

Korea's Energy Insecurities

Comparative and Regional Perspectives

Kent E. Calder

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Foreword

The Korea Economic Institute (KEI) is pleased to issue the third volume in its Special Studies series. In contrast with KEI's other publications, which generally take the form of compilations of relatively short articles on analytical and policy issues by a number of authors, this series affords individual authors an opportunity to explore in depth a particular topic of current interest relating to Korea.

In this book, Dr. Kent Calder examines the actual and potential sources of energy available to each of the two Koreas as well as present and prospective policies to address the insecurities that each country faces. He weaves together the complex political-security considerations and the compelling laws of economics. This book is particularly timely in light of the recent Declaration of Principles agreed at the fourth round of the six-party talks.

KEI is dedicated to objective, informative analysis. We welcome comments on this and our other publications. We seek to expand contacts with academic and research organizations across the country and welcome proposals for other Special Studies.

Joseph A. B. Winder
President
Korea Economic Institute
November 2005

Preface

Much has been said and written about the North Korean nuclear crisis as well as how the world should deal with the DPRK itself. Energy lies at the heart of virtually all policy approaches to the Korean peninsula's future—be they diplomatic, political-military, or economic in character. Energy was central in the efforts to deal with the 1994 confrontation between the United States and North Korea, and energy is a key element in the ongoing six-party talks.

For all their policy importance, the details of Korea's energy insecurities remain curiously opaque to general readers and even to most political and economic decision makers as well. This monograph is a modest effort to help fill that basic knowledge gap. I have been interested in the topic for years and have worked on Asian energy problems, in both their economic and security dimensions, for more than a decade. I am grateful to the Korea Economic Institute, especially President Joseph Winder and Vice President James Lister, for suggesting a serious study of the question and allowing total intellectual freedom as to how to proceed, as well as supporting travel and research.

Many have helped make this project a reality over the many months and, indeed, years that it has been in progress. Sincere thanks are due to the Korea Foundation for its help in inspiring the author's deep basic interests in Korea's political economy and its future. Seoul National University's Graduate School of International Studies provided a fruitful research environment. Yukie Yoshikawa provided creative, insightful, iconoclastic, and energetic research assistance without which this project simply could not have been completed. Commentators Fereidun

Fesharaki, Mikkal Herberg, and Park Bok-yeong provided insightful comments that greatly improved the final manuscript. Mary Marik did expert copyediting.

Yet the final product, in reality as well as in rhetoric, must be the responsibility of this author alone. My hope is that this work, on the basis of its strengths and despite any shortcomings, will deepen a broadening transnational dialogue over Korea's energy insecurities. That debate clearly has major implications not only for the Korean peninsula but also for the sort of world that Northeast Asia and its trans-Pacific partners will confront in future years.

Kent E. Calder

Introduction

For more than a half century, the specter of renewed conflict across the demilitarized zone (DMZ) has dominated thinking about Korea's future. To be sure, the prevailing political-military situation at the DMZ is dangerous, periodic changes in diplomatic atmospherics notwithstanding. Close to two million men remain under arms on the Korean peninsula, more than the standing armies of either the United States or the former Soviet Union. A heavy share of those forces are still forward deployed within 50 miles of Seoul and its 12 million civilians, across a no-man's-land never marked by a formal peace accord.

During the past 15 years, the North-South confrontation has been transformed into a more complex and multifaceted security challenge. In 1993 the Democratic People's Republic of Korea (DPRK, or North Korea) successfully launched No-dong mobile missiles into the East Sea (Sea of Japan). And in 1998 the DPRK launched a multistage Taepodong missile over Japan itself. Pyongyang also has extensive chemical, biological, and nuclear weapons programs, as is well known. When North Korea solves demanding technical problems impeding weaponization of its nuclear devices and weapons delivery, it will have the credible potential to seriously threaten both Japan and nations beyond.

Yet the political economy of the Korean peninsula, together with its long-standing military confrontations, is rapidly changing—the North Korean missile and nuclear crises notwithstanding. Economic growth and technological change are relentlessly shifting the locus of power on the peninsula south of the DMZ. Even amid dramatic, historic developments in the North Korean nuclear crisis, it is important now to think

beyond traditional security threats to broader, often neglected challenges of the longer-term future.

Central Importance of Electric Power on the Korean Peninsula

Energy and the uncertainties linked to its varied forms of supply may loom disturbingly large on the Korean peninsula. One need look no further than the specter of North Korean nuclear potential in the wake of Pyongyang's February 2005 declaration that it is a nuclear-weapons state and the surrealistic contrast with the DPRK's desperately broken electric power grid to grasp the interrelated security and economic importance of energy to the Korean peninsula's future. Energy is inevitably a central part of both the problem and the solution to the North Korean nuclear crisis.

Energy is also an excellent vehicle for engaging the national interests of the United States with the healthy, stable evolution of both the Korean peninsula and the whole of the Northeast Asian region. The security interests of the United States in forestalling the proliferation of weapons of mass destruction have been well articulated. Also important is an often neglected political-economic imperative: ways for U.S. energy firms and other U.S. private investors to become positively involved in Northeast Asian development and to demonstrate concretely that such involvement can translate into U.S. jobs and corporate opportunity. Historically, it has been diplomats, missionaries, and especially the military that have dominated the U.S. presence on the Korean peninsula. More business involvement—closer to the pattern of U.S.-China ties—could well help draw the United States toward continental Northeast Asia in a more enduring and balanced fashion than has often been true in the past.

Energy insecurities on both sides of the DMZ have long cast a troubling shadow across Korea's postwar economic development. In South Korea (the Republic of Korea, or ROK), more than three decades of sustained growth before the 1997–98 Asian financial crisis brought rising dependence on volatile international energy markets as the development of a powerful national industrial base outstripped modest domestic resource endowments. Both the oil shocks of the 1970s hit Korea hard. Today, in the wake of the 1997–98 financial crisis, energy dilemmas universally implicit in rapid economic growth once again threaten to reassert themselves in Korea, albeit this time more with respect to electric power infrastructure than to oil. The fact that economic growth has transcended Korea to include most of its neighbors—

especially China—makes Korea’s deepening energy insecurities especially threatening.

The sharp differences in the energy economies of North and South Korea are obvious—a few are income level, adequacy of infrastructure, and access to international markets—and need not be belabored. This monograph, therefore, starts from a more challenging, counter-intuitive, and yet ever more policy-relevant contention: that Korea’s energy economy needs to be seen as an analytical whole. Many of the peninsula’s problems are common to the North as well as the South despite the obvious need for contrasting short-term responses. And the shadows of reunification are deepening.

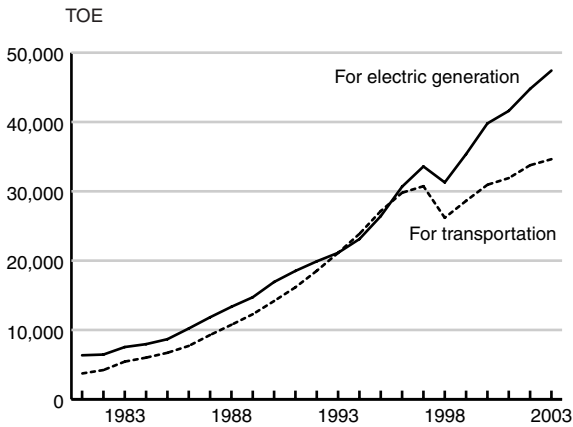
North Korea shares the South’s fundamental problem of limited natural-resource endowment. To be sure, in the North, lower growth as well as the still substantial, if low-quality, local coal reserves have made greater energy self-sufficiency possible. The economic backwardness and political isolation of the North have temporarily bred a converse problem: inadequate foreign exchange to procure needed energy imports. Yet, accelerated growth, when it comes, will bring with it many of the dilemmas that have plagued the South in past years.

Apart from an underlying lack of domestic oil reserves—coupled, in the North’s case, with an inability to secure adequate imports—another basic challenge unites the two Koreas: providing an adequate electric power supply. For the North, the basic issue is twofold: the inefficiency and obsolescence of its hydro and coal-fired electric power generating capacity as well as a chronic lack of spare parts. Because of such difficulties, 70 percent of the country’s entire power generation capacity is either abandoned or in urgent need of repairs.¹

Added nuclear power capacity offers to Pyongyang the appealing, if facile, prospect of one-stop energy independence. Despite a lack of oil and gas reserves, and despite obsolete and decaying conventional electric power generating facilities, North Korea believes that with nuclear power it could potentially eliminate what has long been its economic Achilles’ heel and do so in a fashion consistent with its underlying philosophy of self-reliance. The North’s persistent efforts of the past 15 years to develop nuclear power are thus motivated by autarkic impulses much broader and more complex than simply wanting to pos-

1. Figures are for 2003; see Ministry of Unification (Seoul), www.unikorea.go.kr/en/.

Figure 1.1: Electricity Demand in South Korea, 1981–2003, in tons of oil equivalent (TOE)



Source: KEEI (various years).

sess nuclear weapons, although the North clearly seems to include a persistent quest for nuclear weapons capability as well.

For South Korea, electric power also lies at the heart of its energy equation, albeit in a different way. As indicated in *Figure 1.1*, electric power demand has been rising steadily across South Korea since the Asian financial crisis, even as transportation use of energy has stagnated. The rapid rise in electricity demand is the driver for South Korea's rising coal, nuclear, gas, and hydro use and also for the South's growing concern with energy infrastructure—North and South. In this sense, the June 2005 ROK proposal to supply two gigawatts of power to North Korea through construction of new power stations and the extension of South Korea's grid addresses an energy problem larger than just resolution of the North Korean nuclear crisis, and it needs to be evaluated in those comprehensive terms. The proposal explicitly provides, of course, for new power supply directly to the North, in roughly the amounts promised under the 1995 Korean Peninsula Energy Development Organization (KEDO) agreement. Yet it does so through the construction of large new power plants in the South that can help address the South's deepening shortage of electric power capacity as well. This innovative plan, addressing as it does the energy dilemmas of both North and South from

an integrated perspective, may well have defects of design, but its integrated approach will likely be emulated in future years.

Korea's Energy Insecurities in an International Context

Korea's pronounced energy insecurities, both North and South, can usefully be viewed in an international context that clearly compounds those vulnerabilities. Like Japan, Taiwan, and mainland China's coastal provinces, Korea as a whole lacks domestic oil and natural gas reserves. Yet South Korea, in particular, has a remarkably high level of energy consumption. Although only the world's 26th-largest country in population and 11th in gross domestic product (GDP), South Korea was 10th globally in primary energy consumption during 2002, 7th in oil usage, and 5th in crude oil imports.² It has subsequently become the world's 4th-largest oil importer.

Oil demand may well be slowing in the ROK as the transportation market matures, as industrial consumers economize, and as electric power providers shift to natural gas and nuclear power. Overall, South Korean energy demand will continue to rise, fueling a deepening of Korea's energy insecurities. The Korean Energy Economics Institute projects the growth of primary energy demand in the ROK at between 2.5 and 3.3 percent during the 2004–09 period (KEEI 2005). Practically any positive economic development in the North would accelerate that demand growth still further.

Korea must supply its rapidly rising thirst for energy in what is arguably the most competitive energy neighborhood in the world. One neighbor, Japan, has been the largest liquefied natural gas (LNG) importer and the second-largest oil importer on Earth. And next-door China alone accounted for more than one-third of world oil-demand growth during 2000–04. In tight global markets, Korea's energy-security tasks are indeed sobering in their scale, scope, and intensity.

2. For population, see DOE (2003); for gross domestic product (GDP), see World Bank (2005); and for energy consumption, see BP (2005).

South Korea's Triple Energy-Security Dilemma

South Korea confronts some of the most severe energy-security dilemmas in the world, and these dilemmas form an unusual triad combination, intensifying the challenge that they present to the country's economic future: Most fundamentally, Korea lacks domestic sources of energy to fuel its remarkable, rapidly growing, and energy-intensive economy. To make matters worse, it is unusually dependent on oil as a fuel source. In addition, most of Korea's oil, together with much of its natural gas, comes from the volatile Middle East.

The most basic, underlying problem is that Korea's rising energy demand confronts an extremely limited domestic resource base. With large steel, shipbuilding, and petrochemical sectors, the ROK has one of the most energy intensive industrial structures on Earth; and it is still growing rapidly, which of late has naturally intensified energy use, particularly electricity.

Comparative Perspectives

In the face of rapidly rising demand, Korea³ stands virtually devoid of domestic sources of energy. The only major energy resource in which the ROK is self-sufficient is anthracite coal for its steel industry. Pro-

3. This chapter deals exclusively with South Korea (ROK); therefore, references to Korea should refer to South Korea unless otherwise specified.

duction of anthracite has declined sharply since 1990 owing to rising production costs and the relative inconvenience of using domestic anthracite compared with using imported fuels.

Korea's paucity of natural resources leaves the country no choice but to rely heavily on imports. Of its total energy supply, 84 percent comes from abroad—one of the highest levels in the world. By comparison, Japan imports 82 percent of its energy, Germany 60 percent, and the United States only 27 percent (IEA 2004a).⁴

Korea—obtaining 50 percent of its primary energy from oil compared with a global average of 38 percent—is unusually dependent on oil as a fuel source. Apart from oil's heavy use in transportation as Korea becomes an automobile society, the ROK also uses oil extensively to fuel power plants and provide home heating, with gasification still underdeveloped in comparative terms. To make matter worse, Korea has one of the highest levels of oil dependence on the volatile, uncertain Middle East of any nation in the world—a dependence that has risen sharply during the past decade.

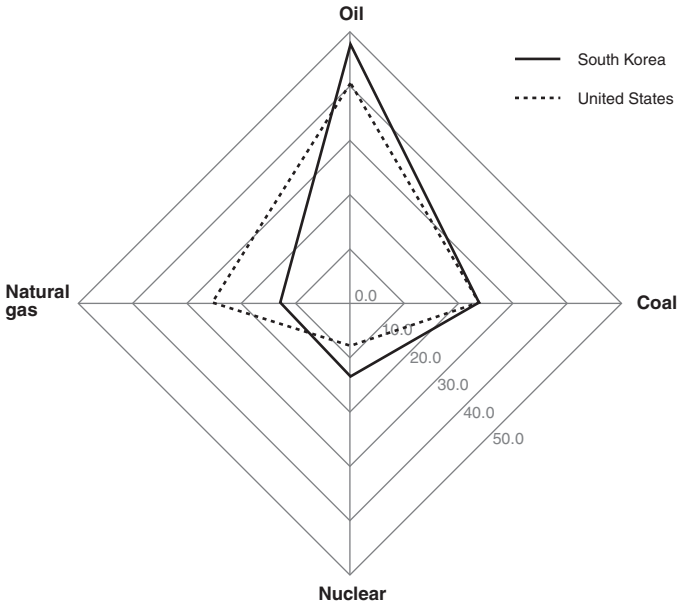
To overcome these multiple dilemmas, both North and South Korea have been unavoidably attracted to nuclear power. In the case of South Korea, reliance on nuclear power deepened rapidly and largely without incident, until checked by domestic nongovernmental organization (NGO) opposition during the 1990s. North Korea's nuclear program, of course, has been much more controversial and politicized owing to the DPRK's clear, admitted efforts to manufacture nuclear weapons.

Korea's Oil Insecurities

As indicated in *Figure 2.1*, oil is overwhelmingly the most important source of primary energy in South Korea, despite the ROK's total lack of onshore oil and its highly exposed position in global oil markets. Indeed, South Korea's 50 percent dependence on oil as a fuel source is significantly higher than even Japan's 47 percent, which represents the highest level among the Group of Seven (G-7) industrialized nations. Recent oil demand growth has also been unusually high in the ROK compared with demand growth in other advanced economies. In many such nations, oil demand has been actually declining in the face of spiraling prices worldwide.

4. Figures are for 2002; they are calculated by net imports divided by total primary energy supply.

Figure 2.1: South Korea's Heavy Reliance on Oil



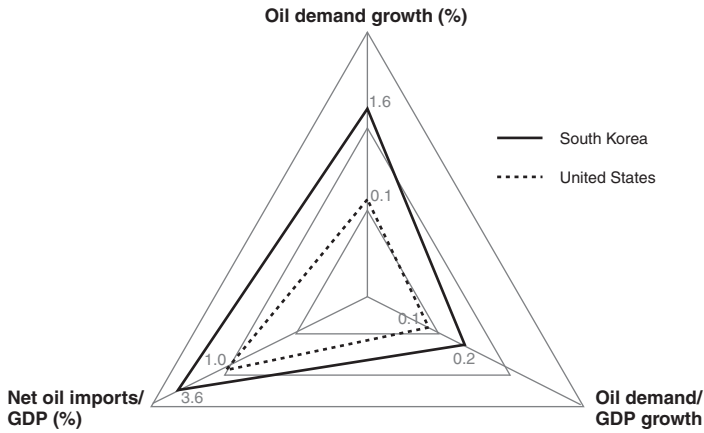
Source: BP (2005).

As shown clearly in *Figure 2.2*, oil imports are also inordinately high in Korea relative to GDP, reflecting both the country's energy-intensive industrial structure and the utter lack of domestic oil reserves. A shift toward a more knowledge-intensive industrial structure, centering on computers and telecommunications, has reduced the energy intensiveness of Korean industrial structure, while diversification toward natural gas and nuclear power has marginally reduced oil dependence. Nevertheless, Korea's distinctive oil reliance remains higher than in any other major industrialized nation.

Korea's oil-centric energy dilemma can be usefully understood by examining the peninsula's domestic energy consumption structure. Korea, like China next door, traditionally has relied heavily on coal for heat and light. It is charcoal, for example, that typically heated the floors under Korean homes. For many centuries, that heating method had been a highly advanced technical innovation.

Figure 2.3 shows, however, that the historical Korean pattern of coal reliance was transformed in the South during the 1980s and early

Figure 2.2: Three Dimensions of South Korea's Oil Vulnerability



Source: BP (2005), DOE (2005).

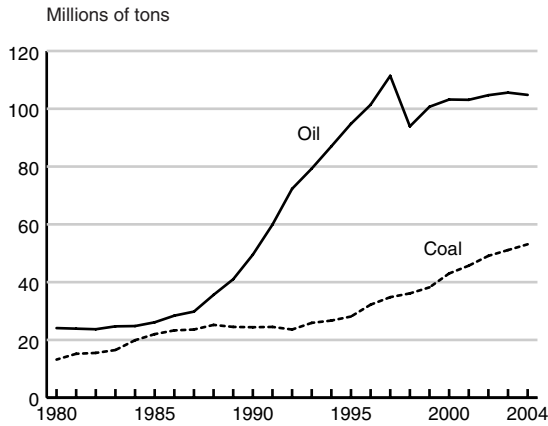
1990s to a new pattern of heavy oil dependence. Indeed, South Korean oil consumption rose 266 percent during the 1980–95 period. In fact, during that era South Korea’s oil use rose faster than oil use in any other Asia-Pacific Economic Cooperation (APEC) economy, contributing 22 percent of the entire Pacific region’s growth in oil consumption during those years.

As Figure 2.3 clearly suggests, there have been two major trends in the recent history of South Korean oil consumption: pre-1997 and post-1998, with the Asian financial crisis as a watershed. During the 1987–97 decade, oil demand expansion was explosive. Since 1998, however, it has been largely static owing to market maturity. In 2004 Korean oil consumption actually declined slightly.

The ROK’s high and deepening reliance on oil as an energy source during the decade preceding the Asian financial crisis occurred for three reasons.

- First was an important, embedded historical reality. Korea had grown to global economic prominence in an era when oil was plentiful and global oil prices were steadily declining, especially when calculated in terms of a strengthening Korean *won*. Economic planners and senior corporate executives found it rational in such times to capitalize on these oil-bearish trends and to

Figure 2.3: South Korea's Dependence on Oil, 1980–2004



Source: BP (2005).

configure Korean industry, especially during the high-growth pre-oil shock decade, in seemingly rational energy-intensive fashion.

- Second, the low and declining level of global oil prices during the 1980s and 1990s, especially when calculated in *won*, together with the Korean government's policy of encouraging imported oil reliance and the growth of energy-intensive industries, gave rise to an additional, more proximate reason for Korea's strong oil reliance: the highly oil-intensive character of Korea's industrial structure. The Korean steel, shipbuilding, petrochemical, and fertilizer sectors remain among the most oil-intensive industries in the world. All continue to be important to a Korean economy that is just now making the transition to a knowledge-intensive industrial structure that neighboring Japan undertook during the 1970s and 1980s.
- Third is the fact that for many years Korea's oil demand was rising so rapidly because of Korea's automotive revolution. After the second oil shock of 1979–80, auto ownership sharply expanded, encouraged by declining oil prices in *won* and cooperative Korean government-business efforts to develop a domestic auto industry. Strengthening of the *won* after 1979 was

especially important in propelling motorization and expanded transport demand because consumer spending tends to be especially price sensitive.

Koreans have developed an almost American-style propensity for driving that contrasts with the greater mass-transit reliance of their Japanese neighbors. In 1999 Korea's annual average driving mileage per vehicle reached 19,500 kilometers, compared with 119,100 kilometers in the United States and only 10,000 kilometers in Japan.⁵ Gasoline consumption per vehicle was 2.4 times that in Japan.

As a consequence of heavy automobile use, Korean energy consumption in the transport sector rose 12-fold, from 5 to 60 million tons of oil equivalent (MTOE) between 1980 and 1995, with most of the gains coming in the last half of that period (Yokoburi 1998, 41–42). This 11.6 percent average rate of annual transportation energy demand growth in Korea (almost entirely oil) was by far the highest in APEC. It contrasted sharply with only 3 percent annual demand growth in Japan and 1.3 percent in the United States.

South Korea has, it should be noted, succeeded in reducing its marginal reliance on oil since the Asian financial crisis of 1997–98. Oil demand growth of 7.3 percent in 1999, for example, was among the highest of any major nation in the world; yet it had moderated substantially by 2002 as the distortions of the Asian financial crisis period wore off. Oil imports have also fallen—by one-tenth, to 3.6 percent of GDP.

Slower economic expansion, industrial transformation toward knowledge-intensive industry, and energy demand saturation in the residential sector all played a role in moderating South Korea's energy-consumption growth. More market-oriented energy policies, to which we will return, also helped. Because of these structural changes, Korea's GDP elasticity of demand for energy has steadily declined since 1999 to levels consistently less than 1, as indicated in *Table 2.1*. For most of the past decade, economic expansion has thus been more rapid than the growth of energy demand. This pattern follows a trend toward energy efficiency common to maturing economies, which has also been noticeable in Japan since the mid-1970s.

Despite some recent moderation of Korea's previously explosive energy demand growth, the broad structural biases of the two decades preceding the financial crisis nevertheless remain fundamentally in place. South Korea continues to be a growing society in transition. The rising

5. "Industry Too Vulnerable to Oil Shock?" *Business Korea* (June 2000), 58.

Table 2.1: GDP Elasticity of Korean Energy Demand, 1990–2001

	1990	1995	1996	1997	1998	1999	2000	2001
GDP elasticity	1.57	1.08	1.46	1.86	1.22	0.85	0.72	0.97

Source: KEEI (2005).

affluence and increasingly mobile lifestyle of the Korean people put continuing upward pressure on energy demand. Oil use continues to be high, if increasingly stable. And Korea of course remains a nation with few domestic energy supply sources of its own.

In North Korea energy demand obviously remains much more limited than in the South. Northern energy demand could hardly go much lower, given the current grim state of economic affairs there. Indeed, the North's overall supply of commercial energy fell by one-half to two-thirds, depending on the assessment, during the course of the 1990s (Williams et al. 2000).

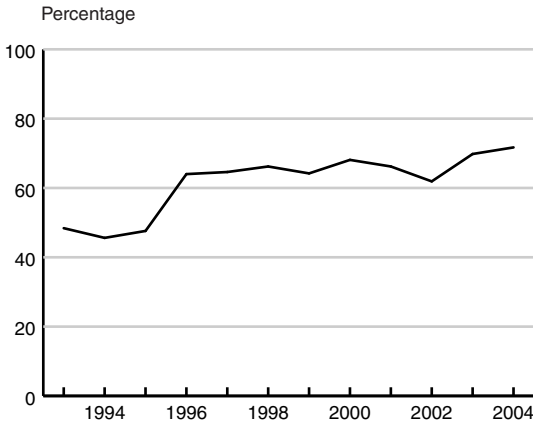
There remains, however, the latent prospect of sharp energy demand increases in the DPRK should political-economic circumstances change, as the North's energy consumption is starting from such a low base. The North, like the South, is a society with only limited sources of domestic supply. Also, North Korea's electric power grid is chronically inefficient, with the prospective capital costs of rehabilitating that sector estimated as likely to reach \$20 billion to \$50 billion over the coming 20 years (Noland 2000, 166–67).

Korea's Dependence on Middle East Energy

As shown clearly in *Figure 2.4*, Korea depends heavily on oil imports from the Middle East. Indeed, Korea is much more dependent than most industrialized nations on the volatile Middle East for its oil supply. Korea's heavy reliance on the Middle East for its oil supplies contrasts especially sharply with that of the United States (21 percent in 2004) and France (26 percent).

Korea's reliance on Middle Eastern oil, furthermore, has been rising steadily. As indicated in *Figure 2.4*, that dependence was below 50 percent in 1994. Yet in one short decade, Korea's reliance on the Middle East rose sharply, to an average well above two-thirds of the country's total imports. Favorable short-run costs and deepening import relations with new trading partners seem to account for the increase.

Figure 2.4: South Korea's Reliance on Middle Eastern Oil, 1993–2004



Source: DOE (2005).

Note: Figure shows Korea's reliance on oil from Gulf and Asian nations usually considered part of the Middle East. It does not include Korea's oil imports from North Africa.

In recent years, Korea has been trying to diversify its energy sources in a determined attempt to escape from extreme reliance on Middle Eastern oil. Yet Korea's diversification efforts have focused on natural gas rather than coal, partly because of environmental considerations. However, this fuel source transformation effort ironically has increased reliance on the Middle East, which provided Korea with 55 percent of its natural gas imports but virtually none of the coal that this gas displaced (DOE 2005). In total, almost half of Korea's overall primary energy was provided by the Middle East in 2003.

Korea's reliance on Middle Eastern energy is substantial and even rising, but it is not necessarily perverse. Despite the Middle East's political volatility, ways exist to reduce related energy insecurities, especially through cross-investment. Middle Eastern investment in Korea is rising; for example, in 2005, it was announced that Dubai International is purchasing a \$312 million stake in management of Busan's new container port.⁶ Two of four Korean oil companies are now controlled by Middle Eastern firms from Saudi Arabia and Abu Dhabi. Only one Ko-

6. *Financial Times Information*, 7 March 2005.

rean oil refiner, the SK Group, has no foreign supply partners, and it is reportedly considering bringing in Mideast investment also. These investment partnerships enhance energy security by creating direct financial incentives for Middle Eastern firms to supply their Korean partners predictably.

Korean National Oil Company (KNOC) is also actively making major new investments abroad that enhance energy security. KNOC reportedly contemplates supplying up to 10 percent of Korea's crude oil itself, much of it from the Middle East. In March 2005, KNOC took part in 20 exploration and production projects overseas, including a major project in Libya's Elephant Field, as well as others in Yemen, Kazakhstan, Eritrea, and Benin.⁷

Korea's Nuclear Embrace

Geopolitics aside, chronic energy shortages in both North and South Korea are clearly a major reason why both halves of the peninsula have found nuclear power attractive, particularly since the oil shocks of the 1970s. North Korea, with substantial uranium reserves at Unggi, Pyongsan, and Hungnam, does not even need to import the raw materials. For South Korea, which lacks indigenous uranium supplies, the burden of uranium imports is nevertheless minuscule compared with the cost and logistical difficulties that Seoul's pronounced dependence on imports of Middle Eastern oil presents. North Korea's controversial past efforts to develop nuclear power are well known and will be considered more fully later in this monograph.

In the South, nuclear power has nearly as long a history as in the North, dating back to the 1960s. In the wake of oil shock 1, South Korea moved aggressively toward nuclear power. Indeed, at a peak in 1987, nuclear power provided more than 50 percent of Korea's power actually generated and still accounted for nearly 40 percent in 2003 (DOE 2005).

Today, nuclear plants, operating in four giant nuclear clusters around South Korea, provide as much as 40 percent of total electricity actually generated in the country as a whole, and 28 percent of total capacity. As suggested on the next page in *Table 2.2*, this Korean commitment to nuclear power is more substantial than in most other major industrialized nations. Indeed, South Korea's reliance on nuclear power for ac-

7. In Yemen, KNOC was involved in both oil and gas projects; for details on KNOC's offshore operations, see the KNOC Web site at www.knoc.co.kr/eng/index.php.

Table 2.2: South Korea's Use of Nuclear Power for Electric Power Generation, 2003

Country	Nuclear power as a percentage of total power generation
France	78.0%
Sweden	48.6%
South Korea	37.8%
Japan	23.3%
Germany	28.1%
United States	19.6%

Source: DOE (2005).

Note: Figures are for actual electric power generation, by source. They differ from figures for final energy consumption in that they include statistics for electric power generation only.

tual power generation is the third highest in the entire world, following France and Sweden. It is double the global average.

Asia's Growth Deepens Korea's Energy Insecurities

Korea's energy insecurities are deeply rooted despite the remarkable job that its policy process and private sector have done in recent years of coping with the underlying domestic energy problems that the country faces. GDP elasticity of demand for energy has steadily declined since 2000, driven by the emergence of new, low-energy-consumption sectors (computers and telecommunications, for example). Improved energy efficiency in the high-consumption areas of steel and petrochemicals has also helped.

Need for Energy Ubiquitous in Northeast Asia

The international dimensions of Korean energy insecurity have grown more difficult, even as Korea's ability to cope with the energy challenge has generally strengthened. One deepening international problem for Korea, noted earlier, has been rising energy dependence on the Middle East, especially with respect to oil and natural gas. There is also the rapid pace of energy demand growth, and high levels of absolute demand, elsewhere in Asia. Four of the top 10 primary energy consumers in the world—China, Japan, and India in addition to Korea—are also now located in Asia, as well as four of the top seven consumers of oil (KKC 2005, 99, 101). All these nations are seeking large and increasing amounts of imported energy, especially oil, along the same sea lanes from the Middle East.

It thus matters greatly to Korea—both economically and strategically, even though global energy markets are of course integrated—how energy demand and supply evolve elsewhere in the East Asian region. That is especially true because the nations surrounding Korea—China, Japan, and Russia, in particular—are all major powers on the world stage, with substantial economic and geopolitical leverage of their own. Their energy consumption patterns affect not only the world market but also possibilities for cooperation—or conflict—closer to home.

Most of Korea's neighbors, unfortunately for Seoul, are nearly as energy-deficient as Korea itself. It is often noted that not a single, major, expanding onshore oil field exists in the vast expanse from Sakhalin south to Indonesia.⁸ Japan, Taiwan, and coastal mainland China—a densely populated complex of close to one billion people—all lack significant oil and gas reserves. Within a decade, even coal is expected to be a net import commodity, China's position as the largest producer in the world notwithstanding.

Energy markets, of course, are global; and energy resources should, in theory, be flexibly transferable from one region to another. Korea's presence in an energy-short neighborhood should thus, in theory, not make much practical difference. Yet the perceived realities are more complex.

Energy vulnerabilities can clearly affect pipeline politics, including terms of access to nearby Russian gas and oil. They also create subtle geostrategic concerns about sea lanes and relationships with the Middle East and Africa. Both distant areas supply Korea with oil and gas in increasing quantities via the same long maritime routes across the Indian Ocean and through the South China Sea.

Those energy insecurities—linked profoundly to pipelines, sea lanes, and regional politics—naturally fuel energy nationalism that grows more intense as global markets tighten. Such concerns tend to be especially pronounced in Northeast Asia because of pervasive resource shortages, steadily rising demand, and a lack of geopolitical leverage to command such resources that the United States, in particular, enjoys. To under-

8. Daqing, in China's Northeast, remains somewhat important, producing approximately one million barrels of oil a day. Yet its oil production has been steadily declining since 2000 by about 40,000 barrels per day. Although Daqing is to some extent supplemented by the also significant Shengli field, the joint contribution of Daqing and Shengli is still vastly outstripped by the explosive recent growth in overall Chinese national oil demand.

Table 3.1: Asia's Central Role among Major Global Energy Consumers, 2004

Global ranking	Country	Primary energy consumption (million tons oil equivalent)
1.	United States	2,298
2.	China	1,178
3.	Russia	671
4.	Japan	505
5.	India	345
6.	Germany	332
7.	Canada	291
8.	France	261
9.	United Kingdom	223
10.	South Korea	212

Source: BP (2005).

stand Korea's energy vulnerabilities, as perceived both south and north of the DMZ, it is thus important to understand the energy circumstances of its neighbors as well as the astonishing speed with which they are changing.

Centrality of China in Korea's Regional Energy Equation

China, of course, looms largest for Korea in Asian energy markets for a number of reasons. It is, as noted in **Table 3.1**, by a significant margin the largest energy consumer in Asia, with more than double the aggregate energy demand of Japan despite Japan's much larger economy. China's huge population and its low energy efficiency account for this seeming anomaly.

Nearly 70 percent of China's energy is consumed in the form of coal, and Chinese consumption leads the world (BP 2005). This fact affects Korea mainly through the environmental problems that it generates. Yet China's oil consumption is also massive and rising rapidly. Since 2003 China's oil consumption has also been the second highest of any nation in the world, after the United States, and its consumption has

been growing faster than in other major consuming nations.⁹ China accounted for more than one-third of total global growth in world oil demand between 2000 and 2004 (BP 2005).

The International Energy Agency (IEA) forecasts that China's crude oil import dependency ratio could more than double from current levels during the coming 25 years, putting still more pressure on global energy markets and on Korea's bids for supply from them. China's import-dependency ratio will prospectively rise from 30 percent in 2000 and roughly 40 percent in 2005 to as much as 80 percent of total demand by 2030 (IEA 2004b). Imports themselves would rise more than fivefold, from around 2 million barrels per day to nearly 11 million. These imports would be a sharply rising share of an explosively growing total package of aggregate energy demand. The IEA also projects that Chinese energy demand will increase during the coming two to three decades at close to double the rate of energy demand growth in the world economy.¹⁰

Although China's impact on global oil prices may well be generally negative from Korea's perspective, there is a silver lining: refined products. In recent years the ROK has developed an efficient oil-refining sector, supported by a market-aligned set of product-pricing policies, with substantial spare production capacity. China, by contrast, has inhibited the growth and prosperity of its refiners through price controls on refined products and other discriminatory policies. It is no surprise that Korea has become a large and increasingly important supplier of refined products to China, profiting from the combination of misaligned energy policies and buoyant demand that has recently prevailed in China.

China's own oil imports are expected to come heavily from the Middle East in the long run. This is a clear factor of concern to Korea, which has similar expectations of tapping into the world's low-cost source of energy—a region that is simultaneously politically volatile. Currently less than half of China's oil flows from the Middle East, with Saudi Arabia and Iran being the largest suppliers. The East-West Center projects, however, that China's overall Middle East dependency will

9. China's consumption surpassed Japan's in 2002. In 2004 Chinese oil consumption was 6.7 million barrels daily, compared with 5.3 million for Japan (BP 2005).

10. The IEA projects that Chinese primary energy demand will grow at 2.7 percent annually for the 2000–30 period, while global energy demand is likely to grow at only 1.7 percent (IEA 2004b).

rise to more than 70 percent by 2015, creating the likelihood of a more proactive Middle East diplomacy on the part of China, to which Korea will need to respond (Wu 1999).

Japan's Continuing Importance

Currently Japan is also a formidable factor in Asian energy markets; Korea must both contend and, at times, cooperate with Japan in its quest for adequate and secure energy supplies. With the second-largest economy in the world, comprising 14 percent of global GDP, and lacking major oil or gas reserves of its own, Japan is a massive importer of both oil (second in the world after the United States) and natural gas (first in the world in LNG imports, representing roughly half of the global market). Japan's energy imports, unlike China's, are not rising rapidly. Yet its absolute level of import demand is even more substantial than China's and is mediated by general trading companies (*sogo shosha*) that are highly adept at natural-resource market transactions. In tight markets, Korean firms would find them potentially formidable competitors.

India as a Rising Factor

India is also rising rapidly as a factor in the Asian energy equation. By 2004 it had become the fifth-largest energy consumer in the world and also the sixth-largest consumer of oil, just ahead of Korea. India's demand for Middle Eastern oil is also rising rapidly, along the same sea lanes and from essentially the same producers as Korea's supplies.

Emerging Occasions for Cooperation and Conflict

The prospective Asian regional energy agenda that Korea confronts has, one should certainly note, both cooperative as well as confrontational aspects. This competitive yet politicized regional environment, with its heavy governmental buying, has helped generate an "Asia premium" of as much as \$1 a barrel in global oil and gas markets in the view of many regional observers,¹¹ although the lack of a regional spot market for a benchmark crude and other market imperfections no doubt also play important roles in generating the higher prices that Asians pay.

Rapidly rising Chinese energy demand compounds the problems. Recently, Japan and China have also been competing sharply to finalize

11. For Chinese views of these matters, see Zha (2005).

a major oil pipeline routing from the Siberian interior to Russia's Pacific coast—the so-called Angarsk-Nakhodka line—on which Japan has offered to spend more than \$5 billion for construction. Russia has been encouraging that competition and linking it to diplomatic demands of its own, intensifying the politicized cast of regional energy markets.

Offshore Energy Prospects

Recent controversy over seabed natural resource reserves in the East China Sea and the West Sea (Yellow Sea) combined with rising global energy prices and the possibility of future discoveries have brought unresolved territorial disputes back onto the political agenda, generating substantial tension among the neighboring countries. Territorial conflicts involve different sets of nations. In both instances, however, these conflicts are both inflaming broader political relationships and inhibiting the exploitation of energy reserves that could be of economic importance to energy-short Northeast Asia.

The waters around the Senkaku Islands in the East China Sea, known to the Chinese as Diaoyutai, reportedly hold rich oil and gas deposits, according to numerous media reports. Many energy specialists are skeptical of the actual prospects, yet the area is bitterly disputed between Japan and China because of conflicting claims to the Senkaku Islands themselves and also to conflicting criteria for establishing jurisdictional rights with respect to offshore resources.¹²

Japan claims as its jurisdictional boundary a hypothetical median line halfway between its clearly established territories, such as Okinawa, and the Chinese mainland. China, by contrast, asserts that the entire East China Sea continental shelf is a “natural prolongation” of the Chinese mainland that extends eastward all the way to the Japanese island of Okinawa. The most attractive areas, from the perspective of the development of resources, appear to lie near Japan's hypothetical median line, slightly on the eastern, Japanese, side of this disputed boundary.

Because of the Sino-Japanese political confrontation, no detailed surveys of potential energy reserves in the disputed waters off the Senkaku Islands have been made public. Some knowledgeable observers suggest that potential reserves, especially of natural gas, could be substantial. At

12. The most important issue is the appropriate demarcation line for the respective national exclusive economic zones. For details of the dispute, see Suganuma (2000).

the extreme, Chinese estimates of potential East China Sea gas reserves over the entire shelf range from 175 trillion to 210 trillion cubic feet in volume, or substantially more than in either Saudi Arabia or the United States as a whole (Harrison 2005, 5).¹³ Western estimates of East China Sea oil reserves, as opposed to gas reserves, have gone as high as approximately 100 billion barrels, or around 40 percent of the levels in Saudi Arabia (Harrison 2005, 5).¹⁴ Other specialists, as suggested earlier, are more skeptical regarding the scale of such deposits, including the controversial Chunxiao discoveries near the Senkaku Islands.

By 1995 Chinese geologists had identified three especially promising gas fields in the vicinity of the median line. From 1995 to 1997 they undertook sporadic seismic surveys, which were followed by more intensive exploration. In August 2003 they set up production platforms at Chunxiao, one of them less than one mile from the median line at the edge of disputed territory. During 2004 and early 2005, Chinese submarines and then destroyers also began frequenting the area. In April 2005, after China refused to share geological data on the three gas fields, Japan authorized three of its companies to begin test drilling on its side of the line.

Further north in the Yellow Sea, just off the west coast of North Korea, there is also prospect of substantial offshore reserves although not on the scale of those expected in the Senkaku-Diaoyutai area. The most optimistic predictions for major discoveries center on two areas: the Kunsan Basin in the southern Yellow Sea, at the boundary of Chinese and South Korean jurisdictions, and in the West Korea Bay basin off the coast of North Korea. Petronas of Malaysia concluded a concession agreement with Pyongyang for exploration but cancelled it following indications of Chinese displeasure. Further feasibility study and development has stalled amid the North Korean nuclear crisis because of a lack of agreement among North Korea, South Korea, and China regarding the territorial issues involved (Paik 2005, 46–47).

13. Chinese estimates reportedly indicate East China Sea gas reserves of 175 to 210 trillion cubic feet, compared with Saudi “proven and probable” gas reserves of 238 trillion cubic feet, and analogous U.S. reserves of 117.4 trillion cubic feet. Some knowledgeable Western analysts suggest that such Chinese reserve estimates should be devalued by a factor of at least five.

14. Saudi Arabia has “proven and probable” oil reserves of 261.7 billion barrels, and the United States 22 billion.

China's emergence as a major energy importer gives it not only new incentives to bid aggressively for disputed resources, as in the East China Sea, but also additional incentives at times to cooperate with its neighbors. Two prospectively important areas where Korean expertise could be catalytic in triggering regional cooperation concern joint stockpiling programs and development of a regional energy transportation network.

Stockpiling Programs

Korean policies for stockpiling are especially imaginative and relevant to the problems China confronts. KNOC lends crude to refiners during times of trouble, using profits from oil trading to expand its stockpile, and also leases space to international oil producers to store their own oil in Korea.¹⁵ Norway's Statoil, among others, has taken advantage of these innovative procedures.

As energy markets tighten, stockpiling is rapidly becoming an issue of major concern across the Asian region. Since November 2003, regional oil forums have been held annually among the ASEAN + 3 nations¹⁶ as they seek close oil cooperation, including the establishment of an oil-stockpiling program for the 13 member countries.¹⁷ In June 2004 China hosted a foreign ministers' meeting of the Asia Cooperation Dialogue, which approved the Qingdao Initiative on energy cooperation that embodied many of these measures. Currently, only Japan and South Korea within Asia have substantial oil stockpiles (Kanekiyo 2005), totaling approximately 173 and 67 days, respectively, so such measures, particularly in the creative forms that Korea has pioneered, could contribute significantly to enhanced regional energy security.

Natural Gas Pipelines

Cooperation for supplies of natural gas is among the most important potential areas for collective action in Northeast Asia. The region is

15. See the KNOC Web site for additional information on oil stockpiling projects, www.knoc.co.kr/eng/index.php.

16. The Association of Southeast Asian Nations comprises Brunei Darussalam, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Vietnam. ASEAN + 3 refers to the members of ASEAN plus China, Japan, and South Korea.

17. See the Web site of the ASEAN Center for Energy, www.aseanenergy.org/.

unique globally in being both economically advanced and industrialized, yet still lacking a regional gas grid. China, at the end of 2004 after years of effort, finally completed its West-East pipeline project to bring natural gas from Xinjiang to Shanghai. Plans to extend pipelines as far as Korea remain enmeshed in geopolitics¹⁸—yet pipeline extensions have important future potential, possibly in the context of the six-party political-economic dialogue now emerging in connection with the North Korean nuclear talks.

Japan has been working together with Russian firms and Royal Dutch Shell on the Sakhalin II project, which started to provide oil in 2004 although natural gas will not be generated in substantial amounts until around 2007.¹⁹ It appears committed to LNG, but Sakhalin I gas may be available for pipeline transmission to Korea. Talks about other international natural gas pipelines continue among large Asian consumers such as China, South Korea, and Japan and neighboring producers Russia, Kazakhstan, and Turkmenistan. Projects among Russia, China, and Korea will be considered in chapter 4.

Another promising gas provider within the East Asian region, although one geographically isolated from Korea, is ASEAN. Under the ASEAN Vision 2020, Southeast Asian nations have proposed a trans-ASEAN gas pipeline among the member countries, at a cost of \$7 billion. The project would, if realized, involve seven major interconnected gas pipelines. As early as 2002, India expressed a desire to extend the ASEAN pipeline to India via Myanmar and Bangladesh, although the feasibility remains to be demonstrated.²⁰ The infrastructural costs of gas pipelines are of course huge and the lead times long, making uncertain political parameters and regulatory environments a continuing obstacle to project realization.

South Korea, as a part of the Eurasian continent, is better situated geographically than Japan to participate in building gas pipelines, although both countries are pivotal participants in the six-party process that could be a catalyst for such pipelines. South Korea's favorable situation is complicated, however, by the fact that many such pipeline routes

18. "PetroChina Intends to Pave Second West-East Gas Pipeline," *SinoCast China Business Daily News*, 31 December 2004.

19. Additional information is available on the Web site of Sakhalin Energy Investment Company Ltd., www.sakhalinenergy.com/.

20. India Plans to Seek Trans-ASEAN Gas Pipeline Extension," *FT Global NewsWire*, 18 October 2002.

would most logically transit North Korea before reaching Seoul. The slow resolution of the North Korean nuclear issue as well as related financial difficulties have delayed pipeline links among Russia, China, and the ROK. Economic and geopolitical preconditions for the realization of an enhanced pipeline network will be considered in chapter 4.

Energy Efficiency Programs

Another major prospective area for regional cooperation is in the quest for energy-efficiency improvements. China's energy efficiency, in particular, is extremely low, which compounds the already substantial impact of China's rapid economic growth on global energy markets and on Korea's own energy situation. Energy efficiency in China remains only one-ninth of Japan's efficiency, one-fifth of the European Union's, and 40 percent of U.S. energy efficiency, according to the Chinese State Energy Research Institute. Even Chinese air conditioners, which one might presume to be made according to a global standard, are roughly one-fifth less efficient than the world average.²¹ Energy consumption at steel mills in China remains 50 percent higher than consumption in Japan, and more than 40 percent higher than in Korea (Kanekiyo 2005). Even Chinese electric power generators consume one-fifth more energy per unit of output than their U.S. counterparts (Kanekiyo 2005). Korea, with recent experience coping with problems like those in China, is well placed to aid China in improving energy efficiency or in cooperating with neighbors such as Japan in doing so.

Environmental Protection

China obviously has good reasons to tackle environmental issues aggressively, and its neighbors, including Korea, have incentive to help. Acid rain and other forms of air pollution from China are major problems for Korea's forests and for its urban dwellers as well. Japan is likewise affected, and it shares a common interest with Korea in cooperating with China.

Coal is in most forms a highly polluting fuel, contributing heavily to such problems as acid rain, and it still accounts for two-thirds of China's primary energy consumption. Motorization and diffusion of home

21. "Electrical Inefficiency a Dark Spot for China: Cities Glow for Show as Factories Black Out," *Washington Post*, 9 August 2005.

electric appliances like air conditioners and refrigerators are also proceeding rapidly in the People's Republic of China (PRC), worsening sulfur dioxide emissions and accelerating global warming tendencies.

Recently, China has been taking environmental protection seriously; pollution is becoming a serious issue, especially because of the impending, politically important Beijing Olympics. Construction of as many as 22 major dams and power stations in China, including the massive Three Gorges project, involving \$14 billion in total investment has slowed or stopped pending environmental review. Projects out of compliance, including a \$5 billion hydropower station in Sichuan province, are reportedly being forced to pay significant fines.²²

Despite recent regulatory tightening, China continues to need technical assistance and financial aid in the area of environmental protection. Japan has been supportive in such fields as reforestation.²³ Japan and China have also been jointly studying ways to develop and evaluate bio-coal briquettes, a substitute for coal, as a means of lessening air pollution (Hayami et al. 2003). Like Japan, Korea can also support China in the environmental area on the basis of its own experience; coal-use efficiency, dissemination of clean-coal technology, and natural gas promotion appear to be especially promising areas for cooperation.

Thus, potentially important areas for regional energy cooperation can allow Korea to play a leading role. So far, however, despite some sporadic cooperation and disturbingly substantial conflict, little concerted or systematic cooperation among Korea, Japan, and China has emerged, creating opportunity costs for the whole region. Ironically, it has taken the North Korean nuclear issue, and the catalytic role of the United States since early 2005 in pursuing this, to bring the reluctant Northeast Asian nations to the negotiating table. This configuration is, however, finally generating a promising multilateral dynamic that could be constructive in addressing the serious problems considered in the following chapters.

22. "China Enforcing Green Laws Suddenly; Beijing Has Targeted 22 Major Energy Projects to Assess Their Environmental Impact," *Christian Science Monitor*, 10 February 2005.

23. For details, see the Web site of Japan's Ministry of Foreign Affairs, www.mofa.go.jp/index.html.

North Korea and the Northeast Asian Energy Equation

North Korea's energy circumstances are in many respects an extreme version of those that South Korea confronts: some coal and hydroelectric power, but no onshore oil reserves and no natural gas. The most attractive potential sources of the hydrocarbons for North Korea, as for South Korea, lie in the Middle East, more than 6,000 miles away. For both North and South, nuclear power has a certain natural logic in energy terms, political-military issues aside. So does natural gas, with Korea's huge Russian neighbor holding nearly one-third of global proven reserves.

The energy circumstances of North Korea are different from its southern twin in one massive way: the North's isolation from the international system as a result of its eccentric foreign policies, its belligerent military posturing, and its persistent attempts to develop nuclear weapons and other instruments of mass destruction. Since the collapse of the Soviet Union, its last consistent ally, at the end of 1991, North Korea's energy infrastructure, like its national economy more generally, has decayed sharply. No foreign energy assistance, other than heavy oil supplied under the Agreed Framework between 1995 and 2002, has come to the country's aid.

North Korea, like South Korea, historically has had a high-energy-use economy (Noland 2000, 143). In the North's case, this was caused by its industrial portfolio, which was focused on heavy and chemical

industries such as metals, machinery, chemicals, mining, and power that were bequeathed largely by the Japanese. The heavy industrial bias, with its high-energy-use orientation, was then perpetuated and even intensified during the first two decades after the Korean War as the DPRK economy moved to an increasingly militarized footing.

Primary commercial energy use in the DPRK per unit of output was approximately three times the level in China in 1990 and about half the level in Japan, which had a GDP per capita 20 times as high as North Korea at the time (Noland 2000, 144). Inefficient use of fuels, owing to obsolete equipment as well as lack of market pricing and reliance on relatively less efficient fuels such as coal, has intensified the high-energy bias originally created by industrial structure.

This high-energy orientation of the North's economy, together with poor underlying energy resource endowments and the importance of energy to North Korea's military, make energy a priority concern for the DPRK's political-military leadership. Kim Il-sung noted in the mid-1980s that "[w]ithout electricity, we cannot produce anything, either in peacetime or wartime" (Ahn 2003, 118). Kim's statement is proving to be even more true now, a generation later.

North Korea's leadership appears concerned not only with the quantity of energy inputs for the DPRK's economy but, increasingly, with their quality as well. Power outages and the current volatility of operating current, among other problems, have become increasingly pronounced over the past decade as North Korea's electric power grid, which dates back in unified national form to 1958, becomes increasingly obsolescent. As the information revolution proceeds worldwide, in both its civilian and military dimensions, and as state-of-the-art industrial facilities become more and more technology intensive, the quality of electric power becomes more important to the DPRK in all aspects of economic and military life. A computerized society, North Korea is beginning to discover, cannot run on the erratic power supply with which Pyongyang, not to mention provincial towns, is presently afflicted.

North Korea's Domestic Energy Situation

North Korea's domestic energy situation needs to be considered in terms of four basic aspects: supply of basic energy, electric power generation, electric power transmission, and energy alternatives or secondary energy usage apart from electric power. As noted in chapter 1, electric power is the North's Achilles' heel, where its energy problems come together, and the factor that most directly affects the functioning of the

North's overall economy. The DPRK's circumstances are dire along all four basic aspects, and the energy problems that the North confronts in all these areas are interrelated. Yet the nature of the difficulties involved is somewhat different in each area.

Supply of Basic Energy

In terms of basic energy supply—that is, the availability of coal, hydroelectric power, oil, natural gas, and nuclear power—North Korea's energy insecurities are broadly similar to those of South Korea, Taiwan, and Japan. North Korea does not have any major operating onshore oil fields although in August 2002 Sovereign Ventures Pte. Ltd. (SVPL) of Singapore announced that it had found minor oil and gas reserves in its contracted area of North Korea, on the Chinese border along the Tumen River (Harrison 2005, 44).

The DPRK does appear to have potentially major offshore oil deposits located on the seabed west of Anju in the Yellow Sea, with potential reserves of as much as 12 billion barrels of oil (Harrison 2005, 13). North Korea has tried to develop these offshore reserves in cooperation with a wide range of foreign parties, including the Chinese (1965–80); the Soviets (1986); the Australians (1988–90); the Swedes (1993); the Malaysians (1997); the Singaporeans (2001); and the British (2004) (Paik 2005, 39–49). Yet on each occasion either territorial issues between the DPRK and nearby China or financial and legal questions prevented these ventures from achieving meaningful results.

Ultimately, serious exploration of these promising offshore oil reserves will need to await a resolution of the Korean nuclear crisis. The prospects of such exploration could be a meaningful incentive for the DPRK to accede to and actually observe an agreement acceptable to the other five parties to the nuclear talks. Proximity and territorial issues vis-à-vis China make it clear that actual exploration would also require the assent of China, which would retain leverage in the actual development process also.

North Korea, to be sure, does have substantial hydroelectric power capacity; in fact, the North's capacity is well over double the South's despite the huge converse gap between the capacities of the Koreas in other aspects of energy.²⁴ Its mountainous terrain and relatively plenti-

24. Actual hydroelectric power generation in the North appears to have been around 7.60 million kilowatts in 2002, compared with 3.15 million kilowatts in the South (Ahn 2004, 121–22).

ful rainfall provide the DPRK with unusual hydroelectric potential from a global comparative standpoint. Its rate of developable hydroelectric power per square kilometer is 77.4 kilowatts compared with the global average of 50 kilowatts (Ahn 2004, 21).

Hydro provides well over half of today's electric power supply in the DPRK, and production could clearly go higher with additional capital investment and application of more sophisticated technology.²⁵ Yet, during the Korean dry season, the operating capacity of hydroelectric power plants in the DPRK drops sharply, severely decreasing the amount of power generated and, thus, giving a distinctly cyclical character to North Korea's secondary energy supply. This is especially inconvenient and frustrating to North Korean economic planners because 85 percent of the DPRK's hydropower is harnessed for industrial use.

North Korea also has significant coal resources, especially anthracite and lignite coal, mostly produced from underground mines (Von Hippel et al. 2001, 12). This domestic coal, although relatively low in quality, is nevertheless North Korea's main fuel for electricity generation. Yet coal mining usually requires electricity for lighting, jackhammers, and moving coal out of the mines.

In addition, many important coal seams are actually beneath the seabed, especially off the western coast near Anju, which requires seawater to be continuously pumped out for the mines to operate. Several of these mines were flooded in the mid-1990s. In addition, the coal that can be produced in North Korea is uneven in quality, which creates significant operational problems, especially for new coal-fired plants.

In 2001, coal provided approximately 86 percent of North Korea's primary energy consumption, a share that rose sharply during the 1990s as the DPRK's isolation from the broader world intensified. Following the halt of KEDO crude oil shipments in December 2002, North Korea turned even more intensively to coal as the only fuel it could increase through its own efforts. In 2003, for example, the North increased budget allocations to coal production by more than 30 percent—by far the largest increase in the country's nonmilitary budget.²⁶ The DPRK is at-

25. In 2002 hydroelectricity contributed about 54 percent of the total electricity supply in the DPRK; see the IEA Web site, www.iea.org/.

26. Other budget expenditure increases included agriculture (increase of 21.3 percent), science and technology (increase of 15.7 percent), and electricity (increase of 12.8 percent) (Ahn 2004, 54).

tempting to increase coal production by both improving technology and modernizing existing large-scale mines as it also develops smaller mines.

A final crucial element of North Korea's primary energy situation is the impact that the suspension of the KEDO agreement is having on the DPRK's energy circumstances. This impact is concentrated at the Pyongyang thermoelectric power plant—the one plant in North Korea equipped to be fueled by heavy oil. This plant used 2,000 to 5,000 tons of crude oil supplied by the United States during the seven years the KEDO agreement was operational. In January 2003, however, after the halt in KEDO heavy-oil shipments, only 6 of 13 boilers were operating, and the electricity generated fell to the lowest level of the generator's capacity (KDI 2003, 83). Suspension of the 1995 agreement has apparently continued to have a noticeable impact that should provide the DPRK with tangible economic incentives for resolution of the nuclear crisis.

Electric Power Generation

Electric power generation has been a central priority of the North Korean regime for nearly a half century, as noted earlier. Indeed, it lay at the heart of the first Seven-Year Plan (1961–70). That plan stressed the development of thermal-power generation to supplement the hydroelectric power on which the DPRK relied for 90 percent of its total electricity supply at the time.

Expanding power generation was also consistently a priority of the Six-Year Plan (1971–76); the second Seven-Year Plan (1978–84); and the third Seven-Year Plan (1987–93). Although the DPRK has not drafted comprehensive economic plans since the last of these was completed, its most recent attempt at shaping its economic future—the Three-Year Plan for Fuel and Power (2003–05)—concentrates specifically on that sector, suggesting the continuing importance to North Korea's technocratic leaders of electric power (Ahn 2004, 97–121).

Despite the importance of electric power generation capacity to the DPRK's economic development and the priority that improvements in that area appear to hold for the nation's leaders, power generation remains a serious domestic economic constraint. Hydroelectric power plants generate approximately two-thirds of North Korea's electricity, and thermal power plants approximately one-third. All except the Pyongyang thermal power station, which relied on the heavy fuel oil that was cut off when the KEDO agreement was suspended in 2002, are coal fired.

The DPRK's electricity supply thus suffers indirectly from a range of difficulties relating to coal production and transportation. One is the decrepit quality of the rolling stock that transports 90 percent of North Korea's coal by rail. In addition to this, as much as 85 percent of the DPRK's hydroelectric capacity has been damaged by flooding (Ivanov 2002, 13).

Overall, as little as 20 to 30 percent of installed North Korean capacity for electric power generation, which totals roughly 8 to 10 gigawatts, may actually be operable (Von Hippel et al. 2001, 13). This is sharply less than at the time of the Soviet collapse at the end of 1991, when the downward spiral in the DPRK's economic circumstances began to accelerate. Infrastructural decline, a drop in coal production, low quality of coal, and a sharp decrease in oil imports have intensified these problems.²⁷

Infrastructural decline has led to a striking and seemingly paradoxical inverse relationship between generating capacity and power production in the North since the collapse of the Soviet Union. As indicated in *Table 4.1*, power production capacity expanded more than 55 percent between 1990 and 2003, much of it concentrated in small-scale local plants largely independent of the unreliable national grid. Yet actual power production appears to have declined by more than 40 percent during the same period. By 2003 North Korea's generating capacity was less than one-seventh of that in the South, but its actual power production was only one-thirteenth that of the South owing to chronic production and transmission difficulties and a grid in very poor condition.

The North Korean government itself is clearly concentrating a major share of the domestic resources it devotes to nonmilitary pursuits on the electric power sector. It invests its revenues from People's Subsistence Bonds, for example, in power generation (Ahn 2004, 99). Yet this priority treatment is not effectively arresting the steady deterioration of a crucial sector whose decay is generating pervasive, corrosive effects across the DPRK political economy as a whole. North Korea can thus be expected to value highly any major foreign proposals for energy assistance targeted in the electric power generation and transmission areas. Such projects, together with appropriate service provision and pro-

27. The drop in coal production and quality depress operating ratios because of their impact on transportation; most of the coal used in North Korean power plants, ironically, is transported by rail. The decline in oil imports obviously affects the ability of oil-fired plants to operate.

Table 4.1: Electric Power Production in the DPRK, 1990–2003

	1990	1997	1998	1999	2000	2001	2002	2003
Production capacity (10,000 kW)								
Total	501	739	739	739	755	755	777	777
Hydro	291	444	444	444	459	479	481	481
Thermal	210	295	295	295	296	296	296	296
Power generated (100 MkWh)								
Total	277	193	170	186	194	202	190	196
Hydro	156	107	102	103	102	106	106	107
Thermal	121	86	68	83	92	96	84	79

Source: MOU (2004).

grams for training personnel, could hold the key to the North's economic revival.

Electric Power Transmission

Electric power transmission is a third major difficulty that North Korea has with its supply of domestic energy; it is related closely to problems of generation. North Korea's original power grid was created in Japanese colonial days, well over 60 years ago, and was decimated during the Korean War. Refurbished by the Soviet Union in the 1960s and 1970s, the grid has experienced inadequate servicing since the collapse of the USSR at the end of 1991. The lack of spare parts, scavenging of metal (as barter for food) from remote lines in the countryside, and general physical deterioration have severely degraded the system. Power outages are thus common throughout the country, including even in Pyongyang, and energy loss through inefficient transmission is enormous.

As late as the early 1990s, connections between elements of the power grid's transmission and distribution system were in fact operated by telephone and telex, without the support of automation or computer systems (Hayes et al. 2005). A United Nations project during that period did reportedly install some control equipment at a power plant and at selected control centers in the Pyongyang area, but few other system upgrades have been performed. As a consequence, power outages, poor frequency control, and other technical problems continue to plague the

system. Voltage and frequency fluctuations are orders of magnitude greater than international standards.

North Korea has taken recent steps to address one of its serious electric power grid problems. In mid-2005 North Korea announced a new, computerized grid management system that would allow the DPRK's electric power providers to know exactly how much power was being consumed by a given consumer in any region.²⁸ This new system would also allow the DPRK's electricity providers to cut off or limit the amount of power consumed by any given consumer. It remains unclear how effectively the proposed system will be implemented or how much it will actually enhance much-needed energy efficiency.

Energy Alternatives: Nuclear and Beyond

Given North Korea's underlying lack of oil and gas, together with the mounting infrastructural problems it confronts in both electric power generation and transmission, the DPRK naturally has a long-standing and perhaps deepening interest in civilian nuclear power, quite apart from any military applications. This interest in civilian nuclear power is further enhanced by the fact that North Korea is self-sufficient in uranium production, with substantial domestic deposits in the Unggi, Pyongsan, and Hungnam regions of the DPRK. These deposits, combined with North Korea's growing technical capacities, give Pyongyang the potential ability to operate a closed nuclear fuel cycle quite independent of the broader world. In short, nuclear power is North Korea's ultimate route to both energy independence and political autonomy.

Roughly 28 percent of South Korea's generating capacity is nuclear, but North Korea currently has none (Hayes et al. 2005). It does, of course, operate one 5,000-kilowatt pilot nuclear plant at Yongbyon, at which construction started in 1979 and operation began in 1986. This pilot plant, modeled after the Calder Hall nuclear facility in the United Kingdom, uses natural uranium as fuel and, to provide weapons-grade plutonium for North Korea's military nuclear program, has produced the 8,000 irradiated fuel rods that have apparently been reprocessed since the breakdown of the Agreed Framework in 2002.

Under the Agreed Framework, concluded between North Korea and the United States in October 1994, North Korea was to suspend construction on its suspect nuclear projects. In return, two 1,000-megawatt

28. *Asia Pulse*, 1 August 2005.

light-water reactors (LWRs) were to be provided to the DPRK by a target date of 2003 as well as 500,000 metric tons of heavy fuel oil annually until the reactors became operational. These provisions were meant to replace the potential energy supply from the suspect nuclear projects, including Yongbyon. Upon completion of the reactors and after a three-year grace period, North Korea was to begin repaying the cost of these new reactors over 17 years.

Construction actually began on one of the reactors, at Kumho in North Korea, with South Korea and Japan expending approximately \$1 billion each in support of the project through KEDO, which was established under the Agreed Framework. A freeze was imposed on the Kumho reactor project in November 2003, however, and activity at the construction site has since focused on preservation and maintenance of facilities and plants on which construction had previously begun (KEDO 2004, 5). The partly finished Kumho project, nominally consisting of two LWRs, remains the only clearly civilian nuclear facility in North Korea.

Apart from nuclear power, still in its controversial infancy in North Korea, few substantial alternatives to coal and hydroelectric power have proceeded very far. Natural gas—an important option in much of the world because of its high energy efficiency and positive environmental qualities—is conspicuously difficult to develop under current circumstances in the DPRK despite the proximity of Russia with more than 30 percent of proven global gas reserves. Should a trans-Korean gas pipeline materialize, natural gas could be important for electric power generation through a series of moderate-sized, combined-cycle, gas-fired plants along the pipeline. Such a prospect is, however, infeasible over the short run, and North Korea cannot afford the substantial foreign-exchange cost of importing LNG or constructing the infrastructure to use it effectively (Calder 2004).

In the North Korean countryside, biomass—involving the conversion of animal and human fertilizer into energy—remains a major source of power, suggesting how desperate and how disconnected from the mainstream national economy much of the countryside has become. Biomass is important in India and Africa but is rarely used in the industrialized world. In 2002, such combustibles, renewables, and wastes accounted for 5.2 percent of the DPRK's total primary energy consumption (Komaki 2005, 79). With the assistance of the Nautilus Institute, which is based in San Francisco, California, North Korea has also built seven wind-

powered generators, although the generating capacity is only nine kilowatts per unit (Ahn 2003, 122).

Review and Prospects

North Korea's energy insecurities thus mirror those of the ROK itself. The DPRK lacks both oil and natural gas although there is some possibility of significant offshore reserves of both, provided territorial disputes with neighboring China can be resolved and foreign capital and technology successfully attracted. Indeed, the prospect of assistance with offshore energy development is one little-recognized option of potential value to North Korea that might be considered during the ongoing six-party nuclear negotiations.

In the political-military sphere, North Korea's most direct energy vulnerability is clearly its lack of oil. Petroleum products, of course, would be vital to any extended military action against South Korea or other nations—on land, in the air, or at sea—and those vital petroleum products appear to be in extremely short supply in the DPRK at present. Although a decade ago North Korea obtained substantial oil from Iran, its supplies have been increasingly limited to China, giving the PRC significant potential leverage against the North that it presently appears loath to exercise.

North Korea's most pressing energy weakness on the civilian side of its political economy clearly relates to electric power: both generation and transmission. Two-thirds of the DPRK's electricity, including 85 percent of that supplied to industry, is hydropower, which has the great disadvantage of being subject to seasonal variation. The thermal one-third of power capacity is plagued by transportation difficulties for coal, and by the unavailability of heavy fuel oil, which was provided by the United States until the breakdown of the KEDO agreement in December 2002.

North Korea's electric power grid, now close to half a century old even in its post-Korean War incarnation, is likewise in increasingly precarious shape. Outages and radical voltage fluctuations in the domestic grid are common. The national grid is increasingly breaking down and becoming regionalized, with a proliferation of small, inefficient power plants providing decentralized sources of power.

The crisis of the domestic power grid is serious from a North Korean perspective for two key reasons: the power grid inhibits economic development in existing sectors; and it complicates the task of upgrading industrial processes, utilities, and potential military capacity through

computerization and automation. Stagnation in electric power development, in short, is becoming a straitjacket for the whole North Korean political economy, crippling its ability to cope with global technological developments far beyond the sphere of energy.

Resolution of North Korea's chronic energy problems is obviously of priority interest to the DPRK, although its actual willingness to trade off its military nuclear program for civilian energy assistance remains somewhat unclear, the September 2005 Beijing six-party declaration notwithstanding. The fact that the DPRK's first step back into the economic-planning arena, after long-term plans were discontinued in the early 1990s, was the Three-Year Plan for Fuel and Power (2003–05) suggests this priority. So do high declared budget allocations to both coal production and electric power.

Possibility of Six-Party Cooperation

Should a viable resolution to the North Korean nuclear problem—in all its dimensions—finally be achieved, much potential exists for continuing six-party cooperation to address the DPRK's energy problems. Indeed, from an economic perspective, the six-party framework appears to be an ideal vehicle for doing so. Capabilities and incentives of each of the six parties in addressing North Korean energy issues strongly complement one another and are enhanced by thinking and planning in a broad regional context. The Northeast Asian region as a whole, after all, has both severe prospective energy shortages, especially with respect to electric power, and major underlying regional strengths, particularly in natural gas reserves and hydroelectric potential.

Given the prospects of rising interdependence and ultimate reunification, South Korea has strong incentives to cooperate and to invest heavily in North Korean infrastructure as the shadows of reunification deepen. Japan has relevant technology, especially in long-distance power transmission and energy efficiency, and is widely expected to make a major financial contribution to North Korean economic development at some point in order to normalize political relations and resolve historical issues.

Russia's incentives to cooperate, and its potential contribution, are also substantial. Apart from its huge long-term potential as a natural gas and hydropower supplier, Russia built most of the thermal power plants currently operating in North Korea, and its support with power generation and wiring would be natural. China's assent to any offshore North Korean energy development that might transpire in the West Sea would

be needed, and the PRC could help with refurbishing the two oil pipelines connecting China and the DPRK, as well as with construction of energy infrastructure.

A U.S. role in North Korean energy development—obviously following full resolution of the nuclear crisis, including the DPRK's clear abandonment of its military nuclear program—could be important for diplomatic reasons, and the economic contribution could be significant also. U.S. NGOs have already helped the DPRK in the alternate energy area, and the United States provided heavy fuel oil to the North under KEDO. U.S. energy exploration, production, and transmission technology is the state of the art in many areas and could well be provided if the nuclear issue were fully resolved. U.S. support could also be crucial to provision of assistance by the World Bank and other global financial institutions that would no doubt need to provide a major part of the funding for any large-scale North Korean energy development projects.

The U.S. role within the broader six-party nuclear negotiation process is so pivotal that a U.S.-sponsored Northeast Asian energy cooperation initiative—laying out a vision for multilateral cooperation beyond resolution of the nuclear crisis—makes eminent sense. It needs, however, to be accompanied by reinforced bilateral consultation with the ROK and with Japan, on related issues. However effective alliance consultation may have recently been on conventional political-military issues with these two key allies, it can usefully be deepened at the interface of energy and security.

Seoul's Energy Options for the Future

Amid a simultaneous strategic nuclear controversy and deepening energy crisis, the Korean peninsula is at a historic crossroads. Both Korean governments, together with Korean society and well-wishers throughout the world, need to take decisive steps to both solve the nuclear crisis and deal with the peninsula's deepening energy problems while being sensitive to the linkages between the North and the South and to the momentous long-term implications of the actions themselves. There is a historic chance now for a multilateral package that can both speak to Korea's profound energy insecurities—the South's as well as the North's—and help bring peace to one of the most potentially volatile regions on Earth.

Previous chapters explain the energy insecurities of the two Koreas and how they came to be; they note the total lack of onshore oil and gas on both sides of the DMZ and the surprisingly parallel vulnerabilities for the energy-intensive economies of both North and South that these unusual deficiencies create. They also detail the rapid recent surge of energy demand throughout East Asia and the nuanced challenges and opportunities that this shifting regional dynamic poses for Korea.

This chapter looks beyond the present toward a potentially momentous and dynamic, yet also chronically uncertain, Korean energy future. It does not attempt to forecast that future or prescribe which policy course should be taken. In the interest of ensuring longer-term relevance, it strives instead to outline in detail the emerging energy options that the two Koreas confront. In doing so, it strives to cast light for

general readers, in a timeless way, on what choices key actors can potentially make as well as the pros and cons of making them.

Fuel Choices

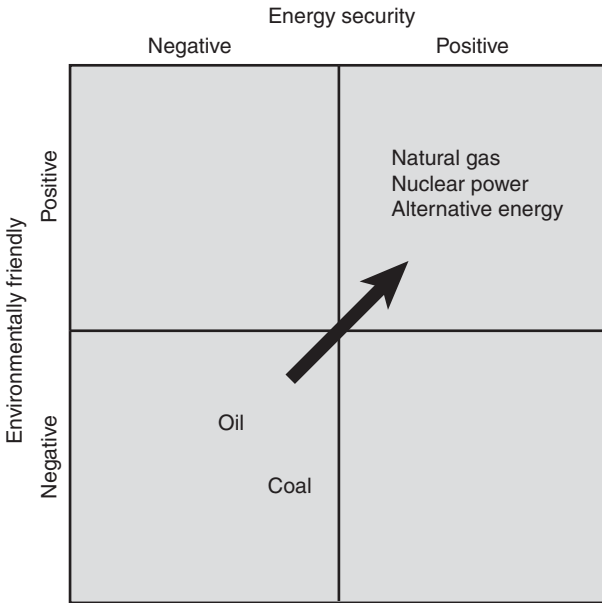
Korean consumers have five basic choices among varieties of fuel: oil, natural gas, nuclear power, hydroelectric power, and alternative forms of energy. Each choice is to some extent historically embedded—the absence of pipelines, for example, makes a short-run choice of natural gas more difficult in Korea than it would be in the United States, Canada, or Western Europe. Yet there are also substantial degrees of freedom that this chapter will attempt to explicate.

Apart from the interfuel issue (choice among types of fuel), there is also the important issue of energy conservation. North Korea has one of the most energy-inefficient economies in the world, even as it ranks simultaneously among the most deprived in terms of energy supply. Energy efficiency thus needs to be a front-rank issue for the DPRK. It is also important for the ROK, which has its own chronic energy vulnerabilities as well as levels of energy efficiency that remain significantly behind Japan, even if the efficiencies in South Korea are substantially higher than in either China or the United States.

The various interfuel choices that the two Koreas confront vary with respect to their attractiveness—in terms of both environmental and energy security parameters—as well as cost structure. Broadly speaking, nuclear power, coal, and natural gas use have relatively high upfront capital costs, in declining order of magnitude. Yet they have converse patterns of operating costs, with nuclear power, waste-storage issues apart, being the cheapest once high initial construction costs have been completed. These differences in cost structure make assumptions regarding who bears construction costs and the prognosis for energy prices crucially important for determining optimal interfuel choices, from an economic standpoint. The questions of construction cost are precisely the sort of issues in play through the six-party process.

Choices in favor of oil and coal are to some extent embedded in both parts of the peninsula, but they are not necessarily the most attractive choices for Korea's future. Broadly speaking, the optimal strategy for both Koreas, from an energy-security perspective, is to move from coal and oil toward natural gas, nuclear power, and alternate energies—in other words, from the lower left-hand to the upper right-hand quadrants of *Figure 5.1*. The stronger the assumption of outside assistance—through the six-party process, for example—the stronger these transi-

Figure 5.1: Interfuel Choices for the Korean Peninsula



tion imperatives become because of the high up-front capital costs involved. The feasibility and attractiveness of nuclear power are particularly affected, from a cost standpoint, by one's assumptions regarding outside assistance.

Nuclear power, alternative forms of energy such as wind power, and natural gas are all attractive options for Korea for different reasons.

Nuclear Power

Nuclear power will also most likely be an economically attractive option for both North and South or, equally, for a reunified Korea in the long term, assuming relatively high energy prices, although it is an alternative with important logistical and political downsides. Its attractiveness is enhanced greatly, relative to other options, as noted above, when there is some provision for outside assistance because that neutralizes the otherwise important drawbacks of high up-front capital costs. It would thus not be surprising, from a microeconomic standpoint, that the DPRK would be eager for a civilian nuclear plant, even apart from its clear military aspirations in the nuclear area.

Installed nuclear power already comprises approximately 28 percent of Korea's electric generating capacity, and its marginal costs of production are the lowest of any energy alternative. The only needed raw material, after all, is uranium, potentially available rather inexpensively even on the Korean peninsula itself. Yet public opposition to nuclear power, leveraged by democratization, has risen sharply during the past two decades because of its safety and storage problems. New nuclear plants are also expensive to build, especially now that a range of security precautions have proliferated since Three Mile Island, Chernobyl, and 11 September 2001.

Alternative Energy

Alternative energy is a third relatively attractive option for Korea. It provides a large measure of energy security and is also environmentally friendly. Both capital costs and operating costs are relatively low. North Korea has already built seven windmills with the aid of the Nautilus Institute, and South Korea plans to include about 10 gigawatts of renewable energy-powered generation, especially wind-powered energy, in its own plans to expand capacity (Chung 2005). Yet the production economics of alternate energy are such that it cannot easily become the sort of major alternative to oil and coal that natural gas and nuclear power can potentially be.

Natural Gas

Natural gas is attractive because it is highly efficient and generates little environmental pollution. It is somewhat cumbersome to use in transportation although Korea makes extensive use of both gas-powered buses and liquefied petroleum gas-powered taxis. Gas is relatively cost-effective to use in electric power plants; indeed, so-called combined cycle gas-fired thermal power plants are said to be the most economically attractive power plants in the world today when both capital and operating costs are taken into consideration. They provided 26.3 percent of South Korea's generating capacity in 2004 (KEPCO 2004), and the likelihood is that this ratio will rise steadily higher in coming years.

Capital costs for natural gas are also relatively low, depending on project configuration, relative to nuclear power. Yet Korea, like its Northeast Asian neighbors, uses relatively little gas, despite that fuel's intrinsically attractive properties. In North Korea, gas use is negligible. In

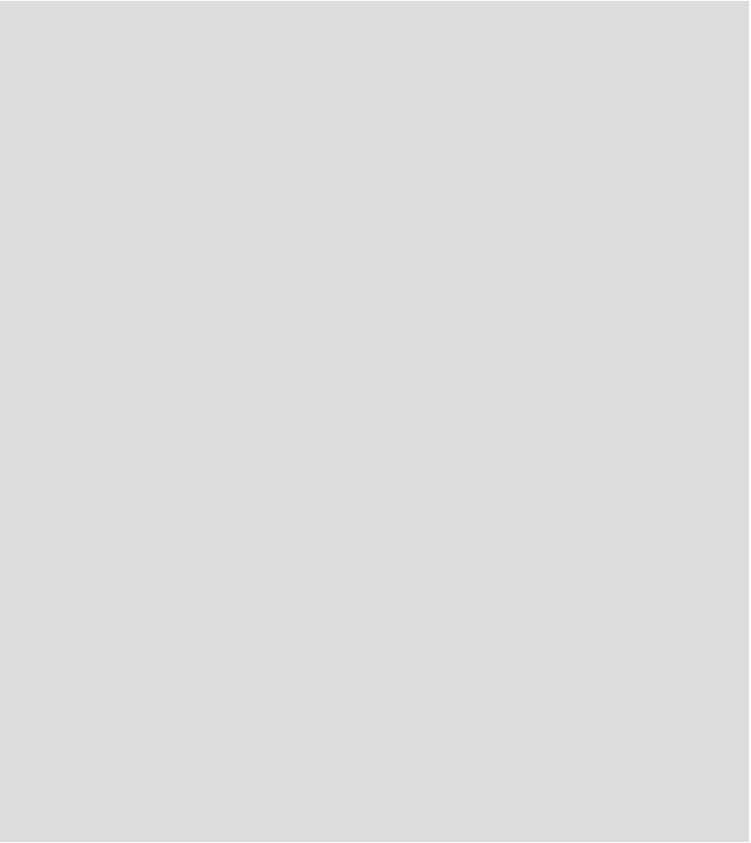
South Korea, only 13.1 percent of South Korea's primary energy is derived from gas compared with approximately 23.4 percent in Germany and 25 percent in the United States (BP 2005). Korea, however, consumes gas more extensively, relative to total energy demand, than does Japan.

High infrastructural costs for trunk lines, regional pipes, and distribution pipes are clearly one important reason that a Korean gas grid has not proceeded faster. Political risk factors, with respect to both North Korea and Russia, are an additional consideration with respect to piped gas. Policy indecision has recently also been important. Nevertheless, the infrastructural basis for future expanded gas usage in Korea is clearly being prepared. Over the past decade, South Korea has built a network of domestic pipelines that significantly surpasses the network in Japan, the largest importer of LNG in the world.

As shown in *Figure 5.2*, the ROK boasts three LNG terminals and an extensive pipeline network on its west coast, along with east-west pipelines crisscrossing the whole of South Korea. This extensive infrastructural development has been possible owing to the monopoly by Korea Gas Corporation in the gas industry, enabling it to readily construct nationwide pipelines.

In contrast with Korea, Japan does not have a systematized nationwide pipeline network, partly because of regulations that do not facilitate a pipeline distribution system nationwide. Local monopolies (which impede the provision of gas beyond authorized company service areas) and related pricing policies make this difficult. However, through a series of recent deregulations during the 1999–2003 period, Japanese gas providers were allowed to sell gas beyond their service areas under certain conditions (Suzuki 2001). These developments encouraged some interconnection among gas providers. In 2002, for example, Tokyo Gas, Shizuoka Gas, and Teikoku Oil Company announced joint pipeline construction in adjacent areas; and in the following year, Hiroshima Gas and Fukuyama Gas announced the establishment of a construction company for joint pipelines (Hasegawa 2003).

The ROK is also pursuing more varied and ambitious uses for natural gas than is Japan. Seoul, for example, has been promoting demand for natural gas through tax incentives, through the introduction of natural gas vehicles such as gas-powered buses, and through an expansion of the domestic natural gas grid. These efforts have led Korean gas consumption to increase both nationally (12.5 percent) and in many indi-



vidual sectors including industry (24.3 percent), household (7.5 percent), and commercial/public (15.6 percent).²⁹

Thus, there is considerable potential for expansion in gas consumption on the Korean peninsula as a whole, particularly for electric power combined-cycle usage in the North, where overall energy consumption remains very low. The North's low income level cannot support extensive residential use, but electric power applications appear feasible. Expansion of gas usage for generating electric power could come either as LNG likely supplied to South Korea from the Middle East, Southeast

29. Figures are for the respective increases between 1998 and 2001; see the Korea Energy Economics Institute Web site that features the *Energy Review Monthly*, www.keei.re.kr/keei/frame/eng_kerm.html.

Figure 5.2: South Korea's Natural Gas Grid



Source: Korea Gas Corporation.

Asia, or Australia or as piped gas most likely from Russia and potentially supplied to either of the Koreas or both.

The two forms of natural gas supply have very different pros and cons, and very different sorts of infrastructural requirements. Making the choice will thus be at once important for Korea's energy future and difficult. As with nuclear power, natural gas supply decisions are heavily entwined with the resolution of the Korean nuclear crisis and will potentially be influenced by its lines of resolution.

LNG. LNG has the considerable merit of being flexibly sourced from any part of the world. It is liquefied at source, transported worldwide in supercooled canisters, and then gasified and transmitted to its destination within the recipient nation by pipe. The price of LNG is thus market sensitive, although supply is usually tied to long-term contracts; it generates only very limited geopolitical leverage between producer and recipient. When market and production source are more than 1,000 miles apart, LNG economics usually win, in the view of knowledgeable specialists.

Piped gas. Piped gas presents a very different geoeconomic equation. It involves much larger initial development and infrastructural costs than does LNG, including massive long-distance construction, although the subsequent per-unit delivery cost is relatively low. These costs can be prohibitive over distances of several thousand miles although the cost equation changes when tasks are undertaken by integrated industrial groups, such as Korea's *chaebol*, that can profit from many sides of a commercial equation, including material and construction-equipment supply as well as finance and product marketing. Government support, of course, can further increase project feasibility, making pipelines another topic interlinked with political discussions like the six-party talks.

Piped gas also creates a structural relationship between producer and consumer, which ultimately can have substantial geopolitical implications. Russia, for example, has reportedly at times used the leverage of its gas pipelines to Moldova and Ukraine to influence those countries' elections by raising gas prices arbitrarily on strategic, politically sensitive occasions. Diversified sourcing can reduce the impact of such manipulation but not fully eliminate it.

Natural gas sourcing arrangements, of course, can also potentially be a hybrid of the LNG and piped-gas paradigms discussed above. Concretely, gas can be piped to an export destination, liquefied, and then shipped worldwide. On the receiving end, there can also potentially be a

major piping element. When some liquefaction occurs, gas thus becomes a more fungible commodity, diluting its strongly geopolitical flavor. Although LNG may not yet be highly marketable in the short run, there is an emerging spot market—currently 7 to 8 percent of global LNG supplies—that makes LNG somewhat more flexible than piped gas.

Three Alternative Korean Energy Futures: North Korea and Global Energy Prices as Critical Uncertainties

Korea's energy insecurities seem likely to continue far into the future, but it is not so clear how Korea will respond, either in policy terms or economic terms. Will its deep and potentially precarious dependence on Middle Eastern oil and LNG persist? Will that fateful dependence intensify? What of the nuclear and the piped gas options? This section develops a typology and set of hypothetical propositions for considering these important questions.

From an energy-security point of view, the most basic imponderable about Korea's energy future is what interfuel trade-offs Korea will confront. What role will oil, coal, gas, and nuclear power play in Korea's energy mix? Such choices, of course, have important security implications. If oil or LNG is prominent, energy sea lanes to the Persian Gulf will be a major concern for Korea and its allies. If piped gas is likely to be important, political-risk issues in Northeast Asia, especially relating to Russia and the course of Korean reunification, will loom large. If nuclear power seems attractive and plausible, concerns about the Nuclear Non-Proliferation Treaty will clearly demand attention, as they have during the six-party talks. The more vital coal seems likely to be, the more China may figure in Korea's energy security thinking.

It is strange that few analysts have tried to understand systematically the political-economic trade-offs among energy sources that Korea confronts in coming years, or the factors that will shape Korea's choices. Economists suggest that such interfuel trade-offs will be increasingly possible technically, throughout the world, in coming years (Wu 1999). Such an understanding of interfuel choices is crucial to grasping the long-term political-economic significance of the ad hoc energy-security decisions now being made in Korea and elsewhere.

Scenario analysis of how political-economic variables and interfuel choice might interrelate needs to start with a healthy respect for the uncertainties involved. For example, almost no one predicted the Asian financial crisis of 1997–98, yet it produced double-digit swings in South

Korea's GNP and energy demand during the 1997–99 period. Similarly, few anticipated the Pyongyang summit of June 2000 or the political-economic consequences flowing from it. Future economic growth and energy demand oscillations—more politically contingent in Korea than almost anywhere else in the world—could also prove volatile.

The uncertainty of future energy prices, coupled with the unsettling likelihood that they may well oscillate between extremes, suggests the general importance of scenario analysis in understanding how the energy future will evolve. Such scenario analysis could be especially important in the case of Korea. Broad global developments that could deeply influence Korea's future are chronically uncertain. Economic developments in South Korea are politically contingent to an unusual degree. And the endogenous forces shaping Korea's political and economic future are also difficult to predict with confidence.

Possible Energy Options

Figure 5.3 suggests that three plausible departures from the status quo are conceivable in Korea's energy future. Should low energy prices return as a viable prospect, the chances are good that Korea would continue relying on the global low-cost energy supplier: the Middle East. Conversely, should high energy prices persist, pressures will intensify for a departure from that pattern toward greater regional diversification.

Prospects for departure from the status quo, however, are also deeply linked to two critical uncertainties: the prospects for North-South relations within Korea, and the future of Russian energy policies. Many scenarios for substantial change in Korea's political status quo, ranging from a lingering "*juche* twilight" for the current DPRK regime to full-scale reunification of the entire Korean peninsula, are quite conceivable. And Russian regulatory parameters also have uncertain aspects, especially given the important emerging role in Northeast Asian energy issues of the Russian company, Gazprom.

Deepened Oil Reliance?

Almost any major, sustained North-South political change would, over the long run, mean substantially more energy demand in the North. Indeed, the DPRK could hardly consume less than at present. More institutionalized North-South reconciliation would imply deeper overall Korean integration with the world economy, larger capital inflows, and hence more rapid growth for the whole peninsula.

Figure 5.3: Korea's Interfuel Choices in Political-Economic Context, 2005–15

		Energy price	
		Predictably high	Predictably low
North-South political-economic détente	Yes	<p>A Rising Russian gas dependence? Middle East options?</p>	<p>B Middle East oil and gas dependence</p>
	No	<p>C Strong nuclear dependence</p>	<p>D Status quo</p>

Changes in the North would most likely also stimulate more North-South trade, resulting in additional growth and energy demand in the South as well. That energy-demand growth could well be skewed toward gasoline for truck and automobile transportation, certainly to a greater degree than at present. Taken together, emerging energy patterns in North and South, within a more unified Korea, could thus mean even deeper dependence on oil and on low-cost Middle Eastern suppliers of that oil, at least until alternate Northeast Asian regional energy infrastructure developed.

Deepened Nuclear Dependence?

A second possible departure from Korea's energy status quo could be strong and possibly increased nuclear dependence, as suggested in quadrant C of Figure 5.3. South Korea already has one of the highest levels of nuclear dependence in the world. In actual power generation, it is the third most heavily nuclear nation, ranking next after only France and Sweden. More than twice the global average share of electrical power is

provided in South Korea by nuclear power, although oil remains dominant in primary energy consumption, as Figure 2.1 suggested.

Populist resistance in an increasingly democratic South Korea no doubt clouds nuclear power's future there to some degree. In October 1999, for example, 12 gallons of radioactive water leaked at South Korea's Wolsong nuclear power plant, four days after the Tokaimura accident in Japan. Although South Korea has had no major accidents since it began using nuclear power in 1978, this 1999 mishap was the worst of seven relatively minor spills at Wolsong since its 1984 startup. Polls taken after the spill showed that 62 percent of Koreans opposed further nuclear construction, and 14 percent wanted all operating nuclear power plants phased out.³⁰ In 2003, some 500 fishermen and environmental activists staged a protest aboard 200 boats demanding that the government cancel its plan to build a nuclear waste dump on an islet off the coastal region of Puan County.³¹

Should global energy prices prove to be high and should the political status quo in North-South relations remain ambiguous or turn more hostile once again, nuclear reliance could have a compelling logic for Korea as a whole. This would be particularly true if North-South political disputes prevent the realization of a trans-Korea gas pipeline. If energy prices are high and North Korean energy demand rises significantly, nuclear reactors could provide valuable domestic energy supplies for a North Korea otherwise lacking them. Yet the issue of nuclear reactors is necessarily linked to the problem of transmission systems, which, in the North Korean context, would involve massive capital costs because of the deplorable state of the existing electric power grid.

The Natural Gas Alternative?

Natural gas is an attractive energy choice for Korea on both energy efficiency and environmental grounds, as we have seen. Yet usage remains relatively limited. Only approximately 12 percent of South Korea's primary energy is derived from gas compared with 23.4 percent in Germany and 25 percent in the United States (BP 2005), although gas usage in the ROK is marginally higher than in Japan.

30. Nicole Gaouette, "Asia's Nuclear Power Dilemma," *Christian Science Monitor*, 27 October 1999.

31. "Puan Residents Stage Naval Protests," *Korea Times*, 1 August 2003.

There is thus considerable potential for expansion in gas consumption on the Korean peninsula as a whole, especially in the North, beginning with electric power generation. At this point, practically all of South Korea's gas currently comes in the form of LNG because of the absence of a well-developed transnational gas grid for piped natural gas across the expanse of Northeast Asia. Resultant Korean demand has propelled the ROK to the standing of second-largest LNG importer in the world, with Korea's global import share of approximately 20 percent second only to Japan's.

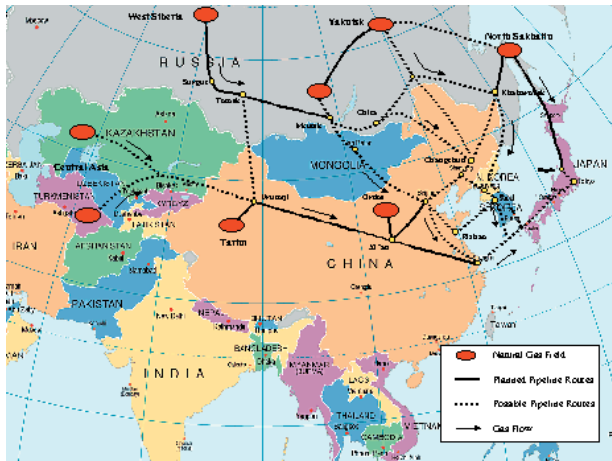
Imported piped gas clearly could be available. Korea has massive gas supplies virtually next door in the huge reserves of Siberia and Sakhalin Island. The Russian Federation holds one-third of the world's entire proved natural gas reserves, and the vast majority of those reserves are concentrated far east of the Urals, in Siberia and on Sakhalin. The reserves could be more easily accessed by pipeline than by any other arrangement, especially if broad regional policy support were available.

Three basic pipeline options between Russia and Korea are available, as indicated in *Figure 5.4*. The simplest would run roughly 3,200 kilometers from Sakhalin Island, through the Russian Far East and North Korea, and south along the Korean east coast toward Seoul. Japanese interests have been discussing these reserves with the Russians since the mid-1960s; more recently U.S. and Anglo-Dutch interests have entered discussions (Burrows and Windrem 1994, 435). The Sakhalin route, a central piece of the Soviet Union's Vostok Plan of the early 1990s (Valencia and Dorian 1998), has substantial attraction for the Russians because it could provide important gas infrastructure to major urban centers of the Russian Far East, such as Khabarovsk and Vladivostok, en route. Gas to supply this route would likely flow from the Sakhalin I project or from new ventures because Sakhalin II is already contracted for LNG supplies, largely to Japan. The key to a Sakhalin pipeline is passage across North Korea, without which it would not happen.

The second pipeline option, much longer and less feasible economically, could be the Kovykta route. This would prospectively link the Kovykta gas field, northwest of Lake Baikal, to the cities of Shenyang, Beijing, and Dalian in China and would reach Pyeongtaek in the ROK via an underwater pipeline through the Yellow Sea. The planned gas pipeline,³² nearly 5,000 kilometers long, will provide China and Korea

32. "Gas Pipeline Expected to Be Completed on Schedule," *FT Global News Wire*, 26 April 2004.

Figure 5.4: Pipeline Options in Northeast Asia



Source: Northeast Asian Gas and Pipeline Forum, www.nagpf.org/

with 20 billion cubic meters and 10 billion cubic meters of gas, respectively, and is tentatively scheduled to start flowing at the end of 2008.

The third pipeline option between Russia and Korea, and the most attractive alternative to Sakhalin from a Korean energy-security perspective despite its formidable infrastructural demands, is the Sakha Republic (Yakutia) route. Yakutia sprawls across a distance greater than 3,000 kilometers north of Korea, covering one-fifth of the vast Russian federation (3.1 million square kilometers) but hosting a population of only 1.3 million people. Much of Yakutia’s desolate Arctic and sub-Arctic terrain remains unprospected and potentially promising. Russian and Chinese firms involved in feasibility studies have had difficulty establishing feasible pipeline routes. In addition, production economics in Korea for such long-distance gas projects would be profoundly affected by deregulation policies in the Korean gas sector that remain unclear.³³

Note that two of the three basic Russia-to-Korea gas pipeline options at least consider the prospect of transiting North Korea. The ultimate locus of consumption, after all, is South Korea, and the source of

33. “Russian and Chinese Companies Unable to Agree on Gas Pipeline Route,” *FT Global News Wire*, 15 January 2003.

supply is one of the three Siberian locations mentioned above—all located to the north of the Korean peninsula. In the absence of a verifiable nuclear nonproliferation agreement with the DPRK, it is obviously premature to move toward agreement on a trans–North Korea pipeline from any of the three major prospective sources of Russian gas, even though it would be cheaper than alternatives and more attractive to most Korean parties concerned. A relaxation of tensions and the prospect of high energy prices might well make such ventures potentially more attractive from the standpoint of Korean energy security, although pipeline options face competition from Middle East options.

Conclusion

Korea's energy insecurities, as we have seen, are not straightforward problems and cannot easily be classified as either economic or political-military. They cut across classical standards of analysis, with the essence all too often opaque and impenetrable to outsiders. Korea's painful combination of resource deficiency and a lack of geopolitical leverage to command access to deficient resources is especially hard for Americans to understand, given the abundant resources they have readily at hand and the political-military leverage they possess to acquire resources they lack.

On the economic side, the heart of Korea's perverse energy equation is the high and rising level of local demand and the nation's deeply rooted difficulties in assuring adequate domestic supply, especially in tight global markets. North and South Korea differ in virtually every conceivable political-economic respect, yet they are strikingly similar in the painful configurations of their common energy dilemma: they are high-energy-use economies, with substantial heavy industrial bases, that have virtually no local oil or gas supply. Fortunately, this common predicament gives North and South a common long-run interest in enhanced energy supply—be it gas, nuclear power, or alternate energy. That common interest serves as a natural bridge over the bitter sea of distrust that more than a half century of Cold War has left behind.

Domestic Policy Parameters in the ROK

Expanded energy supply will, it is hoped, be enhanced by multilateral cooperation, possibly in the context of the six-party talks. To be sustain-

able, multilateral cooperation needs a coherent set of market incentives behind it. Thus, clearer Korean government policies guiding deregulation and market opening in the natural gas sector are especially crucial. In November 1999, for example, the Korean Ministry of Commerce, Industry, and Energy announced plans for restructuring the gas industry, including the privatization of the Korea Gas Company (KOGAS). These plans have not been fully implemented, however, and the precise lines of their reformulation remain ambiguous. Clear, supportive policy parameters with respect to natural gas will be crucial to mobilizing private-sector support—both domestic and foreign—for ambitious gas development programs, especially with respect to regional pipeline development.

Security Decisions for the DPRK

Transcending economics, Korea's energy equation has, of course, another face—ironically, more easily visible outside Korea than within: the specter of nuclear proliferation. Given North Korea's rapid advances in missile delivery systems during the past 15 years, the security challenges that the DPRK has long posed to the South and to U.S. forces deployed there are now matters of intense concern to Japan, and potentially to others as well. As the Northeast Asian security equation grows more complex and regional and as bipolarity wanes in the post-Cold War world, it is highly appropriate that a broad-based multilateral, yet regional, security framework begin evolving in Northeast Asia, nurtured by the six-party process. Such a framework cannot supplant America's core alliances with the Republic of Korea and Japan, but it can play an increasingly important supplementary role.

In chapter 3, it was noted that energy problems loom large in North Korea. Although food supplies are a prior issue in human terms, energy problems constitute the largest single obstacle to the North's healthy economic development, especially the sort of dynamic, information-age development on the Chinese pattern that the DPRK seems to covet. Of greatest importance are stable energy supplies—particularly the high-quality, stable-voltage electrical power that would allow North Korea to increase its use of computers and other sophisticated information-management systems. It may well be, however, that North Korea's greatest needs are for low-profile, relatively inexpensive aid in such areas as training and technical assistance in the development of energy planning and resource-management capacity, together with rehabilitation in coal supply, reduced end-use waste, and development of alternate-energy ca-

pacities. Whether North Korea's leaders recognize and accept this alternative formulation remains unclear.

The DPRK's announced intention, incorporated in the September 2005 Beijing framework communiqué, to abandon its military nuclear program should be applauded. How it will be implemented, however, remains to be seen. What is clear from these pages are the important opportunities for a pattern of North Korean development, synergistic in resolving the energy needs of the entire Northeast Asian region if a meaningful six-party nuclear agreement can be achieved, observed, and implemented.

Centrality of Electric Power

The gas, nuclear, and power-grid issues considered here—all largely relating to electric power—could figure in a lasting resolution to the current nuclear crisis. They are all substantively important, especially for addressing Northeast Asia's energy insecurities and reducing regional energy costs. From a political standpoint, these issues crucially engage key domestic interest groups in major prospective donor nations like Japan and South Korea. The backing of such groups could be important in driving forward proposals for agreement because South Korea and Japan will likely foot the largest portion of the financial costs of an agreement, as they did with respect to the Agreed Framework of the 1990s.

In July 2005, in what is probably the most important concrete policy proposal on North-South energy issues since the Agreed Framework, the ROK proposed that it would provide two gigawatts of electricity to the DPRK, beginning in 2008. The South's proposal should be an important and useful litmus test of Pyongyang's intentions because the DPRK has been consistently demanding an international solution to its energy problems and the proposal provides concrete access to energy. If the DPRK is truly committed to abandoning its military nuclear program and sincerely prioritizes an efficient supply of the reliable electric power that its economy so badly needs, it will consider this proposal seriously.

The ROK's July 2005 proposal differs significantly from the Agreed Framework in that it provides for generating facilities in the ROK rather than north of the DMZ, which is both more technically realistic than the Agreed Framework given current conditions in the DPRK, and more effective because it provides means of assuring that provisions of the broader agreement under negotiation will actually be implemented. It is

also one of the first serious policy proposals to treat the energy problems of North and South Korea in an integrated fashion—an increasingly important analytical quality going forward. If realized, the ROK proposal could be a pivotal step toward both North-South and broader regional confidence building. Transmission lines to be extended northward to Pyongyang from the ROK could well be the first stage of a fully refurbished regional electric power grid, should North Korea convincingly abandon its nuclear weapons program and should sufficient development capital be available.

Technically speaking, the ROK's proposal does not consider the thorny issue of nuclear power generation. It does not provide for the creation of an electric power grid to transmit secondary energy after it is generated, a subject that the Agreed Framework of the 1990s similarly did not address but that is a fundamental developmental issue for Northeast Asia. The Korean Ministry of Unification has also admitted that the South Korean government does not contemplate refurbishing North Korea's crumbling electric power grid under the proposal.³⁴

Some revision of the proposal, including a major upward revision in the total cost of the package, would obviously be needed in order to make the proposed solution effective. In addition, much about the DPRK's commitment to abandon its military nuclear program also obviously remains unclear. Thus, the ROK's new proposal must be considered to be only one constructive step in the six-party negotiating process, perhaps to be elaborated as the DPRK's own sincerity in the nuclear negotiations grows clearer.

Regional Options

There are important Middle East options, this study found, against which Korea and the world should realistically benchmark regionalist energy development proposals currently fashionable in the context of the six-party talks. Middle Eastern countries can invest—and are investing—more in Korea and are partnering with Korean firms in approaches to China. Innovative Korean oil stockpiling policies, including the rental of storage space to foreign producers under KNOC's International Joint Stockpiling Project, are also reducing the potential risks of Korea's traditionally high Middle East dependence still further.

34. "Seoul's Energy Carrot Looks Like Lemon," *Korea Times*, 23 July 2005.

This study clearly found, however, that the resolution of Korea's energy insecurities has an important regional dimension that transcends the narrow economic considerations involved. Both diversification of energy supplies and resolution of the nuclear crisis require serious attention to cooperative regional energy schemes. Japan, China, and Russia, as well as the United States, have a stake in the outcome—not only in persuading the DPRK to abandon its nuclear pretensions but also in a Northeast Asian regional energy supply regime that increases the supply of energy available to all and broadens the distribution of that energy. The nuclear crisis can be a catalyst for regional energy development options, especially for electric power and natural gas, that might otherwise be less feasible.

Pivotal Role for Seoul

These regional tasks, brought to the fore by the North Korean nuclear crisis in ways they might not otherwise have been, have global stakes. North Korea's nuclear proliferation is a problem for all the world, not least because of possible links to terrorism that might someday emerge. Similarly, Northeast Asia's rapidly surging energy demand, led by the massive demand expansion in China, is causing a global price spiral that threatens stagflation many thousands of miles from Beijing itself.

To resolve these energy problems of global importance, Northeast Asia badly needs regional, multilateral mechanisms—with U.S. participation and appropriate security safeguards—that address problems in their full complexity. Korea, at the hub of the Northeast Asian region and with the most to gain from stable regional interdependence, can take a constructive lead in this and has, in fact, done so, with its two gigawatt power supply proposal. Seoul needs to mediate in the moderate, inclusive fashion that was the hallmark of Paul Henri Spaak, Jean Monnet, and other key European leaders who were present at their region's active creation a half century ago.

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