–131.

Khavul, S., & Bruton, G. D. (2013). Harnessing innovation for change: Sustainability and poverty in developing countries. *Journal of Management Studies*, *50*(2), 285–306.

Kim, D. (1999). IMF bailout and financial and corporate restructuring in the Republic of Korea. *The Developing Economies*, *37*(4), 460–513.

Kim, K. (2006). *The 1997–98 Korean financial crisis: Causes, policy response, and lessons.* Paper presented at the IMF Seminar on Crisis Prevention in Emerging Markets, Singapore.

Kim, N., & Kim, J. (2013). *Income inequality in Korea, 1933-2010 evidence from income tax statistics.* (Working Paper No. 2013-05).

Kim, S., & Ko, J. (2013). Energy efficiency gap of ESCO projects and policy measures. *GRI Research Collections*, *15*(3), 337–364.

Kim, S., & Thurbon, E. (2015). Developmental environmentalism: Explaining South Korea's ambitious pursuit of green growth. *Politics and Society*, *43*(2), 213–240.

Kim, Y. (2016). An analysis of economic factors on changes in GHG reduction plan. *Korea Energy Economic Review*, *15*(1), 139–177.

K-indicator. (2018, October 2). Retrieved from http://www.index.go.kr/unify/idx-info.do?idxCd=9009

Koirala, B. P., Koliou, E., Friege, J., Hakvoort, R. A., & Herder, P. M. (2016). Energetic communities for community energy: A review of key issues and trends shaping integrated community energy systems. *Renewable and Sustainable Energy Reviews*, *56*, 722–744.

Kong, T. Y. (2013). *The politics of economic reform in South Korea: A fragile miracle*. Florence: Taylor and Francis.

Korea Environment Institute. (2013). *A study on the future social vision for climate change and energy policy paradigm change*. Seoul: Korea Environment Institute.

Korea Institute of Public Finance. (2012). *History of tax system in Korea; History and assessment by category: Consumption taxes and custom duties*. Seoul: Korea Institute of Public Finance.

Kuhn, T. S. (1963). *The structure of scientific revolutions*. Chicago, IL: University of Chicago Press.

Lee, S. (2017). *A start and an end of Gori nuclear power plants reactor #1. Hangyoreh21.* Retrieved from http://h21.hani.co.kr/arti/society/society_general/43765.html

Lee, S. (2018). Communication strategies for improving public acceptability of changing electricity prices following new environment and energy policies. *Environmental Policy*, *26*(1), 223–245.

Levin, K., Cashore, B., Bernstein, S., & Auld, G. (2012). Overcoming the tragedy of super wicked problems: Constraining our future selves to ameliorate global climate change. *Policy Sciences*, *45*(2), 123–152.

Lie, J. (1990). Is Korean management just like Japanese management? *Management International Review*, *30*(2), 113.

Lorek, S., & Spangenberg, J. H. (2014). Sustainable consumption within a sustainable economy–beyond green growth and green economies. *Journal of Cleaner Production*, *63*, 33–44.

Lovins, A. B. (1979). *Soft energy paths: Toward a durable peace*. New York, NY: Harper & Row.

Lucas, R. E., Jr. (1993). Making a miracle. *Econometrica: Journal of the Econometric Society*, *61*(2), 251–272.

Lunb, R., & Panda, S. M. (1994). The role of gender in the quest for sustainable agricultural development. *Norsk Geografisk Tidsskrift*, *48*(3), 113–122.

Martínez-Alier, J., Pascual, U., Vivien, F., & Zaccai, E. (2010). Sustainable de-growth: Mapping the context, criticisms and future prospects of an emergent paradigm. *Ecological Economics*, *69*(9), 1741–1747.

Mathews, J. A. (2012). Green growth strategies—Korean initiatives. *Futures*, *44*(8), 761–769.

McCright, A. M., & Nichols Clark, T. (2006). Dimensions of local sustainability. In A. Moller, T. Clark, & A. McCright (Eds.), *Community and ecology* (pp. 87–91). Bingley: Emerald Group Publishing Limited.

McDonagh, E. L. (1976). Attitude changes and paradigm shifts: Social psychological foundations of the Kuhnian thesis. *Social Studies of Science*, *6*(1), 51–76.

Messing, M., Friesema, H. P., & Morell, D. (1979). *Centralized power: The politics of scale in electricity generation*. Cambridge, Mass: Oelgeschlager, Gunn & Hain.

Morgan, G. (1980). Paradigms, metaphors, and puzzle solving in organization theory. *Administrative Science Quarterly*, *25*, 605–622.

Moss, L. S. (2013). *Joseph A. Schumpeter: Historian of economics: Perspectives on the history of economic thought*. Hoboken: Routledge.

MOTIE & KEEI. (2017). *Korea energy statistics yearbook 2017*. Sejong, Korea: MOTIE & KEEI.

Mundaca, L., & Richter, J. L. (2015). Assessing 'green energy economy' stimulus packages: Evidence from the US programs targeting renewable energy. *Renewable and Sustainable Energy Reviews*, *42*, 1174–1186.

NEI. (2018, May 16). Retrieved from www.nei.org

Numminen, S., & Lund, P. D. (2017). Frugal energy innovations for developing countries–a framework. *Global Challenges*, *1*(1), 9–19.

Nye, D. E. (1999). *Consuming power: A social history of American energies*. Cambridge, Mass: MIT Press.

OECD. (2009). *Declaration on green growth. Adopted at the meeting of the council at the ministerial level.* Retrieved from http://www.oecd.org/env/44077822.pdf

OECD. (2011a). *Towards green growth*. Paris, France: OECD.

OECD. (2011b). *OECD green growth studies: Energy*. Paris, France: OECD Publishing.

OECD. (2018, April 18). Retrieved from http://www.oecd.org/china/greengrowthinactionchina.html

OECD/IEA. (2017). *Energy prices and taxes 2017*. Paris, France: OECD/IEA.

Ostrom, E. (2010). Beyond markets and states: Polycentric governance of complex economic systems. *American Economic Review*, *100*(3), 641–672.

Pachauri, R. K., Allen, M. R., Barros, V. R., Broome, J., Cramer, W., Christ, R., … Dasgupta, P. (2014). *Climate change 2014: Synthesis report. Contribution of working groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Geneva, Switzerland: IPCC.

Pack, H., & Nelson, R. R. (1999). *The Asian miracle and modern growth theory*. Washington DC: The World Bank.

Park, B. (2003). Territorialized party politics and the politics of local economic development: Stateled industrialization and political regionalism in South Korea. *Political Geography*, *22*(8), 811–839.

Park, K. (2011). Issues on energy price system and its direction for improvement. *Korea Energy Economic Review*, *10*(2), 142.

Pattberg, P. H. (2007). Conquest, domination and control: Europe's mastery of nature in historical perspective. *Journal of Political Ecology*, *14*, 1–9.

Piggot, G. (2018). The influence of social movements on policies that constrain fossil fuel supply. *Climate Policy*, *18*(7), 942–954.

Renewable Energy Institute. (2017). *Feed-in tariffs in Japan: Five years of achievements and future challenges*. Tokyo, Japan: REI.

Saunders, R. W., Gross, R., & Wade, J. (2012). Can premium tariffs for micro-generation and small-scale renewable heat help the fuel poor, and if so, how? Case studies of innovative finance for community energy schemes in the UK. *Energy Policy*, *42*, 78–88.

Schmalensee, R. (2012). From "green growth" to sound policies: An overview. *Energy Economics*, *34*, S6.

Schmidt, D., & Heilmann, S. (2010). Dealing with economic crisis in 2008-09: The Chinese government's crisis management in comparative perspective. *China Analysis*, *77*, 1–24.

Schneidewind, D. K., Schneidewind, D. K., & Schneidewind, D. (2016). *Economic miracle market South Korea*. Singapore: Springer.

Schulz, C., & Bailey, I. (2014). The green economy and post-growth regimes: Opportunities and challenges for economic geography. *Geografiska Annaler: Series B, Human Geography*, *96*(3), 277–291.

Schumpeter, J. A. (1939). *Business cycles*. Cambridge: Cambridge University Press.

Selectra. (2018, March 15). Retrieved from https://selectra.info/energie/guides/demarches/tarifs-sociaux

Simon, D. (1989). Sustainable development: Theoretical construct or attainable goal? *Environmental Conservation*, *16*(1), 41–48.

Sonnenschein, J., & Mundaca, L. (2016). Decarbonization under green growth strategies? The case of South Korea. *Journal of Cleaner Production*, *123*, 180–193.

Späth, P., & Rohracher, H. (2010). 'Energy regions': The transformative power of regional discourses on socio-technical futures. *Research Policy*, *39*(4), 449–458.

Stiglitz, J. E. (1996). Some lessons from the east Asian miracle. *The World Bank Research Observer*, *11*(2), 151–177.

Stirling, A. (2014). Transforming power: Social science and the politics of energy choices. *Energy Research & Social Science*, *1*, 83–95.

Stocker, T. F., Qin, D., Plattner, G., Tignor, M., Allen, S. K., Boschung, J., … Midgley, P. (2013). *IPCC, 2013: Summary for policymakers in climate change 2013: The physical science basis, contribution of working group I to the fifth assessment. Report of the Intergovernmental Panel on Climate Change*. Geneva, Switzerland: IPCC.

Sun, P., & Nie, P. (2015). A comparative study of feed-in tariff and renewable portfolio standard policy in renewable energy industry. *Renewable Energy*, *74*, 255–262.

Taminiau, J. (2015). *A paradigm analysis of ecological sustainability.* (Unpublished doctoral dissertation). University of Delaware, Newark, DE.

The Korea Presidential Committee on Green Growth. (2009). *A five-year plan for green growth (2009–2013)*. Seoul: The Korea Presidential Committee on Green Growth.

The Korea Presidential Committee on Green Growth. (2011a). *Korea's green growth strategy: A Korean approach to green growth*. Seoul: The Korea Presidential Committee on Green Growth.

The Korea Presidential Committee on Green Growth. (2011b). *Road map for building low carbon green society 2020: Finalization of greenhouse-gas reduction target by sector, industry, and year*. Seoul: The Korea Presidential Committee on Green Growth.

The Korea Presidential Committee on Green Growth. (2012). *An update on Korea's green growth progress and prospects*. Seoul: The Korea Presidential Committee on Green Growth.

The Korean Government. (2008a). *The Korea 1st national energy master plan 2008–2030*. Seoul: The Korean Government.

The Korean Government. (2008b). *The president's speech at the national ceremony celebrating the 60th anniversary of the country's foundation*. Seoul: The Korean Government.

The Korean Government. (2008c). *The Korea 4th basic plan on electricity demand and supply (2008~2022)*. Seoul: The Korean Government.

The Korean Government. (2012). *The detailed operation plan of the electrical industry foundation fund (fiscal year 2011)*. Seoul: The Korean Government.

Tompkins, E. L., & Adger, W. N. (2005). Defining response capacity to enhance climate change policy. *Environmental Science & Policy*, *8*(6), 562–571.

UNEP. (2011). *Towards a green economy: Pathways to sustainable development and poverty eradication*. St-Martin-Bellevue, France: United Nations Environment Programme.

Weinrub, A., & Giancatarino, A. (2015). *Toward a climate justice energy platform: Democratizing our energy future*. Oakland, CA: Local Clean Energy Alliance & Center for Social Inclusion.

Willmott, H. (1993). Breaking the paradigm mentality. *Organization Studies*, *14*(5), 681–719.

World Commission on Environment and Development. (1987). *Our common future*. Oxford, New York: Oxford University Press.

Yeo, Y. (2015). *Petroleum 135 years, historic record in Korea*. Seoul, South Korea: Knowledge and Sensibility.

Yu, G., & Rowley, C. (2009). The changing face of Korean human resource management. In G. Yu & C. Rowley (Eds.), *The changing face of Korean management* (pp. 29–51). London: Taylor and Francis Group.

Yun, J. (2012). *Safety for the stable electric power supply.* Paper presented at the Kosco Symposium (pp. 163–165) Pohang: Korea.

Yun, T., & Park, K. (2016). *Estimation of population in energy poverty and analysis of energy consumption characteristics*. Ulsan, Korea: Korea Energy Economics Institute.

Zeschky, M., Widenmayer, B., & Gassmann, O. (2011). Frugal innovation in emerging markets. *Research-Technology Management*, *54*(4), 38–45.

Zoboli, R., Paleari, S., Speck, S., & Asquith, M. (2013). *Towards a green economy in Europe. EU environmental policy targets and objectives 2010–2050* (pp. 1–48). Copenhagen: European Environment Agency.

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