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INTRODUCTION TO THE SPECIAL ISSUE

Timothy Savage

Key words: U.S.-DPRK Pilot Renewable Village Energy Project, windmill, NGO

On May 13, 1998, a 100-foot tall metal tower was raised in a cabbage patch in Unhari village on the west coast of North Korea. Visible for miles around, this tower was the first installment of a system that has thus far come to include seven wind-powered turbines with a total of just over ten kilowatts of generating capacity; a powerhouse that includes measuring instruments and batteries for storing the power generated; and a water-pumping windmill that provides drinking water to the village.

The windmill project grew out of a series of trips that Nautilus Institute Executive Director Peter Hayes made to the Democratic People's Republic of Korea, beginning in 1991. When tension over the DPRK's nuclear program threatened to spiral toward war in 1994, the Institute responded by launching the Northeast Asian Peace & Security Network (NAPSNet), an e-mail and (eventually) web-based news and analysis service aimed at countering the tendency of crises to spiral out of control due to incomplete or erroneous information.[1]

On November 21, 1997, as the DPRK languished in its third consecutive year of famine, a delegation of North Korean renewable energy experts came to the United States at the invitation of the Nautilus Institute. The delegation visited several renewable energy sites in the United States, including the Sacramento Utility Municipal District solar cell central station; the Zond Corporation wind farm in Tehachapi, California; the National Renewable Energy Laboratory in Colorado; and many other renewable energy firms. Along the way, the visitors received expert briefings on renewable energy and energy efficiency at Lawrence Berkeley Laboratory and from specialist renewable energy organizations, including the American Council for an Energy Efficient Economy, the International Institute for Energy Conservation, the Atlantic Council, the National Rural Electric Cooperative Association, the National Wind Energy Association, and the Solar Energy Industries Association.

In Washington, D.C., where the delegation's visit was co-hosted by the Atlantic Council's Conflict Resolution Program, it met with U.S. Department of Energy officials, the first time that a DPRK delegation had visited that department's headquarters. The delegates were also briefed at the World Bank on renewable energy international programs, the first-ever visit by a DPRK delegation to the World Bank.

At the conclusion of the visit, the DPRK Renewable Energy Delegation and the Nautilus Institute agreed to establish the U.S.-DPRK Pilot Renewable Village Energy Project. The project uses small-scale U.S. wind power turbines to meet humanitarian energy-related needs in rural end uses such as in household lighting, medical clinics, agricultural water pumping, and food processing. The project had several goals: to bring attention to the DPRK's energy crisis as a root cause of the famine conditions; to help prepare the DPRK to be able to accept international aid; to learn more about the feasibility of applying renewable energy technology in the DPRK; and to demonstrate that Americans and North Koreans could put aside their differences and work toward a common goal. Prior to this project, U.S. nongovernmental organizations (NGOs) had been limited by both the U.S. and DPRK governments to the delivery of food aid, so the Nautilus project was the first true cooperative development project between an American NGO and a North Korean organization, in this case the Korean Anti-Nuclear Peace Committee (KANPC).

In order to meet the requirements for a humanitarian exemption from the sanctions then in place against North Korea, it was specified that the site for the project had to be a flood-affected rural village. After examining several candidate sites, Nautilus and KANPC chose the March 3 Cooperative Farm in Unhari. Built on reclaimed tidal flats, the village had been severely affected by flooding and tidal waves.[2]

The first Nautilus mission to the DPRK in May 1998 installed the first tower and laid out the plans for building the power-house and installing the system. We then returned in September of that year to raise the other towers, install the turbines, and hook the system up to twenty households, a kindergarten, and a clinic. At this time, we also conducted the household energy use survey described in this volume, and gave the villagers energy efficient compact fluorescent light bulbs. The mission went ahead successfully even though tensions had been raised by the DPRK's launch the previous month of a three-stage rocket that flew over Japan. The third mission took place in September 2000, at which time we installed a water-pumping windmill and transferred an ultraviolet water purification unit.[3]

The project required intense cooperation among the Nautilus team, the DPRK engineers, and the villagers of Unhari. We worked side-by-side in all phases of design and implementation of the system. Meals were taken at the village guesthouse, and curious children had to be driven away to prevent accidents. Many people who had probably never before seen a Westerner and who were raised to fear Americans were now treated to the daily sight of Americans and Koreans working together to bring them electricity.

The articles in this special issue of *Asian Perspective* are largely based on the knowledge and experience gained from working in the village, and from information provided by our North Korean colleagues in the bilateral and multilateral meetings. Although for the sake of brevity we have only listed the names of the principal authors for each of the articles, all of them draw on the work of all members of the Nautilus team, who should thus be considered de facto co-authors. (The team members are Chris Greacen, Peter Hayes, Masami Nakata, Mick Sagrillo, Timothy Savage, David Von Hippel, and James H. Williams.) Because our project, though small in scale, exists within the context of the larger political questions surrounding the Korean peninsula, we have also included articles from leading experts on the U.S.-

DPRK Agreed Framework and on international aid to the DPRK.

The project could not have succeeded without the extraordinary efforts put forth by our North Korean colleagues. They worked hard to overcome obstacles, both physical and political, time and again demonstrating their commitment to the project. Thus in no small part, they too should be considered authors of this work.

We wish to thank the editors of *Asian Perspective* for giving us the opportunity to publish our work here. The research and writing for this volume were made possible by a grant from the Korea Foundation.

An article in *Nucleonics Week* in November 2000 quoted an unnamed staff person in the U.S. Congress as saying, "the only international project which will be generating any electricity in the DPRK in the foreseeable future are some windmills" built by the Nautilus Institute.[4] We look forward to the day when that is no longer true.

NOTES

1. The NAPSNet Daily Report can be viewed on the web at www.nautilus.org/napsnet/dr/index.html. E-mail subscriptions are free and can be obtained by visiting the signup page at www.nautilus.org/kiosk/signup.html.
2. More details about this village are found in the rural energy survey article in this volume.
3. Photographs from the three missions are available on our website at www.nautilus.org/gallery/dprkrenew/index.html.
4. Mark Hibbs, "'Frustration' Led U.S. To Mull Shifting Kedo To Fossil Project," Vienna, Tokyo, and Bonn, October 16, 2000. Summarized at www.nautilus.org/napsnet/dr/0010/oct19.html#item1.

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MODERNIZING THE US-DPRK AGREED FRAMEWORK: THE ENERGY IMPERATIVE

Peter Hayes, David Von Hippel, and Nautilus Team

This article examines the problems with the implementation of the October 1994 U.S.-DPRK Agreed Framework and suggests possible modifications. The Agreed Framework is a set of guidelines that help to regulate and render more predictable the behavior of the parties toward each other. There is nothing in the Framework to stop the two parties from reformulating and updating the agreement. The Bush administration and the DPRK will need to come to terms on a new, modernized agreement that serves their current needs while maintaining the diplomatic gains of the Framework to date. The nature of the DPRK's energy-sector problems means a multi-pronged approach on a number of fronts is required. In this article, we identify five priority areas where we see DPRK energy sector assistance as both necessary and in the best interests of all parties. A U.S.-backed, coordinated program of grassroots energy-sector assistance to the DPRK would yield huge dividends in terms of confidence building and regional security. At the same time, in order to retain credibility with the DPRK, the United States must abide by its commitments to date, including the Agreed Framework.

Key words: Agreed Framework, coal-fired power plants, energy-sector assistance, Independent Power Producers, U.S.-DPRK relations

The Agreed Framework: History, Status, and Options

As a condition of the October 1994 Agreed Framework signed by the governments of the United States and the Democratic People's Republic of Korea (DPRK, North Korea), the DPRK is to be supplied with two pressurized-water-type light-water nuclear reactors (referred to as LWRs) for electricity generation in exchange for abandoning its existing graphite-moderated nuclear research reactors and taking further steps to comply with nuclear safeguards. Work at the reactor site (at Sinpo in the DPRK) began in August 1997 with an official groundbreaking attended by project personnel from several countries. Until the reactors are completed, the Korean Peninsula Energy Development Organization (KEDO) has an obligation under the Framework to supply 500,000 metric tons (te) annually of heavy fuel oil (HFO) to the DPRK. KEDO oil deliveries started in 1995. The oil delivered by KEDO is intended to be used to fuel electricity generation facilities, and the use of KEDO HFO in the DPRK is subject to monitoring by KEDO.

The Agreed Framework is not a formal treaty or even an agreement in any binding sense. It is simply a set of guidelines that helps to regulate and render more predictable the behavior of the two state parties toward each other. The Framework allows them to walk forward in tandem, but separately. Along the way, there may be—and already have been—many and substantial detours. As long as the essential milestones are met by each party to the agreement, the Agreed Framework increases the predictability as to each party's behavior with respect to the other, and reduces uncertainty on both sides. There is nothing in the Framework to stop the two parties from reformulating the agreement in a mutually agreed-upon manner. Furthermore, it is both likely and reasonable, after seven years, that the agreement would need updating to account for new circumstances affecting the vital interests of both parties. It is inevitable that the U.S. Bush administration and the DPRK will need to come to terms on a new, modernized agreement that serves the current needs of both states while maintaining the diplomatic gains of the Framework to date.

The United States currently bears the cost for purchasing and delivering, via KEDO, 500,000 metric tons of heavy fuel oil to the DPRK each year. Deliveries are scheduled to continue until the LWRs provided via KEDO are complete. Realistically, that could be between 2007 and 2010. International HFO prices roughly doubled during 1999, and could go even higher if the United States steps up military action in the Middle East in response to the September 11 attacks. Even assuming that the average price paid by KEDO for HFO in the first half of 2000, approximately $190 per ton, holds through the end of KEDO HFO deliveries, the annual cost of fuel oil delivered to the DPRK will be $95 million. Through completion of the LWRs, the net present value of these deliveries would be some $530 to $700 million.

HFO was chosen as the fuel to be supplied to the DPRK under the Agreed Framework because it has limited uses in the DPRK. In particular, HFO is practically useless to the DPRK military. HFO from KEDO is intended for use in electricity generation and heating plants, but there is only one large generating plant in the DPRK designed specifically to use HFO. This plant, located on the DPRK's northeast coast, lacks the capacity annually to utilize the entire 500,000 tons of HFO. As a consequence, KEDO HFO is also used to some degree in plants designed to be fueled with coal, meaning that KEDO must deploy relatively expensive monitoring equipment at a number of different sites. Heavy fuel oil is also relatively high in sulfur, which may cause problems in DPRK boilers that were designed to burn sweet crude from the Soviet Union.

Given the considerable expense of HFO, and the limited utility of HFO in the DPRK, we suggest that the Bush administration consider exploring with the DPRK alternative services that could be provided with a portion of the funds now earmarked for HFO. Tapering down oil deliveries, and using the savings (or a portion of the savings) to fund activities such as refurbishment of existing power plants, aid for grid planning and modernization, supply of energy-efficiency services, and assistance with harnessing renewable energy would help many of the "putting the horse back in front of the cart" activities described later in this study to get well underway. In addition, expenditures that formerly went "up in smoke" would, at least in part, be recycled back to the United States.

Clearly any change in oil deliveries must be carefully negotiated with the DPRK and with KEDO partners. While it is clear that the DPRK views the nuclear portion of the Agreed Framework as a matter of prestige and as having the imprimatur of the late President Kim Il Sung, there is reason to believe that the HFO component is less sacrosanct in Pyongyang. The DPRK's reaction to a proposal that substitutes services and equipment for HFO is uncertain, but it seems to us that a package of services designed to upgrade the DPRK infrastructure, and to be delivered so as to displace HFO deliveries at an acceptable rate, might be of considerable interest to the DPRK. Alternatives include supplying only enough oil for the oil-fired plant, or having one of the services provided be an upgrade to the oil-fired plant to make way for the time when the refinery with which the plant is associated goes back on line. Another alternative is to offer to provide, in exchange for reducing HFO deliveries, some coal for existing power plants for a limited time. Note that this latter alternative would need to be coupled with assistance in refurbishing selected DPRK coal-fired power plants.

As just one example of such a "trade," the following might be considered. The United States could make an offer to the DPRK that the United States would spend perhaps 50 to 75 percent of the expected net present value of the agreed-upon HFO deliveries (perhaps $260 to $500 million), spreading the spending over the five priorities areas identified below at $50 million or more per item over five years, or $10 million per priority per year for five years. This type of approach limits (and reduces) U.S. costs, and provides the DPRK with more assistance "up front" in areas that make it better able to peacefully help itself. Alternatively, the United States could offer to concentrate funding on one of the priorities. In order to make sure, however, that other priorities get the necessary attention, such assistance would need to be tied to opening the doors for World Bank (IBRD and IFC) involvement in the DPRK energy sector—by taking the DPRK off the "terrorist list"—and working out a division of donor responsibility whereby, for example Japan takes on one of the major priority assistance areas, the ROK (Republic of Korea) another, and the European Union (EU) another, with coordination by an organization like KEDO. Such a scenario could be attractive to both the DPRK and the United States in that the DPRK gets a "multiplier effect" in assistance in exchange for cooperating, the United

States' costs are reduced, and opportunities for U.S. firms in the DPRK are potentially opened up in ways that a pure program of HFO purchase and delivery could never hope to facilitate.

There are many obstacles to such a deal being struck. For one thing, it seems highly unlikely that the Bush administration will consider removing the DPRK from the terrorist list in the aftermath of September 11 and President Bush's State of the Union address, which branded the DPRK as part of an "axis of evil." Furthermore, the removal of the DPRK alone does not guarantee U.S. support for letting the DPRK join international financial institutions. The United States must also consider "third party issues," and it seems quite likely that Japan would raise some objections. Japanese officials were privately quite upset that they were not consulted in the decision by EU countries to normalize relations with the DPRK, even though the momentum behind these moves came largely from the ROK. Even if the political will to improve relations with the DPRK can be found in Washington, Tokyo could remain a stumbling block.

Specific Energy-sector Problems and Their Ramifications

The DPRK's supply of commercial energy has fallen by one-half to two-thirds or more in the last decade, with impacts felt throughout the economy. While the demise of the energy sector is just one result of, and one cause of, the DPRK's overall economic decline, it is clear that economic recovery will not occur without a major reversal of the present situation. Below, we briefly discuss several particular energy-sector problems with ramifications for ways in which energy-sector assistance to the DPRK can most usefully be provided.

Decay of the Transmission and Distribution (T&D) Grid

The electricity transmission and distribution grid has a nominal frequency of 60 Hz (cycles per second), and is designed to deliver 240 volts at the end-user (household) level. The main transmission lines in the DPRK are rated at 220 and 110 kV (kilovolts), with additional transmission and bulk distribution lines at 60 and/or 66 kV, and additional bulk distribution feeders at 10 and 3.3 kV. Though the DPRK grid is nominally a national system, evidence indicates that it operates as a collection of increasingly fragmented local grids. Even in the best of times (around 1990), the dispatch system was primitive by modern standards, with orders for closing or opening of switches, for example, relayed by (unreliable) telex or telephone. A United Nations Development Programme project carried out in the early to mid-1990s supplied the DPRK with a computer control system for use with one power plant and a limited number of substations near Pyongyang, but no significant additional progress in T&D modernization has occurred.

Concurrently, the lack of spare parts, reported scavenging of metal (for barter for food) from remote lines, and overall wear and tear degrades the transmission and distribution system. Even in Pyongyang, power outages are reportedly frequent, and in the village where we worked, only 100 kilometers from Pyongyang, grid power was normally available to residents only between midnight and 5 A.M. We measured grid voltages that ranged from 140 volts to about 200 volts, and frequencies from 48 to 52 Hz. Note that in a modern grid, fluctuations of even a 0.1 Hz are considered excessive. Given the poor state of the conductors and transformers in the distribution system, distribution losses are undoubtedly excessive as well.

The status of the DPRK grid has a special meaning for the utilization of the LWRs being supplied by KEDO. In short, without an extensive modification of the grid and *either* a connection to another system—the ROK's, China's, or Russia's—or a direct connection to another grid with a limited connection to the DPRK grid, the LWRs cannot be used. LWRs must have a stable source of backup power for coolant pumps and other equipment, and must be operated such that the sudden loss of load is kept to an absolute minimum. Neither is possible with the DPRK grid as it is currently configured. Furthermore, the total capacity of generation included in the DPRK grid, even if it were altogether functional (which is far from the case), is too small to support two 1000+ MWe (megawatts of electric capacity) nuclear units.

Rehabilitating the DPRK's T&D system will require new conductors, substation equipment, switching equipment, and perhaps above all, modern control facilities. Existing right-of-ways may be adequate, but in many places new towers or poles will be needed as well. The labor to accomplish these changes is readily available in the DPRK, though training will be needed in some areas. Rebar, channel iron, and cement can be supplied locally as raw materials for towers and supports, but grid-quality wire may not be available in-country without retooling a manufacturing facility specifically for the purpose. Even bolts and nuts are hard to come by in quantity. We have estimated the overall cost of grid reconstruction at $3 to $5 billion.

The DPRK Coal Sector

Lacking oil or natural gas production facilities, the DPRK's sole domestic fossil fuel is coal. The DPRK has substantial reserves of anthracite and lignite coal, and most coal is produced from underground mines. Some mines are mechanized, but many are not. Coal is the principal fuel for electricity generation, but coal mining typically requires electricity for lighting, jackhammers, and a capacity for moving coal out of the mines. Electricity shortages and T&D problems therefore reduce the amount of coal that can be mined. Key coal seams in the important Anju area actually lie beneath the seabed, and require seawater to be continuously pumped out in order for the mines to operate. Mines in the Anju area were flooded in the mid-1990s.

Coal quality in the DPRK varies across a wide range. We tested a sample of coal at 5000 kcal/kg, only slightly below the average U.S. coal; but a reported range for DPRK coal is 1000 to 6000 kcal/kg, at some 12 to 65 percent ash. Coal at 1000 kcal/kg is little better, in terms of energy value, than dirt, and poor coal burns inefficiently, leaving a mountain of ash. It is not clear that DPRK coal, even if it were available in sufficient *quantity*, would be of high enough *quality* for use in a large modern coal-fired power plant.

Coal must be moved from the mines to power plants—most of which are located near population centers—and other consumers. The rail system is the primary mode of bulk transport in the DPRK, but it, too, suffers from advanced decay. The lack of diesel fuel, reliable electricity, spare parts, and steel for rails all contribute to decay. Coal reserves and coal mines sufficient to feed existing coal demand, and perhaps more, do exist in the

DPRK, but it will realistically take many years before infrastructure rehabilitation allows the quantities of coal that can be extracted and moved to consumers to exceed even 1990 levels.

Electricity Generation Infrastructure: Current Status and National Goals

The installed capacity for electricity generation in the DPRK is on the order of 10 gigawatts (GWe, or thousand megawatts), approximately half of which is hydroelectric and half thermal. Except for one 200 MWe plant that was built to use heavy fuel oil, essentially all of the thermal power is coal-fired. About ten large thermal plants and twenty large hydro plants account for over 60 percent of capacity. A large number of small thermal plants has been reported, but may in fact have never been operable. The combination of lack of spare parts, maintenance difficulties at aging facilities, T&D constraints, fuel supply constraints, and damage from natural disasters means that the actual operable capacity in the DPRK is probably, by our estimate, closer to 2 to 3 GWe at present.

The DPRK leadership, in practical recognition of the grid and fuel supply problems that the electricity system faces, is urging individual counties to develop, essentially, their own local electricity supplies and grids, focusing on small and mini hydroelectric facilities and (in the more distant future) wind power. These numerous small plants amount to about 500 MWe and may operate at low efficiency and capacity factors in the DPRK context. Meanwhile, additional development of larger hydroelectric facilities continues, but not rapidly.

The Impacts of Poor End-use Efficiency

End-use equipment in virtually all sectors is grossly inefficient in the DPRK. Domestically-produced electric and electronic devices would look familiar to Americans of the 1940s and 1950s. The lack of modern alloys and casting methods mean that DPRK electric motors physically dwarf their modern counterparts of equivalent capacity. North Korean incandescent light bulbs are virtually unbreakable, but produce so little actual illumination that housewives clapped with delight when the replacement compact fluorescent bulbs we provided, even at one per room, were turned on. Coal-fired boilers are reportedly often less than 50 percent efficient, resulting in wasted energy and excessive pollutant emissions. Industrial plants were built by taking Soviet designs (already relatively inefficient) and "beefing them up" so that the plants would survive under what Soviet engineers knew would be extra-arduous DPRK conditions. Systems for distribution of steam and hot water are highly likely to be porous as well. Tractors would be collectors' items in the United States. Even kerosene-style lamps—which are typically fueled with diesel oil—are for the most part just beverage cans with a wick inserted. The net result of inefficient end-use equipment is that the coal that does reach consumers, and the electricity that is generated (and isn't lost along the way), provide only a fraction of the energy services that they should. Fixing end-use equipment in the DPRK will be much cheaper than fixing the supply side, and will make existing fuel supplies go much further.

Providing Coordinated Assistance for the DPRK Energy Sector

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 rapidly to 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 (though the land it does have might be just sufficient to feed its population with some improvements in agricultural methods), and above all, capital and the means to generate it (other than through weapons sales). As a consequence, given the energy-sector problems outlined above, a coordinated program of assistance from the United States and other countries that builds upon these skills will be needed. Providing key assistance in a timely manner will enhance security in Northeast Asia, accelerate the process of North-South Korean rapprochement, and help to position the United States and U.S. 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. A multi-pronged approach on a number of fronts is required, with a large suite of coordinated, smaller, incremental projects that address needs in a variety of areas. Installing a large power plant in the DPRK without addressing problems of fuel supply, end-use efficiency, and electricity transmission and distribution, and without helping the DPRK to develop the means peacefully to earn the money to pay for the plant plus its operating expenses, is putting the cart before the horse. Providing a power plant with no fuel supply, or a power plant with fuel supply but no workable grid, or fuel supply and an upgraded grid but no power plant, or even a power plant with fuel supply and an upgraded grid but no efficient end-use equipment (or no end-use equipment at all) with which to use the electricity, are neither cost-effective nor even feasible options in the DPRK. A coordinated approach is necessary.

Below, we identify five priority 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 U.S. engineers and other program staff in direct contact with their DPRK counterparts and with DPRK energy end-users. In our own experience working on the ground in the DPRK, Americans working hard to help and to teach North Koreans has great effectiveness in breaking down barriers between our peoples. Actions speak louder than words or missiles in negotiating with North Korea.

Priority #1: Help to Rebuild the T&D System

The need for refurbishment and/or rebuilding of the DPRK T&D system, and the types of materials and equipment that will be required, have been identified briefly earlier in this article. The most cost-effective approach for U.S. 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 Tumen River area. Ultimately, it will be necessary to engage the World Bank as a leader in DPRK power sector refurbishment, probably with funding from the Japanese government. In the short-to-medium term, local solutions might focus on projects that would help the DPRK earn foreign exchange in an acceptable manner, such as by repairing T&D infrastructure and local power plants in particular areas so that facilities such as key mines can operate.

Priority #2: Help to Rehabilitate Power Plants and Other Coal-using Infrastructure

Rehabilitating existing thermal power plants, industrial boilers, and institutional/residential boilers will result in improved efficiency so the coal that is available goes further, reduces pollution, and improves reliability so that the lights and heat stay on longer. Accomplishing these upgrades will require a combination of training, materials (especially control systems), and perhaps assistance to set up and finance manufacturing concerns to mass-produce small boilers and heat-exchange components.

An initial focus, in the area of boiler technology, should be on improvements in small, medium, and district heating boilers for humanitarian end-uses such as residential heating and provision of heat and hot water for hospitals, schools, and orphanages. If possible, it would be optimal to provide such upgrades in areas of the country away from Pyongyang, those hardest hit by the DPRK's economic malaise.

The DPRK building stock, even in rural areas, tends to make extensive use of masonry and concrete, with leaky windows and doors, and minimal insulation. A program of boiler upgrades should go hand-in-hand with a program of "weatherization" (insulation, caulking, weather-stripping, and window replacement). Even minimal weatherization measures promise significant savings, with attendant reductions in coal use (making the supply go further), and in local and regional pollution.

Another early focus should be on rehabilitation of boilers in key industries that could help the DPRK to "bootstrap" the civilian economy. As a specific example, the DPRK has one of the world's largest deposits of the mineral magnesite, which is used in making refractory (furnace-lining) materials. Helping to rebuild the boilers or kilns that are used to produce magnesite, along with the fuel and ore-supply chains that feed them, would bring much-needed foreign exchange into the country. We suspect that with U.S. government participation and guidance, a private sector partner from the United States or elsewhere could be found to assist with this type of rehabilitation, and to share in the profits of a joint-venture firm.

In the short run, it may also be useful for the United States to provide the DPRK with coal for selected power plants in areas now poorly served by the existing coal and electricity supply systems. Providing such supplies, perhaps in an agreed-upon exchange for reduced HFO deliveries, would help restore humanitarian services and assist in economic revival while other energy sector upgrades are underway, and could reduce U.S. exposure to high HFO prices.

Priority #3: Help to Rehabilitate 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. The U.S. coal industry has significant expertise to assist with evaluating and upgrading coal mines in the DPRK, including improvements in mining technologies, evaluation of coal resources, mine ventilation systems, and mine safety. Coal processing to remove ash and improve fuel value could be another focus of assistance.

In parallel with any mine upgrades, rehabilitation of the coal transport network must also take place. This involves making sure that train tracks between mines and coal users are operable, that locomotives have electricity or fuel, and that working coal cars are available. In turn, this may mean providing or helping to set up a remanufacturing facility for steel rails, providing or helping to renovate factories for rail car and locomotive parts, and other types of assistance.

Priority #4: Assist with Development of Alternative Sources and 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. Some of the key areas where the United States and partners could provide assistance are:

- *Small hydro turbine-generator manufacturing:* Much of the rugged topography of the DPRK is well suited to small, mini-, and micro-hydroelectric development, and the DPRK government has given its blessing for local authorities to undertake hydro projects. The DPRK does manufacture some small turbine-generator sets, but it is clear that assistance would be helpful to produce more reliable and cost-efficient units, as well as to expand mass production. From our factory visits we have noticed that the microhydro units currently manufactured in DPRK are a propeller/turbine variety. This is a difficult technology to build, as it requires bearings that operate submerged in water. There may be considerable gains to be had by introducing other microhydro turbine technologies such as cross-flow or pelton turbines that have proven easy and cost-effective to manufacture in other developing countries.

- *Wind power:* Likewise, the dissemination of wind turbines is both a national goal and, from our first-hand observations, a keen interest of individuals in the DPRK. The barren ridges of the interior of the country are likely to be excellent wind power sites. The DPRK-manufactured wind generators and control components that we have seen, however, are at best grossly inefficient, and more likely non-functional. Design assistance and joint venture manufacturing of wind power systems are needed. A first phase might be the manufacture of lower-technology water-pumping windmills, similar to the type that we installed at the village of Unhari.

- *Agricultural equipment efficiency measures:* Helping North Koreans to feed themselves should be a high priority. The rice harvest in the DPRK, based on our observations in the “rice basket” of the country, is a nearly completely manual process. To increase productivity, improvements are needed in tractor design and maintenance (including spare parts manufacture) to make the diesel fuel that is used in agriculture go further. Improvements in motors and drives for electrically-driven agricultural equipment, such as rice threshers and mills, will stretch supplies of electricity.

- *Residential lighting improvements:* Three or four times as many households can be supplied with much higher quality light with the same amount of electricity if DPRK incandescent bulbs are replaced with compact fluorescent light bulbs (CFLs). Ultimately, joint venture manufacturing (or at least assembly) of CFLs in the DPRK could be undertaken, but until then provision of CFLs of robust quality should accompany any local power supply or T&D improvement initiative. We have found this measure to be invaluable for securing grassroots support, as it provides a direct and tangible improvement in the lives of ordinary Koreans.

- *Industrial and irrigation motors:* The opportunities for efficiency improvement in large electric motors and motor drive systems are estimated to be considerable. Imports of efficient motors, pumps, air compressors, and other motor-related equipment may be the first step (once power quality has been improved sufficiently), followed by assistance in setting up facilities to manufacture or assemble equipment in the DPRK. Improving the reliability and efficiency of irrigation pumps will help the DPRK move toward feeding its populace.

- *Power back-up systems:* For critical loads such as hospitals there is a huge need for reliable electricity. Inverter / battery / generator backup systems, possibly integrated with small-scale renewable energy options such as wind power (see above), can ensure 24-hour electricity in areas where grid power may only be available intermittently or not at all.

- *Humanitarian measures:* Even the best orphanages, hospitals, and schools in the DPRK are cold and bleak today. Providing on-site power, preferably with renewable energy systems, water purification equipment, and efficient lighting and other end-use devices are necessary and highly visible first steps toward meeting humanitarian needs in the DPRK.

Priority #5: Work to Open Opportunities for IPP Companies to Work in the DPRK

As noted above, the scale and complexity of the energy sector problems in the DPRK mean that the most reasonable way to address those problems is on a local and regional level. Though the U.S. government might reasonably provide technical assistance and limited direct humanitarian aid, as well as support for international efforts, it is probably unreasonable to expect the United States to directly underwrite the renovation of DPRK infrastructure on even a county scale. What the U.S. government can do, however, is pave the way for companies such as Independent Power Producers (IPPs) from the United States to operate in the DPRK. In this liaison role, the U.S. government could provide assistance to U.S. firms in identifying, negotiating with, and working with DPRK counterparts, underwriting performance guarantees, and providing low-interest financing. The U.S. government can also help by providing North Korean counterparts with training in the economics of project evaluation and in international contract law, both of which are, at present, alien concepts in the DPRK. The goal would be to assist IPP firms in working with DPRK authorities to set up with local and regional infrastructure (for example, power plants of less than 50 MWe) using small hydro installations, wind farms, or mid-sized coal-fired plants. In most cases, infrastructure projects would need to be coupled with the initiation or reestablishment of local revenue-generating activities so that IPP services can be compensated.

Policy Options to Avoid

Various groups have recently suggested changes in the course of U.S. policy regarding the DPRK energy sector. Although change in policy is inevitable, some of the changes that have been suggested are, in our opinion, inadvisable. Unilaterally abandoning the Agreed Framework and providing large coal-fired power plants (in connection with changes in the Agreed Framework or otherwise) are two of these "policies to be avoided."[1]

Update, But Do Not Abandon, the Agreed Framework

The Agreed Framework is the underpinning of the current U.S.-DPRK relationship. Breaking the agreement would be seen as a major breach of trust by the DPRK. The transfer of LWR technology included in the Agreed Framework is sought by the DPRK as a means to maintain both a civilian nuclear program and a studied ambiguity as to its nuclear proliferation intentions. For the United States, the ROK, and Japan, the attraction of the Framework is that it is, and has been, a means to start the thawing of relations with the DPRK, a way to lessen the probability of nuclear-weapons proliferation, and a means to exert better international control over the DPRK nuclear program. Despite its shortcomings—of which DPRK engineers are abundantly aware—the LWR transfer is a necessary first step to a political opening by North Korea, an opening that could lead to investments that will help integrate the economy of the DPRK with the other economies of the region. This integration would enhance stability and security in the region in the medium and long term, and is the underlying logic implicit in the hopes of U.S. and South Korean policymakers to achieve a "soft landing" for the DPRK economy and polity.

The burden for financing the LWR transfer rests mostly on the ROK, which has both the most to gain and to lose by the success or failure of the Framework. If the United States were unilaterally to abandon the Agreed Framework, it would not only seriously affect U.S.-DPRK relations; it would probably have a negative effect on U.S.-ROK and U.S.-Japan relations as well. Under such circumstances, U.S. influence in the region might well erode, with the slack being taken up by other regional powers. Negotiating with the DPRK to update certain provisions of the Agreed Framework, however, is both possible and reasonable, as we indicated earlier in this study.

Do Not Provide New Coal-Fired Power Plants Until the Refurbishment of the Electric and Coal Infrastructure is Well Underway

It has been argued that the drawbacks of the LWR transfer, including the technical issues described earlier in this article—the high cost of the reactors, and the increase, once the reactors begin to run, of stocks of nuclear material in the DPRK—make it appropriate to renegotiate the Agreed Framework so as to replace one or both of the LWR units with coal-fired power plants. There are several reasons why we do not believe this to be prudent, including:

- The civil engineering work done so far at the LWR site may be only partially applicable to a coal-fired power plant at the same location. Though the site is probably technically suitable for the large flows and storage of fuel and wastes inherent in a coal-fired power operation,[2] its location far from major electricity loads, though desirable for a nuclear plant, is suboptimal from a power transmission standpoint for a coal-fired plant.

- The ROK and Japan, which are providing funding, labor, and technology for the project, are likely to be much less interested in assisting with a coal-fired plant. It seems likely that the ROK will ultimately end up operating the LWRs, quite possibly as an extension of the ROK grid. The South Koreans' interest in adding a coal-fired plant to that grid is likely to be considerably lower than adding an LWR, with which they now have considerable experience. U.S. insistence on switching to coal-fired power may leave the United States footing the bill, will probably raise costs (as the ROK's labor input would be lower), and leaves the United States or U.S. firms holding DPRK debt.

- As noted earlier, the short-to-medium-term availability of coal in the DPRK, due to mining infrastructure and coal transport constraints, is problematic at best. Extracting and delivering the 7 million tons of domestic coal per year that 2 GW of coal-fired plants would consume is likely to be an impossible task for years even if a substantial program of coal infrastructure rehabilitation began today. Even if it were possible, providing this quantity of fuel would mean diverting it from other areas of the DPRK economy, causing shortages elsewhere, probably among those who are the most at risk. Importing that quantity of coal annually would cost hundreds of millions of dollars that the DPRK does not have, meaning either that imports would have to be heavily subsidized by the United States or others; or that the DPRK would finance its needs for foreign exchange with more exports of armaments; or that the plants would largely sit idle. By design, fuel costs per unit of energy generated are much lower for LWRs than for any fossil-fueled plant. The fuel and operating costs that the DPRK would bear in producing power with a coal-fired plant would be far higher than with the nuclear plant. Given the favorable terms for the DPRK's repayment of the LWRs' capital costs, the higher fuel and operating costs for a coal-fired option will make that option considerably more expensive (many billions of dollars over the plant lifetime), and thus considerably less desirable to the DPRK, than the LWRs.

- Though the nuclear safety concerns related to LWR operation in a shaky grid system would not apply to a coal-fired plant, any plant built within the DPRK grid faces the same problems in distributing its output. Building a different type of plant will not solve the grid-related problems that are obstacles to running any large generating plant at the LWR site.
- A large coal-fired power plant installed in the DPRK will either require coal of consistent quality, or will need to be designed to accept the widely varying levels of coal quality available in the DPRK. It is unclear that large, modern, Western-style coal plants would be suitable to the coal available in the DPRK. Spare parts from Western sources will be needed to keep the plant running, and maintenance needs under DPRK conditions may be greater than expected.
- Finally, the transfer of a large coal-fired power plant will not be of interest to the DPRK, which has had coal-fired plants for years and probably will not be actually short of coal-fired capacity for years to come. Coal-fired power neither provides the international status of nuclear power, nor provides much of an opportunity for the DPRK to learn something new. It is probable that a U.S. offer of a coal-fired plant in the place of the LWR will divert DPRK policymakers from attending to systematic solutions to structural problems, steering them instead toward piecemeal approaches that are likely to fail. As an example of the latter, the DPRK told the ROK in negotiations that it "wants 500,000 kW [of] power to be promptly supplied to the DPRK through a transmission line."[3] Although this request on its face may not appear terribly unreasonable, the poor match between the size, frequencies, and stability of the ROK and DPRK grids means that the two systems cannot be connected in any substantial way unless: first, enough power were to flow northward to stabilize the demand / supply balance on the DPRK grid and bring the frequency up to ROK levels; second, enough reliable generation capacity were to be built in the DPRK to allow the grid frequencies in the two countries to be matched; third, the portion of the DPRK served by the line from the ROK was isolated from the rest of the DPRK grid; or, fourth, a large AC to DC to AC converter station was built at the border in order to allow the exchange of power without matching frequencies. With the possible exception of isolating a portion of the DPRK grid, which is administratively difficult and still fairly expensive, each of these options would take years to carry out and would cost hundreds of mil-

lions to billions of dollars.[4] A major transmission line between the countries will probably eventually be implemented; but, like a major coal-fired plant, it will not work without a foregoing coordinated effort to shore up all of the other elements of the DPRK energy infrastructure. Focusing on an impossible "quick fix" from either a transmission line or a new coal plant is likely to result in technical and political failure that could stymie the process of rapprochement.

Conclusion

From the outside, the DPRK's manifold energy-sector problems would seem to be an intractable morass indicative of the imminent collapse of a society. No one, however, should underestimate the toughness, discipline, or ability to endure privation of the North Korean people—especially given the extraordinary social and political control exercised by the DPRK government. A U.S.-backed, coordinated program of grassroots energy-sector assistance to the DPRK would yield huge dividends in terms of confidence building and regional security—dividends such as avoiding the costs of conflicts, maintenance of U.S. influence in the region, and ultimately, profits for U.S. businesses as well. Such a program, carefully designed and negotiated, could start in one or more local areas of the DPRK and work with DPRK authorities to provide energy infrastructure rehabilitation, energy efficiency measures, opportunities for earning foreign exchange, and harnessing of new sources of energy.

At the same time, in order to retain credibility with the DPRK, the United States must abide by its commitments to date, including the Agreed Framework. Attempts, for example, to substitute coal-fired power plants for the LWRs specified in the Agreed Framework will be unacceptable to the North Koreans, uninteresting to the South Koreans, impractical for fuel supply, electricity T&D, and likely fuel-quality reasons, and could cause an unfortunate policy backlash. The DPRK propaganda machine is expert at providing unflattering portraits of Americans and the United States. Placing Americans in positions to provide aid to and work with North Koreans is, in our experience, the surest way to counter the influence of these images, to win the confidence of the North Korean people, and, ultimately, to contribute to improvements in security on the Korean peninsula.

NOTES

1. Henry Sokolski, "This Is No Way to Curb the North Korean Threat," *Nautilus Institute Policy Forum Online* (PFO 00-07A: October 29, 2000). Note that in the referenced document Sokolski refers to substituting a "non-nuclear" power plant for the first LWR unit to be provided under the Agreed Framework, but does not specify the type of fuel to be used.
2. Special care in constructing a coal-fired plant at the LWR site may need to be taken to prevent contamination of surrounding waters from runoff from coal and waste piles.
3. *Chosun Ilbo* (Seoul), Februrary 8, 2001, as summarized in Nautilus Institute's Northeast Asia Peace and Security Network Daily Report, February 9, 2001.
4. In the case of the AC-DC-AC converter option, an added drawback is that the converter system—which would cost hundreds of millions of dollars to purchase and set up—would be rendered entirely obsolete if the ROK and DPRK grids are joined at some point in the future.

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SPEEDING UP THE IMPLEMENTATION OF THE 1994 U.S.-DPRK AGREED FRAMEWORK

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This article argues that the continued delays in the light-water reactor construction project are endangering the ultimate success of the project on a number of levels. The longer that the construction of the reactors is delayed, the higher the costs to the members of the Korean Peninsula Energy Development Organization, and the less likely that the discrepancies in the DPRK's initial declaration to the International Atomic Energy Agency can be cleared up. A number of incentives are proposed to induce the various parties involved to fulfill their commitments under the Agreed Framework more quickly than currently required. Among these are that South and North Korea can learn a great deal through the decommissioning and dismantling of the DPRK's old graphite-moderated reactor, which might have commercial viability in the future.

Key words: Agreed Framework, IAEA, KEDO, light-water reactor, nuclear safeguards

Introduction

It is well known that the 1994 U.S.-DPRK Agreed Framework (hereinafter referred to as the “Agreed Framework”) was a reaction to the DPRK’s announcement of its intention to withdraw from the Nuclear Non-Proliferation Treaty (NPT) in March 1993. The Agreed Framework froze the DPRK’s nuclear weapons program in return for the supply of two light-water reactors (LWRs) and energy alternatives, and calmed the crisis that threatened to lead to war on the Korean peninsula in the spring of 1994.

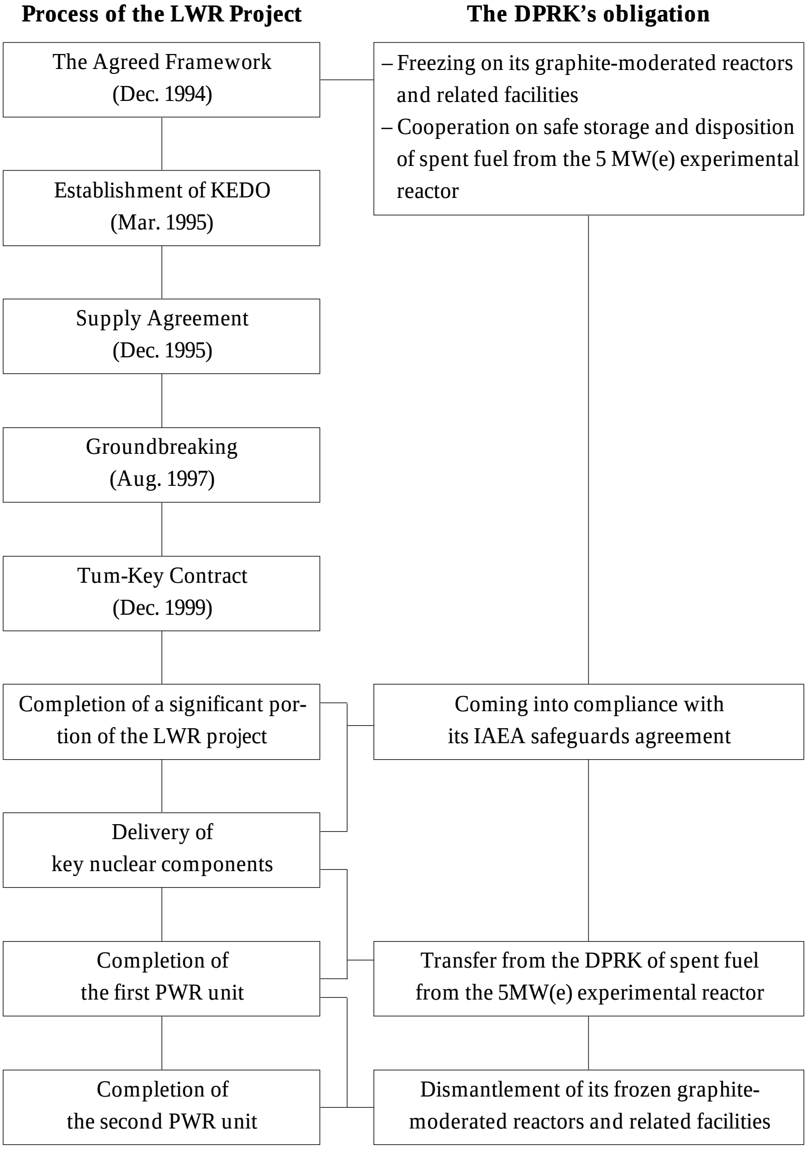
Over seven years have passed since then. If the work had gone well, the concerns about the DPRK’s nuclear threats would have subsided and the LWR project would be almost completed at this point. However, the implementation of the Agreed Framework has been delayed for several years and further delay is expected due to the uncooperative relationship between the United States and the DPRK.

The United States has been insisting that the DPRK should have come into compliance earlier with its full-scope International Atomic Energy Agency (IAEA) safeguards agreement. On the contrary, the DPRK has been arguing that the United States should compensate it for the probable loss of electricity that would have been generated if the two reactors being built by the Korean Peninsula Energy Development Organization (KEDO) were operating from 2003, the original target date in the agreement.

The delivery schedule of the LWR project and the schedule of relevant steps to be performed by the DPRK under the Agreed Framework are given in Figure 1.[1] As this shows, there is no obligation for the DPRK to accept IAEA inspections before completion of a significant portion of the LWR project, such as construction of the reactor building and containment structure for the first LWR unit.[2] The United States likewise has no obligation to make compensation for the loss of electricity due to the delay of the LWR project, because the year 2003 is just a target date.

By strongly insisting on arguments that lack a reasonable basis, both countries threaten to delay further not only the LWR project but also IAEA inspections in the DPRK. Delaying implementation of the Agreed Framework would worsen the situation as it would increase the costs of KEDO activities, including the LWR project, the heavy fuel oil (HFO) deliveries, and administrative expenses. Uncertainties regarding the IAEA’s ability to verify the DPRK’s nuclear materials would also increase with further

Figure 1. A Delivery Schedule of the LWR Project and Corresponding Steps to be Performed by the DPRK



delays. In addition, President George W. Bush's "axis of evil" remark regarding the DPRK in late January 2002 seriously increased the tensions on the Korean peninsula. This could further worsen the bad relationship between the two countries.

Background of the Agreed Framework

The DPRK acceded to the NPT in December 1985 under pressure from the former Soviet Union.[3] However, for more than six years the DPRK delayed ratifying a safeguards agreement with the IAEA before finally doing so on January 30, 1992. The agreement called for the IAEA to inspect the DPRK's nuclear facilities after ratification.

The IAEA began its ad hoc inspections in the DPRK in late May 1992, following the DPRK provision of its initial nuclear inventory report on May 4, 1992.[4] When the IAEA discovered discrepancies in the DPRK's declaration of nuclear materials, in February 1993 it invoked the right to make "special inspections" of two sites that the DPRK had not declared and that the IAEA suspected of housing nuclear waste. The DPRK, however, refused on the grounds that those two sites were military installations, and announced its intention to withdraw from the NPT in March 1993.[5] Tensions on the Korean peninsula increased and the prospect of war hung over the peninsula in the spring of 1994.

Following three high-level negotiations between the United States and the DPRK, the two countries concluded the Agreed Framework to produce an overall settlement of the nuclear issues on the Korean peninsula on October 21, 1994.[6]

Current Status of the LWR Project

In March 1995, KEDO was established according to the requirements of the Agreed Framework. KEDO and the DPRK have signed an agreement on the supply of the light-water reactors, consisting of two pressurized light-water reactor (PWR) units with two coolant loops and a generating capacity of approximately 1,000 MW(e) each.[7] According to the supply agreement, the protocols that have been agreed between KEDO and the DPRK on the LWR project so far are:[8]

- *A Protocol on Quality Assurance and Warranties*, which came into effect on December 3, 2001, and included principles for establishing and implementing quality assurance activities as well as KEDO's warranties for generating capacity, major components, nuclear fuel quality, and specified civil construction works for the project.

- *A Protocol on Training*, which came into effect on October 20, 2000, that specifies the training for the staff and management of the DPRK operating organization to ensure that they are optimally prepared to operate and maintain the two PWRs in a safe and reliable manner.

- *A Protocol on Non-Payment*, which came into effect on May 4, 1997, that specifies actions to be taken in the event of nonpayment of financial obligations in connection with the LWR project.

- *A Protocol on Site Take-Over, Site Access and Use of the Site*, which came into effect on January 7, 1997, regulating the use of, access to, and takeover of KEDO's site in the DPRK.

- *A Protocol on Labor, Goods, Facilities and Other Services*, which came into effect on January 7, 1997, outlining the services that the DPRK will make available to KEDO.

- *A Protocol on Juridical Status, Privileges and Immunities, and Consular Protection*, which came into effect on July 10, 1997, specifying KEDO's juridical status, privileges and immunities, and consular protection in the DPRK.

- *A Protocol on Communication*, which came into effect on July 10, 1997, concerning the supply of unimpeded and efficient communications and related issues at KEDO's site in the DPRK.

- *A Protocol on Transportation*, which came into effect on July 10, 1997, concerning appropriate and efficient transportation routes to and from KEDO's site in the DPRK, and related issues at the site.

The protocols that still have to be agreed between the KEDO and the DPRK on the LWR project concern nuclear liability, delivery schedule, terms of repayment, spent nuclear fuel, and nuclear safety and regulation.[9]

Challenges to the DPRK Posed by the LWR Project

Even though the Agreed Framework has thus far frozen the DPRK's nuclear weapons program in return for providing two PWRs in the DPRK, it is uncertain whether or not the DPRK will keep its promise in the near future. And there are a number of significant unsolved issues concerning the ongoing LWR project that should be cleared up by the DPRK.

First, the DPRK must come into compliance with its full scope IAEA safeguards agreement before the delivery of key nuclear components, such as the reactor vessel and the steam generator, so that the IAEA can resolve the outstanding issues arising from the disputed declaration of nuclear materials of the DPRK. Considering that it takes two to three years to install the key nuclear components, besides about a two-year period of plant operation for testing purposes, the key nuclear components should be delivered to the DPRK by 2005 or 2006 to complete the construction of the first PWR unit by 2008.[10] Therefore, taking into account the three to four years that the IAEA's inspection time will take even with full cooperation on the DPRK side,[11] the DPRK would need to accept IAEA inspections within 2002 or by the next year to be able to complete construction of the first PWR unit by 2008.

Second, the Agreed Framework requires that the United States and the DPRK conclude a bilateral agreement for peaceful nuclear cooperation, which requires the consent of the U.S. Congress, prior to the delivery of key nuclear components, according to the U.S. Atomic Energy Act. It is, however, quite uncertain whether and when the U.S. Congress would give its consent to the agreement and even whether the George W. Bush administration will start negotiating the agreement.[12]

Third, given the perilous state of the DPRK's electrical grid, electricity generated from the reactor cannot be matched to the DPRK's electricity demand without refurbishing its power grid even if the construction of the first LWR unit is completed by 2008. The KEDO's PWRs cannot be operated safely due to the unreliability of the DPRK's grid. The cost to upgrade the DPRK's electrical grid system so that it can distribute the huge amount of power that the reactors would generate would be a big financial burden to the DPRK and is estimated to total several hundred million to several billion U.S. dollars.[13]

Fourth, the DPRK should ensure nuclear liability insurance in the event of an incident in connection with the PWR plants. A minimum operator's liability of 300 million Special Drawing Rights (roughly equivalent to $400 million) has been recommended.[14]

Fifth, the DPRK should begin to dismantle its frozen graphite-moderated reactors and related nuclear facilities, including the reprocessing facility, when the first PWR unit is completed. The DPRK should complete such dismantlement before the second PWR unit is completed. The decommissioning and decontamination (D&D) of nuclear facilities requires huge costs, high technology, and long periods of work. The D&D of the DPRK's 5 MW(e) reactor, which operated for eight years, would cost several tens of millions of dollars.[15]

Sixth, according to the Agreed Framework the DPRK should begin removing the plutonium-bearing spent nuclear fuel from the 5 MW(e) reactor stored at Yongbyon—now canned with the U.S. Department of Energy's (DOE) assistance—when delivery of the key nuclear components for the first PWR unit begins. North Korea should complete shipping the spent nuclear fuel out of the DPRK to an as yet unspecified location when the first PWR unit is completed.[16] Movement of the spent nuclear fuel out of the DPRK would cost several tens of millions of dollars.[17]

Seventh, the DPRK should prepare independent electrical sources with an electricity capacity of approximately 8 percent of that of the PWRs, as required for their safe operation, before beginning operation of the PWRs.[18]

Considering the scope of all these challenges, it is doubtful how and when the DPRK will meet them and be able to implement the LWR project.

Financial Challenges Of KEDO

KEDO's current costs are mainly confined to the LWR project and the HFO purchase. The budget estimate for the LWR project in November 1998 was $4.6 billion.[19]

With regard to the LWR project, the ROK has agreed to provide 70 percent (approximately $3.22 billion) of the project's actual cost in Korean won within the estimated budget, while Japan has agreed to provide approximately $1 billion in Japanese yen.[20] The ROK through September 2001 had paid approximately $470 million for the LWR project using national deficit spending.[21] National debt will be the ROK's source of financing for the LWR project only until 2003.[22] Beyond that point, the ROK has no concrete plan to meet the remaining budget for the LWR project. The ROK will incur additional costs due to any delays of the LWR project, which could be a financial burden.

Japan had paid approximately $200 million for the LWR project by September 2001.[23] Japan has insisted that it will not provide further financing for the LWR project beyond the approximately $1 billion originally agreed to in 1998.[24] This could further worsen the financial challenges of the LWR project.

With regard to the HFO purchase, the United States had paid approximately $290 million for the HFO shipments to the DPRK by September 2001.[25] For the year 2000, KEDO delivered 500,000 metric tons of HFO to the DPRK at a total cost of approximately $95 million, due to a rise in world prices of HFO.[26] Since agreement has not been reached on a specific schedule for completing the first LWR unit, the duration of the HFO purchase and deliveries has not yet been determined. Thus, delay of the LWR project could be a financial burden to the United States since, until completion of the first unit, it needs to continue to provide the HFO to the DPRK to offset the energy foregone due to the freeze on the DPRK's nuclear program.

Overall, KEDO will continue to face financial difficulties if it does not receive sufficient contributions. It is doubtful that the LWR project can be sustained in the long term without significant modifications in the implementation of the Agreed Framework.

Flexibility in Implementing the Agreed Framework

Because the Agreed Framework is not a legally binding international treaty, it can be modified by mutual agreement without spoiling its purpose, which is a resolution of the nuclear weapons issue on the Korean peninsula. The DPRK cannot just wait until the construction of the first LWR unit is completed to relieve its energy shortage. And the United States cannot just wait for the DPRK to come into compliance with the IAEA safeguards because the likelihood of that is very uncertain. Thus, it seems possible and desirable to renegotiate certain aspects of the KEDO project considering its very slow progress. Of course, each party to KEDO will need incentives to agree to changes. In particular, the United States, the ROK, the DPRK, and Japan must all concur on the essentials of proposed modification.

Suggestions

The following steps are recommended to break the current impasse in progress toward implementation of the Agreed Framework due to the recently stalled relationship between the United States and the DPRK.

First, the DPRK should come into full compliance with the IAEA safeguards by 2002 to prevent further delay in implementation of the Agreed Framework, even though it is not under obligation to do so right now. There is an outstanding conflict between the DPRK and the IAEA over the disputed declaration about reprocessing in the past and the demand for special inspections of waste from the graphite reactor thought to be buried at Yongbyon. It is uncertain how the DPRK can resolve the issue of the disputed nuclear waste. However, precedents exist in the case of South Africa as to how the DPRK could amend its prior declaration. South Africa amended its previous declaration to IAEA when it admitted to having had a nuclear-weapon program.[27]

Second, regarding an incentive for the DPRK's acceptance of full-scope inspections by the IAEA, the United States should make arrangements to provide the DPRK with a significant amount of electricity, for example, 500 MW(e) annually. This additional electricity could be provided from 2003 until the year when the first LWR begins its operation. The ROK government would be willing to consider the DPRK's call for electricity aid.[28] The rehabilitation of existing thermal power plants in the DPRK would be a practical option for electricity provision to the DPRK.[29]

Two other incentives might be helpful for the ROK government in preparing a budget for the additional cost of providing electricity to the DPRK, besides financing 70 percent of the LWR project's cost. One is to encourage ROK-DPRK cooperation in science and technology (S&T), especially energy S&T, for example hydro-dam construction technology and nuclear energy safety. Another area for North-South cooperation is research and development (R&D) on decommissioning and decontamination of the DPRK's frozen reactors and related nuclear facilities. The D&D business is expected to be one of the few growth areas in the world nuclear market in the near future. Both Koreas could accumulate know-how concerning D&D technologies through the process of dismantlement of the DPRK's nuclear facilities.

The HFO equivalent of the DPRK's foregone reactor-generated electricity could be practically provided by rehabilitating existing thermal power plants and the coal-using infrastructure in the DPRK, increasing energy efficiency, and expanding renewable energy use in rural areas.[30] These are the kinds of alternatives suggested by the Nautilus Institute. They could provide additional business opportunities as well as environmental benefits to all participating countries.

Conclusions

The DPRK's coming into earlier compliance with its full scope IAEA safeguards agreement would be the best choice to allow the DPRK to receive a significant amount of electricity in the short term as well as the two PWRs from KEDO in the long term. Early compliance would also contribute to resolving the increased tension on the Korean peninsula following Bush's "axis of evil" remark. During this process, the ROK is expected to play a key role in sustaining the LWR project inasmuch as the United States and Japan are currently reluctant to commit further financial support to it because of the financial burden the project's delay has caused.

NOTES

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24. "Disagreement between the ROK and Japan," *Dae-han-mae-il*.
25. *Status of KEDO*, p. 11.
26. KEDO, *Korean Peninsula Energy Development Organization Annual Report 2000/2001*, p. 10. The United States paid $290 million for HFO to the DPRK from December 1995 to August 2001. *Status of KEDO*, p. 11.
27. David Albright, "South Africa and the Affordable Bomb," *Bulletin of the Atomic Scientists*, vol. 50, No. 4 (July-August, 1994). Text online at http://www.thebulletin.org/issues/1994/ja94/ja94Albright.html.
28. The DPRK insisted in December 2000 that the ROK provide it with 500 MW of electricity per year to ease its energy shortage. However, the United States requested that the ROK halt the inter-Korean energy talks because of concerns that an inter- Korean agreement on the issue might compromise U.S. leverage in talks with the DPRK on North Korea's nuclear and missile programs. See *Korea Herald* (Seoul), August 1, 2001.
29. The Nautilus Institute identifies rehabilitating power plants as a priority area for assisting the DPRK's energy sector. Von Hippel et al., Modernizing, p. 14. In 2000, the ROK government also concluded that rehabilitating the DPRK's power plants would be an economical and feasible option for providing electricity to the DPRK. "The Relationship between South and North Korea is Stuck Due to a Problem of Electricity Provision to DPRK," *Weekly Chosun*, February 18, 2001(in Korean).
30. Von Hippel et al., *Modernizing*.

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KEDO: WHICH WAY FROM HERE?

Mitchell B. Reiss

Contrary to the early skepticism, the Korean Peninsula Energy Development Organization (KEDO) has not only survived; in some ways it has actually flourished. KEDO and the DPRK (North Korea) have been able to forge a solid working relationship, which has been reflected in numerous agreements that interpret and implement the original commitments set forth in the 1994 Agreed Framework. More important is what KEDO has prevented—including the halting of its reprocessing of fissile material for atomic bombs. Inspectors from the International Atomic Energy Agency (IAEA) have been allowed continuous access to monitor this "freeze." To date, there have been no publicly confirmed reports of the North cheating on this arrangement. Yet If KEDO were judged on its ability to efficiently manage an international construction project, it would be fortunate to receive a "gentleman's C." But that may be the wrong way to assess its performance. Fundamentally, KEDO is a political endeavor, not a commercial project, and in that respect it has made a substantial contribution to peace building. Even without knowing the ultimate outcome of the KEDO project, its stabilizing presence has allowed the DPRK and the major powers in the region to begin a process of diplomatic and economic engagement.

Key words: light-water reactors, KEDO, peace building, Turn-Key Contract, U.S.-DPRK relations

Introduction

It is easy to forget the controversy and the challenges faced by the Korean Peninsula Energy Development Organization (KEDO) when it was first created. A product of the October 1994 Agreed Framework between the United States and the Democratic People's Republic of Korea (DPRK), it was incorporated in March 1995 and began its actual operations four months later with a skeleton staff, temporary office space, and a single telephone line. Its mission was clear: to build two 1,000 MW(e) nuclear power reactors in North Korea and provide 500,000 metric tons of heavy fuel oil annually until the first reactor was completed.[1]

Far less clear was how this ambitious goal would be achieved. Diplomatically, the North was the world's most secretive country, a militaristic, xenophobic "Hermit Kingdom" that was technically still at war with the United States and the Republic of Korea (ROK). Logistically, there were no sea or land transportation routes or communications between the two Koreas to facilitate the light-water reactor (LWR) project. Due to the North's economic backwardness, KEDO would have to provide everything from the sophisticated nuclear components to the kimchi to feed the South Korean construction workers.

Further, KEDO did not exist in a vacuum, but rather was subject to the often-turbulent strategic environment in Northeast Asia, as well as the domestic politics of its three founding members, the United States, South Korea and Japan. Many in the U.S. Congress, which came under Republican Party control two weeks after the Agreed Framework was signed, voiced serious reservations about the wisdom of the nuclear bargain struck by the Clinton administration. Less vocally, South Korean and Japanese officials also had doubts about whether KEDO could succeed. In addition to the question whether KEDO could surmount the diplomatic, logistical, and political hurdles, it was uncertain how, or even whether, it could raise the funding for this multibillion-dollar enterprise.

The Record So Far: A Glass Half Full . . .

Contrary to this early skepticism, KEDO has not only survived; in some ways it has actually flourished. KEDO and the DPRK have been able to forge a solid working relationship, which has been reflected in the 1995 Supply Agreement and numerous subsequent protocols, memoranda of understanding, and high-level expert agreements that interpret and implement the original commitments set forth in the Agreed Framework. These agreements range from ensuring that all KEDO workers in the DPRK have full diplomatic immunity to wage levels for North Korean workers to technical details of nuclear safety procedures.

Forty nationals from the founding member states and the European Union staff the headquarters office in New York City; they support the more than 1,000 KEDO workers at the LWR construction site at Kumho, on the northeast coast of the Korean peninsula. Construction work on the LWR plants officially started in February 2000 and is moving ahead according to the schedule set out in the December 1999 "Turn-Key Contract" (TKC) between KEDO and KEPCO (Korea Electric Power Company), the prime contractor. Significant progress has been made on the barge docking facility, where major components and supplies will be unloaded, grading of the power plant site, living quarters, and other site infrastructure support. KEDO has also continued to deliver 500,000 metric tons of heavy fuel oil annually to the North, despite the spike in oil prices during the past year.

More important than what KEDO has achieved is what it has prevented. Since 1994, the DPRK has halted activity at the Yongbyon nuclear complex, including a reprocessing facility capable of separating enough fissile material for twenty to forty nuclear bombs per year. Construction of a 600 MW(t) nuclear reactor near Taechon in the northwestern part of the country has ceased. Inspectors from the International Atomic Energy Agency (IAEA) have been allowed continuous access to monitor this "freeze." To date, there have been no publicly confirmed reports that the North has cheated on this arrangement.[2] In addition, the spent fuel produced by the 30 MW(t) reactor at Yongbyon, containing plutonium sufficient for five or six nuclear bombs, has been canned and also placed under IAEA safeguards.[3] Under the Agreed Framework, the DPRK will have to export this spent fuel before the first LWR is completed.

The numbers only tell part of the story. Harder to quantify is the influence KEDO has exerted on North Korea through its almost constant interaction. Since 1995, KEDO has been the primary and in some instances the only venue where North Korean officials could talk directly and routinely with their South Korean, American, and Japanese counterparts. The value of this dialogue should not be underestimated. KEDO negotiators consistently have been surprised at the North's misunderstanding of or outdated knowledge about the way the KEDO member governments operate, and about the basic technical details relating to a nuclear power project. According to one KEDO official, "The number one job in every discussion with the North is to educate them about the way the world works." Similarly, daily interaction at the Kumho site between South and North Korean construction workers has defeated Pyongyang's best efforts to insulate at least some of its long-suffering populace from "ideological contamination" from Seoul. And even if the June 2000 North-South summit between ROK President Kim Dae Jung and DPRK Kim Jong Il has not yet delivered the enormous expectations it generated, it is still arguable that this unprecedented meeting would not have taken place without the years of groundwork laid by KEDO.

. . . Or Half Empty?

But it is also possible to characterize KEDO in a far less positive light, not as the engine of progress on the Korean peninsula, but rather as the *Brigadoon* of international organizations—a place where time has largely stood still.

It is an open secret even among the North Koreans that the project will not be completed by the 2003 target date specified in the Agreed Framework.[4] The project is as much as seven years behind schedule, but even that projection may be overly optimistic.

While interest among KEDO's three founding members has waxed and waned since its inception, it now seems to be at an all-time low. Further, KEDO has only attracted two new members since 1997, bringing its total to thirteen, and still does not include many of the major countries in East Asia.[5] Aside from the United States, South Korea, and Japan, only two other countries made financial contributions during 2001, and these totaled less than $1 million.[6] The European Atomic Energy Commission, which joined the KEDO executive board in 1997, did not make any contribution in 2001. This highlights KEDO's perennial problem of securing funds to finance heavy fuel oil deliveries. These fuel shipments have been late for each of the past five years, thereby harming KEDO's credibility with the North and undercutting its efforts to have Pyongyang strictly abide by its agreements.

The LWR project was only a part of the Agreed Framework, which envisioned that the United States and the DPRK would gradually normalize diplomatic and economic relations (e.g., Washington would lift trade sanctions and foreign investment barriers). The DPRK also pledged to engage in North-South dialogue. Expectations on this score have been disappointed. The North took six years to hold a summit meeting with the South. Meanwhile, it possesses stockpiles of chemical weapons. It is believed to have pursued a biological warfare program since the 1960s. It has a robust ballistic missile development and export program.[7] And it has positioned the bulk of its conventional military forces just north of the Demilitarized Zone (DMZ), menacingly close to Seoul.[8] To be fair, these matters extend well beyond KEDO's competence or influence. But KEDO's interaction with the DPRK has not had the beneficial "spillover" effects that some of its advocates initially claimed.

Future Challenges

From its earliest days, KEDO has faced a host of what might be termed "internal" and "external" challenges. This remains true today.

Internal Issues

The Organization has postponed negotiating a number of the thornier protocol agreements essential to implement the LWR project. The most complicated and time-urgent of these negotiations concerns the nuclear liability protocol, which must establish a comprehensive, internationally acceptable nuclear liability regime in the DPRK. This will require KEDO to explain how such a regime would operate and then persuade Pyongyang to enact appropriate domestic legislation that will remove from the DPRK operator of the LWR plants all liability from any claims arising from a nuclear incident.

If this hurdle can be surmounted and the project completed, the North will still either have to purchase nuclear liability insurance on the world market or stand behind any nuclear liability from the LWR plants. In the event liability insurance proves unattainable or unaffordable, the DPRK may propose instead that it indemnify KEDO in the event KEDO or its contractors incur expenses because of a nuclear incident. Would the North's assurances give sufficient comfort to KEDO, its contractors and subcontractors? Significantly, the TKC requires that KEDO provide protection to the prime contractor and subcontractors prior to the date when the first nuclear components are shipped to the DPRK. If such legal and financial protection is not provided to KEPCO's satisfaction, then it reserves the right to walk away from the LWR project and incur no further liability. KEPCO has signed similar agreements with its subcontractors. In short, the project could fall apart unless the nuclear liability issue is adequately resolved. And all of these nuclear liability pieces must fall into place in relatively short order or else there is a real risk the LWR project may be further delayed.

Another troublesome protocol deals with the schedule for delivering the two LWR plants. This protocol is designed to map out the specific milestones and time frame for the construction of the LWR plants, as well as the steps the DPRK must take for the project to be completed according to the schedule. For the past four years a draft of this protocol has been debated among the KEDO executive board members. A key area of disagreement has been how to handle the timing of the North's coming into full compliance with its Nuclear Nonproliferation Treaty (NPT)/IAEA safeguards obligations. Some members have argued for adhering to the schedule outlined in the Agreed Framework, which obligates Pyongyang to come into compliance only after KEDO has completed a "significant portion" of the LWR project, i.e., after delivery of the turbine generators but before the delivery of "key nuclear components" such as the reactor vessel, steam generators and main coolant pumps. Other members have insisted upon "accelerated" compliance to ensure that the project will not be delayed and costs increased during the time the IAEA needs to investigate and analyze the data.[9]

In addition, one of the KEDO executive board members would prefer to present the delivery schedule to the North without any specific dates for fear of Pyongyang's reaction once it is officially presented with a schedule confirming that the reactor project would not be completed by the 2003 target date. The concern here is that the DPRK would then demand compensation from KEDO for the delay in bringing the project on line. Since the KEDO founding charter requires that all decisions must be made by consensus, these internal disagreements mean that this draft protocol has still not been presented to the DPRK.

A third yet-to-be-negotiated protocol addresses nuclear safety issues and the North's regulation of the LWR plants. KEDO has already met with the DPRK regulatory authority to discuss nuclear-related safety issues. But developing a culture of safety in the North will take time; it will take even longer if some KEDO members continue to balk at sharing safety and technical data with Pyongyang. Also, nuclear regulators traditionally have the freedom to visit any part of a nuclear facility and even shut it down on their own authority. Will the KEDO members grant this right to the North, even if, theoretically, it could delay the project further? And if this right is denied, will that compromise safety when the LWR plants are eventually handed over to the DPRK? One possible compromise currently under consideration that could defuse this issue is a "coordinated inspection regime," which would allow routine inspections at regular intervals and ad hoc inspections upon the demand of either party.

Pyongyang would also like to renegotiate a wage agreement that was concluded in 1997 to increase the wages paid for North Korean workers at the site. When KEDO refused to accede to Pyongyang's demands in 1999, Pyongyang pulled half of its labor force from the site. KEDO responded by hiring Uzbek workers as a stopgap measure. But the LWR project will need thousands of skilled and unskilled workers—and it was always anticipated that the North would provide cheap labor to keep down the LWR project price. KEDO continues to hold discussions with the DPRK on this matter.

A potentially much more expensive problem is the need to find a new supplier of the turbine generators for the LWR plants. In 1999, General Electric made known it would not participate in the project, citing in part concerns over nuclear liability. KEDO has identified an alternative supplier, but as of February 2002 a contract has not yet been signed. Some observers believe that this uncertainty over the turbine generators has wasted a year. A change in supplier will also mean redesigning the turbine generator and auxiliary buildings, thus adding to the overall cost of the project.

Finally, funding KEDO's obligations is also a major challenge. According to an executive board resolution implementing the December 1999 TKC, the LWR project will cost $4.6 billion. Of this amount, South Korea agreed to underwrite 70 percent; Japan pledged the yen-equivalent of $1 billion, which translated to approximately 22 percent. (The United States has not contributed any funds to LWR construction.) Left undecided was how KEDO would fill this projected 8-percent shortfall (100 percent less 92 percent). For the past two years, Tokyo has agreed to cover the shortfall by drawing down the necessary funds from its $1-billion commitment. However, Japan has recently stated it will cease doing so after February 2002, preferring instead to pay only 22 percent of KEDO's project costs on an annual basis until its $1-billion commitment is exhausted. At this point, it is unclear how KEDO will secure the necessary funds to cover the disparity between its accounts payable and accounts receivable. Making matters worse is that the $4.6 billion project cost figure is widely considered unrealistic. Most observers place the project's overall cost at an order of magnitude greater, perhaps double the original cost; as the project cost inflates, so too will the amount of funding needed to cover the 8-percent shortfall.

More immediately, finding the funds for heavy fuel oil (HFO) shipments will continue to bedevil KEDO until the first LWR plant is completed (when such shipments will cease, according to the Agreed Framework). HFO prices peaked at $96 million in 2000; depending on the world oil market, they could stay near that level for the foreseeable future. During the Clinton administration, the Republican-led Congress reluctantly appropriated only some of the funds needed for these shipments. However, early signs suggest that the Bush administration will be much less parsimonious. In 2001, the administration contributed over $70 million to KEDO, most of which was earmarked for HFO.

External Issues

The external problems that complicate KEDO's work are no less formidable for lying beyond KEDO's immediate control.

The DPRK is obviously the key external actor. For the past few years, the IAEA has requested that the DPRK come into full compliance with its safeguards obligations, to no avail.[10] Since ensuring the correctness and completeness of all the DPRK's nuclear materials and facilities with its initial declaration will take three to four years, according to the IAEA's Director-General,[11] the IAEA has proposed concrete steps Pyongyang could take to preserve nuclear information and generally shorten the verification time-frame. Pyongyang has refused, and cited the Agreed Framework language that links its acceptance of IAEA verification to progress in the implementation of the KEDO project.

Any delay in constructing the LWR plants will increase costs. A delay of three to four years would require cessation of all work and the repatriation of South Korean workers from the site. Moreover, it is likely that the IAEA's technical analysis of the DPRK nuclear program will be less than one hundred percent conclusive. In other words, even with the North's full cooperation, there may be uncertainty over how much plutonium Pyongyang has separated that could be used for nuclear bombs, due to incomplete bookkeeping, different accounting practices, and the failure to preserve information. Depending on the amount of technical uncertainty, the KEDO project could be delayed further while the executive board members make a political decision whether or not to proceed.[12]

The DPRK is also going to require new power transmission lines to carry the electricity generated by the two LWR plants. The North's current grid is in an abysmal state, with frequent brownouts and blackouts throughout the country. Nor can this issue be postponed indefinitely, because of the long lead-time required to secure financing and complete construction. KEDO has been adamant in telling the North Koreans that the electrical grid is their responsibility.[13] In addition to the transmission lines, the North will need to have in place a reliable source of backup electricity before the LWR plants start up.

Inevitably, the state of North Korea's relations with South Korea will influence KEDO's future, for both good and ill. Will the long-promised rail line be cleared across the DMZ? Will the Kaesong economic zone be developed? Will Pyongyang take steps to encourage South Korean tourism at Mt. Kumgang? Will family exchanges be increased, with the North agreeing to a permanent site where families can meet regularly? Will the South accede to the North's demand for electricity and, if so, will this undermine the rationale for the KEDO project? Will Kim Jong Il make his promised return visit to the South? And can any or all of these steps be taken before the end of Kim Dae Jung's term, or will they become ensnarled in the upcoming presidential contest? The questions are easier to pose than the answers.

An additional cross for KEDO to bear is tension between two of its founding members, South Korea and Japan. While KEDO has been exemplary in promoting closer ties between the two countries, recent events are a reminder that slights, both real and perceived, lurk very close to the surface and can flare up at any moment. Last year's publication of school textbooks that whitewash Japan's occupation of Korea during the 1930s and 1940s, and the government's refusal to ban them, caused great consternation in Seoul (and throughout East Asia). A Japanese patrol boat that rammed a Korean fishing vessel in the Sea of Japan in mid-September highlighted an ongoing dispute over fishing rights in the region. A month before, over South Korean objections, Prime Minister Koizumi Junichiro visited the Yasukuni shrine, which memorializes Japanese war dead, including some convicted war criminals. For Koreans suspicious of a possible resurgence of Japanese militarism, Tokyo's recent successful launch of a satellite seemed a precursor to a ballistic missile capability. And even before Koizumi responded to the events of September 11 with offers of military support, many Koreans harbored a deep-seated distrust of Japan's asserting a larger military role for itself in the region.

Finally, U.S. policy toward the DPRK will bear upon KEDO's work. After a six-month review of North Korea policy, the Bush administration came out squarely in favor of continued support for KEDO and for the larger process of engagement with the DPRK. But there are few illusions about the dangers the North Korean regime presents. In Congressional testimony in March 2001, the Commander-in-Chief of U.S. Forces/Korea, General Thomas Schwartz, stated that during the past year, a time of warmer diplomatic relations between the two Koreas, the North Korean armed forces had gotten "bigger, better, closer and deadlier."[14] The following month, Pyongyang announced a new defense deal with Moscow to provide more advanced equipment for its million-man army. More recently, in his January 2002 State of the Union Address, President Bush described North Korea as part of an "axis of evil, arming to threaten the peace of the world." He declared that "the United States of America will not permit the world's most dangerous regimes to threaten us with the world's most destructive weapons."

Still, Secretary of State Colin Powell and other State Department officials have repeatedly stated that the United States will meet with the DPRK anywhere, anytime without preconditions. To date, the DPRK has not taken up Washington's offer.

Impact of September 11

Even before the events of September 11, 2001, it was unclear whether this lull in U.S.-DPRK diplomacy marked a brief pause between negotiating rounds or the beginning of a longer period of cooler relations. After September 11, that question became moot. For the foreseeable future, the Bush administration's primary attention will be directed to fighting and winning the "war against terrorism."

With heightened scrutiny of all terrorist activities, an additional obstacle to U.S.-DPRK negotiations over the non-KEDO aspects of the Agreed Framework is that North Korea remains on the State Department's list of state sponsors of terrorism. According to the State Department, during the past year the DPRK "continued to provide safe-haven to the Japanese Communist League-Red Army Faction members who participated in the hijacking of a Japanese Airlines flight to North Korea in 1970. Some evidence also suggests that the DPRK may have sold weapons directly or indirectly to terrorist groups during the year."[15]

This indictment is more complicated than it first appears.

According to some reports, Pyongyang has offered to return the Japanese Red Army members, but Tokyo has not yet agreed to accept them. During 2000, North Korea engaged in three rounds of terrorism talks with the United States, culminating in a joint statement in which "the DPRK reiterated their opposition to terrorism and agreed to support international actions against such activity."[16] On October 6, 2000, the two sides also issued a joint statement condemning international terrorism and pledging to exchange information to combat terrorism.[17] And after the September 11 events, Pyongyang publicly denounced the terrorist attacks and sent a private message to President Bush pledging its "cooperation" in the fight against terrorism.

Nonetheless, as long as the North remains on the State Department's terrorism list, it is at least as likely that some members of the Bush administration and Congress may call for stiffer, more punitive measures instead of a new round of diplomatic engagement. Indeed, President Bush's State of the Union Address, where he publicly identified North Korea as one of three countries that threaten the United States and international peace, indicates a much tougher line toward Pyongyang.

In this environment, the reinforcement of American forces on the Korean peninsula may be misinterpreted by the North and lead to an escalation of military tensions. More probable is that Pyongyang will view the United States as losing interest in Northeast Asia. (An early diplomatic casualty of September 11 was the cancellation of the President's trip to the ROK and Japan in October, though this was remedied in February 2002.) Under a worst-case scenario, North Korea may take provocative action to compel Washington to pay attention. This may take the form of Pyongyang's hindering further the work of IAEA inspectors, announcing it will no longer suspend its missile tests, or actually testing one of its ballistic missiles. Even if these more pessimistic scenarios do not develop, September 11 and its ramifications have made KEDO's job more difficult.

Conclusion

If KEDO were judged on its ability to efficiently manage an international construction project, it would be fortunate to receive a "gentleman's C." The project is well behind schedule and still must overcome a number of serious legal, engineering, and financial problems before the LWR plants are built. But that may be the wrong way to assess its performance. Fundamentally, KEDO is a political endeavor, not a commercial project. Judging on this basis yields a much different conclusion.

The Agreed Framework nuclear deal, and KEDO, have made the events of the mid-1990s a distant memory. In 1994, the DPRK had removed from its Yongbyon reactor nuclear fuel with enough plutonium for five or six nuclear weapons. It had kicked IAEA inspectors out of the country. Both the DPRK and the United States mobilized troops and reinforced their positions along the DMZ. Many observers believed there was a real chance of a second Korean War.

Today peace has not broken out on the Korean peninsula, but North Korea is no longer so isolated and is opening up slowly to the outside world. Its contacts with South Korea are broader and more sustained than at any time in history. With respect to nuclear matters, Pyongyang has placed the spent fuel from the Yongbyon reactor under international safeguards. Its declared nuclear program remains frozen and under international supervision. Without these measures, a full-fledged North Korean nuclear weapons program could today produce up to fifty-five bombs a year.

Although questions about Pyongyang's hiding weapons-grade plutonium or even a nuclear bomb are far from resolved, KEDO has played a central role in capping the North Korean nuclear threat. Moreover, the successful completion of the KEDO project offers the most practical, peaceful way to answer these questions. But even without knowing the ultimate outcome of the KEDO project, its stabilizing presence has allowed the DPRK and the major powers in the region to begin a process of diplomatic and economic engagement. If this opportunity has not been fully exploited by the DPRK and the major powers, that is hardly KEDO's fault.

Phrased euphemistically, KEDO has been enormously successful in "kicking the can" down the road. Importantly, its past record demonstrates the ability to continue kicking this particular can for the next few years, at least. This contribution should not be underestimated.

So whither KEDO? Years from now, will it be viewed as the prototype to a new type of international organization, one composed of key regional actors dedicated to tackling a single problem? Or will it be seen as a fatally flawed model that woefully miscalculated the perfidy of the North Koreans? No one can say for sure. But this much is certain: For the foreseeable future, KEDO will continue much as it has before—its past achievements minimized, misunderstood, or overlooked; its current good deeds dismissed or taken for granted; and its future prospects uncertain, held hostage to larger political forces.

NOTES

1. For a history of the U.S.-DPRK negotiations that led to the Agreed Framework, see Michael J. Mazarr, *North Korea and the Bomb: A Case Study in Nonproliferation* (New York: St. Martin's Press, 1995); Mitchell B. Reiss, *Bridled Ambition: Why Countries Constrain Their Nuclear Capabilities* (Washington, D.C.: Woodrow Wilson Center Press, 1995), pp. 231-319; and Leon V. Sigal, *Disarming Strangers: Nuclear Diplomacy with North Korea* (Princeton, N.J.: Princeton University Press, 1998).
2. In August 1998, news reports about a suspicious facility located at Kumchang-ni led some observers to think it might house a clandestine nuclear facility. U.S. inspections in May 1999 proved this particular fear to be groundless.
3. These and subsequent figures on DPRK plutonium production and nuclear weapons capability are taken from David Albright, "How Much Plutonium Did North Korea Produce?" in David Albright and Kevin O'Neill, eds., *Solving the North Korean Nuclear Puzzle* (Washington, D.C.: ISIS, 2000), pp. 111-26.
4. "A scrutiny of the real state of the LWR construction makes it clear that the LWRs are not likely to be completed by the year 2003 and even by the year 2010. . ." Korea Central News Agency (KCNA), June 28, 2001.
5. The two most recent members are the Czech Republic and Uzbekistan. Finland withdrew from KEDO on February 1, 2001, stating that it would contribute to KEDO through its membership in the European Atomic Energy Community. See *KEDO Annual Report*, 2000-2001 (New York: KEDO, 2001), p. 12.
6. The two countries were Canada and Singapore, which contributed $624,883 and $300,000, respectively. Ibid., p. 16.
7. See Office of the (U.S.) Secretary of Defense, *Proliferation: Threat and*

Response, January 2001, pp. 9-11. See also, U.S. National Intelligence Council, "Foreign Missile Developments and the Ballistic Missile Threat to the United States Through 2015," September 1999, online at www.cia.gov/cia/publications/nie/nie99msl.html.

8. Many analysts view the DPRK conventional military threat as a lesser concern than the North's nuclear, chemical, and biological weapons programs and its ballistic missile capabilities. This threat was not placed in the October 1999 report issued by former Secretary of Defense William J. Perry at the request of US Forces/Korea Command. The Perry Report is reprinted in Albright and O'Neill, *Solving the North Korean Nuclear Puzzle*, pp. 299-313.
9. According to State Department officials, Washington's North Korea policy review favors a reinterpretation of the Agreed Framework language that would call for accelerated DPRK compliance. Personal interviews, Washington, D.C., September 20, 2001.
10. "The Agency continues to be unable to verify the correctness and completeness of the initial declaration on nuclear material made by the DPRK. And it is therefore unable to conclude that there has been no diversion of nuclear material in the DPRK." Report by the Director-General, IAEA General Conference, GC(45)/26, August 6, 2001.
11. Mohamed El-Baredei, Statement to the 45th Regular Session of the IAEA General Conference 2001, September 17, 2001, online at www.iaea.org/worldatom/Press/statements/ebsp2001n009.shtml. This time frame assumes full DPRK cooperation.
12. It is also possible that the KEDO project would not be delayed, but would be terminated. For a comprehensive examination of the verification issue, see Michael May, ed., *Verifying the Agreed Framework* (Center for Global Security Research/CISAC, April 2001).
13. However, KEDO has informed the DPRK that it is willing to use "its good offices" to assist the DPRK "in its own efforts to obtain through commercial contracts, which include a commercial loan, such power transmission lines and substation equipment as may be needed to upgrade the DPRK electric power grid." Letter from KEDO Executive Director Stephen W. Bosworth to DPRK Ambassador Ho Jong, December 15, 1995.
14. Testimony of General Thomas A. Schwartz, U.S. Senate, *Committee on Armed Services*, March 27, 2001.
15. U.S. Department of State, *Patterns of Global Terrorism, Overview of State-Sponsored Terrorism*, April 2001, online at www.state.gov/s/ct/rls/pgtrpt/2000/index.cfm?docid=2441.
16. Ibid.
17. This statement can be found at http://secretary.state.gov/www//briefings/statements/2000/ps001006.html.

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RURAL RE-ELECTRIFICATION IN THE DPRK

Chris Greacen and Nautilus Team

Any effective effort to address North Korea's famine crisis requires revamping rural energy infrastructure, which must include the substantial task of rural re-electrification—rebuilding or at least repairing the majority of the electrical distribution system, which is in a terrible state. This article uses the best available data to attempt to draw a picture, albeit an incomplete one, of the DPRK's rural electrification problems and possible solutions. Improving electricity services requires investments in a variety of levels: in end-use energy-efficient equipment, in improved distribution, dispatch, transmission, and generation, and in human capital. Any investment in equipment must be predicated on a careful understanding of institutional arrangements, the structure of incentives that flow from these arrangements, and the plausible impacts of outside assistance on these arrangements and incentives. In all, the path to effectively addressing rural re-electrification in the DPRK is undoubtedly long and expensive. But the costs of failing to address rural electrification in the country are certainly higher, especially in terms of human suffering and lost productivity.

Key words: end-use equipment, microhydro systems, rural re-electrification

The Challenges of Rural Electrification

As the "Fuel and Famine" article by James Williams in this volume describes, any effective effort to address North Korea's famine crisis requires revamping rural energy infrastructure. Part of this effort will involve the substantial task of rural re-electrification—rebuilding or at least repairing the majority of the electrical distribution system in rural areas.

Power lines in rural areas are, of course, only part of a larger system (generation / transmission / distribution) for the provision of electricity. Substantial investments are needed at all levels of the electrical system to ensure that rural DPRK gets the electricity it needs to run its agricultural economy. Moreover, electrification is only one of many important elements of rural infrastructure. Roads, clean water, communications, food storage and processing, and access to other forms of energy for planting, harvesting, and cooking are all critical for a healthy rural economy. All of these are in decline in the DPRK, and these shortages in turn increase the challenges of rural re-electrification.

Nevertheless, improvement in rural electrification is a critical need, especially as electricity is essential for water pumping and agricultural processing in the DPRK. Because of the importance of electricity for agricultural production in the rural DPRK, and because of specific characteristics of rural electrification technology and institutional arrangements, the challenges of rural electrification merit individual attention.

Given the extremely limited access afforded to Western observers, it is impossible to ascertain the condition of the grid in the rural DPRK with any degree of certainty. However, even with limited data we can begin to piece together the outlines of the situation, and as well as discuss some of the issues and challenges that are likely to confront any effort at rural re-electrification in the DPRK. As much as anything, the observations in this essay point to the need for a better understanding to flesh out a picture that at this point has many blank spots.

The following assessment of the condition of the grid is based on conversations with North Koreans, visual observations from travelling in the countryside, and experiences and measurements in the countryside and in cities. Many of these observations were made during three visits to the DPRK by a team from the Nautilus Institute to work on the village wind power project in Unhari Village, Onchon County, between May 1998 and October 2000.[1] Additional observations and data were provided by other Westerners who have worked in the DPRK.

This assessment relies on measurements of grid voltage and frequency (and the absence of electricity power outages) taken in Pyongyang (the capital city), Nampo (a port city on the western seaboard), and Unhari village. Measuring frequency (how many times per second the electricity "changes direction") provides some information about the status of the power plant itself, and its relation to the loads. For any power grid to function properly, the frequency has to be the same at all locations on the grid.

Voltage measurements (the "pressure" of the electricity) provide clues about the ability of the distribution system to transmit power to the load. Unlike frequency, the voltage at any moment in time will depend on the location within the grid. For example, if voltages are high near power plants, but low in the periphery, we can surmise that there are problems with the distribution system. Variations in voltage and frequency over time provide information about the stability of the grid.

The Need for Electricity in Rural Areas

In a 1998 interview in Pyongyang, a senior engineer of the Ministry of Electric Power Industry (MEPI) stated that 100 percent of the country's villages are connected to the electricity grid. If true, this is an impressive accomplishment, matched by few developing countries in the world, especially ones with as much mountainous terrain as the DPRK. But whatever the exact percentage, it does appear that the DPRK, rural areas included, was once heavily electrified. At least in the villages that Nautilus teams have visited, crucial functions in the rural economy rely on electricity. Foremost among these are water pumping and agricultural processing.

In the western part of the DPRK, irrigation water flows in rivers and canals are located below fields. Because of the layout of the irrigation system and the location of the water, gravity fed irrigation is impossible and water must be pumped to the fields.

Electrically powered pump houses are a common sight. A typical water pump uses a three-phase, 380-volt, 40-horsepower electrical motor. Electricity consumption is probably around 50 kW.

Water pumping is especially critical for the large portion of the DPRK's farmland that is reclaimed tidelands. The soil in these areas has a heavy salt content and must be flushed with significant amounts of fresh water to reduce salinity to levels that crops can grow. Furthermore, electricity is essential for rice hulling and other agricultural processing. Rice hulling is done in electricity-powered hullers located in villages.

The lack of domestic oil or natural gas industries in the DPRK underscores the importance of electricity for these rural motive-power applications. All oil that is used is imported and drains the DPRK's precious foreign exchange. For stationary applications such as water pumping or threshing, electricity is therefore the most viable option.

As David Von Hippel's survey of rural household energy use in this issue explains in great detail, there are a host of domestic uses of electricity in North Korean households, including lighting, refrigerators, and televisions. Unfortunately, though it may be true that a majority of DPRK villages are connected to rural grids, it appears that these grids are in dire need of repair or replacement, and during most hours of most days the lines are not energized.

Institutional Arrangements

Responsibility for rural electrification is allocated at a variety of levels. Major power stations are operated directly by MEPI. Medium power stations are operated by the Department of Electricity under the Provincial Administrative and Economic Committee, as are transmission lines that pass through their areas of jurisdiction. The provincial electricity department is responsible for both urban and rural electricity. Smaller power stations and smaller intra-county distribution lines are the responsibility of county electricity departments. MEPI provides technical guidelines to the electric department in each province.

In Unhari village in which we worked, the familiarity of the local village technician in dealing with the 3.3 kV distribution line, and the autonomy with which the village modified the distribution line, suggested that responsibility for maintenance and repairs of the line lie largely with the village. This is unlike most situations in developed or developing countries, where electricians are generally allowed to work on lines at low voltage (several hundred volt) service levels, while higher tension wires of distribution lines are only accessible to utility specialists. There is generally good reason for this practice: Electrical wires of 1,000 volts and above are particularly dangerous.

If our experiences are any indication, DPRK electrical technicians and engineers are well-trained, intelligent, and enthusiastic. However, given the importance of a U.S. delegation in the DRPK, it is very likely that those we had the privilege of working with were above-average.

The Condition of the Grid

Based on our observations and data collected (see case studies below), we found that the grid in the DPRK is in poor and declining condition. The cities have the best quality electricity, but even there power is intermittent and of poor quality. Several brownouts (low voltage events) happen every day, and blackouts are daily events. Frequency is low and fluctuates wildly because of overtaxed, poorly coordinated generation equipment. For example, we measured grid frequencies from 46 to 55 Hz (cycles per second), compared with the nominal value of 60 Hz. Note that in a modern grid, fluctuations of even 0.1 Hz are considered excessive. In urban areas, voltage is lower than it should be (averaging 190 volts in Pyongyang compared with nominal 230 volts) and also fluctuates wildly.

In rural areas these problems are severely compounded by degraded transmission and distribution lines and transformers. When electricity is available in rural areas, the voltage is often so low that equipment is easily damaged. Voltages of 110 volts or less (half the nominal 230 volts) are not uncommon. In addition, power to rural areas is usually shut off because electricity allocation practices favor urban areas most of the time. In the rural village in which we worked locals told us that electricity is only available five hours a day in 2000, often only in the middle of the night (power was available most days only from midnight to

5 A.M.) for much of the year. Power shortages are particularly acute during the winter and during irrigation season when pumping draws a lot of power. Electricity is more available in spring and fall.

The physical infrastructure of the grid is weak. Poles seem in short supply, and it is not unusual to see two short poles lashed together to form a taller pole. Moreover, materials from which poles might be made are also in short supply. In the several hundred kilometers we traveled, we saw very few trees, much less ones suitable for making electricity poles. Concrete poles are sometimes used in the DPRK, but they require cement and iron reinforcement bars, as well as a transportation infrastructure to bring them from the site of manufacture to the installation site. Given the general industrial decline in the country, these requirements all present significant challenges.

Wire was clearly in short supply, and narrow gauge wire was used. Narrow wire, though inexpensive, is problematic because it has higher electrical losses and is more prone to breaking than thicker wires. As the system ages, more and more splices are made to reconnect breaks in the lines. From what we saw it is likely that most of these splices are not protected from corrosion. From these observations, the laws of physics tell us that electrical losses (series resistive losses, inductance, and low shunt resistance) are high. Thus, a significant amount of the electricity generated in the DPRK is wasted en route to end-users.

The Need for Metering

From our observations in the DPRK, it appears that when electricity is delivered to end-users there are no meters to record individual consumption. This is not particularly surprising given the DPRK's state planned economy. However, a consequence of this arrangement is that users face few incentives to conserve.

In the absence of meters, the only incentives that end-users in the DPRK have to use less electricity are dictates from authorities prohibiting certain uses at certain times, and altruism. Given the devolution of responsibility for the grid to local areas, it seems unlikely that central government dictates the uses to which electricity can be put. At the very least, it is difficult to imagine that restrictions on consumption are thoroughly enforced; monitoring and enforcement of thousands of distributed users are prohibitively costly. More fundamentally, the grid in the DPRK is a scarce resource, and exploitation by one user reduces resource availability for others. In addition, because of the dispersed nature of electricity loads it is impossible to keep anyone connected to a line from using power if the line is energized. Taken together, these are the preconditions for a "tragedy of the commons." An economically rational user would use as much electricity as he/she can whenever it is available, reducing availability for everyone else.

Implementing effective metering will provide incentives for efficient use. On the one hand, it will provide incentives for the use of efficient and properly sized motors and other equipment. On the other hand, it will encourage conservation in consumption behavior, providing an incentive to turn off equipment when it is not needed.

The Need For Energy Efficient End-Use Equipment

Metering alone, however, won't ensure efficient electricity use. Efficient end-use equipment must be made available at reasonable costs, and people must understand its advantages. Currently, motors are apparently sized based on "what is available and sufficient." Given the current lack of access to equipment, this is completely understandable. But while this type of specification procedure may satisfy the needs of a particular farm or pumping station, it wreaks havoc on the grid. One way or another the big picture of grid stability should be taken into consideration. Motors and other equipment should be sized according to the actual demands, and efficiency should be given priority. Reducing end-use energy consumption reduces demand at every stage of electricity infrastructure, from generation to transmission to distribution, and reduces the scale of investments necessary for re-electrification.

Response: Enthusiasm for Small Renewables

The poor condition of the grid combined with the expense of oil and gasoline has driven those who are able to afford it to invest in their own generation. Because the high cost and lack of availability of diesel or gasoline precludes the use of engine-generators, small renewable energy systems are used. These systems clearly are in place to provide electricity at times when the grid is unelectrified.

During the drive from Pyongyang to Nampo City, for example, we estimated we saw twenty to thirty small (less than 5-meter rotor diameter) wind turbines located on the tops of buildings and on hilltops and dikes. Revealingly, these wind turbines could even be seen installed on the tops of some buildings in Pyongyang. Many of these (and almost all of the functioning ones) appeared to be installed at military sites. Many of the wind turbines appeared to be locally made and primitive in construction, built of discarded materials such as brake drums and radiator fans, or low-tech construction techniques such as hand-carved wooden blades and weldments (an assembly of welded metal pieces). In Pyongyang, we visited a factory that made a somewhat more polished version of wind turbine, but construction techniques were still very crude even compared to wind turbines manufactured in rural China. Factory representatives told us that they had made 2,000 of these units in 1999.

Microhydro systems are also quite popular in hill areas. In a factory we examined examples of 4 kW microhydro units—500 were made in the year 2000. These use a synchronous generator driven by a belt from an in-line propeller turbine. The propeller turbine was not cast or machined; instead, it was a crude weldment with pitted and spotty welding.

Other Responses

Our surveys of village energy use also indicate that during power outages, people commonly use oil or kerosene lamps (often beverage bottles with a piece of cloth inserted as a wick). Though the practice is against village rules, we also found households that use the grid (when available) to charge a 12-volt lead acid battery. The battery is then used to power some appliances such as radio/cassette players.

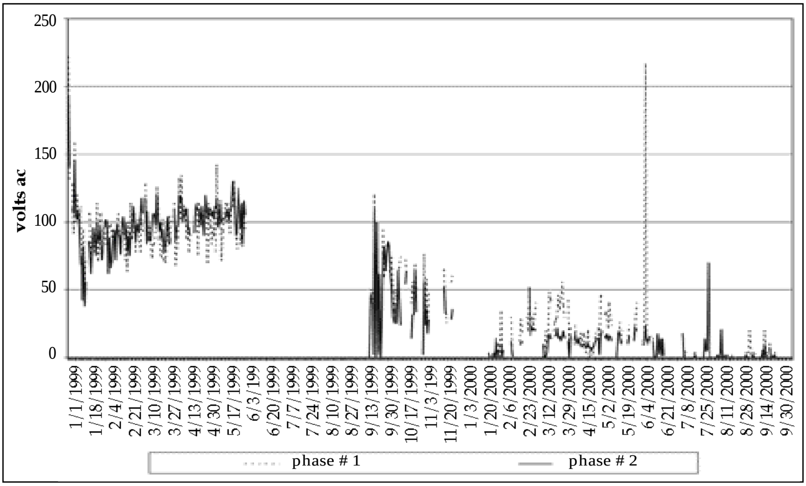
Case Study: Unhari Village

The Nautilus Institute's most direct experience with the DPRK grid was at Unhari village. Unhari, while an actual working village and not a Potemkin village, is likely better off than many villages in the county. The homes appear bigger and in better condition than in surrounding villages. The area is surrounded by considerable farmland, and the farm had its own coal mine to provide cooking fuel. The village has an interesting demographic profile as well, which probably contributes to its relative affluence. The village is composed entirely of veterans and their wives discharged in 1972 from the army. Almost all are in their fifties.

The village was adversely affected by the flooding of 1995-1996 and again by a tidal wave in 1997. The settlement has 600 families, and is already connected to the electric grid, but grid power was said to be intermittent as a result of natural-disaster related impacts on the electricity supply system. (Whether the intermittent power problem was really the result of these specific natural disasters seems very debatable. More likely it was the result of progressive decline in the local, regional, and national grid related to the general industrial decline of the country). Power for the village reportedly comes from thermal power plants in Pyongyang and Bukchan. The farm owns a portable 14 kW diesel generator, but uses it infrequently due to the high cost of diesel, which must be purchased.

The wind power project is operated and maintained by two village technicians. As part of operating procedures, we asked the technicians to record various electrical measurements at three-hour intervals every day, including the voltage of the grid. AC grid voltage during evening hours is shown above (*Figure 1*). The data over the course of two years show a progressive decline of electricity availability at Unhari. During the early part of 1999, grid power was present in early evening, at low but probably usable voltage levels: it hovered around 100 volts, whereas nominal voltage is 220 or 230 volts. During the same months of 2000, however, grid voltage was basically nonexistent with one exception (which is probably a stenographic error on the part of the operator) on the first of June 2000. Graphs for late evening and morning time (not shown) are similar. This graph

Figure 1. AC Voltage from the Grid, Supplied to Inverter #1 and Inverter #2 in Evening Time at Unhari Village



Note: Data was recorded between 6:00 pm and 8:30 pm. The gaps in the data were because of missing records. The values below 50 volts are probably phantom voltages picked up by system's distribution wires acting as "antennas."

suggests that in rural areas like Unhari, "non-essential" loads (like evening lighting loads) that were powered in 1999 are no longer being powered by the ailing DPRK grid.

From conversations with operators, we learned that in 2000 electricity was typically available only five hours a day. It often came in the middle of the night (from midnight to 5 A.M.), but sometimes came at other times such as the middle of the day. Needless to say, these are the two times probably least useful for the villagers, since they are generally asleep in the middle of the night, and are out working in the fields in the middle of the day.

It is worth noting that the village wind power system we installed was very much appreciated by villagers, simply because it provided electricity during times when people wanted it. The village, against our strong technical recommendations, tripled the number of homes (from twenty to sixty) that draw power from the system. The appeal of evening-time electricity apparently outweighed the risk of damaging the system, and the risk of alienating Pyongyang-based engineers and VIPs who had served as liaisons on the project.

The village wind power system can produce only a limited amount of electricity. When electricity supplies were low and / or consumption was particularly high, the powerhouse operator would walk from house to house and demand that residents turn off particular appliances. After a year of running the system, the operator had fine-tuned this direct approach to demand-side management, and could keep consumption at certain limits by specifying (and enforcing) the number of lights and other appliances that people could turn on. We never found out, however, if the farm manager's house was exempt from these curtailments.

The wind power system interfaces with the grid at Unhari. When grid power is available, it is used to charge the system batteries to supplement power from the wind turbines. One of the most grid-related experiences came in the process of connecting our system to the grid. The point of connection was a three-phase 3.3 kV to 230-volt transformer. A locally made three-phase switch mounted on the pole above the transformer allowed power to the transformer to be tuned on and off. The switch was made with welded scrap metal and ceramic insulators. A pulley arrangement using straps made of old radiator belts and bailing wire allowed the operator to engage the switch without being exposed to the 3,300 volts.

This switch tells us that whoever (probably the village electrical technician) is responsible for maintenance and adding new equipment to the high-tension side of local distribution grids has access only to the crudest of materials and tools, but works with considerable ingenuity. One wonders how much equipment in the entire system is patched together like this and built from scraps.

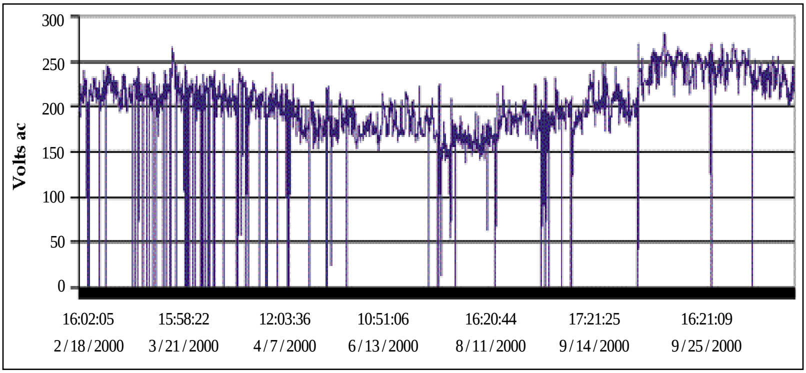
Case Study: Pyongyang

Power quality in Pyongyang tells us something about the origins of rural electrification power quality problems. On the one hand, power quality in Pyongyang is clearly higher than in Unhari village. Electricity is prioritized to urban areas, especially Pyongyang, particularly during peak demand times such as the evening. Thus, in contrast to villages where power is "out" most of the time, power appears to be "on" most of the time in the capital city (or at least in the parts of the city that host expatriate workers). Also, when power is available, the voltage is much higher than in the villages. Because power generation is located in or near Pyongyang, the much higher voltages in the capital gives weight to the suspicion that distribution losses are very high.

On the other hand, even urban areas suffer extreme power quality problems, indicating that many of the problems are systematic in nature and not localized to rural areas. A series of power quality measurements taken by a computer uninterruptible power supply (UPS) in a Pyongyang office building[2] during a portion of the year 2000 (*Figure 2* below) indicate that an average of one blackout and several "brownouts" (voltage below 190 vac) were experienced during business office hours each day. In addition, voltage spikes over 250 volts were common.

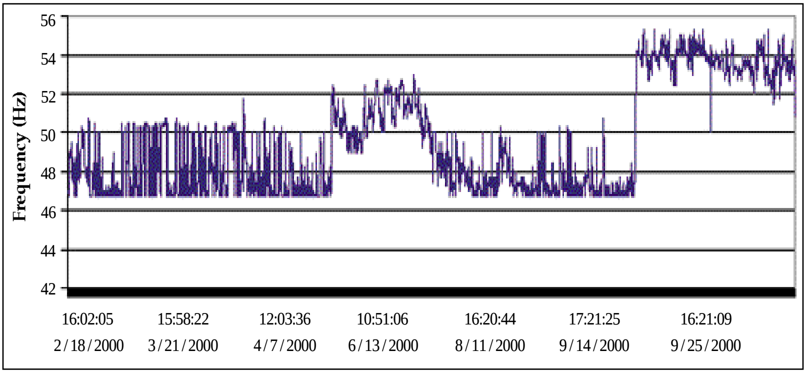
The UPS also measured grid frequency every 5 minutes. The low frequency of the grid (*Figure 3* below) tells us the generators are being spun much slower than their designed speed. The nominal frequency of the DPRK grid is 60Hz. The rotor of a

Figure 2. Voltage Data Recorded by a Computer UPS in Pyongyang During Office Hours (February 18-October 2, 2000)



Note: The large number of blackouts is clearly indicated. It should be noted that the duration of power outages is not shown on this chart because once the blackout occurred, computer shutdown procedures were initiated and the UPS stopped recording power availability. Thus, this graph shows something about the number of power outages that happened when the computer happened to be turned on, but tells nothing about the percentage of time that power was out.

Figure 3. Grid Frequency Data During Office House (February 18-October 2, 2000)



Note: Frequency appears to mostly range between 47 Hz and 50 Hz, except toward the end of the measurement period when frequency averages around 54 Hz. Because both the mode (the most commonly occurring value) and the minimum of these measurements is 46.75 Hz, it appears that the UPS was unable to measure frequencies below this level—and it is likely that frequencies were often lower than 46.75 Hz.

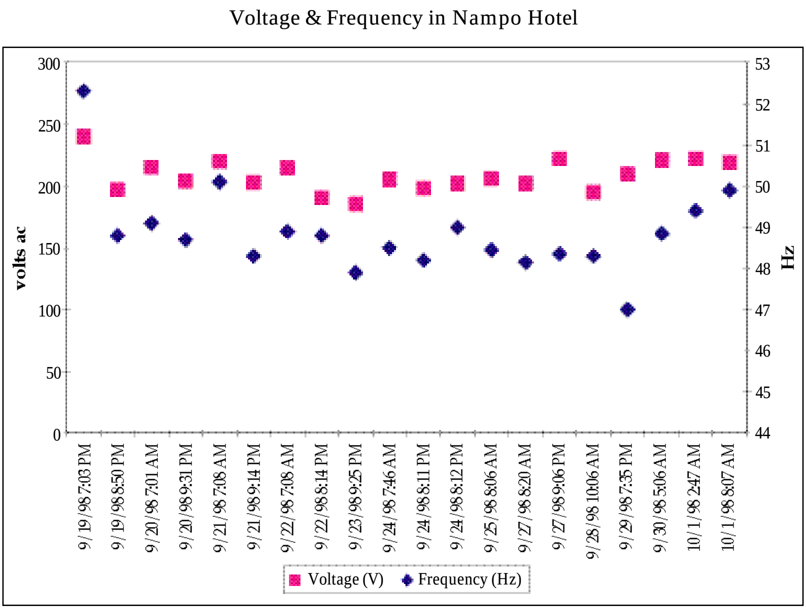
two-pole synchronous generator for a 60 Hz system should spin at 3,600 rpm. But these generators may spin as slowly as 2,700 rpm or even lower. This is likely because load is significantly higher than the generators are designed for. The generators are dragged down, much as a car engine is slowed by a steep hill if the driver fails to downshift.

The variability in these frequency measurements indicates that the system is fluctuating wildly—changing as much as 3.5 Hz over a 5-minute period. For comparison, consider that the frequency of most modern grids is held strictly to within ± 0.1 Hz.

Case Study: Comparison of Nampo with Unhari Village

A comparison of two sets of frequency and voltage measurements from the Nampo Hotel in the western port city Nampo and Unhari village in 1998 tell a complementary story. Cities, it seems, have higher voltages because they are not subject to the voltage degradation from a terrible distribution system.

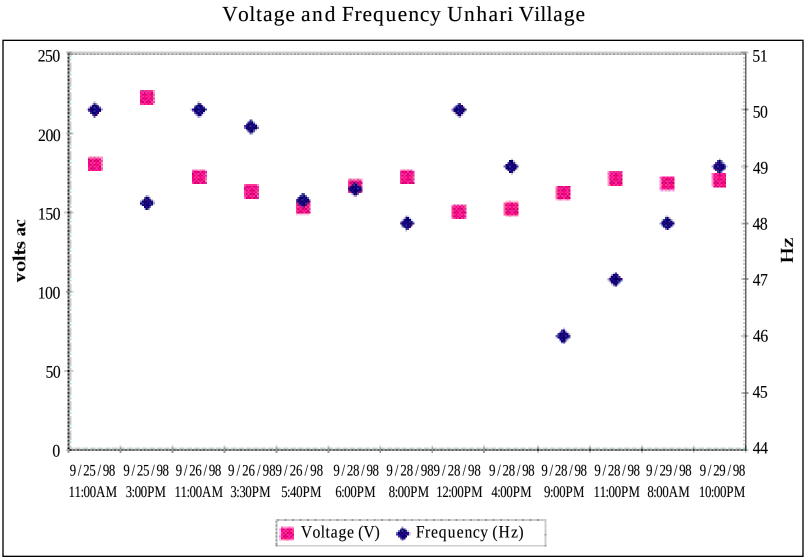
Figure 4. Voltage and Frequency Measured at the Nampo Hotel, Nampo City



Note: The average of voltage measurements is 208.6 volts, while the average of frequency measurements is 48.9 Hz.

Figures 4 and *5* show voltage and frequency measurements taken at Nampo Hotel and Unhari village respectively. Both data sets were taken over roughly the same days between late September and early October 1998, using the same Fluke 87 true-RMS digital multimeter. As with the Pyongyang data, frequencies and voltages vary wildly (these are, it seems, universal properties of the grid). A close comparison of *Figures 4* and *5* show, however, that voltage measurements in the villages were consistently considerably lower than in Nampo, while frequency measurements were roughly the same. In Nampo, the average of measured voltages was 208.6 volts, while in Unhari village the average of recorded data was 169.3 volts. The average of frequency measurements in the two locations, however, differed little: 48.9 Hz and 48.3 Hz respectively. The lower average voltage in Unhari (but similar frequency) provides further evidence

Figure 5. Voltage and Frequency Measured at Unhari Village



Note: The average of voltage measurements is 169.3 volts, while the average of frequency measurements is 48.6 Hz.

for a degraded distribution system between Nampo City and the villages.

What Can Be Done?

Fixing the rural electrification problems in the DPRK will require a holistic set of investments. End-use equipment (motors, lights, household appliances) that is both energy efficient and robust should be made available to households and communities. A metering system should be put in place, with tariffs structured in a way that encourages efficient energy use. New wires, transformers, capacitor banks, switches, and controls are needed at the distribution level. Investments are probably needed at the transmission level. Certainly at the generation level, power plants need to be refurbished and rebuilt. Hydroelectric plants damaged during floods need to be reconsidered and possibly rebuilt. And coal mines now flooded or inaccessible due to crumbling transportation and electrical infrastructure need to be reopened.

Provision should be made so that small distributed generation such as microhydro stations, wind turbines, and industrial combined steam and power generation (co-generation) can integrate with the grid. Using these local sources of generation, particularly those using renewable energy sources, will allow the DPRK to make use of the energy resources it does have, reduce its needs to import fuel, and reduce environmental impacts of electricity generation. These technologies play a special role in rural areas, given the lack of electrical services there.

This is a tall order, complicated by several factors. Because of overwhelming scarcities of all kinds, there would be strong temptations to divert materials to satisfy other pressing needs. The lack of transportation and communication infrastructure would create logistical challenges. And confusion over overlapping authority and responsibilities may exist from village to county to national levels.

The use of energy-efficient equipment presents particular challenges. Much of this equipment uses electronics that may be sensitive to the frequency and voltage fluctuations that are endemic in the DPRK grid. Indeed, finding equipment that can operate reliably under the harsh electrical conditions prevalent in North Korea will be difficult and at times impossible. In the village wind project we learned this in the form of a costly lesson: the energy-efficient compact fluorescent bulbs we provided to Unhari village quickly burned out when exposed to the low grid voltages at the village. When they burned out, villagers replaced these lights with crude DPRK-made incandescent bulbs that use five times as much power to produce the same amount of light. In a subsequent mission, we brought high-quality German compact fluorescent bulbs that are rated for voltages as low as 170 volts, but it remains to be seen how well they will function at the even lower voltages frequently observed at Unhari village.

Small Steps First

Given the complexity of the tasks of rural re-electrification, and the fact that this is a relatively unexplored issue in the larger context of constructive engagement with the DPRK, it is appropriate to identify a set of small steps to develop valuable expertise and experience. These include several studies, as well as "no regrets" steps that would probably be valuable in any eventuality.

First and foremost, there is a clear need for a better understanding of the existing rural electrification system and its strengths and weaknesses. A *DPRK rural re-electrification study* would involve understanding the institutions as well as the hardware.

On the institutional side, visits to village, county, and national levels should be made in order to understand exactly who is responsible for what. The study would seek to answer questions such as the following: "What avenues are open at these different levels for interaction with an international team that aims to help revamp the grid?" "What institutional changes would need to be made to accommodate billing and collection?" "What are possible arrangements for effective and sustainable dissemination and integration of energy efficient end-use technologies?" In carrying out the institutional study, researchers would play a secondary role of negotiating access to villages, switching stations, repair facilities, and other places that are necessary for the "hardware" elements of the study.

On the hardware side, a bottom-up hardware study would begin with a village-level (perhaps a few villages in a particular county) study of electricity use. The next step would be to trace the wires from the village through the distribution system and the transmission system to the power plants that make the electricity, evaluating the condition of the grid. This component would identify where upgrades and new investments would make the biggest impact and which elements of the existing system are worth saving. The study would make liberal use of data-logging equipment to monitor the availability and quality of electricity throughout a year at the village, distribution, transmission, and power plant levels.

The deliverable goods from the study would be a document that identifies a concrete sequence of steps for rural re-electrification, probably focusing at a single county level. In subsequently implementing such a pilot county-level project, experience would be gained that would enable a scaled-up provincial or national effort.

Efficient and Robust End-use Equipment Study

A study of robust and efficient end-use equipment, with a focus on motors for irrigation pumps and agricultural processing, should be made to identify off-the-shelf technology options for demand side management in the DPRK. Pilot installations of this energy-efficiency equipment should be made in rural areas in the DPRK, and the use and performance of this equipment should be monitored by recording data loggers.

"No Regrets" Steps

In addition to these studies, it is possible to recommend several "no regrets" steps. First, discussions should begin with DPRK counterparts to identify opportunities for mutual collaboration on rural energy efficiency and rural re-electrification efforts. DPRK agencies engaged in electricity should be strongly encouraged to consider ways in which end-use metering and tariff collections can be integrated into their protocols. Second, the DPRK should receive technical assistance to improve the designs of micro-hydroelectric power plants and wind turbines, and other renewable energy technologies using designs that have been effectively produced in other developing countries. These technologies already play a role in meeting crucial electricity needs (in communications, for example) in rural areas, but suffer from poor quality. The Nautilus Institute's work in sharing American wind expertise in the DPRK should be expanded to include micro-hydropower and perhaps other technologies. In the short term these technologies can provide valuable power during the majority of the time when the grid is unavailable. In the long term, the equipment can be interconnected to the grid, providing distributed utility grid benefits such as voltage support, reactive power, and reductions in spinning reserves.

Conclusions

We understand very little about rural electrification in the DPRK. But what we do understand is cause for significant concern. We know enough from isolated measurements to be relatively certain that the grid in the DPRK is in a terrible state, especially in rural areas. Generation in the whole country is severely overtaxed. Dilapidated transmission and distribution further severely degrade the quantity and quality of electricity available for use in rural areas. We know that crippled rural electrification is a severe impediment to rural productivity, and hence a severe constraint on the ability of the DPRK to feed itself.

We also know from observations and measurements that improving electricity services in rural areas requires investments in a variety of levels, from end-use energy-efficient equipment, to improved distribution, dispatch, transmission, and generation, to significant investment in human capital to implement and operate these investments. Furthermore, rural electrification challenges in the DPRK are not limited to hardware. Any investment in equipment must be predicated on a careful understanding of institutional arrangements, the structure of incentives that flow from these arrangements, and the plausible impacts of outside assistance on these arrangements and incentives. If that is not challenging enough, substantial activities in rural re-electrification will require interacting with North Korean society at a range of unprecedented levels.

From this point it is easy to recognize the need for certain specific studies, including an in-depth study on hardware and institutional aspects of rural electrification in the DPRK, and a study to identify, install, and monitor robust energy-efficiency equipment suitable for DPRK rural applications. In addition, manageable "no regrets" steps can be readily identified. These include discussions with DPRK counterparts on collaboration on rural re-electrification and metering, and the provision of technical assistance for North Korea's existing distributed renewable energy technologies. At the end of the day we know that the path to effectively addressing rural re-electrification in the DPRK is undoubtedly long and expensive. But the costs of failing to address rural electrification in the country are certainly higher, especially in terms of human suffering and lost productivity.

NOTES

1. Details of the project can be found at www.nautilus.org/dprkrenew/galleryindex.html.
2. Chris Greacen, *Analysis of Pyongyang Grid Data from UPS Recordings* (internal Nautilus Institute study, 2000).

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CASE STUDY OF A RURAL ENERGY SURVEY IN THE DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA: METHODS, RESULTS, AND IMPLICATIONS

David Von Hippel, James H. Williams and Nautilus Team

This article discusses the result of the rural energy survey performed in the village of Unhari in North Korea by a joint team of U.S. and DPRK researchers. The survey is believed to be the first household energy survey ever conducted in North Korea according to international standards. The initial survey was carried out in September and October 1998; additional informal interviews with residents and village leaders were conducted in a subsequent visit two years later. This report presents the setting of, methods used in, and overall results of the Unhari rural energy survey, provides analysis of survey results, and discusses potential "next steps" in carrying out surveys of this type in the DPRK. The results of the survey provided a great deal of insight into the energy needs of rural communities in the DPRK, and showed the usefulness of conducting such surveys in other areas of the country where energy-efficiency and/or renewable energy measures might be implemented. Implementing energy efficiency measures on an ongoing basis in the DPRK requires re-thinking and creative adaptation of the methods used to encourage energy-efficiency and renewable energy in other countries.

Key words: Nautilus/KANPC Wind Energy Project, renewable energy sources, Unhari rural energy survey

Introduction

In November 1997, a five-person group of energy specialists from the Democratic People's Republic of Korea (DPRK) came to the United States for a study tour on energy efficiency and renewable energy organized by the Nautilus Institute for Security and Sustainable Development. At the conclusion of this tour, a Memorandum of Understanding was signed for a collaborative humanitarian project to apply renewable energy technologies-in this case wind-powered generators made in the United States-in a flood-affected rural village in the DPRK. In the DPRK, the counterpart agency to Nautilus is the Korean Anti-Nuclear Peace Committee (KANPC). This collaborative project has, to date, taken the form of three missions by a team of U.S. specialists to the village of Unhari on the southwest coast of North Korea. The second of these missions, undertaken in September and October 1998, included an initial rural energy survey. On the third mission, carried out in September and October of 2000, additional informal interviews with residents and village leaders were used to briefly assess changes in the village, as well as to gather more information about areas where uncertainties remained. The report that follows presents the setting of, methods used in, and overall results of the Unhari rural energy survey, provides analysis of survey results, and discusses potential "next steps" in carrying out surveys of this type in the DPRK.

The Project

Context

The initial rural energy survey, and the humanitarian wind energy project of which it was a part, were motivated by uncertainty regarding the electricity needs of Unhari village, and, more generally, uncertainty regarding rural energy supply and demand in the DPRK in light of the widely reported declining status of the DPRK energy system. For a more complete discussion of the geopolitical context in which the DPRK finds itself, as well as of the background and status of energy-sector problems in the

DPRK, please see the companion articles on "Fuel and Famine" and "NGO Engagement with North Korea" in this volume.

Accurate information about the rural energy sector can help to play a role in solving energy-sector problems like those described in the other articles in this issue. In many cases, rural energy surveys provide the most straightforward and complete way of providing information on which to base decisions regarding what types of fuels are needed, what types of technologies might be applied, what kinds of energy-sector investments will be most beneficial, and what types of local preferences will affect the "uptake" of different energy options. Data from rural energy surveys—if the surveys are thoughtfully conceived and carefully implemented—can play a major role in helping the DPRK government (including national and local officials) to identify and prioritize rural energy-sector investments. Similarly, reliable rural energy survey results are a crucial means of helping potential providers of humanitarian and economic development aid (including providers of multilateral and bilateral aid and loans) from the international community to evaluate opportunities for offering assistance to help fulfill DPRK energy needs. Without the kind of independent data that properly carried out rural energy surveys can supply, bilateral international organizations will find it much more difficult to justify specific aid or investments in the rural energy sector of the DPRK.

Physical Setting

The Nautilus/KANPC Wind Energy Project is set in the village of Unhari in Onchon County, the DPRK. Onchon County is located on the western coast of North Korea at approximately 38° 53' North latitude and 125° 12' East longitude, approximately 50 kilometers west-southwest of Pyongyang. Unhari is located on the coast of the West Korea Sea (also called the Yellow Sea), and includes reclaimed tidal flats that extend approximately two kilometers west from the village toward the sea. These reclaimed lands are used for rice cultivation.

The village of Unhari actually includes the dwellings and other buildings associated with two farm cooperatives. The March 3rd Cooperative Farm of the village of Unhari includes about 500 households and has a reported total population of approximately 2,300 people. The area associated with the March 3rd Cooperative adjoins the territory of another cooperative to the south. From this point on in this document, for simplicity, we will refer to the dwellings, territory, and equipment associated with the March 3rd Cooperative Farm as belonging to the "village" or to "Unhari," even though the physical area that is the village of Unhari, strictly speaking, encompasses both cooperatives.

The residential dwellings in the village (that is, the March 3rd Cooperative Farm), and the schools, medical clinic, and other services associated with them, are contained in an area of about 5 hectares. The village also controls a total of 850 hectares (ha) of nearby irrigated fields, including 800 ha of rice paddies and 50 ha of vegetables. The residential dwellings in the village are laid out in a rectangular area about 100 meters deep (roughly east-west) by 700 meters long (roughly north-south), with dwellings set in a grid of five or six rows by 30 columns. The area of dwellings is divided by roads and drainage channels into four "blocks." Unhari is served by electricity from the grid, but outages are frequent, and grid power quality is low. All of the households included in the rural energy survey did have electricity service.

To the north of the area of residential dwellings is an area of vegetable fields, which were planted in cabbage during the project missions. The towers for the wind power turbines were set up in this cabbage field. The "powerhouse" containing the control equipment and battery bank for the wind power system was built at approximately the northwest corner of the residential area and adjacent to the field area. A small hill rises to the north of the area of cabbage fields.

The village of Unhari, at least that portion of it associated with the March 3rd Cooperative Farm, has had a relatively brief history. The cooperative was established and constructed in 1974, reportedly as a consequence of an "on-the-spot" instruction by President Kim Il Sung. The village was settled virtually entirely by a single group of military veterans, their spouses, and their families. It is unclear whether a substantial village existed on the site before 1974. Farm officials seemed to indicate that no previous village existed, which would be consistent with the village being formed for the purpose of cultivating reclaimed tidelands.

The history of Unhari's establishment helps to explain why virtually all of the dwellings in the village were reported to be of the same age and are very similar in type, despite the variation in housing types that were observed as the team traveled through nearby towns.

The fact that the village was settled essentially all at once, and by military veterans, also explains the surprisingly narrow age distribution of the heads of household—as well as the age distribution of householders in general—that was found during the residential survey. Most of the veterans (heads of household), as well as their wives, are currently in approximately their early 50's, their children are generally young adults, and the relatively few young children that were reported in the surveyed households are typically the grandchildren of the couples that settled Unhari in 1974.

Project Background

To place the rural energy survey described in this paper in context, a few words about the broader wind energy project of which it was a part are in order.

The Nautilus/KANPC Wind Energy Project was designed as a way to provide some humanitarian aid, in the form of technology and technical assistance, from the United States to people in an area of the DPRK that had suffered from recent natural disasters. Working carefully within the confines of U.S. sanctions on the DPRK and within the DPRK's own conditions for acceptance of assistance from abroad, project organizers agreed that a demonstration of renewable energy technologies in a rural village affected by recent weather-related disasters would be the most workable approach. Wind power was selected as the technology of choice for several reasons. Wind power has been of keen interest to DPRK engineers for some time. Some areas of the DPRK have suitable wind regimes for power generation. Additional phases of a wind power program could easily involve assistance and technology from China. And wind power equipment was found to be exportable to the DPRK under U.S. laws that prevailed in 1998.[1] The Unhari site was suggested by KANPC and other North Korean agencies as fitting the criteria of possessing a suitable wind resource and being a flood-affected area, while being relatively accessible to Pyongyang and to freight transport facilities at Nampo.

In addition to the project's benefit in providing assistance to local residents and as a demonstration of technology, a major goal of the project was to show that a collaborative project involving technicians and organizers from the DPRK and from the United States could be carried out successfully and in a spirit of cooperation and trust.

The first mission of the Nautilus project team to the Unhari site (and other candidate sites) was carried out in May 1998. It included meetings with local and county officials, installation of a tower on which wind monitoring equipment was mounted, and training of DPRK engineers in reading and reporting wind data. The second mission of the Nautilus team, as noted above, took place over two and a half weeks in late September and early October of 1998. The goals of the second mission were, first, to install seven small wind generator units (ranging in size from 500 to 4500 watts of capacity); second, to install and connect power conditioning, electricity storage, and system monitoring equipment; third, to connect the village clinic, the village kindergarten, and as many households as practicable to the wind power system; fourth, to supply the connected residences and other facilities with energy-saving devices such as compact fluorescent light bulbs; and last, to carry out an initial rural energy survey in the village.

The survey played a crucial practical role in the project by allowing Nautilus and DPRK technicians to reliably estimate the electrical loads that the village households and other facilities were likely to place on the wind power system, as well as to estimate the timing of those loads. Coupled with the data on wind regimes and information about the status of the local grid, the survey data ultimately allowed the project team to figure out how many households could reliably be connected to the wind power system. Connections to twenty households were completed at the end of the second project mission in the pilot phase, pending obtaining a more complete picture of the actual load and wind energy system characteristics—information ascertained in the course of supplying electricity. Ultimately, by decision of the villagers, sixty households were connected to the wind power system.

The rural energy survey component of the project also had a broader motivation within the overall scope of engagement of the DPRK in international activities. By cooperating in the performance of a relatively rigorous, if initial, survey of householders, the North Korean counterparts in the project demonstrated their willingness to help collect and to make available the information necessary to carry out a technical energy assistance project. As the types of data that are produced in an energy survey are necessary for a variety of development projects, including electricity infrastructure refurbishment, renewable energy, and energy efficiency improvement, the cooperation of DPRK authorities in permitting this rural energy survey can be viewed as a first step in implementing larger and broader projects with both Nautilus and other participants from the international community.

Brief Description of the Survey

The rural energy survey was carried out by a team of North Korean interviewers, guided by a member of the Nautilus project team. The Nautilus team member accompanied the DPRK team on visits to five households at the beginning of the survey, and also, near the end of the survey, on visits to several previously surveyed households for the purpose of asking follow-up questions. The interviewers were provided with a survey instrument composed of twenty individual forms, with varying number of questions on each form. The survey questions, originally written in English, were translated into Korean by the survey team when householders were interviewed. The responses of the householders to the interview questions were recorded on the survey form. The survey team was supplied with tape measures, a scale, and a volt/amp/ohm multi-meter to take measurements during the interview process. The household sample for the survey was divided into two parts. The first forty-seven of the sixty-seven households interviewed were located in the block of houses closest to the powerhouse, and were chosen by local authorities as being the households most likely to receive electricity from the wind power system. The choice of surveying households that were candidates for connection to the wind power system was also a pragmatic one, as it helped householders more readily to accept the intrusion of the survey team into their homes at a busy time of year. The final twenty sample households were chosen at random from among the households in other blocks of homes in the village.

The household survey component of the rural energy survey included data collection in the following general areas:

- demographic information, including the ages and number of household residents, levels of education, and number of wage-earners;
- information on the size, type, and configuration of the dwelling used by the household;
- information on which fuels are and have been in use by the household;
- information on home space heating appliances and fuels in use;
- data regarding household electricity connections to the grid and tariffs paid for electricity;
- data on the end-uses that electricity is currently used for in the household;
- data on the use of electric lighting;
- data on the use of automotive batteries to provide electricity;
- information on the use of non-electric lighting;
- information on the use and ownership of electric appliances;
- data on the use of electric cooking devices;
- information on non-electric cooking and water heating devices and fuels used;
- information on energy use for providing goods and services for others outside the household;
- information on sources of fuels used in the household;
- data on supplies and collection of wood and of biomass fuels; and

- miscellaneous information, such as on water use, the number of electrical outlets, planned appliance purchases, division of household expenditures, and the voltage level in the household at the time of the interview.

The portion of the survey devoted to collecting information about energy use in areas of the village other than households was less formal and structured than the household survey. A set of survey forms was used to guide on-site interviews in the village clinic and kindergarten, as well as in-office interviews with the farm manager (in effect, the village leader) and other local officials. The interview process, however, often led to questions and topics beyond the coverage of the survey forms. In this initial survey effort, it was not possible to cover all energy end-uses in the village in exhaustive detail. Nonetheless, information on energy use in areas such as water pumping, public bathing facilities, village services, tractor usage, and other end-uses were obtained, in addition to detailed information on lighting and appliance use in the clinic and kindergarten. As noted at the outset of this article, some follow-up data collection via interview was done during the third (September-October 2000) Nautilus mission to Unhari.

Methods of Rural Energy Survey

Introduction

As this rural energy survey effort was, insofar as is known by the project team, the first of its kind in the DPRK, it was necessary to adopt a general and flexible approach to conducting the survey. For the household sector, a semi-generic survey instrument was prepared for use in conducting interviews with individual householders. This instrument was modified as the survey team learned more about the village. For non-household energy uses, a generic survey form was also prepared, and was used as a rough guide during interviews with village leaders.

The survey effort was led by a Nautilus project team member, and staffed by three North Korean counterparts. Initial entry and processing of household survey data (using a Microsoft

Excel workbook) was carried out as data became available. Initial survey results were used (as noted above) in deciding upon the loads to be connected to the wind power system. Data from surveys were augmented, wherever possible, by visual observations, and by informal discussions with North Korean project team members and villagers. A small sample of local coal was obtained and was analyzed by a commercial laboratory in the United States.

The household survey instrument, prepared prior to the mission, was largely based on similar instruments used for rural energy surveys by the World Bank and other international organizations. Methods, documents, and survey instruments prepared by the ESMAP (Energy Sector Management Programme) group of the World Bank, the United Nations Development Programme (UNDP),[2] and the Living Standards Measurement Study group, also of the World Bank,[3] were used, as were other references on formal and informal survey methods.[4]

Although the development of the draft survey instrument was informed to a limited extent by information on DPRK conditions, a copy of the draft proposed survey instrument was also provided to the DPRK project counterparts during the first mission in May 1998. At that time, a briefing presentation was made in Pyongyang so that DPRK counterparts could acquaint themselves with the overall survey approach, and could have a chance to suggest changes to the survey instrument before the implementation of the survey during Mission 2. In addition, it was necessary, as was recognized at the outset of the project, to make some modifications to the instrument once the survey (Mission 2) was underway.

Organization and Implementation of Survey Effort

The survey portion of the Nautilus/KANPC Wind Energy Project had to be accomplished in a very limited amount of time, and under relatively unusual conditions. As such, it was not possible to undertake rigorous training of interview team members, or to select the sample of households to be interviewed in an entirely random manner.

In addition to the Nautilus project team member, three North Korean counterparts were assigned to assist in the survey. Two of the North Korean team members were from the Institute of Non-conventional Energy Development of the DPRK Academy of Sciences, and were thus familiar with general energy issues. The third North Korean member of the team, from KANPC, acted as translator and was an active participant in the interview process.

The Nautilus team leader provided a briefing on the survey methods and goals to the project team members, and the team as a whole spent several hours reviewing the draft household survey forms to assure that all team members understood the language and intent of the questions. In a limited number of cases, Korean team members suggested alternative questions, or suggested that specific questions were not necessary.[5]

Following this briefing, the Korean survey team and the Nautilus team leader were joined by several local officials, who guided them to first one and then several other households. During the first few interviews, the Korean team learned what was expected during the interview process, including where more detailed questioning was required and which forms could be completed rapidly. The survey team was also able to identify additional questions that needed to be asked in order to obtain the necessary information for determining the number of households to be hooked up to the wind power system. Visiting several households in the village also allowed Nautilus team members visually to confirm the accuracy of the results and methods of the interviews carried out by the North Korean team.

The pre-selected group of households were chosen by the farm manager and/or by the assistant farm manager, and householders were asked to be at home (the survey took place during the harvest season, so many householders would ordinarily have been absent during the day) at times when the survey team would be visiting. Overall, the forty-seven households selected by village officials comprised 94 percent of the households in the block, and as a consequence were highly likely to be representative of the housing stock in that block. Given the similarity of the surveyed dwellings, these forty-seven households were also likely to be representative of the village as a whole.

For the final twenty households of the household survey sample, local officials allowed the survey team to select households at random from among the five other blocks in the village.

The random selection was accomplished by assigning a number between one and six to each of the blocks, and to each "row" and "column" (relative North / South or East / West location) of buildings within each block. Three dice were then rolled to determine the block, and building within the block, to be visited. The Korean survey team then visited each randomly selected building and knocked on the doors of the households in each building until the team found a householder present.

In a typical interview, the survey team, sometimes accompanied by a local official, was greeted by a householder and led into the main room off of the kitchen. There everyone was seated, and the interview took place, with one team member responsible for reading the questions and clarifying questions and answers with the householder, and one team member responsible for writing down survey responses. The survey team also took a number of measurements and collected specific data by visual inspection. Measurements made included weighing and measuring coal briquettes, measuring rooms, and reading the nameplate wattage (or amperage) on selected appliances. The team also used a multi-meter to measure the resistance (and thus the wattage) of the most commonly used settings on clothes irons, and to measure the voltage in the household visited. Each household survey took approximately 45 minutes to one hour.

Two approaches were used to obtain information on non-household energy use. For specific buildings that were to be connected to the wind energy system—the village medical clinic and kindergarten—the survey team (including Nautilus project team members) made site visits. These site visits included a combination of visual inspection of the facilities and interviews with personnel (doctors, the dentist, the school headmistress, local officials) from each facility. The farm manager and other local officials were interviewed to obtain information on other village energy uses.

The Nautilus team requested, and was given, small (several hundred gram) samples of both raw coal and coal briquettes. These samples were provided from the kitchen of the village "guesthouse" where the project team members (both U.S. and North Korean) shared lunch with local officials. As such, these samples came from the same supplies as the coal used by the rest of the village. As the composition of the coal briquettes varied from maker to maker, however, it is not possible to say how representative the briquette sample is of the briquettes made and used in the households of Unhari. After the Nautilus team returned to the United States, sub-samples (approximately 250 grams each) of the raw coal and briquette samples were sent to a testing laboratory in West Virginia, and the results of several selected standard tests of coal quality and composition were sent by the laboratory to Nautilus.[6]

Analysis of Survey Results

Introduction

The survey described above touched upon many aspects of life in Unhari in varying degrees of detail. Before presenting the analysis of the survey results, it is important to stress that there is considerable uncertainty in virtually all of the estimates presented. In some of the tables below the reader will find figures presented to apparently high degrees of precision (many significant figures) for the sake of ease in manuscript preparation, but virtually all of the results presented should be interpreted as being accurate to, at best, the second digit of the figures presented, and more often the first.

Overall, much has been learned from the Unhari survey, but uncertainties remain. The Nautilus team learns more, thanks to the cooperation of the people of Unhari, on each return trip to the village.

Overall Estimated Energy Balance for Village

The results of the Unhari surveys—both in the residential and non-residential sectors—were put together with general estimates assembled by others to produce an estimated energy balance for the village. This balance has been updated based on responses to questions asked during the third Nautilus mission to the village in September and October 2000, but uncertainties remain as this is a work in progress.

Table 1 presents the estimated energy balance for Unhari village, including its satellite coal mine and (as of 1998) upland corn

Table 1. Estimated Energy Balance for Unhari Village

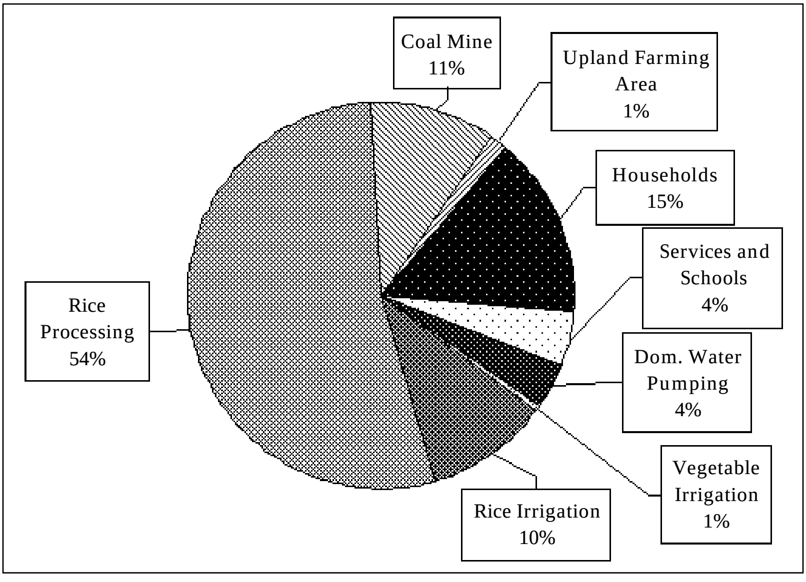
	Electricity		Coal		Rice Straw		Petroleum Prod.		Human Labor		Draft Animals		Total
Sector	kWH	GJ	Tonnes	GJ	Tonnes	GJ	Tonnes	GJ	Hours	GJ	Hours	GJ	GJ
Households	194,907	702	1,015	22,294	64.5	903	4.2	182					24,080
Medical and Dental Clinic	1,260	5	2.5	55			0.05	2.2					62
Kindergarten	962	3	20	439			0.01	0.4					443
Guest House	548	2	6	132			0.02	0.9					135
Workshop	29,364	106		–				–					106
Bathing Facilities	350	1	8	176			001	0.4					177
Other Village Services	18,152	65		–				–					65
Primary and Secondary School	2,639	10	50	1,098			0.05	2.2					1,110
Domestic Water Pumping	51,100	184		–				–					184
Irrigation of Vegetables	7,300	26											
Irrigation of Rice Paddies	130,667	470											
Agriculture (Including Tractors)							64.5	2,785	529,200	143	24,600	44	2,972
Rice Processing	678,000	2,441		–				–					2,441
Motor Pool (Trucks and other)	–	–		–			21.5	943					943
Emergency Diesel Generator							1.60	69					69
TOTAL ON-SITE AT UNHARI	1,115,248	4,015	1,101	24,194	64.5	903	90	3,916	529,200	143	24,600	44	33,215
Coal Mine and Mining Area	134,000	482	10	220			27	1,168	62,500	17			1,887
Upland Corn Farming Area	16,128	58	20	439			0.67	29.1	12,990	3.5	1,980	3.6	534
TOTAL OF UNHARI USE	1,265,376	4,555	1,131	24,853	64.5	903	118	5,113	604,690	163	26,580	48	35,635

production areas. Also included in *Table 1* is a set of estimates of human labor and draft animal use for agriculture, as well as human labor for coal mining. These estimates are quite speculative, but they round out the energy balance for the village.

In terms of total energy consumption, coal provides about 70 percent of all forms of energy used in the village (considering the Unhari site only). By far the major portion of coal use (over 92 percent) is estimated to be for household heating, cooking, and preparation of pig feed. On the basis of energy content (gigajoules), petroleum products account for the next largest portion of energy use in Unhari (about 14 percent); about two-thirds of petroleum products use is estimated to be for tractor fuel. Electricity supplies just under 13 percent of total energy use, with rice straw, human labor, and animal labor accounting for smaller portions of energy demand.

Figure 1 shows the breakdown of estimated electricity use in Unhari, including the coal mining and upland corn operations. Electricity use is dominated by major pieces of equipment, namely the air compressor used in the coal mine, the rice thresh-

Figure 1. Estimated Distribution of Electricity Use in Unhari



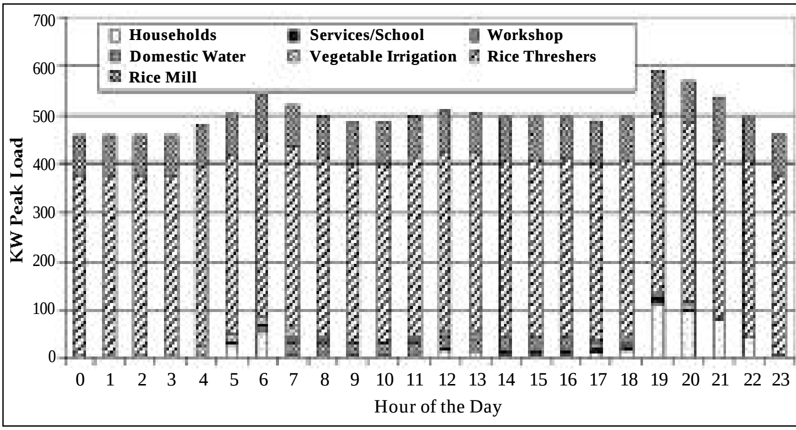
ing and milling equipment, and rice irrigation pumps. It should be remembered, however, that the coal mine provides fuel to one or possibly two other villages, so it is slightly misleading to attribute all of the mine's electricity consumption to Unhari. Other uses of electricity, including household use, services, and water pumping, together account for only about 24 percent of the total estimated electricity use.

Overall Estimated Electrical Load Curve for Village

The survey results allowed the team to calculate load curves for the households of Unhari, as well as for the medical/dental clinic and for the kindergarten. For other sectors, however, only partial data (or rough guesses) as to time of use of electrical equipment were available. As a consequence, a number of assumptions were made in estimating the non-household (except clinic and kindergarten) portions of both the summer and winter load curves shown below. It is hoped that these assumptions will be revised for the follow-up survey work. As the peak estimates shown are for just two representative days of the year, they can be expected to correspond generally, but not perfectly, with the estimates of annual electricity use provided above.

Figure 2 provides an estimated late-summer (harvest-time) load curve for Unhari. The load curve features an evening peak, a smaller morning peak, and a period after midnight of very low electricity use. The total maximum village load, excluding the coal mine and the upland corn site, is roughly estimated at 591 kW. The rice thresher and rice mill together make a huge contribution to the load at most times of the day, accounting for just under 77 percent of the load during the peak hour (7 p.m.), and an even greater portion of the load during the other hours of the day. The household contribution to the load determines the peak time, and is 19 percent of the load at 7 p.m. The contribution of the workshop to village loads in the middle of the day is significant (though highly uncertain) at about 25 kW. Figure 2 shows that virtually all of the load during the post-midnight hours—except for refrigerators and a few guard post lights—is due to the thresher and rice mill. Overall, the load factor for the estimated summer load curve (daily kWh use/(24 * Peak Load))

Figure 2. Estimated Summer Electrical Load Curve for Unhari Village

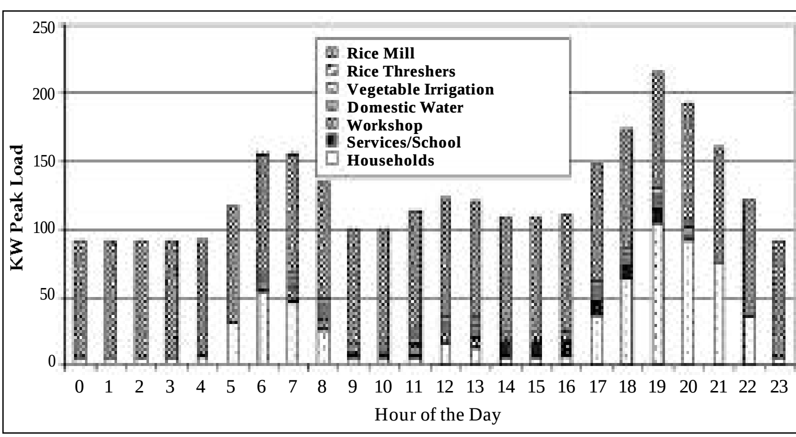


is just under 85 percent, reflecting the dominance of the rice processing equipment.

Winter Load Curve

The estimated winter load curve for Unhari, as provided in *Figure 3*, shows the same general pattern of morning and evening peaks as summer electricity use, but the overall peak

Figure 3. Estimated Winter Electrical Load Curve for Unhari Village



load is much lower, at 215 kW. With the thresher not operating in the winter, the single major load is the rice mill, although households make up a more substantial fraction (48 percent) of peak load in the winter than in summer. The winter load factor for the village, based on the curve shown, is 58 percent.

As noted at the outset of this section, there are unknowns about the timing—and in many cases, the size—of non-household loads that could cause shifts in the shape and / or magnitude of the load curves shown. Learning more about how the rice threshing and milling equipment, as well as tools in the workshop, are loaded and actually operated would be some of the higher priorities in terms of additional data collection.

Potential Changes in Energy Balance/Load Curves in Response to Changing Economic Conditions

For Unhari, the major manifestation of *worsening* economic conditions in the DPRK as a whole might arguably be a continued decline in the availability of diesel fuel and / or of electricity. A reduction in the availability of diesel fuel could reduce coal availability in Unhari by making it harder to transport the annual allotment of coal to villagers. Draft animals, to the extent that they are available, could be pressed into service for coal transport. A reduction in coal availability could be compensated for partially by an increase in the use of rice straw, but few other solid fuels are available in significant quantity for heating and cooking. A further reduction in the availability of diesel fuel will force even more of the agricultural activities to be done with manual (and, possibly, draft animal) labor, which would probably reduce crop yields (for example, by lengthening the amount of time needed for land preparation, planting, and harvest). Thus, a reduction in diesel availability would increase the manual and animal labor figures in the energy balance; but it is unclear that significant additional manual and animal labor could, in fact, be available, particularly if restrictions on availability of food tighten further.

A reduction in the availability of electricity will result in more lighting with diesel lamps (to the extent that diesel remains available), but the major impact will be on the processing of rice and on water pumping. If electricity supply were insufficient to run the threshing machine, it is not clear how it would be possible for Unhari to process the majority of its rice crop. Similarly, electricity is needed for the rice mill. Both of these devices could conceivably be powered (possibly at a lower rate of operation) from the power take-off of one or more tractors, but to do so would require the availability of diesel fuel. At about 0.3 liters of diesel per kWh of tractor output, this implies that about 90 tons of additional diesel fuel would be needed to run the thresher and rice mill each year at their rated power—implying approximately a 100-percent increase in village diesel use.[7]

Conversely, an *improvement* of the overall DPRK economy could be expected to enhance the availability of electricity and motor fuels, as well as the availability of mechanized equipment (through provision of new equipment and improved availability of spare parts for old equipment). The improved availability of diesel fuel and petrol could have a marked impact on the amount of manual labor needed for agriculture. Most of the work is currently done largely by hand (such as in transplanting, weeding, and harvesting) and could be done much faster by machines. A report of missions to the DPRK sponsored by the UNDP under the AREP (Agricultural Recovery and Environmental Protection) project suggests that the labor requirements for fully mechanized rice cultivation could be on the order of 10 percent of the labor requirements for "crisis situation" rice agriculture, and fuel requirements would increase by a factor of five.

At Unhari, given the current availability of tractors and diesel fuel, it seems unlikely that requirements for manual labor in agriculture would fall substantially, or that the consumption of motor fuel would rise to five times current levels; but a decrease in manual labor of 50 percent and an increase in fuel use for agriculture of 100 percent or more seems plausible. Increased availability of fuel would also result (assuming that more spare parts are available) in a marked increase in motor fuel for transport, in particular passenger transport.[8] To the extent that the improved economy resulted in more disposable income for householders and better availability of electricity-consuming appliances, household electricity consumption would be expected to rise substantially, but peak consumption is likely to rise less, as the first major appliance most homes will purchase will likely be a refrigerator (which has a relatively even contribution to day and night loads). Peak power use in households would rise substantially if electric cooking devices become popular—but none were in use in the surveyed households as of 1998.

Expenditures of Household Income on Fuels

The average household in the Unhari survey receives an estimated 3,500 won as cash income per year. Expenditures on energy, as surveyed, are estimated at 12 won per year for electricity, 2.4 won per year for diesel fuel (for lighting), and 80 won per year for coal, for a total of about 94 won, or under 3 percent of the total household cash income. Those households that use auto batteries for supplemental electricity pay a somewhat higher effective fraction of their income for energy, approximately 5 percent. Though electricity prices are heavily subsidized, the low level of electricity consumption in the households in Unhari may in fact mean that residential customers pay a rate for electricity that is not very different from what at least the operating costs of generation might be (exclusive of capital costs). Considering the official exchange rate of about 2.1 DPRK won to one U.S. dollar, and the annual average estimated electricity use of the surveyed households (390 kWh), the average per-unit electricity cost is about US1.5 cents / kWh. Those households using less electricity (for example, those without refrigerators) pay a substantially higher effective rate.

This comparison is, of course, extremely simplistic, as complications regarding exchange rates of the won with other currencies are daunting. There are, in fact, two DPRK currencies: an internal "red" won that cannot be converted to hard currencies, and a separate "blue" won that can be converted to dollars at an official rate. The official conversion rate between the red and blue won is unknown (if in fact it exists). Estimates based on the relative purchasing power of the DPRK and ROK won suggest that the DPRK won is overvalued relative to the dollar by a factor of between 1.9 and 3.7.[9] There have been reports of unofficial currency exchanges at 200 DPRK won per dollar. These estimates offer a wide range of potential exchange rates to choose from. Our own, anecdotal, collection of price data for goods purchased by Unhari villagers can be used to estimate a range of effective exchange rates as well. For example, the Chinese-manufactured fans purchased in the DPRK for 35 to 50 won would probably sell for $20 or so in the United States. Similarly, used color televisions (of Japanese or Chinese manufacture) that sell for 200 won in the DPRK might sell for $40-$75 in the United States. These few examples suggest that the official exchange rate might not be so far off as a measure of purchasing power, at least for goods imported to the DPRK.

The increases in residential use of auto batteries and other smaller (including flashlight) batteries, modest as they are, probably reflect householders' responses to more frequent grid electricity supply problems. These increases in battery use also represent a displacement of some of the costs of electricity supply to electricity end-users. Data on the costs of flashlight batteries in the DPRK was not collected, although it is possible that most such batteries are imported from China and thus represent quite expensive energy, on a per kWh basis. Given an average cost of auto batteries of about 40 won, and an average battery lifetime of 2.6 years, those households that use auto batteries to provide supplemental electricity pay effectively more than twice as much for their electricity, as the standard electricity tariff would imply.

Implications of Results with Regard to Shortages of Household Fuels

With the exception of electricity, which apparently (based on indirect reports from Unhari, not on the survey itself) is supplied sporadically for large portions of the year, there did not seem to be an absolute *shortage* of household fuels in Unhari. Many households were able to collect rice-threshing wastes at no cost even though only a modest fraction of households actually used rice wastes as a fuel. Likewise, additional coal was apparently available, at least in some instances, for purchase. Whether doing so requires special and onerous arrangements (e.g., to transport coal) is not known.

Implications of Results for Energy Efficiency and Renewable Energy Measures in Rural Areas of the DPRK

The results described above provide some guidance as to what energy efficiency and renewable energy measure might be applicable at Unhari, as described below. The Nautilus team's conjectures as to the applicability of Unhari-specific results to other areas of the DPRK are also provided.

In the household sector, current electricity use is sufficiently limited that the only options that would seem to provide significant savings are associated with lighting. For lighting, the main energy-efficiency option is to replace the typical incandescent bulbs with compact fluorescent bulbs. Replacing the 40-watt incandescent bulbs that are used most with 9 or 15-watt compact fluorescent bulbs results in a savings of about 25 to 30 percent of annual energy use and of peak household power requirements. Given the low current penetration of refrigerators and other major appliances at Unhari, there are few other substantial electric energy efficiency options for present household use. However, as the DPRK economy improves, the use of household refrigerators may well increase rapidly. In the absence of affordable, energy-efficient units, it seems likely, given current patterns of appliance supply in the DPRK, that the refrigerators most households purchase will be used appliances from other countries in the region. If this trend begins to emerge, introducing high-efficiency refrigerators, possibly through joint-venture in-country manufacturing, may provide for significant electric energy savings, and possibly significant peak savings as well.

Although the survey team did not observe the ondol heating/cooking systems in the village during the peak heating system, in general, the ondol system seems to be an efficient method of heating and cooking that produces relatively little indoor air pollution. Moreover, since coal is the main fuel available at Unhari, and the ondol systems are integral to the structure of the residential buildings of the village, it is impractical to think that these systems will be replaced any time soon. Coal savings, however, could potentially be achieved through building a combination of envelope improvements, including improvements to windows and doors, wall insulation (possibly sprayed on from the outside), and ceiling insulation.

In non-household sectors, the major electricity savings opportunities are likely to come from improvements in electric motor and drive systems, or in improvements in the equipment for which electric motors are used. Although an engineering analysis has not yet been done, it seems likely that the village water system could be modified—perhaps with the installation of a cistern or water tower on the east side of the village, so that a water pump with a smaller-capacity motor could be used. It might be necessary to renovate some of the existing water supply plumbing to reduce leaks and friction losses in order to make such a scheme work. It is also probable that significant improvements can be made on the motor and drive systems on the threshing and milling machines, for example, by replacing the existing motors with much more efficient and smaller units. As a particular example, the rice mill at Unhari has an annual output of 3,200 tons of rice, operates for a reported 4,600 hours per year (twenty-three hours a day, 200 or so days per year), and uses a 90 kW motor. A rice mill of Chinese manufacture is advertised to have a productivity of 700 to 1000 kg per hour, and uses 11 kW of power.[10] Assuming that the Chinese mill provides equivalent output to the mill in use at Unhari, a reduction in power and electrical energy consumption of over 80 percent would seem to be possible. Although no formal engineering analyses have been done to date, it seemed to the Nautilus team that much of the equipment in the village that used electrical equipment—including pumps, the (currently non-operational) air blower for the kindergarten heating system, and even the dental equipment in the clinic—could potentially be actuated with more efficient motors of much smaller capacity.

A fundamental difficulty, however, with implementing electric energy efficiency measures at Unhari is the problem of power quality. It is likely that most types of efficient lighting equipment, efficient motors, and efficient refrigerators discussed above could not withstand for long the types of power quality fluctuations (including voltage and frequency deviations) that have recently been endemic to Unhari. This implies that the implementation of most electric energy efficiency measures will require one (or more) of the following: power conditioning devices in the line between the higher-efficiency equipment and the grid; an alternative power source for those homes or facilities using the new equipment or appliances (as has been supplied in Nautilus/KANPC Wind Power Project); or rehabilitation of the grid itself to improve its power quality.

Substantial diesel savings could be achieved by using more modern, higher-efficiency tractors. It is possible that additional energy savings could also be achieved through the use of better tractor implements and/or alternative cropping practices, though analysis of these sorts of changes are well beyond the scope of this article. In any event, the increase in motor fuels use when motor fuels availability increases (assuming a corresponding increase in spare parts for agricultural machinery) will swamp any reduction in diesel use due to improved tractor efficiency. It is possible that a modest amount of diesel fuel could be saved through distribution of higher-efficiency oil lamps. The oil lamps in use in Unhari (and also in Nampo, where the Nautilus team stayed during the mission) were often found to be makeshift and reportedly inefficient (though ingenious) devices fabricated from beverage cans and other local materials.

There are several types of renewable energy measures that, based on survey results, might have the potential to contribute to the energy supply at Unhari. Although the solar resource at Unhari is probably only moderate, solar hot water systems could be useful, for example, to heat water for the public baths and/or the guesthouse, or possibly to help pre-heat water for residential use. Given the climate at Unhari, and the intermittent electricity supply, systems that use a glycol heat exchange fluid (as opposed to directly heating tap water for use) and a heat exchange fluid circulating pump with its own solar photovoltaic power source might be optimal.

Solar and/or wind-powered electricity generation systems also have the potential to contribute to energy supply at Unhari. Based on the experience of the project team to date, wind power systems have the best potential to contribute to electricity supply during the late fall, winter, and spring months, which is when grid electricity tends to be most problematic at Unhari. The solar resource is best in the summer months, so a solar/wind hybrid system might actually provide the best coverage. Solar water pumping for irrigation is also a possibility, though the power requirements needed for irrigation of the rice crop are quite substantial. Wind-powered water pumps may not be optimal for irrigation applications at Unhari, as summer tends to be less windy than other times of year in the area; but these pumps could potentially be implemented for domestic water pumping, assuming that the water supply system was revamped to provide a cistern or water tower for storage.[11]

Given the intensive land use at Unhari, and given that existing biomass wastes seem to be used as either fuels, soil amendments, building materials, or for other purposes, the prospects of biomass providing a substantially greater portion of the energy budget of the village on a sustained basis seem to be remote.

As the Nautilus project team did not do more than pass through other rural areas in the DPRK, the general applicability of the Unhari survey results is uncertain. Based on our observations of housing types in the villages and towns that we passed, and on conversations with local officials, it seems probable that the fuel sources used and electric appliances and equipment present in Unhari are similar to those found elsewhere. However, it also seems likely that Unhari has somewhat better supplies not only of coal but also of electricity relative to many other villages (particularly those in the northern and eastern parts of the country). Owing to the location of the Unhari in one of the most productive agricultural areas of the nation, the inhabitants of the village also seem to be somewhat more "prosperous" (as manifested, for example, by their belongings) than those of other rural areas of the country.

In passing through the countryside near Unhari, we saw a variety of different types of dwellings, ranging from single-story, tile-roof houses of perhaps 60 to 100 square meters of floor area to small three-story apartment buildings with eight to twelve units. All dwellings appeared to be made of either brick or concrete block, or of brick with a covering layer of concrete. A few single-story houses under construction in the village adjacent to Unhari had timber frames, and timber seemed to be used to frame the roofs of most smaller buildings. In many different locations we saw piles of powdered (or semi-powdered) coal, with briquette production ongoing. Households in areas of the DPRK that have severe winters, such as in the interior of the Korean peninsula and in the north of the country, may well require more winter heating fuel, and may well use more biomass fuel in the event that coal is less available than at Unhari.

This, of course, is conjecture, and would need to be confirmed with energy surveys in those areas.

Next Steps

The initial estimated load curves based on the Unhari household survey were used to inform the decision to connect 20 households to the wind power system, in addition to the clinic and the kindergarten.[12] Some of the major conclusions from the survey results, plus a short list of potential next steps for survey work in the DPRK, are provided below. The major lessons learned can be divided into those related to the survey process and those related to the survey results. Broader conclusions about lessons learned and about working with DPRK counterparts can be found in companion articles in this volume.

Major Process-related Lessons Learned

- *The need to be able to adjust surveys "on the fly":* A rural energy survey team operating in the DPRK is likely to be less knowledgeable about local conditions than teams that operate in most other areas of the world.[13] It is therefore necessary to be flexible in the survey approach, allowing methods and the survey instrument to be modified as the survey progresses so as to allow optimal data collection in the limited time available. Modifications must be done in such a way that the ability to glean useful information from survey results is not compromised.

- *The importance of being clear and friendly in approach:* A smile is important in breaking barriers. The Nautilus team found that our efforts at presenting our objectives and proposed methods clearly, and answering questions put to us in a forthright manner, helped to gain the trust of the officials and other people we were working with. Similarly, both Nautilus and DPRK project team members made concerted efforts to explain to householders why the survey was being conducted, and what it was used for. An interested, respectful, and friendly manner by survey staff helped put householders, none of whom had ever participated in an international project such as this, more at ease.

- *The importance of a "whole village" approach:* In order to identify major opportunities for energy efficiency improvements and/or implementation of renewable energy systems, it is necessary to obtain an overview of energy use in the village as a whole. Our survey, for example, focused on the household sector; but, as was noted above, the major opportunities for increasing the efficiency of electricity use are almost certainly in other areas.

- *The importance of an "all-fuels" approach:* The use of different fuels and other energy forms are interrelated. A reduction in diesel availability means more human and animal labor are needed, and increasing frequency of electricity supply disruptions cause more diesel to be used as an alternative lighting fuel (for example). As a consequence, it is necessary to obtain a clear picture of how the village uses all fuels, including manual and animal labor, to evaluate how the village energy balance will change with changes in local, regional, or national energy supply.

- *The importance of seasonality:* One of the areas in which the Unhari survey could have been improved is in the degree to which information was obtained about the seasonality of energy use. For example, questions were asked about the pattern of electricity supply disruptions, but these questions specified no particular time of year. As a consequence, most respondents seemed to interpret the question as applying to the prevailing (late summer/early fall) season, and answered accordingly. Obtained anecdotal information suggests that power outages are considerably more frequent, and of longer duration, in the winter months. Questions about monthly fuel use did not clearly differentiate between seasons either, which could have led to modest errors.

Some of the major conclusions related to the survey results have included:

- *The population of households in Unhari is very homogeneous:* Relatively little variation was found in appliance ownership, energy use, or peak power consumption among households. Patterns of living were also quite similar from house to house, and the individual dwelling units were for the most part identical in configuration, if not in decoration. The similarity in housing units is a function of the entire village being established essentially at once in 1974, and populated by military veterans and their spouses.

- *Coal is the dominant fuel in Unhari:* On an energy-content basis, coal provides the largest share (about 76 percent) of the overall energy use in the village, even including manual labor. By far the major portion of coal use (over 92 percent) is estimated to be for household heating, cooking, and preparation of pig feed. Homes in Unhari were designed and built with integral ondol-type cooking and heating systems that use coal briquettes as fuel.

- On the basis of energy content (gigajoules), *petroleum products* account for the next largest portion of energy use in Unhari (about 12 percent); about two-thirds of petroleum products use is estimated to be for tractor fuel. Electricity supplies slightly less than eight percent of total energy use—although electricity is used for vital functions such as lighting, rice threshing, and water pumping. Rice straw, human labor, and animal labor account for smaller portions of the total energy used in Unhari.

- *The electricity consumption of households in Unhari is very low:* Estimates based on survey results suggest that the average household uses on the order of 400 kWh per year, or about one-tenth of the amount of electricity that an average household in the United States uses for electric water heating alone. Electricity use in Unhari households would probably increase substantially if refrigerator ownership were more common. In many cases householders described refrigerators as their next electrical appliance purchase.

- *There is a considerable potential for energy savings through efficient lighting:* Implementation of compact fluorescent bulbs to replace incandescent bulbs in households and service/school buildings would save energy and provide a better quality of light. As with other potential energy efficiency measures, however, power quality concerns and "fixes" may play a major role in determining which options are practical, and which are not.

- *Electric motor-driven equipment is the major consumer of power:* Residential electrical energy use is modest, by the estimates presented above, relative to the amount of electrical energy and power that is consumed in the medium and large electric motors that drive water pumps and rice processing equipment. These applications may be ripe for energy efficiency improvements, if power quality problems can be overcome.

- *Agricultural production seems to suffer from a lack of motor fuels:* Although the supply of diesel fuel to Unhari seems to be higher than has been reported for other areas of the country, it is clear that the rice farming operations that were taking place in the Unhari area at the time of the survey were substantially under-mechanized by the standards of industrialized societies, and probably by the standards of previous practices in the DPRK as well. Manual and animal labor has substituted, to some degree, for the lack of rice combines and other motorized implements.

- *Opportunities for implementation of renewable energy systems exist, but must be carefully thought through.* Sufficient wind and solar resources exist in Unhari to provide energy services to the population, but harnessing such resources will depend on a careful consideration of the timing and availability of the resources, the timing and extent of electricity demand (particularly non-household demand) and the implementation of energy efficiency measures, particularly improvement in electric motors, in the devices that control them, and in the processes they are used with.

Potential Next Steps

- *Broaden the survey at Unhari:* The rural energy survey work at Unhari could be broadened by including additional households in the village. Follow-up questions (for example, on satisfaction with the wind power system, or on the seasonality of household energy use) could be asked of households that participated in the September-October 1998 survey.[14] More detailed coverage of non-household sectors, including site visits to (and possibly engineering audits of) the rice processing equipment, workshop, water pumping facilities, and services area of the village are also possible survey extensions. Selective use of end-use metering to help confirm survey results in the household and non-household sectors may be helpful. In agriculture, surveys to determine estimated water and fertilizer use budgets could be mounted. Surveys of the use of human and animal power in agriculture would help to illuminate the links between availability of motor fuels, agricultural productivity, and human labor use/productivity. An improved survey of past use of commercial fuels, particularly pre-1990, would also help to identify an appropriate "baseline" for analysis of changes in the DPRK energy system since that time.

- *Refinement of survey techniques, and application to other areas of the DPRK:* Understanding of the energy needs and budgets of rural households in the DPRK would be broadened considerably by application of rural energy surveys in other areas of the country. In order to conduct such surveys effectively, it is necessary to identify a set of professionals, probably including a team of specialists from within the DPRK. Additional international experts will also be necessary for a broader survey effort. The joint team would examine and refine the survey instrument and approach, work to fully train DPRK survey personnel in the conduct of the survey, and plan, implement, and evaluate pilot surveys before initiating a full, multi-area survey.

- *Broader test application of energy-efficiency and renewable energy measures:* There are a number of areas, identified above, where energy-efficiency and/or renewable energy measures might be implemented in rural areas of the DPRK. In many cases, implementation of energy efficiency measures will require that engineers familiar, for example, with agricultural processing systems or water pumping technologies, undertake a series of "Energy Audits" in agricultural processing installations, rural industrial plants, and other potential hosts for energy efficiency improvements. Similarly, site assessments for host areas for renewable energy demonstrations, as well as discussions about (ultimately) production of renewable energy equipment in the DPRK, could be undertaken. An important element of test applications of energy efficiency and renewable energy measures in the DPRK will be to identify incentives for local decision makers to adopt such measures by themselves (or, at least, embrace those offered from outside). Given the lack of electricity metering in many parts of the DPRK (including Unhari), and absent a near-term change in the way electricity is disbursed to local institutions, implementing energy efficiency measures on an ongoing basis in the DPRK requires re-thinking and creative adaptation of the methods used to encourage energy efficiency and renewable energy in other countries.

NOTES

1. On June 19, 2000, U.S. President Bill Clinton announced that the United States was easing substantially sanctions against the DPRK in categories that fall under the Trading with the Enemy Act, the Export Administration Regulations, and the Defense Production Act. Counterterrorism or nonproliferation controls prohibiting exports of military and sensitive dual-use items, and statutory restrictions, such as U.S. missile sanctions, remain in place.
2. V.T. Tuntivate, *Household Energy Survey Handbook* (December 20, 1995). Prepared for the Power Development, Efficiency, and Household Fuels Division of the Industry and Energy Department of the World Bank.
3. See, for example, M.E. Grosch and J. Muñoz, "A Manual for Planning and Implementing the Living Standards Measurement Study Survey," *Living Standards Measurement Study*, No. 126 (World Bank, 1996).
4. For example, World Bank-UNDP Bilateral Aid Energy Sector Management Programme, *China: County-Level Rural Energy Assessments, A Joint Study of ESMAP and Chinese Experts*, No. 101/89 (May, 1989); K. Kumar, ed., "Rapid Appraisal Methods," *Regional and Sectoral Studies* (World Bank, 1993); B.M. Kjellstrom Katyega and H. Kadete, *Report on a Technical Fact Collection Visit to Babati, Arusha Region, 11 to 19 July, 1989*, Stockholm Environment Institute (Stockholm, 1990); D.D. Case, *The Commu -*

nity Toolbox: The Idea, Methods, and Tools for Participatory Assessment, Monitoring, and Evaluation in Community Forestry, Community Forestry Field Manual 2, Food and Agriculture Organization of the United Nations (Rome: 1990); H.K. Hadikusumah et al., *Wood Fuel Flows: Rapid Rural Appraisal in Four Asian Countries*, Regional Wood Energy Development Programme in Asia, Food and Agriculture Organization, No. GCP / RAS / 131 / NET (Bangkok, 1991); and UNDP / World Bank documents, *Pakistan Integrated Household Survey* (1991), including *Interviewer Manual, Part 1: Field Operations*, and *Female Questionnaire*.

5. It should be noted that both the household and non-household survey instruments were reviewed prior to the start of the survey itself by the leader of the KANPC counterpart team. The KANPC team leader had no objections to any of the questions proposed.
6. Standard Laboratories, Inc., South Charleston, West Virginia, USA.
7. See Agricultural Recovery and Environmental Protection (AREP) Programme, Democratic People's Republic of Korea, *Identification of Investment Opportunities*, "Working Paper 2: Agricultural Mechanization" (1998). Data from Table 1 of "Appendix 1: Agricultural Machinery and Power in DPR Korea."
8. In their paper *Famine in North Korea: Causes and Cures*, Marcus Noland, Sherman Robinson, and Tao Wang present economic modeling results for the DPRK that suggest that there would be marked sectoral shifts in the North Korean economy, including a major shift in the distribution of labor forces from the agricultural sector to the light industrial sector, if the DPRK economy were to undergo a "complete recovery," including opening to international trade. Institute for International Economics (IIE) *Working Paper* 99-2 (Washington, D.C.: IIE, 1999).
9. Soo-Mi Rhee, *Purchasing Power of the DPRK Won*. Personal communication, May 4, 1999.
10. Based on a Worldwide Web advertisement and technical specifications summary for the "Model NZJ-10 / 8.5 combined rice mill," produced by Sichuan Machinery Company, Ltd., Sichuan, China, online at http: // qing-jiang.com / product6e.htm. (Visited June 4, 1999.)
11. In fact, a water-pumping windmill was installed at Unhari by the Nautilus / KANPC team during the September-October 2000 mission. Though this windmill was initially intended to be installed to provide irrigation pumping, after discussion with village leaders (and at their suggestion) it was decided that the windmill would be most useful if installed as a back-up domestic water pump. This decision has reportedly been well justified, as power supply at Unhari during the winter of 2000 / 2001 has been even more problematic than in previous years, meaning that the wind-powered water pump was a major source of domestic water for the village.
12. Since the 1998 Nautilus mission, village leaders in consultation with KANPC and Non-conventional Energy Development Center decided to connect additional households to the wind power system, bringing the

total number of connected households to sixty.

13 This statement held, it is probably fair to say, for both the Nautilus and Korean participants on the survey team, as even those team members from the DPRK, being city dwellers, were not fully familiar with living patterns in rural areas of the DPRK.

14. Some follow-up interviews in September-October 2000 were carried out with representatives of some of the households involved in the original survey. These interviews, however, focused mainly on the satisfaction of the householders with the wind power system, and their experience with the compact fluorescent light bulbs provided as part of the wind power system installation.

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FUEL AND FAMINE: RURAL ENERGY CRISIS IN THE DPRK

James H. Williams, David Von Hippel, and Nautilus Team

This article examines the origins and impacts of the DPRK's rural energy crisis, and explores the technical and economic dimensions of international responses to the crisis. The rural energy crisis is actually multiple energy crises—distinct and separate shortfalls of solid and liquid fuels and electricity, each of which affects productive activities and living conditions in different and cross-cutting ways. Rural society appears to be a stable element within the DPRK, and may even be considered a backbone of the regime. However, if supplies of commercial energy to the rural sector were to fall well below the current 20- to 40-percent levels, or are maintained at very low levels for a very long period, the combined effects on living conditions and the environment could destabilize rural society. Improving the DPRK's rural energy situation is feasible, desirable, and affordable from both humanitarian and geopolitical perspectives. To the extent that improved bilateral relations between the United States and the DPRK allow the process of rebuilding the DPRK's infrastructure to begin, rural energy is a particularly appropriate and beneficial area of initial focus for donors and investors.

Key words: biomass, energy crisis, North Korean agriculture, rural energy rehabilitation

The DPRK's Energy Crisis

The Energy Picture as the Cold War Ended

It is well known that the Democratic Peoples' Republic of Korea (DPRK) suffers from chronic shortages of both food and energy. It is increasingly evident that inadequate energy supplies are the immediate cause of the collapse of North Korean agriculture, and must be addressed in order for a sustainable recovery to take place. This article examines the origins and impacts of the DPRK's rural energy crisis, and explores the technical and economic dimensions of international responses to the crisis.

After three decades of autarkic, Soviet-style economic development, the economy of the Democratic People's Republic of Korea, by the end of the cold war, was industrialized and energy intensive. It required substantial inputs of commercial energy to fuel transportation, support heavy industry (including self-sufficient production of primary industrial products such as steel, cement, and chemicals), and meet the needs of a predominantly urban (60 percent in 1990) population. In 1990, estimated per capita energy use in the DPRK was 71 gigajoules per person (2.4 tons coal equivalent / person), more than twice that of China in the same year, and over half that of Japan.

The energy resources used to fuel North Korean industrialization were partly domestic in origin. The DPRK has substantial coal and hydropower resources, with coal reserves estimated at between 1 billion and 10 billion tons, and developable hydroelectric potential estimated at 10-14 GW.[1] Most of the DPRK's energy infrastructure—coal mines, thermal power plants, and hydroelectric plants—was built during the 1950s to 1980s with substantial financial and technical assistance from the Soviet Union and its allies. The DPRK claimed to have extended its national electricity transmission and distribution grid to every one of its rural villages by 1968.[2]

Although the DPRK's energy system provided the foundation for the country's rapid industrialization, the system was also riddled with actual and potential problems. The obvious Achilles heel was the DPRK's complete dependence on imported oil. During the cold war, the DPRK received heavily subsidized oil supplies from the Soviet Union (USSR). In 1990, crude oil imports amounted to about 2.5 million tons from three sources: China, Russia, and Iran. Import of refined products such as diesel and gasoline from China came to another 0.6 million tons.[3] One oil refinery was built at the port of Rajin to process crude oil delivered by tanker from Russia and the Middle East; another was built at the terminus of a pipeline from China.

The system also suffered from fundamental economic irrationality, with energy supplies distributed by the state according to quotas fixed in the central plan. This arrangement was highly vulnerable to mismanagement and misallocation; it lacked independent revenue streams to produce new investment capital; and it included few mechanisms for market feedback to supply and demand. Electricity consumption, for instance, was not even metered.

In the 1990s, the vulnerabilities of the DPRK's energy system were made manifest by the dissolution of the Soviet Union and a series of natural disasters, resulting in three severely damaging blows. First, Soviet support had buffered the DPRK's inability to earn foreign exchange—due variously to its general economic decline, bad credit arising from its default on previous international loans, and U.S. sanctions—and thereby pay for its own oil imports. With the collapse of the USSR, the new Russia curtailed subsidized oil supplies to the DPRK, putting oil exports on a strictly commercial basis, sold at prevailing market rates. With the DPRK very short on credit and foreign exchange, it could not afford to continue importing at former levels. Imports from Russia fell by 90 percent in a few years, as did imports from the Middle East. The DPRK's main oil supplier is now China. In 1996, oil imports stood at around 40 percent of their 1990 level.[4]

Second, the dissolution of the USSR also had an impact on the modernization and maintenance of the DPRK's energy infrastructure. The spare parts and expertise to maintain energy supply infrastructure—generators, turbines, transformers, transmission lines—and energy consuming equipment—boilers, motors, pumps, chemical reactors—were no longer subsidized. Much of the DPRK's infrastructure was already at retirement age or beyond in 1990; some facilities dated back to the Japanese occupation in the 1930s. Furthermore, lack of environmental controls—impacts on humans and ecosystems aside—had a damaging cumulative effect on equipment, as for instance high-sulfur emissions shortened the useful life of coal-fired boilers.

Third, natural disasters in the mid-1990s, while not the principal cause of many of the problems in the DPRK's energy system, nonetheless hit an already fragile system with debilitating blows. Severe flooding in 1995 and 1996 were followed by severe drought and a tidal wave in 1997. In addition to destruction of crops and agricultural land, these disasters impacted the energy system in numerous ways. Coal mines were flooded. Severe deforestation and inappropriate land conversion increased erosion, leading to major siltation problems in reservoirs that reduced hydroelectric generation. Drought subsequently reduced water supplies below the levels needed to generate power. Electric transmission and distribution lines were damaged, as were roads and transportation equipment. Heavy erosion and scavenging for food denuded landscapes, reducing the availability of biomass for energy use.

Energy Crisis

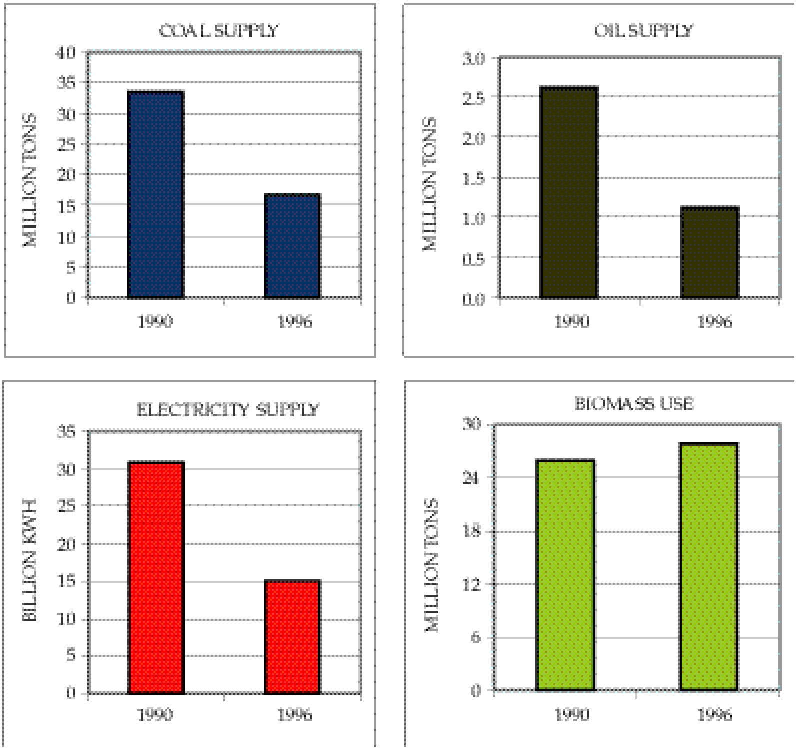
The combination of the three factors described above, plus other influences, resulted in a severe contraction in the supplies and consumption of fuels and electricity in the DPRK between 1990 and 1996. *Figure 1* shows the estimated changes in supplies of coal, electricity, oil, and biomass (wood and crop wastes) between 1990 and 1996, and *Figure 2* shows estimated 1990 and 1996 demand for commercial energy forms by sector in the DPRK.[5]

The consequences of shortages of fuel and electric power are felt throughout the North Korean economy:

- **Transportation.** Electric and diesel trains, and diesel trucks, are responsible for most of the transportation of goods in the DPRK. It is estimated that road and rail freight transport was reduced to 40 percent of its 1990 values by 1996.[6]

- **Manufacturing.** Energy intensive industries have been powerfully affected. Iron and steel production is estimated to have been reduced to 36 percent of 1990 levels by 1996. For cement,

Figure 1. Commercial Energy Supply in North Korea, 1990 and 1996.



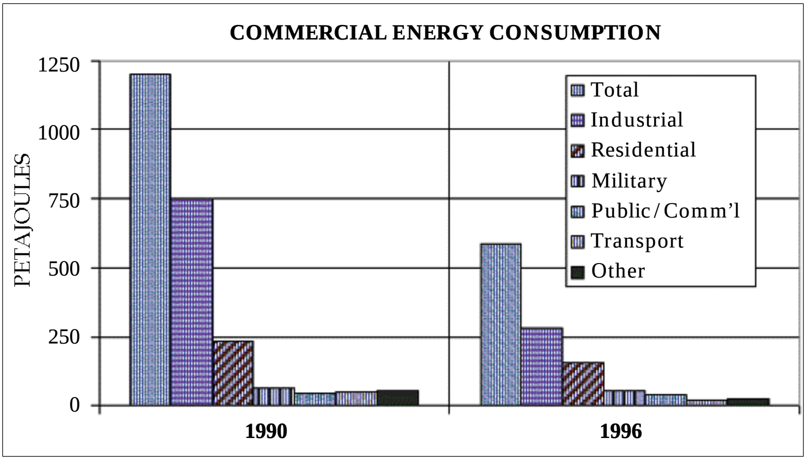
Note: All forms of commercial energy supply declined. Biomass energy use increased.

the figure is 32 percent. Lowered production of primary inputs in turn affects other industries that depend on them: automotive, building, and agriculture.[7]

- Residential and commercial. Residential and commercial lighting, heating, and cooking are all affected by energy shortages. Indirect effects include health impacts, loss of productivity, and reduced quality of life.

- Public Health. One tragedy noted by many international medical relief workers is the abysmal condition of hospitals, in which energy shortages play a crucial role. Many hospitals and clinics

Figure 2. Commercial energy consumption in North Korea by sector, 1990 and 1996.



Note: Total estimated consumption fell by 51% during the period. Consumption decreased in all sectors, but by very different rates.

are unheated in winter, lack electricity for lighting and medical equipment, and even lack the ability to boil water for human consumption.

- **Negative synergisms and vicious circles.** The consequences of energy shortages interact with each other, with food shortages, and with general infrastructure decline to produce seemingly insuperable vicious circles. For example, the lack of sufficient coal to run factories that build spare parts or make steel means that there will not be sufficient spare parts to keep coal trains operating, or the steel to repair tracks. In turn, delivery of coal to factories is difficult because the trains are often not running. Another example is that poor power quality damages electrical equipment; devices used to protect equipment, such as variable transformers used in households to power televisions, increase electricity demand and power factor without increasing useful output, which in turn lowers power quality.

In summary, in the last decade the DPRK's supply of commercial energy has fallen by one-half to two-thirds, with impacts felt throughout the economy. While this is just one result of, and one cause of, the DPRK's overall economic decline, it is clear that economic recovery will not occur without a major reversal of the present situation.[8]

The Rural Energy Crisis: Shortages Everywhere

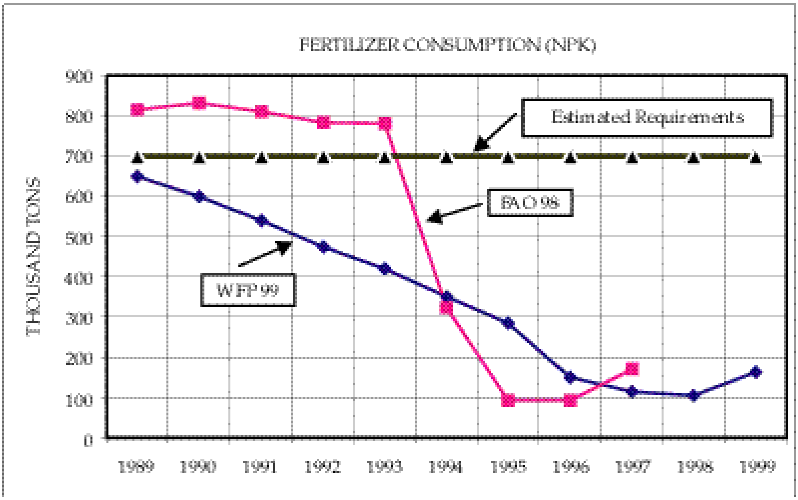
Fertilizer

Modern agriculture relies on steady inputs of inorganic chemical fertilizers. To grow grain crops under North Korean soil and climate conditions requires 400-500 kg/ha of the basic macronutrients nitrogen, phosphate, and potassium (NPK). United Nations (UN) and DPRK agricultural experts estimate the total North Korean requirement at 700,000 tons a year (NPK).[9] The actual bulk amount of fertilizer required to achieve this goal could range from 1.5 to 2.5 million tons a year, depending on the nutrient contents of the different fertilizers employed (for example, urea contains more than twice the amount of nitrogen per ton than ammonium phosphate).

The DPRK historically manufactured 80 to 90 percent of its own fertilizer.[10] Prior to the current energy crisis, North Korean fertilizer production is estimated at 600,000 to 800,000 tons per year (NPK).[11] Whether production fell steadily during the 1990s, or precipitously around 1994 as North Korean government figures show, is uncertain (*Figure 3*). What is certain is that since 1995, domestic production has been less than 100,000 tons per year. Aid and foreign purchases have brought the 1999 total to 160,000 tons, less than one-quarter of the amount required.

The drastic decline in fertilizer production is a result of fertilizer factories being out of operation or operating at minimal levels. This is due at least in part to the poor condition of Soviet-built plants, which has been blamed on natural disasters.[12] The important nitrogen fertilizer plant at Hamhung has been inoperable since at least 1994, and the DPRK government has requested international assistance to refurbish the plant.[13] In addition to problems of damage or disrepair, the energy crisis affects fertilizer production in several important ways. The North Korean

Figure 3. Two versions of North Korean fertilizer consumption (calculated based on content of nitrogen-phosphorous-potassium nutrients) 1989-99.



Note: Consumption is the sum of domestic production and imports. FAO data, as reported by the North Korean government, shows a steep decline starting in 1994. More recent data from WFP shows a steady decline throughout the period. The dashed line shows the level of fertilizer input required to achieve normal crop yields.

fertilizer industry uses coal as both energy source and chemical feedstock. The amount of coal required to produce 700,000 tons per year (NPK) is estimated at 1.5 to 2.0 million standard tons of coal per year.[14] This represents as much as 10 percent of the available annual coal supply, a very significant fraction and thus in competition with other high-priority uses. More important, moving up to 2 million tons of coal represents a serious strain on the transportation system, especially railways, which are already suffering from severe electricity shortages. Electricity shortages also directly impact the ability to provide the requisite 5 billion kWh of electricity used in the production of 700,000 tons of fertilizer. Finally, the transportation bottleneck also limits the ability to ship fertilizer from factories to farms. For these reasons, even if the DPRK's fertilizer plants were refurbished or rebuilt, energy shortages would continue to be a serious constraint on domestic fertilizer supply.

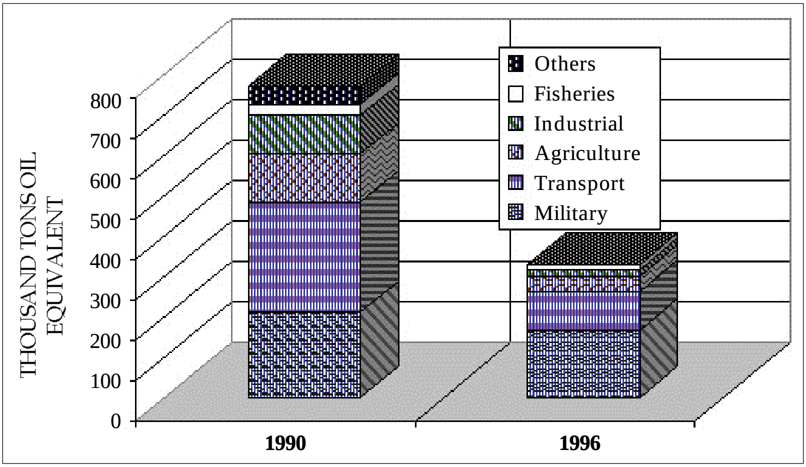
Due to the fertilizer shortage, North Korean agriculture has operated at 20 to 30 percent of normal levels of soil nutrient inputs. This shortfall is the largest single contributor to reduced crop yields, and thus to food shortages. Outright purchase of fertilizer to compensate for a 500,000 to 600,000 ton annual shortfall, at an international market rate of $300 to $400 a ton (NPK), would cost $150 to $240 million.[15] Lack of foreign exchange has prevented the DPRK from aggressively pursuing this course. The South Korean government has provided a total of 615,000 tons over the last three years, only about one-third of what is needed. Though increases in fertilizer supplies are undoubtedly necessary in order to improve food production in the DPRK, it is highly likely that improvements in fertilizer application practices could improve the efficiency of commercial fertilizer use, and reduce the need for commercial fertilizer per unit of food output in the DPRK. These improvements in agricultural practices include better balancing of nutrients in fertilizers, improved soil conservation practices, and enhanced use of organic fertilizers.

Diesel Fuel

North Korean agriculture requires petroleum products to fuel mechanical equipment used in field and food processing operations, with an estimated total of 3 million mechanical horsepower needed on farms.[16] The main fuel consumers are some 70,000 general-use diesel tractors (28 hp each), which constitute two-thirds of the total mechanical power.[17] Other equipment includes 8,000 tractor-crawlers for use in tillage, and 60,000 small engines used in transplanting, weeding, reaping, threshing, and shelling.[18] Based on typical consumption rates of 110-130 liters per hectare per year for rice and maize, UN and DPRK agricultural experts estimate the annual fuel requirements on North Korean farms at 140,000 tons of petroleum products, mostly diesel fuel.[19]

In 1990, North Korean agriculture is estimated to have used at least 120,000 tons of diesel fuel.[20] Since the energy crisis began, agricultural consumption has declined to 25,000 to 35,000 tons per year.[21] Given that the total current North Korean oil

Figure 4. Diesel Fuel Consumption in 1990 and 1996.



Note: Although estimated total consumption dropped from 750,000 tons to 300,000 tons, military use suffered a much smaller decline, from 200,000 to 160,000 tons. The amount of diesel fuel remaining for use in all other sectors combined in 1996 was 140,000 tons. This is equal to the yearly requirements for agriculture alone.

supply is estimated at 1.5 to 2 million tons, it may be difficult initially to understand why more fuel cannot be made available to the agricultural sector.[22] The key is that most agricultural machinery, including all tractors, is designed to use only diesel fuel, and cannot use other petroleum products without expensive retooling. Diesel fuel makes up less than 20 percent of the products refined from crude oil. North Korean diesel fuel supplies, which come from crude oil imports refined in the DPRK and to a lesser degree from direct purchases of refined diesel, have fallen from 750,000 tons in 1990 to around 300,000 tons per year. At the same time that supplies have dropped by 60 percent, the share consumed by the agricultural sector has fallen from 15 percent in 1990 to around 10 percent at present. The reason that agricultural use has dropped more than proportionally is that military allocations have remained firm, with a much less than proportional decrease.[23] After the current estimated military allocation of 160,000 tons of diesel fuel is accounted for, the amount of diesel remaining for use in all sectors—including agriculture, transportation, and industry-is only 140,000 tons. Agricultural use alone is necessarily only a fraction of that remaining amount (see *Figure 4*[24]).

Fuel shortages resulted in a 70- to 80-percent reduction in the use of tractors and other farm machinery. The shortfall has been felt both directly, through lack of fuel to run equipment, and indirectly, through the impact of energy shortages on maintenance and spare parts. As a 1998 UN expert mission noted,

> an acute shortage of fuel, electrical power, raw materials, consumable machine tool parts (e.g., cutting steels) and other inputs . . . has severely restricted the flow of essential replacement parts needed to keep the agricultural machinery in operating condition. These same constraints have also severely depressed the manufacturing volume and distribution of new replacement machinery and equipment to the farms . . . [A] significant proportion of the "motorized" agricultural equipment is out of service due either to having reached the end of its service life, or due to lack of vital spare parts . . . [However] even if the entire machinery park could rapidly be brought back into service, the equipment could still not be operated unless it also became possible to restore adequate fuel supplies . . . In quantitative terms, the total farm power available from tractors and small engines has probably been reduced during the 1998 season from a potential figure of about 2,200 MW down to only 20% of this figure.[25]

The loss of mechanized power to farms entails much higher inputs of human and animal labor (discussed below). Moreover, it decreases crop yields by reducing the efficiency of tasks, such as spreading fertilizer, and by making it more difficult to accomplish key tasks, such as transplanting and harvesting, in a timely fashion. Additional purchases of diesel fuel to make up the annual shortfall of 80,000 to 120,000 tons would cost $21 to $32 million per year at current international prices.

Electricity

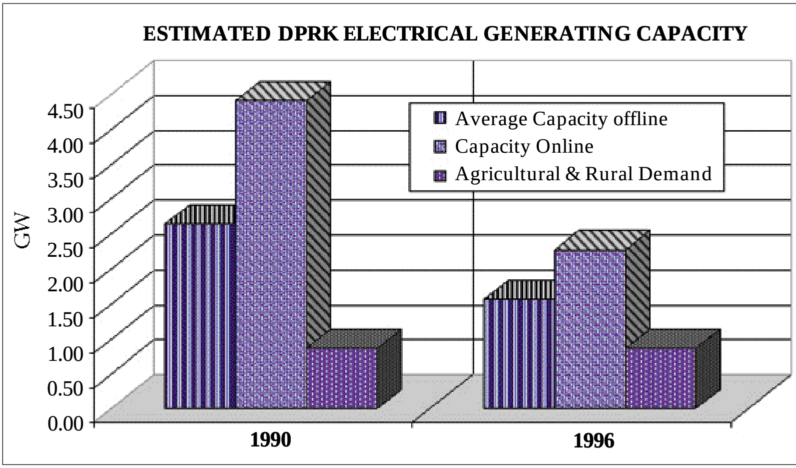
The most important use of electricity in North Korean agriculture is to power water pumps for irrigation and drainage. Irrigation pumping is indispensable for rice cultivation, which requires more water than provided by natural precipitation, and moreover requires that the water be delivered at precise times during the growing season. Altogether, 1 million hectares of rice, maize, and other crops are irrigated, mostly from surface water that is pumped into reservoirs or directly onto fields, through more than 10,000 kilometers of canals and pipes, by more than 30,000 pumping stations.[26] Most of the pumps in this network are electrical. With the water-use efficiencies of the irrigation network taken into account, rice requires an average of 10,000 cubic meters of irrigation water per hectare per year. For wheat and maize, the figures are respectively 3,500 and 1,600 cubic meters per hectare per year.[27] UN irrigation experts estimate that the electricity requirement for pumping this amount of water averages 1,200 kWh per hectare per year, corresponding to an annual national requirement of 1.2 billion kWh.[28] Electricity is also used to operate other stationary equipment on farms, such as threshing and milling machines, and machine tools in farm and district workshops. These are estimated to require another 460 million kWh per year.[29] The total agricultural electricity requirement is estimated at 1.7 billion kWh per year.

Rural sector electricity use also includes residential, public, and commercial uses. Despite very low per capita use of electricity by Western standards, 1.5 million rural households are still the largest non-agricultural rural user, requiring over 900 million kWh per year for electrical loads such as lights, refrigerators, irons, and televisions. Public and commercial users—such as clinics, schools, offices, workshops, and stores—require another 300 million kWh per year. Thus, electricity demand in the rural sector—with agriculture and other rural uses taken together—is 2.9 billion kWh per year.

Current rural electricity consumption is estimated at 1.9 billion kWh per year, a shortfall of 1 billion kWh. The most critical problem for agriculture has been a decline of 300 million kWh in electricity for irrigation pumping. Electricity consumption for other agricultural uses has declined to about 350 million kWh, bringing the total for agriculture to 1.3 billion kWh. In the remainder of the rural sector, electricity consumption has been reduced by half, from 1.2 billion kWh to 0.6 billion kWh.

Even with electricity generation declining from 46 billion kWh in 1990 to 24 billion kWh in 1996, it might appear that the DPRK could reassign power from other sectors to the rural sector

Figure 5. Irrigation Pumping Demand Represents over One-quarter of Online Generating Capacity in Peak Seasons.



to compensate for the 300 million kWh shortfall in irrigation pumping. However, the key issue is not the total amount of electricity supplied over the course of a year, but rather the peak power required during the period of heaviest demand, namely the irrigation season. Over half of irrigation pumping takes place during the month of May, with power demand during this period at least 900 MW. Total national generating capacity in 1996 was 4.7 GW. With an average capacity factor of 0.65, the average generating capacity online was 3.1 GW. After transmission and distribution losses of 19 percent are accounted for, irrigation pumping demand represents over one-third of all of the DPRK's generating capacity (see *Figure 5*). Moreover, with the national grid fragmented, irrigation pumping might represent an even higher percentage of generating capacity within some generation "islands." Given its very large fraction of total demand, competition with minimum electricity requirements in other sectors such as industry and transportation, and the technical problems of "islanding," high line losses, high power factors, and low reserve capacity, it appears that increasing the power available for irrigation pumping may be very difficult.

The 25 percent shortfall in electricity for irrigation pumping leads to a comparable shortfall in irrigation water provided to crops, decreasing crop yields. A 1998 UN expert mission confirmed that:

> The unreliable water supply is mainly due to unreliable pumping, which is mainly caused by an unreliable electricity supply. . . . Examinations of records at three major pumping stations indicated that they had suffered an average of nearly 600 power failures per year, over 2300 hours per year with no power, an average voltage reduction of over 15 percent . . . and a 10 percent average frequency reduction. . . . The frequent power failures result in considerable waste of water . . . the shortfall in water available to the crops is estimated to be about a quarter of the total requirement.[30]

The main consequence of a 50-percent drop in electricity consumption in the rural residential, household, and commercial sectors is a decline in basic services and quality of life. In rural villages, power is reportedly rarely available to residences during the winter months. Households also experience frequent outages and brownouts during other seasons. Aid workers have reported that clinics and hospitals often have no power available. If it were possible for the DPRK to purchase electricity on the international market—difficult under present circumstances for technical reasons alone—the cost of meeting the 1 billion kWh shortfall, at $0.04 to $0.06/kWh, would be $40 to $60 million. Meeting the shortfall through improvements in domestic supply would probably increase this cost by a factor of two or more, depending on the technology employed.

Coal

The principal use of coal in the rural areas of the DPRK is for cooking and heating. It is the key form of commercial energy for the residential and public/commercial sectors. Households generally use coal in the form of coal briquettes made from coal dust. These are burned in traditional *ondol* stoves, which pipe the hot exhaust gases from cooking fires under the floors of living spaces, providing space heating. The average household is estimated to require 2.6 tons of briquettes per year. The rural sector has a total coal requirement of 3.9 million tons per year.

Coal production in the DPRK is estimated to have fallen by

50 percent between 1990 and 1996, with mines inoperable due to flooding and lack of spare parts, and with coal transportation greatly reduced due to fuel and electricity shortages. The recent annual shortfall of coal in the rural sector is estimated at 1.4 million tons. Because some rural areas have access to local coal mines, coal use in the rural sector is estimated to have declined somewhat less than in the DPRK as a whole. Many rural areas, however, do not have accessible, functioning local mines.

The consequence of the rural coal shortfall is that household coal consumption for cooking, heating, and preparing animal feed has declined on average by 40 percent, to 1.6 tons per year. Given the variability in access, and the difficulty in transporting coal to remote areas, some areas probably consume only a fraction of the average. Where access to biomass as a substitute fuel is also limited, impacts on health and quality of life are probably severe. Public buildings such as schools and hospitals often have limited coal supplies. In some areas, relief workers have reported significant health effects from waterborne diseases, due to the lack of fuel to boil water.

Biomass

Biomass—wood, fiber, and crop wastes—is used heavily in the DPRK's rural economy for fuel, fodder, fertilizer, handicrafts, and building material. Biomass consumption is limited by availability. Nine million hectares of the DPRK are covered by forests, but these are in generally poor condition, with only 3 million hectares classified as productive forests. As a consequence, the DPRK has in recent years imported wood from the Russian Far East on a labor exchange basis.

The dominant use of biomass fuels is for household cooking and heating. In 1990, rural sector biomass fuel consumption was an estimated 22.7 million tons. Since that time, biomass consumption has risen by an estimated 1.3 million tons per year to make up for shortfalls in coal and other fuels. The rise in biomass fuel consumption is cause for concern because of the burden it places on competing uses—such as animal fodder and compost—that in turn impact food supplies. Increased biomass harvesting also impacts rural ecosystems such as forests, streams, and croplands by reducing ground cover, disrupting habitats, and increasing soil erosion and siltation. Additionally, more household time and effort is spent in foraging, at a time when other labor requirements are high and nutritional availability is low.

Rural Energy Crisis and Rural Society

As illustrated above, the DPRK rural energy crisis is actually multiple energy crises—distinct and separate shortfalls of solid and liquid fuels and electricity, each of which affects productive activities and living conditions in different and cross-cutting ways. Shortages are, however, only a portion of the picture, as the extreme inefficiency with which fuel and other resources are often used in the DPRK limits the services that can be supplied.[31] Some of the most serious impacts of combined supply constraints and inefficiency include: lower food production; increased need for human and animal labor; lack of transportation; reduced basic human services; negative impacts on health; environmental degradation; vulnerability to natural disasters; and the continued risk of a new food catastrophe.

Rural society appears to be a stable element within the DPRK, and may even be considered a backbone of the regime. With the ability to revert to traditional modes of production in the absence of modern inputs, rural society as a whole appears to be suffering less from food and material shortages than urban society, and has reportedly even been absorbing some of the unemployed urban population. Traditional social patterns and the authority of functional local leaders such as cooperative farm managers appear so far to have withstood the general economic collapse. However, if supplies of commercial energy to the rural sector were to fall well below the current 20 to 40 percent levels, or are maintained at very low levels for a very long period, the combination of continued low agricultural production, environmental degradation, vulnerability to natural disasters, declining living standards, urban out-migration, and nascent social discontent could destabilize rural society. This is a factor that should be taken into account by those attempting to predict the stability of the DPRK regime, as rural instability could contribute significantly to regional fragmentation and the possibility of civil war.

Rural Energy Profiles: Data Tables for National, County, and Farm Levels

This section summarizes estimates of the rural energy situation for the DPRK. *Table 1* presents estimates of energy and other material inputs into the rural economy, subdivided into agricultural, residential, and public/commercial sub-sectors. (Rural industrial, military, and transportation sub-sectors are not included.) Estimates are presented according to two scenarios, labeled "Crisis" and "Recovery." The "Crisis" scenario represents the current situation. It is based on Nautilus Institute estimates for 1996,[32] with some modifications based on more recent UN reports.[33] The "Recovery" scenario represents a rehabilitated, post-energy crisis North Korean rural sector. It projects reasonable and desirable levels of agricultural inputs and outputs, based on best available data for actual 1990 levels,[34] modified in some cases to reflect recent expert opinion regarding long-term sustainable levels. The numerical difference between Crisis and Recovery scenario figures is shown in the column labeled "Shortfall." These numbers represent the current shortages of different types of energy and other key quantities. Specific causes and impacts of energy shortages for different fuel types and different aspects of agriculture and the rural sector are discussed above.

Tables 2 and *3* provide Crisis, Recovery, and Shortfall estimates for two important sub-national administrative units, namely counties and cooperative farms. The numbers in these tables were obtained by dividing the appropriate quantity in Table 1 by the total number of units at the county (approximately 200) and cooperative farm (approximately 3,000) levels, respectively. As cooperative farms comprise nearly nine-tenths of both rural population and agricultural production, the errors or misrepresentation imposed by using this simple calculation to obtain average figures are small. The resulting numbers in *Tables 2* and *3* illustrate the approximate conditions in average counties and farms; while rough, these figures are nonetheless useful in considering the impacts of the rural energy crisis at different scales, and also in assessing possible energy/agriculture rehabilitation strategies.[35]

Talbe 1. DPRK Rural and Agricultural Energy: National Level

	Recovery Scenario		Crisis Scenario		Current Shortfall	
AG & RURAL STATISTICS						
Farm Population	**6,045,000**	persons	**6,045,000**	persons		
Farm Households	**1,300,000**	households	**1,300,000**	households		
Total Grain Crop Area	**1,370**	kha	**1,430**	kha		
Rice Area	574	kha	580	kha		
Maize Area	496	kha	590	kha		
Other Crop Area	300	kha	260	kha		
Total Grain Production	**6,824**	kt	**3,748**	kt	**3,076**	kt
Rice Production	3,444	kt	1,798	kt	1,646	kt
Maize Production	2,480	kt	1,534	kt	946	kt
Other Production	900	kt	416	kt	484	kt
Rice Yield	6.0	t/ha	3.1	t/ha	2.9	t/ha
Maize Yield	5.0	t/ha	2.6	t/ha	2.4	t/ha
Other Yield	3.0	t/ha	1.6	t/ha	1.4	t/ha
Irrigated Area	**980**	kha	**980**	kha	**0**	kha
Irrigation Water Use	**6.8**	million m3	**5.1**	million m3	**1.7**	million m3
Fertilizer NPK	**750**	kt	**166**	kt	**584**	kt
Bulk Fertilizer	**1,786**	kt	**636**	kt	**1,150**	kt
Human Field Labor	**450**	million hours	**743**	million hours	**-293**	million hours
Animal Field Labor	**30**	million hours	**63**	million hours	**-33**	million hours
ENERGY STATISTICS						
Agriculture						
Oil	**116**	kt	**35**	kt	**81**	kt
Field	61	kt	18	kt	42	kt
Processing	55	kt	17	kt	39	kt
Electricity	**1,693**	million kWh	**1,270**	million kWh	**423**	million kWh
Irrigation	1,231	million kWh	923	million kWh	308	million kWh
Processing	462	million kWh	347	million kWh	116	million kWh
Coal	**333**	kt	**299**	kt	**33**	kt
Biomass	**3,100**	kt	**2,790**	kt	**153**	kt
Rural Residential						
Oil	**20**	kt	**2**	kt	**18**	kt
Electricity	**917**	million kWh	**550**	million kWh	**367**	million kWh
Coal	**3,413**	kt	**2,048**	kt	**1,365**	kt
Biomass	**17,862**	kt	**19,648**	kt	**-1,786**	kt
Rural Public/Commercial						
Oil	**20**	kt	**10**	kt	**10**	kt
Electricity	**303**	million kWh	**121**	million kWh	**182**	million kWh
Coal	**119**	kt	**36**	kt	**83**	kt
Biomass	**1,786**	kt	**1,608**	kt	**179**	kt
Total						
Oil	**155**	kt	**47**	kt	**109**	kt
Electricity	**2,912**	million kWh	**1,941**	million kWh	**972**	million kWh
Coal	**3,865**	kt	**2,383**	kt	**1,482**	kt
Biomass	**22,748**	kt	**24,046**	kt	**-1,298**	kt

Talbe 2. DPRK Rural and Agricultural Energy: County Level

	Recovery Scenario		Crisis Scenario		Current Shortfall	
AG & RURAL STATISTICS						
Farm Population	**30,225**	persons	**30,225**	persons		
Farm Households	**6,500**	households	**6,500**	households		
Total Grain Crop Area	**6,850**	ha	**7,150**	ha		
Rice Area	2,870	ha	2,900	ha		
Maize Area	2,480	ha	2,950	ha		
Other Crop Area	1,500	ha	1,300	ha		
Total Grain Production	**34,120**	t	**18,740**	t	**15,380**	t
Rice Production	17,220	t	8,990	t	8,230	t
Maize Production	12,400	t	7,670	t	4,730	t
Other Production	4,500	t	2,080	t	2,420	t
Rice Yield	6.0	t/ha	3.1	t/ha	2.9	t/ha
Maize Yield	5.0	t/ha	2.6	t/ha	2.4	t/ha
Other Yield	3.0	t/ha	1.6	t/ha	1.4	t/ha
Irrigated Area	**4,900**	kha	**4,900**	kha	**0.0**	kha
Irrigation Water Use	**34**	thousand m3	**26**	thousand m3	**8.5**	thousand m3
Fertilizer NPK	**3,750**	t	**830**	t	**2,920**	t
Bulk Fertilizer	**8,929**	t	**3,180**	t	**5,749**	t
Human Field Labor	**2,250**	thousand hrs	**3,715**	thousand hrs	**-1,465**	thousand hrs
Animal Field Labor	**150**	thousand hrs	**315**	thousand hrs	**-165**	thousand hrs
ENERGY STATISTICS						
Agriculture						
Oil	**580**	t	**174**	t	**406**	t
Field	303	t	91	t	212	t
Processing	276	t	83	t	193	t
Electricity	**8,465**	thousand kWh	**6,348**	thousand kWh	**2,116**	thousand kWh
Irrigation	6,153	thousand kWh	4,615	thousand kWh	1,538	thousand kWh
Processing	2,312	thousand kWh	1,734	thousand kWh	578	thousand kWh
Coal	**1,664**	t	**1,497**	t	**166**	t
Biomass	**15,500**	t	**13,950**	t	**1,550**	t
Rural Residential						
Oil	**99**	t	**10**	t	**90**	t
Electricity	**4,583**	thousand kWh	**2,750**	thousand kWh	**1,833**	thousand kWh
Coal	**17,065**	t	**10,239**	t	**6,826**	t
Biomass	**89,310**	t	**98,241**	t	**(8,931)**	t
Rural Public/Commercial						
Oil	**98**	t	**20**	t	**78**	t
Electricity	**1,514**	thousand kWh	**606**	thousand kWh	**908**	thousand kWh
Coal	**596**	t	**179**	t	**417**	t
Biomass	**8,931**	t	**9,824**	t	**(893)**	t
Total						
Oil	**777**	t	**203**	t	**573**	t
Electricity	**14,562**	thousand kWh	**9,704**	thousand kWh	**4,858**	thousand kWh
Coal	**19,324**	t	**11,915**	t	**7,409**	t
Biomass	**113,741**	t	**122,016**	t	**(8,274)**	t

Talbe 3. DPRK Rural and Agricultural Energy: Co-operative Farm Level

	Recovery Scenario		Crisis Scenario		Current Shortfall	
AG & RURAL STATISTICS						
Farm Population	**2,015**	persons	**2,015**	persons		
Farm Households	**433**	households	**433**	households		
Total Grain Crop Area	**457**	ha	**477**	ha		
Rice Area	191	ha	193	ha		
Maize Area	165	ha	197	ha		
Other Crop Area	100	ha	87	ha		
Total Grain Production	**2,275**	t	**1,249**	t	**1,025**	t
Rice Production	1,148	t	599	t	549	t
Maize Production	827	t	511	t	315	t
Other Production	300	t	139	t	161	t
Rice Yield	6.0	t/ha	3.1	t/ha	2.9	t/ha
Maize Yield	5.0	t/ha	2.6	t/ha	2.4	t/ha
Other Yield	3.0	t/ha	1.6	t/ha	1.4	t/ha
Irrigated Area	**327**	kha	**327**	kha	**0.0**	kha
Irrigation Water Use	**2,267**	thousand m3	**1,700**	thousand m3	**567**	thousand m3
Fertilizer NPK	**250**	t	**55**	t	**195**	t
Bulk Fertilizer	**595**	t	**212**	t	**383**	t
Human Field Labor	**150**	thousand hrs	**248**	thousand hrs	**-98**	thousand hrs
Animal Field Labor	**10**	thousand hrs	**21**	thousand hrs	**-11**	thousand hrs
ENERGY STATISTICS						
Agriculture						
Oil	**39**	t	**12**	t	**27**	t
Field	20	t	6	t	14	t
Processing	18	t	6	t	13	t
Electricity	**564**	thousand kWh	**423**	thousand kWh	**141**	thousand kWh
Irrigation	410	thousand kWh	308	thousand kWh	103	thousand kWh
Processing	154	thousand kWh	116	thousand kWh	39	thousand kWh
Coal	**111**	t	**100**	t	**11**	t
Biomass	**1,033**	t	**930**	t	**103**	t
Rural Residential						
Oil	**7**	t	**1**	t	**6**	t
Electricity	**306**	thousand kWh	**183**	thousand kWh	**122**	thousand kWh
Coal	**1,138**	t	**683**	t	**455**	t
Biomass	**5,954**	t	**6,549**	t	**(595)**	t
Rural Public/Commercial						
Oil	**7**	t	**1**	t	**5**	t
Electricity	**101**	thousand kWh	**40**	thousand kWh	**61**	thousand kWh
Coal	**40**	t	**12**	t	**28**	t
Biomass	**595**	t	**655**	t	**(60)**	t
Total						
Oil	**52**	t	**14**	t	**38**	t
Electricity	**971**	thousand kWh	**647**	thousand kWh	**324**	thousand kWh
Coal	**1,288**	t	**794**	t	**494**	t
Biomass	**7,583**	t	**8,134**	t	**(552)**	t

Rehabilitating the DPRK's Rural Energy System

Benefits of Rural Energy Sector Rehabilitation

Improving the DPRK's rural energy situation is feasible, desirable, and affordable from both humanitarian and geopolitical perspectives. To the extent that improved bilateral relations between the United States and the DPRK allow the process of rebuilding the DPRK's infrastructure to begin, rural energy is a particularly appropriate and beneficial area of initial focus for public and private donors and investors, bilateral and multilateral.

The primary and most direct benefit of rural energy sector rehabilitation would be to restore North Korean agriculture to normal operation. To take maximum advantage of improved energy supply, rehabilitation efforts should be undertaken in tandem with other technical improvements in agriculture as outlined in the AREP (Agricultural Recovery and Environmental Protection) and IFAD (International Food Distributors Association) reports (see notes), such as restoring cropland damaged by flooding, diversifying crops, removing marginal land from production, and developing improved seeds. Nonetheless, as is clear from the reports of international agricultural experts, provision of sufficient energy inputs is the central and most costly element of agricultural rehabilitation. With a secure energy supply available to agriculture, the DPRK would be in a position to produce adequate food for its own consumption, and to eliminate or greatly reduce its need for food aid.

Restoring the energy supply to agriculture would have the collateral benefit of helping to maintain the stability of rural society. As the urban industrial infrastructure has collapsed, rural areas have remained the intact backbone of North Korean society. Village life and traditions remain relatively stable, and local leaders such as farm managers retain a measure of authority based on their functional leadership. Farms have even been able to absorb and feed some of the excess urban population during the present crisis. Nonetheless, the capacity of rural areas to survive continued shortages of inputs, degradation of agricultural ecosystems, and personal privation is probably not unlimited. The rural sector currently has little resilience with which to cope with major new natural disasters, or man-made disasters such as an untimely collapse of the irrigation system. Restoring an adequate rural energy supply can do much to stave off social collapse in the rural areas, avoid dangerous regional fragmentation scenarios, and maintain a societal building block for the future.

On a geopolitical level, rural energy system rehabilitation would present relatively little risk of diversion by the North Korean military, as the amounts and types of energy inputs needed for agricultural and rural consumption do not conform well to military requirements. In the cases where they do, diversion from agriculture could be relatively easily monitored. Rural energy rehabilitation also does little to directly restore North Korean heavy industry and its ability to maintain a high level of military production. Rather, restoring rural energy supplies helps to stabilize the food situation while permitting time for the development of plans for international economic assistance to accompany concrete improvements in the military / security situation. At the same time, restoring the rural energy sector is consistent with different long-term economic reconstruction scenarios, whether along the lines of Chinese-style reforms or a "*chaebol*-ization" model consistent with economic integration with South Korea. It would do so by restoring the food supply to urban workers, stimulating overall reforms of the energy sector, and freeing up rural labor for export-oriented production of light industrial or agricultural specialty products.

From a U.S. perspective, involvement in the relatively low cost, low military-risk task of improving the DPRK's rural energy supply allows the United States to take a substantial initiative rather than leave China by default in the role of long-term guarantor of the DPRK's food supply and principal arbitrator of the DPRK's international relations. At the same time, rural energy rehabilitation in the DPRK offers ample opportunities for bilateral and multilateral cooperation with China, Russia, Japan, and South Korea.

Among the benefits of rural energy sector rehabilitation is the fact that it is *conceivable*. In contrast to the profound conundrums faced in reforming North Korean industry, the energy problems of the rural sector seem, if not necessarily easy to solve in practice, at least conceptually straightforward. There do not currently exist reliable economic statistics for the DPRK, nor a large cadre of international experts with experience there. In this light, rural energy rehabilitation constitutes a very significant but not completely daunting first step toward future economic reconstruction on a national scale. Rural energy rehabilitation lends itself to pilot programs, incremental steps, linkage to experimental reforms, and an initial focus on limited geographical areas. Such approaches allow an opportunity for the collection of realistic data, better assessment of technology inventories, and better estimates of supply and demand. One could argue that rural energy rehabilitation is a necessary step to provide the knowledge and experience baseline for planning the full-scale rehabilitation of the DPRK's national energy infrastructure, which is in turn the key to restoring the entire North Korean economy.

From the perspective of international assistance to the DPRK, rural energy sector rehabilitation is financially feasible. Capital costs will be at least an order of magnitude less than the cost of completely rebuilding the entire national energy infrastructure. On an annual basis, costs will be comparable to the current funding parameters for international food assistance and the Korean Peninsula Energy Development Organizations (KEDO). The reason for the relatively low cost of rural energy rehabilitation is simple. Less than one-third of the North Korean population is rural; rural household per capita energy use is lower than urban household per capita energy use; and the agricultural sector uses less energy than the industrial sector. Quantitatively, in 1990 the rural sector (including the agricultural, residential, and public/commercial subsectors) consumed only 130 petajoules out of a national total of 1,204 petajoules of commercial energy, or 10.8 percent. From the perspective of the shortfalls described earlier, the current shortfall in commercial energy in the rural sector is estimated at 52 petajoules, out of 613 petajoules for the DPRK as a whole, or 8.4 percent.[36] Rural sector energy use is about one-tenth the national total, and, roughly speaking, energy costs will follow this pattern. Some specific cost estimates for rural energy rehabilitation are given below

Elements of a Rural Energy Rehabilitation Program

The main components and costs of a hypothetical rural energy rehabilitation program for the DPRK are outlined below

(*Tables 4* and *5*, and *Figure 6*). The goal of a rural energy rehabilitation program would be to provide the modern energy inputs necessary to allow North Korean agriculture to recover a sustainable production level and the basic needs of the rural population to be met. The priority areas would be those for which energy shortfalls most seriously affect agricultural production, human health, and fundamental quality of life. These areas include maintenance of soil fertility, farm mechanization, irrigation and drainage, and lighting, heating, cooking, and refrigeration for households and essential public institutions such as clinics and schools.

A comprehensive rehabilitation program for rural areas would feature a combination of short- to medium-term energy supplies from imports and medium to long-term capital construction and rehabilitation projects. Components of an import program would include fertilizer, tractor fuel, and electricity at levels sufficient to enable agricultural recovery in the shortest attainable time. The capital construction program would include projects necessary to achieve the sustainable rehabilitation of the North Korean rural energy sector in the medium term (approximately five years). It is possible to outline some of the main elements of such a program: rehabilitation of the rural electricity transmission and distribution grid, development of reliable local

Table 4. Rural Energy Import Requirements (Worst Case)

Energy Type	Need Addressed	Total Requirement	Annual Shortfall	Int'l Price	Annual Cost
Fertilizer	Soil fertility	750,000 tons (NPK)	600,000 tons (NPK)	$300/ton (NPK)	$180 million
Electricity	Irrigation, food processing, lighting	3.0 billion kWh	1 billion kWh	$.05/kWh	$50 million
Fuel	Tractors, small engines	150,000 tons	100,000 tons	$270/ton	$27 million
Coal	Cooking and heating	4 million tons	1.5 million tons	$50/ton	$75 million
TOTAL					$332 million

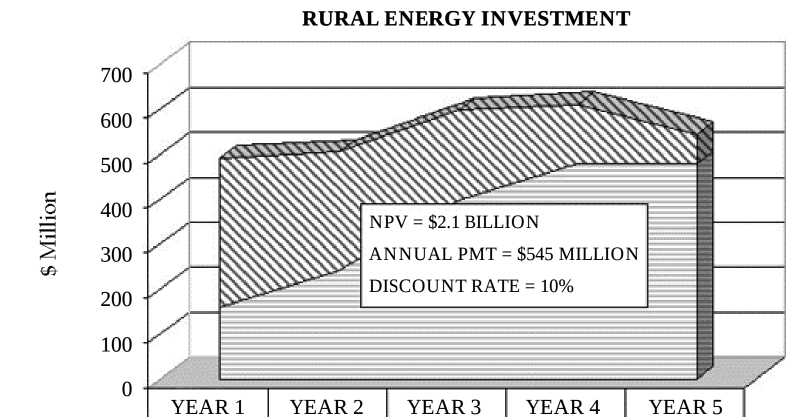
Table 5. Rural Energy Capital Construction Requirements[37]

PROJECT	CAPACITY	NEED	CAPITAL COST
Electrical generation	500 MW	Meet peak demand during irrigation and threshing season	$500 million
Rehabilitate rural T&D system	60,000 km, 3 GVA	Reduce losses, increase reliability	$300 million
Rehabilitate irrigation system	6 million m^3/year	Improve energy efficiency and reliability of water delivery	$250 million
Fertilizer Factory modernization	500,000 ton/year	Increase domestic fertilizer production	$100 million
LPG storage and pipeline system	200,000 ton/year	Electrical generation, transportation fuel, household and public cooking and heating	$250 million
Tractor factory modernization	75,000 tractors	Service and upgrade tractor stock, possibly convert fuel types	$100 million
Improve rural transportation	200 million km-tons	New vehicles, improve roads and railways	$250 million
TOTAL			$1,750 million

power generation, improvements in the energy efficiency of the irrigation and drainage system, modernization of fertilizer and tractor factories, and improvements in the transportation of agricultural inputs and products. Many of these projects have already been proposed in the context of UN-sponsored agricultural reconstruction studies. In *Tables 4* and *5*, below, the costs and financial trajectory of a theoretical rural energy rehabilitation program are explored, using rough estimates based on comparable costs elsewhere in the region.

It is clear that many detailed questions pertaining to the technical specifications and costs of a major investment program, the division of financial burdens between DPRK and foreign

Figure 6. Investment Trajectory for 5-year North Korean Rural Energy Sector Rehabilitation Program, with Costs as Outlined in Tables 4 and 5.



	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5
IMPORTS	332	266	199	133	66
PROJECTS	159	239	398	477	477

Note: Annual costs are given in current-year dollars.

sources, and between public and private capital, the determination of the desirable and achievable balance between energy imports and domestic supplies, and the integration of rural energy sector reforms with the long-term rationalization and reform of the North Korean economy as a whole, must be studied and negotiated at great length. Similarly, analysis of investments in very large energy projects that would potentially benefit not only the rural sector but the entire economy (including the military)—such as interconnection of the DPRK to Northeast Asian regional electricity grids and hydrocarbon pipelines; the construction and rehabilitation of major hydroelectric stations, thermal power plants, coal mines, and oil refineries; and the improvement of energy efficiency in transportation and industry—will require extended and painstaking political and economic analysis. Implementation of such projects will require a much greater level of resolution of outstanding political and military questions than currently exists, and substantial steps toward the integration of the DPRK with the international economy.

These caveats notwithstanding, the approximate economic scale of a rural energy rehabilitation program can be seen in *Tables 4* and *5*, and in summary form in *Figure 6*. This program is based on worst-case assumptions about North Korean import needs and rehabilitation costs. This is useful for setting an upper bound on costs for discussion purposes, but it should be noted that an actual program might be substantially less expensive. *Table 4* describes a program of full import support to make up for rural energy shortfalls, assuming that the DPRK makes no more direct foreign purchases than it does at present. The result is a worst-case import program roughly comparable in cost to current food aid programs, in the neighborhood of $332 million per year. *Table 5* assumes the highest reasonable level of capital costs, based on the idea that many unusual costs would be borne under North Korean conditions. The result is an estimated $1.75 billion in capital investments in current-year dollars. These results are combined in *Figure 6*, which calculates estimated levelized costs based on a five-year program with a declining trajectory for import supports (from $332 million per year in the first year to $66 million per year in the last year), a ramped-up trajectory for capital investment, a 10-percent discount rate, and a five-year payment period. It is assumed that the DPRK assumes all costs following the completion of the five-year program.

Conclusion

In this article we have attempted to describe, in a quantitative (albeit rough) fashion, the manifold difficulties faced by people in the rural DPRK in obtaining energy services. It is clear from our studies that rehabilitating the DPRK's rural energy sector is the *sine qua non* for solving the country's agricultural problems. While international food aid has helped to alleviate the problems of famine and malnutrition, the need to switch from an aid to a development strategy is already past due. International donors, be they states, private concerns, or international financial institutions, need to switch their focus to the rehabilitation of the DPRK's energy, industry, and agricultural sectors. Only then can a sustainable solution to the DPRK's food problems be found, and the development of North Korea truly begin.

NOTES

1. David Von Hippel and Peter Hayes, *Demand and Supply of Electricity and Other Fuels in the Democratic People's Republic of Korean* (DPRK) (Nautilus Institute paper prepared for Northeast Asia Economic Forum, 1997), pp. 15-17.
2. Helen-Louise Hunter, *Kim Il-Song's North Korea* (New York: Praeger, 1999), p. 196.
3. Von Hippel and Hayes, *Demand and Supply of Electricity*, p. 94, A1-1.
4. Ibid., p. 94.
5. Ibid.
6. Ibid., p. 91.
7. Ibid.
8. In the three or so years prior to the publication of this article, some observers have suggested that the combination of food and economic aid to the DPRK from outside, plus internal efforts at economic revival, have resulted in modest improvement in the DPRK economy, at least in some locales. Other observers see a pattern of continuing decline. Nautilus Institute will update its DPRK energy sector analyses in the coming months.
9. Food and Agriculture Organization (FAO)/World Food Program (WFP), *Special Report: FAO/WFP Crop and Food Supply Assessment Mission to the Democratic People's Republic of Korea* (June 29, 1999), p. 4; UN, *DPR Korea: Agricultural Recovery and Environmental Protection (AREP) Program, Working Paper 3: Crops and Agriculture* (1998), pp. 11-26.
10. Ibid. According to DPRK figures provided to FAO, about 20 percent of phosphate fertilizer, and all of potassium fertilizer, were imported. Potassium fertilizer is not produced domestically.
11. FAO/WFP, *Special Report*, p.4; UN, *DPR Korea, Working Paper 3*.
12. UN, *DPR Korea, Working Paper 3*, Appendix 1, Fertilizer Request
13. Peter Hayes, eyewitness account while on a UN Development Programme mission.
14. Von Hippel and Hayes, *Demand and Supply of Electricity*, p. A1-50. Roughly 40 percent is used for feedstock.
15. Urea (46 percent N) is $150/ton. DAP (di-ammonium phosphate, 18 percent N, 46 percent phosphate) is $250/ton. UN, *DPR Korea*, Appendix 1, Fertilizer Request.
16. Ibid., *AREP Working Paper* 2, p. 2.
17. Ibid. and International Food Distributors Association, *DPRK Reconnaissance Mission Report* (1990). The 75,000 workhorse Chollima 28 horsepower diesel tractors are concentrated in the approximately 1.1 million hectares of prime rice and maize land, yielding an average of about seven tractors per 100 hectares.
18. UN, *DPR Korea, AREP Working Paper 2*, Appendix 1, p. 14.
19. Ibid., Appendix 1, p. 11.

20. Von Hippel and Hayes, *Demand and Supply of Electricity*, p. A1-1
21. Ibid., p. A1-2, estimates 35,000 tons (1.5 PJ). UN, *DPR Korea, AREP Working Paper 2,* p. 2, estimates 20 percent of pre-crisis levels.
22. Von Hippel and Hayes, *Demand and Supply of Electricity*, p. A1-9, "Estimated Energy Balance for the Year 1996: Refined Products by Product Type."
23. Ibid., p. A1-34. Military diesel use is estimated to have declined from 200,000 tons of diesel in 1990, to 160,000 tons in 1996.
24. Ibid., pp. A1-7 and A1-9.
25. UN, *DPR Korea, AREP Working Paper 2,* p.2.
26. Ibid., *AREP Working Paper 1*, p. 6. The irrigated area is 980,000 hectares. Ibid., p.14, for a description of the irrigation system, which includes 32,000 pumping stations, 2,000 km of 0.3-1.5 m steel pipe, and over 10,000 km of canals.
27. Ibid., p. 9, for irrigation needs of different crops. These figures are measured at the source.
28. Ibid. Based on actual data for the Pyongnam irrigation district, which contains 10 percent of the total irrigated area of North Korea, and extrapolated to the rest of the country. The average lifting head in Pyongnam is 50 meters, and this is assumed to hold for the rest of the country. Pumpset efficiency is estimated at 69 percent. A large water diversion project now under construction on the west side of the DPRK, the Kaechong-Taesong Lake irrigation canal, is designed to replace some of the irrigation water now pumped from the vicinity of the Nampo barrage with gravity-fed irrigation water from the upper reaches of the river. This diversion project could, when complete, substantially reduce the DPRK's overall electricity requirements for irrigation pumping.
29. Von Hippel and Hayes, *Demand and Supply of Electricity*, p. A1-61.
30. UN, *DPR Korea, AREP Working Paper 1,* p.11.
31. Examples of low-efficiency electricity use in the rural sector in the DPRK include irrigation and rice processing. A comparison of equipment efficiencies for the latter application is provided in a companion article in this issue, "Case Study of a Rural Energy Survey in the Democratic People's Republic of Korea (DPRK): Methods, Results, and Implications."
32. Von Hippel and Hayes, *Demand and Supply of Electricity*.
33. UN, *DPR Korea, AREP Working Paper 3*; FAO / WFP, Special Report.
34. Von Hippel and Hayes, *Demand and Supply of Electricity*.
35. Sources used to calculate the figures shown in Tables 1 through 3 include Von Hippel and Hayes, *Demand and Supply of Electricity*; David F. Von Hippel et al, *Rural Energy Survey in Unhari Village, The Democratic People's Republic of Korea (DPRK): Methods, Results, and Implications* (Nautilus Institute, September 1999); FAO / WFP, *Special Report; and UN, DPR Korea, AREP Working Paper 3*.
36. This does not include the embedded energy value of fertilizer. The

rehabilitation program calls for direct import of fertilizer, until and if North Korea restores its own fertilizer production. If fertilizer were included at its embedded energy value, it would add another 53 PJ, doubling the rural share of current shortfall.

37. Among the options presented in Table 5, the LPG / natural gas pipeline option should probably be considered as a longer-term possibility, with considerable uncertainty as to its technical feasibility and cost-effectiveness. It may be, for example, that provision of LPG in cylinders to supplement household cooking fuels is a more reasonable short-term option.

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THE MANAGEMENT OF ECONOMIC DEVELOPMENT ASSISTANCE IN THE DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA

Thomas F. McCarthy

This article suggests how the Democratic People's Republic of Korea might manage its relationships with the International Monetary Fund and the major multilateral development banks. The DPRK can handle conceptual economic policy formulation and traditional investment planning work better than most outside observers think; but it will need to strengthen institutional competency. Though many observers expect that the DPRK's relationships with international financial institutions will be driven primarily by a process of Korean economic integration, the DPRK's political priorities may well be to use those institutions' resources to increase its range of options by building bridges to China, Russia, and the European Union. The international financial institutions will be better able to help the DPRK deal with the political and institutional dimensions of development if they recognize the potentially constructive role of China. The United States needs to relax its restrictions on the financial institutions' preparatory work in the DPRK if it wants an economic opening to get under way.

Key words: development management, IFIs, NGO, United Nations Development Program

International Cooperation with North Korean Development

This article suggests how the Democratic People's Republic of Korea (DPRK) might manage its relationships with the International Monetary Fund (IMF) and the major multilateral development banks (collectively, the "IFIs," or international financial institutions).[1] It suggests that the DPRK can handle conceptual economic policy formulation and traditional investment planning work better than most outside observers think, but that friction with the IFIs could arise quickly because of institutional barriers to the actual implementation of lending programs. More importantly, uncertain management of new policy initiatives as well as investment projects—and the resulting poor economic performance—could easily undermine political commitment to economic change. Strengthening institutional competency is therefore crucial.

The article also suggests that "development management" should be looked at from a broader strategic perspective than has been used by most "experts" on North Korea. Too many observers expect that the DPRK's relationships with the IFIs will be driven primarily by a process of Korean economic integration. That is not an illogical assumption and it may well prove largely true over time. But it is also necessary to remember that the DPRK may have very different political priorities, particularly in the short term. It may well try to use IFI resources to increase its range of options, both economic and political. This scenario could see the country quite deliberately balancing its "exposure" to a U.S.—and *chaebol*—dominated, post-Kim Dae Jung regime by using IFI assistance to build compensating bridges to China, Russia, and the European Union. This second course is certainly likely if the DPRK continues to perceive the United States, rightly or wrongly, as fundamentally opposed to the Korean "reconciliation" process.

Getting its approach to "development management" right will depend to a good extent on the strategic directions in which DPRK leadership decides to look—or feels compelled to look—for the country's economic future. One approach to working with the IFIs might function well if DPRK leaders look primarily to some form of gradual economic integration with a trusted Republic of Korea (ROK; South Korea) for future growth. Quite another might be more appropriate if they see a strategic need to strengthen ties with non-Korean partners.

As in the case of its fundamental development "strategy" options, the DPRK also is likely to weigh carefully its choices concerning development "management" advice. The IFIs need to be sensitive and flexible in approaching policy management and investment planning activities in the DPRK, particularly during the period when institutions and people are learning to work together. In particular, the IFIs, and their owners, should expect the DPRK to turn heavily to China and possibly Russia for near term counsel. It will take time and patience to build confidence in other sources of economic policy advice, particularly American.

The process of creating the professional and institutional skills needed to support an economic opening, and to build effective working relationships with the IFIs, requires substantial time—years, not months. It should have begun long ago. But the United States, primarily, and Japan as well, have prevented the IMF and the banks from beginning even unofficial preparatory policy studies or basic technical assistance and training work.

These political barriers to institutional development work were aggravated by the United Nations Development Programme's (UNDP) failure to meet its very explicit Geneva promises in 1998 to provide substantial interim technical assistance and training support, a major breach of faith that it has still been unable to rectify. Four years after promising a one million dollar a year technical assistance program, the UNDP still has only one professional expatriate staff member in Pyongyang. Organizations such as the UNDP can play important bridge-building roles under such transitional circumstances if, but only if, they have adequate budgets and are able to attract their best professional staff to assignments in Pyongyang. That has not been the case so far.

The already delayed work on professional training and institutional development issues needs to begin now. With the absence of quick and high quality international support from the IFIs, the UNDP, and other groups, the DPRK may be unable to sustain the sorts of policy initiatives needed to get growth underway, irrespective of whether its policies focus on economic integration with the ROK or on a wider array of strategic economic partnerships. The easiest way to get this process moving is to give the IMF, the World Bank, and the Asian Development Bank (ADB) the same freedom to work in the DPRK that they have in other countries. Preventing them from getting down to business only prevents the process of economic opening from getting started.

Getting IFI Work Underway

Policy management work—removing the most fundamental barriers to growth—obviously will be the first order of business for the IFIs in the DPRK. The DPRK has had ample time to consider the results of economic change in the ROK and in China. It is much better prepared to deal with these issues than most people realize. Agreeing on the outlines of a basic policy framework for a more open economy should not pose a major conceptual challenge if the regime decides that it wants to move in that direction.

DPRK leaders know that they have no real choice but to open up economically. And they very much want to do just that, but on their own terms and at their own pace. Increasingly, DPRK efforts are bearing concrete fruit, with solid prospects of ROK power, transport, and other infrastructure investment; near-certain Russian-sponsored investments in rail and natural gas; and growing interest in infrastructure and natural resource investment opportunities by firms from Australia, Canada, and the European Union countries. For better or worse, U.S. foreign policy priorities have already excluded most U.S. companies from these rapidly emerging opportunities, in the DPRK and probably in the larger region as well.

Some countries or firms obviously will invest at least partly for political reasons. But even the most politically driven economic partners are unlikely actually to make substantial investments until an acceptable policy framework and reasonable institutional safeguards are in place. That work must be the DPRK's next order of business. Major changes in its institutional environment are imperative if it is to attract significant foreign investment. But these "next steps"—real movement toward change—remain in a chicken or egg limbo. DPRK leaders believe, rightly or wrongly, that as long as the United States acts, openly or otherwise, to exclude the country from the IFIs and the wider world of international finance there will be few obvious benefits from major reforms (and few reasons for "informal" dealings with the IFIs). Decision-making about economic modernization therefore remains entangled in the complex and U.S.-dominated process of the DPRK's admission to the IFIs. As long as one does not occur, the other also will not.

U.S. resistance offers the DPRK the nebulous benefit of being able to pinpoint blame, but it does nothing to get things moving. And it obviously does nothing to make life better for the Korean people. The quicker the United States ends its opposition to the DPRK's entry into the IFIs, if only to call the country's bluff, the sooner some sort of institutional and economic change can begin, with all of its predictable and unpredictable consequences.

At some inevitable point, the DPRK will be able to join the IFIs and the work of opening its economy, and its society, can begin. The banks and the IMF have ample practical experience as well as the technical skills needed to offer first-class professional help. The DPRK is certain to welcome such assistance as it seeks its own, almost certainly unique, answers to development policy questions. The IFIs and private financial and legal advisers should readily be able to help it identify enough attractive alternatives to allow a process of sensible decision making about economic modernization to begin.

The DPRK is equally certain to seek wider counsel with regard to the delicate linkages between policy reform and political stability. That stability will always be the overriding constraint on its decision-making.

In this crucial policy management area, in addition to its own resources, the DPRK will turn not only to the IMF and the World Bank but also to the Bank's largest single borrower, the DPRK's oldest friend, and the world champion of regime survival. Both the IFIs and the DPRK should consider themselves lucky that China is also one of the countries that has made the best use of IMF and World Bank policy formulation and management advice and, perhaps more importantly, that China has come to trust both institutions. At the end of the day, then, we can hope that China's policy influence will be constructive as well as possibly dominant. The IFIs also need to listen. It might even prove true that Chinese advice turns out to be as useful to them as to the DPRK.

This is not the moment for hypothesizing about the specifics of the DPRK's likely first steps toward policy reform. The DPRK's economic problems are profound and, in a sense, almost "crude." However, at least at the beginning, policy work clearly will not require economic rocket science. A long series of hard but doable tasks need to be addressed and completed. Authority over fiscal and monetary policy must be clarified. Prices and wages must move to something close to border levels. Interest rates must be rationalized. Basic statistical information must be gathered and analyzed. International banking ties must be established. The population must be prepared for the disruptions and suffering that will accompany change. These are essentially the same predictable "sticks and stones" rituals followed by all of the centrally planned economies.

Infrastructure Modernization

Infrastructure modernization needs to get underway quickly, not as an end in itself, but as a *sine qua non* condition for attracting private sector investment of any sort, whether foreign or domestic. The DPRK needs immediate and major investments in power, transport, communications, and, probably, irrigation infrastructure. To some extent the international banks can condition lending for infrastructure on the adoption of agreed economy policy measures, but "total" success seems unlikely for two different sets of reasons.

First, infrastructure in North Korea has deteriorated to the point that rehabilitation work simply can no longer be delayed. There is little time or room for "policy dialogue." Even the best economic policies won't work with the severe infrastructure constraints now encountered in the DPRK. Second, many infrastructure investments in the DPRK are so intrinsically attractive that regional investors and lenders are likely to go forward irrespective of "policy perfection." The obvious money-making opportunities intrinsic in linking Japan and Korea to China and

Europe by rail, of selling natural gas and other natural resources to Seoul, and of rebuilding the original regional hydropower grids are—almost alone—enough to get infrastructure investment going in the DPRK.

As in the case of economic policy formulation, both the ROK and China can offer many “lessons not to be learned again.” It is important to remember that both countries have confronted essentially the same problems that are now facing the DPRK. The DPRK can draw its own conclusions about what has gone well and what has not. It will have a strong basis for doing so because the experiences of both countries have been so extensively documented and analyzed by development economists. With regard to near-term infrastructure and investment promotion issues, it seems particularly relevant to recognize that neighboring parts of China face many of the same industrial policy and infrastructure modernization challenges as the DPRK, and that many of these common problems, including power, may be susceptible to cooperative solutions.

As anyone who has visited Pyongyang knows, DPRK managers and engineers are not at all unfamiliar with the execution of traditional infrastructure projects, economically sound or otherwise. The country has already been totally rebuilt once with “foreign aid.” The Soviet Union and its European allies always had major industrial and infrastructure investment programs, in all sectors of the North Korean economy. China also has long supported the DPRK and continues to be by far its largest international “donor.” Its border provinces and nearby industrial centers offer obvious opportunities for early economic cooperation.

The DPRK has demonstrably powerful planning and management capabilities. Things get done, however inefficiently and cumbersomely. At least at the beginning, when fine-tuning will not be called for and while their “entrepreneurial spirit” is still building, most North Korean government agencies will be able to meet their commitments to IFIs. This may not represent the politically correct approach to development, but we need to remember that the IFIs loved these sorts of government capabilities just fifteen years ago.

Finally, we should remember that the DPRK once saw itself as a development aid player, with numerous assistance projects in Africa and elsewhere. Without getting into the effectiveness of these endeavors, they created a substantial cadre of officials with practical experience in the management of the more basic sorts of development assistance efforts.

Managing IFI Relationships

The key challenge for the IFIs in the DPRK, and everywhere else, will be to help develop a sound institutional framework for development. Work in the DPRK will be much more challenging than in the more open centrally planned countries. Freeing up communications and transportation to allow commerce to grow, loosening controls over factories and cooperatives, opening more markets, and establishing more transparent legal regimes are all examples of the sorts of profound institutional changes that the government must be willing to risk if policy initiatives and new investments are to have an impact. The DPRK's ability and willingness to pursue these sorts of adventures will depend very largely on internal political factors over which donors will have little control or, probably, even understanding.

The IFIs need to be extremely careful and sensitive in proposing institutional models for development policy management. They need to remember that what is now the DPRK has never had substantial dealings with "Western" development institutions, and that its own institutions are rooted in traditions that pre-date the Japanese invasion and the beginning of industrialization. There will be no "returning to" or resurrecting anything that is likely to be relevant to IFI-guided economic development experiences. The DPRK is not East Germany or even China. No other centrally planned economy was nearly as isolated. The IFIs will have to take great care in extrapolating from their experiences in other settings. They will have to accept things as they are. In particular, the will need to adapt to carefully-separated, "stove-piped" communications systems requiring substantial time for decision making and using quite rigid management and control systems. (The extent to which potential private sector investors, able to put their money in any country they choose, will accept these constraints is another question entirely.)

The DPRK is unusual in other ways as well. Because it has had diplomatic relationships with only a few Western countries, official bilateral aid agencies as well as the IFIs have never been present in Pyongyang. Instead, the “development community” presence over the last five or so years, or since about the beginning of the “natural catastrophes” and openly recognized food shortages, has consisted largely of the WFP and its staff, smaller contingents from other UN agencies, and a changing collection of resident and non-resident nongovernmental organizations (NGOs). Even taken together, these official and NGO organizations provide nothing approximating meaningful economic development assistance, in terms of professional skills, resource transfers, or anything else. At the wildest stretch of the imagination, the total amount of actual development investment—concrete resource transfers for productive investment—hasn’t come to more than a few million dollars a year (especially when any possible “food-for-work” development impacts are left aside). Simply put, aside from Chinese and (more recently) ROK fuel and fertilizer support and modest IFAD (International Food Distributors Association) lending in agriculture, the DPRK has not received any substantial development assistance from any country in well over ten years.

The long and short of this is that the small number of DPRK officials with experience that could be useful in “development management” have instead devoted their time and intellectual energy to food aid management work, to relationships with under-funded and understaffed UN agencies, and to firefighting to prevent NGO problems from undermining diplomatic relationships with Europe and the United States. None of their skills or efforts has been bought to bear on practical economic development work.

The DPRK has sought assistance to deal with its predictable institutional problems since at least 1998, with almost no response from the international community. Continued delays in building the professional and institutional skills needed to address these barriers to economic change are now needlessly but certainly inevitable. Those delays, in turn, will, again needlessly, slow the pace of change and probably undermine the status and influence of the technocrats who have been supporting a more open economy.

Neither the DPRK nor the international community has much time left if these institutional tasks are to be addressed before the country has to confront the practical challenges of managing official development assistance. The UNDP is probably the only realistic "platform" for such an effort. After more than four years of promises, the UNDP in Pyongyang has been unable to marshal even minimal professional staff or budget resources. Nevertheless, there are no obviously attractive alternatives to UNDP assistance if the DPRK and the donor community want to be ready to support near-term IFI policy work and lending. Donors need to decide very quickly either to provide adequate and very early support for a dramatically revitalized UNDP program or move toward other possible alternatives such as European Union assistance or direct, and costly, execution by the World Bank and the IMF. The longer they wait, the harder and riskier it will be to support DPRK efforts to open its economy.

In sum, the DPRK should be able to handle initial IFI policy formulation and investment planning work quite adequately. Institutional weaknesses will make practical implementation difficult and possibly undermine political support for economic modernization. The IFIs will be better able to help the DPRK deal with the political and institutional dimensions of development if they recognize the potentially constructive role of China. The United States needs to relax its restrictions on IFI preparatory work in the DPRK if it wants an economic opening to get under way. And the donor community needs to either provide quick and significant support to recently initiated UNDP efforts to improve its performance in the DPRK or choose another "platform" for its assistance efforts.

NOTES

1. An earlier version of this paper was presented at the August 26-28,2001 "Conference on North Korea in the World Economy" sponsored by the Korea-America Economic Association and the William Davidson Institute at the University of Michigan School of Business.

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NGO ENGAGEMENT WITH NORTH KOREA: DILEMMAS AND LESSONS LEARNED

Timothy Savage and Nautilus Team

This article explores the dilemmas that nongovernmental organizations in particular face in dealing with North Korea, considering both the experience of international aid workers in responding to other emergencies, and the peculiar aspects of working in the so-called "Hermit Kingdom." Some of the dilemmas of working in North Korea are common to complex emergencies, while others are due to the unique characteristics of the Korean situation that challenge the prevailing assumptions and modes of operation of international aid workers. The relations between the problems of North Korea's economic development and the international political situation surrounding the Korean peninsula are discussed, along with some lessons that can be learned from the Nautilus Institute's experiences in working on renewable energy issues in the North. Engagement of North Korea, the article concludes, is a long-haul process that is necessary to promote reconciliation and build peace on the Korean peninsula.

Key words: development projects, humanitarian aid, NGO, U.S.-DPRK relations

The DPRK Crisis as a Complex Emergency

The decision of the Democratic People's Republic of Korea

(DPRK, North Korea) in 1995 to accept outside food aid from its putative enemies ushered in a fundamental transformation of North Korea's relations with the outside world. Since that time, North Korea has struggled with the inherent contradictions of trying to maintain its unique political system while simultaneously expanding its horizons beyond the coterie of nations with which it has traditionally maintained relations. There have been some notable successes, including the historic North-South Summit in June 2000 and the DPRK's successful normalization of relations with all nations in the European Union except France. Nonetheless, the relationship of North Korea with the outside world continues to be a matter of constant negotiation. This article explores the dilemmas that nongovernmental organizations (NGOs) in particular face in dealing with the DPRK, considering both the experience of international aid workers in responding to other emergencies, and the peculiar aspects of working in the so-called "Hermit Kingdom."

Dilemmas of Working with North Korea

In recent years, the international aid community has increasingly been called on to respond to "complex emergencies"—situations of multi-sector collapse, usually with a variety of causes, such as natural disasters, political strife, and economic mismanagement. International aid workers face numerous dilemmas in these emergencies. Should aid workers profess solidarity with the victims of hunger, or remain neutral and focus on alleviating suffering? Should they limit themselves to emergency aid, or promote development to prevent future famines? Should they only work with the most disadvantaged members of the population, or is it acceptable to engage the ruling classes if doing so can help foster overall improvement?[1]

Some of these dilemmas crop up when working in North Korea. At the same time, North Korea has unique characteristics that challenge the prevailing assumptions and modes of operation of international aid workers. In most recent famines, aid workers have confronted active military conflict, political chaos, or both. In contrast, the DPRK government remains firmly in control of the country, despite continuing prognostications of its imminent collapse. Rather than an active clash, the Korean peninsula is caught up in a fifty-year old cold war across a euphemistically named "Demilitarized Zone (DMZ)." Instead of whether to take sides in a civil war, humanitarian workers in North Korea face the dilemma of whether aid is helping to prop up a government that many find distasteful to the extreme.[2]

The DPRK's ruling philosophy, *juche*, is often translated as "self-reliance," but it is perhaps more easily understood as the opposite of *sadaejuûi*, "serving the great"—a frequent practice throughout Korean history whereby certain factions in the ruling class enhanced their domestic political power by seeking alliance with outside powers, usually China. According to this viewpoint, Korea's tragic experiences during the twentieth century—colonization, division, war, and even the recent famine—were imposed upon it by outside powers that sought domination over the peninsula and by their Korean lackies. In North Koreans' eyes, South Korea, with its historic ties to Japanese collaborators and its military dependence on the United States, represents the continuance of *sadaejuûi* on the peninsula. This historical understanding helps account for the distrust that North Koreans show even toward those foreigners who profess benign intentions. Americans in particular are regarded as "wolves," with North Koreans being the prey.

It is therefore not surprising that DPRK officials and international aid workers have frequently clashed over the issues of access and monitoring. As a report by the Relief and Rehabilitation Network noted, DPRK officials "understand the necessity to monitor aid donations but suspect that they are being asked to accept donations for the purpose of monitoring."[3] In some instances, disputes over monitoring have led international agencies to pull out of the DPRK altogether, most notably the French-based medical aid group Medecins Sans Frontieres (MSF, Doctors Without Borders).

At the heart of the monitoring issue is the accusation that the DPRK may be diverting aid for military use. Some critics of aid to the DPRK have cited testimony from DPRK refugees in China that they never received aid as evidence of such diversion.[4] This criticism, however, ignores a simpler explanation. The World Food Programme limited food aid recipients to children under 15, pregnant and nursing women, the elderly, and adults in "food for work" programs. Most refugees do not belong to one of these populations. It is also important to understand that the usual civilian-military dichotomy does not reflect well the reality of North Korea. Anyone who has visited the DPRK has seen uniformed men and women building roads and harvesting crops, while farmers without alternative means of transportation hitch rides on the backs of military trucks. Under the rubric of the "military-first policy," the DPRK has created a society where the line between military and civilian has been blurred beyond the point of being a relevant category for analysis.

Still, critics argue that humanitarian aid to the DPRK only helps to prolong the regime whose policies led to famine in the first place. Fiona Terry of MSF stated in an article in the *Guardian*, "By channeling [food aid] through the regime responsible for the suffering, it has become part of the system of oppression."[5] Norbert Vollertsen, a volunteer for German Emergency Doctors who was expelled from North Korea for criticizing the regime, has been active in arguing that the DPRK government should not be engaged as long as it continues to violate human rights.[6] A similar argument is made by what might be called the "collapsist" school of DPRK-watchers in Washington and Seoul. According to this view, the DPRK government is a Stalinist anachronism that is doomed to fall, and prolonging its existence by providing it with humanitarian aid will only lengthen the suffering of its people and increase the economic disparities between the two Koreas.[7] A corollary to this argument holds that aiding the DPRK allows it to spend a huge percentage of its GNP on its military so that it can continue to threaten South Korea, the United States, and their allies.

The Case for Continued Engagement

Given the DPRK's emphasis on regime survival and military security, however, there is little reason to believe that North Korea, if deprived of food aid, would divert resources from spending on weapons systems to feeding its populace. Instead, the withdrawal of food aid would only increase the suffering of the most vulnerable populations—the old, the sick, and young children. Facing this Hobson's choice, aid agencies have made the correct decision to focus food aid on these groups, rather than undertaking a quixotic quest to force the DPRK government to change its military policy. By engaging the DPRK in a way that forces the government to adhere to international norms, on the other hand, there is a chance of affecting long-term change in the country.

History offers few if any examples of authoritarian governments being brought down by famine conditions, although the opposite—famines being brought about by the collapse of a government—is frequently the case. It is also worth noting that pundits have been predicting the imminent collapse of North Korea for over a decade.[8] Withholding aid to North Korea would not guarantee the collapse of the government, but it would undoubtedly increase the suffering of the populace. It is also important to remember that while the international community provides aid to the DPRK's people, the most important source of government-level aid is China, which has its own political reasons to continue to support North Korea regardless of what the rest of the world chooses to do. The ability of Western governments to force the end of the DPRK regime through anything short of military action is quite limited.

Even were the withdrawal of aid to cause the regime to collapse, the consequences of this collapse are uncertain and risky. Possible repercussions include massive flows of refugees to China, Japan, and / or South Korea; a military coup by hardliners in the DPRK; and even a second Korean War, with the probability of casualties in the millions. Engaging North Korea with the goal of preventing war and building peace on the Korean Peninsula is the more responsible course. Former U.S. Defense Secretary William Perry recognized as much when he noted in his policy review for the Clinton administration that the U.S. needed to "deal with the North Korean government as it is, not as we might wish it to be."[9]

NGOs working in North Korea also face the dilemma, familiar to many humanitarian situations, as to how much they should be seen as supporting the policies of their own governments. This is especially the case for U.S. NGOs, which often have closer cooperative relations with the government than their counterparts in other countries, such as France.[10] Allying with government in pursuit of humanitarian ends is not a problem in and of itself, but NGOs must be careful to retain a degree of independence. U.S. food aid policy often has as much to do with domestic agricultural price support as with famine relief or even foreign-policy considerations. While the Nautilus team was at Nampo, we met some other foreigners who were cleaning and bagging the food aid coming into the DPRK. They described the grain provided by the United States as full of dirt, twigs, dead mice, and feces—basically the detritus at the bottom of the silo. If nothing else, NGOs involved in helping the United States provide food aid to North Korea could do a better job in pushing for quality control.

U.S.-based NGOs also must be cautious about being seen as agents of the U.S. government due to the general DPRK distrust of American intentions. It is probably not an exaggeration to say that some elements within the DPRK government view all foreigners as potential spies. Those DPRK agencies that actively collaborate with Americans and other foreigners on cooperative development projects face potential criticism from within the DPRK, something that the foreign aid community should always bear in mind when trying to push DPRK counterparts in directions that they may be reluctant to head. At the same time, NGOs have served a valuable role in helping the U.S. government to better understand the DPRK's views, which is especially important given the limited amount of government-to-government contact between the two countries. Indeed, many NGOs have felt that their DPRK counterparts tolerated them only because of the access that they were seen as providing to one or another branch of the U.S. government, although that has not been the Nautilus Institute's experience.

Unfortunately, the downturn in U.S.-DPRK relations since President George W. Bush took office has greatly hampered the ability of NGOs to engage North Korea. The DPRK has cited the negative relations between the two countries as justification for canceling some private exchanges. For their part, U.S. foundations have reduced their funding for NGO engagement with North Korea, apparently believing that the money will be wasted unless the Bush administration decides to change its stance. Both sides are missing the point. It is precisely because government-to-government relations between the U.S. and the DPRK remain at a standstill that nongovernmental exchanges retain such a high degree of importance. All those involved—funders, NGOs, and the North Koreans themselves—must remember that building peace after fifty years of division, war, and confrontation requires long-term commitment and endurance.

The DPRK Food Crisis and Korean Division

The DPRK's situation is unique among cases of complex emergency in that North Korea constitutes one half of a divided nation. Many South Koreans view aid to the North as a gesture of brotherhood. The current ROK government of Kim Dae Jung has made clear that it expects North Korea to continue with its present government for the foreseeable future, and has focused its "sunshine policy" on putting economic cooperation ahead of political discussions. Although not immune from donor fatigue, South Koreans have a perspective on the DPRK situation that is very different from others involved in the relief effort. Whereas international aid workers understand the DPRK's situation in terms of their experience in responding to humanitarian crises globally, South Koreans often explicitly relate food aid to how it will affect national aspirations for reunification. Perhaps not surprisingly, these different perspectives have led to tensions between the international aid community and ROK NGOs, as was evident at an international conference on humanitarian aid to North Korea held in Seoul in June 2001. Should the ROK agenda be given priority in dealing with the DPRK crisis, or should developmental professionals with long international experience be allowed to take the lead in deciding the best way to respond to the DPRK food situation?

On the one hand, international aid professionals must take into account the nationalistic aspirations of the Korean people. More than the rest of the international community, South Korea has a major political incentive to remain engaged in aiding North Korea over the long haul to prevent war and promote national reconciliation. Reducing the social and economic costs of eventual reunification will require developing the North's economy to reduce the disparities with the South. Koreans on both sides of the DMZ will have to deal with the consequences of development attempts long after international aid workers have returned to their home countries or shifted their focus to other crises.

At the same time, South Koreans must realize that brotherly feeling toward their northern counterparts does not erase five decades of bitter competition. Although it may well be true that all Koreans seek reunification at some level, the DPRK and ROK views of what a reunified Korea will look like still have not converged.[11] Certainly, North Korea does not envision reunification coming about through the disappearance of the DPRK state, as many South Koreans do. If South Korea is really committed to the continued existence of North Korea, it must accept that developmental decisions should be made based on current DPRK realities, rather than on ROK priorities for reunification. The two nuclear reactors being built under the 1994 U.S.-DPRK Agreed Framework is a good example of this problem. As a condition of its support for the Framework, South Korea insisted that the reactors be the so-called "ROK standard" ones, despite the difficulties in integrating that model reactor with the DPRK electric grid.[12] Such shortsighted decisions reflect a belief, widely shared at the time, that North Korea would collapse and the reactors would become ROK property before they were ever completed. South Koreans also must accept that international aid agencies and NGOs will continue to play a vital role in the DPRK's development. Not only do they bring their developmental expertise and international standards to the Korean problem, but they are also less politically threatening to the DPRK than their South Korean counterparts.

Cooperative Development in the DPRK: Lessons Learned

At the Third International Conference on Humanitarian Aid to North Korea, participants agreed that the focus must shift from emergency food aid to development. In doing so, questions of monitoring will be replaced by other, in some ways more intractable, dilemmas. Is it possible to foster development according to international standards in a country like the DPRK which, relying on the doctrine of self-reliance, restricts the activities of foreign aid workers? Should developmental decisions be made based on the wants and needs of North Korea, or will they be subjugated to the international political situation surrounding the peninsula? How can NGOs play a constructive role in such a complex situation?

Prior to the start of the Nautilus Institute's wind power project in 1998, most U.S. NGOs had been restricted by both the U.S. and DPRK governments to food aid delivery. The Nautilus project was thus among the first to focus its efforts on a cooperative development project that involved North Koreans and Americans working side-by-side. Although small in scale, it was hoped that the project, if carried out successfully, would help to focus attention on the DPRK's energy problems as a major cause of the DPRK's food shortages, help prepare North Koreans to accept international development aid, and demonstrate that cooperative engagement with the DPRK is possible.

With U.S.-DPRK relations at a standstill following President George W. Bush's designation of the DPRK as part of an "axis of evil," it seems unlikely that much developmental aid will be coming from the United States in the near future. U.S. donors are wary of aiding the DPRK in the post-September 11 political climate, while for its part the DPRK will not allow groups from countries with which it does not have relations, such as the United States and South Korea, to set up resident offices in the country. Therefore it is likely that any developmental aid in the short-term will have to come from other sources, such as Canada and the European Union. Although these groups may find themselves regarded somewhat differently in North Korea than their American counterparts, they would do well to take heed of some of the lessons learned from NGO projects such as ours.

Keep It Small

There is a tendency that appears common to both halves of the Korean peninsula to favor large-scale, grandiose projects, such as the Mt. Kumgang tourism project started by Hyundai Corporation. Although bigness can sometimes result in impressive accomplishments, the larger the project, the higher the chance for failure, and the longer it takes to see tangible results. It should be kept in mind that cooperative engagement is still very much of an experiment in the DPRK, and the success of a given project is vital to overcome the initial skepticism in both the DPRK and donor countries.

The first phase of the Nautilus-KANPC (Korean Anti-

Nuclear Peace Committee) project cost $250,000 and took six months to begin delivering services. The success of the two missions in 1998 has allowed Nautilus to continue its relationship with its DPRK partners and expand it to other fields beyond the village project, including involving them in multilateral discussions on Northeast Asian energy issues. More than three years later, the wind turbines stand as a visible example that cooperation between Americans and North Koreans is indeed possible.

Safety First

One of the biggest difficulties that Nautilus has encountered in working in North Korea is the very different safety culture that prevails in the United States compared with the DPRK. American engineers are used to working according to worst-case scenarios—preparing for any contingencies, however unlikely, to avoid failure and minimize hazards. North Koreans, however, tend to focus on speed in construction projects, trusting in their ability to deal with the consequences should something go wrong. Where Americans tend to rely on legalistic and bureaucratic means to prepare themselves in case something goes wrong, in North Korea decisions usually take on a political and personal cast. We have asked unsuccessfully on several occasions for a copy of the DPRK's liability regulations, and have been forced to conclude that they probably do not exist.

One example in particular illustrates this difference of approach. A tense moment arose when the Nautilus engineers could not come to an agreement with their DPRK counterparts over how to ground the lightning rods for the towers. The North Koreans felt that their competence as engineers was being called into question, and insisted on doing things their way in their country. The solution finally had to be hammered out in a one-on-one session between the heads of the two delegations. Peter Hayes, the Nautilus Executive Director, finally impressed on his counterpart that should someone be accidentally killed by one of the towers, we would be blamed and future U.S.-DPRK cooperative engagement would endangered. We won our point, and our emphasis on safety has prevailed since. We take great pride that we have now pulled off three missions without any injury more serious than a minor scrape.

Always Follow Through on Commitments

Many times, NGOs working in a situation such as North Korea's, where the political tension is so high, do not adequately consider the risks that their counterparts are taking in working with them. Once-off projects do little to break down barriers or build relationships, and can damage the credibility of proponents of engagement in both countries. We have always relied on a memorandum of understanding as the basis for the project, spelling out what we would do and what we expected of our DPRK counterparts. While not a panacea for solving all disputes, it has proven useful to be able to point to prior written agreements when our partners have tried to make sudden changes in the project.

Our continuing commitment is especially important for the people of Unhari village where we worked. While some NGOs have complained of their lack of access to the local population, in our case the villagers have been intimately involved in the project. We interfered with their lives, trampled up their cabbage fields, came into their houses, ate their food, and utilized their labor. In exchange, we needed to show them that we were not going to walk away once the initial work was completed. Our commitment has had a noticeable effect on the villagers' reactions to us. In the first mission held in May 1998, the tension at the initial meeting was palpable. By the third mission in September 2000, the mood had changed to one of a reunion among old friends.[13] Ultimately, the personal relationships built in this kind of project can go a long way to helping to break down the barriers caused by longstanding enmity, at least in our experience and among our contacts.

Don't Underestimate Local Concerns

The United States stereotypes the DPRK as a top-down, centralized country where all directives come from Pyongyang. In our experience, however, local concerns have played a major role in determining the direction of the project. After we had installed the wind turbines and left the village, the villagers removed the kindergarten and the clinic and hooked up forty more households to the system. This was not a wise decision from a technical standpoint and will probably shorten the life span of the system; but it was an understandable response to local interests, as it gave more villagers a personal stake in the success of the project. Interestingly, shortly after the villagers took their action, the farm manager retired and moved into one of the houses on the block served by the wind power system. Was the farm manager playing a form of local politics, using the additional hookups to “buy off” constituents who might otherwise grumble about an apparent abuse of power? Such experiences are not uncommon in village-based development projects, as aid workers must often decide whether the intrinsic value of a project justifies moving forward despite the possibilities that local actors will manipulate it for their own ends.[14]

Regardless, projects must maintain some flexibility to respond to legitimate local concerns. On the third mission, based on months of planning with our counterparts in Pyongyang, we brought a water-pumping windmill that had been designed for irrigation use. At the initial meeting with the villagers, however, they determined quite quickly that the amount of water pumped would not make a significant difference in their irrigation needs, and that therefore it would make more sense to use the windmill to supply drinking water during times when the diesel pump was unavailable due to lack of fuel. Seeing the sense in this decision, we worked creatively with the villagers to re-jigger the equipment to fit their needs. The lesson of this experience is that one-size fits-all projects are rarely successful in responding to local conditions, and adjustments often have to be made on the fly.

Adhere to International Standards

Ultimately, a project like the one at Unhari makes only a very minor dent in the DPRK’s energy needs. Its real value is as a demonstration of the DPRK’s ability to receive international development aid on a larger scale. Much of this involves getting the DPRK to adhere to international standards and practices. The household energy use survey at Unhari, described elsewhere in this volume, is one example of many instances in which we have provided our DPRK counterparts with training on international standards. We also organized a workshop at the

University of California, Berkeley with experts from Lawrence Berkeley National Laboratory, the World Bank, and others. We took a delegation of DPRK energy specialists to the Washington to visit the World Bank and the U.S. Department of Energy. We have trained North Koreans in Long-Range Energy Alternative Planning software as one of the countries participating in the East Asia Energy Futures project.[15] The North Koreans who have received this training will be well-positioned to cooperate with international institutions should the barriers to their involvement in DPRK development be removed.

Training, Training, and More Training

If there is one thing that the DPRK is eager for, it is training of all kinds and in all fields. While we have found DPRK engineers to be extremely quick learners and well-versed in basic principles, they have had little access to the latest technological advancements and are keen to learn as much as possible about the newest kinds of renewable energy technologies. We have implemented training at all levels, from on-the-spot guidance in the village, to field trips to renewable energy sites in the United States and China, to more formalized workshops and seminars at the University of California and elsewhere. This is one of the biggest costs of the project; it takes two to three times as long to explain every step of the construction to our DPRK counterparts as it would for us to simply install the equipment ourselves. The long-term payoff, however, will be increased North Korean ability to address their energy problems through their own efforts.

Collaboration is a Two-Way Street

One of the advantages that a cooperative development project in North Korea has over an aid delivery project is the level of direct DPRK involvement required. For the project to work, ultimate ownership must devolve to the people who are going to utilize the equipment. Rather than simply transferring goods to them, we insisted that our DPRK partners provide planning, labor, and materials to the project. As many aid professionals have pointed out, providing one-way aid not only fails to deal with the long-term development issues that are crucial to over-coming the crisis; it can actually undermine the social developments that are necessary to create the solutions to the problem. Aid recipients become dependent not only on the donations, but also on the official distribution system. Innovative methods of crisis management are undermined. Now in the sixth year of the DPRK's food crisis, it is past time to start moving away from food aid and toward more development projects, a point made time and again by the aid workers who attended last year's international conference on humanitarian aid to the DPRK.[16]

Conclusions

Moving from food aid delivery to development will be an extremely difficult political task. Preventing starvation is one thing, but promoting the rebuilding of a regime that many consider odious and dangerous is quite another. The United States, South Korea, and Japan are not going to support large-scale improvements of the DPRK infrastructure without a lessening of military tensions and improvement in political relations. It is notable that whereas WFP appeals for food aid for the DPRK have often been exceeded, United Nations Development Programme appeals for rehabilitation aid have been mostly ignored.[17]

Ultimately, no progress can be made without an improvement in U.S.-DPRK relations. Although it is unlikely that the United States would provide a great deal of direct developmental aid to North Korea, Washington's veto over lending to the DPRK by international financial institutions remains a barrier that prevents the DPRK from receiving developmental funds. It is also highly unlikely that Japan will move ahead of the United States in improving relations with North Korea. South Korea alone cannot bear the financial burden of supporting North Korea. The European Union (EU) will probably become a more important donor following its recent normalization of relations with the DPRK, but the lack of any proximate security concerns for Europe on the Korean peninsula brings into question the EU's staying power should progress remain slow and potential for profits small. Whether the EU would be willing to help the DPRK if doing so flies in the face of U.S. policy is another question that remains to be answered.

Even before the September 11 terrorist attacks, George W. Bush had not placed improvement of relations with the DPRK high on his agenda. The summit meeting between Bush and Kim Dae Jung shortly after the former took office was widely considered a disaster in ROK policy circles, as disagreements both between the allies and within the Bush administration were made public in often embarrassing ways. The administration then announced a review of policy toward the DPRK, which while perhaps a necessary step for a new administration did ensure that no progress could be made for a few months. When Washington finally agreed to the concept of renewing talks with the DPRK, it insisted on adding the issue of the DPRK's conventional forces to the agenda, while simultaneously refusing to discuss the possibility of U.S. troop withdrawal from the ROK. Not surprisingly, the DPRK did not jump at this opportunity.

In the aftermath of September 11, Bush's now infamous State of the Union Address, in which he termed the DPRK part of an "axis of evil," leaves little prospect for a rapid improvement in U.S.-DPRK relations. While interpretations that Bush's speech increased the likelihood of U.S. military action against the DPRK were incorrect,[18] the statement does signal some trends in U.S. policy that will be difficult to overcome. First is that the United States is clearly clinging to the policy of "benign neglect," continuing to send food aid and adhere to the Agreed Framework, but unwilling to expend any political capital to improve relations. This can be seen in the frequency with which President Bush peppers his calls for resumption of dialogue with personal insults against DPRK leader Kim Jong Il.[19] Second, the speech shows that the nonproliferation experts, who tend to favor uniform approaches to the challenges posed by weapons of mass destruction, currently hold sway in the administration, while the regional experts, who usually take a more nuanced approach toward engagement, have very little influence on policy.

The status quo of militant containment, while it has thus far been effective in preventing a second Korean War, cannot be the basis for a sustainable peace. The ongoing military confrontation on the peninsula is both costly and dangerous, and is the root cause of the DPRK's efforts to develop weapons of mass destruction and the means to deliver them. Ultimately, the division of Korea seems too much of a historical anomaly to ever fully stabilize, so it is highly likely that one way or another Korea will eventually be reunified. How this comes about is crucial to the well-being of the 40 million Koreans and their neighbors. A war would probably result in the destruction of the DPRK regime and unification under the ROK government; but it would cost millions of Korean live and tens of thousands of U.S. casualties, and it could potentially spread to China, Russia, and Japan. A sudden German-style reunification through collapse and absorption is also a possibility, but the end of national division would then be purchased at the price of severe economic and social problems that would probably last for several decades.

The policy alternative is a prolonged, sustained program of engagement for reconciliation. In place of grand sweeping gestures, this policy favors gradual, incremental steps to chip away at the barriers—political, military, economic, and cultural—that separate the two Koreas. It aims at preventing the devastation of war in the first scenario mentioned above, and mitigating the negative consequences of the second. Along the way, there will be numerous pitfalls, many of them created by the DPRK government, others a function of the continued regional tensions. Reconciliation on the Korean peninsula is a process for the long haul, and will have to be carried out bit by bit, person by person, windmill by windmill.

NOTES

1. Claire Pirotte, Bernard Husson, and François Grunewald, eds., *Responding to Emergencies and Fostering Development: The Dilemmas of Humanitarian Aid* (London and New York: Zed Books, 1999).
2. See, for example, Fiona Terry, "Food Aid to North Korea is Propping Up a Stalinist Regime," *Guardian Weekly*, September 6, 2001. Fiona Terry is a researcher for Médecins Sans Frontières.

3 Jon Bennett, "North Korea: The Politics of Food Aid," Overseas Development Institute, London (1999), p. 15.

4. Terry, "Food Aid to North Korea."
5. Ibid.
6. Sohn Suk-joo, "German Doctor Makes Urgent Call for Human Rights in NK," *Korea Times* (Seoul), February 8, 2001. Summarized in the *North-*

east Asia Peace and Security Network Daily Report (NAPSNet) online at www.nautilus.org/napsnet/dr/0102/FEB09.html#item9.

7. This argument is best articulated in Nicholas Eberstadt, *The End of North Korea* (Washington, D.C.: American Enterprise Institute, 1999).
8. Nicholas Eberstadt, for example, predicted the collapse of North Korea in a talk given at the Heritage Foundation on July 12, 1990. See online at www.fas.org/news/skorea/1990/900713-rok-usia.htm.
9. Dr. William J. Perry, "Review of United States Policy Toward North Korea: Findings and Recommendations," Washington, D.C., October 12, 1999. Available at www.state.gov/www/regions/eap/991012_northkrea_rpt.html.
10. Joanna MacRae, "Forward," in Pirotte et al., eds., *Responding to Emergencies*, p. xix.
11. One indication of the gap that remains was the political flap that arose in the South Korea over the visit of some ROK activists to the "Monument to Three Chapters for National Unification" in Pyongyang. The furor this created led the ROK National Assembly to adopt a no-confidence resolution that forced the resignation of Unification Minister Lim Dong-Won, the main author of Kim Dae Jung's "sunshine policy."
12. This problem is discussed in David Von Hippel and Peter Hayes, "Modernizing the Agreed Framework," in this issue.
13. This difference is evident in photographs taken during the various missions, which can be viewed online at www.nautilus.org/gallery/dprkrenew/index.html.
14. Pascal Vincent, "Who Determines the Objective," in Pirotte et al., eds., *Responding to Emergencies*, pp. 21-22.
15. For more information about this project, please visit the Nautilus Institute web site at www.nautilus.org/energy/eaef/futures.html.
16. See online at www.withdprk.org/conference.htm.
17. Erich Weingartner, "NGO Contributions to DPRK Development: Issues for Canada and the International Community," (Vancouver: University of British Columbia, 2001), p. 26.
18. It should be noted that this interpretation was not limited to critics of the administration's policy, such as the students who turned out to protest Bush's visit to Seoul in February. Hawkish *New York Times* columnist William Safire, in his column of January 31, 2002, rather gleefully speculated about the mode of U.S. military action against North Korea, taking the fact of such action to be a foregone conclusion.
19. For example, while calling for renewed dialogue with the DPRK at last year's Asia-Pacific Economic Cooperation (APEC) meeting in Shanghai, Bush also referred to Kim Jong Il as "secretive" and "suspicious." Wire service articles summarized in the NAPSNet Daily Report for October 26, 2001: www.nautilus.org/napsnet/dr/0110/OCT26.html#item1.