The DPRK Energy Sector: Recent Status, Problems, Cooperation Opportunities, and Constraints

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Introduction[1]

During the 1990s, continuing through these early years of the 21st century, and particularly in recent weeks, 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. Below we review the recent history and current status (based on our estimates) of the DPRK energy sector; list some of the key energy sector problems facing the DPRK; and offer suggestions as to opportunities for international cooperation on DPRK energy sector problems, highlighting those opportunities with the potential to encourage the development of regional infrastructure.[2]

Recent History and Status of the DPRK Energy Sector

The economic, if not social and political, landscape in the DPRK changed markedly during the 1990s. Although little data have been available from inside the DPRK, information from outside observers of the country indicates that the North Korean economy was at best stagnating, and most probably in considerable decline, through the mid-1990s.[3] This economic decline has been both a result and a cause of substantial changes in energy demand and supply in North Korea over the last decade. Though recent anecdotal evidence suggests that the economy in some parts of the DPRK, particularly near Pyongyang, may have improved in recent years, it is not clear that the energy supply situation has changed substantially nationwide since 2000.

Among the DPRK energy-sector changes on the supply side since 1990 has been a vast drop in fuel imports from the former Soviet Union and Russia. Crude oil imports from Russia in 1993,

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[1] Much of this summary is derived from a paper entitled "Regional Energy Infrastructure Proposals and the DPRK Energy Sector: Opportunities and Constraints" prepared by the authors for the KEI-KIEP Policy Forum on "Northeast Asian Energy Cooperation," Washington, DC, January 9, 2003. For the full workshop paper, please see *http://www.keia.org/2-Publications/2-6-Other/NortheastAsiaEnergy/northeastAsiaEnergy.html*.

[2] For additional information on the topics covered in this section of this summary paper, please see D. Von Hippel and P. Hayes, "The DPRK Energy Sector: Current Status and Options for the Future," prepared for the International Workshop on "Upgrading and Integration of Energy Systems in the Korean Peninsula. Energy Scenarios for the DPR of Korea," Como, Italy, September 19-21, 2002; and D. Von Hippel, P. Hayes, and T. Savage (2002), "The DPRK Energy Sector: Estimated Year 2000 Energy Balance and Suggested Approaches to Sectoral Redevelopment." These and other DPRK-related papers and reports are available at *http://www.nautilus.org/papers/regional.html#dprk*.

[3] *Far Eastern Economic Review* (1995), *1995 Asia Yearbook, North Korea*.

for example, were on the order of one-tenth what they were in 1990,[4] and have fallen to practically zero since. Oil import restrictions have further reduced the availability of refined products in the DPRK. These restrictions arose partly (if indirectly) from external economic sanctions, and partly from North Korea's inability to pay for oil imports with hard currency. This lack of fuel, particularly for the transport sector, has contributed to the DPRK's economic malaise since 1990. Also contributing to the decline in the country's economic fortunes has been the inability to obtain key spare parts for both energy infrastructure and for factories, including factories built with foreign assistance and/or technology in the 1970s.

These overall economic and energy-sector trends provide the backdrop to the assessment of the current status of the DPRK energy sector, discussion of future energy sector problems, and international approaches for energy sector assistance that are provided below.

Changes in the DPRK energy sector between 1996 and 2000 have, for the most part, been of a substantially more incremental nature than the changes it experienced during the first half of the 1990s. Among the key changes (or continuing processes) for the energy sector between 1996 and 2000 are:

- A continuing **decline in the supply of crude oil** from China, significantly reducing the overall output of the DPRK's remaining major (Northwest Coast) refinery.

- Continuing degradation of **electricity generation infrastructure** due to lack of spare parts, maintenance not performed, or use of aggressive (high sulfur) fuels in boilers designed for low-sulfur coal.

- Continuing degradation of **electricity transmission and distribution** infrastructure, resulting in much **reduced availability of electricity** in most parts of the country away from Pyongyang.

- Continuing **degradation of industrial facilities**, and the damage to industrial electric motors from poor quality electricity (electricity with highly variable voltage and frequency).

- Evidence of significant international trade in **magnesite (or magnesia)**.

- Continuing difficulties with **transport of all goods, especially coal**.

- Difficulties in **coal production** related to lack of electricity, as well as mine flooding (in the Anju region).

- Some **economic revival**, but mostly, it seems, associated with foreign aid and/or with areas of the economy that are not energy intensive.

[4] US Census Bureau (1995), "The Collapse of Soviet and Russian Trade with the DPRK, 1989-1993: Impacts and Implications." Prepared by N. Eberstadt, M. Rubin, and A. Tretyakova, Eurasia Branch, International Programs Center, Population Division, US Census Bureau, Washington, DC, USA. March 9, 1995.

Figure 1.1 compares estimated final energy demand by sector for the years 1990, 1996, and 2000, and Figure 1.2 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. The first is the continuation of the trend of 1990 to 1996 whereby the residential sector uses an even larger share (now more than half) of the overall energy budget by 2000, while the industrial sector share shrinks to under a quarter of the total. This change is the combined result of continued reduction in fuel demand in the industrial sector, relatively constant use of wood and other biomass fuels in the residential sector, and 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/biomass fuels to the energy budget as a whole is estimated to have increased dramatically over the course of the decade, while the importance of commercial fuels has decreased.

Figure 1.1

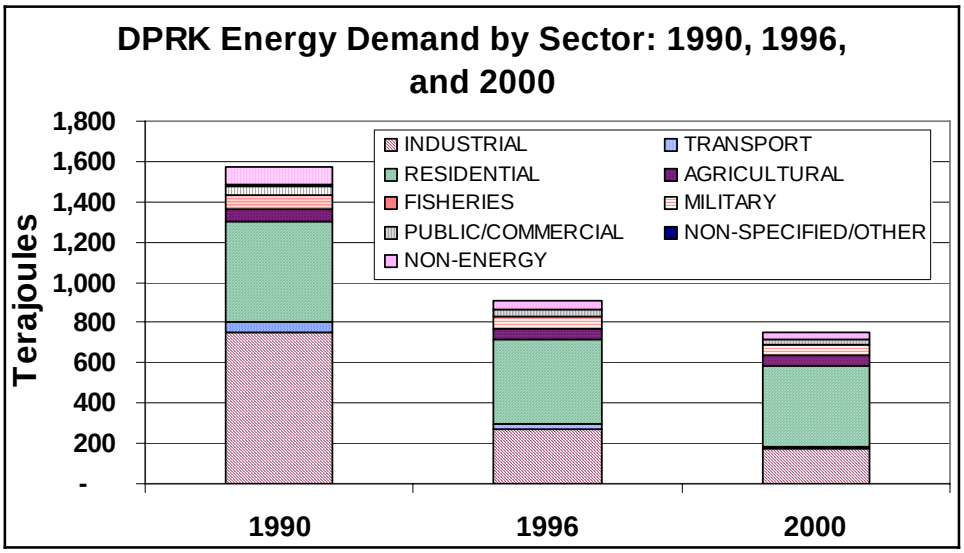
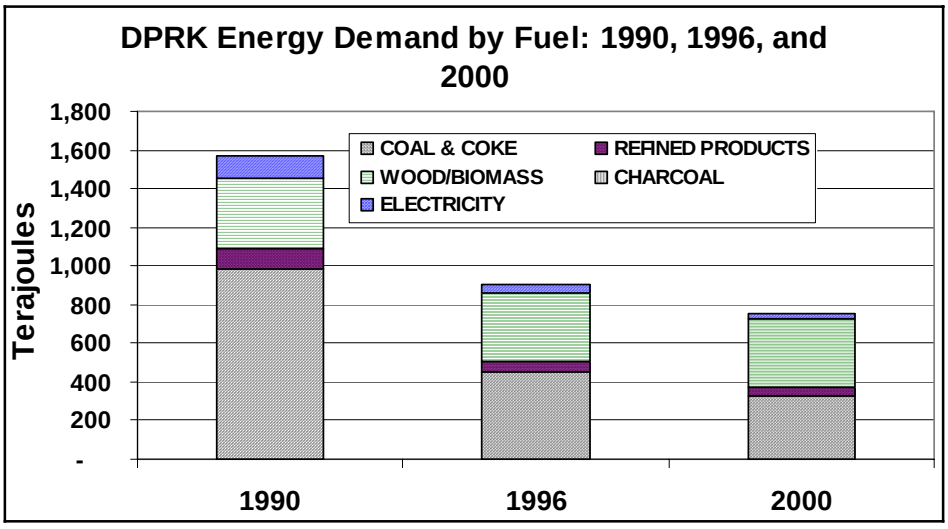


Figure 1.2



The DPRK electricity sector is often a focus of interest, both for the impact that the sector has on the economy of the DPRK and on the daily lives of its citizens, and also because the status of the electricity sector had (and may again have) important political implications related to the KEDO Light Water Reactor (LWR) project, and to electricity grid interconnection options.[5] Analysis of the current status of the DPRK electricity sector suggests that:

- The **thermal power generation** system in the DPRK has been eroding significantly. In virtually all of the large power stations, only selected boilers and turbines are operating, and those that are still in use operate at low efficiency and low capacity factors[6] due to maintenance problems and lack of fuel.

- As a consequence of the difficulties with thermal power plants, **hydroelectric plants** have shouldered the burden of power generation in the DPRK, but hydroelectric output is limited by maintenance problems and, equally important, by the seasonal nature of river flows in the DPRK.

Figure 1.3 shows the estimated structure of electricity supply in the DPRK in 1990/1996 (for comparison) and in 2000, broken down as generation in hydroelectric plants, generation fueled with heavy fuel oil (HFO, independent of whether the plant was designed to use oil), and thermal plants fueled with coal. Note that this figure displays gross generation: some of the electricity produced is used in the power plant itself, some is lost as a result of "emergencies," and more is lost during transmission and distribution. The total estimated supply of electricity decreased substantially between 1990 (46 terawatt-hours, or TWh[7]) and 1996 (24 TWh), and fell still further (by our estimate) by 2000 (to 14 TWh). Reflected in Figure 1.3 is the significant drop in hydroelectric output as a result of damage from the floods of 1995 and 1996, and a considerable drop in thermal plant output between 1996 and 2000.[8]

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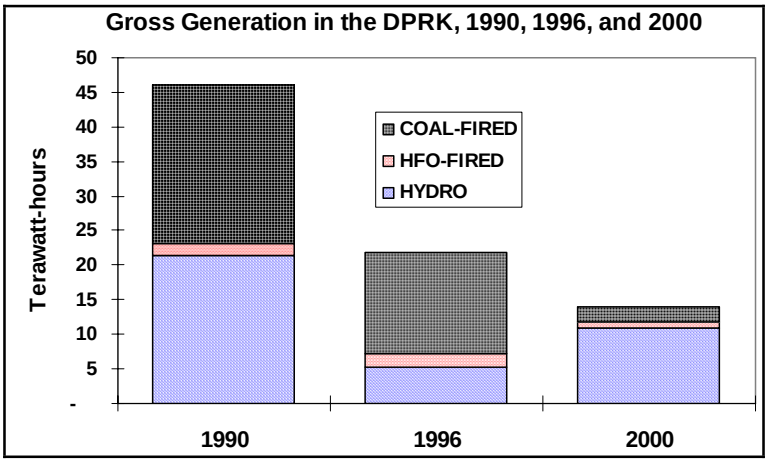
[5] As the major element of a 1994 agreement between the United States (and its allies) and the DPRK, a consortium of nations (the United States, ROK, Japan, and the European Union), organized as the Korean Peninsula Energy Development Organization (KEDO). Until the beginning, in late 2002, of the current 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 constructing two 1150 MW reactors at the Kumho site on the east coast of the DPRK. These reactors were intended (theoretically) 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 2000 to 3000 MW are actually currently operable), the grid would be too small to safely operate the KEDO 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 Russia/China (or, more likely, both) will be required if the KEDO reactors are ever to generate power. This requirement adds a significant political (and economic) impetus to the development of Northeast Asia grid interconnections. For a more thorough discussion of this issue, see the Nautilus essay "Modernizing the US-DPRK Agreed Framework: The Energy Imperative" (D. Von Hippel, P. Hayes, M. Nakata, T. Savage, and C. Greacen, 2001), available at *http://www.nautilus.org/DPRKBriefingBook/agreedFramework/ModernizingAF.pdf*.

[6] The "capacity factor" of a power plant reflects the equivalent fraction of time (for example, during a year) that the power plant is producing its full rated output.

[7] One terawatt-hour is equal to 3600 terajoules, 3.6 million gigajoules, or one billion kilowatt-hours (kWh).

[8] It is clear that the degradation of the electricity sector has not gone unnoticed by DPRK authorities. Reports in the media and elsewhere indicate that the DPRK is actively seeking both low-cost and longer-term (for example, contacts/contracts from

Figure 1.3 Estimated Sources of Electricity Supply: 1990, 1996, and 2000



The authors have not yet quantitatively evaluated changes in the DPRK's energy situation since 2000. Qualitatively, the trend in the DPRK energy sector since that time seems to indicate either general energy sector stasis or a continued overall slow decline, with some visitors reporting a worsening situation with power blackouts, even in Pyongyang, while other visitors see modest improvements in some areas. Among the changes in the DPRK energy sector reported since 2000 are:

- The deliveries by KEDO to the DPRK that began in late 2002 have ceased. Though KEDO oil represented only a small fraction (about 2 percent) of total DPRK energy supplies, it accounted for a much larger fraction of electricity and (probably) district heating fuel use.

- The ROK agreed to supply power from the ROK to the Kaesong industrial part, starting with a first phase with capacity of 15 MW.[9] Power on this line started flowing in March of 2005.

- Electricity imports from China have increased, though the 2003 increase to about 10 GWh over a 10-month period still amounts to only about 0.1 percent of estimated year 2000 generation.[10]

- Cross-border trade in oil products with China and Russia has increased, though since this trade may largely be undocumented, the amounts may be difficult to verify as being significantly different than in 2000.

- The DPRK has increased construction of a large number of very small (probably hundreds of kW to a few MW hydroelectric and coal- and (possibly) biomass-fired power plants. These

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approximately 2001-2002 to the present on T&D infrastructure refurbishment with the Swiss multinational ABB) "fixes" to its problems.

[9] See, for example, Kim Tae-gyu (2004), "S. Korea to Supply Electric Power to Kaesong in NK." *The Korea Times*, December 3, 2004, accessed at *http://times.hankooki.com/lpage/200412/kt2004120322501753460.htm*.

[10] Yonghap News Agency, 2003. "U.S. Oil Cutoff Boosts NK's Electricity Imports from China," Seoul, November 30, 2003. Summarized in AESnet, see *http://www.nautilus.org/aesnet/DEC1603.html#item4*.

plants presumably feed local, not national or regional, grids. The existence of these plants has been reported by DPRK sources, but their operational status has not been confirmed.

Key DPRK Energy Sector Problems

Key energy-sector problems in the DPRK include:

- **An inefficient and/or decaying infrastructure.** Much of the energy-using infrastructure in the DPRK is reportedly antiquated and/or poorly maintained, including heating systems in residential and other buildings. Industrial, power supply (as noted above), and other facilities are likewise either aging or based on outdated technology, and often (particularly in recent years) are operated at less-than-optimal capacities (from an energy efficiency point of view).

- **Suppressed and latent demand for energy services.** Lack of fuels in many sectors of the DPRK economy has apparently caused demand for energy services to go unmet. When and if supply constraints are removed there is likely to be a surge in energy (probably particularly electricity) use as residents, industries, and other consumers of fuels increase their use of energy services toward desired levels.

- **Lack of energy product markets.** Compounding the risk of a surge in the use of energy services is the virtual lack of energy product markets in the DPRK. Without fuel pricing reforms, there will be few incentives for households and other energy users to adopt energy efficiency measures or otherwise control their fuels consumption. Anecdotal indications are that some pricing reforms are under way in the DPRK economy, but it is not yet clear (to the authors) to what extent pricing reforms have been implemented in the energy sector.

Opportunities for International Cooperation on DPRK Energy Sector Problems

Key economic resources for the DPRK include a large, well-trained, disciplined, and eager work force; an effective system for dissemination of technologies; the ability to rapidly mount massive public works projects by mobilizing military and other labor; and extensive reserves of minerals. What the DPRK lacks are modern tools and manufacturing methods, fuel, arable land, and above all, investment capital. As a consequence, given the energy sector problems outlined above, a coordinated program of assistance from the ROK, the United States, and/or other countries that build upon these skills will be needed. Providing key assistance in a timely manner will enhance security in Northeast Asia, accelerate (or, given recent events, help to reestablish) the process of North Korean rapprochement to its neighbors, and help to position countries and firms as major suppliers for the DPRK rebuilding process.

The nature of the DPRK's energy sector problems, however, means that an approach that focuses on one or several massive projects—such as a single large power plant—will not work.[11] A multipronged approach on a number of fronts is required, with a large suite of coordinated, smaller, incremental projects addressing needs in a variety of areas. Below, we identify priority

[11] This argument should *not*, however, be interpreted to mean that the KEDO LWR project should be totally abandoned (at least without the negotiated agreement of the DPRK). For all of its many faults, the reactor project has been one of the few (and dwindling) remaining avenues for constructive communication with the DPRK. Moreover, it represents at this point a major "sunk cost" to the ROK, and would be a useful asset (in both the political and practical senses) to the ROK and DPRK in a future where inter-Korean cooperation becomes more important.

areas where we see DPRK energy sector assistance as both necessary and in the best interests of all parties. All of these interventions would put foreign (US, European, ROK, or other) engineers and other program staff in direct contact with their DPRK counterparts and with DPRK energy end-users. In the authors' experience working on the ground in the DPRK, visitors working hard to help and to teach North Koreans has great effectiveness in breaking down barriers between peoples. Among the recommended steps:

- **Provide technical and institutional assistance in implementing energy efficiency measures.** Focusing in particular on energy efficiency, regional cooperation would be useful to help the DPRK provide the DPRK with access to energy-efficient products, materials, and parts; pursue sector-based implementation of energy efficiency measures; and carry out demonstration projects.

- **Promote better understanding of the North Korean situation in the ROK.** South Koreans have a deep and natural interest in what goes on in the DPRK, but generally have no better access to information on the DPRK than those in other countries. It will be important in particular to involve South Korean actors in the types of assistance activities described here.

- **Work to open opportunities for private companies to work in the DPRK.** Grants or loans from foreign governments cannot begin to fill the needs for energy infrastructure in the DPRK, but the US, ROK, European, and other governments can help to facilitate the efforts of private companies (including independent power producers) from abroad in the DPRK energy sector.

- **Cooperation on technology transfer for energy efficiency and renewable energy applications.**

Specific energy sector initiatives that will assist the process of rapprochement with the DPRK, help the DPRK to get its economy and energy sector working in a sustainable (and peaceful) manner, and help to pave the way for additional cooperative activities in the energy sector include:

- **Assistance for internal policy, economic, and legal reforms to stimulate and sustain energy sector rebuilding in the DPRK.** This could include reform of energy pricing practices (and the physical infrastructure to implement them), capacity-building for careful energy planning to allow aid to be based on need and rational objectives, training for energy sector actors, strengthening regulatory agencies and educational/research institutions in the DPRK, and involving the private sector in investments and technology transfer.

- **Rebuilding of the T&D system.** The need for refurbishment and/or rebuilding of the DPRK T&D system has been touched upon earlier in this paper. The most cost-effective approach for international and ROK assistance in this area will be to start by working with DPRK engineers to identify and prioritize a list of T&D sector improvements and investments, and to provide limited funding for pilot installations in a limited area—perhaps in the area of a special economic zone or in a "demonstration" county.

- **Rehabilitation of power plants and other coal-using infrastructure.** An initial focus should be on improvements in small, medium, and district heating boilers for humanitarian end-uses such as residential heating.

- **Rehabilitation of coal supply and coal transport systems.** Strengthening of the coal supply and transport systems must go hand in hand with boiler rehabilitation if the amount of useful energy available in the DPRK is to increase.

- **Development of alternative sources of small-scale energy and implementation of energy-efficiency measures.** The North Koreans we have worked with have expressed a keen interest in renewable energy and energy-efficiency technologies. This interest is completely consistent with both the overall DPRK philosophy of self-sufficiency and the practical necessities of providing power and energy services to local areas when national-level energy supply systems are unreliable at best. Such projects should be fast, small, and cheap, and should (especially initially) emphasize agricultural and humanitarian applications.

- **Rehabilitation of rural infrastructure.** The goal of a rural energy rehabilitation program would be to provide the modern energy inputs necessary for North Korean agriculture to reach a sustainable production level and the basic needs of the rural population to be met.

- **Begin transition to gas use in the DPRK with Liquid Petroleum Gas (LPG) networks.** LPG is more expensive than natural gas, but the infrastructure to import LPG, relative to liquefied natural gas (LNG), is much easier and less expensive to develop. It also allows imports in smaller quantities. LNG is also clean-burning, and has limited military diversion potential. Setting up LPG networks can be a first step toward the use of natural gas in the DPRK. Ultimately, natural gas pipelines and LNG terminals, shared with neighboring countries, can serve as a step toward economic development coupled with regional integration.

Recent years have seen a variety of proposals for regional energy sharing among the countries of Northeast Asia, including proposals for gas pipelines and electricity grid interconnections bringing energy resources from the Russian Far East through the DPRK to the ROK, typically with some electricity or gas used in the DPRK, rent paid to the DPRK to allow the infrastructure to transit its territory, or both. Such developments, while definitely neither small-scale nor short-term in nature, would provide significant opportunities for engagement of the DPRK with the regional and international communities, and have the advantage of being very strongly in the interests of both Russia and the ROK.[12]

[12] For discussions of many of the elements of electricity grid interconnections in Northeast Asia, and in particular proposed ROK-DPRK-RFE interconnections, see the papers and presentations prepared for the series of workshops on "Power Grid Inter-connection in Northeast Asia," organized by Nautilus Institute and regional partners. See *http://www.nautilus.org/archives /energy/grid/index.html*, *http://www.nautilus.org/archives/energy/grid/2002Workshop/index.html*, and *http://www.nautilus .org/archives/energy/grid/2003Workshop/index.html*.

Conclusion

A successful approach to near-term energy sector redevelopment in the DPRK requires coordinated action on many different fronts, each done at a relatively small scale, and preferably with many different "actors" from outside the DPRK—ranging from NGOs to government aid programs to international organizations—engaging a range of different organizations within the DPRK. Doing so will not be easy, but funneling many projects through a single "gateway" organization in the DPRK risks quickly overwhelming that organization, resulting in opportunities for delays, inefficiency, and worse. Working with DPRK counterparts to identify projects that are of most interest within the DPRK, while still providing the development and humanitarian benefits desired by outside donors, will also be required. The emphasis should be on projects that DPRK institutions, including local organizations, can learn from and replicate, and which help in local economic development. Putting international experts in positions where they are working actively and closely in-country, and particularly in the field, with DPRK counterparts, while definitely not easy, is a key element in assuring the success of such projects.

Apart from the obvious need to get past, peacefully, the current international political crisis related to the DPRK's nuclear weapons program, moving forward with DPRK energy sector redevelopment will need to overcome a variety of hurdles. These barriers include:

- Lack of financing from outside sources (though there are various remedies for this, many of which would likely be available rapidly if the political situation notably improved).

- Lack of trained counterparts in the DPRK (including need for technical and economic training, but also lack of understanding of how others in the international community expect projects to be developed, organized, and administered).

- The need to couple energy sector redevelopment with economic redevelopment (so that the DPRK can self-fund follow-up redevelopment efforts).

- The need to rebuild (or build anew) key transport, energy, and communications infrastructure.

- A lack of information—likely *both* inside and outside the DPRK—about what DPRK energy needs (and the status of energy infrastructure) really are.

Getting past these hurdles will require an overall international vision and approach in packaging redevelopment aid, coordination and communication in (but not centralized provision of) aid efforts, working with DPRK counterparts to build human capacity at every opportunity, and, above all, patience and a long-term commitment to the engagement and redevelopment process.