Energy Security and the Role of Green Economies in East Asia



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by David von Hippel

Contributing authors: Yi Wang, Kae Takase, Tetsunari Iida, Myungrae Cho, and Sun-Jin Yun

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I. Introduction

David von Hippel writes that following the Fukushima nuclear disaster, there is an increasing 'recognition that new paradigms are needed to deal with expanding complexity in the relationships between the issues and actors involved in energy sector-related decisions. The old paradigms of traditional supply-focused "energy security" are insufficient for the task. Trends toward regional energy-sector, economic, and in some cases social integration, the expanding role of civil society and local government in affecting key energy decisions, and the tightening connections between climate change considerations, economic development (including development of "green economies"), and addressing North Korean nuclear weapons and related issues, are only a few of the complex threads that affect, and are affected by, energy sector decisions.'

This Special Report is an extract (*Chapter 3*) to the book *Complexity, Security and Civil Society in East Asia*, edited by Peter Hayes and Yi Kiho, published by Open Book Publishers in June 2015 (http://www.openbookpublishers.com/product/326/).

To read the entire book or download the free PDF version, click here.

David von Hippel is a Nautilus Institute Senior Associate working on energy and environmental issues in Asia, as well as on analysis of the DPRK energy sector.

II. Policy Forum by David von Hippel

Energy Security and the Role of Green Economies in East Asia

Introduction

Energy Security in a Post-Fukushima World

On March 11, 2011, a massive earthquake and subsequent tsunami devastated a substantial area of Japan on the Pacific coast of Honshu, north of Tokyo, with tragic consequences for the citizens of Japan and unfolding impacts in the country and elsewhere. Among the many facilities affected by this natural disaster was the Fukushima I nuclear power plant. Over the weeks and months following the earthquake (continuing, in fact, to the time of this writing), several reactors and spent nuclear fuel storage areas at the Fukushima I plant underwent slow-motion destruction. The result was fuel decomposition and the release of more radioactivity to air and water than in any nuclear power accident, save the 1986 explosion at the Chernobyl reactor in Ukraine. Damage to Fukushima I was initiated by the impacts of the earthquake and tsunami on the plant itself and on the local area — knocking out grid power to the plant, for example.[1] The continued degradation of the plant, however, has been sustained by a cascading series of events. Some of these events resulted from unavoidable choices made during in the frantic triage of the reactor crisis. Others were arguably set in motion by decisions made years ago by those who determined the shape of Japan's path to energy security.

The lessons of Fukushima continue to unfold, and are perhaps only just beginning to be appreciated. These lessons are having and will have significant impacts on the way that public policy is developed and carried out in Japan,[2] in the Northeast Asia Region,[3] and beyond.[4] Among these impacts is the recognition that new paradigms are needed to deal with expanding complexity in the relationships between the issues and actors involved in energy sector-related decisions. The old paradigms of traditional supply-focused "energy security" are insufficient for the task. Trends toward regional energy-sector, economic, and in some cases social integration, the expanding role of civil society and local government in affecting key energy decisions, and the tightening connections between climate change considerations, economic development (including development of "green economies"), and addressing North Korean nuclear weapons and related issues, are only a few of the complex threads that affect, and are affected by, energy sector decisions.

Even before Fukushima, energy security issues had increased in complexity at the end of the 20th century and in the early years of the 21st century. Drivers of this increase included a greater number of energy importers and exporters, and different relationships between traditional suppliers and buyers (most notably, between Europe, Russia, and the other former Soviet Union states, but also between China and its sources of fuel). The change was also shaped by China becoming a large net oil and even coal importer and the Republic of Korea (ROK) becoming a supplier of nuclear power technology. Furthermore, a combination of price rises, wars, technological and physical bottlenecks tended to increase complexity; that is, they resulted in a marked increase in the number of connections between those nations and other organizations affected by energy issues, in the types of relationship existing between organizations, in the groups that are connected, and in the kinds of links made between energy security-related issues. New types of connection included, for example, energy security considerations related to climate change, in which countries were much more modestly engaged pre-1990.

Standard Definition of Energy Security

Many of the existing definitions of energy security begin, and usually end, with a focus on maintaining energy supplies — particularly supplies of oil.[5] Cornerstones of this supply-based focus include reducing vulnerability to foreign threats or pressure, preventing a supply crisis from occurring (which would arise either from restrictions in physical supply or an abrupt and significant increase in energy prices), and minimizing the economic and military impact of a supply crisis once it has occurred. As noted above, however, national and international energy policies are currently facing many new challenges and, as such, need to have their effectiveness judged by additional criteria.

Why has oil been the primary focus of energy security policy? First, oil is still the dominant fuel (~33 percent) in the global primary energy supply (as of 2012).[6] (Primary energy use refers to inputs to energy transforming sectors such as power generation or oil refining before it becomes useful energy for society). Second, the Middle East, where the largest oil reserves exist, is still one of the most unstable areas in the world. Third, and related to this last observation, oil supply and prices are often influenced by the political decisions of oil suppliers and buyers. Fourth, world economic conditions, as the last several years have shown, are still vulnerable to oil price volatility, since there are certain key sectors that are heavily dependent on oil (such as transportation, petrochemicals, agriculture, and others) with limited short-term alternatives for substitution. Fifth, the key words here are "volatility" and "instability." Although globalization has improved the transparency of the oil market, prices remain to some extent at the mercy of speculators, fluctuations in currency values (which are subject to manipulation by oil suppliers), and, of course, the forces of market supply and demand.[7] This instability has been dramatically demonstrated recently, with oil prices roughly doubling between mid-2007 and mid-2008, followed by a 75 percent decline in price by early 2009

and a return to early-2008 price levels (of ~$100 per barrel) by early 2011, continuing at more or less that level through 2013.8

Few works have made a serious attempt to clarify the concept of energy security. One effort was that of the Working Group on Asian Energy and Security at the Massachusetts Institute of Technology (MIT)'s Center for International Studies. The MIT Working Group defined three distinct goals of energy security:

1. Reducing vulnerability to foreign threats or pressure,
2. Preventing a supply crisis from occurring, and
3. Minimizing the economic and military impact of a supply crisis once it has occurred.9

These goals implicitly assume that an "oil supply crisis" is the central focus of energy security policy. In essence, the two tenets of conventional energy security policy are (1) reducing threats to oil supply and (2) operating in a mode of crisis management. These tenets have traditionally constituted the primary shared view among key energy policy-makers in the East and West.

Though the major energy consuming/importing countries share the above characterization of conventional energy security thinking, there are critical divisions in policy. Two important factors influencing energy policy differences between countries are natural and geopolitical conditions. One country might have abundant natural resources and another may not. Some consuming countries are located close to energy-producing countries; others are far away and require transportation of fuel over long distances. Those conditional differences can lead to variances in energy security perceptions.

In sum, there are three major attributes that define differences in energy security thinking between countries: (1) the degree to which a country is energy resource-rich or energy resource-poor, (2) the degree to which market forces are allowed to operate as compared to the use of government intervention to set prices, and (3) the degree to which long-term versus short-term planning is employed.10 Despite these differences, however, energy policies in both resource-poor and resource-rich countries are arguably converging. Both recognize the need to construct a new paradigm in energy policy, driven by common considerations such as climate change and informed and affected by events in the increasingly networked global community.

Energy Security Issues in Northeast Asia

Over the last two decades, economic growth in Northeast Asia — a region of more than 1.5 billion people comprising Japan, the Republic of Korea, the Democratic Peoples' Republic of Korea (DPRK), Mongolia, China, Hong Kong (Special Administrative Region of China), and Chinese Taipei (Taiwan), plus the Far Eastern Federal District (okrug) of the Russian Federation — has rapidly increased regional needs for energy services. In China and the Republic of Korea in particular, growth in the need for energy services, and for the fuels used to supply that need, has brought with it a raft of environmental problems, including rapidly mounting greenhouse gas emissions and increased emissions of other air pollutants, the latter significantly impacting local and regional air quality. The countries of the region already constitute the largest import market for liquefied natural gas (LNG) and are a major (and growing) oil import market as well. Northeast Asia accounts for a progressively larger share of world primary energy use; even as energy use in the rest of the world has increased, Northeast Asia's share rose from 18.6 percent in 1999 to 25.2 percent in 2007.11

Though the region as a whole possesses resources that could contribute substantially toward its future energy needs, many major energy resources, including natural gas, oil, coal, hydroelectric

power in the Russian Far East, and gas and hydro in Western China, are far from population centers. The spread of interest in shale gas production, including imports of US shale gas to the ROK and China, and production of gas from Chinese shales, was of keen interest in 2012-2013, but prospects for both of these potentially significant initiatives remain unclear at best. Major infrastructure investments will be required to bring these resources to market, and additional economic, political, technical, and environmental considerations also apply. This is particularly true when these resources cross one or several borders, and most particularly when one or more of the borders (as with pipelines or power lines from Russia to the Republic of Korea) are shared by the DPRK. Furthermore, the Six-Party Talks on denuclearization of the DPRK — and whatever forum for discussion succeeds the Six-Party Talks once the parties return to the table — link international assistance in rebuilding the DPRK's economy and energy sector to the nuclear weapons issue. Nuclear power is heavily used in the region, but issues related to the nuclear fuel cycle (uranium enrichment, nuclear waste/materials management, and prevention of proliferation of nuclear weapons and related technologies, for example) remained substantially unresolved before Fukushimaand are even more uncertain today. Increasing infrastructural, political, economic, and civil society connections between many of the cities of the region, including those located on the geographical arc from Beijing to Tokyo via Seoul, mean that problems related to urban development and security are increasingly shared between nations. As a result, regional energy cooperation, approaches to the DPRK nuclear weapons dilemma, nuclear fuel cycle issues, urban security, military security, and perhaps even partial solutions to global and regional environmental problems are intertwined in the region. All of these issues have significant implications for the energy security of the region and beyond.

Addressing Energy Security in a Complex World

Given the many entwined issues affecting and affected by energy policies in Northeast Asia and beyond, a broader definition of energy security is needed to address the problems (and opportunities) facing the region both today and in the coming years, particularly as the deeply interconnected issues of urban security/insecurity, the development of green economies, climate change, and problems associated with North Korea must be considered in any policies that seek to increase energy security in the countries of the region. All of these issues strongly affect the ROK; therefore, the formulation of effective ROK energy, environmental, and economic development policies requires the application of a broader energy security definition. The development of government policies that are "robust" across multiple dimensions of these problems, including (but not limited to) the implementation of aggressive programs of energy efficiency, renewable energy, and distributed generation — taking advantage of nascent and growing civil society and commercial networks that promote such changes — will be among the key methods for improving energy security, defined in the broad sense in Northeast Asia.

Chapter Road Map

Section 2 of this chapter begins with a discussion of the general issues associated with energy security in Northeast Asia, noting recent, current, and likely future patterns of energy use that form the background of energy security dilemmas in the region. Elements of a broader concept of energy security are presented — including traditional energy security elements such as supply and price security, but also extending to intimately-related energy security challenges in multiple dimensions — along with suggested methods to evaluate the energy security implications of different future "paths" for providing energy services. Section 3 describes key linkages between energy security and urban security/insecurity, suggesting that the calculus of energy security may be extended to evaluate urban insecurity issues in order to identify solutions that address both types of insecurity at the same time. Section 4 discusses the linkages between the green economy — the movement

toward adopting economic patterns that help to reduce human-caused pollutant emissions and environmental impacts while also addressing human development needs — globally and in the region, and examines approaches to improving the overlap between energy security and green economy considerations as they affect both climate change and DPRK issues (that is, regional and global security issues caused by the combination of the DPRK's nuclear weapons program and its humanitarian and economic problems). We review case studies of green economy policies in Japan, China, and the ROK. Section 5 details key connections between climate change (including climate change mitigation and adaptation efforts, as well as the impacts of a changing climate) and energy security, and between DPRK issues and energy security. Section 6 provides an illustrative application of the energy security analysis of alternative policies, including considerations of urban insecurity and the green economy. We emphasize impacts related to climate change and the DPRK. We conclude with a summary of lessons learned regarding policies that appear to provide important benefits in improving energy security in the region while simultaneously addressing other goals. We also offer insights on key "pressure points" for civil society to move such policies along. Section 7 emphasizes the potential role of ROK foreign policy, if influenced by the voices of civil society, in improving the energy security of the region while simultaneously ameliorating urban insecurity, securing the benefits of the green economy, and making progress on climate change and DPRK issues.

Energy Security in Northeast Asia

Northeast Asia's Energy Sector: Recent Past, Current Status, and Future Trends

Energy supply and demand in Northeast Asia drive the large and vibrant (as well as the not-so-large and/or not-so-vibrant) economies of the region. The energy sector of Northeast Asia is a central factor in the creation and growth of environmental problems, such as local air pollution and climate change, and of local, regional, and international problems ranging from competition over energy resources to the DPRK nuclear weapons issue. How these problems are dealt with in the future will arise from how the nations of the region and beyond pursue their energy policies. An appreciation of where the Northeast Asia energy system has come from in recent decades, where it stands now, and where, based on "business as usual" projections, it may be in the future, is key to identifying those policies that the ROK and the other nations of the region (and beyond) might adopt in addressing these issues.[12]

Energy Demand and Demand Growth in Northeast Asia

The countries of Northeast Asia — mainly Japan, the ROK, and Taiwan, but increasingly China as well — already constitute the world's largest market (63 percent of 2012 global exports) for LNG[13] and one of the largest for crude oil and petroleum products (nearly 20 percent of global demand). Table 3.1 shows the distribution of primary energy use by fuel in the countries of Northeast Asia. The region also uses more than half (57 percent, up from about 33 percent in 1999) of global coal production, with 75 percent of regional coal use occurring in China. In 2012, the countries of Northeast Asia consumed over 21 percent of the world's petroleum, 12.4 percent of its nuclear energy (a significant decline from previous years, caused by the shut-down of many Japanese reactors for post-Fukushima safety checks), 26.1 percent of hydroelectric generation, and 10 percent of natural gas, the latter up from 5.5 percent in 1999.

Table 3.2 provides 2012 (for the most part) estimates of population in each of the countries (or, in the case of the Russian Far East and Hong Kong, sub-country regions) of Northeast Asia and shows the use of primary energy per capita by country. By way of comparison, the DPRK consumed approximately 0.8 tonnes of oil equivalent (TOE) of primary commercial fuels per capita in 1996 and China about 0.6 TOE/capita in 1999, while South Korea used 3.9 TOE per capita and Japan 4.0 TOE

per capita in 1999. Since that time, as shown in Table 3.2, energy use per capita has decreased slightly in Japan, increased significantly in the ROK, and more than tripled in China, while decreasing in the DPRK.

Table 3.1: Primary Energy Use in Northeast Asia and the World, 2012 (except as noted)

Primary Energy Use in Northeast Asia and the World, 2012*
(Unit: PJ)

Country/Area	Natural Oil	Natural Gas	Coal	Nuclear Energy	Hydro-electric	Renew-ables	Total	Fraction of NE Asia	Fraction of World
China	20,250	5,420	78,432	923	8,155	1,336	114,516	74.70%	21.90%
Chinese Taipei	1,765	614	1,720	383	51	48	4,581	3.00%	0.90%
DPRK (North Korea)	38	-	342	-	43	213	423	0.30%	0.10%
Hong Kong (China SAR)	751	106	318	-	-	0	1,175	0.80%	0.20%
Japan	9,135	4,399	5,207	170	767	342	20,021	13.10%	3.80%
Mongolia	33	-	98	-	-	4	136	0.10%	0.00%
ROK (South Korea)	4,554	1,885	3,427	1,424	29	33	11,352	7.40%	2.20%
Russian Far East	442	120	483	2	47	-	1,131	0.70%	0.20%
Total Northeast Asia	36,969	12,544	90,027	2,902	9,093	1,976	153,334	100.00%	29.40%
NE Asia Fraction of World	21.40%	10.00%	57.60%	12.40%	26.10%	19.90%	29.40%		
Total Rest of World	135,968	112,518	66,144	20,561	25,705	7,964	369,038		70.60%
TOTAL WORLD	172,937	125,062	156,171	23,463	34,798	9,940	522,371		100.00%

Sources: Gulidov, R., et al., “Update on the RFE Energy Sector and on the RFE LEAP Modeling Effort,” in Asian Energy Security Project Meeting Energy Futures and Energy Cooperation in the Northeast Asia Region (Beijing: Nautilus Institute, 2007); Victor Kalashnikov, Ruslan Gulidov, and Alexander Ognev, “Energy Sector of the Russian Far East: Current Status and Scenarios for the Future,” Energy Policy, 39(11) (2011), doi: 10.1016/j.enpol.2009.09.035

Table 3.2: Population and Energy use Per Capita in Northeast Asia, 2012

Country/Area	Population (million)*	Primary TOE/cap*	Primary GJ/cap*
China	1,376.90	1.99	83.2
Chinese Taipei	23.3	4.69	196.4
DPRK (North Korea)	24.5	0.41	17.3
Hong Kong (China SAR)	7.2	3.92	164.3
Japan	127.1	3.76	157.5
Mongolia	2.7	1.19	50
ROK (South Korea)	49	5.54	231.8

Russian Far East	6.6	4.1	171.5
Total Northeast Asia	1,617	48.24	2019.7

Note: Estimates are for 2012 except in the cases of the DPRK (2010), RFE (2005), and Mongolia (2009/2010).

Sources: Population figures used for these calculations are from United Nations Population Projections, Medium Variant (2012), http://esa.un.org/unpd/wpp/unpp/panel_population.htm, except for those of Chinese Taipei (Taiwan), which are from "Population Projections for R.O.C. (Taiwan): 2012-2060," and the RFE, which is based on data from P.A. Minakir, "Russia and the Russian Far East in Economies of the APR and NEA," in Minakir, P.A., Economic Cooperation between the Russian Far East and Asia-Pacific Countries (2007).

Despite the explosive recent growth, energy use in Northeast Asia —particularly in China, DPRK, and Mongolia — would seem to have substantial room to grow more before it reaches the levels currently maintained by Japan, the ROK, and other developed nations. Transport services, which the Chinese and North Koreans currently use relatively lightly and very lightly respectively, is one of the key areas of growth (as any recent visitor to a major Chinese city will affirm), and in all probability transport energy use will increase significantly. Residential energy use can also be expected to rise in these countries. Projected continued increases in energy use (see below) underscore the need for policies that consider the multiple connections between energy supply and demand and other issues in the region.

Figure 3.1 summarizes primary energy use in the countries of Northeast Asia (plus the Far Eastern District of Russia) over the period from 1990 through 2006. During those 16 years, the total energy use by the region increased by a factor of two, led by a tripling of energy use in China and an increase of about 150 percent in the ROK and Taiwan. This happened despite primary energy use in Japan, the second largest energy user in the region, growing hardly at all from 2000 through 2007 (after having grown by about 20 percent during the previous decade). During the period from 1990 through 2007, Northeast Asia's share of global primary energy demand grew by half, from about 17 percent to over 25 percent. Note that the totals shown in Figure 3.1 do not (with the exception of the DPRK) include use of biomass fuels, which provide a significant (though decreasing) portion of residential energy use in China and in Mongolia, as well as in the DPRK.

Figure 3.1: Primary Energy Use in Northeast Asia by Country, 1990-2012

Sources: Data for all countries except the DPRK, Mongolia and the RFE are from British Petroleum Co., "BP Statistical Review of World Energy"; DPRK data are based on David F. von Hippel and Peter Hayes, "An Updated Summary of Energy Supply and Demand in the Democratic People's Republic of Korea (DPRK)," EGS Working Paper 2014-02, April 2014, https://nautilus.org/wp-content/uploads/2011/12/Russia-Energy-Changes.ppt; Mongolia data are from USDOE/EIA, 2013, "Mongolia Overview/Data" http://www.eia.gov/countries/country-data.cfm?fips=MG#tpe; and RFE data are compiled from Victor Kalashnikov, "Electric Power Industry of The Russian Far East: Status and Prerequisites for Cooperation in North-East Asia," Draft Report Prepared for the Working Group Meeting on Comparisons of the Electricity Industry in China, North Korea and the Russian Far East, East-West Center, Honolulu, Hawaii, 28-29 July 1997; Victor Kalashnikov, Alexander Ognev, and Ruslan Gulidov, "Updates on the RFE Energy Sector and the RFE LEAP model, and Inputs to and Results of RFE Future Energy Paths," presentation prepared for the Asian Energy Security Workshop, May 13-16, 2005, Beijing, China; and Ruslan Gulidov and Alexander Ognev, "The Power Sector in the Russian Far East: Recent Status and Plans," prepared for the 2007 Asian Energy

Security Project Meeting Energy Futures and Energy Cooperation in the Northeast Asia Region, Tsinghua University, Beijing, China, October 31–November 2, 2007, https://nautilus.org/wp-content/uploads/2011/12/Russia-Energy-Changes.ppt. 2011 and 2012 data for the DPRK and RFE, 2011 and 2012 data for Mongolia, and 2007-onwards data for the RFE are extrapolations from previous years' data.

The trends in primary energy use by fuel in Northeast Asia are shown in Figure 3.2. Coal use has dominated the absolute growth in energy use over 1990 through 2012, with China accounting for the bulk of that increase.

Figure 3.2: Primary Energy Use in Northeast Asia by Fuel, 1990-2012

Sources: Data for all countries except the DPRK, Mongolia and the RFE are from British Petroleum Co., "BP Statistical Review of World Energy" (2013); DPRK data are based on David F. von Hippel and Peter Hayes, "An Updated Summary of Energy Supply and Demand in the Democratic People's Republic of Korea (DPRK)," EGS Working Paper 2014/02, April 2014, http://www.egskorea.org/common/download.asp?downfile=2014-2_workingpaper_NK_Energy_Hippel_Hayes0.pdf&path=board; Mongolia data are from USDOE/EIA, "Mongolia Overview/Data" (2013), http://www.eia.gov/countries/country-data.cfm?fips=MG#tpe; and RFE data are compiled from Victor Kalashnikov, "Electric Power Industry of The Russian Far East: Status and Prerequisites for Cooperation in North-East Asia," Draft Report Prepared for the Working Group Meeting onComparisons of the Electricity Industry in China, North Korea and the Russian Far East, East-West Center, Honolulu, Hawaii, 28-29 July 1997; Victor Kalashnikov, Alexander Ognev, and Ruslan Gulidov, "Updates on the RFE Energy Sector and the RFE LEAP model, and Inputs to and Results of RFE Future Energy Paths," presentation prepared for the Asian Energy Security Workshop, May 13-16, 2005, Beijing, China; and Ruslan Gulidov and Alexander Ognev, "The Power Sector in the Russian Far East: Recent Status and Plans," prepared for the 2007 Asian Energy Security Project Meeting Energy Futures and Energy Cooperation in the Northeast Asia Region, Tsinghua University, Beijing, China, October 31-November 2, 2007, https://nautilus.org/wp-content/uploads/2011/12/Russia-Energy-Changes.ppt. 2011 and 2012 data for the DPRK and RFE, 2011 and 2012 data for Mongolia, and 2007-onwards data for the RFE are extrapolations from previous years' data.

Coal, natural gas, and hydroelectric power use have expanded the most in relative terms, with average growth rates of between 8 and 9 percent annually between 2000 and 2012. Coal and hydroelectricity use grew by an average of just under 5 percent annually between 1990 and 2007, but by 2.7 and 4.1 percent annually, respectively, from 2007 through 2012. In part, the slower growth was a function of the global recession of 2008-2010 and of China's effort to diversify away from coal use. Nuclear power use expanded by an average rate of 3.7 percent annually between 1990 and 2007, but at a much slower pace — 1.2 percent annually — between 2000 and 2007, as the nuclear power fleets in Japan and the ROK have filled many of the few remaining reactor sites. Since 2007, nuclear power use in the region actually contracted by an average of 4.4 percent annually, largely as a result of the shutdown for safety evaluations of the Japanese reactor fleet and, to a lesser extent, the reactor fleets of other nations. Oil use has grown by about 3 percent annually between 2000 and 2012, with large increases in use in China offset by a trend away from oil use in the non-transport sectors in Japan and the ROK.

Figure 3.3: Electricity Generation in Northeast Asia, 1990-2012

Sources: DPRK is from Peter Hayes and David von Hippel, “Foundations of Energy Security for the DPRK: 1990-2009 Energy Balances, Engagement Options, and Future Paths for Energy and Economic Redevelopment,”NAPSNet Special Report (Nautilus Institute, 2012). Mongolia data is from USDOE/EIA, “Mongolia Overview/Data” (2013), http://www.eia.gov/beta/international/country.cfm?iso=MNG; and RFE data is from Ruslan Gulidov and Alexander Ognev, “The Power Sector in the Russian Far East: Recent Status and Plans,” prepared for the 2007 Asian Energy Security Project Meeting Energy Futures and Energy Cooperation in the Northeast Asia Region, Tsinghua University, Beijing, China, October 31-November 2, 2007, https://nautilus.org/wp-content/uploads/2011/12/Russia-Energy-Changes.ppt. Generation figures shown are for gross generation (that is, including in-plant electricity use), except for Mongolia and the RFE. All other data is from British Petroleum Co., “BP Statistical Review of World Energy” (2013).

Even more striking than the growth in primary energy use — and indeed one of its main drivers — has been the increase in electricity generation (and consumption) in the region. As shown in Figure 3.3, total electricity generation in the region nearly quadrupled between 1990 and 2012, with generation in China increasing by a factor of nearly eight, generation in Taiwan increasing by a factor of nearly three, and generation in the ROK increasing by a factor of 4.4. Even though electricity production in Japan, which in 1990 had the highest generation in the region, grew by only 31 percent (an average of 1.2 percent annually), the fraction of global generation accounted for by the Northeast Asia region grew from just over 15 percent in 1990 to nearly 31 percent in 2012. Electricity generation in the rest of the world grew at an average rate of 2 percent annually during the period.

Although population growth has been a driver of energy use in the region, it has not been the key driver. The total number of people in the region surpassed 1.5 billion in the year 2000, but overall population in the region increased by only 12.7 percent between 1990 and 2006, an average of less than 1 percent (0.75 percent) annually. The rate of population growth has further decreased, to an average of 0.57 percent/year from 2007 through 2012. Most of the region’s countries either have populations that are already declining — Japan, Russia and the Russian Far East, and (possibly) the DPRK — or that are expected to start declining in the next decade or so.14

Economic growth, on the other hand, has certainly been a key driver of expanding energy use in Northeast Asia. Figure 3.4 presents trends in gross domestic product from 1990 through 2010 for the countries of the region, expressed in Purchasing Power Parity (PPP) terms. Real GDP in China increased by a factor of 6.6, and GDP in Taiwan and the ROK more than doubled (increasing 2.5- and 2.7-fold, respectively) during the 20 years covered by the graph, while the Japanese economy grew by less than one quarter overall.

Figure 3.4: Northeast Asia GDP by Country, 1990-2010

Sources: Data were derived from Primary Energy Use data from British Petroleum Co., “BP Statistical Review of World Energy and Primary Energy Use per unit PPP” (2013); GDP data from USDOE/EIA, “International Energy Statistics – Energy Intensity Using Purchasing Power Parities, 1990-2011”
(2013), http://www.eia.gov/cfapps/ipdbproject/iedindex3.cfm?tid=92&pid=47&aid=2&cid=regions&syid=1990&eyid=2011&unit=BTUPUSDP. Note that though DPRK data were derived as above from USDOE/EIA data, they should be considered highly approximate. Data for the Russian Far East through 2006 have been estimated very roughly from data in P.A. Minakir, “Russia and the Russian

Far East in Economies of the APR and NEA," in Minakir, P.A., Economic Cooperation between the Russian Far East and Asia-Pacific Countries (2007). After 2006, the RFE GDP was assumed to grow at approximately the rate of growth of GDP in the Russian Federation as a whole.

The efficiency with which an economy uses energy as an input in its overall economic output is reflected in its energy use per unit of GDP. Figure 3.5 charts primary energy use in the countries of Northeast Asia per unit of economic output in units of kilojoules (kJ) per year-2005 US dollar of PPP-adjusted Gross Domestic Product. For the more established economies (Taiwan, Hong Kong, Japan, and the ROK) primary energy use per unit of GDP varied somewhat year to year, but changed very little over the period from 1990 through 2006. In contrast, in the economies in transition — Mongolia, the DPRK, and the RFE — energy use per unit of GDP fell markedly. This decrease was due to a number of factors, including structural adjustment (a reduction in activity in a number of high-energy-input industries) and an improvements in efficiency as some Soviet-era infrastructure was replaced or decommissioned (mostly in the RFE and Mongolia). In China, primary energy use per capita fell from 1990 through about 2000, likely due to a combination of replacing older industrial equipment with more efficient newer equipment, phasing out smaller, older infrastructure (such as smaller, less-efficient coal-fired power plants), and an economy gradually shifting toward less energy-intensive industries. After 2000, trends in consumption caused primary energy use per unit GDP in China to rise somewhat — for example, more road vehicles and per capita transportation use, homes with greater floor space (and energy requirements) per resident, and construction of more commercial building space per person.

Figure 3.5: Primary Energy Use per Unit GDP in the Countries of Northeast Asia, 1990-2010

Sources: Data from USDOE/EIA, "International Energy Statistics – Energy Intensity Using Purchasing Power Parities, 1990-2011" (2013), http://www.eia.gov/cfapps/ipdbproject/iedindex3.cfm?tid=92&pid=47&aid=2&cid=regions&syid=1990&eyid=2011&unit=BTUPUSDP, except for RFE, where primary energy use per unit GDP was derived from the sources noted for Figures 3 and 4.

Projections of Energy Use in Northeast Asia

Figures 3.6 and 3.7 present projections of primary energy use by country and by fuel for the countries of Northeast Asia. These projections were largely derived from initial or draft "reference" or "BAU" (Business-as-Usual) case projections, most of which have been developed or conveyed by country working groups in the Nautilus Institute's collaborative Asian Energy Security project. The exception is the projections for China, which were derived and extrapolated from energy use trends shown in Zhou et al. (2008).15 This composite is just one of many possible energy sector "futures" for the region, and it is based on assumptions regarding changing trends in energy use that are affected by national, regional, and global economics, as well as by evolving national policies. With this limitation in mind, the projections shown suggest that energy use in Northeast Asia will nearly double between 2010 and 2030, with approximately 90 percent of that growth coming from China. On a fuel-by-fuel basis, demand for oil and for hydroelectric energy are projected to double in the 20 years between 2010 and 2030, while coal use increases by more than 50 percent, gas use nearly triples, and nuclear power and hydro use roughly double. In terms of absolute increases, oil shows the second largest growth — driven by expansion of transport energy demand, especially in China — with coal just ahead.

Figure 3.6: Projected Reference-Case Primary Energy Use in Northeast Asia by Country



Source: These projections were largely derived from initial, draft “reference” or “BAU” (Business-a--Usual) case projections, most of which have been developed or conveyed by country working groups in the Nautilus Institute’s collaborative Asian Energy Security project, except for projections for China, which were derived and extrapolated from energy use trends derived from Nan Zhou, Michael A. McNeil, David Fridley, Jiang Lin, Lynn Price, Stephane de la Rue du Can, Jayant Sathaye, and Mark Levine, Energy Use in China: Sectoral Trends and Future Outlook, Report # LBNL-61904, Lawrence Berkeley National Laboratory, 2008.

Placed in perspective, for example, the additional 31 EJ (Exajoules, equal to 1000 Petajoules) of annual oil demand for the region projected here corresponds to about three quarters of a one billion tonnes, or roughly 5.5 billion barrels, not much less than the 7.4 billion barrels produced in 2010 by Saudi Arabia and Russia — the world’s two largest oil producers — combined. Given estimates by some researchers that show the world’s output of petroleum peaking soon (see, for example, Zittel and Schindler, 2007),16 if not already, this projected increase in oil demand in just one region is clearly cause for concern.

Figure 3.7: Projected Reference-Case Primary Energy Use in Northeast Asia by Fuel



Source: These projections were largely derived from initial, draft “reference” or “BAU” (Business-a--Usual) case projections, most of which have been developed or conveyed by country working groups in the Nautilus Institute’s collaborative Asian Energy Security project, except for projections for China, which were derived and extrapolated from energy use trends derived from Nan Zhou, et al., Energy Use in China: Sectoral Trends and Future Outlook.

In addition to implications for global energy supplies, the growth in energy needs projected above has significant implications for global greenhouse gas emissions, Table 3.3 provides a summary of historical estimates and projections for emissions in the countries of Northeast Asia and a view of the increasing importance of emissions of carbon dioxide (CO2) from the region relative to the rest of the world. Northeast Asia’s share of world CO2 emissions increased from 17.9 percent in 1990 to over 32.6 percent by 2010, and, based on a variety of estimates, it will account for 40 percent of global emissions by 2030.

Table 3.3: Historical and Projected Emissions of Carbon Dioxide in Northeast Asia

Carbon Dioxide Emissions (Unit: million tonnes of carbon dioxide)								
Country/Area	1990	1995	2000	2005	2010	2015	2020	2030
China	2,178	2,723	3,272	5,464	7,997	10,022	11,532	14,028
Chinese Taipai	118	182	256	289	287	318	353	435
DPRK (North Korea)	131	80	34	39	33	48	79	90
Hong Kong (China SAR)	40	47	56	80	92	[Included in China total]		
Japan	1,047	1,116	1,201	1,241	1,180	1,243	1,220	1,215
Mongolia	10	9	6	6	8	10	13	21
ROK (South Korea)	242	381	439	494	581	600	627	666
Russian Far-East	80	71	71	80	92	98	105	135
Total Northeast Asia	3,845	4,610	5,335	7,693	10,269	12,340	13,930	16,590
Total Rest of World	17,678	17,400	18,815	20,569	21,233	21,477	22,516	24,874

TOTAL WORLD	21,523	22,010	24,150	28,262	31,502	33,817	36,446	41,464

Sources: Historical data from USDOE EIA, "International Energy Statistics – Total Carbon Dioxide Emissions from the Consumption of Energy, 1990-2011" (2013), http://www.eia.gov/cfapps/ipdbproject/iedindex3.cfm?tid=90&pid=44&aid=8&cid=regions&syid=1990&eyid=2011&unit=MMTCD, except DPRK from David F. von Hippel and Peter Hayes, "An Updated Summary of Energy Supply and Demand in the Democratic People's Republic of Korea (DPRK)," EGS Working Paper 2014-02, April 2014, http://www.egskorea.org/common/download.asp?downfile=NK_Energy_2014-2_final_Hippel_Hayes.pdf&path=board; and RFE, rough estimates from Ruslan Gulidov, Victor Kalashnikov and Alexander Ognev, "Update on the RFE Energy Sector and on the RFE LEAP Modeling Effort," prepared for the 2007 Asian Energy Security Project Meeting Energy Futures and Energy Cooperation in the Northeast Asia Region, Tsinghua University, Beijing, China, October 31-November 2, 2007, https://www.google.com.au/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0CB8QFjAA&url=http%3A%2F%2Fnautilus.org%2Fwp-content%2Fuploads%2F2011%2F12%2F01-RFE.pptx&ei=c6EkVMLdIYvioATF64KQCA&usg=AFQjCNEPDMEV0Pdg5FttVejt2FYcaQwqUg&bvm=bv.76247554,d.cGU&cad=rja; and Victor Kalashnikov, "Electric Power Industry of The Russian Far East: Status and Prerequisites for Cooperation in North-East Asia," Draft Report Prepared for the Working Group Meeting on Comparisons of the Electricity Industry in China, North Korea and the Russian Far East, East-West Center, Honolulu, Hawaii, 28-29 July 1997. Projections data from USDOE EIA, International Energy Outlook 2013, Table A10, World carbon dioxide emissions by region, Reference case (2013), http://www.eia.gov/oiaf/aeo/tablebrowser/#release=IEO2013&subject=0-IEO2013&table=10-IEO2013&region=0-0&cases=Reference-d041117, for China, Japan, ROK, and Total World.

Energy Supplies in Northeast Asia: Resources, Energy Imports and Exports

To supply the energy needed to meet current and projected demand, the Northeast Asia region as a whole already has a considerable endowment of energy resources, including both fossil fuels and renewable energy resources. Most, however, of the remaining untapped fossil fuel reserves and hydroelectric potential in the region are far from population centers and often in difficult-to-access areas — they are mostly found in the Russian Far East. As a result, there has been rapid growth in the region's net energy imports, including oil, gas, and coal.

Japan and the ROK have limited coal reserves — an estimated 350 and 126 million tonnes, respectively17 — and have ceased (or all but ceased) domestic production. Neither country has significant reserves of gas or oil, though exploration, particularly in offshore areas, continues. Available hydroelectric resources in both countries are largely already in use, though both countries have wind energy resources in some areas. China has a reported 115 billion tonnes of coal reserves — about a 45-year supply at current production levels, along with 2.1 billion tonnes of oil (just an 11-year supply at 2007 production levels), and about 1.9 trillion cubic meters of natural gas — about a 27-year supply. China's exploitable hydroelectric resources are the largest in the world, at about 400 GW (gigawatts, or million kilowatts), of which roughly one-third have been tapped. The bulk of China's gas and hydroelectric resources are located in the western part of the country and require the construction of transmission pipelines and power lines to reach the major cities in eastern China. China has significant wind resources, largely in remote areas in the northwest and northeast, including Inner Mongolia, although offshore wind resources in areas of eastern China are also significant. The DPRK has abundant coal deposits, with estimates ranging from "reserves" of 600

million tonnes to “resources” of up to 15 billion tonnes. The DPRK has some remaining untapped hydroelectric potential, though mostly at smaller sites, and no significant oil or gas production, though some resource finds have been reported.18

The Russian Far East’s energy endowment includes a reported 10.8 billion tonnes of oil, 24.3 trillion cubic meters of natural gas, and 1.2 trillion tonnes of coal, as well as hydroelectric potential on the order of 200 GW and 20 billion cubic meters of wood stocks that can be harvested at a rate of about 66 million cubic meters annually.19 These vast resources are located in remote and often forbidding terrain, requiring major investments to bring them to market.20 As such, even if developed rapidly, these resources will only provide a fraction of the regional energy requirements projected in the coming years.

China was a net oil exporter until 1993, but its imports net of exports has since grown to over 260 million tonnes of crude oil and oil products by 2010, second only to the United States.21 Japan had net imports of about 210 million tonnes of crude oil and oil products in 2010, the ROK had net imports of 775 million barrels (just over 100 million tonnes) in 2009,22 and Taiwan had net imports of 54 billion liters of oil equivalent (about 60 million tonnes).23 Japan, the ROK, and Taiwan were also top importers of liquefied natural gas (LNG), at about 93, 44, and 15 billion cubic meters, respectively, during 2010. Though Japan and the ROK once produced most of their own coal, both now produce only 1 percent of what they consume, importing coal with energy value of 123 and 75 million tonnes of oil equivalent (Mtoe), respectively, in 2010. Taiwan imported 40 Mtoe of coal in 2010. China both imports and exports coal, but its trade flows of coal are dwarfed by its vast domestic production (over 3.2 billion tonnes, or 1800 Mtoe). The near-total dependence on energy imports by Japan, the ROK, and Taiwan has been perceived as a significant energy-supply security liability. It is one reason that all three countries, and especially Japan and the ROK, have invested so heavily in nuclear power and worked to ensure that their own energy companies (especially oil companies) secure (own and develop) fuel supplies in other nations, in addition to taking other steps to improve their energy security. As China’s energy needs continue to outpace its own production of many fuels, it has also sought to secure energy supplies abroad and take steps domestically to improve its energy supply security.

Introduction of an Inclusive Concept of Energy Security

Need for a Broader Definition of Energy Security

Although improving energy-supply security, or addressing energy-supply insecurity, has been a traditional focus of energy policy, today the variety of challenges related to energy provision and use argue for a much broader consideration of what energy security really means. The challenges facing national and regional energy policy in today’s interconnected world, and in the increasingly interconnected Northeast Asia region, include such multi-faceted problems as mitigating and adapting to global climate change; addressing the security threat of North Korean nuclear weapons, with its strong ties to energy, economic, and social issues; and adjusting to the increasing role of civil society in energy sector decisions. All these challenges go beyond what can be handled by a narrow energy-supply/energy-cost perspective.

The energy sector is not the only source of the anthropogenic greenhouse gas emissions that are causing the earth’s climate to change, based on the conclusions of the Intergovernmental Panel on Climate Change24 and the vast majority of scientists working on the topic. The energy sector is, however, the largest contributor to global climate change, particularly in Northeast Asia, where emissions from coal combustion dominate. The reduction of greenhouse gas emissions — that is, mitigation of climate change by reducing the emissions that drive it — is already a major element of the stated policies of most of the countries of Northeast Asia. Given the strong connection between

greenhouse gas emissions and the energy sector, climate change considerations play an increasing role in energy policy and thus need to be considered a part of the energy security calculus. Furthermore, as some degree of climate change is inevitable (indeed, has already occurred), no matter what steps to mitigate the problem are undertaken, some degree of adaptation to climate change will be required. A number of certain or likely adaptation strategies are directly or indirectly related to the energy sector. A far-from-exhaustive list of examples here would include the reinforcement of seawalls and other structures against rising seas and storm surges to protect coastal power plants and port facilities used for fuel imports and exports, the reinforcement of electricity transmission and distribution networks against the impacts of severe storms, and the provision of additional peak power-supply capabilities to meet the needs for summer air conditioning as average temperatures rise. Thus, climate change adaptation also needs to be considered when evaluating the energy security impacts of different policies.

Although climate change affects and involves all nations, the countries of Northeast Asia are the most affected, or potentially affected, by the DPRK nuclear weapons dilemma. The problem of how to secure the DPRK's nuclear weapons, nuclear materials, and nuclear know-how is arguably not a direct energy issue, but it is intimately linked to the energy insecurity (the lack of energy security) in North Korea. The DPRK began using its nuclear program — which was at first, ostensibly, geared toward creating a civilian nuclear power program — as a threat and a bargaining chip after 1990 when the dissolution of the Soviet Union deprived the DPRK of a considerable fraction of outside support for its energy sector. Since then, several international negotiations with the DPRK have focused on members of the international community providing different types of energy aid to the DPRK, including most prominently the "Agreed Framework" of 1994 and the "Six-Party Talks" in the mid-2000s.25 Energy aid was to be provided in exchange for steps toward winding down the North Korean nuclear weapons program and securing the DPRK's nuclear materials. As the lack of sufficient energy supplies plays a role in preventing the DPRK from redeveloping its economy and providing its population with adequate food, heat, and other services, the energy security/insecurity of the DPRK is tightly connected with economic, security, social, humanitarian, and political issues. These issues not only affect the DPRK but spill over to its neighbors, with impacts on border security, refugee concerns, and, for the ROK, military security (witness the sinking of the ROK naval ship Cheonan and the shelling of the island Yeonpyeong in 2010).26 In addition, some regional policies that might help to improve regional energy security, such as infrastructure to share the vast energy resources of the Russian Far East with China, the ROK, and Japan, are in part at the geographical mercy of the DPRK, which lies on the route for pipelines and power lines between the Russian Far East and Seoul. For Northeast Asia, the North Korean nuclear weapons issue is inextricably linked with energy security issues.

Another pervasive trend in Northeast Asia and in other regions has been the increased voice of civil societyin key policy decisions. This voice, which differs in strength, to be sure, in different nations, affects and is affected by energy policy discussions and outcomes. In the ROK and Japan, for example, the concerns of local residents and their civic representatives, as well as local and national non-governmental organizations, are significant factors in deciding where nuclear energy facilities may and, more significantly, may not be sited. The Fukushima incident, by raising the profile of the potential impacts of nuclear energy on local communities, seems to be further increasing the response of civil society on the nuclear power issue. Similarly, civic groups of various kinds have had an increasing role in affecting decisions on other types of major energy infrastructure, as well as on overall energy and environmental policy. As a consequence, the impact of civil society on policies affecting the energy sector, and vice versa, needs to be a considered part of any comprehensive concept of energy security.

Elements of the Concept of Broader Energy Security

National energy policies in the new century face challenges on multiple fronts.27 The substance of these challenges needs to be incorporated into a new concept of energy security and used when evaluating policies designed to improve energy security/address energy insecurity. Energy security policies in various countries are now showing trends of convergence rather than divergence, in part due to the increasing speed with which news and ideas are shared among peoples in our increasingly complex and interconnected world. This convergence does not eliminate regional and national differences. Yet it is an encouraging sign that may minimize the potential conflict stemming from differences in energy security concepts as reflected in the energy security policies adopted by different countries.

The following is a quick review of the major challenges that need to be included in an energy security concept sufficiently comprehensive as to be broadly applicable to the complex impacts of energy-sector and related policies.

Economic

Though the economic impacts of policies addressing energy security have typically been a part of the standard energy security calculus, at least in a limited way through considerations such as stockpiling fuel supplies to avoid or reduce shocks to the economy arising from sudden increases in the costs of imported energy, a more comprehensive approach to energy security requires looking beyond the impacts of price shocks. A nation's choice to pursue different energy strategies may have a significant effect on the future of its economy. For example, a decision to aggressively pursue energy efficiency or renewable energy may have a significantly positive influence on the domestic development of those industries. Similarly, a conscious decision to move away from a coal-powered economy will cause economic dislocation for workers in the coal mining industry. The complex and dynamic nature of economies often makes it difficult to determine with any certainty the economic impacts of a policy designed to improve energy security, but consideration of the impacts of energy policies on key economic sectors, including both the direct and interactive effects of the policies, is a necessary part of a comprehensive energy security analysis.

Environment

Perhaps the most serious challenge to traditional (supply-security-oriented) energy policy thinking is the need to protect the environment. If environmental problems are to be solved, energy policies will have to be reformulated. International environmental problems present the greatest impetus for change. Two international environmental problems inherently linked with energy consumption, particularly fossil fuel consumption, are acid rain and global climate change.28 Trans-boundary air pollution (acid rain) has been an international issue in Europe and North America and is a developing issue in East Asia. It even has trans-Pacific elements.29

As noted above, global climate change poses an even broader and more complex challenge to energy policy than trans-boundary air pollution. Although there are relatively straightforward technical solutions to reduce the emissions of acid rain precursors — including flue-gas desulfurization devices — greenhouse gas emissions cannot be so easily abated by "end-of-pipe" methods.30 A comprehensive approach toward greenhouse gas emissions is necessary. The climate change issue also brings in a much longer time perspective than businesses and governments are used to dealing with, in terms of planning both for climate change mitigation and, increasingly, for adaptation to the inevitable (or likely) impacts of ongoing changes in climate. Other environmental issues, such as radioactive waste management, require long-term perspectives. In sum, environmental issues must be incorporated into the energy security concept.31

Technology

Risks associated with the development and deployment of advanced technologies challenge current energy policy assessments. Conventional thinking understates such risks and tends to see them as short-term rather than long-term. Risks include nuclear accidents such as those at Three Mile Island in the United States (1979), Chernobyl in the former Soviet Union (1986), and, of course, Fukushima in Japan (2011); natural disasters with impacts on energy infrastructure such as Hurricane Katrina's impacts on oil and gas production in the Gulf of Mexico, the impact of the July, 2007 earthquake near Niigata, Japan on the seven-unit Kashiwazaki-Kariwanuclear plant; and the combination of nuclear technology and natural disaster risks that have surged into the world's general consciousness with the Fukushima disaster. Other examples of manifestations of technological risk include the failure of research and development efforts to perform as expected (such as the synthetic fuel, fast-breeder reactor, and solar thermal programs in the United States during the 1970s and 1980s).

Technological risks can be transnational. The accident at Chernobyl is a good example of an incident with decidedly cross-boundary direct implications, and the Fukushima incident, though its radiological impacts on other nations is unclear, has had a reverberating impact on the public's opinion of the nuclear industry worldwide.32 Also, markets for advanced technologies are becoming global. As a result, technological risks can be exported. Nuclear technology, for example, is being exported to a number of developing countries, most notably China and India, but also Vietnam and potentially Indonesia, Thailand, Pakistan, and Malaysia,33 in addition to Middle Eastern nations such as the United Arab Emirates.34 As the world rapidly moves toward a technology-intensive energy society, a new energy security concept must address the various domestic and international risks associated with advanced technologies.

Demand-side management

Another challenge to energy policy thinking is the need to address energy demand. Conventional energy policy seeks to assure supply while assuming that demand is given. This notion has been changing since the mid-1980s, when the concept of demand-side management (DSM) was first incorporated into energy planning. Now, management of energy demand is almost on an equal footing with management of supply — new technologies such as distributed generation and "smart grids" blur the distinction between demand and supply — and it is recognized as a key tool in the achievement of climate change mitigation and other environmental goals. DSM does not, however, eliminate uncertainties that are inherent in energy policy planning. Unexpected demand surges and drops occur depending on, for instance, changes in weather patterns and economic conditions.

There are risks associated with energy demand just as with supply. Conventional energy policy thinking has tended to underestimate demand-side risks. Risks stem from, for example, demand surges (periods of peak demand in response to extreme conditions resulting from global climate change). These are a serious concern for utility management, but managing peak demand is not easy, particularly given uncertainties in consumer behavior. Long recessions are another major concern for energy industry managers, since recession means large supply-capacity surpluses. Uncertainty (risk) on the demand side of the total energy picture is therefore a key component of a new concept of energy security.

Social-cultural factors

Not In My Backyard (NIMBY) and environmental justice concerns are becoming global phenomena, making it increasingly difficult, time-consuming, and costly to site "nuisance facilities" such as large power plants, waste treatment and disposal facilities, oil refineries, or liquefied natural gas terminals. Although the public recognizes the need for such facilities, many communities prefer not to have the plants in their neighborhood. Opposition to plant siting has elevated the importance of

local politics in energy policy planning. Who has the right to decide where to locate the facilities? Who has the right to refuse? Can any rational policymaking process satisfy all stakeholders? These questions pose not only a challenge to energy security policy, but also to democratic institutions themselves. NIMBY epitomizes the social and cultural risks that need to be recognized in policymaking agendas and which present a challenge to current energy policy thinking. As noted above, the increasing role of civil society in energy sector decisions is a part of this challenge.

There are "enviro-economic" concerns as well. It is often the case that the party who bears the risk should get economic compensation. But how much compensation is reasonable, and who should be qualified to receive such compensation? These issues are often difficult to decide.

Public confidence represents another social factor influencing energy policy. Once lost, public confidence becomes hard to recover. "Public confidence" should be distinguished from "public acceptance," which is commonly used in traditional energy policy thinking. Promoting public acceptance is often the object of public relations campaigns. Promoting public confidence involves more than public relations. Examples of efforts to increase public confidence in energy decisions include, for example, efforts by the U.S. Department of Energy (DOE) to increase information disclosure and by the Japanese government to make the nuclear policymaking process more transparent through holding roundtable discussions. Accounting for social-cultural factors and increasing public confidence in energy choices are therefore central components of a new concept of energy security.

International relations and military risks

New dimensions in international relations and military risks challenge traditional energy policy-making. The end of the Cold War brought in its wake a new level of uncertainty in international politics. Although the risk of a world war is drastically reduced, the threat of regional clashes has increased, as ongoing conflicts in the Middle East, the Balkans, North Africa, and the former Soviet states of the Caucasus demonstrate. The international politics of plutonium fuel-cycle development, with its associated risks of nuclear terrorism and proliferation, remains an area where energy security and military security issues meet, with the North Korean nucleardilemma, as noted above, a special case of this set of problems. The brave new world of post-Cold War international relations must be accounted for in a new concept of energy security.

A Comprehensive Definition of Energy Security

The above key components — environment, economics, technology, demand-side management, social and cultural factors, and post-Cold War international relations — are central additions to the traditional supply-side point of view in the following comprehensive energy security concept.

> A nation-state is energy secure to the degree that fuel and energy services are available to ensure (a) survival of the nation, (b) protection of national welfare, and (c) minimization of risks associated with supply and use of fuel and energy services. The six dimensions of energy security include energy-supply, economic, technological, environmental, social and cultural, and military/security dimensions. Energy policies must address the domestic and international (regional and global) implications of each of these dimensions.[35]

What distinguishes this energy security definition is its emphasis on the imperative to consider extra-territorial implications of the provision of energy and energy services while also recognizing the complexity of implementing national energy security policies and measuring national energy security. This emphasis is particularly apt in a region like Northeast Asia, where the energy security and other policies of neighboring nations significantly interact. The definition is also designed to

include emerging concepts of environmental security, which include the effects of the state of the environment on human security and military security and the effects of security institutions on the environment and on prospects for international environmental cooperation.[36]

Methods for Evaluating the Broader Energy Security Impacts of Different Energy Paths or Scenarios

Given the broader definition of energy security provided above, the application of a suite of analytical tools and methods, and a framework within which to apply them, are called for in order to systematically compare the various attributes of different energy security policies or policy scenarios.

Such a framework should help to identify the relative costs and benefits of different "energy futures" — essentially, future scenarios driven by suites of energy and other social policies. Below we describe some of the policy issues associated with the dimensions of energy policy presented earlier and offer a broadly defined framework for evaluating energy security.

A Conceptual Framework for Energy Policy

We provide a listing of each dimension of energy security as defined below in Table 3.4, along with a sampling of the policy issues associated with which each dimension of energy security. The two right-hand columns of Table 3.4 provide examples, many drawn from the energy security approaches described above, that might be used to address the types of both "routine" and "radical" risk and uncertainty faced in the planning, construction, and operation of energy systems. While Table 3.4 provides a broad, though by no means complete, list of policy issues, the categories shown are not necessarily independent. Certain energy technologies will be influenced by climate change (hydroelectric power and inland nuclear power plants, for example, may be affected by changes in water availability) and/or by requirements for climate change adaptation. And there are many other examples of interdependence that need full consideration of the energy security impacts of candidate energy policies.

Table 3.4: Energy Security Conceptual Framework

Dimension/Criterion of Risk and Uncertainty Associated with Energy Security	Energy Security Policy Issues	Energy Security Strategies/Measures	
		Reduction and Management of Routine Risk	Identification and Management of Radical Uncertainty
1. Energy Supply	☐ Domestic/Imported ☐ Absolute scarcity ☐ Technology/Fuel Intensive? ☐ Incremental, market-friendly, fast, cheap, sustainable?	☐ Substitute technology for energy ☐ Efficiency first	☐ Technological breakthroughs ☐ Exploration and new reserves

2. Economic	☐ Cost-benefit analysis ☐ Risk-benefit analysis ☐ Social opportunity cost of supply disruption ☐ Local manufacturing of equipment ☐ Labor ☐ Financing aspects ☐ No regrets	☐ Compare costs/benefits of insurance strategies to reduce loss-of-supply disruption ☐ Investment to create supplier-consumer inter-dependence ☐ Insurance by fuel (U, oil, gas, coal) stockpiling, global (IEA) or regional quotas (energy charters)	☐ Export energy intensive industries ☐ Focus on information intensive industries ☐ Export energy or energy technology
3. Technological	• R&D Failure • Technological monoculture vs. Diversification • New materials dependency in technological substitution strategies	• Invest in renewables • Mixed Oxide Fuels recycling • Plutonium /Fast Breeder Reactors • Uranium from seawater • Spent fuel management issues	• Ultimate Nuclear Waste Storage
4. Environmental	• Local externalities • Regional externalities both atmospheric and maritime • Global externalities • Requirements for adaptation to climate change ☐ Precautionary Principle	• Risk-benefit analysis and local pollution control • Treaties • Mitigation planning • Adaptation planning ☐ Technology transfer	☐ Thresholds and radical shifts of state such as sea level rise and polar ice melt rate
5. Social-Cultural	• Consensus/conflict in domestic or foreign policy making coalitions • Institutional capacities • Siting and downwind distributional impacts • Populist revulsion or rejection of technocratic strategies • Perceptions and historical lessons • Role of civil society in energy decisions	• Transparency • Participation • Accountability • Side payments and compensation • Education • Training • Engagement with civil society organizations	
6. Military-Security	• International management of Plutonium • Proliferation potential • Terrorism and energy facilities • Sea lanes and energy shipping • Geopolitics of oil/gas supplies • North Korean nuclear weapons issues	• Non-proliferation Treaty/Safeguards regimes • Security alliances • Naval power projection • Transparency and confidence building • DPRK Energy assistance and denuclearization agreements	• Disposition and disposal of excess nuclear warhead fissile materials • Military options for resolving energy-related conflicts, securing infrastructure

Source: Modified from David von Hippel, Tatsujiro Suzuki, James H. Williams, Timothy Savage, and

Peter Hayes, “Energy Security and Sustainability in Northeast Asia,” Energy Policy, 39 (2011), pp. 6719-30,http://dx.doi.org/10.1016/j.enpol.2009.07.001

Testing the Energy Security Impacts of Different Energy Scenarios

Given the broad definition of energy security provided above, how should a framework be organized for evaluating the energy security impacts of different policy approaches? Some of the challenges in setting up such a framework include deciding on a manageable but useful level of detail, incorporation of uncertainty, risk considerations, comparison of tangible and intangible costs/benefits, comparison of impacts across different spatial levels and time-scales, and balancing analytical comprehensiveness and transparency. To meet these challenges, we devised a framework based on a variety of tools, including the elaboration and evaluation of alternative energy/environmental “paths” or “scenarios” for a nation and/or region (for example, with the Long-range Energy Alternatives Planning System (LEAP)37 software tool used in the Asian Energy Security Project), diversity indices, and multiple-attribute (trade-off) analyses, as described below. Central to the application of the framework is the search for “robust” solutions — a set of policies that meet multiple energy security and other objectives at the same time.

The framework for the analysis of energy security includes the following steps:

1. Define the objective and subjective measures of energy (and environmental) security for evaluation. Within the overall categories presented in Table 3.5, these measures could vary significantly between different analyses.
2. Collect data and develop candidate energy paths/scenarios that yield roughly consistent energy services, but use sufficiently different assumptions to illuminate the explored policy approaches.
3. Test the relative performance of paths/scenarios for each energy security measure included in the analysis.
4. Incorporate elements of risk.
5. Compare path and scenario results.
6. Eliminate paths that lead to clearly suboptimal or unacceptable results, and iterate the analysis as necessary to reach clear conclusions.

Some of the possible dimensions of energy security, and potential measures and attributes of those dimensions, are summarized below in Table 3.5. The right-hand column includes a listing of possible interpretations — that is, a listing of the direction in which a given measure would typically indicate greater energy security. It should be noted that many of these dimensions and measures can and do interact — and that a solution to one problem may exacerbate another. Formal or informal application of analytical methods such as “systems thinking” can assist the execution of steps 4 and 5, above. These methods allow the interaction of the different elements of complex processes to be seen more clearly than if pairs of systems interactions are viewed independently.38

There is often a temptation in step 5 of the energy security analysis procedure to place the attributes of energy security into a common metric: for example, an index of relative energy security calculated through a ranking and weighting system. We recommend avoiding this temptation. Such systems almost invariably involve procedures that amplify small differences between paths/scenarios, play down large differences, and give an illusion of objectivity to weighting choices that are by their nature quite subjective. Instead, as described below, we recommend laying out the energy security attributes of each path/scenario side by side in a matrix, or table, allowing reviewers, stakeholders, and decision makers to see the differences and similarities between different energy futures for

themselves, and to apply their own perspectives and knowledge, in consultation with each other, to determine what is most important in making energy policy choices. Also, not explicitly included in steps 5 or 6 are mathematical tools for optimizing energy security results over a set of paths or scenarios. Optimization can be attractive as it appears to identify one “best” path for moving forward. Optimization models can in some cases offer useful insights, provided the underlying assumptions and algorithms in the analysis are well-understood by the users of the results. Like weighting and ranking, however, optimization involves subjective choices made to appear to be objective, especially when applied across a range of different energy security attributes, and as such it should be employed only with caution and with a thorough understanding of its limitations in a given application.

Table 3.5: Dimensions and Measures/Attributes of Energy Security

Dimension of Energy Security	Measures/Attributes	Interpretation
Energy Supply	Total Primary Energy	Higher = indicator of other impacts
	Fraction of Primary Energy as Imports	Lower = preferred
	Diversification Index (by fuel type, primary energy)	Lower index value (indicating greater diversity) preferred based on index formula as derived by Neff (1998)
	Diversification Index (by supplier, key fuel types)	Lower index value preferred (see above)
	Stocks as a fraction of imports (key fuels)	Higher = greater resilience to supply interruption
Economic	Total Energy System Internal Costs	Lower = preferred
	Total Fuel Costs	Lower = preferred
	Import Fuel Costs	Lower = preferred
	Economic Impact of Fuel Price Increase (as fraction of GNP)	Lower = preferred
Technological	Diversification Indices for key industries (such as power generation) by technology type	Lower = preferred
	Diversity of R&D Spending	Qualitative—higher preferred
	Reliance on Proven Technologies	Qualitative—higher preferred
	Technological Adaptability	Qualitative—higher preferred

Environmental	GHG emissions (tonnes CO2, CH4)	Lower = preferred
	Acid gas emissions (tonnes SOx, NOx)	Lower = preferred
	Local Air Pollutants (tonnes particulates, hydrocarbons, others)	Lower = preferred
	Other air and water pollutants (including marine oil pollution)	Lower = preferred
	Solid Wastes (tonnes bottom ash, fly ash, scrubber sludge)	Lower = preferred (or at worst neutral, with safe re-use)
	Nuclear waste (tonnes or Curies, by type)	Lower = preferred, but qualitative component for waste isolation scheme
	Ecosystem and Aesthetic Impacts	Largely Qualitative—lower preferred
	Exposure to Environmental Risk	Qualitative—lower preferred
Social and Cultural	Exposure to Risk of Social or Cultural Conflict over energy systems	Qualitative—lower preferred
	Exposure to Military/Security Risks	Qualitative—lower preferred
Military/Security	Relative level of spending on energy-related security arrangements	Lower = preferred

Source: Modified from David von Hippel, et al., "Energy Security and Sustainability in Northeast Asia,"http://dx.doi.org/10.1016/j.enpol.2009.07.001

Other Tools and Methods for Energy Security Analysis

One set of analyses critical to the comprehensive evaluation of energy security, but not directly performed by LEAP39 or similar tools, is the evaluation of the energy security impacts of risk for different energy paths. The incorporation of the elements of risk in energy security analysis can involve a more qualitative but systematic consideration of different potential futures in order to "arrive at policy decisions which remain valid under a large set of plausible scenarios";40 sensitivity analysis — which studies variations in one or more plans (or paths) when key uncertain parameters are varied; probabilistic analysis — in which "probabilities are assigned to different values of uncertain variables, and outcomes are obtained through probabilistic simulations";41"stochastic optimization" — in which a probability distribution for each uncertain variable is assigned during an optimization exercise, incorporating uncertainty in the discount rate used in an economic analysis; and "search for a robust solution," which Hossein Razavi describes as using "the technique of trade-off analysis to eliminate uncertainties that do not matter and to concentrate on the ranges of uncertainty which are most relevant to corresponding objective attributes."42

Although any or all of these six techniques could be applied within the energy security analysis framework suggested here, probably the most broadly applicable and transparent of the techniques above are scenario analysis, sensitivity analysis, and "search for a robust solution." In the Pacific Asia Regional Energy Security (PARES) analysis of the energy security implications of two different medium-term energy paths for Japan, for example, we used a combination of paths analyses and sensitivity analyses to test the response of the different energy paths to extreme changes in key variables.

Diversification indices

In a paper prepared for the PARES project, Thomas Neff borrows from economics, financial analysis, and other disciplines to create a set of tools, based on diversity indices, which can help to provide a

metric for the energy security implications of different energy supply strategies.[43]

Neff starts with a simple diversification index, the Herfindahl index, written in mathematical terms as:



where  is the fraction of total supply from source "i." This index can measure, for example, the diversity of the types of fuels used in an economy (where  would then be the fraction of primary energy or final demand by fuel type). Alternatively, within a single type of fuel (such as oil), the index can be applied to the pattern of imports of a particular country by supplier nation. The index has a maximum value of 1 (when there is only one supplier or fuel type) and goes down with increasing diversity of number of suppliers or fuel types, so that a lower value of the index indicates more diverse, and perhaps more robust, supply conditions.

Deliberation of risk in specific fuel import patterns can be worked into the index, Neff argues, through consideration of the variance in the behavior of each supplier and by application of correlation coefficients that describe how variance in the behavior of pairs of suppliers (for example, the oil exporters Saudi Arabia and Indonesia) are or might be related. The correlation might be positive for countries that tend to raise and lower their exports together, or negative as when supplier A increases production to compensate for decreased production by supplier B.

Neff also addresses the topic of market, or systematic, risk: that is, the risk associated with the whole market changing at once — whether the market is for stocks, oil, or uranium. Applying parameters that describe the degree to which individual suppliers are likely to change their output when the market as a whole shifts (the contribution of the variance of an individual supplier to overall market variance) allows the calculation of the variance of a given energy supply pattern. Hence, the calculation of such as "portfolio variance" provides a measure of the relative risk inherent in any given fuel supplier pattern versus any other.

Multiple attribute analysis and matrices

Deciding upon a single set of energy policies (or a few top options) from a wide range of choices is a complex process, necessarily incorporating both qualitative and quantitative aspects, and should be approached systematically for credible results. There are different methods with many gradations for deciding which set of policies or which energy path is the most desirable. These range from simply listing each attribute of each policy set or path in a large matrix and methodically eliminating candidate paths, noting why each is eliminated, to more quantitative approaches involving "multiple attribute analysis."

In one type of application of multiple attribute analysis, each criterion (attribute) used to evaluate energy policies or paths is assigned a numerical value. For objective criteria, the values of the attributes are used directly (present value costs are an example), while subjective criteria can be assigned a value based on a scale of 1 to 10. Once each attribute has a value, a weight is assigned. These weights should reflect a consensus as to which attributes are most important in planning. Multiplying the values of the attribute by the weights assigned, and then summing up the attributes, yields "scores" for each individual policy set or path that can be compared. Although this process may seem like an attractive way to organize and make more objective a complicated decision/evaluation process, great care must be taken to apply the analysis so that (1) all subjective decisions — for example, the decisions that go into defining the system of weights used — are carefully and fully documented, and (2) the system avoids magnifying small differences (or minimizing large differences) between policy or path alternatives.

Whatever tool or technique is used to decide between policy sets or paths, it is ultimately the policymakers and their constituencies who will decide which policies are to be implemented or which energy path is worth pursuing. As a consequence, one of the most important rules of applying multiple attribute analysis is to present the analytical process in a transparent manner so that others can review the assumptions and decisions made along the way.

The most straightforward approach to comparing paths is to simply line up the attribute values for each path side by side and review the differences, focusing on those that are truly significant. For example, if the difference in the net present value (NPV) cost of plan A is one billion dollars greater than that of plan B, this disparity may seem at first glance like a lot of money, but it must be examined relative to the overall cost of the energy system or to the cost of the economy as a whole. To an energy system that accrues, say, one trillion (1012) dollars in capital, operating and maintenance, and fuel costs over twenty years, a difference between plans of one billion (109) dollars is not only trivial, it is dwarfed by uncertainties in even the most certain elements of the analysis. The key, then, is to search for differences in the plans' attributes by including truly meaningful qualitative and quantitative values.

One straightforward way to visualize the similarities and differences between paths, both quantitative and qualitative, is the use of a comparison matrix or matrices. These tables show the different attributes and measures of each path (cost, environmental emissions, military security, and others) as rows, while the results for each scenario/path form a column in the table.44 In theory, the matrix format allows for the comparison of a large number of different attributes for a large number of different paths. In practice, the more that the attributes can be reduced to a significant few, and the more that the paths can be reduced to those showing clear differences relative to each other, the more the comparison matrix will be useful and easy to comprehend. The matrix format is also compatible with the use of other tools and methods for evaluating aspects of energy security, including, but by no means limited to, the sampling of tools and methods presented above.

One advantage of the matrix method of paths comparison is that it allows input on both quantitative and qualitative attributes and measures of energy security. In some cases, comparing attributes quantitatively across paths is theoretically possible (for example, employment impacts or spending on security arrangements), but it is not feasible from a practical perspective, at least for the study at hand. In other cases, quantitative measures may simply not exist (as in the case of exposure to social and cultural risk). In these types of cases, the only option for measuring the relative attributes of different paths may be qualitative analysis. There is no one correct way to accomplish a qualitative analysis, but such an analysis should address the issue from different points of view (for example, cultural impacts on different segments of society), clearly define operating assumptions, and show a thinking-through of the relationship between cause (differences between energy paths) and effect (differences in attribute outcome). Qualitative analysis is by definition subjective, but it is a necessary part of the overall analysis of different energy paths, which otherwise runs the risk of confusing the attributes that are countablewith the issues that count.

Energy Security and Urban Security Issues

Definition of Urban Security

Like energy security, urban security and its converse, urban insecurity, consist of a complex combination of many overlapping and interlinked factors. All of the factors that help to define human security in general —including access to adequate food, clean water, shelter, health care, transportation and other energy services, employment, meaningful and pleasant human interaction, educational opportunities, and reasonable safety from the risks of natural and man-made disasters, crime, oppression by others, and other stresses — are magnified in urban environments by the

simple concentration of people. As Sanghun Lee notes, two-thirds of the world's population live in cities, and cities produce three-quarters of the world's greenhouse gas emissions. 45 At the same time, half of the world's urban residents live in substandard housing (or worse). Poverty exacerbates urban insecurity.

Not all urban security problems relate directly to energy security/insecurity, but many do, either directly or indirectly. When urban security and energy security problems interact, many urban security issues tend to exhibit a concentrated microcosm of energy security issues that affect nations as a whole, while other issues are almost unique to urban areas. Special urban insecurity challenges include urban poverty, the fragility of aging infrastructure, water supply problems, and the interaction of a variety of issues with climate change vulnerabilities such as sea level rise or extreme weather events.

Overlaps Between Urban Security/Insecurity and Energy Security

Below we outline key areas where urban security considerations overlap with energy security considerations and vice versa. We note the key pressure points that can be affected by policies in areas of overlap. The list is by no means exhaustive. Our purpose here is to identify some of these key overlaps as a prelude to describing how the energy security analysis methods summarized earlier in this chapter might be applied to related urban security issues as well.

Energy security-related policy choices, whether made by public entities or effectively left to private markets/decision makers, have special impacts on cities because cities are the planet's major consumers of energy services; they consume these services in a concentrated manner that requires focused energy supplies. Viewed another way, choices made to increase or reduce urban security by adjusting the way that cities are organized and provide goods, services, and employment for their residents often have ramifications for the energy sector, and thus for energy security. There are a number of examples of choices for energy and urban policy-making in which urban security and energy security intersect and interact. To illustrate some of these connections, we focus on two policy areas with coupled energy and urban security aspects — electricity supply and demand and transportation system policies — then explore them with respect to five indicative areas of energy security/urban security interactions: implications for climate change and local/regional pollution, distribution and implications of risk of accidents or attacks at critical facilities, implications of energy choices for economic development, implications of new modes for urban organization, and implications of the growing role of civil society in cities.

Electricity Supply and Demand

Choices related to the provision of electricity services, whether at the national or urban level, can have a profound effect on urban security. These choices include the positioning of power generation and electricity transmission facilities, the sufficiency of electricity supplies, the fuels/energy sources used to power generation, the degree to which energy efficiency is emphasized, and the degree to which distributed generation is undertaken. These choices offer many energy and urban security tradeoffs.

Situating power plants inside cities, depending on the generation of fuel and the technology used, may subject lower-income and other populations to local air pollution and related health issues. At one time, the siting of power plants inside cities was fairly typical in many nations, with the practice most recently demonstrated in the Northeast Asian context by parts of China and the DPRK. Power plants were co-located with cities for labor reasons as well as for easy access to heat for buildings and industrial facilities. Siting power plants outside cities may (or may not, depending on power plant design, location, and the prevailing atmospheric conditions) reduce local air pollution

concerns; however, it requires an extensive transmission infrastructure to bring power into a city. This approach may have its own health and safety outcomes. The choice of power generation technologies and fuels can have a profound impact on emissions of local and regional air pollutants, as well as on greenhouse gases. Relative to coal-fired power, natural gas-fired power plants can emit half the greenhouse gas emissions per unit of electricity provided, reduce sulfur oxide and particulate emissions, and eliminate production (and required disposal) of coal ash, but they generally produce power at a higher cost. Nuclear power and renewable energy produce few or zero air pollutant emissions, but involve varying tradeoffs relative to fossil-fueled plants, as noted below.

Choices related to the spatial organization and type of power supply imply different risks for cities. These risks may arise from accidents — through human error or natural disasters — but also include the possibility of attacks on key facilities. Major fossil fuel storage facilities, such as coal terminals and liquefied natural gas storage tanks, are often located at ports surrounded by cities. These waterfront facilities are potentially vulnerable to tidal surges during severe storms, which may occur with greater frequency as global climate change continues. They are also potentially vulnerable to attack, either by other nations (a potential DPRK attack on ROK fossil fuel facilities has to be a consideration for urban planners) or by subnational groups such as terrorists. The placement of these facilities within major population centers amplifies the implications of a successful attack both for human life and the economy. Similarly, and underscored by the Fukushima reactor disaster, the placement of nuclear power and nuclear fuel cycle facilities within cities means that successful attacks on those facilities could expose large populations to radiation risks. The impact of locating nuclearfacilities within cities on facility security is less clear. Placing facilities in cities may mean that more “eyes” are on the facility at any given time, but, on the other hand, with many more people moving around the facility’s area due to its location, an attacker may have more of an opportunity to blend in with the crowd. In the case of nuclear facilities, there are at least two reasons why even locating them outside cities does not necessarily reduce risk to nearby populations. First, a radiation plume from a severe accident will go where the wind takes it, and though location of nuclear facilities in a generally downwind direction from population centers may help to reduce the risk of exposure to radioactive aerosols, it cannot eliminate it completely. Second, a nuclear facility located outside an urban area today may find itself part of a highly-populated suburb before its lifetime of 40 years or more is complete, as has happened many times in the United States. At that point, plans to evacuate local populations in the event of a nuclear emergency may become unusable due to the increase in traffic congestion.

Having sufficient and affordable supplies of power throughout the day and year is crucial to the economy of a city and to the well-being of its residents. Power outages can grind the local economy to a standstill and create opportunities for criminals to prey on homes and businesses while power is off-line. It can also affect the delivery of basic services such as food, water, sanitation, public lighting, and health care. Citizens and businesses in cities under-served by power supplies are forced, if they can afford it, to invest in on-site power supplies that are expensive, difficult to keep fueled, and which contribute to local pollution. Lagos, Nigeria was (as of 2011) an example of a city hamstrung by poor power supplies and other infrastructure issues despite its vibrant economy.[46] Apart from power interruptions, electricity that is unduly expensive can make an economy less competitive than it if its electricity supplies were cheaper. For example, high energy prices can affect whether certain industries decide to leave a city and can thus influence employment opportunities in urban areas.

A city’s aggressive emphasis on improving energy efficiency can help to improve the reliability of electricity systems by contributing to local employment and reducing system loads, pollutant emissions, the amount of new supply infrastructure required, and “urban heat island” impacts (though decreasing the amount of heat the city generates). Likewise, a commitment to developing

distributed generation, especially when powered by renewable energy, can improve the reliability of electricity supplies in a city and create local employment, among other benefits and depending on how it is implemented.

The degree to which urban areas around the world are developed in a planned and orderly fashion varies from intensive controls on urban growth to practically no controls on growth at all. Many cities have begun to embrace new modes of urban organization with careful land use planning for "livability." Clustered residential and commercial services with easy access to parks and other recreation reduce the need for transportation and lower traffic congestion. Clustered growth can also significantly impact the use of energy. For example, planned residential/commercial clusters can share distributed generation facilities, including renewable energy facilities, as well as heat and power systems to provide electricity, heating, and cooling to nearby buildings. In addition, planned developments may give designers more control over the energy performance of the buildings in the development, for example, by designing and arranging building units for optimal cooling by prevailing breezes in the summer, and for heat retention and passive solar heating in the winter.47 Enhancing the "livability" of cities can, therefore, enhance both urban security and energy security.

The rising influence of civil society on energy sector choices, including those involving electricity generation facilities, is particularly strong in urban areas. The concentration of people both potentially affected by and with a strong interest in affecting energy sector decisions can catalyze further civil actions on topics ranging from the review of power plant siting and power supply choices, to the siting of transmission and distribution facilities, to decisions on land use and urban development, which, as noted above, can have their own impacts on energy use. One could argue that the increasing power of civil society to influence decisions that have in the past been made by public and private-sector actors with much less public input, coupled with some of the concerns above (pollution and risk reduction, urban development/redevelopment concerns), may favor the development of electricity sources that are often more limited in scale and in impact, including distributed generation, energy efficiency, and renewable energy sources. These choices will, in turn, affect both urban and energy security.

Transportation Policy Choices

Transportation policy choices in urban areas affect urban security and energy security. Cities that provide wide access to convenient, low-cost public transportation will likely require less energy input (with its attendant energy security benefits, including reduced fuel imports). They will also produce lower air pollution (with its attendant health and safety impacts), particularly if they limit the use of private vehicles, than cities that rely on private autos for most transport. Depending on how public transportation is implemented, such cities can also be made safer and more pleasant for residents by providing opportunities for more non-motorized transport.

Many of the transportation policy choices that a city makes have significant impact on local pollution emissions. Policy options, including developing subway, light rail, and bus rapid transit systems, can bring people into the urban core efficiently without requiring private vehicles. Some cities have restricted the use of private vehicles in the urban core, and others have implemented vehicle fleets (such as taxis) using cleaner-burning fuels, such as liquefied petroleum gas (LPG) or compressed natural gas (typically for larger vehicles such as buses). All of these measures are designed to enhance livability and improve efficiency for urban residents and workers, but they also reduce air pollutant emissions and related health impacts, thus providing additional urban and energy security benefits. To the extent that transport policies are effective in moving people or goods more efficiently and with lower energy intensity, a decrease in greenhouse gas emissions is also likely. Some fuel-switching measures for road vehicles (gasoline or diesel to LPG, CNG, or fossil-fueled electricity) can also reduce greenhouse gas emissions, but typically not as much as by shifting

modes. Other transportation policies with potential impacts on both urban and energy security include the development of electric vehicle charging stations, possibly in combination with distributed generation (including renewable generation) and the introduction of “smart grid” concepts to use electric vehicle batteries as electricity storage devices for the distribution grid,[48] both of which can affect urban and energy security.

Some of the transportation policy choices that arguably enhance urban security from the points of view of livability and congestion/pollution reduction, however, may also reduce urban security by concentrating travelers in transport hubs (main subway or rail stations, for example) and thus increasing the potential damage and disruption from attacks or accidents at those hubs. Of course, other facilities associated with private-vehicle-oriented transport systems, including major intersections often beset by gridlock, fuel storage facilities, and key freeway interchanges or river bridges, may also be vulnerable to major disruptions due to terrorist attacks or accidents. Evaluating the net effect on urban and energy security of transportation policy tradeoffs requires an assessment of the vulnerability of multiple transport infrastructure development scenarios.

Transportation policy choices in cities, like urban electricity sector choices, will have implications for economic development. The map of new mass-transit facilities and, alternatively, the map of new road networks can and do guide the development of housing and commercial zones. Spatial choices strongly influence where workers can live while still being able to hold jobs in the urban core.

Beyond its economic impact, transportation planning is a key element of urban land use planning in general, and thus has a significant impact on the viability, for example, of the types of clustered residential and commercial developments described briefly above. Without access to mass transit facilities, clustered development would either have to depend on private vehicles to allow residents to get to their jobs, with attendant impacts on local parking and pollution, or be more or less self-contained in terms of employment for residents (with the exception of telecommuters).

Civil society in urban areas can and does impact on transportation policy. This influence can drive policies in different directions. Urban areas with clogged freeways may see a groundswell of public support either for transportation alternatives to freeways or for the construction of additional freeways, with very different impacts on urban and energy security. Civil society groups can help to identify development projects that appear to have given inadequate consideration to transportation needs, and thus force changes in plans to enhance urban security. The input of civil society groups favoring clustered development patterns can force city and private planners to take quality-of-life considerations seriously. The presence or absence of a vibrant civil societyresponse to (or drive for) urban renewal has in many cases shaped, or failed to shape, the redevelopment of urban districts in neighborhoods. As such, the response of civil society to transportation policy issues helps to influence urban security and, in many cases, has implications for energy security as well.

Evaluating Urban Security Issues Within an Energy Security Calculus

The sampling of relationships between energy security and urban security policy choices in the issues described above underscores the complexity of these choices and the need to evaluate them using a framework that considers energy and urban security issues together. One approach is to identify how candidate policies with energy security impacts touch upon urban security and how urban security policies affect energy security. The next step would be to identify measures of those interactions/impacts and evaluate different policy scenarios (energy policies, urban policies, or a combination of the two) qualitatively and quantitatively as appropriate to the different measures. Then, one would provide a side-by-side comparison of the impacts of different scenarios in a way similar to that outlined above for the six categories of energy security attributes. Below we offer a sampling of how this approach might work.

Extension of Energy Security Analysis to Intersecting Urban Security Issues

In Table 3.6, we provide a brief adaptation of Table 3.5 that, for each of the dimensions of energy security, suggests a set of measures and attributes, and offers interpretations of those measures and attributes that could be relevant to the evaluation of the combined energy/urban security impacts of different policy choices. The measures and attributes in Table 3.6 could be considered in addition to or instead of the attributes in Table 3.5, depending on the scope and goal of the security analysis. Note that this is just a sampling of the possible measures and attributes that could be considered and is by no means an exhaustive list.

Table 3.6: Urban Security Measures/Attributes with Energy Security Implications

Dimension of Energy Security	Measures/Attributes	Interpretation
Energy Supply	Urban energy self-sufficiency/use of local resources	Higher = generally preferred
	Diversification Index for electricity (by electricity plant, plant type, or incoming transmission line)	Lower index value (indicating greater diversity) preferred
	Intensity of urban energy use (as measured by energy use per person or per unit GDP)	Lower = preferred
	Urban area stocks of key imported fuels as a fraction of imports (key fuels)	Higher = greater resilience to supply interruption
Economic	Total urban energy system internal costs	Lower = preferred
	Total urban energy system capital costs for required upgrades	Lower = preferred

Table 3.6, cont.

Economic	Impact of energy sector investments/policy choices on local employment and income	Higher = preferred
	Contribution of energy policies to development of local expertise in new technologies	Qualitative—Higher preferred
Technological	Reliance on proven technologies	Qualitative—Higher preferred
	Technological adaptability (including in response to climate-change-driven events)	Qualitative—Higher preferred
Environmental	GHG emissions (tonnes CO2, CH4) caused by activities in the urban area (even if not emitted there)	Lower = preferred
	Urban area acid gas emissions (tonnes SOx, NOx)	Lower = preferred
	Impacts on or risks to local/urban water supplies	Lower = preferred
	Urban area local air pollutants (tonnes particulates, hydrocarbons, others)	Lower = preferred
	Local ecosystem, aesthetic, and “livability” impacts	Largely Qualitative—Lower preferred
	Exposure to environmental risk, including climate change-driven risk	Qualitative—Lower preferred

Social and Cultural	Exposure to risk of social or cultural conflict over development of energy or related systems in the urban area	Qualitative—Lower preferred
	Potential for civil society to help shape policies to yield improved urban security	Qualitative—Higher preferred
	Degree to which energy sector choices contribute to urban security (through improved employment, quality of life, poverty alleviation, access to key services, for example)	Qualitative—Higher preferred
Military/Security	Exposure to security risks related to attack on key energy or other urban infrastructure facilities	Qualitative—Lower preferred
	Relative level of urban spending on security arrangements	Lower = preferred

Source: Adapted from Table 5 by the authors for application to urban security issues.

Interaction of Energy Security and Urban Security Policies: Examples

As noted above, policies designed to improve urban security/reduce urban insecurity and policies designed to improve (typically national) energy security/reduce energy insecurity can interact in numerous ways. Below we provide two hypothetical examples of overlapping policies, and we explore their possible impacts with respect to some of the measures and attributes described in Table 3.6. We should emphasize that both of these scenarios are intended to be purely illustrative of the potential for complex policy interactions, and thus are not intended to represent policy recommendations. To facilitate the illustration, both scenarios are assumed to apply to a coastal urban area of 10 million people located somewhere in Northeast Asia. In both cases, the scenarios are evaluated relative to a "business as usual" baseline in which the urban area undertakes limited targeted development/redevelopment, continues to be dependent on a mix of private and public transport, continues to obtain virtually all of its energy, food, and other resources from outside the urban area, and relies principally on fossil fuels to provide energy services.

Urban Security Improvement Scenario

In the Urban Security Improvement (USI) scenario, policies focus on improving the quality of life in urban areas by promoting a combination of urban development and redevelopment that emphasizes clustered residential and commercial developments so that people may live in neighborhoods and districts with everyday services readily available nearby and significant open space provided in the form of parks, playgrounds, community gardens, and nature preserves. A comprehensive, effective, and affordable mass transit system is developed to move people between neighborhoods/districts to a compact urban core and to industrial and other areas where workplaces are located. Some or all of the neighborhood areas emphasize the availability of affordable housing for low-income residents. Throughout the urban area, there is a commitment to deploying local resources for food and energy and to using energy and other resources as efficiently as possible. The possible performance of the Urban Security Improvement scenario with respect to the energy/urban security dimensions and measures/attributes in Table 3.6 is discussed below.

- Energy Supply: Relative to the baseline scenario, the USI scenario offers higher urban energy self-sufficiency, likely higher diversity (a lower value of the diversity index) in terms of electricity supply sources, and a lower intensity of energy per person and (probably) per unit of GDP. The impact of the scenario on stocks of imported fuels is unclear, though the types of development patterns suggested by the USI scenario may suggest less emphasis on fuel storage.

- Economic: The USI scenario's total energy costs relative to a baseline scenario will depend largely on the capital costs of the distributed technologies, renewable and otherwise, and the prices of any fossil fuel use avoided. The total energy cost of the USI scenario could therefore be either higher or lower than the baseline scenario. It is likely that the capital cost of the USI scenario, which depends on more advanced and smaller-capacity technologies, would be higher overall than in a baseline case. Given the local energy/resources development emphasis of the USI scenario, as well as its emphasis on efficiency, recycling, and other labor-intensive activities (in addition to imported fuel use reduction), it seems likely that local employment and income generation will be stimulated more by the activities implied by the USI scenario.
- Technological: The USI case offers greater learning potential for the development and application of new technologies, but as a consequence relies less on proven technologies. The loss of the latter may be compensated for by increased adaptability through the use of distributed energy systems of different types, which are less likely to be simultaneously at risk from technological failure or from failure caused by catastrophic storms or floods, for example. They may also prove more flexible in adapting to a changing climate.
- Environmental: The USI case is likely to reduce net GHG emissions relative to the baseline case through a combination of greater efficiency in energy use, more aggressive use of renewable and low-carbon fuels, and some sequestration of carbon in biomass in urban open spaces. The USI case is likely to reduce emissions of some pollutants relative to the baseline case, such as sulfur oxides, but to the extent that distributed generation using gas or other fuels is a major feature of the case, it may increase local emissions of some pollutants. Impacts on water use and quality are likely to be positive in the USI case due to the availability of open space for groundwater recharge and water efficiency/recycling efforts. We expect local ecosystem, aesthetic, and "liveability" impacts to be positive and exposure to environmental risk lower overall than in the baseline case.
- Social and Cultural: With its emphasis on small projects and the preservation and creation of neighborhoods, as well as on collaboration between stakeholders in project design, the USI scenario probably offers less risk of social conflict and a greater role for civil society than the baseline scenario. By emphasizing the development of residential/commercial clusters, the USI scenario likely improves the local economy, resulting in reduced poverty, lower crime rates, and thus increased urban security.
- Military/Security: The USI scenario focuses in part on distributed generation and the use of local energy resources, which would tend to reduce the consequences of an attack on any one facility, and may or may not reduce the overall costs of securing critical facilities. With its emphasis on mass transport, however, the USI scenario probably offers targets for attack (busy train and subway stations, for example, or other transit hubs) that represent greater risk of damage and disruption than the more distributed transportation sector targets in a baseline scenario.

Energy Supply Security Improvement Scenario

A second illustrative alternative to the baseline scenario is one with many components that are similar to the overall energy policies pursued by a number of Northeast Asian nations, including Japan and the ROK, until at least the last decade or so. Here, the nation looks to develop nuclear power as an alternative to fossil-fueled electricity generation, and consequently builds up large stockpiles of fossil fuels, most notably crude oil and oil products, to reduce the potential disruption caused by constraints in imported fuel supplies or by rapid increases in world fuel prices. These nuclear and fuel storage facilities are assumed to be on the periphery of the urban area. Some of the possible implications of the Energy Supply Security Improvement (ESSI) scenario with regard to the measures/attributes in Table 3.6 are as follows:

- Energy Supply: Relative to the baseline scenario, the ESSI scenario offers higher urban energy self-sufficiency through expanded use of nuclear power. It may or may not yield higher diversity in terms of electricity supply sources. The ESSI scenario would be expected to have little or no impact on intensity of energy use. By definition, the scenario would increase stocks of imported fuels.
- Economic: The ESSI scenario's total energy costs relative to a baseline scenario will likely be higher due to the cost of nuclear power and its related infrastructure. The scenario's capital costs would also be higher. Although the ESSI may provide some short-term economic benefits relative to the baseline scenario, during the construction of nuclear and fuel storage facilities it seems likely that the lasting positive impact on local employment and income generation would be modest at best, since the negative economic impacts of likely higher prices for electricity offset the impacts of any additional long-term jobs arising from the nuclear and fuel storage facilities.
- Technological: The ESSI case implies little learning potential for the development and application of new technologies, assuming that the nuclear power plant is of a standard type previously built in the country where it will operate and that it relies on proven technologies. The large new facilities that are part of the ESSI case are more likely to be at risk from technological failure or from failure caused by catastrophic storms or floods (or earthquakes); they are also likely to prove more flexible in adapting to a changing climate.
- Environmental: The ESSI case is likely to reduce net GHG emissions relative to the baseline case through the use of nuclear power (displacing some fossil-fueled generation included in the baseline case). Depending on the type and location of the generation displaced, moreover, it is likely to reduce nearby emissions of local and regional air pollution. Impacts on water use and quality may be slightly negative in the ESSI case due to routine leakage from expanded oil storage and handling facilities, with the potential for catastrophic oil releases and subsequent impacts in the event of a major accident or natural disaster. Local ecosystem, aesthetic, and "liveability" impacts of the ESSI case would be expected to be related to whether the new nuclear and oil storage facilities are located on previously "virgin" lands (in which case the impacts are likely to be negative) or in existing industrial areas (in which case impacts are likely to be minor).
- Social and Cultural: Recent history suggests that many proposals for large, new energy facilities are at risk of social and cultural conflict, particularly proposals for nuclear facilities (in the post-Fukushima era). Civil society groups could be expected to oppose, or at least to demand thorough and critical examination of, proposals for the types of energy facilities included in the ESSI scenario. The scenario is likely to have minimal impacts on the local economy, poverty, crime rates, and other social and cultural urban security issues.
- Military/Security: The ESSI scenario, with its focus on large projects, would tend to increase the consequences of an attack on any one facility and would probably increase the overall costs of securing critical facilities.

The examples above offer brief illustrations of how to evaluate the complex interactions, across many different attributes, of the relative energy and urban security benefits of a given policy direction. Different criteria for comparison can be employed, and an infinite number of different scenarios can be considered. As in the energy security framework described earlier in this chapter, many of the results of the analysis will be difficult to compare quantitatively across attributes, so it will be up to the analyst, and the stakeholders supported by the analyst, to develop their own subjective weighting of the different attributes to reach a decision as to which scenario is most attractive. In general, the goal is to search for policies that are "robust" — that is, contribute positively — across a range of energy and urban security evaluation criteria.

Energy Security and Green Economics

Energy security, particularly as we have broadly defined it earlier in this chapter, has considerable overlap with "green economics." Green economy advocates and policy thinkers see the development of a green economy as a way of achieving multiple objectives related to improving energy (and, often, urban) security. In this section of the chapter, we review the concept of the "green economy." We then provide three case studies relating how policymakers and others in China, Japan, and the ROK have interpreted green economy concepts and how they have begun to implement policy.

"Green Economies" and Related Concepts: Origin and Drivers of Green Economy Movements

Recent years have seen many nations, as well as sub-national jurisdictions such as provinces, states, and cities, identifying the development of or shifting to a "green economy" as a key policy goal. The United Nations Environment Programme (UNEP) defines a "green economy" as follows: "A Green Economy is one that results in improved human well-being and social equity, while significantly reducing environmental and ecological scarcities. In its simplest expression, a green economy can be thought of as one which is low carbon, resource efficient, and socially inclusive."[49] This general and overarching definition leaves plenty of room for interpretation. Indeed, many authors and nations have interpreted the concept differently.

The concept of a green economy generally denotes a way of producing goods and services so as to make a reduced or, ideally, minimal impact on the environment while still building a robust and sustainable economy. Much-improved energy and resource use in the production and consumption of goods and services is a major part of the green economy. Examples of technologies and processes typically considered part of a green economy include the development and widespread deployment of "zero-net-energy" buildings,[50] an emphasis on the development of renewable energy sources, the shifting of production of locally-consumed items (including food) toward local suppliers to reduce transport costs (and support the local economy), waste management with reduced environmental impacts and the reduction of waste generation overall, and improvements in recycling of materials and in planning for reduced life-cycle impacts of the goods and services that people use.

Beyond these examples, the green economy also entails much-improved stewardship over the world's agricultural lands, fisheries, oceans, fresh water, forest resources, and atmosphere, with goals of long-term preservation and, where needed, remediation and revitalization, as well as sustainable resource use. Green economy concepts are applicable throughout the economy, including in the building, manufacturing, and transport sector (as noted above). They also apply to tourism and city planning, as illustrated by the "Urban Security Improvement" example evaluated earlier in this chapter.

The implementation of green economy concepts requires the consideration, management, and coordination of a wide variety of complex interdependencies in numerous dimensions and at many different scales. Examples of these interdependencies are endless, but include:

- Nations attempting "green" management of their natural resources are dependent on both nearby countries and far-flung nations to do their part (and to do so consistently over years, decades, and centuries) in managing shared and contiguous resources.
- Industries seeking to produce "green" products and services are dependent on the development of markets for those products and, if needed, the development and enforcement of regulations to guide the markets as well as the development of suppliers and service providers that will allow and promote "green" operations.

- Households, groups, firms, and governments seeking to implement green economy principles are dependent on accurate and persuasive information about green economy development, much of which has been and will be developed by civil society organizations.
- Substantial progress on green economy development will depend on the availability of investment capital, which will in turn entail a shift in how investors evaluate investment opportunities to more fully reflect criteria such as environmental sustainability.

These interdependencies have a negative side. It makes it hard in many cases for individual households, businesses, or governments to affect substantial change by acting on their own. On the positive side, however, the coordination and information-sharing between groups transitioning to green economies means the spread of green economy concepts, once begun, could be quite rapid.

The introduction to a recent UNEP report on the green economy suggested the green economy concept "moved into the mainstream of policy discourse" in 2008. The UNEP report goes on to state, "This recent interest in a green economy has been intensified by widespread disillusionment with our prevailing economic paradigm, emanating from the many concurrent and recent crises – particularly the recession of 2008-2009. At the same time, increasing evidence is pointing to an alternative paradigm, in which increased wealth does not lead to growing environmental risks, ecological scarcities and social disparities."[51]

Despite the recent rush by many in government and industry to embrace (at least in theory) green economy concepts, the theoretical foundations of the green economy were laid long ago by luminaries including Margaret Mead, Buckminster Fuller, Dennis and Donella Meadows, Amory Lovins, and many others, as well as global movements toward sustainability and environmental preservation, of which the 1992 UN Conference on Environment and Development was a major milestone.[52] The implementation of green energy concepts on various scales has been going on for decades, manifest in organic and local farming movements, environmental education efforts, local materials recycling programs, and numerous others, many of which are the products of civil society actions and efforts by determined and committed individuals. The question remains whether these many, mostly small-scale efforts can be successfully knitted together by governments and other actors into a cohesive, global green economy movement that makes real and continuous progress toward sustainable development goals, or whether the green economy concept will be eased out of the policy mainstream by the next global crisis or, alternatively, by the next global economic upturn. The role of civil society, and of local governments, in keeping the pressure on national and global organizations to continue pursuing green economy goals will likely be pivotal.

The case studies of green economy policies in China, Japan, and the ROK provided below are based on presentations prepared for the conference, Interconnected Global Problems in Northeast Asia: Energy Security, Green Economy, and Urban Security, which was held in Seoul, ROK, in October, 2010. Each demonstrates different interpretations of the green economy concept in the three nations, and each suggests different ramifications for the implications of green growth policies for their energy security.

Case Study of Green Economy Policies: China

With by far the largest population, the fastest economic growth, and, in recent years, the largest economy in Northeast Asia, China faces special challenges in transitioning to a green economy. Below we present a brief overview of the background to China's energy and economic situation, a summary of recent legislation related to green economic development and of progress toward a green economy in recent years, and a discussion of China's policies and challenges for moving

forward with the development of a green economy in the near-term and more distant future.53

Background: Recent Trends in China's Energy and Economic Situation

Since 2000, China's economic and energy sector has been characterized by another round of rapid growth, building on the gains of the 1990s and before. The high economic growth rate — about 10 percent annually, on average — has many positive effects, but it has also created new problems. Although the economic rise of China has markedly raised the standard of living for a huge proportion of China's residents and made China the world's second-largest economy, it has also led to significant environmental problems and obliged China to become a large net importer of energy, among other impacts. At present, China finds itself in what might be termed the "middle stage." Although the services and light industrial sectors of the Chinese economy are growing, the heavy and chemical industries remain responsible for about 70 percent of China's industrial output, and these industries are extremely resource, energy, and pollutant discharge-intensive. Rapid urbanization has been a key element of China's growth, with the fraction of China's population accounted for by urban dwellers rising by over 1 percent annually in recent years. With urbanization and overall economic growth has come a transition in household consumption patterns. As average per capita GDP has risen to over US $1000, many more Chinese households can afford major appliances, cars, and larger homes. These new acquisitions have helped to drive rapidly expanding energy use. Since about late 2002, the overall stress on resources and energy use, and the attendant, serious environmental pollution caused by resource and energy use, has been increasingly recognized as a major problem that needs to be addressed.

Figure 3.8 shows the trends in overall energy consumption in China. Between 2000 and 2008, overall energy use more than doubled, increasing at an average rate of 8.9 percent annually, though the growth rate of energy consumption has decreased substantially from the early years of the decade. Figure 3.9 shows the trend in coal production in China. Between 2001 and 2008, coal production increased by an average of about 200 million tonnes each year.

Figure 3.8: Overall Energy Consumption and Growth Rates in China, 2001-2008 (units: 10,000 tonnes coal equivalent)

Source: Wang, Y., "China's Approach to Green Development and Transformation of Economic Development Plan," Presentation for the workshop Interconnected Global Problems in Northeast Asia, Seoul, Korea, October 20, 2010.

Figure 3.9: Coal Production in China, 2001-2008
(units: million tonnes coal)

Source: Wang, Y., "China's Approach to Green Development and Transformation of Economic Development Plan," Presentation for the workshop Interconnected Global Problems in Northeast Asia, Seoul, Korea, October 20, 2010.

As a result of urbanization and an increased overall standard of living, among other factors, China's electricity needs have increased even faster than average energy use. As Figure 3.10 shows, China's installed generation capacity increased by a factor of more than 2.5 between 2000 and 2008, with more than 100 GW of capacity (the equivalent of about 1.5 ROK electrical systems) added in China in recent years.

Figure 3.10: Electricity Generation Capacity in China, 1978-2008
(units: gigawatts)



Source: Wang, Y., "China's Approach to Green Development and Transformation of Economic Development Plan," Presentation for the workshop Interconnected Global Problems in Northeast Asia, Seoul, Korea, October 20, 2010.

Figure 3.11: Fraction of Chinese Energy Supply by Fuel Type, 1978-2007



Source: Wang, Y., "China's Approach to Green Development and Transformation of Economic Development Plan," Presentation for the workshop Interconnected Global Problems in Northeast Asia, Seoul, Korea, October 20, 2010.

The huge growth in overall energy use, coal use, and electricity generation, however, has had barely any impact on the structure of fuel supply in China. Coal remains the dominant energy resource, as shown in Figure 3.11.

China's Sustainability Challenges and Related Recent Legislation

China faces a number of key sustainability challenges on which action in the next five to ten years will be crucial. China became a net oil importer in 199354 and has since become a major importer of both crude oil and natural gas, mostly as LNG. The lack of sufficient domestic resources to fuel its economy has made energy supply security a major concern. At the same time serious environmental pollution, much but not all of which has been related to energy consumption and production, has emerged as a key issue for China's future. Though China's economic growth has rebounded faster than in most of the rest of the world, the impacts and lessons of the global financial crisis on China continue to be felt and learned. Improving energy security, making a transition to a sustainable economy, and addressing global climate change are emerging as significant issues. But the continued importance of other development issues, including poverty alleviation, providing sufficient employment, developing a system of social insurance, and alleviating economic and social disparities in the different regions of China, poses a number of dilemmas and conflicts in developing policies to achieve multiple goals. Resolving these dilemmas and conflicts in the coming years will determine whether China continues on a path that looks unsustainable in many ways, or transitions to a new model of sustainable development.

China has begun to develop laws and regulations intended to guide the country toward a more sustainable "green" economy. Some of the ideas that have come into the Chinese consciousness in the past decade, and have been instrumental in initiating government action, are as follows. All of these ideas bolster the theme of making a transition toward market-based, regulation-oriented, and sustainable development.

- 2002: A new industrialization pathway
- 2003: Scientific outlook on development: balanced development; people-centered, comprehensive, coordinated, and sustainable development
- 2004: Resource-Efficient and Environment-Friendly Society (REEFS) and Circular Economy (CE)
- 2005: Harmonious society including relationship between man and nature, with China becoming an innovation-oriented country

- 2009: Green economy and low carbon development
- 2010: Transformation of economic development pattern

Based on the ideas above, a number of laws have been developed over the past decade that define China's current legislative framework for sustainability. They include:

- Environmental Impact Assessment Law (2002)
- Cleaner Production Promoting Law (2003)
- Renewable Energy Law (2006)
- State Council Circular on REEFS (2006)
- Industrial regulations, codes, standards
- Energy Conservation Law (amended, 2007)
- Plan of Renewable Energy Development in Mid- and Long-Term (2007, under revision)
- Circular Economy Promotion Law (2008)
- Regulations on E-Waste Management (2009)
- Renewable Energy Law (amended, 2009)
- Energy Law (under review by the National People's Congress as of 2010)

In the last five years, China has undertaken a number of actions to provide guidance in combating climate change. China set mandatory targets of energy efficiency during the period 2006-2010, targeting an increase in efficiency of about 20 percent nationwide, designed to yield about 1.5 billion tonnes of carbon dioxide equivalent emissions reduction (CO2e). A National Climate Change Assessment Report was released in December 2006, and an update was produced in 2010. The National Climate Change Program was released in June 2007, along with a volume on China's Science and Technology Actions on Climate Change. In October 2008, a white paper entitledChina's Policies and Actions on Climate Change was released. The National Leading Group on Climate Change, chaired by Premier Wen Jiabo, was established along with the Department of Climate Change under the NDRC (National Development and Reform Commission) in 2008. A new NPC (National People's Congress) Resolution on Climate Change was signed on August 27, 2009, and the National Energy Commission was established in 2010 as a super-coordinating body on energy-related policies in China.

Achievements and Problems During the 11th Five-Year Plan

The ideas, laws/regulations, and actions described above have laid the framework for the green economy achievements under China's 11th Five-Year Plan, spanning the period from 2006 through 2010. Below we describe a summary of the Plan's major goals, achievements, and problems encountered.

The 11th Five-Year Plan aimed to use comprehensive measures, together with a continued growth model modified by transfer and structural adjustment, and an orientation toward innovation, to accomplish several main goals in improving energy efficiency and reducing pollutant emissions. The mandatory targets the plan set for 2006-2010 included reducing energy consumption per unit of GDP by 20 percent, reducing the discharge of key pollutants such as sulfur dioxide (SO2) and Chemical Oxygen Demand (COD) — a measure of the pollutant load of organic material discharged

to water — by 10 percent, reducing water use per unit of industrial value-added by 30 percent, and reforestation to increase the forest coverage rate by 1.8 percent annually.

The mandatory 20 percent reduction in energy intensity below 2005 levels by 2010 received clear policy support from government. Energy intensity reduction targets averaging about 20 percent, but varying in different regions of China (see Figure 3.12), were assigned to provinces, as well as to the "Top-1000 Enterprises" (the 1000 largest, mostly industrial enterprises nationally) and to the economic sectors, with reductions to be obtained under central government supervision. Energy efficiency improvements (as opposed to shifts in industrial structure) were intended to make the largest contributions to support the target, with industrial restructuring, such as closing small and inefficient plants where possible, also playing a role.

The longer-term target for the policy was to make a cumulative reduction below BAU emissions totaling 5.6 Gt (Billion tonnes) CO2e from 2007 to 2020. It is estimated that from 2005 through 2009 a 15.61 percent cut in energy intensity was achieved, along with 13.14 percent and 9.66 percent reductions in SO2 and COD emissions, respectively. Other supporting policies promulgated during the 11th Five-Year plan included a renewable energy policy that featured, as of 2009, connection and "must-buy" provisions related to utility additions of renewable capacity to their grids, including a provision for planned Mandatory Renewable Portfolio standards for utilities and the extension of grids to accommodate renewable supply sources (especially wind power). Special feed-in tariffs for renewables and a Special Fund to support research and development, demonstration projects, and renewable energy industry development and commercialization were also implemented. Other policies for the 11th Five-Year plan included fuel efficiency standards for cars and vehicles, excise tax restructuring to promote the purchase of vehicles with smaller engines, and ambitious water conservation/water quality and waste management targets.

Figure 3.12: Distribution of Energy Intensity Reduction Targets in China by Province



Source: Wang, Y., "China's Approach to Green Development and Transformation of Economic Development Plan," Presentation for the workshop Interconnected Global Problems in Northeast Asia, Seoul, Korea, October 20, 2010.

China used various approaches to improve energy efficiency during the 11th Five-Year Plan. These approaches included controlling the growth rates of the economy and of energy use; adjusting existing stocks of fuels and energy-using equipment; optimizing the industrial structure for improved energy intensity, implementing an objective-based responsibility system among enterprise managers to implement energy efficiency (EE) improvements; implementing a "Ten Key EE Programs" initiative and a Top 1000 Enterprises energy conservation action plan (with its own target of reducing energy use by 100 Mtce in five years); improving the collection and management of energy statistics and meteorological data; improving EE in governmental agencies ("lead by example"); and providing public information, education, and training on energy efficiency throughout China.

In response to the global economic downturn, the Chinese government used a combination of economic stimulus measures designed, in part, to promote a "green recovery" in China. These measures included direct investment in environmental areas totaling 5 percent of a total 4 trillion Yuan 2008-2010 stimulus package, with another 10 percent of the funds in the stimulus package devoted to energy efficiency investments. An additional 10 percent was devoted to "green direct investment," while an additional 38 percent of the package was indirectly designed to benefit the green economy. Other stimulus measures with "green" impacts included investments in the development of new strategic industries, including EE and environmental industries; investment of

over 7 billion Yuan in research and development targeted at energy efficiency improvement, pollution reduction, and addressing climate change; and large scale construction of new technologies and infrastructure, such as renewable energy and high speed rail transport. Despite the focus on green economy investments, the impact of the economic stimulus program on China has not been entirely straightforward. For example, the stimulus program had the side-effect of helping to somewhat restore activity in traditional, energy-intensive industries. In addition, a "rebound effect" was noted, whereby the reduction in energy use through energy efficiency resulted, in the short term, in helping to expand domestic energy demand, as consumers applying EE measures found themselves spending less on energy and availing themselves of some of those savings to increase their use of energy services (for example, by purchasing and employing more energy-using devices).

The transportation sector has been another focus for green economy policies in China during the 11th Five-Year Plan. The overarching policies in the sector have stressed fuel economy improvement, electric vehicle development, and the promotion of public transport. A clean vehicle demonstration project includes conventional vehicle improvement as well as the development of battery electric, hybrid, and fuel cell vehicles, in part through expansion of China's "10 cities and 1000 vehicles" program to twenty cities. Through the "10 cities and 1000 vehicles," launched in December 2007, the Ministry of Transportation has placed 1,000 or more "new energy" vehicles and their fueling/charging infrastructure in each of ten cities to catalyze the deployment of new energy vehicles.55 These efforts have been supplemented by policies to boost the promotion of plug-in vehicles in China, starting in June 2010 with a pilot program in five cities offering subsidies of 50,000 Yuan for plug-in hybrid cars and 60,000 Yuan for all-electric (battery-powered) cars. Other transportation sector measures in the last five years have included bus rapid transit demonstration and full-scale construction projects in over twenty cities, aggressive expansion of high speed rail with 6552 km in service as of late 2010 and over 18,000 km planned for service by 2020, as well as local activities to promote the use of green vehicles.

Over the past decade and more, the pace at which the skylines of China's cities have been changing is truly breathtaking. All of this building sector activity is both a challenge and an opportunity, since the most cost-effective way to improve the energy efficiency of buildings, which may be in service for thirty years or more, is to make sure that high energy efficiency is a key consideration when buildings are initially constructed. Figure 3.13 shows the scope of this challenge. The floor area of buildings in China is projected to more than double in the two decades between 2010 and 2030, with most of that growth in the residential sector. Growth in residential housing floor area occurs despite population growth rates that are falling toward zero and an aging population, with key factors being rapid urbanization and rising incomes, meaning that households can afford larger homes. To improve the energy efficiency of new buildings, the Chinese government has implemented programs including National Design Standards for Green Buildings, a Green Building Development Strategy, Green Building Technology Guidelines, Best Design for Demonstration Buildings, as well as programs to develop advanced building materials and windows to integrate renewable energy products and improve the efficiency of central heating and cooling systems.

Figure 3.13: Estimated floor area of buildings from 2010 to 2030

Source: Wang, Y., "China's Approach to Green Development and Transformation of Economic Development Plan," Presentation for the workshop Interconnected Global Problems in Northeast Asia, Seoul, Korea, October 20, 2010.

China is the worldwide leader in renewable investment, the world's largest exporter of solar cells

and the world's largest solar water heating market. China's renewable electricity targets by 2020, as expressed in 2009,include:

- 80 GW small hydro (increased from 55GW in 2009)
- 200 GW wind (up from 25.8 GW in 2009, with considerable capacity in Inner Mongolia — as shown in Figure 3.14)
- 30 GW biomass
- 20 GW solar PV
- 300 million m2 of solar water heaters
- 24 billion m3 of annual biogas production capacity

Renewable electricity deployment is supported by the development of energy storage technologies and increased efforts to strengthen the power grid and implement "Smart Grid" technologies, including an emphasis on developing and deploying distributed energy systems. As of the late 2000s, the on-grid prices of coal-fired power fitted with sulfur dioxide removal systems (0.47 Yuan/kWh) were within the range of costs for different types of renewable power systems. Wind and biomass power, in some applications, were nearly competitive with coal-fired power in China as of 2010, with wind at 0.5 to 0.65 Yuan/kWh and biomass at 0.4 to 1.0 Yuan/kWh. The rapid increase in wind power generation capacity has been a major achievement of the 11th Five-Year Plan. China's wind power increased at an annual growth rate of over 100 percent during 2004-2009. Supported by the Renewable Energy Law and related policies and regulations, China's installed wind power capacity ranked number two globally by 2009 and, at 25.8 GW, was over five times the initial capacity projected for 2009 when the 11th Five-Year Plan was completed in 2010. As of late 2010, wind power capacity is projected to be 200 GW in China by 2020, whereas the target set in 2007 called for only 30 GW. There are 80 companies in China producing wind power systems, and 70 percent of the parts for the key 1.5 MW wind power unit are made in China.

During the 11th Five-Year Plan, China has also become the world's leading country for solar photovoltaic (PV) cell and panel production. In 2009, China produced solar cells with a total capacity of 4 GW, of which most were exported; the total installed capacity in China in 2009 was 300 MW. Major photovoltaic and polysilicon industry clusters are located in the eastern and central provinces of China as shown in Figure 3.14. Ongoing policies, including subsidies for Solar Building Integrated Photovoltaic systems (BIPV) and a national Solar Roofs plan, are designed to build Chinese demand for PVs; meanwhile, growth in PV exports are continuing. China is also the world's leading producer of solar water heaters, accounting for 65 percent of the world's total. In 2009, China's annual production capacity for solar water heaters stood at 30 million m2 of water heating panel area, with a cumulative output through 2009 of 145 million m2.

Figure 3.14: Location of Photovoltaic Industry Centers in China



Source: Wang, Y., "China's Approach to Green Development and Transformation of Economic Development Plan," Presentation for the workshop Interconnected Global Problems in Northeast Asia, Seoul, Korea, October 20, 2010.

Biomass has historically been a staple fuel in China, particularly in rural areas, although its use has lessened substantially in recent years as commercial fuels have been introduced (primarily coal and oil products). Recent efforts have focused on diversifying sources of biomass as well as on

developing new technology paths and products. Over the last thirty years, China has been researching and deploying digester systems to convert manures and other organic wastes to a methane rich "biogas" for household and other uses. As of 2009, biogas production in China stood at 14 billion m3 annually, supplying fuel for 80 million people in mostly rural areas. Some deployment of biomass-fired power systems has also taken place with installed capacity of 3.24 MW achieved by 2009. Biomass-derived fuels for vehicles are in the initial stages of production in China, with annual fuel ethanol production of 1.65 million tonnes and bio-diesel production of over 0.5 million tonnes in 2009, but biofuels production in China, as elsewhere, raises concerns of food security to the extent that crops destined for biofuels compete for farmland and other agricultural inputs with food crops.

The accomplishments and goals of China's 11th Five-Year Plan also included progress on "clean coal" technologies and nuclear power. The combustion of coal in Integrated Gasification Combined Cycle (IGCC) units offers opportunities for "polygeneration," that is, the co-production of electricity, coke, chemical products, and heat from coal, in different combinations as needed, combined with carbon capture and sequestration (CCS) to reduce the greenhouse gas emissions from coal production. The generation of valuable co-products helps to make the systems more economic. The IGCC system also allows the removal of pollutants, such as sulfur oxides and particulate matter, and promises higher thermal efficiency for power production. The goal of IGCC and polygeneration development is to make the technology cheap and available for use throughout China. A related technology under development in China is the production of liquid fuels from coal via "Coal to Liquids" (CTL) systems. These systems produce liquid fuels from coal via indirect liquefaction and can be coupled with CCS systems. Like IGCC systems, they allow the removal of key air pollutants.

Nuclear power use in China has been growing faster than in any other nation. In 2009, nuclear capacity totaled 9 GW and spread over eleven operating reactor units, and while this total represented about 1 percent of the total installed generation capacity in China at the time, with an additional thirty reactors permitted (about 33 GW) and twenty units under construction, the share of nuclear power will rise. The goals of the 11th Five-Year Plan included nuclear generation capacity of 40 GW in 2015 and over 70 GW in 2020; the latter goal translates to more than 150 million tonnes of reduced CO2 annual emissions relative to coal-fired generation. Nuclear technology priorities for China include the development of a "third generation" pressurized water reactor, such as the "AP1000" and "CAP1400," and the development of safe and effective systems for nuclear spent fuel disposal. Longer term projects include research on high-temperature gas-cooled reactors, low-temperature heat-supply reactors, fast breeder reactors, and the use of accelerator-driven systems (ADS). These transform some of the radioactive materials in nuclear wastes to elements and isotopes that are easier to dispose of. Other projects include the development of thorium-fueled reactors, as well as participation in fusion power research projects such as the ITER (originally, International Thermonuclear Experimental Reactor) effort, which is building a fusion reactor prototype in the south of France.[56]

The green economy elements detailed above — energy efficiency, vehicle efficiency, clean vehicle development, mass transit, renewable energy, clean coal technologies, and nuclear power—are among the key components of China's "Energy Technology Roadmap to 2050," published in 2009 toward the end of the 11th Five-Year Plan.[57]

China's Approach to Sustainable Energy Development in the 12th Five-Year Plan and Beyond

China's general approach to continuing the process of sustainable energy development through the next (12th) Five-Year Plan and beyond 2020 is to transform economic development patterns by building a resource-efficient and environment-friendly society. As part of this process, China aims to maintain the development of new strategic industries such as EE, clean energy, new energy vehicles, environmental services, and others. It aims to set in place a special plan of energy savings and

environmental protection at the State Council level including a roadmap, priorities, an action plan, and demonstration projects designed to facilitate movement toward a green economy.

The process of governmental restructuring in 2013, taking a “mega department” approach, is expected to facilitate the operation of the green economy through integration and implementation of coordinating mechanisms related to the energy sector. Green economy transformations will also be supported by policy reviews and mandatory target-setting encompassing targets for energy and carbon intensity, control over energy consumption, economic incentives including energy product price reforms and green taxation, and capacity building, including in the collection of energy statistics and the monitoring/enforcement of compliance with energy-related regulations. “Green innovation” will be supported to lower the cost of green economy products and services, with measures involving subsidies for low-carbon technology development in areas such as small renewable energy systems, biochar production,58 and other technologies.

The 12th Five-Year Plan continues the approach of the 11th Plan by instituting a mandatory energy intensity reduction of about 18 percent for China as a whole (varying from 16 to 20 percent in different provinces). New targets for carbon intensity reductions (carbon emissions per unit of GDP) were announced on November 26, 2009, targeting a 40 to 45 percent cut by 2020 compared with 2005 levels.

The emphasis on the development of new and clean energy sources will continue, with a goal of increasing non-fossil energy from its 7.5 percent share of overall energy use (excluding traditional biomass use) in 2005 to 15 percent in 2020, with nuclear power constituting at least 5 percent of total power generation in 2020. China will continue to pursue clean coal technologies with advanced technologies such as super-critical and ultra-super-critical coal-fired generation, IGCC, polygeneration, and CCS supported as demonstration projects.

Clean vehicle research and development will also continue with alternative fuel vehicles, hybrid cars, electric cars, and fuel cell vehicles. The 12th Five-Year Plan will also include further efforts to enhance the carbon sinks in China’s ecosystems, including a target of increasing forest cover from the 18 percent it was in 1999-2003 to around 23 percent in 2020, representing about 40 million ha of reforested land.

The 12th Five-Year Plan also includes capacity building for and carrying out of climate change adaptation planning, as well as more mandatory targets for reduction of atmosphere pollutants such as nitrogen oxides (NOx) and water pollutants such as nitrogen, phosphorous, and others.

Reaching the green economy targets of the 12th Five-Year Plan will call for a number of different approaches. Energy efficiency is the preferred starting point, yielding the least-expensive reductions in energy use and emissions. But given China’s dependence on coal, the development of clean coal use is crucial (including, as appropriate, with CCS). If overall energy consumption amounts to 4.6 billion tce in 2020 as projected and the non-fossil energy contribution to primary energy reaches the target of constituting 15 percent of non-fossil energy, hydro power will need to rise to an estimated 8 to 9 percent of total primary energy supply by 2020, wind power capacity will need to be 200 GW, solar capacity 20 GW, and biomass-fired 30 GW to total 4 percent of total primary energy use. Nuclear power will need to be 70 GW, producing 1 percent of primary energy needs. Other sources of energy will together need to provide 2 percent of primary energy needs, including solar water and space heating (800 million square meters by 2020), bio-diesel (2 million tonnes/year), and bio-ethanol (10 million tonnes/year).

In reaching these targets, technology development will certainly play an important role, but an even more serious effort is required to overcome non-technical barriers to moving to a green economy in

China. Comprehensive solutions are needed to reform and develop the legal, administrative, and economic instruments that will provide the proper climate for the green economy. Policies for green and low carbon technology innovation and development need to be matched with policies for cooperation on these issues. Technology demands assessment at the level of reporting, monitoring, and verification by the technology, classification, and demand sector to properly focus green economy efforts.

Collaboration among newly industrialized and developing countries will play a role in developing and disseminating green economy concepts and products, as will joint research, development, and distribution at the bilateral and multilateral levels. Sharing of best practice in technologies, policies, and other green economy needs will also help catalyze China's (and the world's) progress toward a green economy, and the establishment and operation of a multi-lateral Green Transition Fund, together with its implementing mechanisms, would help to fund and guide green economy efforts.

For China to succeed in its green economy transition, a systematic and integrated approach will be required that includes elements of technology development and deployment, policy improvements, preparation of a clear plan/roadmap for the transition, and the practicing of green economy concepts including demonstrations, industry development, and market development.

Case Study of Green Economy Policies: Japan

The challenges that Japan faces in transitioning to a green economy are substantially different to those faced by China but, in many ways, no less daunting. Japan is one of the wealthiest countries in the world. With the world's third largest economy, its technological capabilities are of the first order. The population is highly educated. Japan also has a tradition of saving and frugality, as well as a spiritual connection with the natural world. Japan's economy, however, has shown modest growth at best for over a decade, and a declining and aging population is an impediment to future sustained growth. Although Japan's energy use and greenhouse gas emissions have changed relatively little since 2000, with CO2 emissions even decreasing in recent years, this decline has been largely the result of the recent economic stagnation rather than of government policies. Energy supply security has, for many decades, been a major focus of Japan's policy because it has very limited fossil fuel resources of its own. This focus remains, though a number of policies have been developed that nominally steer Japan towards a greener economy. Their implementation, as described below, has generally been slow.59

Recent Trends in Japan's Energy Sector and Economy60

As of 2009, Japan had the world's third-largest economy (among individual nations) in terms of GDP (purchasing power parity-adjusted), after the United States and China. It ranked third in electricity consumption, third in oil consumption, and fifth in natural gas consumption.61 Lacking major deposits of fossil fuel resources, however, Japan is reliant on energy imports and was, as of 2004, the second largest importer of fuels after the United States and the third largest importer of oil (after the United States and China). Japan's modest coal resources are still mined at a very low level, but domestic coal production in recent years has been heavily subsidized and uneconomic relative to coal imports from Australia, South Africa, the United States, and China. Domestic coal production has disappeared from public statistics.

Japan has a few operating oil and gas wells and some reserves of both oil and gas, but less than 2 percent of its oil and gas needs are produced domestically.62 Japan has an estimated 34 GW of hydroelectric resources, of which about 65 percent have already been tapped.63 As a result, Japan's economy is highly dependent on imports — particularly imported coal, oil, LNG (liquefied natural gas), and uranium for its nuclear power industry. Over 80 percent of Japan's oil imports come from

the Persian Gulf (as of 2011), while about two thirds of its natural gas imports — as LNG — come from Southeast Asia and the Pacific (Indonesia, Malaysia, Brunei, and Australia), as of 2010, with additional LNG sourced from the Middle East and from Russia, among other locations.64

Figure 3.15: Ratio of Imported Energy to Total Primary Energy Use in Japan, 1965-2011 (Values shown are ratios as of 2011)



Source: Derived by Kae Takase from data in EDMC Handbook of Energy & Economic Statistics in Japan 2012.

Despite some diversification since 1980 — mainly stemming from an increased use of nuclear power and natural gas — Figure 3.15 shows how Japan's very high import dependency continues. It is not surprising, therefore, that concerns over energy supply security have historically dominated energy policy debates in Japan.

Japan has one of the lowest rates of energy use per unit of GDP among the industrialized nations of the world. This status reflects, among other factors, an emphasis since the "energy crises" in the 1970s on energy efficiency in manufacturing and other sectors, as well as the displacement, over the last few decades, of much of Japan's heavy industrial base to other countries as high value-added industries such as electronics and services have come to dominate Japan's economy. Figure 3.16 shows the division of final energy demand by consuming sector in Japan in 2011. Figure 3.17 compares trends in energy demand by sector over the period 1990-2011, showing industrial demand has remained nearly static, while commercial sector demand, for example, has increased by over 40 percent.

Figure 3.16: Final Demand by Sector in Japan, 2011



Source: Derived by Kae Takase from data in EDMC Handbook of Energy & Economic Statistics in Japan 2012.

Figure 3.17: Index of Final Demand by Sector in Japan,
1990 to 2008 (1990 = 100)



Source: Derived by Kae Takase from data in EDMC Handbook of Energy & Economic Statistics in Japan 2012.

Japan's population — about 127.8 million as of 2011 — has reached its peak and is starting to decline.65 After a period of slow or no growth — average annual GDP growth was about 1.2 percent from 1990 through 2005 — Japan's economic picture had begun to improve somewhat in the years prior to the global economic crisis and the March 2011 earthquake and its aftermath. Japan's energy use and carbon dioxide emissions have also continued to grow, but more slowly than the economy (see Figure 3.18).66

Figure 3.18: Energy and Economic Trends in Japan, 1965-2012 (Index at left relative to 1965 values, scale at right represents change in energy use per unit change in GDP)



Source: Derived by Kae Takase from data in EDMC Handbook of Energy & Economic Statistics in Japan 2012. Kae Takase, "The Japanese Energy Sector, Energy Policies, and the Japan LEAP Modeling Effort," presentation prepared for the Nautilus Institute project Spent Fuel and Reduction of Radiological Risk After Fukushima (2013),https://nautilus.org/wp-content/uploads/2013/08/Takase_201305.pdf.

Japan's CO2 emissions trends can be decomposed into three contributing factors. The so-called "Kaya equation" expresses the annual change ("Δ") in CO2 emissions as the product of the change in energy use per unit of GDP ("ΔE/GDP"), the change in CO2 emission per unit of energy use ("ΔCO2/E"), and the change in GDP ("ΔGDP") over a given time period.67 Figure 3.19 shows the contributing factors to Japan's trends in energy use emissions from 1965 through 2011 in ten-year increments (except for 2010 through 2011). In general, the energy intensity of GDP ("E/GDP") is falling, reflecting a combination of true energy efficiency increases and reduced energy intensity due to the continued restructuring of Japan's economy away from heavy industries.

Japan's CO2 emissions, as shown in Figure 3.20, rose only modestly from 1990 through 2007, in part due to a reduction in CO2 intensity of energy use (CO2/E) — mostly reflecting a trend toward expanded use of natural gas and nuclear energy. CO2 emissions from 2005 through 2009 fell due to a combination of decreased energy intensity and CO2 intensity, along with negative trends in GDP, particularly as a result of the global recession of 2008-2009.

Figure 3.19: Contributing Factors to Trends in Energy Use in Japan, 1965-2011 (Units: percent average annual change)

Source: Kae Takase, "The Japanese Energy Sector, Energy Policies, and the Japan LEAP Modeling Effort," presentation prepared for the Nautilus Institute project Spent Fuel and Reduction of Radiological Risk After Fukushima (2013), https://nautilus.org/wp-content/uploads/2013/08/Takase_201305.pdf.

Figure 3.20: Energy Use (1010 kcal) and CO2 Emissions (Mt CO2) in Japan, 1990-2012

Source: 1965-2011 data derived by Kae Takase from EDMC Handbook of Energy & Economic Statistics in Japan 2012. Data for 2012 estimated by Governance Design Laboratory from various sources.

Greenhouse Gas (GHG) Reduction Policies in Japan

The historical trends in the evolution in Japan's energy sector, economy, and emissions form the backdrop for Japan's energy security and green economy-related policies in recent years. As of a few years ago, the prospects for meeting Japan's 2012 greenhouse gas emissions reduction commitments under the Kyoto Protocol to the United Nations Framework Convention on Climate Change looked relatively bleak, as achieving the target (before accounting for carbon sink credits from such sources as growing forests and Kyoto Mechanism credits) would have required a 12.7 percent reduction from 2007 emissions.68 The impact of the global economic downturn, however, made Japan's task in meeting its short-term Kyoto Protocol obligations much easier. As shown in Figure 3.21, Japan achieved a 0.6 percent reduction compared to base-year emissions levels in the period between 2008 and 2012 and, with additional help in the shape of Kyoto Mechanism credits, the target of 6 percent reduction from 1990 level was achieved.

As it turned out, Japan's GHG emissions did stay below the 2012 target, though offsetting drivers — economic dislocation as a result of the remnants of the global recession, a driver compounded by the impacts of the Sendai earthquake and tsunami, but countered in part by greater consumption of fossil fuels used for electricity generation to compensate for nuclear plants shut down after the Fukushima catastrophe — make this drop in emissions less than straightforward to explain.

Figure 3.21: Greenhouse Gas Emissions in Japan in Comparison with Kyoto Protocol Commitments (Units: Million tonnes CO2 equivalent)



Source: Ministry of Economy, Trade and Industry (METI), "Past Emission Reduction Targets and Achievement, and policy measures" (2013), http://www.meti.go.jp/committee/summary/0004000/pdf/035_02_01.pdf.

Reaching Japan's medium and long-term targets for emissions reduction, however, is another matter. Table 3.7 shows the transitions over time in Japan's greenhouse gas emissions reduction targets. Japan most recently committed to a 25 percent reduction from 1990 emission levels by 2020 under the Copenhagen code, as shown in Figure 3.22 (with an extrapolation to 2050). But after the governing political party in Japan changed from the Democratic Party of Japan (DPJ) to the Liberal Democratic Party (LDP) in late 2012, the target underwent a "zero-based review" according to the "Japan Revitalization Strategy" set forth by the new cabinet.69 (A zero-based review is one conducted without consideration for funding, staffing, or organizational constraints.)

Table 3.7: Historical Transitions in Japanese Greenhouse Gas Emissions Reduction Targets

	Plan	Prime Minister (Party)	Target
1997.12	Kyoto Protocol	Ryutaro Hashimoto (LDP)	Reduce 6% compared to the 1990 levels in the period of 2008-2012 (Japan)
2007.5	Cool Earth 50	Shinzo Abe (LDP)	Reduce 50% of World emissions
2008.6	Fukuda Vision	Yasuo Fukuda (LDP)	Reduce 60-80% (Japan)
2009.6	Aso Target	Taro Aso	Reduce 15% compared to 2005 levels by 2020 (8% compared to 1990 levels) (Japan)
2009.9	Speech by Hatoyama	Yukio Hatoyama	Reduce 25% compared to 1990 levels by 2020
2012.9	Innovative Strategy for Energy and the Environment	Yoshihiko Noda	Reduce 5-9% compared to 1990 level by 2020 (if GDP grows, reduction will be 2-5%)

Source: Mainichi Newspaper, "Discussion of CO2 reduction target disrupted," 26 August 2013.

Japan's overall policies for improving energy supply security traditionally focused on three principles: improving self-sufficiency in energy use, diversifying sources of energy (including energy types and geographical sources), and reducing GHG emissions as described in "The Energy Basic Plan" approved by the cabinet in 2010. The Basic Energy Plan of 2010 set a very ambitious target calling for a high rate of energy efficiency improvement, especially in the household sector, and a high rate of development of zero-emission sources of electricity (namely nuclear power and renewable electricity). After the earthquake, the cabinet considered the possibility of a zero-nuclear power future for Japan and, after much discussion, published a document entitled "Innovative Strategy for Energy and the Environment" in September 2012. This document, however, was not approved by the cabinet due to strong opposition to the concept of a zero-nuclear future.

Figure 3.22: Historical Greenhouse Gas Emissions in Japan, and Required Trends to Reach Medium and Long-term Targets (Units: Million tonnes CO2 equivalent)

Source: Historical statistics from data in EDMC Handbook of Energy & Economic Statistics in Japan 2012. Future extrapolations derived by Kae Takase based on stated Japanese climate policies.

After the LDP regained power in December 2012, Prime Minister Abe announced the CO2 emission target for 2020, as well as the Energy Basic Plan and any other energy related plans, should be "zero-based" reviewed and revised. In Prime Minister Abe's economic recovery plan, the "Japan Revitalization Strategy," which was approved by the cabinet in June 2013, it is clearly stated that every target or plan related to CO2 emissions and energy are to be reviewed and revised.

In the meantime, Feed-in Tariffs (FIT) for renewable electricity sources in Japan have been fully implemented, and the tariff for the first year (beginning in July 2012) and second year of the FIT program have been high enough to encourage many companies to start renewable generation businesses. Table 3.8 provides a summary of the FIT schedule.

Table 3.8: Tariff Levels for Renewable Energy Sales to the Japanese Grid

Energy source	Type	Coverage of Purchase	Price (Yen per kWh)		
			2012 FY	2013 FY	Purchase period (years)
PV	Up to 10kw	Surplus	42 (34 w/FC)	38 (31 W/fc)	10
	10kW and above	All	42	37.8	20
Wind	Up to 20kW	All	57.75	57.75	20
	20 kW and above	All	23.1	23.1	20
Small hydro	Up to 200 kW	All	35.7	35.7	20
	200-100 kW	All	30.45		20
	Above 1000 kW	All	25.2		20
Geothermal	Up to 15,000 kW	All	42	42	15
	15,000 kW and above	All	27.3	27.3	20
Biomass	Methane fermentation gasification	All	40.95	40.95	20
	Unused wood combustion (1)	All	33.6	33.6	20
	Wood combustion (2)	All	25.2	25.2	20
	Waste (non-wood) combustion (3)	All	17.85	17.85	20
	Recycled wood combustion (4)	All	13.65	13.65	20

Note: "FC" denotes tariff when a PV system is coupled with a home fuel cell system fueled with oil or gas, with the combined output (net of home use) sold to the grid. 1) Using "unused" timber from forest thinning or regeneration cutting. 2) Using wood other than "unused" or "recycled"(waste wood from lumber sawing or imported woods), and palm chaff, rice husk sourced biomass. 3) Burning biomass such as domestic waste, sewage sludge, food waste, refuse-derived fuel (RDF), refuse paper and plastic fuel (RPF), or black liquor from the wood pulp industry. 4) Burning biomass such as construction and demolition waste.

Source: Ministry of Economy, Trade and Industry (METI), "Portal site for renewable policy of Japan"

(2013).

As a result, renewable generating capacity has been rapidly growing in Japan since 2012, and the sum of capacity approved for FIT by May 2013 was exceeded by total accumulated capacity in March 2013. Most of the approved (in other words, future) capacity consists of non-residential photovoltaics (PV), which refers to megawatt-class and medium-class PV power plants on the roofs of buildings, and similar large PV systems. The dominance of PV power among FIT-qualifying systems stems from the short lead time for installing PV; wind and geothermal power projects will also be commissioned in the coming years.

Figure 3.23: Recent and Planned Short-term Additions to Renewable Energy Capacity in Japan (Units: Megawatts)

Source: Ministry of Economy, Trade and Industry (METI), "Status of Renewable Energy Generation Facilities" (2013), http://www.meti.go.jp/press/2013/08/20130820005/20130820005-2.pdf

As of 2010, Japan's nuclear reactor fleet included fifty-four plants with a total capacity of 49 GW and an additional two plants under construction. Twelve more units are planned. Recent trends in reactor usage in Japan, however, have not been encouraging, with the annual capacity factor of nuclear power (the equivalent fraction of the year that reactors were running at full capacity) falling from over 80 percent in the late 1990s to about 60 percent in recent years. As shown in Figure 3.24, nuclear output in Japan had fallen from its peak of the late 1990s even before the 2011 Fukushima accident. Note that the 2007 decline in nuclear output shown in Figure 3.25 is the result of the July 2007 earthquake near Niigata, which caused the temporary shut-down (followed by continuing outages for safety checks) of the 7-unit Kashiwazaki-Kariwa nuclear power station. A combination of events, including accidents at nuclear power plants and revelations about nuclear mismanagement, were already causing public confidence in nuclear power to wane even prior to the disaster at the Fukushima I plant, which resulted in the drop to zero output shown on the right side of Figure 3.25.70 The small rise from zero shown for 2012 in Figure 3.25 represents the restart of the Ohi #3 and #4 units in July-August 2012. As the Fukushima I accident has played out over the months, the Japanese government's commitment to nuclear power has looked progressively weaker, to the point where, in July 2011, Prime Minister Kan called for a phase-out of nuclear power.71 These events, coupled with ongoing delays, cost overruns, and technical problems at the Rokkasho reprocessing plant, which was to have been the model for nuclear fuel recycling and waste management in Japan, combine to make the future contribution of nuclear power to Japan's GHG emissions reduction goals increasingly uncertain.

Figure 3.24: Historical Trends of Nuclear Power Monthly Output in Japan, 1986 through 2012 (1010 kcal)

Source: Ministry of Economy, Trade and Industry (METI), "Monthly Report on Electric Power Statistics" (2013).

Prospects for Meeting GHG Reduction and Green Economy Targets in Japan

Despite the modest progress on renewable energy to date, and the currently bleak outlook for the nuclear power industry in Japan, concerted green economy policies focusing on renewables and energy efficiency offer the potential for Japan to realize its environmental and energy security goals. Figure 3.25 shows the results of quantitative energy paths analysis by Kae Takase, co-author of this

chapter, indicating that very significant reductions in Japan's GHG emissions are possible even in a scenario in which Japan's nuclear capacity declines by 60 percent (to about 20 GW) by 2030, so long as an aggressive program of energy efficiency and renewable energy deployment is undertaken (the "National Alternative with Minimum Nuclear" or "NA+Nuc. Min." See case in Figure 3.23).[72] The high-renewables, high-efficiency scenario with a "Maximum Nuclear" deployment (about 68 GW by 2030) would reduce emissions still further, but the relative contribution of the additional nuclear capacity in the Maximum Nuclear case, relative to the Minimum Nuclear, contributes only about 15 percent to the overall 2030 GHG reductions.

It is also more than conceivable that if the significant additional costs of the Maximum Nuclear deployment were directed toward energy efficiency and renewable energy, the reduction in emissions could be even greater than in the "NA+Nuc. Max" case. What is more, as shown in Figure 3.26, the rates of change of the factors in GHG emissions reduction implied by the various scenarios are not inconsistent with recent experience in Japan. Even assuming relatively robust (for Japan) economic growth, the change in energy use per unit of GDP, reflecting ongoing shifts in Japan's industrial structure and energy efficiency, will decrease at a lower rate than in 2002-2007. And while the change in CO2 emissions per unit of energy use, reflecting "de-carbonization" of energy supplies, would decrease at the highest level ever in the "NA+Nuc. Max" scenario through 2020, the rate of change is not unfathomable given Japan's experience over the years.

Figure 3.25: Scenarios of GHG Emissions Reduction in Japan
(Units: million tonnes of CO2)



Source: Prepared by Kae Takase (2013/2014) based on LEAP (Long-range Energy Alternatives Planning) modeling results as undertaken for the Nautilus Institute project Spent Fuel and Reduction of Radiological Risk After Fukushima.

Figure 3.26: Factors Analysis for GHG Emissions Reduction Scenarios (Units: annual change in factors)



Source: Prepared by Kae Takase (2013/2014) based on LEAP (Long-range Energy Alternatives Planning) modeling results as undertaken for the Nautilus Institute project Spent Fuel and Reduction of Radiological Risk After Fukushima.

Recent years have seen some encouraging developments in Japan with respect to policy and social trends that relate to GHG reduction efforts and green economy development. An "Eco-points" program has been developed that awards points for the purchase of high-efficiency electric home appliances and equipment (for example, refrigerators, TVs, air conditioners, insulation, and high-performance windows). Points can be exchanged for green products or travel vouchers, gift certificates, and other items. It is estimated that the program has already resulted in a reduction of national CO2 emissions of 0.1 percent at a net cost (that is, factoring in fuel cost savings) of 2000 yen per tonne of emissions reduction over the lifetime of the high-efficiency devices installed. Programs providing subsidies for "eco-cars" (hybrid and high-efficiency cars) and efficient boilers have also been provided. The combination of these programs, in addition to green economy publicity and other factors, has resulted in social change in Japan. It is becoming "fashionable" to buy hybrid cars, to live in a house with PV on the rooftop, to exchange old air conditioners for efficient units, and to receive eco-points.

Economic modeling of different ways of reaching Japan's GHG emissions reduction goals

underscores the utility of “green economy” investments. Matsuhashi and his co-authors modeled a 15 percent reduction in Japan’s GHG emissions by 2020, excluding credits for carbon sinks and other Kyoto protocol mechanisms.[73]Their results suggest that an emphasis on improving energy efficiency —such as for vehicles, homes, and appliances — and lowering costs for efficient devices and for photovoltaic power systems yield much higher household utility (that is, reduces household expenditures) across all income classes relative to approaches that rely mostly on fuel-switching (toward gas and nuclear power) and carbon taxes, but not on energy efficiency.

Although the implementation of strong policies related to green economy development has been relatively slow in Japan, a number of groups both within and outside of the Japanese government have given significant thought to a green economy transition for Japan. A Roadmap Committee on GHG emissions reduction, convened by the Central Environmental Council of Ministry of the Environment, has developed a set of Low-Carbon Society (LCS) scenarios and policies to promote an LCS in Japan.[74] This comprehensive effort (of which only selected results are discussed here) studied environmental options geared toward achieving a Low-Carbon Society in Japan, including “Techno-Socio Innovation” studies of elements such as changes in urban structure(including green buildings, self-sustained cities, decentralized services), information technology, social development (eco-awareness, effective communication, and dematerialization), and transportation system evolution (next generation vehicles, efficient transportation system, and advanced logistics). Scenarios built out of these elements were developed and evaluated using economic and technical models to determine their sufficiency for reaching GHG reduction goals. The scenarios also proposed directions for long-term global warming policies. Junichi Fujino notes that the LCS effort identified a dozen changes that are consistent with a green economy that would make it possible for Japan to achieve 70 percent CO2 emissions reductions by 2050, namely:

1. Comfortable and green built environment
2. Anytime, anywhere appropriate appliances
3. Promoting seasonal local food
4. Sustainable building materials
5. Environmentally-enlightened business and industry
6. Swift and smooth logistics
7. Pedestrian-friendly city design
8. Low-carbon electricity
9. Local renewable resources for local demand
10. Next generation fuels
11. Labelling to encourage smart and rational choices
12. Low-carbon society Leadership.[75]

Significant reductions in Japanese GHG emissions will require a necessarily complex, integrated combination of elements incorporating many of the aspects of the broad energy security definition articulated earlier in this chapter (energy supply, technology, environment, economics, and social/policy considerations).[76]

Requirements for Successful Green Economy/Renewable Energy Development in Japan

Japan’s traditional focus on energy supply security, with its emphasis primarily on diversifying oil

and gas imports and on nuclear power, is being tested by the requirements of greenhouse gas emissions reduction and a host of other economic, political, and social factors. Japan's modest efforts at promoting renewable energydevelopment and its solid commitment (at least until very recently) to nuclear power both run contrary to recent international trends. As shown in Figure 3.27, Japan's renewables and nuclear energy policies are not consistent with trends in the rest of the world, which show an accelerating deployment of renewable power systems and a very limited net new nuclear capacity, contrary to the claims of several organizations that nuclear power is undergoing a "renaissance." The major exception to this pattern, as noted earlier in this chapter, is China, which is adding both nuclear and renewable capacity at a rapid rate. The European Union added significant gas-fired, wind, and PV capacity from 2000 through 2008, while decommissioned coal-fired and nuclear capacity exceeded new capacity additions.

Recent experience in a number of cases shows cost estimates for nuclear power and solar photovoltaic power heading in opposite directions. A nuclear plant under construction in Finland seems to be perpetually forty-five months from completion, and its estimated costs have risen by a factor of three, with "busbar"77 costs of power from the reactor (including interest) estimated at 0.12 euros per kWh, or about 17 US cents/kWh. According to at least one group, and based on historical and projected costs in the United States, the relative busbar costs of solar PV power and nuclear power, on average, "crossed over" in 2010, such that costs for electricity from solar PV systems are now less than those for nuclear power plants.78 Annual global investment in new renewable energy capacity rose 500 percent from 2004 to $150 billion in 2009. Around the world, national and regional plans are emphasizing renewable power and the development of transmission systems, including international transmission connections to accommodate the sharing of renewable capacity. Plans and proposals, including the European Wind Energy Association's Offshore Network Development Master Plan and the "Gobitec" scheme to move wind power from the Gobi desert of Mongolia and China to population centers in China, Korea, and even Japan, are examples of such international transmission connections that seek to share the risk and benefit for a future international "energy community."79

Figure 3.27: Global Trends in Annual Additions to Wind, Solar, and Nuclear Power Capacity (GW)

Source: Iida, T., "Changing Climate Change & Energy Policy and Politics in Japan," Presentation for Nautilus Institute Workshop Interconnections of Global Problems in Northeast Asia, Seoul, Korea October 18, 2010.

In 2010, the two major political parties in Japan had different policies on renewable energy and GHG emissions targets. The Democrats called for medium-term GHG reductions of 25 percent relative to 1990, while the LDP called for 8 percent reductions from 1990. The Democrats sought a fairly substantial rise in the fraction of electricity generated from renewable fuels (from 9 percent — including existing hydro — to 24 percent in 2020), while LDP policy only proposed to increase non-hydro renewables by 1.6 percent in 2014, a move that was already legislated! The Democrats wanted to extend Feed-in Tariffs to all renewables, abandon the renewable portfolio standard, and introduce cap and trade legislation by 2012. The LDP would apply Feed-in Tariffs only to rooftop PVs, retain the renewable portfolio standard, and have no plans for cap and trade legislation. As of late 2010, however, following the historic change in Japan's government, with voters re-installing the Liberal Democratic Party and unseating the long-serving LDP, policies on GHG reduction and renewable energy in Japan became highly uncertain over the following years. .

A large part of the reason why Japan's GHG and renewable energy policies remain ineffective relative to other nations that have embraced FIT and renewable portfolio standard policies

(Germany is a prime example)[80]is that much of Japan's decision making on these issues happens at the ministerial level. The Ministry of Economy, Trade, and Industry (METI) has jurisdiction over the energy sector, while the Ministry of Environment (MoE) has jurisdiction over climate change. The two ministries tend to have different attitudes about policies promoting renewable energy. METI, along with the Japanese electric utility monopolies, tends to have negative or reluctant attitudes about renewable energy policies, while MoE, siding with non-governmental organizationsand the bulk of the general public, takes a more positive attitude. The leadership of Japan's industrial firms gravitates towards a middle position on the issue.

More generally, the structure of policymaking as it has traditionally been practiced in Japan does not lend itself to effective policymaking on GHG, renewable energy, or green economy issues. As shown in Figure 3.28, there tends to be a disconnect in Japan between policymaking on the macro scale (national policies), with detailed promulgation of and enforcement of regulations, and other policies within Japanese ministries ("meso sub-politics" in Figure 3.27). Then there is a further disconnect between the ministries and micro-scale results and goals (individual projects, for example). In addition, the press, non-governmental organizations, and members of civil society, tends to be less engaged at each level of the knowledge economy than is desirable in a society where the free flow of information and opinion between levels of government and the various actors in society combine to achieve a policy goal.

Figure 3.28: The Political Structure of and Information Flow in Energy and Climate Issues



Source: Iida, T., "Changing Climate Change & Energy Policy and Politics in Japan," Presentation for Nautilus Institute Workshop Interconnections of Global Problems in Northeast Asia, Seoul, Korea, October 18, 2010.

Despite the traditionally top-down or ministry-driven structure of energy and climate politics in Japan, there is a significant history of key environmental policies actually being led at the local/municipal level. The development of Japan's national legislation on air and water pollution in the 1960s and 70s was initiated by Tokyo municipal ordinances from the late 1940s onward. Similarly, municipal initiatives in Tokyo on GHG reporting, energy efficiency labeling, and solar energy use preceded national action by several years. Japan's successful development of a green economy, and of the renewable energy systems that will help to power it, depends on making use of imaginative vision at all levels of government and civil society, seizing political windows of opportunity afforded by unforeseen events (such as the Fukushima accident), and then using innovative policies and financing techniques to create markets for green products and services. These same resources are likely to be required to address problems of urban insecurity in Japan; indeed, many of the approaches necessary for green economy development will also improve urban security, as well as directly addressing problems of climate change mitigation (through GHG emissions reduction) and adaptation (through moving to distributed energy systems). In addition, the regional and international networks developed in moving toward a green economy in Japan are likely to assist in addressing Japan's relationship with the DPRK by offering multiple opportunities for engagement on issues that are both highly useful to the DPRK and politically non-threatening to either nation.

Case Study of Green Economy Policies: Republic of Korea

The ROK's economy has been one of the economic marvels of the last few decades, growing rapidly and steadily, with few downturns. By 2010, the ROK had the world's 12th largest GDP and was ranked 10th among nations in electricity consumption and production, 10th in gas imports, 9th in oil

consumption, and 4th in oil imports.81 The ROK has become an international force in several industries, including steel, automobiles, and electronics, and it has seen a vast increase in the living standards of its people, as well as in urbanization. Like Japan, much of the ROK's energy needs are supplied by imports, and like Japan, the ROK has embraced nuclear power as a key source of electricity. Unlike Japan, however, for the ROK the DPRK serves as a much more significant factor, albeit a quite uncertain one, in its development of energy systems and drive toward energy security.

The last decade has seen some transitions in the ROK energy sector, including a move toward partial restructuring of its electricity, expanded investment in oil and gas producer nations, and a drive toward exports of nuclear technologies. The last few years, as of 2011, have also seen the development, and the very early phases of implementation, of green economy principles in the ROK and of policies related to the reduction of greenhouse gas emissions.

In the section that follows we provide background on the energy sector and energy security policies in the ROK, describe the genesis and current status of green economy and GHG emissions reduction policies and projections, review the strengths and weakness of existing green economy policies, and suggest how green economy and energy security policies in the ROK might interact with issues such as urban security, climate change, and improvement of the DPRK situation.82

Overview of the ROK's Energy and Economic Situation

At of the end of the Korean War, the ROK's economy and infrastructure, to the extent that it had survived the ravages of conflict, was largely agricultural, with most energy provided by biomass (wood and crop wastes) and from the ROK's modest reserves of anthracite coal. The country's rapid industrialization, particularly in the last thirty years, has been fueled by imported energy to the extent that, as of now, only a small percentage of energy is supplied from domestic sources, and much of that comes from the combustion of municipal and other wastes. Already by 2006, domestic coal constituted only about 2 percent of total ROK coal use, and much less than one per cent of total energy use. Figure 3.29 shows the trends in ROK GDP, primary energy use (that is, including inputs to processes such as electricity generation and oil refining), and final energy use (use of energy by consumers).

Both GDP and primary energy use have increased since 1981, with strong growth throughout the period with the exception of the Asian Financial Crisis of 1997 to 1998 and the global recession of 2008-2009. GDP grew approximately seven-fold from 1981-2013, while primary energy use grew by a factor of 6. As implied in Figure 3.29 and shown more clearly in Figure 3.30, the trend in intensity of energy use (that is, the use of energy per unit of ROK GDP) has shown two distinct trends, increasing (more energy use per unit of GDP) until about 1997 and then slowly decreasing through 2013, a fall due to a combination of greater efficiency of energy use and a slow shift to less energy-intensive industries. Although, as shown in Figure 3.30, the growth in energy consumption exceeded growth in GDP in every year from 1990 through 1997, from 1999 to 2009 growth in GDP surpassed growth in energy consumption in every year except 2003. Since the recession of 2008-9 this pattern has changed again, with primary energy consumption growing somewhat faster than GDP. Electricity consumption has consistently grown faster than primary energy consumption, as ROK consumers' end-uses of electricity have increased faster than those for other fuels.

Figure 3.29: GDP, Primary Energy Use, and Final Energy Use in the ROK, 1981-2013

Source: Derived by Sun-Jin Yun from Korea Energy Economics Institute (KEEI), 2010, Yearbook of Energy Statistics.

Figure 3.30: Trends in Economic and Energy Sector Activity and Intensities in the ROK, 1990-2012



Source: Derived by Sun-Jin Yun from Korea Energy Economics Institute (KEEI), 2010, Yearbook of Energy Statistics.

One of the most notable changes in the last two decades in the ROK energy sector has been the increase in the use of natural gas, with a corresponding decrease in the use of oil. Industry still consumes the majority of final energy use in the ROK, with nearly half of industrial energy use coming from feedstock materials, mainly the oil product "naptha," which is used as an input in the petrochemicals industry.

Among industries, the energy-intensive subsectors (iron and steel, non-metallic products including cement, and petrochemicals) have accounted for about three quarters of energy use and about 30 percent of industrial value added over the past two decades, though within the energy-intensive industries there has been a significant shift in the fractions of energy used toward petrochemicals and away from the other two traditional heavy industries, even as the fractions of value added by heavy industries have remained roughly constant.

The largest change since 1990 has been the vast increase in the fraction of industrial value added in the ROK economy that has come from the fabricated metal subsector, including vehicle production, though the fraction of energy consumed in that subsector has risen only modestly. The fraction of industrial energy used and value added produced by the paper and publishing, textile and apparel, food and tobacco industries has declined over time, and though the fraction of energy used in "other" industries, including, for example, the electronics industry, has increased substantially since 1990, its share of value added has declined.

Limited domestic energy resources, a growing manufacturing base in industries highly relevant to nuclear power development, and the desire to develop expertise in nuclear technologies, among other considerations, led the ROK to emphasize nuclear power as an energy supply security measure. Twenty nuclear reactors are now under operation, with ongoing expansion expected to result in twenty-eight operating reactors by 2016. Nuclear generation accounted for 35 percent of generation in 2007, and plans call for an additional twenty-two reactors to be constructed by 2022. By 2007, the ROK's nuclear capacity and generation ranked sixth among the world's nations, its fraction of generation produced by nuclear power ranked fourth, and the ROK was first by a wide marge among nations in nuclear capacity per unit of land area.[83] The ROK has also been actively promoting nuclear technology exports, including a recent deal to build reactors in the United Arab Emirates.[84]

The Development of the ROK's Climate and Green Economy Policies

A combination of factors has focused ROK attention on climate and green economy policies in recent years. Over the last century, climate records show that Korea's temperature has increased by 1.5℃, a rate double the global average (0.7℃), and the temperature in Seoul has increased by 2.5℃.[85] At the same time, the ROK's high energy consumption and near-complete import dependence are strong inducements to reduce exposure to energy supply security risks by developing domestic resources. The ROK also ranks ninth among the world's nations in CO_2 emissions, sixth in overall greenhouse gas emission, and first in the rate at which its GHG emissions grew between 1990 and 2004, nearly doubling (increasing by 90.1 percent) over that span. As of 2006, energy use constituted by far the largest fraction of the ROK's GHG emissions, at over 84 percent, with industrial sector non-energy emissions, including emissions of chlorofluorocarbons from

refrigeration systems and other sources; sulfur hexafluoride, perfluorocarbons, and other compounds used as solvents and cleaning agents in the electronics and other industries; and CO2 from cement production constituting the next largest source of emissions at somewhat less than 10 percent.86 Of energy-related sources of GHG emissions, energy transformation (dominated by electricity generation) was the largest, at over 35 percent, with industry accounting for 30 percent.

The ROK's first major set of climate change-related policies was set out in the 1999 draft of the "1st Comprehensive Counter Plan for the Framework Convention on Climate Change (1999-2001) Act on Countermeasures Against Global Warming." From 1999 through 2007, the ROK's policy responses relating to climate change tended to be modest in scope, calling for emissions reduction from "business as usual" levels that were not particularly aggressive and which were protective of what was seen as the required increases in energy use to drive a growing economy. In the Basic National Plan for Energy as of 2007, growth in energy use slows from the levels of the last decade, but overall energy use continues to climb, even assuming a program of demand-side management (DSM) is implemented.

In 2008, however, and as indicated in Table 3.9, a major change occurred in the ROK's climate policies, which shifted from what can be termed a "defensive" position to one that is relatively proactive in addressing climate issues. Though the Lee Myung-bak administration began its tenure with an emphasis on high economicgrowth, supported by massive civil engineering development, its second year (2008) saw a sudden turn toward the principles of green growth. This policy change was underscored by presidential announcements, at the G20meetings in Japan and Italy in 2008 and 2009, of the ROK's plans for aggressive mid-term GHG emissionsreduction targets, followed by the release in August 2009 of three scenarios for the ROK's reduction targets as produced by the Presidential Committee on Green Growth.

Both domestic and international considerations played into the Lee administration's change in approach. In his speech on the 60th anniversary of national independence, President Lee emphasized green growth as a "new national development paradigm" that would allow future generations to secure a reasonable standard of living, in contrast to the focus in the previous sixty years on economic growth and export targets, with reductions in GHG emissions now a key indicator of "low-carbon green growth." At the same time, the administration sought to upgrade the ROK's international image by positioning it as an "early mover" in the green economy transition, thus improving the ROK's "brand value," and also as a trusted and respected mediator between developing and developed nations, building on the ROK's status as a (relatively) newly industrialized nation with strong economic links to both the developed and developing world.87

Table 3.9: Evolution of the ROK's Climate Policies, 1999-2008

Plans	Sector/project	Detail	Note
The 1st comprehensive counter plan (1999)	4/36	1. Decreasing GHG emissions (27) 2. Applying the flexible mechanism (1) 3. Decreasing PFC, HFC, SF6 emissions (1) 4. Creating infrastructure for reducing GHG emissions (7)	* Korea's first national plan on climate change * A three year plan

The 2nd comprehensive counter plan (2002)	5/84	1. Building negotiation capacity (6) 2. Exploiting technologies for GHG emissions reduction (20) 3. Enhancing GHG reduction measures (40) 4. Kyoto mechanism and building statistical database 5. Scaling up citizens' participation and cooperation	* Establishing basic framework
The 3rd comprehensive counter plan (2005)	3/91	1. Establishing a foundation for the implementation of agreements (30) 2. Reducing sectoral GHG emissions (45) 3. Building infrastructure for adapting to CC (16)	* Adding adaptation measures
The 4th comprehensive counter plan (2007)	5/19	1. GHG emissions reduction (6) 2. Climate change adaptation (3) 3. Research and development (4) 4. Building infrastructure (4) 5. International cooperation (2)	* Presidential transition period * A five year plan
The comprehensive plan on combating climate change	4/176	1. Developing climate industry as a new economic driving force (48) 2. Improving the quality of life and the environment (106) 3. Contributing to the global efforts to combat CC (12) 4. Key policy tools (10)	* 'Low carbon, green growth' vision * A five year plan

Note: The authors would like to gratefully acknowledge the assistance of Nyun-Bae Park, Research Professor, Sejong University, ROK, in assembling this Table.

The nominal goals of the ROK's recent climate and development policies are to pursue the development of a "new economy coupled with ecology," in effect creating a virtuous circle between economy and ecology, leading to a green economy that can be a new growth engine for the ROK. Despite the development of an array of related policies, however, it is too early to discern significant actual green economy progress in the ROK resulting from green growth strategies promulgated during 2009 and 2010. Figure 3.31 summarizes a mid-term "target" scenario for the year 2020, based on GHG emissions reductions announced by the Ministry of Environment in 2014. The target scenario represents a considerable departure from the pattern of emissions growth to date and from the BAU (business as usual) case, since the BAU case includes a continued reduction in emissions per unit of economic output that is overwhelmed by the impacts of increasing affluence on per-capita emissions in the ROK, even as the ROK population begins to decline. The target scenario shown in Figure 3.31, with 2020 emissions 30 percent lower than the BAU case and a few percent lower than in 2005, calls for reductions in emissions in all sectors of the ROK economy, with reductions of 25 to 34 percent in the transportation, building (including residential and commercial), transformation (for example, power production), and public sectors, and somewhat lower reductions in other sectors, including industry. This 2014 target scenario follows the pattern of an earlier set of

emissions reduction scenarios adopted by the ROK government in November 200988 and submitted to the UN in January of 2010.

Figure 3.31: Mid-term GHG Reduction Target and Road Map in the ROK



Source: Ministry of Environment, “GHG reduction road map was prepared” (2014) (press release).

Following President Lee’s speech on the 60th anniversary of the National Foundation Day (August 15, 2008), all government ministries were almost immediately engaged in producing a plethora of policy programs to institutionalize green growth strategy, with competition between ministries not uncommon. In just over five months between August 2008 and January 2009, the following policy programs below (and others) had been put forward, all of which focus on developing new energy and industrial technologies and generating new jobs in the field of the green economy:

- The National Energy Basic Plan and Industrial Development Strategy for Green Energy
- The Basic Plan for Comprehensive Action against Climate Change
- The Long-term Master Plan for National Research and Development on Climate Change
- The “Green New Deal”
- Comprehensive Measures for R&D on Green Technologies
- The Vision and Development Strategy for New Growth Power

The three institutional pillars for green growth in the ROK to date have been the establishment of the Presidential Commission on Green Growth in January 2009, the launching of the National Strategy and Five-Year Plan for Green Growth in July of 2009, and legislation of the Basic Act on Low-Carbon Green Growth in December 2009, which went into effect on April 14, 2010. A “Five-Year Green Growth Plan” envisioned the elevation of the ROK to the 7th-leading “Green Power Country” as of 2020, and to the 5th by 2050, based on three strategies and ten policy directions:

- Strategy 1: climate change adaptation and energy independence, including effective reduction of GHG emissions, reduction of petroleum use, increasing energy independence, and strengthening of the ROK’s adaptation capability against climate change impacts.
- Strategy 2: creation of “new growth power” through green technology development and its utilization to promote green industries, deepen the ROK’s industrial structure, and build the base of the green economy.
- Strategy 3: quality-of-life improvement and upgrading of national status through the construction of green space and green transportation systems, green reform of the patterns of everyday life, and embodiment of the global model nation of green growth.

These strategies are supported by a number of sector-specific goals and targets, including those in Table 3.10 below for the building, transportation, industrial, and energy transformation sectors; the latter, notably, includes and extends the ROK’s goals for expansion of nuclear power.

Table 3.10: ROK GHG Emission Mitigation Policies

Building sector	Transportation sector
31% reduction by ‘20 compared with BAU	33~37% reduction from BAU by ‘20

Strengthening energy performance standards: 50% reduction in heat and cooling from ‘12, passive house level from ‘17, mandatory zero energy from ‘25	Designating green transportation zone; green vehicle first; discount point from mass transit
Energy consumption cap from ‘10	Expansion of rail road in the share of total SOC (‘Shipper-owned container’) traffic 29% in ‘09 to 50% in ‘20)
Energy management in energy intensive building from ‘11	Over 65% share of mass transit
Certificate of energy consumption from’ 12 in case of purchasing and rent	
Industrial sector	Transformation sector
Energy target setting program from ‘10 (for energy intensive industries with more than 0.5 MTOE)	Expansion of nuclear (41% of installation by ‘30, 59% of generation)
	Introduction of RPS in ‘12
	Building smart grid

Source: Presidential Committee on Green Growth (PCGG), “Presidential Committee on Green Growth suggests national GHG emission reduction targets,” 11/04/2009 press release.

To implement these strategies, the ROK was to spend 107 trillion won (0.107 trillion US dollars) on green growth projects between 2009 and 2014, equivalent to 2 percent of GDP, with an annual growth rate of 10.2 percent.

Strengths and Weaknesses of Current Green Economy Policies in the ROK

Although the green energy policies developed during the last few years in the ROK are a notable departure, at least nominally, from earlier policies, it is not clear that the ROK’s policy shift represents a heartfelt conversion to the green economy concepts as defined earlier in this section. Rather, ROK green economy policies to date have tended to focus on the establishment of techno-bureaucratic and hardware-oriented institutions for green growth, and they have resulted in the over-politicization of green growth without building much of a constituency and concern for green growth among the general public. Instead of improvements in the ROK’s environment, the last few years have arguably seen a deterioration of the environmental performance of the national economy. The 2010 Environmental Performance Index released by the World Economic Forum rated the ROK 94th of 163 countries, a drop of forty-three places since 2008 and the lowest ranking among OECD member nations.89

It can be argued that the idea of “green growth” as it is currently being implemented in ROK policy is a largely a product of conceptual and ideological degradation of previous meanings of the term. The “two ecos” (economy and ecology) have been at the heart of environmental policy in the ROK since the Kim Dae-Junggovernment (1998-2003). Moreover, sustainable development, a higher-level conception of green growth, was instituted as a national priority policy during the Kim Dae-Jung and the Noh Moon-Hyun governments (2003-2008). The current advocates of green growth in the ROK misinterpret sustainable development as a Western-centered and ecology-biased concept, and thus not suitable for the ROK. There has thus been a process of excluding and discriminating against traditional “green” views, beginning with the degradation of the original Presidential Commission on Sustainable Development (PCSD) into a ministerial commission under the control of Minster of Environment, with its policy review position taken over by the current Presidential Commission on Green Growth (PCGG).

Although the PCSD was typical of a governance body representing a wide range of different stakeholders, the PCGG is composed almost entirely of pro-governmental techno-bureaucratic experts representing largely the interests of the business community and excluding traditional green advocates from civil society. This has resulted, essentially, in the representation in green-growth policymaking of just one perspective, that of advocates for market-driven green growth. When the second term of the PCGG commenced in July 2010 and took up the theme of market-driven green growth in its 8th general meeting, suggestions from the industrial and business communities were the primary topics debated, with business and allied interests complaining loudly that green growth policies included in the proposals offered "only green, no growth," a reversal of the "only growth, no green" complaints of the environmental community at an earlier stage of the policy debate.

As a result of this shift in how the concept of green growth is put into practice in the ROK, the prospects for true reform of the ROK's environmental performance based on current policies are limited by the paradox of the ROK's policies of green growth and the green economy. Essentially, these policies presently emphasize the economy first and "green" second. The current green growth strategy comprises two key approaches: (1) "low-carbonization," meaning reduction of greenhouse gas emissions and other environmental pollution to accomplish "defensive green growth" and (2) "green industrialization," meaning the generation of new growth, power, and jobs for "offensive green growth." These priorities are reflected in the chapter structure of the "Basic Act on Low-Carbon Green Growth," which reads:

1. Promotion of Green Economy and Industry
2. Measures for Climate Change and Energy
3. Construction of Sustainable Territory and Environment

Operationally, in green growth policy implementation, priority has been placed on "the promotion of green economy and industry," while policies to address climate change, energy security, sustainable land use, and other environmental causes are implemented only to the extent that they support the priority agenda. This reveals the standpoint of the current Korean government: "the economy (growth) is first, green is second." Such growth, even if considered "green," is unlikely to result in significant environmental clean-up due to the following chain of logic. First, the linkage between low-carbon development and green industrialization is "green technology." Green technologies, in turn, are eco-efficient technologies that offer a relative reduction in the amount of environmental pollution per unit of economic (resource and energy) input, but do not necessarily imply that the absolute amount of environmental pollution produced by the economy will be lower than "business as usual" or some other policy scenario. This further implies that the more green growth based on the principle of eco-efficiency is successfully pursued, the more environmental pollution it generates. As a result, the green economy generated by the ROK's current green growth policies is likely to end up being neither sustainable nor secure.

The ROK's "green growth" energy policy may be efficient, but by more standard global definitions of the concept, it is rather un-green. Although the ROK's 2020 target for greenhouse gas reduction is 30 percent of the 2020 BAU emissions estimate, on closer examination the largest portion of green energy included in policies to achieve the target comes from nuclear power, a type of efficient but un-green energy. It is planned that nuclear power use will increase from 36 percent of total 2007 power generation to 59 percent in 2030, while absorbing the largest share of the budget for green technology development (35.9 percent in 2009). This planned nucleardevelopment, however, is not without opposition in the ROK. Within a few years, the ROK's existing sites for nuclear power plants will have all of the reactor units they can reasonably accommodate, and new plant sites will be required. As of 2009, although more than 80 percent of ROK residents acknowledged the need for

nuclear power, a growing number (over 60 percent) were concerned about nuclear safety, and just over a quarter of survey respondents found the prospect of new nuclear plants in their own communities acceptable.90 It is likely, in the aftermath of the Fukushima accident, that a similar survey would find less positive public perceptions of nuclear power in the ROK.

Meanwhile, renewable energy, more typically considered to be a form of green energy, will continue to occupy a minor proportion of the total energy consumption during the forthcoming fifty years or so, rising from about 2.7 percent in 2009 to 6 percent in 2020, and only then to a more substantial 30 percent in 2050. Concern for energy independence as manifested in the ROK's green power policies is not so acute: the ROK's rate of energy independence (the fraction of energy supplies from domestic sources) excluding nuclear power in 2007 was 3.4 percent, but rose to 16 percent if nuclear power is considered a domestic resource (though the ROK imports nuclear fuel and licenses some nuclear technologies from other nations).

There is no clear target for energy independence based on green energy. As the ROK's export-oriented economic growth system operates almost entirely through imports of cheap energy from overseas, the proposed goal of energy independence through the application of current policies appears merely rhetorical in anything but the very long run, and only then with the most aggressive of fuel substitution policies. This likely lack of progress on energy supply security implies that without changing Korea's economic growth regime, which is sustained by the lowest energy efficiency (measured as income per unit of energy use) among OECD countries, in part because of the concentration of heavy industries in the ROK, substantially improving energy supply security seems infeasible in the ROK under current green growth policies.

A substantial fraction of the ROK's green growth program is an outgrowth of a bias toward large civil engineering projects as drivers of development. As such, the green growth program features arguably "high-carbon" construction of so-called "green cities." In this focus, the green growth strategy stems from the civil engineering growth that the current ROK administration, with its renewed (relative to previous administration) emphasis on civil engineering projects, is inclined to pursue emphatically. The Green New Deal program, part of the green growth strategy package, clearly shows this propensity. 64 percent of the total program budget (some 50 trillion won, or nearly half of the total green growth budget) is to be allocated to projects associated with civil engineering work, including the restructuring of four major rivers, generating 910,000 construction jobs out of the total 950,000 jobs estimated to be created under the Green New Deal.

Though the ROK is a highly urbanized society, there is as yet no national target to reduce the total energy consumed and greenhouse gas produced in urban areas, though globally cities consume 75 percent of total final energy and produce 80 percent of total GHG emissions. In the ROK, most of the policy efforts planned for the greening of cities tend to be skewed toward constructing new green cities, which are projected to use 30 percent less energy than existing cities consume, rather than improving the energy efficiency of existing built areas. It is unclear from existing plans whether the considerable GHG emissions used in constructing new cities have been factored into the overall carbon budget for the project, or whether GHG emissions savings will somehow be achieved by retiring existing built areas as new cities are built. As a case in point, the pilot project to build a low-carbon city now underway in the district of Keongpyo in Kangneung (Gangneung)91 is largely a demonstration of new promising green technology and industry, and it is understood by local residents to be primarily a new regional development project.

Typical of the ROK's focus on civil engineering in its green growth program is the government's plan to supply 1 million "green homes" as a flagship project for the green economy. The green home project is designed to generate new housing technologies and industries in the ROK. The approach used in this project is typical of a top-down government-initiated policy program in that it expands

the supply of more environmentally efficient housing by addressing the “hardware” of the housing stock, but with little effort to involve consumers in greening the patterns of their everyday life. By contrast, in Ireland, a program also called “Green Homes” has a vastly different focus.92 Ireland’s program has been initiated by community-based organizations and focuses on greening family life as well as community life (for example, through a “green school” component).

The ROK’s green growth strategy, if pursued as currently planned, has a significant probability of running afoul of Jevon’s Paradox, which states that as the efficiency with which a resource is used increases, the use of the resource tends to increase as well, absent measures (such as higher taxes) to prevent it, as consumers find they can afford more of the resource. As a result, it is likely that the more South Korea’s green growth is pursued, the more energy its economy will consume and the more greenhouse gases it will produce because the green economy policies rely on the intriguing principle of eco-efficiency. Thus, more investment in eco-efficient hardware such as passive housing, green industries, and green cities will be likely to end up causing more total energy to be consumed and producing more total greenhouse gas than is presently produced.

Conclusion: Green Economy Policies in the ROK

The ROK’s green growth strategy, as currently formulated, includes some impressive targets and demonstration projects, but at its heart emphasizes economic growth and national industrial competitiveness rather than the true “greening” of the South Korean economy. As such, the ROK’s current “green” policies are in effect mostly policies for further benefiting existing ROK industries, including the nuclear and construction industries. As a result, energy and urban security in South Korea’s feeble green economy can be secured only insofar as South Korea’s current growth policy regime is either abandoned or recast/reborn as a genuine environmental welfare regime. To do so, more autonomy, and likely more resources, should be granted to the civil society organizations that are best placed to initiate the greening of the everyday lives of South Koreans in cities and towns at the grassroots level.

Such a shift calls for analysis of the additional inputs nascent local policies will need to succeed, and for a re-alignment of the development goals of the green economy with the goals of sustainable development. Such a re-alignment would, among other aims, seek to change patterns of energy consumption in existing cities, pursuing a green economy that makes better use of local resources and reduces the separation, which is considerable in the ROK, between where energy (especially electricity) is produced and where it is consumed by adopting much more distributed (including renewable) generation.

Tools to accomplish such a re-alignment would include energy pricing schemes that favor local electricity generation (such as attractive Feed-in Tariffs for distributed generation) and promote energy efficiency (such as rates that increase as a household or business consumes more). Efforts should be made to site power plants closer to consumers so as to more directly relate the impacts of electricity generation and transmission to those who use the power (and reduce the impacts on those who do not). Again, support for distributed generation and “smart grid” development can help.

In addition, green economy strategies in the ROK should seek to improve the affordability of energy services to low-income residents93 and to take advantage of the fact that after energy consumption reaches a certain level, long since exceeded in the ROK, human welfare, as measured by the Human Development Index, rises very little with increasing energy use,94 meaning that an emphasis on improving the efficiency with which energy is used but not necessarily expanding the use of energy services, on average, by Koreans, should be a central goal.

Existing ROK green growth policies tend to use the type of top-down policy strategies that are

traditional in South Korea. Achieving true sustainable energy and economic development, founded on the three goals of economic, environmental, and social sustainability, will require a different approach, one that blends considerations of efficiency and energy supply security with low-carbon and low-pollution systems, as well as a commitment to equity and democratic participation. Energy sector approaches such as energy efficiencyimprovement, renewable energy adoption, use of decentralized energy systems, and enhanced participation of residents in energy decisions and the running of energy systems can be combined with other approaches, such as changes in land use to promote more balanced and low-impact use of the ROK's land, enhanced production and use of local food, and lifestyle transformation.

As a part of a sustainable development approach, expanded local energy use may offer several advantages, including:

- More energy democracy, providing local residents with opportunities (and responsibilities) to participate in production and consumption decisions;
- A transition to soft-path energy, moving from centralized supply-oriented systems to more decentralized, demand management-oriented systems, with an expansion of the use of renewable energy;
- Improving energy security through efficiency improvement and renewable energy development, thus responding to peak oil and energy resource depletion problems;
- Improving energy justice in that local communities would be more responsible for both the costs and benefits of energy production; and
- Revitalizing the local economy, in that money required for energy production and consumption would circulate within a community to a greater extent, rather than leaving the community (and often the country).

These approaches to the achievement of a green economy address issues of energy security, urban security, and climate change. These green economy/sustainable development approaches can also, if developed and implemented appropriately, help to improve the ROK's relationship with the DPRK, and thus make progress on resolving the DPRK nuclear weapons situation.

First, by addressing sustainable energy and economic development issues on the local level, but implemented with national coordination, processes in the ROK can serve as models for use in the DPRK, and the local emphasis may provide good opportunities for engagement with DPRK counterparts on non-political and grassroots levels that are likely to be less threatening to the DPRK than engagement on large, centralized projects. Second, if the ROK is seen to be moving away from nuclear power to less centralized alternatives, the DPRK may feel less pressure to move forward on nuclear energy and nuclear weapons development. Third, as the ROK develops expertise in local power, it will be in a position to share that expertise with the DPRK, including, for example, in joint ventures on energy production and other technologies appropriate for use in both countries and contributing to the local economies in both nations.

Conversely, the threat of a DPRK attack arguably affects, at least in some ways, how the ROK government develops and implements its policies, in that when threatened, any organization tends to concentrate decision-making power and limit access to information. On a less theoretical level, the threat of a DPRK attack may, for example, argue against the placement of key energy infrastructure in areas near the Demilitarized Zone (DMZ) where they would be more vulnerable to attack or sabotage. If progress is made in addressing the DPRK nuclear weapons issue, thereby reducing tensions between the two Koreas, it may help to stimulate the ROK government to promote a less-

centralized, more local approach to a green economy transition, one more in keeping with the more usual concepts of sustainable development.

Conclusion: Green Economy Efforts in Northeast Asia — Key Similarities, Differences, and Ways Forward

Green economy policies in China, Japan, and the ROK show some similarities, but also significant differences. Below we briefly summarize what we see as the consistent and diverging elements in the policies reviewed, identify the needs for moving green economy policies forward, and identify policies that seem to be generally "robust" region-wide — that is, applicable to a wide variety of policy goals in multiple settings.

Consistent Elements in the Genesis and Shape of Green Economy Policies in the Region

Green economy policies in China, Japan, and the ROK have all grown out of the recognition that current patterns of environmental degradation due to the use of energy and other resources are not sustainable, and that changes are needed. In each case, though to varying degrees, the goal of being perceived as a global leader/early adopter in the green economy movement also played a role in promoting interest in green economies among policymakers, as did the promise of the economic benefits of being a leader in the production of green technologies. Most elements of the green economy plans in the three countries are similar — improvements in residential and industrial energy efficiency, land stewardship, mass transit systems, vehicle efficiency, and building energy performance all feature in the green economy plans in each nation, as does a greater effort at deploying renewable energy systems and nuclear power (with the exception of very recent announcements in Japan). Official plans in none of the three countries, to date, have much emphasized the role of local governments and civil society in achieving a green economy, which is at least in part because all three countries have a strong tradition of top-down government.

Differing Elements in the Genesis and Shape of Green Economy Policies in the Region

Despite these similar green economy elements, the three countries are starting from different points in terms of development, resources, and social situations, and thus the policies developed to date differ. China, with a lower (but rapidly rising) state of economic development than the other two nations and with greater indigenous energy resources, but also ten and twenty times the populations of Japan and the ROK, is promising (and, in some cases, already delivering) a more aggressive effort on energy efficiency and certainly on renewable energy than the other two. Japan's green economy plans have tended to be less ambitious than the others, in part due to the poor state of the economy in recent years, as well as to the utility-dominated structure of Japan's energy sector policymaking. The ROK has, since 2008, shown a sudden shift toward the development of green economy policies, but to date, most of these policies appear to have benefitted established industries more than the environment or energy users in South Korea.

The three countries also seem to place differing levels of importance on the use of energy pricing and energy taxes to move markets toward greener consumption, with China showing more willingness to use price signals (albeit starting from lower price regimes for energy and energy-using devices), and Japan and the ROK being rather less willing to do so. In addition, the three countries are at different levels when it comes to the influence of civil society and local government on key energy sector decisions (among others). Civil society and local government groups in Japan likely have more influence, at present, over major decisions than similar groups in the ROK, with the civil society movement in China currently less developed than in the other nations.

A final, specific difference between nations is in their likely response to the Fukushima nuclear plant

accident in Japan. With a stronger tradition of civil society and as the nation directly affected by the Fukushima disaster, the influence of the disaster on Japan's policies, and most notably its nuclear policies, is likely to be more profound than in South Korea or China,[95] though it seems likely that the incident will affect nuclear power in those countries as well, as it has elsewhere.

Consistent Needs in the Region for Bringing the Goals of Green Economy Policies to Fruition

Throughout the region, achieving the goals of green economy policies will now require a number of inputs. First, it will require sustained and detailed planning, as green economies tend to be more complex in terms of interaction between sectors, between regulators and producers, and between central and local actors than more standard industrial economies. Second, the needs for capacity development to bring about green economies is vast everywhere. In China, by our rough estimate, hundreds of thousands of trained building inspectors will be needed to enforce China's building efficiency laws; how that cohort of inspectors will be trained to effectively monitor China's building sector at the local level is at present unclear. Third, a patient, consistent approach will be needed on the part of governments to retooling existing economies toward green principles. An important element here is that these efforts need to be consistent not just within individual administrations, but spanning administrations, as the transitions necessary to address long-term issues such as climate change will require ongoing efforts for decades and generations. Fourth, implementing green economies will require a continuous program of public education reaching to and involving the grassroots level, in addition to a program of educating leaders in politics and industry to convince them of the imperative for action. Finally, and probably most difficult, the implementation of an effective green economy transition depends on a gradual devolution of decision-making authority and activity in a number of sectors from the central level to the local level, as local production of energy, food, and other goods, and local efforts at conservation, education, and pollution reduction, must underpin green economy efforts. At the same time, communications between the central and local levels must be dramatically increased, as achieving an effective green economy requires combining many actions at the local level to effect changes at the national level. Local actions must also coordinate with ongoing national-level goals and systems, be they overall GHG emissions reduction targets, national electrical grids, or, perhaps eventually, carbon capture and sequestration facilities.

Differing Needs in the Region for Bringing the Goals of Green Economy Policies to Fruition

Although the list of common needs for bringing green economy concepts into effective practice is long, there are also some needs that are more specific to the individual countries of the region. China, for example, has arguably much further to go in terms of adopting effective air and water pollution control measures to support a green economy. The ROK may need to undergo a significant change in the way that it does business, including its emphasis on heavy industries and top-down economic management in the private and public sectors, in order to effectively implement a green economy. Japan will likely need to reorganize the institutional structure of its energy sector to provide both institutions and individuals with the proper incentives to build and operate green energy systems, as well as to promote energy sector cooperation among the regions of Japan (in building a truly national gas transmission grid, for example)[96] and in sharing resources with other nations in the region.

Overall Findings and the Value of Civil Society/Local Government Networks

The process of building toward green economies in ways that also put nations, regions, and the globe on a path toward true sustainable development, together with the numerous policies, programs, and changes in economies and society that this transition requires, can generally be "robust" throughout the region in delivering green economy benefits to many groups. In addition,

this process may, depending on its implementation, serve as a vehicle to ease international tensions related to economic development and resource acquisition by requiring and fostering engagement networks at multiple levels (see below). Many of the policies intended for building green economies are also, either incidentally or by design, effective in improving energy security, addressing climate change, and, in some cases, positively affecting the DPRK situation, as described in the country case studies above.

In Northeast Asia and, indeed, globally, there are currently a wealth of fast-growing networks in which local jurisdictions are banding together to share experiences and jointly work toward green economy goals. A sampling of these organizations is provided in Table 3.9, and the connections between them and other actors, many of them civil society and local government organizations that are "networking globally, but acting locally," are growing fast.97

Successful development of a green economy, and of the renewable energy systems that will help to power it, depends on imaginative vision at all levels, seizing political windows of opportunity afforded by unforeseen events (such as the Fukushima accident) and then using innovative policies and financing techniques to create markets for green products and services. The process of development is and will continue to be an evolutionary one, as Japan and other nations make the transition from the 20th-century standard of an energy system dominated by centralized, mostly fossil- and nuclear-fueled technologies decided upon through top-down decision-making in an industrial economy to a 21st-century paradigm featuring distributed renewable energy, energy efficiency, and information technologies developed in response to market and social forces within a knowledge-based economy and through a process of local innovation and global networking.

Figure 3.32 provides a schematic of the type of "triple decoupling" needed to achieve a transition to a green economy. The three types of decoupling are separating environmental impacts from energy use and economic activity, the provision of energy services from economic activity, and the welfare of human beings from both the amount of energy services consumed and economic growth as conventionally defined, relying instead on improvements in the quality of economic activities to boost welfare. This last economic decoupling has also been described as "shifting from debt-financed consumption (which is unsustainable) as the primary economic driver of our economies, to sustainability oriented investments in innovation as the primary economic driver of our economies."98

Figure 3.32: Triple Decoupling for a Green Economy

Source: Iida, T., 2010, "Changing Climate Change & Energy Policy and Politics in Japan," presented atInterconnected Global Problems in Northeast Asia: Energy Security, Green Economy, and Urban Security, Seoul, Korea, October, 2010.

Accomplishing this decoupling will require consideration and integration of a complex set of factors in each nation, and across the region. These factors include (but are not limited to) technology and energy infrastructure, existing and new laws, government and other institutions, national and sub-national budgets, evolutions in lifestyles (including as populations in the region age), making good use of social capital and experience (both within and across nations), and making room for the participation in decision processes of stakeholders representing many points of view.

Another key to bringing about green economies in the region will be the sharing of information, experience, and resources of all types across nations, through both the civil society and local government networks described above and through economic links between nations. These types of

connections in Northeast Asia will be facilitated by, and will themselves facilitate, a solution to the DPRK nuclear weapons issue. The process of building connections between nations will not be easy, and will require considerable coordinated patience and political will among all parties over the span of a generation or more, but it will certainly be worth the effort.

Implications of Climate Change and North Korean Issues for Energy Security in Northeast Asia

Introduction

As is evident from the discussion on green economy policies above, the quest for progress on climate change mitigation — in the form of reduction of greenhouse gas emissions — is a key driver of recent energy security and green economy policies. Climate change also influences energy security because different plans for addressing energy security result in different levels of risk to energy facilities (and those served by them) from the impacts of climate change; thus, different climate adaptation strategies have different implications for different approaches to energy security. Given the importance of cities in any energy security assessment, urban security is also affected by climate change itself, as well as by efforts to mitigate and adapt to climate change.

Another issue that has potential impacts on energy security in the region — though unlike climate change, this one is (mostly) specific to Northeast Asia — is the regional security challenge posed by the North Korean nuclear weapons program, by its tenuous economy, and, more broadly, by relations between the DPRK and its neighbors. The status of the DPRK in relation to its neighbors affects a number of potential energy infrastructure choices in the ROK, and also significantly affects the prospects for regional energy cooperation. In addition, the ways in which other countries, in particular the ROK, choose to develop their own green economies may either open up opportunities to engage with the DPRK or reduce the possibilities for meaningful engagement.

Below we briefly outline how climate change and North Korean security might drive influence the results of policies designed to address energy security, urban security, and the development of green economies.

Influence of Climate Change on Energy Security Policies

Other chapters in this book, and earlier sections of this chapter, have touched upon the many interactions of the climate change issue with energy security policies, ranging from climate change mitigation as a driver of energy security policy to adaptation to climate change-related risks as a requirement of energy security, with challenges posed by the direct impacts of climate change on energy systems and energy users somewhere in between. Most of these interactions also have ramifications for urban security and green economy policies. A full and detailed listing of the interactions of climate change and energy security is well beyond the scope of this volume; a small sampling of these issues is provided below.

Climate Change Challenges in Northeast Asia

Some (but hardly all) of the energy security-related climate change challenges that are facing Northeast Asia include the following (and as alluded to in more detail in the country case studies earlier in this chapter):

Key Mitigation Challenges

- Reducing greenhouse gas emissions starting from a point of heavy fossil fuel dependence, while at the same time allowing for economic growth.

- Greatly increasing the efficiency of energy use.
- Developing alternative, non-fossil energy sources in nations where energy resources are limited without significant negative impacts on economies.
- Retooling existing energy sector institutions (both private and public) to facilitate the accomplishment of emissions mitigation, including capacity-building and public education on a vast scale.

Key Direct Challenges

- Protecting coastal energy (and other) infrastructure from storm/tidal surges and sea level rise.
- Protecting energy systems from the impacts of more severe weather brought on by climate change.
- Adjusting to the impact of higher temperatures on energy systems (such as the impact of water temperature increases and changes in fresh water availability on thermal power plant performance/availability and the impact of higher air temperatures on transmission line performance).
- Providing energy services for displaced populations.

Key Adaptation Challenges

- Compensating for climate impacts on human needs through greater use of energy services, with specific requirements ranging from greater use of air conditioning, to additional water pumping, to additional water treatment required due to factors such as saline intrusion into aquifers or climate-induced changes in soils in key watersheds.[99]
- Adapting energy systems to compensate for the greater risk to those systems due to a more variable climate (ranging from hardening/raising seawalls for coastal energy facilities, to strengthening or burying transmission lines, to diversifying energy sources so that damage to one source yields less economic disruption).
- Selecting and planting biofuels crops in a way that factors in changing climates.
- Development of necessary technologies for adaptation in a timely manner, and funding that development.

Climate Change Mitigation as a Driver of Energy Security Policies

Given these challenges (and many more), climate change mitigation has already become a key driver of energy security policies as demonstrated by the country studies provided above. Nations are now obliged to report impacts on greenhouse gas emissions as a key feature of their future energy sector plans, and climate mitigation performance is a central tenet of the green economy movement, though the balance between “green” and “economy” varies considerably depending on whose interpretation one looks at. Measures of climate change mitigation appear explicitly in the multi-attribute energy security calculus provided earlier in this chapter. In general, climate change mitigation requirements drive energy security policies in the direction of improving the efficiency of energy use and increasing the diversity and absolute capacity of non-carbon-based (or low-carbon) energy systems. The international impacts of national climate change mitigation policies must also be considered, however, and one nation’s progress on GHG emissions reduction may either improve the global climate — for example, by expanding markets and expertise in energy efficiency and renewable energy systems — or be effectively climate-neutral or negative — such as when countries

close their own energy-intensive industries, and thus effectively supply their own demand for the products of those industries by using the output of other nations.

Impacts of Climate Change Adaptation on Energy Security Policies

Anthropogenic greenhouse gas emissions stretch back to prehistoric deforestation, but since the beginnings of significant use of fossil fuels during the Industrial Revolution, they have increased the degree to which the earth's atmosphere retains solar heat to the extent that a significant increase in average global temperature is inevitable in the coming half-century and beyond, no matter what mitigation measure are taken. In fact, measurable global warming has already occurred. The inevitability of some level of climate change does not mean that mitigation efforts are not worthwhile, but it does mean that policies, programs, and actions to adapt to a changing climate will be necessary. Climate change adaptation policies can affect energy security policies in many ways. A very small selection of these possible impacts follows:

- Location of energy facilities: Climate change adaptation considerations will affect the location of some energy facilities. In the most basic instance, it will be necessary to site many coastal power plants or fuel transport terminals at higher elevations to protect them from sea level rise and storm surges. However, adaptation may mean that some power plants cannot be sited on rivers if the impacts of changing climate make inadequate the flow of cooling water at certain times of the year.
- Modifications to energy supply infrastructure: Adaptation to climate change will require a host of modifications to energy infrastructure, ranging from the construction of higher seawalls and levees to protect facilities near oceans, rivers, and lakes; to hydroelectric reservoirs to accommodate higher peak flows; to hardening transmission networks, wind turbines, and offshore oil and gas rigs against severe weather; to increasing peaking power capacity to accommodate power demand during periods of extreme heat. Other examples of required changes are increased capacity to provide power, clean water, and other necessities in an emergency (including, for example, emergency distributed generation), providing energy supplies for refugees from climate events, and even planning and implementing energy systems for new cities that must be created as existing low-lying urban areas are inundated by rising seas.
- Modifications to energy demand infrastructure: Examples of demand-side modifications to adapt to changing climate conditions include constructing buildings that require less water and energy to operate, re-sizing the capacity of systems such as air conditioning to meet expected demand, and, in extreme cases, moving to where climate may be more favorable.
- Modifications to planning: Climate change adaptation will affect energy security in many ways through its impact on planning requirements. Adapting to climate change will require changes in the ways that societies at virtually every level plan for the future. Urban and land use planning, for example, will have to strengthen its consideration of the interaction and integration of energy supply, demand, and climate considerations, as well as of how systems such as water, energy supply, and agriculture might need to be altered. Planning horizons will need to extend further into the future than is typical now, and there may need to be an increase in the regulation of the energy sector to ensure that planning is sufficiently long-range, coordinated, and integrated to serve society's needs for adapting to a changing climate.[100]

Impact of North Korean Issues on Energy Security Policies

The presence of a nuclear-armed, often-belligerent, yet in many ways desperately energy-insecure DPRK in the middle of Northeast Asia affects energy security, and energy sector options that might be used to address energy security, throughout the region. Some of the ways in which DPRK issues

affect energy security were alluded to above in the context of ROK energy policy. In general, North Korean security issues affect energy security in Northeast Asia, now and possibly in the future, in the following ways:

- Considerations related to defenses against potential DPRK attack: In designing and siting its energy systems — including nuclear power and other fuel-cycle facilities, as well as major conventional energy systems such as thermal power plants, refineries, and LNG terminals — the ROK, and to a lesser extent, Japan, needs to be cognizant of the vulnerability of energy systems to a direct or covert attack by the DPRK. This requirement limits and affects some energy system choices and has broad implications for many energy security criteria.
- Influence of a nuclear DPRK on nuclear fuel cycle choices by others: The fact that the DPRK has nuclear weapons and nuclear weapons capability, and has furthermore been developing missile technologies, cannot help but alter the way that the ROK and Japan think about nuclear deterrence. This topic is dealt with in much more detail in other chapters in this book, but in general, it seems highly likely that nuclear energy fuel-cycle decisions by Japan and the ROK are colored by DPRK nuclear weapons issues. For the ROK and Japan, developing or retaining nuclear energy fuel cycle processes that build or maintain the ability to, in a crisis, construct their own nuclear weapons to counter a DPRK threat, has to be a consideration, however tacit or denied, in their own energy security thinking.
- The DPRK as a "player" (or not) in regional mega-projects: There have long been proposals and even plans to move some of the vast energy resources — gas, coal, hydroelectricity, and oil — of the lightly-settled Russian Far East to the major demand centers of the ROK, China, and even Japan. Though some of these proposals have begun to come to fruition in recent years, progress in developing these large resource-sharing projects (power transmission lines, pipelines, transport facilities, and jointly-owned refineries, for example), particularly given the potential benefits for all participants in such trade, has been slow.[101] It seems very likely that if the DPRK enjoyed more "normal" relations with its neighbors (and the rest of the international community), these projects would have moved much more rapidly. So long as the DPRK nuclear stalemate continues, progress on these mega-projects for regional resource-sharing with the Russian Far East, and the energy security benefits (and costs) they represent, is not likely to accelerate.
- DPRK energy sector assistance considerations: When and if a breakthrough occurs in negotiations on the DPRK's nuclear weapons program, one of the key demands that the DPRK will make in return for freezing and eventually eliminating its nuclear weapons program will be energy sector assistance. This assistance will obviously affect the DPRK's energy security, but it will also likely impact the energy security of its neighbors in many ways. For example, the ROK may choose to help the DPRK complete the nuclear reactors at Simpo and purchase the power from those reactors, with impacts potentially both good and bad on its electricity supply security. As a very different example, the ROK and other nations might be obliged to increase their own commitment to and expertise in renewable energy and energy efficiency in order to provide energy assistance to the DPRK in those areas.[102]
- Clean Development Mechanism considerations: Again, when and if a breakthrough in negotiations with the DPRK occurs, the ROK and other nations will likely see opportunities to earn carbon credits through investment in a wide range of potential emissions-reduction projects in the DPRK. These will in turn likely have an impact on the energy security of other Northeast Asian nations by affecting investment in their own energy sectors in ways that could either be positive (through furnishing good examples of GHG reductions, and by cutting national GHG reduction costs) or negative (by diverting potential investment funds from domestic to DPRK projects).
- DPRK "collapse" considerations: In the unlikely (in our view,) events of a collapse of the DPRK regime or a negotiated political (or de facto economic) reunification of Korea, the international

community, with the ROK at the forefront, will likely bear much of the costs for redeveloping the DPRK energy sector and addressing DPRK energy insecurity. This will by definition increase energy security in the DPRK, but it is also likely, at least in the short run, to strain attempts at increasing energy security elsewhere by diverting investment funds and the attention of planners, for example. A special, short-term (possibly longer) case for the DPRK's immediate neighbors would be the need to provide energy services for a large number of border-crossing refugees in the event of a DPRK regime collapse.

- Green economy preparations: Consideration of the DPRK as a market for and/or potential supplier of green economy goods and services may affect green economy preparations in the countries of the region.

Assessing the Energy Security Impacts of Climate Change and DPRK Issues

Initiatives to address climate change and the DPRK nuclear weapons impasse (along with the related problems of energy/economy/development) can have significant impacts on energy security in the countries of Northeast Asia. Identifying and, where possible, estimating the extent of those impacts in a consistent and transparent manner is a necessary element in an even-handed and thorough comparison of energy policy alternatives. In the section that follows, we suggest an extension of the energy security analysis structure presented in the second section of this chapter to accommodate these (and potentially other) cross-cutting issues.

Energy Security in a Complex World

Interaction of Energy Security and Related Issues

Once the traditional, narrow focus on energy security as the means to obtaining sufficient fuel at a reasonable price is abandoned, a broader and far richer interaction of energy security policy choices with other issues is evident. The framework for energy security analysis summarized earlier in this chapter, and in writings by the authors and our collaborators dating back to 1998, emphasizes the multi-disciplinary aspects of energy security, with six energy security dimensions — energy supply, economic, technological, environmental, social/political, and military security — used to organize the evaluation of the energy security impacts of alternative policies.

In this chapter, many (though hardly all) of the interactions of energy security issues with other cross-cutting concepts and issues have been identified. Energy security and urban security are closely tied because providing energy services to urban populations typically consumes the bulk of national energy needs, and because many aspects of urban security depend on how and when energy services are provided. The "green economy" movement, though implemented in very different ways and at very different levels of effort in different nations, is in large measure an attempt to address the six dimensions of energy security in a comprehensive manner. Climate change mitigation and adaptation are policy goals that are intimately related to the dimensions of energy security, with desired outcomes primarily related to the environmental dimension, but with impacts on all of the other dimensions of energy security. Responding to the North Korean nuclear weapons program and to the DPRK's related "energy insecurities" is a policy issue unique to Northeast Asia, though a number of countries around the world are intimately involved. Policy solutions (or lack of solutions) to DPRK nuclear weapons-related issues can and do also affect the energy security of the nations of the region in multiple ways, from altering the siting of energy facilities, to limiting international resource sharing options, to influencing domestic energy system choices. Identifying and evaluating the interaction of policies to address these cross-cutting issues with the dimensions of energy security, and the impacts of energy security policies on these issues, is a crucial step in the policy evaluation process. Failure to consider cross-cutting impacts may lead

to over- or under-appreciation of the costs and benefits of specific policies, unintended consequences from policy applications, and missed opportunities for applying policies that are "robust" across multiple energy security dimensions and with respect to multiple issues. As a result, a complete analysis needs to be able to look at the implications of policies for these multiple, related issues together, rather than separately.

Working Multiple Considerations into the Energy Security Calculus

In an ideal world, analysts would be able to quantify all relevant parameters of a policy choice, weight those parameters in a manner that everyone could agree on, and thereby come up with a single index of energy security for any given policy plan.[103] Unfortunately, this energy policy analyst's dream is just that. Some of the most important dimensions of energy security stubbornly, and probably indefinitely, defy quantification, while some of the measures for those that can be quantified have shortcomings and/or special interpretations that must be fully understood.[104] Parameter weightings may seem objective when applied, but even the best weighting formulations include (and often obscure) substantial subjective judgment. Even when the weightings are arrived at through open, inclusive, transparent processes that involve a wide range of stakeholders, which is possible and appropriate, comparison of the resulting weightings across categories may result in conclusions that defy common sense, thereby jeopardizing the validity of the analysis.

The alternative to attempting a single index of energy security is to use the approach outlined earlier in this chapter, in which the different energy policies, plans, paths, or scenarios are scored, qualitatively and quantitatively, for their performance among the multiple dimensions of energy security in a "matrix" approach. The resulting matrix allows side-by-side comparison of options, with policymakers and stakeholders free to explicitly weight the different dimensions in the identification of a preferred strategy. This method does not avoid the application of subjective judgment — as such judgment is largely unavoidable in these complex decisions — but it does render such judgments much more explicit and transparent, facilitating understanding among parties on major policy decisions.

The matrix approach to energy security policy analysis can be adapted to include consideration of cross-cutting issues such as urban security, green economy development, climate change mitigation and adaptation, and DPRK nuclear weapons/energy insecurity issues. One way to accomplish this is to add measures and attributes under the different energy security dimensions (as identified in Table 3.5, above, for example) that reflect the performance of different policies with regard to the cross-cutting issues. Each cross-cutting issue may require one or more indicative measures and attributes in each of several energy dimensions. For example, possible energy security measures and attributes specifically related to urban security might include (but, again, are certainly not limited to):

- Diversity of energy supply sources for a particular city (Supply dimension).
- Capital and overall costs of a city's energy supplies and the impacts of energy sector outlays on the urban economy (Economic dimension).
- The impact of an energy policy on the technological diversity of energy supply and demand systems in an urban area (Technological dimension).
- GHG emissions produced in providing a city's energy needs, non-GHG air pollutants and water pollutants emitted within the urban boundaries, and the effect of an energy policy on the urban area's climate change adaptation needs and processes (Environmental dimension).
- The degree to which an energy policy lends itself to input by civil society and local government in the urban area (Social/Political dimension).

- The degree to which an energy policy increases or decreases the risk to an urban population of a major accident or state/non-state attack on energy facilities in the urban area (Military security dimension).

To explore the impact of cross-cutting issues on the energy security implications of different energy (or related) policies, an individual energy security matrix could be prepared for each cross-cutting issue of interest. A perhaps better, though possibly more cumbersome, approach is to attempt to develop key measures and attributes relating to each cross-cutting issue, and to evaluate the performance of several energy policies/plans with respect to all of those measure and attributes at the same time. Shading or coloring can be used to more clearly identify which attributes affect which cross-cutting issues. It is only by seeing the performance of the policies with regard to multiple issues that the links between issues, and the cross-issue impacts of policies, can be properly appreciated.

Lessons Learned: National and Regional Energy Policies that Address Multiple Issues

Discussions in this chapter on the complex linkages between energy security, urban security, the development of green economies, climate change, and the DPRK nuclear weapons/energy insecurity considerations have pointed to a number of energy policies that appear to be "robust" — that is, useful and productive to implement under a variety of conditions — with respect to these many different, but intimately linked, issues. Some of these policies with likely positive impacts on many different issues are offered below, along with a discussion of how civil society and local government actors could help bring them to fruition.

- Energy (and water use) efficiency improvement policies: Improving the efficiency with which electricity and other fuels are used has benefits across the spectrum of energy security dimensions and with regard to all of the cost-cutting issues. Efficiency improvements reduce urban insecurity by making supplies of energy and water go further, and by effectively increasing reserve capacity in times of stress. Using less energy reduces GHG emissions and is by definition a key feature of a green economy. Building and demonstrating expertise in energy and water efficiency offers Northeast Asian (and other) nations a key opportunity to peacefully engage the DPRK on a topic that is of use to and largely non-controversial for North Koreans. Local governments are key players in implementing energy efficiency efforts, due to the basic "bottom-up" requirements of most efficiency programs. Civil society groups contribute expertise to energy and water efficiency efforts, and help to catalyze and keep watch on both local efficiency programs (for example, programs offered by local or regional utilities) and national energy efficiency efforts, such as the promotion of energy efficiency standards for appliances, equipment, vehicles, and buildings.
- Land-use/urban planning to retain/remake green space and provide easy access to essential services: Related to energy efficiency improvements are planning and implementing changes in land use and land use development in such a way as to simultaneously reduce the need for energy and transport services and improve quality of life by building integrated living, work, and commercial spaces that serve as communities. Again, these activities are central to most concepts of the green economy, assist with climate change mitigation and potentially adaptation, and address a number of urban insecurity concerns. Here, the involvement of civil society and local government are central and crucial to making sure that land-use decisions make long-term sense and are consistent with the needs of residents and other stakeholders.
- Development of renewable energy resources: Much-expanded development and use of renewable energy systems is required if GHG emissions reduction is to become a reality. Renewable energy systems need not necessarily use domestic resources, but to the extent that they do, they can be used to address energy supply security concerns, help build local economies, and reduce non-GHG

pollution from fossil fuel use, among other attributes. Local governments and civil society in Northeast Asia can and do play active roles in promoting renewable energy use, including technology development, and in assuring that renewable energy systems offer a positive social impact.

- Development of distributed energy systems: Coupled with but not the same as renewable energy policies, the development of high-efficiency distributed energy systems, harnessing local production of electricity for use both on-site and on a shared grid, often in combination with heat for use locally, makes sense from the perspective of energy security (across multiple dimensions) and also provides urban security benefits, climate change mitigation/adaptation benefits, and helps with issues related to the DPRK (ranging from being another good topic for DPRK engagement to making the consequences of a DPRK attack on a single-energy facility less devastating). Renewable or fossil-fueled (for example, combined heat and power) energy systems can be integrated with buildings and industrial facilities, or can be shared in neighborhoods. Here, as with renewable energy systems, civil society and local government need to be active in promoting distributed energy systems through advocacy, expertise, and the development of local programs and regulations that support them. But they will also need to put pressure on central governments to fine-tune national policies in order to provide favorable treatment for distributed energy systems. Such treatment would include, for example, laws, regulations, and utility policies that stimulate the purchase of distributed renewable energy (such as grid interconnection rules and Feed-in Tariffs). Civil society and local government also need to encourage the development of "smart grid" systems that can help in encouraging energy efficiency, adapting in the event of climate events, and smoothly integrating distributed generation, electricity storage, and electric vehicles (as well as electricity storage using electric vehicles) into grid planning and into the grid itself.
- Planning for nuclear waste management: Although not a major topic of this chapter, making plans, and especially plans shared across nations, for the safe and effective management of nuclear fuel cycle materials and wastes is key to future energy security in multiple dimensions. Nuclear waste management affects the prospects for nuclear power (and new nuclear technologies), thereby affecting any GHG emissions mitigation impact that the deployment of nuclear power might have. Waste management also affects the cost of nuclear power, though not hugely. Whether the nuclear reactor fleet grows substantially in the coming decades or never grows at all, the volume of nuclear wastes currently extant and that will be produced by the current generation of reactors requires secure management. Options for nuclear materials management vary widely in terms of their impact on the environment and society, and here civil society can play a crucial role in making sure that the many issues related to waste management are clear to both decision-makers and to the public. Moreover, local governments have and will have a considerable influence on the types and locations of waste management facilities.

Implementing any or all of the above strategies, however, requires one element in short supply nearly everywhere — the human capacity to thoughtfully design, discuss, evaluate and carry out these types of policies within government, industry, and civil society. With typically highly-developed educational systems, the countries of the region have the necessary foundations to build such capacity, but the involvement of civil society and other groups will be crucial in making sure that sufficient financial and human resources are direct into programs to adequately prepare green economy leaders and workers for the future.

Developing and Applying Methods of Analysis of Energy and Related Policies

In this chapter we have outlined methods for evaluating the impact of energy and related policies on energy security, in its multiple dimensions, as well as on intimately related cross-cutting issues. Further methodological development is needed in order to more fully integrate the evaluation of the

impacts of policies on cross-cutting issues and, especially, to develop better ways of highlighting and summarizing the results of policy comparisons for easy access by relevant decision-makers, as well as by the civil society groups and others that would use the results of comparisons to guide policy development. A major challenge is how to make such summaries approachable and useful, while still retaining the richness and salience of the multi-dimensional analysis. A second general area of "next steps" is to develop more detailed energy policy paths, similar to those reviewed above for the ROK, in each country of the region, evaluate their energy security results using the "matrix" analytical structure and other tools, and use the combination of this analytical framework and national energy paths to evaluate how coordinated energy policies in Northeast Asia might contribute to improved regional energy security.

Opportunities for ROK Foreign Policy to Drive Energy Security in Northeast Asia

Although it is not the country with the largest land area, population, or economy in the region, the ROK occupies a crucial and central place not just in the geography of Northeast Asia, but in its policy future as well. Below we summarize how the ROK influences energy security policy in the region in general, identify some specific ROK policies that affect regional energy security and related issues, and describe how ROK policies might be adjusted to provide for improvements in energy security and in the other cross-cutting issues discussed in this chapter, both domestically and region-wide.

The ROK's Influence on Regional Energy Security

The Korean peninsula in general, and the ROK in particular, is geographically located in a central hub among Northeast Asian nations, connected by land to the lightly populated but resource-rich expanse of the Russian Far East via populous, rapidly developing China, and separated by only a few hundred kilometers of sea from highly-industrialized Japan. As a result of this geographical position, most proposals for regional energy and transport hubs go through the ROK.[105]

As a major fuels importer, the ROK's choices of how it obtains fuel supplies affect potential fuel suppliers, including Russia (with whom the ROK has for years been in consultations regarding potential power-line and pipeline projects, as well as road and rail projects), but they also have implications for other major energy importers, including Japan and China, who might either share or compete for Russian Far East resources exported via major international energy (and transport) infrastructure projects. The ROK's decisions to pursue LNG and refinery projects affect the international markets for LNG and crude oil, and thus also influence transport and production projects in those sectors worldwide. ROK commercial interests seek, with government backing, to develop and secure oil and gas supplies on several continents, where they compete with Northeast Asian and other "players" for economic and political influence in resource-rich nations.

As the home to companies that are major manufacturers and exporters of a large number of energy demand devices and equipment — ranging from household appliances to vehicles to machinery — the ROK's own efficiency standards, and those that apply to goods for export, affect energy demand throughout the world. As a major user of nuclear power, as well as a producer and, as of 2015, planned exporter of nuclear technologies,[106] the ROK affects the use of nuclear power in other nations. In addition, and as noted in more detail in other chapters of this book, the ROK's positions on nuclear fuel cycle activities in general, and particularly on the reprocessing of nuclear wastes by extracting plutonium for further use in reactors (the ROK nuclear sector's favored, though not yet developed, technology for reprocessing is a variant known as "pyroprocessing"),[107] affects (and is affected by) the positions on nuclear fuel cycle technologies taken by neighboring countries, especially the DPRK and Japan. And, as a major electronics manufacturer, the ROK is in a position to be a leading force for the development and implementation of low-cost solar photovoltaic power

systems.

The ROK is at once a nation with aspirations to lead the world in the development of green technologiesand in transitioning to a green economy, and a nation with significant political, financial, and mercantile connections with industrialized and developing nations around the world. It is thus poised to provide an example — for good or for bad — to other countries on how to affect a transition to a green economy.

As one of the two main players in the sixty-year-plus saga that is the partition of the Korean peninsula, the ROK has a major influence on when, if, and how conflicts with the DPRK are to be resolved, and, once resolution is underway, the path by which the DPRK's evolution (or not) to a modern economy and "normal" nation, up to and including reunification with the ROK, will take place.

Finally, but as just as importantly, as a nation where civil society and local governments are just beginning to exert their influence in the national energy policy arena, the ROK is in a position, through networks with similar groups across the region and the globe, to be a catalyst for changes in the way that the ROK and its neighbors respond to energy security and related challenges.

Potential ROK Policies to Enhance Regional Energy Security

The ROK's policy choices, and how it pursues them in the coming decade, have significant potential to shape energy security — broadly construed to include not only the six dimensions described above, but elements of urban security, green economy, climate change mitigation/adaptation, and DPRK issues as well — both domestically and in the Northeast Asia region for years to come. A complete listing of the policies that the ROK might pursue, and their impacts, is beyond the scope of this chapter, but a sampling of such policies follows, briefly describing their potential impact and keyed to the ROK's influences on regional energy security.

- The ROK's policies of seeking to diversify energy sources by purchasing oil, gas, electricity, and perhaps coal from the Russian Far East have helped to move along discussions of regional energy networks, but more could be done to support such infrastructure projects. For example, the ROK could continue to work with governments in the region and commercial interests to move closer to resolving some of the key financial, technical, and environmental issues that have to some extent slowed the development of regional energy supply infrastructure. Key among these is resolution of the North Korean nuclear and energy insecurity problem. The ROK could use the prospect of the DPRK's involvement in (and profiting from) regional energy infrastructure development as an inducement to engage on nuclear weapons and related issues. In so doing, the ROK would be helping to address the DPRK issue as well as its own energy security needs. The ROK could also condition its involvement in regional energy sharing schemes on making sure that such schemes result in a net reduction of greenhouse gas emissions region-wide.
- In order to enhance energy efficiency as much as possible both at home and abroad, and thereby build demand-side and manufacturing infrastructure for both a domestic and export-oriented green economy, the ROK should adopt stringent energy efficiency standards for the energy- and water-using devices made in the ROK, including both standards as to the efficiency of devices sold for use in the ROK and standards of devices destined for export. By adopting the most stringent practical efficiency standards, the ROK will contribute to energy and GHG savings at home and abroad, and will also serve help to raise standards for energy efficiency worldwide.
- Relatedly, and to help move green economy activities forward, the ROK should rapidly adopt local and national regulations, standards, and guidelines to recycle all types of materials, and to incorporate recyclability into manufactured goods, as much as possible. This will reduce the

energy and materials intensiveness of the ROK economy, and indicate to the world that the ROK is serious about its green economy efforts.

- In the nuclear sector, the ROK should undertake a serious and even-handed exploration of the benefits of different fuel cycle options, but do so in a way that also considers the probable implications of its policies on the nuclear policies of Japan and, in particular, the DPRK. Moreover, the ROK should open its nuclear policy discussions to a much wider group of stakeholders, including those from civil society and local government. Specifically, the ROK should carefully examine the costs (including social and political costs) and benefits of any kind of reprocessing activity, and seriously consider officially abandoning reprocessing, which would likely be a helpful step in getting the DPRK to agree to give up its nuclear weapons program. And the ROK should also carefully examine different alternatives for storage and eventual disposal of nuclear wastes and spent fuel, again in close consultation with local governments and other stakeholders. Finally, as a nuclear technology exporter, the ROK should explore and adopt export regulations designed to strictly meet non-proliferation standards, and work with other nuclear suppliers to make sure that client countries adhere to the IAEA Additional Protocol and other stringent nuclear oversight mechanisms.
- The ROK should encourage domestic manufacturing of advanced renewable energy and distributed generation devices through, for example, a combination of national competitions for renewable energy innovation, Feed-in Tariffs for renewable power that are consistent with the most aggressive among developed nations, utility incentives for customers to adopt renewable power, renewable portfolio standards for distribution utilities, and much more aggressive national targets for renewable energy development. Local governments, encouraged by civil society, could develop their own renewable energy ordinances and incentives, as well as equipping local government buildings and other installations with renewable energy systems (and energy efficiency measures) in “lead by example” programs.
- The ROK should review its green economy initiative to focus on bottom-up measures to build the green economy rather than top-down impositions, including de-emphasizing mega-projects such as new “green cities” and nuclear power. This will mean working closely with local governments and civil society organizations at the local level to design custom green-economy solutions that work for specific communities, as well as working with industry on green economy-related research and development.
- The ROK should rethink its approach to engagement with the DPRK, which as of 2015 largely consisted of non-engagement. The ROK has much to gain, both for its near-term and long-term energy security future, if engagement with the DPRK bears fruit. Possible benefits to the ROK include access to the DPRK’s mineral and energy reserves, the potential to move forward with mutually-beneficial regional energy sharing options, the possibility of sharing energy facilities (potentially including nuclear power sites and LNG terminals) with the DPRK, access to the DPRK’s markets and labor force, the potential to receive Clean Development Mechanism credits for GHG-reducing measures in the DPRK, and, most importantly, the opportunity to help rebuild the DPRK’s entire energy system and other infrastructure in advance of eventual Korean reunification.

Key Lessons for ROK Domestic and Foreign Policies

The suggested policies that the ROK might pursue to improve domestic and regional energy security have several basic common threads. With respect to its activities and policies abroad, the ROK should develop strict guidelines for how it interacts with other nations so as to strongly support green economy, sustainability, and non-proliferation goals everywhere through its products, services, international aid, and other interactions. In order to develop and maintain international leadership in these areas, the ROK government should adhere to these guidelines in all of its

activities abroad, embody them in its activities at home, and demand adherence to the guidelines by ROK companies. Civil society should be involved in helping the government develop its green economy/sustainability support guidelines and, once the guidelines are implemented, should maintain oversight of ROK activities globally to make sure that they are adhered to. Local governments could help support these guidelines by fostering relationships (for example “sister city” ties) with local governments in other nations geared toward modeling and promoting green economy principles.

With respect to the special case of interactions with the DPRK, the ROK should look for and embrace engagement opportunities wherever and whenever it is prudent to do so; focusing on green economy engagement in particular is likely to be more acceptable in the ROK and easier for the DPRK to say “yes” to. Civil society groups can support such engagement through pressuring the government to engage, and by carrying out their own capacity-building and aid projects with the DPRK, to the extent that such cooperation is possible.

With respect to domestic energy security policies, many of the energy sector and related policies that are the most robust in terms of both the broad energy security dimensions and their impacts on cross-cutting issues are policies that, for the most part, need to be implemented at the grassroots level. This means that local governments will have a key role in developing, implementing, and supporting these activities, but national government actors will need to support the bottom-up efforts with consistent, patient policies and enforcement, and with funding. Companies will need to develop products and services to support the local green economy effort. And civil society will need to assist efforts at all levels, press for more aggressive action where appropriate, and demand transparency in the development and implementation of green economy and related energy policies.

The complexity of the energy security dilemmas facing the ROK, the region, and the world mean that many different government and non-government actors will have stakes in energy security decisions. It is crucial that these actors have the opportunity to talk with one another to share information and ideas, but the Korean government (as with many other governments) has traditionally been structured so as to discourage discourse between key analysts and decision-makers in different ministries, except for those at the very top. The access to government officials by those outside the government has also been uneven, with some groups — notably business-related — enjoying much better access than others. Setting up and operating inter-ministerial task forces with both responsibility and authority to address issues that cross ministerial boundaries may help to alleviate this problem, but a general society-wide move toward inclusive decision-making is desirable, though the transition is unlikely to be rapid. Civil society is in the best position to try and catalyze such a transition by calling for transparency and accountability on issues of importance.

Key Lessons for ROK and Northeast Asian Energy Policies

Energy security has traditionally been viewed as simply or largely a matter of securing sufficient and consistent supplies of fuel at a reasonable cost. Energy security policies, however, have consequences in so many different dimensions that this narrow definition is woefully insufficient for the evaluation of possible future actions. Consideration of at least six dimensions of energy security policies — energy supply, economics, technology, environment, social/political, and military security — is needed in order to begin to understand the full level of candidate policies’ impacts. Moreover, energy security concepts overlap considerably with Northeast Asian issues such as urban security, development of green economies, climate change mitigation and adaptation, and addressing the coupled issues of DPRK nuclear weapons and energy insecurity. When energy and related policies are developed in a way that fails to adequately consider the complex, cross-cutting nature of these issues, the resulting policies are liable to face major problems in implementation and result in significant unintended consequences, many of them undesirable. Adopting a more comprehensive

analytical framework for energy policies is hardly a guarantee against policy failure, as the future is nothing if not capricious, but it does provide expanded opportunities to spot and address problems before they develop, and, perhaps most importantly, it provides a comprehensive way to transparently explore issues and simultaneously offer opportunities for stakeholders from a variety of different backgrounds, disciplines, and interests to contribute to policy analysis and development. The involvement of a broader coalition of stakeholders, notably including civil society and local government, as well as elected officials, government ministries, and commercial interests can help assure that energy policies, if chosen by broad consensus based on a review by many parties across multiple attributes, will be easier to implement, and more likely to perform as intended, than policies developed and considered more narrowly.

Energy policies that focus on energy efficiency, renewable and distributed energy development, consideration of local community development, and related, largely bottom-up types of measures are typically likely to make the most progress on moving the ROK and its regional neighbors toward green economy goals and solutions to other problems. Bottom-up approaches in the ROK, as in most if its neighboring states, have not, however, been the traditional means of policy development — rather the opposite. This fundamental disconnect of top and ministry policymakers with those that need to be involved in on-the-ground program/project design and implementation must be addressed if significant progress is to be made on developing energy-secure green economies in the region while simultaneously addressing climate, DPRK security, and other issues as well.

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101 See, for example, von Hippel, D., et al. (2011). Also papers by a number of authors prepared for Nautilus Institute workshops, Power Grid Interconnection in Northeast Asia (Seoul: Nautilus Institute),https://nautilus.org/projects/by-name/asian-energy-security/workshop-on-powe--grid-interconnection-in-northeast-asia/

102 See, for example, von Hippel, D. and Hayes, P., "DPRK Energy Sector Development Priorities: Options and Preferences," Energy Policy, 39(11) (2011), doi: http://dx.doi.org/10.1016/j.enpol.2009.11.068. Hayes, P. and von Hippel, D. (2012).

103 For further discussion of some of the difficulties involved in establishing composite metrics for energy security, see von Hippel, D., et al. (2010).

104 A common measure of the energy efficiency of an economy, energy use per unit of GDP (or its inverse, GDP per unit of energy used) is an example here, as it depends on multiple factors, including how efficiently energy is used to accomplish specific tasks, which fuels are used (as some can be used at higher efficiencies than others), and to what extent changes in the index are the result of shifts in the economy to less energy-intensive industries, which can be accomplished either by reducing the materials-intensity of the domestic economy or by moving the production of energy-intensive goods and services to other nations — two approaches with very different impacts on global energy and environmental problems.

105 See, for example, Paik, H., "Northeast Asian Energy Corridor Initiative for Regional Collaboration," Journal of East Asian Economic Integration 16(4) (2012).

106 See, for example, Nuclear Power in South Korea (London: World Nuclear Association, 2013),http://www.world-nuclear.org/info/Country-Profiles/Countries-O-S/South-Korea/#.UgPXcW33M5s

107 "Pyroprocessing" is a variant of reprocessing in which "the plutonium separated from spent fuel

by pyroprocessing remains mixed with other elements." See, for example, Horner, D., Pyroprocessing Is Reprocessing: U.S. Official, Arms Control Today (Arms Control Association, 2011). See also Kim, D. and McGoldrick, F., Decision Time: US-South Korea Peaceful Nuclear Cooperation, Academic Paper Series (Washington, DC: Korea Economic Institute, 2013).

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Nautilus Institute
608 San Miguel Ave., Berkeley, CA 94707-1535 | Phone: (510) 423-0372 | Email:
nautilus@nautilus.org