Growth in Energy Needs in Northeast Asia: Projections, Consequences, and Opportunities

David F. Von Hippel and Peter Hayes
Nautilus Institute for Security and Sustainable Development

1. Introduction

Over the past two decades and more, rapid economic growth in Northeast Asia—a region of more than 1.5 billion people—has rapidly increased regional needs for energy services. In the People’s Republic of China (PRC) and the Republic of Korea (ROK) in particular, growth in the need for energy services, as well as for the fuels—gasoline, coal, electricity, natural gas, and others—that are used to supply those needs, has brought with it a raft of environmental problems, including (a) rapidly mounting greenhouse gas (GHG) emissions and (b) increased emissions of other air pollutants, with significant effect on local and regional air quality. As a recent, eye-opening example of the increased needs, China added more than 100 GW of generating capacity—equivalent to 150% of the total generation capacity in the ROK as of 2007—in the year 2006 alone, with the vast bulk of that added capacity being coal-fired.

The countries of the region already constitute the largest importer market for liquefied natural gas (LNG) and are also a major oil import market. The Northeast Asian regional share of world primary energy use has been increasing as well; even as energy use in the rest of the world has increased, Northeast Asia’s share has increased from 18.6% in 1999 to 24.1% in 2006.

Though the region as a whole possesses resources that could contribute substantially toward its future energy needs, many major energy resources—including natural gas, oil, coal, and hydroelectric power in the Russian Far East (RFE), and gas and hydro in western China—are far from population centers. As such, major infrastructure investments will be required to bring these resources to market; additional economic, political, technical, and environmental considerations also apply, particularly when these resources cross one or several borders, and most particularly when one or more of the borders (as for pipelines or powerlines from Russia to the Republic of Korea) are shared by the Democratic People’s Republic of Korea (DPRK). Further, the Six-Party Talks process of negotiating the removal of nuclear weapons from the DPRK links consideration of providing assistance in rebuilding the DPRK’s economy and energy sector with nuclear weapons issues, so that the regional energy cooperation, the solution to the DPRK nuclear weapons dilemma, and perhaps even the partial solutions to global and regional environmental problems are intertwined.

In the remainder of this article, we will begin with brief sketches of the recent, current, and future drivers of energy supply and demand in each of the countries of Northeast Asia; provide a summary of regional projections of energy use, noting some of the probable consequences of energy use expansion; touch on some of the opportunities for regional energy cooperation, noting the prospects and limits of cooperation to meet needs for energy services; continue with the challenges and opportunities in a regional context posed by the DPRK energy and security situation; and end with notes on what the United States, in particular, might do to influence the path of energy cooperation in Northeast Asia.

2. Energy Use in the Countries of Northeast Asia—Trends, Drivers, and Projections

The countries that make up the region that will be referred to herein as “Northeast Asia” range from industrialized, heavily populated, and energy-resource-poor nations (Japan and the Republic of Korea); to nations that have limited energy resources and that seek development or redevelopment (Mongolia, DPRK); to China, which has significant resources but a huge population and rapidly growing energy demand; to the subnation that is referred to as the Russian Far East, which has a small population inhabiting a vast, resource-rich (but forbidding) landscape. Not surprisingly, these countries show very different trends and projections of energy use. Energy use trends and projections, plus the driving forces behind them, are discussed briefly for each country.
Japan

Japan’s population—about 127.5 million as of 2005—is nearly stable and will start to decline in the next decade. After a period of quite slow or no growth—average gross domestic product (GDP) growth of about 1.2% from 1990 through 2005—Japan’s economic picture has begun to improve somewhat in recent years. Japan has modest hydroelectric output and very small domestic gas production; moreover, although it has some coal reserves of about 360 million tonnes, the high production costs of domestic coal relative to the cost of imported coal have caused Japan to all but shut down its indigenous coal industry. As a result, Japan’s economy is highly dependent on imports—particularly imported coal, oil (largely from the Middle East), LNG, and uranium for its nuclear power industry. Japan’s energy use and carbon dioxide emissions also continue to grow, but more slowly than the economy (see Figure 1).

Figure 1: Trends of GDP, Primary Energy Use, Final Energy Consumption, and Carbon Dioxide Emissions in Japan.

Despite relatively slow recent growth in energy use, meeting Japan’s commitment to reduce GHG emissions under the Kyoto Protocol to the United Nations Framework Convention on Climate Change will require significant modifications to business as usual. Japan’s policies for using government policies to achieve emissions reduction emphasize energy efficiency, but the policies largely use voluntary measures. Though policies such as emission trading and an environmental tax are under discussion, they have yet to be implemented. Japan’s government policy calls for expansion of nuclear power generation capacity from 50 GW (gigawatts, or billion watts) in 2007 to about 66 GW in 2020, with implementation of life extension for existing plants and, ultimately, fast breeder reactors to conserve uranium.

However, the following realities suggest that significant expansion of Japan’s nuclear power program faces serious obstacles: (a) the high cost of nuclear fuel reprocessing facilities (on the order of US$180 billion to build and operate the Rokkasho reprocessing facility and related spent-fuel management infrastructure, over its lifetime); (b) the difficulties in obtaining new sites for reactors and reprocessing facilities (because of safety and other concerns); and (c) the issues related to the storage of nuclear spent fuel (storage pools at reactors are filling up, and long-term storage has been hard to site and seismically problematic). At the same time, growing inventories of plutonium separated both in domestic facilities and at reprocessing centers abroad create both an incentive for using the separate plutonium in conventional or breeder reactors and, potentially, a proliferation concern.
Several studies have indicated that despite Japan’s relatively high efficiency of energy use, much more could be done, and a commitment to aggressively implement energy efficiency measures and to implement renewable energy options is likely to be effective in helping Japan meet its targets for reducing GHG emissions. Figure 2, for example, compares business as usual (BAU) projections of future energy use in Japan with paths (national alternative, or NA, and regional alternative, or RA), including significantly greater energy efficiency and renewable energy. The result is energy use and emissions that will be about 25% lower by 2030.

Figure 2: Three Scenarios of Future Energy Use in Japan: Business as Usual (BAU), National Alternative (NA), and Regional Alternative (RA) Cases Showing Reduction in Final Energy Consumption as a Result of Implementing Energy Saving Technologies. (Units: trillion kcal)^5

Republic of Korea

Like Japan, the Republic of Korea depends heavily on imports of oil, natural gas (as LNG), and coal to drive its economy—with an overall import dependence of more than 96%. Like Japan, the ROK does have some coal reserves, but the expense of mining them has caused domestic production to dwindle to a small fraction of national needs. Like Japan, the ROK has little in the way of significant oil or gas reserves, though some resources may exist in areas near or on maritime boundaries with other nations. Like Japan, the ROK population is near its peak and will begin to decline in just over a decade (by 2019) from a high of about 49.2 million. Unlike Japan, however, the ROK’s economy and energy use continue to grow quite rapidly, with an annual average growth rate of GDP from 1998 through 2005 of 5.6% and an annual average growth rate of primary energy consumption of 4.7%. In 2006, the ROK’s GDP grew 5.2%, but energy consumption rose only 2.1%, suggesting a continuing trend of decoupling of energy consumption and economic growth.

Ongoing policy directions in the ROK, which will help to shape energy consumption in the coming decades, include policies: (a) to enhance energy efficiency that will reduce energy imports dependence and will respond to oil costs (a quarter of the outlays for all imports to the ROK in 2006 were for petroleum); (b) to move toward sustainable energy system in response to environmental challenges; and (c) to pursue regional energy cooperation (on oil, gas, electricity, or a combination of these within the infrastructure). Other factors influencing energy policy in the ROK include a movement toward a more open policy framework and the existence of no more new nuclear sites (in the ROK, at any rate).

An ongoing process of market development and privatization is scheduled to continue, starting with the recent breakup of the elements of KEPCO (the Korea Electric Power Corporation), the selective privatiza-
tion of electricity and KNOC (Korea National Oil Company) assets, and the revision of tax structures for some fuels (including biofuels). **Figure 3** shows a projection for rough BAU growth in primary energy use in the ROK by displaying continuing, though slowing, expansion in the energy use, but with the fraction of energy provided by oil and eventually coal declining at the expense of expanded use of natural gas, nuclear power, and renewable energy.8

**Figure 3**: Projections of Primary Energy Use by Fuel Type in the Republic of Korea, 2005 through 2030 (million tonnes oil equivalent and fraction of total supply by fuel).

![Figure 3: Projections of Primary Energy Use by Fuel Type in the Republic of Korea, 2005 through 2030](image)

Source: See note 8.

Key: AAGR = annual average growth rate; LNG = liquefied natural gas; MTOE = million tonnes of oil equivalent; RE = renewable energy.

**Mongolia**

As of 2006, landlocked Mongolia had a population of 2.6 million people living in a territory of 1.57 million square kilometers set between Russia and China. After growing at 2% to 3% per year through the 1980s, Mongolia’s population growth rate declined rapidly to less than 1% by the late 1990s; it is projected to continue to decrease slowly, so that the nation’s population is projected to reach stasis by 2050. Despite robust economic growth in recent years—no lower than 6% annually since 2002—Mongolia’s use of electricity and coal (used for electricity generation, industry, central-station heat production, and residential energy use in urban areas) grew relatively little.9 Mongolia imports all of its oil as refined products, and growth in refined products use has averaged about 5.4% annually from 2002 through 2006.10 Because much of the growth in Mongolia’s GDP in recent years has stemmed from increases in commodity prices (for copper and livestock, for example) that are received for its exports to China and other rapidly growing economies, it is perhaps not surprising that growth in energy use has not tracked growth in GDP.

Projections for energy use in Mongolia are not numerous. A set of projections for Mongolia prepared under the Asia Least-cost Greenhouse Gas Abatement Strategy (ALGAS)11 project forecasts growth in energy demand from 2000 to 2020, averaging nearly 10% annually. Other estimates, including an estimate of total energy demand for Mongolia averaging less than 2% annually for the same period,12 and Mongolian estimates for electricity and heat demand show growth from 2005 to 2020 in the range of 2% to 3% annually,13 suggesting that growth in energy use will be significantly less than the ALGAS projections. To achieve sustainable economic growth, Mongolia must address: (a) its aging energy infrastructure; (b) its problems with
transparency and other governance-related issues in the operations of its energy sector; (c) its poor energy efficiency on both the supply and demand sides, stemming partially from market inefficiencies caused by fuel price subsidies; and (d) its environmental concerns, particularly related to coal consumption.

Our rough projection of oil, electricity, and coal demand for Mongolia, provided in Figure 4 assumes that these issues are addressed over time, but that growth in energy use occurs at only a fraction of the level suggested by the ALGAS study.

Figure 4: Projections of Energy Demand by Fuel Type in Mongolia, 2005 through 2030.

Source: By authors.

Democratic People’s Republic of Korea

The economic, if not social and political, landscape in the DPRK changed markedly during the 1990s, following the breakup of the Soviet Union. This economic decline has been both a result and a cause of substantial changes in energy demand and supply in the DPRK. Though recent anecdotal evidence suggests that the economy in some parts of the DPRK, particularly near Pyongyang, may have improved somewhat between about 2003 and 2006, it is not clear that the energy supply situation has changed substantially for the better nationwide since 2000. Elements of this economic decline and of subsequent mixed (at best) performance include the following:

- A decline in the supply of crude oil in early 1990s, though supplies—all or virtually all imports from China—have been approximately stable since 2000.
- Continuing degradation of electricity generation, transmission, and distribution infrastructure. There have been reports of somewhat improved electricity availability in recent years, but improvement, if any, appears to be highly variable by location and even from year to year.14
- Continuing degradation of industrial and district heating facilities and of transportation infrastructure, the latter resulting in difficulties with transport of all goods, especially coal.
- Some international trade in the refractory and rather rare mineral magnesite, thus expanding trade with China in coal (over 3 million tonnes in 2006) and metal ores, as well as the beginning of ROK investments, particularly in the mining sector.
- Difficulties in coal production related to lack of electricity and mine flooding.
- Sporadic, highly localized economic revival, but mostly associated with foreign aid or in areas of the economy that are not energy intensive (such as markets, restaurants, small agriculture).
• The cessation of heavy fuel oil (HFO) deliveries by the Korean Peninsula Energy Development Organization (KEDO) as of 2003, and new HFO deliveries begun within the past year as a result of recent Six-Party Talks agreements.
• Construction of small power plants, mainly small hydroelectric plants, but sometimes small thermal (coal or biomass-fired) plants as well. The plants are often not connected to the main power grid—thus serving only local areas—and may have produced relatively little energy per unit of capacity.

**Figure 5: DPRK Energy Use by Sector: 1990, 1996, 2000, and 2005.**

Source: See note 15.

**Figure 6: DPRK Energy Use by Fuel: 1990, 1996, 2000, and 2005.**

Source: See note 15.

*Figure 5* compares estimated final energy demand by sector for the years 1990, 1996, 2000, and 2005, and *Figure 6* provides the same comparison for energy demand by fuel category. In addition to the marked decrease in overall energy consumption, there are two notable features of these comparisons. First is the continuation of the trend of 1990 to 1996, whereby the residential sector uses an even larger share (42% in 2005) of the overall energy budget, while the industrial sector share shrinks to a third of the total. This
change is the combined result of (a) continued reduction in fuel demand in the industrial sector, (b) relatively constant use of wood and other biomass fuels in the residential sector, and (c) reductions in the use of other residential fuels (notably coal and electricity) that are not as severe as the reductions experienced in the industrial sector. Second, and for similar reasons, the importance of wood and biomass fuels to the energy budget as a whole is estimated to have increased dramatically over the course of the 1990s and into the current decade, while the importance of commercial fuels has decreased. Increased use of wood and the resultant over-cutting of forest stocks, along with other human-caused (such as clearing of marginal and highly sloped land for agriculture) and natural events (floods, droughts), have resulted in significant deforestation and degradation of forest lands in the DPRK.

We have prepared (and are currently updating) future scenarios of energy-sector development for the DPRK, using the Long-range Energy Alternatives Planning (LEAP) energy and environment software tool. The choice and shape of DPRK energy “paths” are highly dependent both on resolution of the nuclear weapons issue and on the timing and nature of investments and assistance that would flow from such a resolution.

We compared a “redevelopment” path that has no significant emphasis on energy efficiency improvement (see Figure 7) with a “sustainable development” path emphasizing energy efficiency and (to a lesser extent) renewable energy. We also evaluated—and compared with the other two paths—a “regional alternative” path that included DPRK participation in regional energy infrastructure initiatives (for example, gas pipelines and electricity trading). The results showed a significant reduction in, for example, electricity needs (see Figure 8) and GHG emissions (see Figure 9) for the sustainable development and regional alternative paths, relative to the redevelopment path.

*Figure 7: Preliminary Results, Final Energy Use by Sector: Redevelopment Case.*

![Figure 7: Preliminary Results, Final Energy Use by Sector: Redevelopment Case.](image-url)
The net costs of those reductions may be relatively small or even negative—our earlier work showed negative net costs (that is, net savings) for the sustainable development and the regional alternative paths relative to the redevelopment path, even assuming future oil prices that may be much lower than today’s levels. We are continuing to update these analyses, but we expect that revised results will show the same general
trends, thereby (a) reinforcing the conclusion that the least expensive way to redevelop the DPRK will be as an energy-efficient economy and (b) underscoring the benefits of the energy-efficiency-related regional cooperation options noted later in this article. Some energy efficiency cooperation options may offer opportunities for application of clean development mechanisms to share costs—and carbon credits—between the DPRK and investor countries.

China

China’s economic rise continues to be nothing short of stunning, with annual rates of GDP growth in this decade ranging from a low of 8% to more than 11%.18 Though the focus of the economy is shifting as it matures—from agriculture and primary industry toward secondary industry and services—growth in the need for energy resources to fuel economic development continues at a rapid pace. During 2006, for example, China’s primary energy production grew 7.2%, and its total energy demand grew 9.6%, including a 10.4% increase in coal use (to 2.4 billion tonnes), a 14.6% increase in power generation (and a 19.6% increase in capacity to nearly 620 gigawatts), a 7.2% increase in oil consumption, and a nearly 20% increase in natural gas consumption.19

China’s domestic oil production and resources are insufficient to sustain the growth in oil products use; as a result, net crude oil and oil products imports rose 17.9% in 2006. Though China’s population is stabilizing (current growth is less than 0.6%/year with the population estimated to peak at 1.46 billion just after 2030), the increasing industrialization and urbanization continues to drive growth in energy use, along with (and among other factors) a growth in per capita income, a trend toward increasing floor area per household (including in rural areas), and an increasing demand for warmer and cooler (seasonal) homes.

In recognition of the economic and environmental costs of rapidly increasing energy use, China’s government is pushing forward with policies in areas such as nuclear power expansion, increased use of renewable fuels, and energy efficiency. Even with increasingly aggressive implementation targets, nuclear power will likely provide less than 5% of power generation by 2030. Though the implementation of renewable energy sources and the use of natural gas are rising, including considerable construction of large hydroelectric facilities in the near term, projections suggest that coal will still supply 50% of China’s energy needs by 2030.

Future scenarios for implementation of energy efficiency (and renewables) have suggested significant (13–26%) savings in primary energy use,20 but implementation will require an incredible (though entirely worthwhile) effort in capacity building alone to achieve those targets. Simply considering the amount of training required to equip officials in all parts of China to enforce the stringent building energy codes being promulgated by the national government is a mind-boggling exercise. A recently announced program to save 3 exajoules (3 billion gigajoules) by 2010 by focusing on energy efficiency improvements in the 1,000 largest industrial enterprises in China is certainly a laudable start to what will need to be a vast, sustained, and well-organized program—if energy efficiency goals are to be met. Figure 10 shows the results of a BAU projection of future energy use by sector in China; in it, final demand grows to more than 5 billion tonnes of coal equivalent by 2030.21

Russian Far East

The vast (6.2 million square kilometers) Russian Far East (RFE) region22 is home to a population of about 4.6 million people. The RFE is rich in mineral (including coal), oil and gas, and hydraulic resources, but it has a limited infrastructure, at present, to extract those resources and to move them to international markets. Both the economy and population of the region declined after the breakup of the Soviet Union, and though the RFE has seen positive economic growth in recent years, that growth has been at a lower rate than the rate...
in Russia as a whole. The region’s earlier population decline has been stemmed in recent years. Oil and gas production in the RFE has increased recently as new projects have come on line (particularly in the Sakhalin area), but coal, electricity, and heat production and consumption have remained largely stable during the past few years, even as gross regional product has increased.

**Figure 10: Projection of Business as Usual Energy Demand by Sector in China.**

![Figure 10: Projection of Business as Usual Energy Demand by Sector in China.](image)

Source: See note 21.

Though the RFE has been actively seeking ways of developing its resources, key features of the RFE energy policy in recent years have included enhanced state control in national oil and gas sector, including granting exclusive rights for international exports and imports of natural gas to Gazprom and of electricity to Inter-RAO. Limitations have also been set on foreign companies’ participation in Russia’s energy sectors, with all deals subject to federal control. At the same time, there are ongoing efforts to build domestic energy markets and to attract foreign capital into Russian Federation energy firms.

The future energy demand and the economic growth in RFE are likely to be, to a significant extent, a function of the development of resource exports. All of the following underscore this link: (a) recent federal policies, including the revival of long-term planning for energy sectors of Russia in general and of the RFE in particular (oil and gas, nuclear, electricity); (b) the 2006 presidential announcement of the Global Energy Security concept; and (c) the emphasis on “multilateral and open energy security optimization on both demand and supply sides, stressing energy interdependence.”

The Russian federal government has increased its attention on the RFE with respect to potential exports to Northeast Asia. As a result, a number of major strategic initiatives are in the process of consideration and elaboration for the RFE, including projects for economic and social development and investments in the refining industry, in gas and oil extraction, in transportation, and in electricity infrastructure development. **Figures 11 and 12** present, respectively, projections for final energy demand and primary energy production.
in scenarios reflecting reference, national alternative (emphasizing energy efficiency and renewable energy), and regional alternative (in which the RFE engages in major energy exporting projects with countries of the region). The effect of energy exports on the regional economy shows in the higher energy demand by 2030 (relative to the other scenarios), as well as in the much higher energy production by that year.

**Figure 11:** Final Energy Demand for Three Scenarios of Energy Sector Development in the Russian Far East.

![Figure 11: Final Energy Demand](image)

Source: See note 23.

In these figures, “mln TCE” stands for million tonnes of coal equivalent.

**Figure 12:** Primary Energy Demand for Three Scenarios of Energy Sector Development in the Russian Far East.

![Figure 12: Primary Energy Production](image)

Source: See note 23.

In these figures, “mln TCE” stands for million tonnes of coal equivalent.

### 3. Energy Use and Its Effects in Northeast Asia

*Table 1* shows the distribution of primary energy use by fuel in the countries of Northeast Asia. Those countries already collectively constitute the world’s largest market (64% of 2006 global exports) for LNG, as well as one of the world’s largest markets for crude oil and petroleum products (nearly 20% of global
demand). It also uses nearly half (more than 46%—up from about 33% in 1999) of global coal production, with about two-thirds of regional coal use being in China. The countries of Northeast Asia consumed slightly under 20% of the world’s petroleum and nuclear energy, 17.5% of hydroelectric generation, and 6.7% of natural gas use—up from 5.5% in 1999.

Table 1: Primary Energy Use in Northeast Asia and the World, 2006

<table>
<thead>
<tr>
<th>Country/Area</th>
<th>Oil</th>
<th>Natural</th>
<th>Coal</th>
<th>Nuclear Energy</th>
<th>Hydroelectric</th>
<th>Total</th>
<th>Fraction of NE Asia</th>
<th>Fraction of World</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>349.8</td>
<td>50.0</td>
<td>1,191.3</td>
<td>12.3</td>
<td>94.3</td>
<td>1,697.8</td>
<td>64.8%</td>
<td>15.6%</td>
</tr>
<tr>
<td>Chinese Taipei</td>
<td>52.5</td>
<td>10.7</td>
<td>39.5</td>
<td>9.0</td>
<td>1.8</td>
<td>113.6</td>
<td>4.3%</td>
<td>1.3%</td>
</tr>
<tr>
<td>DPRK (North Korea)</td>
<td>1.0</td>
<td>-</td>
<td>9.7</td>
<td>-</td>
<td>0.8</td>
<td>11.4</td>
<td>0.4%</td>
<td>0.1%</td>
</tr>
<tr>
<td>Hong Kong (China SAR)</td>
<td>13.2</td>
<td>2.2</td>
<td>7.5</td>
<td>-</td>
<td>-</td>
<td>22.9</td>
<td>0.9%</td>
<td>0.3%</td>
</tr>
<tr>
<td>Japan</td>
<td>235.0</td>
<td>76.1</td>
<td>119.1</td>
<td>68.6</td>
<td>21.5</td>
<td>520.3</td>
<td>19.9%</td>
<td>6.1%</td>
</tr>
<tr>
<td>Mongolia</td>
<td>0.6</td>
<td>-</td>
<td>1.5</td>
<td>-</td>
<td>-</td>
<td>2.0</td>
<td>0.1%</td>
<td>0.0%</td>
</tr>
<tr>
<td>ROK (South Korea)</td>
<td>105.3</td>
<td>30.8</td>
<td>54.8</td>
<td>33.7</td>
<td>1.2</td>
<td>225.8</td>
<td>8.6%</td>
<td>2.6%</td>
</tr>
<tr>
<td>Russian Far East</td>
<td>10.6</td>
<td>2.9</td>
<td>11.5</td>
<td>-</td>
<td>1.1</td>
<td>27.0</td>
<td>1.0%</td>
<td>0.3%</td>
</tr>
<tr>
<td>Total Northeast Asia</td>
<td>768</td>
<td>173</td>
<td>1,435</td>
<td>124</td>
<td>121</td>
<td>2,621</td>
<td>100.0%</td>
<td>24.1%</td>
</tr>
</tbody>
</table>

Table 2 provides 2005/2006 estimates of population in each of the countries (or, in the case of the Russian Far East and Hong Kong, subcountry region) of Northeast Asia, and it shows the use of primary energy per capita by country. The DPRK consumed approximately 0.8 tonnes of oil equivalent (TOE) of primary commercial fuels per capita in 1996, and China used about 0.6 TOE per capita in 1999, while South Korea used 3.9 TOE per capita and Japan used 4.0 TOE per capita in 1999. Since that time, as shown in Table 2, energy use per capita has increased slightly in Japan, has increased significantly in the ROK, and has more than doubled in China, while decreasing in the DPRK.

Table 2: Population and Energy Use Per Capita in Northeast Asia, 2006

<table>
<thead>
<tr>
<th>Country/Area</th>
<th>Population (million)*</th>
<th>Primary TOE/cap*</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>1,313.8</td>
<td>1.29</td>
</tr>
<tr>
<td>Chinese Taipei</td>
<td>22.8</td>
<td>4.98</td>
</tr>
<tr>
<td>DPRK (North Korea)</td>
<td>22.4</td>
<td>0.51</td>
</tr>
<tr>
<td>Hong Kong (China SAR)</td>
<td>6.9</td>
<td>3.30</td>
</tr>
<tr>
<td>Japan</td>
<td>127.6</td>
<td>4.08</td>
</tr>
<tr>
<td>Mongolia</td>
<td>2.9</td>
<td>0.71</td>
</tr>
<tr>
<td>ROK (South Korea)</td>
<td>48.9</td>
<td>4.62</td>
</tr>
<tr>
<td>Russian Far East</td>
<td>4.6</td>
<td>5.87</td>
</tr>
<tr>
<td>Total Northeast Asia</td>
<td>1,550</td>
<td>1.69</td>
</tr>
</tbody>
</table>

*Source: See note 26.
TOE = tonnes of oil equivalent.
Estimates are for 2006, except DPRK, Mongolia, and RFE, which are for 2005.

The major point here is that energy use in Northeast Asia—particularly in China, the DPRK, and Mongolia—would seem to have substantial room to grow before it reaches the levels currently maintained by Japan, the ROK, and other developed nations. The consumption of transport services—which Chinese and North Koreans currently use relatively lightly and very lightly, respectively—is one of the key areas of growth (as any recent visitor to a major Chinese city will attest) and, in all probability, will result in a significant increase in transport energy use in those countries.

Figures 13 and 14 present views of projections of primary energy use by country and by fuel for the countries of Northeast Asia. The projections were largely
derived from reference or BAU case projections as described earlier, most of which have been developed or conveyed by country working groups in Nautilus Institute’s collaborative Asian Energy Security project. This composite suggests that energy use in Northeast Asia will roughly double in the next 25 years, with 90% of that growth, not surprisingly, coming from China.

**Figure 13: Projected Primary Energy Use by Country.**

Source: See note 27.

**Figure 14: Projected Primary Energy Use in Northeast Asia by Fuel.**
Growth in demand for energy services in Northeast Asia—and for the fuels used to provide those services—has had (and, as growth continues, will continue to have) significant implications in a number of areas. Expansion in energy use is causing and, according to current trends, will continue to cause major consequences for the following:

- Global and regional fuels markets, as the countries of the region require increasing amounts of energy—oil, natural gas, and even coal—from outside the region.
- Global financial markets, as funds are increasingly needed to obtain energy and to build needed energy infrastructure, and thus may be less available for other investments (within the region and elsewhere).
- Local, regional, and global criteria air pollutants, including particulate matter (smoke, sulfur oxides, nitrogen oxides, and volatile organic compounds), emissions of which are increasingly of concern and require increasing investments in control technologies in China and elsewhere in the region.
- Global GHG emissions, which are increasingly of concern worldwide.
- Local land use for energy infrastructure, including land requirements for hydroelectric reservoirs (which have displaced millions of people in the region in recent years), as well as for thermal power plants and energy transport infrastructure.

For one of the earlier implications (global GHG emissions), Table 3 and Figure 15 provide, respectively, a summary of historical estimates and projections for emissions in the countries of Northeast Asia, as well as a view of the increasing importance of emissions of carbon dioxide (CO2) from the region relative to the rest of the world. Northeast Asia’s share of world CO2 emissions increased from 20.6% to nearly 28% by 2005, and, on the basis of a variety of estimates, will account for more than one-third of global emissions by 2030.28

Table 3: Historical and Projected Emissions of Carbon Dioxide in Northeast Asia

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>611</td>
<td>776</td>
<td>794</td>
<td>1,452</td>
<td>2,143</td>
<td>2,558</td>
<td>3,318</td>
</tr>
<tr>
<td>Chinese Taipei</td>
<td>32</td>
<td>49</td>
<td>68</td>
<td>78</td>
<td>95</td>
<td>106</td>
<td>130</td>
</tr>
<tr>
<td>DPRK (North Korea)</td>
<td>126</td>
<td>63</td>
<td>32</td>
<td>38</td>
<td>82</td>
<td>87</td>
<td>83</td>
</tr>
<tr>
<td>Hong Kong (China SAR)</td>
<td>11</td>
<td>13</td>
<td>15</td>
<td>20</td>
<td>[Included in China total]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Japan</td>
<td>275</td>
<td>293</td>
<td>325</td>
<td>336</td>
<td>363</td>
<td>372</td>
<td>381</td>
</tr>
<tr>
<td>Mongolia</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>ROK (South Korea)</td>
<td>66</td>
<td>103</td>
<td>120</td>
<td>136</td>
<td>166</td>
<td>190</td>
<td>225</td>
</tr>
<tr>
<td>Russian Far East</td>
<td>80</td>
<td>71</td>
<td>71</td>
<td>80</td>
<td>98</td>
<td>105</td>
<td>135</td>
</tr>
<tr>
<td>Total Northeast Asia</td>
<td>1,204</td>
<td>1,371</td>
<td>1,427</td>
<td>2,142</td>
<td>2,950</td>
<td>3,421</td>
<td>4,278</td>
</tr>
</tbody>
</table>

| NE Asia Fraction of World    | 20.6%| 22.9%| 22.0%| 27.9%| 31.2%| 32.9%| 34.6%|
| Total Rest of World           | 4,631| 4,627| 5,051| 5,547| 6,492| 6,974| 8,072|
| TOTAL WORLD                   | 5,835| 5,997| 6,478| 7,689| 9,442| 10,394| 12,350|

Source: See note 28.

**Regional Energy-Sector Cooperation Options**

The growth in energy use in the region and its attendant problems—together with the energy, financial, human, and technological resources available in the countries of the region—create opportunities for energy-sector cooperation in Northeast Asia. These opportunities include the following:

- Integration of conventional energy supply infrastructure, such as gas and oil pipelines from the RFE to the ROK—potentially including the DPRK—as well as from the RFE to China and possibly Japan; LNG terminals shared between nations (such as between the DPRK and ROK), and electricity grid interconnections from the RFE to the ROK and the DPRK, to China, and possibly to Japan through Sakhalin Island and Hokkaido.
- Cooperation on energy efficiency and renewable energy development, including technologies such as district heating, and solar, wind, and biomass energy.
- Cooperation on regional emergency and strategic fuel storage.
- Cooperation on nuclear fuel-cycle facilities, including (potentially) shared facilities for enrichment, for spent nuclear fuel management, or for both.

When one considers cooperation options in the context of Northeast Asia and its energy needs, it is necessary to keep in mind that even the largest single proposal to supply infrastructure, on its own, will supply no more than a modest fraction of Northeast Asia’s fuel or electricity needs. For example, the Eastern Siberia to Pacific Ocean Oil Pipeline (ESPO) may ultimately provide 100 Mte/yr of Russian oil to China, Japan, or...
both, but even at that will yield only about 15% of the 2006 Northeast Asia oil demand and about 10% of the projected 2020 oil demand in China alone. In addition, many of the infrastructure proposals will require investments in the tens of billions of U.S. dollars and will involve significant technical complexities, as well as unprecedented (in the region) international legal arrangements (related, for example, to energy pricing, environmental compliance, infrastructure security, and other issues). In addition, most supply-side cooperation options now under consideration will do little or nothing to reduce regional GHG emissions and other pollution. The options with arguably the best prospects for overall emissions reduction and cost savings—energy efficiency and renewable energy—may face implementation (such as intellectual property) hurdles, but they may also offer “win–win” opportunities for cooperating countries.

The Role of the DPRK in Northeast Asian Energy Cooperation

During the decade of the 1990s and continuing through much of this first decade of the 21st century, a number of issues have focused international attention on the DPRK. Most of these issues—including nuclear weapons proliferation, military disagreements, economic collapse, transboundary air pollution, floods, food shortages, droughts, and tidal waves—have their roots in a complex mixture of Korean and Northeast Asian history, global economic power shifts, environmental events, and internal structural dilemmas in the DPRK economy. Energy demand and supply in general—and, arguably, demand for and supply of electricity in particular—have played a key role in many of these high-profile issues involving the DPRK.

Solving the DPRK nuclear issue may not be a strictly necessary condition to allow significant regional cooperation on energy issues and infrastructure, but it would certainly be helpful and would probably accelerate activities in a number of ways and for a number of reasons—including the advantages of a regional context for engagement of the DPRK on energy issues. Even once the nuclear issue is (at least largely) addressed, however, considerable challenges to bringing the DPRK into regional cooperation activities will remain. To cite just a few examples, significant efforts will be needed to upgrade DPRK infrastructure, to provide capacity building, and to help reform legal and administrative systems that allow DPRK to participate fully in regional initiatives (in many cases, similar efforts will be needed in other countries as well). The issue of “geopolitics” (that is, consideration of the effects of regional energy cooperation activities on the relations between powers great and smaller both within and outside the region) is also likely to come into play—in ways that may be difficult to predict—as resolution of the DPRK nuclear issue nears.

In addition to the challenges noted earlier, resolution of the DPRK nuclear issue would undoubtedly open opportunities for cooperation on energy issues. For example, as the DPRK economy becomes more integrated with the economies of the region, pipelines and transmission lines could be developed to pass through and could take a direct route to the ROK, thereby providing service to the DPRK as well. Additional markets for all types of technologies (and services) would open as the DPRK is redeveloped. In fact, redevelopment of the DPRK will provide a considerable opportunity to install efficient end-use equipment and renewable energy systems, because the DPRK economy (and infrastructure) will need to essentially be rebuilt from the ground up. In the process the DPRK may, in a way, provide a “laboratory” for application of energy efficiency and renewable energy measures in a way that other nations, with infrastructure that has been more recently updated, cannot. Regional cooperation on energy sector initiatives also provides an opportunity to use DPRK labor and to help to build a sustainable economy in the DPRK. Finally, as the final international rules for applying Clean Development Mechanisms (CDM)—which allow the credit for GHG emissions reduction between nations—are worked out, redevelopment in the DPRK may provide a host of opportunities for countries within and outside the region to apply CDM in energy sector investments in the DPRK.

A special challenge—and opportunity—related to energy sector cooperation in Northeast Asia is related to the potential influence of the Simpo/Kumho (DPRK) nuclear reactors on grid interconnection proposals. As
the major element of a 1994 agreement between the United States, its allies, and the DPRK, a consortium of nations (the United States, the ROK, Japan, and the European Union) organized as the Korean Peninsula Energy Development Organization (KEDO). Until the beginning, in late 2002, of the current impasse between the DPRK and the United States (in particular, though other countries are involved in and assisting in attempting to resolve the dispute as well) over the DPRK’s alleged nuclear weapons programs, KEDO was providing financing for and was constructing two 1,150 MW light water reactors (LWRs) at the Kumho site near Simpo on the east coast of the DPRK. Though KEDO had been officially shut down as of mid-2006 and although the LWR project “terminated” (see http://www.kedo.org/), completion of the reactor project remains, as noted earlier, a key point of negotiation in the Six-Party Talks and a key political demand of the DPRK.

The Simpo/Kumho reactors were intended to help alleviate DPRK electricity shortages, but use of these reactors in the DPRK grid was always problematic, at best. First, the DPRK grid is highly fragmented, and reactors—even a fraction as large as those being operated—could not be operated without tripping on and off to a dangerous degree. Second, even if the DPRK grid were fully integrated and its plants were operating at their nominal (as of 1990) 10,000–12,000 MW capacity (of which we estimate that on the order of 2,000 to 3,000 MW were actually currently operable as of 2005), the grid would be too small to safely operate the reactors without serious grid stability concerns. Third, no source of reliable backup power is now available to the Kumho site that would allow the reactors to be operated within international nuclear safety rules. What these technical constraints mean, effectively, is that some type of interconnection with the ROK or with Russia or China (or, more likely, both) will be required if the reactors (if completed) are ever to generate power. This requirement, if reactor construction is restarted, is likely to add a significant political (and economic) impetus to the development of Northeast Asia grid interconnections, potentially affecting the timing, and type, of north–south grid interconnections.

The Potential Role of the United States in Northeast Asian Energy Cooperation

Though not located in the Northeast Asia region, the policies of the United States have traditionally had considerable influence in regional affairs. Many of the infrastructure and other cooperative activities described earlier, as well as most of the types of energy cooperation involving the DPRK, will stand a much better chance of success if joined or if encouraged by the United States. Conversely, the activities may have little chance of succeeding if the United States remains on the sidelines or, worse, actively discourages cooperation initiatives.

The United States could play a number of positive roles in encouraging northeastern Asian energy cooperation, including the following:

- Working with U.S. companies and others to promote the licensing of key technologies for manufacture and use in the region. Leading candidates for technology licensing would be renewable energy technologies for solar, wind, and tidal power, and for energy efficiency technologies (advanced lighting products, appliances, transportation equipment, building energy efficiency technologies, combined heat and power systems, and building or motor control electronics, for example). However, other opportunities may include waste-treatment and environmental control technologies; fossil-fuel-extraction-related technologies (coal mining safety equipment, coal-bed methane technologies, and technologies for oil and gas exploration and extraction under harsh conditions, for example); and electricity sector control technologies. In some cases, promoting those technologies may mean lowering or modifying U.S. barriers to export or licensing.
• Assisting with capacity building and technical training. There are a number of topic areas where the United States could assist the countries of the region with developing the human infrastructure needed to efficiently and effectively participate in the cooperative activities identified earlier. Those areas will vary by country and will include—but are certainly not limited to—development and regulation of energy markets, energy and environmental law, environmental regulation, energy management in buildings, energy-efficient building design and construction, environmental management, renewable energy system design and implementation, development and implementation of energy-efficiency programs, environmental emissions control, and environmental cleanup.

• Co-development and co-marketing of key energy-efficiency and renewable energy products. The United States has significant domestic opportunities for improving energy efficiency and for expanding the use of renewable energy. There are likely a number of opportunities to form research and development consortia—possibly between national laboratories in the United States and in the northeastern Asian countries and with key industries on both sides of the Pacific—as well as to promote, through coordinated national policies (for example, energy codes for buildings and appliances, GHG emissions restrictions), markets for the resulting energy-efficiency and renewable energy products. Adding the 1.5 billion consumers of Northeast Asia to the 300 million in the United States would create formidable markets for those products and should, if designed properly, accelerate the movement to mass market of technologies such as very efficient automobiles, electronics, lighting, appliances, high-efficiency/low-cost solar photovoltaic systems, combined heat and power systems, and other devices.

• Setting a positive example by making a serious effort to reduce national GHG emissions and to improve and aggressively promote energy efficiency and renewable energy, including setting stringent energy efficiency or renewable energy standards. Most observers of the international environmental scene would agree that the U.S. government has not, particularly in the current decade, provided strong and positive international leadership in the areas of climate change mitigation, energy efficiency, or renewable energy. Reversing this trend is highly likely to provide a boost to the efforts of the countries of Northeast Asia to make improvements in this area, both through the effect that U.S. policies would likely have on markets for related energy efficiency and renewable energy goods (increasing the speed of development, and ultimately bringing down prices through economies of scale) and by setting an example for policymakers and consumers in the region.

• Encouraging productive investment in the DPRK. U.S. policies toward the DPRK to a large extent determine the degree to which countries closely allied to the United States (Japan and the ROK, for example, as well as the European Union, Australia, and others) interact economically with the DPRK. U.S. policies may have a more limited effect on how China and Russia, for example, interact with the DPRK, but there is little doubt that if the United States were to reach an agreement with the DPRK and other parties whereby the United States could set out workable guidelines for encouraging investment in and business with the DPRK, the result would be a considerable increase in the opportunities available for all parties for energy cooperation involving the DPRK, thereby bringing some of the opportunities outlined earlier in this article closer to fruition.

Alternatively, U.S. policies may develop in such a way as to frustrate attempts at energy-sector cooperation by the countries of the region. Here are some examples:

• The United States may feel threatened by cooperation between the countries of Northeast Asia. One possibility here is that U.S. policymakers may feel that geopolitical considerations regarding the influence of Russia or China (or both) with Japan, the ROK, and the DPRK make the promotion of energy cooperation—including, for example, the economic linkages and dependencies that
major international energy infrastructure would imply—not to be in the United States’ best interests. Among a listing of considerations that show the potential complexities involved in multination cooperation in Northeast Asia (specifically, on Korean reunification), P.A. Minakir, paraphrasing R. Scalapino, notes, “The USA is not interested in the easing of the tension in this region, as under these conditions the ‘natural’ reasons for the U.S. military and political control will stop existing.”

- The United States may (continue to) provide a negative example on energy efficiency and GHG emissions reduction. For those countries whose people often look to U.S. lifestyles as models (deserving or not), it will be more difficult to make significant progress on improving energy efficiency and reducing GHG emissions—and participating in regional cooperation to do so—if the United States continues to resist taking significant steps to address its GHG emissions.

U.S. policies in general and with regard to the Northeast Asia region in particular may change substantially when a new administration takes office early next year. Given the inertia built into the U.S. political process, however, rapid and substantial change is far from certain. Although the United States is much more than a marginal player in the energy sector of the region, it is not a central player; if energy sector cooperation sufficiently benefits the countries of the region, regional resources—including financial, labor, technological, and natural resources—should be adequate to make cooperation a reality, given the countries have the political will to work together.
Endnotes


5 Takase et al. (2007), ibid.


7 Note that the first year of this period, 1998, was the year of adjustment following the 1997 “Asian Financial Crisis,” when economic growth and growth in energy consumption in the ROK were both negative.

8 Figure 3 is from Chung Woo-jin (2006), “Energy Demand Forecast and Policy Directions in Korea,” presentation prepared for the Asian Energy Security Workshop 2006. http://www.nautilus.org/energy/2006/beijingworkshop/papers.html. The figure is based on projections prepared by the Korea Energy Economics Institute. AAGR stands for “annual average growth rate.”


14 Drawing on anecdotal information from a number of sources, our preliminary assessment is that the overall power supply situation in the DPRK was likely somewhat worse in 2007 than it was in 2005.

The LEAP software tool is developed and maintained by Stockholm Environment Institute—United States. Please see http://www.energycommunity.org/ for information about the LEAP tool.

An additional path, the “Recent Trends” path, which is shown in Figures 8 and 9, assumes that a substantial solution to the DPRK nuclear issue is not forthcoming, and recent trends in the DPRK economy continue.


Projections for China used for this composite regional picture were derived and extrapolated from energy use trends shown in Energy Use in China: Sectoral Trends and Future Outlook, by Nan Zhou, Michael A. McNeil, David Fridley, Jiang Lin, Lynn Price, Stephane de la Rue du Can, Jayant Sathaye, and Mark Levine, Lawrence Berkeley National Laboratory, January 2008, Report # LBNL-61904. These figures appear to reflect more of a maturing trend in the Chinese economy than the projections shown in Figure 10.

Historical data on carbon dioxide emissions by country for 1990 through 2005 are taken from Energy Information Administration USDOE EIA (2007), International Energy Annual 2005, table H.1, “World Carbon Dioxide Emissions from the Consumption and Flaring of Fossil Fuels, 1980–2005,” with the exception of data for the DPRK (from D. F. Von Hippel and P. Hayes, 2007) and RFE (rough estimates from data from R. Gulidov, V. Kalashnikov, and A. Ognev (2006), and from V. Kalashnikov...


30 This discussion should not be taken as an argument on the part of the authors that completion of the Simpo reactors is either the best thing for the DPRK economy or the most cost-effective—in terms of providing energy aid—use of funds for DPRK energy assistance, because it is neither. Our discussion, rather, is designed to point out the political and technical realities associated with the reactor project.

31 From P. A. Minakir, 2007, Economic Cooperation between the Russian Far East and Asia-Pacific Countries, Chap. 2, “Russia and the Russian Far East in Economies of the APR and NEA” (Khabarovsk, Russia: Economic Research Institute, Far Eastern Branch, Russian Academy of Science, and the Sasakawa Peace Foundation), 52. Although this quote does not directly address the U.S. position on energy cooperation in Northeast Asia, it is generally indicative of potential U.S. fears over loss of influence in a more cooperative, and thus less U.S.-dependent, Northeast Asian region.