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SHOULD THE UNITED STATES

SUPPLY LIGHT WATER REACTORS TO PYONGYANG?

Peter Hayes

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INTRODUCTION

The transfer of light water reactor (LWR) technology to North Korea (DPRK) emerged as an important issue at the third round of high-level talks between North Korea and the United States held in Geneva in July 1993. In section I of this paper, I provide some background to the negotiations to date over this issue. In section II, I analyze the relative proliferation intensity of the DPRK developing its present nuclear fuel cycle versus "trading it in" for a light water reactor fuel cycle. In section III, I appraise nuclear power technology in terms of the DPRK's energy economy. In section IV, I review the implications of the likely poor economics of nuclear power in the DPRK, and examine various constraints to transferring LWR technology to the DPRK. In section V, I discuss critical outstanding issues that must be resolved before LWR technology is transferred to the DPRK.

I. THE EMERGENCE OF THE LWR ISSUE

The DPRK has developed its nuclear fuel cycle capability for many years and has obtained substantial assistance from the international community (via the IAEA/UNDP) to this end, especially for uranium prospecting. The specific issue of DPRK cooperation with South Korea (ROK) on nuclear research and development has been raised also in the Korean bilateral commissions pursuant to the 1991 non-aggression declaration, albeit with little progress.

The North Koreans denounced a South Korean proposal to build a nuclear power plant on or near the Demilitarised Zone to be run jointly. But in June 1992, they revealed an interest in light water reactors in discussions with the Director General of the International Atomic Energy Agency, Hans Blix. Blix had told the North Koreans that their reactors were outmoded and uneconomic. In response, North Korean officials recognized the economic advantage of shifting to light water reactors (1).

After the DPRK announced its intention to withdraw from the Nuclear Non Proliferation Treaty (NPT) in March 1993, interest intensified in this possibility. In my discussions with senior North Korean officials in May 1993, I asked three questions:

1) Would North Korea cooperate with South Korea on joint development of peaceful nuclear power technology?

2) Would North Korea agree to putting its plutonium (along with that of South Korea) under joint North-South Korean control?

3) Would North Korea change to light water reactors (LWR) if South Korea or the international community provided the technology?

Senior party foreign policymaker Kim Yong Sun prefaced his response by stating that science and technology traverse political boundaries and ideology. He continued as follows:

About the possibility of nuclear cooperation, whatever the form and size of such cooperation for peaceful purposes, it should be studied and researched. Science surpasses ideology and borders. There are several additional documents on exchanges and cooperation in which cooperation is scientific, not only political and cultural. If we seek broad scientific exchanges, why not nuclear cooperation; but not only nuclear, we should cooperate in all fields. In the 10 point program [for reunification, announced in April 1993], we also mention this issue where it refers to everyone making their own contribution with power, knowledge and money. When we say knowledge, this contains fields such as scientific cooperation including nuclear cooperation for peaceful purposes and not only between North and South Korea, but also with the international community (2).

Thus, it was no surprise that the North Koreans raised the issue of shifting to a light water reactor technology at the second round of high level talks in New York in June 1993. In response, the American negotiators indicated that the United States would support such a move as light water reactor technology is inherently less proliferation prone than the graphite reactors under construction in North Korea. But they suggested that the issue was moot until the DPRK complies fully with its full scope safeguards commitment under the NPT. Moreover, they informed the North Koreans that the appropriate way to pursue this possibility was to discuss it with South Korea and with Russia which has already agreed to supply four such reactors (when the North complies with its NPT obligations and finds a way to pay for the transfer). There the matter rested until Geneva.

In Geneva, the North Koreans raised the reactor technology transfer issue on July 16th after an initial round of discussions had already been completed. The North Koreans stated that the real source of problem in nuclear issue, they said, is their inferior graphite nuclear reactors which they were forced to adopt because no one would help them with anything else. They suggested that the only way to solve the nuclear problem is for the DPRK to adopt and to obtain light water reactor technology.

The Americans promptly agreed. They also stated, however, that only after the immediate problem was solved in relation to implementing the safeguards agreement, would the United States explore ways for North Korea to obtain light water reactors. They cautioned the North Koreans to keep in mind that the US government does not sell power reactors. Moreover, North Korea would have to arrange finance with private corporate suppliers.

Although the North Koreans sought (and did not obtain) an American commitment that the DPRK should be supplied with light water reactors, they also referred to the Russian deal to supply them four reactors. They appeared at the Geneva meeting to be satisfied with Russian LWR technology so long as the United States (or someone else) finances it. In one aside, the Americans suggested that as South Korea has light water reactors, the North Koreans should raise the issue of finance with Seoul.

The North Koreans also stated that the best way to proceed would be to implement their safeguards obligations step by step with progress in achieving light water reactor technology transfer, culminating in access to sites (they did not refer to special inspections specifically although referring to "sites" implies the latter). The American side promptly disabused them of this notion, insisting that substantive discussion and measures to transfer light water reactor technology could come only after the DPRK was in compliance with the safeguards accord.

The text of the joint US-DPRK statement issued on July 19 in Geneva refers obliquely to all of these issues (see Appendix 1). One phrase states: "on the premise that a solution related to the provision of light water moderated reactors (LWRs) is achievable" (which refers to the variety of obstacles that have to be overcome for the United States or any other supplier to transfer LWR technology to the DPRK) including COCOM controls, and US legislation on terrorism and trading with enemy states.

For all these reasons, the statement that "the USA is prepared to support the introduction of LWRs" and "to explore with the DPRK ways in which LWRs could be obtained" is qualified with the phrase "including technical questions related to the introduction of LWRs." This phrase refers in turn to these difficult legal and practical questions outlined above which will be discussed in the next round of talks--should they occur.

Thus, the DPRK's line in Geneva was new and potentially significant. The DPRK shifted blame from US policy to the fact that the North has inferior nuclear technology which, it suggested, inadvertently implies that it is interested in nuclear weapons. It signifies that the leadership in Pyongyang may have tilted away from its anti-NPT hardline, at least temporarily. In short, the approach taken in Geneva appears designed to keep open a face- saving way out of the nuclear impasse created by Pyongyang while sustaining its DPRK's nuclear weapons option for the moment. The LWR issue gives the DPRK a tactical advantage in on-going negotiations as it maintains ambiguity as to its ultimate intentions while giving the appearance of being a confidence building measure that might increase the transparency of the DPRK's nuclear program., (3) Kang Sok Ju (head of the North Korean delegation in the Geneva talks) said, for example, that his government proposed switching to more modern reactors to "prove the point" it does not want nuclear weapons (4).

Undoubtedly, the DPRK also aspires to match South Korea and Japan in terms of perceived technological prowess and prestige associated with nuclear power programs although (as I will argue in section IV) they can ill afford to pursue this objective.

Some American officials at Geneva observed that it is easy for the DPRK to make this move knowing that the many obstacles to transferring light water reactor technology cannot be overcome, at least not in a time frame that is meaningful to the nuclear issue. Others believe that the DPRK is setting its price for compliance at a level which requires the American side to clear the way for upgrading trade and investment relations between the two countries, and thus, with the rest of the world. In this sense, nuclear technology transfer impelled by the threat of nuclear proliferation is an excellent battering ram to pound against the American closed door policy toward the DPRK.

II. PROLIFERATION INTENSITY OF LWRS VS INDIGENOUS REACTORS

The DPRK has developed the basic infrastructure for a nuclear fuel cycle with a view to constructing and operating a nuclear power plant. In 1991, Kim Chol Ki, Director of Science and Technology Bureau of the DPRK Ministry of Atomic Energy Industry told me that North Korea plans to build a 1.76 GWe nuclear power plant as part of the third Seven Year Plan for the DPRK. He anticipated that the plant would have four 440 MWe units operating on a 2-on, 2-off shift to provide back up against outage (5).

Recently, the South Korean Atomic Energy Research Institute released a report entitled "The Present Status of Atomic Energy Development in North Korea" according to which the DPRK has operated a 5 MW reactor at Yongbyon since 1986; and has a 50 MWe reactor under construction at Yongbyon due to operate in 1995, and a 200 MWe power reactor under construction at Taechon due to operate in 1996. The report also stated that the DPRK plans to build a 635 MW power reactor at Sinpo on the Northeast coast (6). An American analyst has reported a different range of reactor sizes and locations in the DPRK than those listed in the more recent South Korean report (7). I have assumed that the former South Korean data is more accurate as it is consistent with the facilities declared to the International Atomic Energy Agency (see Figure 1) (8).

Source: Nuclear News, "North Korea's Nuclear Power Programme Revealed," July 1992, p. 2.

In May 1993, I visited the Heavy Industry Sector exhibit in

Pyongyang which features a display of the DPRK's nuclear fuel cycle facilities. It included a scale cut-away model of the 200 MWe reactor which revealed primary and secondary heat exchange systems for the gas coolant, and two generators. From the SPOT satellite photographs of Yongbyon released by the Tokai Research Image Center in Tokyo, it is evident that the Yongbyon reactors are not intended for electricity production, as no power lines exist to or from the reactor sites.

From this information, I infer that the DPRK's power reactor program commences with the 200 MWe gas cooled reactor, and not with the reactors at Yongbyon. The proposal to shift the DPRK to LWR technology therefore relates to this and any other nuclear power plants that the DPRK might construct. Cases for Comparison: The rationale for proposing to shift the DPRK from its graphite- moderated, gas-cooled reactor program to LWR technology is the latter's relatively lower proliferation proneness. Assuming that the DPRK will have to abandon its indigenous 200 MWe reactor in order to obtain LWR technology, the two fuel cycles must be compared with respect to two criteria (see Table 1). First, the DPRK could be inside or outside of the NPT and the IAEA's full-scope safeguards system will or will not be applied to its nuclear facilities. Second, it could have its own or LWR technology. These possibilities produce four possible outcomes as follows:

1. DPRK is in NPT and has only 200 MWe reactor operating in power, not weapons grade plutonium mode, under full-scope safeguards;

2. DPRK is in NPT, has only an LWR operating in power, not weapons grade plutonium production mode, under full-scope safeguards;

3. DPRK is not in NPT and has only 200 MWe reactor operating in weapons grade plutonium production mode (worst case scenario), without safeguards.

4. DPRK leaves NPT after obtaining an LWR, and operates it in weapons grade plutonium production mode (worst case scenario), without safeguards.

In this study, I will conduct the comparison of proliferation intensity by comparing only two of the four possible cases, namely, the DPRK outside the NPT running a 200 MWe indigenous reactor (case B1 in Table 1) versus the DPRK inside the NPT running an 1 GWe MWe LWR under full-scope IAEA safeguards (case A2 in Table 1).

Table 1: Possible Reference Cases

	A DPRK in NPT with full-scope IAEA safeguards	B DPRK out of NPT with no IAEA safeguards
1 DPRK indigenous 200 MWe reactor only	A1 In NPT 200 MWe indigenous reactor	B1 Out of NPT 200 MWe indigenous reactor
2 Light water reactor only	A2 In NPT LWR transferred	B2 Out of NPT LWR transferred

To simplify the analysis, therefore, I assume that the United States will hold out for the following "package" before it seriously entertains LWR technology transfer to the DPRK:

1) the "radiochemical" laboratory or reprocessing facility will be dismantled along with any other plutonium separation facilities, hot cells, etc;

2) the IAEA will be permitted to resolve discrepancies between North Korean operating records and actual plutonium separation activities as indicated by sampling, inspection of disputed sites, etc;

3) the IAEA Board of Governors will have determined that North Korea is in compliance with its safeguards agreement under the NPT which will be applied fully to the existing reactors at Yongbyon (Alternatively, the DPRK will be persuaded to decommission these plants in return for shifting to LWRs, but this possibility is left open in my scenarios);

4) North and South Korea will agree to and implement an inspection arrangement in accordance with the bilateral denuclearisation declaration.

5) North Korea will abandon construction of its 200 MWe graphite-moderated, gas-cooled reactor in anticipation of receipt of LWR technology;

6) North Korean spent fuel from an LWR will be kept in holding ponds at the reactor site or at a dedicated facility; and plutonium in it will not be separated in offshore reprocessing plants for recycling into LWR MOX fuel or into an eventual fast reactor program in the DPRK;

7) North Korea will rely on external suppliers of enriched uranium LWR fuel. I assume also that a 1 GWe LWR reactor is supplied by South Korea (or that South Korea bankrolls Russia which already has contracts to supply LWRs to North Korea).
Relative Proliferation Propensity: At the end of the Geneva talks, international media reported that US officials prefer that the DPRK adopt LWR technology because it is inherently less suited for making nuclear weapons.

In reality, determining the relative proliferation intensity of different fuel cycles is a complex matter. John Holdren has suggested four factors against which different fuel cycles can be judged for their susceptibility to diversion of fissile materials (see Appendix 2). These factors are:

1) Quality of fissionable materials--the degree of enrichment of uranium and the ratio of fissionable to non fissionable plutonium isotopes;

2) Quantity of fissionable materials--the number of critical masses per GWe-year of operation;

3) Barriers--the chemical barriers to the diversion and use of fissile materials such as form and dilutants of uranium and plutonium; and the radiological barriers associated with spent fuel of low or high burn-up;

4) Detectability--the degree to which the fuel cycle requires new operations or significant modifications, and/or entails radiological releases which can be monitored effectively.

It is evident that the once-through LWR (in the case presented by Holdren, a pressurised or PWR) and CANDU fuel cycles are significantly less susceptible to diversion of fissile materials than other power reactor fuel cycles., (9) It is not easy to directly compare the DPRK's 200 MWe reactor (even after scaling down to account for the difference in plant size between the DPRK plant and that assumed by Holdren) because the DPRK has not released detailed design information for the 200 MWe reactor. It is necessary, therefore, to define a "reference" DPRK power plant to juxtapose to an LWR in terms of their relative proliferation proneness. DPRK Reference Reactor: In this section, I describe the basic physical parameters of the British plutonium production reactors in order to "design" a reference DPRK reactor to compare with LWR technology.

The DPRK reportedly told the International Atomic Energy Agency that their reactors are modelled after the British Calder Hall reactors built to produce plutonium for nuclear weapons (10). They were graphite-moderated, CO2-gas-cooled reactors fuelled with natural uranium metal rods clad in a magnesium allow ("Magnox"). The second generation of four Magnox reactors were known as Chapelcross. Both generations produced plutonium but generated electricity as a byproduct. All eight reactors were nominally rated at 50 MWe (net) (11). Another source rates the early Calder Hall reactors at 225 MWth, and 41 MWe (net);, (12) I adopt 50 MWe in this study.

When operated primarily to produce electricity, the Magnox reactor operators typically set fuel burnup at 3-4,000 megawatt-days/tonne of uranium fuel. The core measured about 14 meters wide by about 8 meters high. Each fuel channel in the reactor contained a stack of six fuel elements, each of which in turn consisted of massive, solid rods of natural uranium metal about a meter long and 3 cm wide. Each stack of six fuel elements weighed about 77 kg. Each core contained about 1,691 fuel channels for a total of assembly of about 10,146 fuel elements. The total uranium fuel contained in the core was about 112 tonnes of natural uranium (excluding cladding).

The fuel could be replaced in later, civilian Magnox reactors while producing electric power by using on-line, continuous refuelling techniques, and about three fuel channels were refuelled per week. Spent fuel from gas cooled Magnox reactors cannot be stored indefinitely in water because the Magnox alloy (magnesium alloy containing 0.8 percent aluminium, 0.002-005 percent beryllium, 0.008 percent cadmium, and 0.006 percent iron) corrodes slowly in water. (Dry storage, however, is feasible although difficult.) Each tonne of Magnox fuel irradiated for a 1,000 megawatt days contained about 998 kg of unconverted uranium and 0.8 kg of plutonium (13).

When operated to produce weapons grade plutonium, as they were between 1956 and 1964, the Calder Hall and the next generation four Cross reactors were run rather differently. Instead of continuous refuelling, the whole core was irradiated and removed about twice a year (allowing for about three months repair and maintenance work). To produce very pure plutonium without the bothersome isotopes that impede weapons production, the burnup rate was reduced to about 400 MWdt/tonne of fuel, at which

Table 2: Relative Proliferation Intensity of LWR vs DPRK Indigenous Reactor

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PWR Once Through   DPRK Indigenous
Fuel Cycle   Reactor
Fuel Cycle
Per GWe-year   Per 0.2 GWe-
year

Operated to Maximize

Plutonium Production

enriched spent fuel   natural
spent fuel
uranium   storage   uranium
storage

1. Quantity of 855 kg U235 250 kg of   336 kg of 315 kg of
fissile material   in 28500 kg Pu (69%U235 in weapons grade
and main dilutants   U238, 3 %fissile) in223,664 kgplutonium in
at this point enrichment26,000+ kg   of U238   approx.

uranium andzero %   223,000 kg of

fission   enrichmentU238 and fission

products   products

2. Further   extensive chemical   enrichment   chemical
processing neededfurther separation   from scratchseparation
from this pointisotopic from uranium   required from uranium to
use in nuclearenrichmentand fission   and fission
products explosives   required products
required

required   for use in nuclear

explosives; storage

may require reproc-

essing of wastes

3. Proliferation Susceptibility Indices (5 = worst, 1 = best)

Quality				
As is	1	3	1	4
Enrichment	5	4	5	4
Quantity	4	4	1	4
Barriers				
Chemical	4	2	4	2
Radiological	5	1-2	5	2
Detection	3	1	5	1

Source: J. Holdren, "Civilian Nuclear Technologies and Nuclear Weapons Proliferation," in C. Schaerf et al, New Technologies and the Arms Race, St. Martin's Press, New York, 1989, pp. 182-185; text for DPRK reactor. Note: see Appendix 2 for definitions of numerical weights.

rate about 79 kg of weapons grade plutonium was produced per reactor year., (14)

On this basis, what can be said about the proliferation propensity of a 200 MWe scale up of the early graphite-moderated, gas-cooled reactors compared with an LWR when measured against the factors listed above (see Table 2)?

In terms of quality, replacing the DPRK reactor with an LWR would increase the international community's leverage over the front end of the DPRK's fuel cycle by virtue of the latter's resultant dependency on imported uranium enrichment services.

On the back end of the fuel cycle, it would also reduce the quality of the plutonium available from spent fuel by increasing the amount of plutonium isotopes which may prematurely initiate nuclear chain reaction in a weapon (unless the LWR were removed from the NPT regime and operated to maximize the production of weapons grade plutonium).

In terms of quantity, a 1 GWe LWR would produce about 250 kg of plutonium per year. A DPRK 200 MWe reactor scaled up from Calder Hall technology and operated in plutonium production mode could produce about 315 kg of weapons grade plutonium. Thus, LWR transfer would decrease the quantity of plutonium to be controlled under safeguards, although only marginally. In neither case, however, would diversion of 1 percent per year yield a "bomb" quantity of plutonium (5 kg for weapons grade plutonium).

In terms of chemical barriers, LWR technology is fairly resistant on the front end in that the fissile material is in oxide form, albeit not mixed with an effective dilutant. However, the gas cooled reactor would use natural uranium fuel which would be even more difficult to utilize for weapons purposes than low enriched uranium oxide for LWR fuel. So long as both fuel cycles do not introduce plutonium recycling, they are equivalent in terms of chemical and radiological barriers to diverting spent fuel from storage to weapons activities. Unfortunately, due to the difficulty of storing spent MAGNOX fuel in water for long periods, North Korea has argued that it may be obliged to reprocess the fuel for safety reasons and has already cited precedents to this effect in Britain, France and Japan (15). Some experts contend that dry storage is feasible, however.

In terms of detectability of diversion, an LWR fuel cycle appears to offer significant advantages. If we assume that the DPRK operates its reprocessing plant in case B1 (go-it- alone with its own 200 MWe plant outside of the NPT system) but would abandon it along with the 200 MWe reactor in case A2 (rely on LWR technology), then the LWR would reduce the opportunities for diversion at various points in the reprocessing and recycling portions of the fuel cycle from relatively high to essentially zero. The LWR is inherently easier to safeguard as shutdown is obvious and required for removal of any fuel rods (although the fact that an LWR is relatively easier to control in this respect is not relevant to the comparison with the DPRK indigenous plant because I assume that this reactor would only operate outside the NPT whereby diversion detectability becomes moot).

Overall, therefore, the major reduction in proliferation intensity associated with switching to LWR technology would be 1) the increased dependency of the DPRK on the international community for enrichment services; and 2), the reduced opportunity for and enhanced detectability of diversion of plutonium from LWR spent fuel under safeguards versus an indigenous reactor operating outside the NPT. Finally, inducing the DPRK to abandon the 200 MWe reactor would lay to rest any possible rationale for completing and operating its reprocessing facility in order to safely store spent fuel. Other than these advantages, the LWR is only marginally less proliferation prone than the indigenous plant from a technical perspective. Other Considerations: Six other factors offset or reinforce these marginal technical advantages of an LWR over an indigenous DPRK reactor.

First, an LWR in North Korea could legitimate continued accumulation of weapons- relevant skills that could be mobilised at short notice to produce nuclear weapons from a large stock of accumulated plutonium in spent fuel. Thus, the acquisition of an LWR is consistent with the DPRK maintaining a posture of studied ambiguity as to its ultimate intentions with respect to nuclear weapons.

Second, the DPRK could reduce the leverage implicit in its reliance on imported enriched uranium fuel by stockpiling this material (assuming it could afford to do so, and that this step passed unnoticed by the international community).

Third, LWR or "reactor grade" fuel containing excessive amounts of the plutonium isotopes Pu 240 and Pu 242 is still useable for a nuclear weapon at a cost to expected yield and certainty of yield than weapons using "weapons grade" material. Moreover, it is not appreciably more difficult to design a weapon using reactor rather than weapons grade plutonium (16).

Fourth, the DPRK could operate an LWR (presumably after departing from the NPT) to minimize the production of these inconvenient isotopes by shutting down the reactor more frequently to remove irradiated fuel (but at a cost to electricity production) (17).

A "modernised" DPRK that is rendered capable of running (or even constructing) an LWR could also become a more active and disruptive exporter of nuclear technologies than it would if it only has access to its own relatively primitive nuclear technology. Weighing against this disadvantage of an LWR is the fact that although the DPRK could become a more capable and potentially disruptive supplier of nuclear fuel cycle technologies, materials (such as graphite) and techniques, it would be less likely to have developed and transfer nuclear weapons capabilities under the political conditions in which an LWR might be transferred to the DPRK. Conversely, it might develop and share nuclear weapons-related expertise with other states in the near-term if left to its own devices; whereas it would take many years (up to fifteen years for advanced reactor core components) for the DPRK to develop exportable expertise in LWR manufacture (18).

One other issue is worth noting. North Korean officials have noted that South Korea's nuclear power reactors might be hit during a war. These reactors present tempting radiological targets (19). By the same token, a large scale nuclear power plant in North Korea presents the South with a reciprocal targeting option. Having a much larger reactor program (twelve power reactors operating or under construction), the South proffers the North 10-15 times as much radiological damage potential as would one reactor in the North to the South. But a large reactor in the North would make the implicit threat to attack a radiological target in wartime a risk shared by both sides, which in principle provides the South with a qualitatively similar deterrent against such attack. Although an LWR might contain much more fission products and radioactive materials than the DPRK's 200 MWe plant, the switch to LWR technology per se would make little difference to this factor.

In this section, I have shown that an LWR offers some inherent advantages over North Korea's own reactor in terms of the criteria of quantity and quality of fissile materials, chemical and radiological barriers, and detectability. I also noted that six other factors should be considered in relation to the transfer of an LWR to the North Korea, namely: continued DPRK ambiguity as to ultimate proliferation intention; fuel stockpiling; the utility of LWR-grade plutonium for nuclear weapons; the possibility that an LWR could be used to make weapons-grade plutonium; North Korea's export behaviour; and the issue of radiological targeting in wartime in the Korean Peninsula.

In the next section, I analyze the economic soundness of a nuclear power plant in the North Korean energy economy.

III. DPRK ELECTRICITY NEEDS AND NUCLEAR POWER

As of 1991, the DPRK planned to build only one nuclear power plant. When that is completed successfully, North Korean officials assert that they will develop further plants "in accordance with the needs of national economic growth (20)."

There is little doubt that the DPRK is suffering from acute energy shortages, both of petroleum fuels (especially in the transport sector, probably in industry, and possibly in fertiliser production), and of electricity. Energy Sector: As is well known, the DPRK relies heavily on coal, hydropower, and imported oil for its energy supplies. Table 3 shows an approximate energy supply balance for the DPRK. This section demarks the energy sector which accounts for the bulk of the DPRK's greenhouse gas emissions

Table 3: DPRK Energy Supply Balance, 1991 estimate

(10-to-the-15th-power joules)

Oil Gas Coal Electricity
Other* Total

Primary Production - - 1285.4
343.3(#) 37.7 1666 Imports
239 - 75.4 -
- 314.0

Exports - - -
?*** - -

Primary Supply 238 - 1360.8

343.3(#) 37.7 1980.5 Net Transformation-12.6 - -314.0 - 167.5 - - 494.1 Final Consumption 226.4 - 1046.8 175.9+ 37.7

1485.9

Source: Economist Intelligence Unit, China, North Korea Country Profile 1992-93, 1993, p. 80, citing Energy Data Associates. Notes: * No accounting for fuelwood and other bioenergy fuels. # Primary electricity production, imports and exports are expressed as input equivalents

on an assumed efficiency of 33 percent. *** No account of small exports of hydroelectricity to China, nor jet bunkers and

international shipping + Output basis.

The institutional arrangements in the energy sector are complicated and reflect a high degree of functional fragmentation. The energy sector in the DPRK has no single specialised institutional authority or ministry responsible for energy analysis, integrated planning and management. These tasks are scattered in agencies and ministries as depicted below:

(a) Coal exploration, mining and supply is under the jurisdiction of the Ministry of

Coal Mining;

(b) The electric power sector development, power generation, distribution and sales

are the responsibility of the Electric Power Industry Commission (see below for

detail);

(c) Energy statistics and energy planning activities are performed by the State

Planning Commission incorporating Central Statistics Bureau under its authority. The

State Commission for Science and Technology acts as a consulting body in these

activities mainly providing appropriate recommendations and software for energy plan formulation and decision making;

(d) Supervision of energy flow and reasonable consumption of the fuel in the transport

sector is assigned as a function of the State Transport Commission;

(e) The Ministry of Atomic Energy is in charge of development, construction, and

power generation of nuclear power plants, as well as nuclear fuel supply;

(f) The External Economic Affairs Commission is responsible for purchase of crude

oil and petroleum fuels, and all imported machinery and equipment for the energy

sector;

(g) The Ministry of Machine Building Industry is responsible for manufacturing and

supply of domestic power equipment. Most of the research and development work

for the energy sector is performed by the institutes affiliated with the Academy of

Sciences, although all the above-mentioned Ministries and Commissions have their

own research institutions;

The non-standing State Committee for Energy, chaired by the Prime Minister,

discusses and decides on major issues in the energy sector;

Research and development activities related to the energy sector performed by

institutions affiliated with the various ministries are coordinated by the State

Commission for Science and Technology. Appendix 3 contains a flow chart illustrating this organizational arrangement. This functionally differentiated and fragmented institutional framework results in poor policy coordination and program implementation. There is no comprehensive energy policy in the DPRK. There is no apparent economic rationale to the existing price structure for different energy forms. There are no even rudimentary markets to facilitate economically efficient transactions between energy-related supply and demand entities. Planning and fuel allocation is also inhibited by the apparent non-existence of a basic energy supply/demand balance in the DPRK. Indeed, a UNDP energy efficiency improvement project in the DPRK is meant to create just such a balance at the proposed Center for the Rational Use of Energy. Electricity Sector: North Korea claims to have about 12,000 MWe of installed capacity, with an available capacity of 10,000 MWe. Approximately 50 percent of the generating capacity is hydroelectric, and about 50 percent is thermal, mostly coal-fired. About 84 percent of the electrical energy is fired by coal. The annual and dail load curves in 1989 for the DPRK are shown in Figure 2. Generating Plant: Although there are more than 500 generating plants, only 62 major power plants are linked to the nationally interconnected transmission system. The latter system in turn transports about 85 percent of the generated electrical energy. (The residual 15 percent of the electrical energy is generated by self-reliant industrial facilities and by small, isolated and mostly hydroelectric units.) Of the plants linked to the transmission system, 20 are thermal (18 being coal-fired, 2 being oil-fired), and 42 are hydroelectric. The largest thermal unit is at Pukchang with an installed capacity of 1,600 MWe. The largest hydroelectric plant is at Supung and has an installed capacity of 700 MWe (7 * 100 MWe turbines). The output of the latter plant is shared by the DPRK and China.

The North Koreans run the thermal, mostly coal-fired plants as baseload units, and use the hydroelectric plants to meet peak load demands. When demand exceeds supply, the supply to consumers is suppressed. The DPRK Electric Power Industry Commission estimates that it has to accommodate a generating gap of at least 500 MWe. Blackouts occur and loads are shedded regularly resulting in large production losses. In the winter (November-December), load shedding reaches 1,000 MWe due to the accumulation of snow. In summer--particularly in March through May--shortage of water at hydroelectric reservoirs forces the power system operators to shed as much as 2,000 MWe for up to an hour at a time. Bad weather can worsen the situation as storms, old and low quality equipment, and incorrect operation of protective devices cause the transmission system to fail.

Consequently, the quality of electric power in the DPRK is also poor in terms of frequency (often found at 57-59 Hz well below the permissible deviation from the standard 60 Hz) and voltage (which frequently fluctuates). The power factor at load centers is also low and averages 0.8 which can damage badly end use equipment. Transmission and Distribution System: The transmission system is isolated from neighbouring countries (except for a 60 KV line feeding power to a remote area of China). The DPRK uses 220 and 110 KV lines for bulk transmission; 60, 10 and 3.3 KV for distribution; and 380/220 V at 60 Hz for distribution to consumers. The Government states that 100 percent of households and industry are electrified. As not all consumers are metered, the exact quantity and sectoral distribution of electrical end use are not known. The Government states that transmission losses are about 10 percent, and distribution losses are about 6 percent. However, some observers believe that this official estimate (like generation figures) are optimistic, to say the least. The transmission and distribution system reportedly urgently needs to be refurbished (see Figure 3). Generation Difficulties

The DPRK government claimed that generation in 1989 was about 50-55 TWhe. Informed observers in Pyongyang estimate that the actual generation in 1992 was about 31-32 TWhe and that the annual shortfall is between 10-12 TWhe. This difference reflects all the problems of generation, load shedding, and transmission and distribution losses referred to above.

In the DPRK's generating plants, machinery cannot be maintained or repaired adequately due to the shortage of spare parts, testing equipment, and obsolete and incomplete monitoring and control instrumentation in the power plants. The official estimate of thermal power generation of the thermal-to-electricity conversion efficiency of 34 percent is likely a substantial overestimate. At the Pyongyang Thermal Power Station, for example, major equipment is deteriorating due to the limited capabilities to track thermal performance, poor instrumentation and testing equipment, and the lack of a comprehensive maintenance program. All these technical problems are worsened by the shortage of skilled staff able to use what equipment exists. About 211 GWhe of electricity generated at the station (or 5 percent of its nominal and 7 percent of its actual rated output at a 100 percent capacity factor) is lost due to acute problems such as boiler outage, etc. Coal Shortages: The power sector is also afflicted by problems originating in the coal mining industry. Coal shortages (reportedly due to the classic command-and-control bind of shortage of coal for steel and power production on the one hand, and transport constraints on getting coal to end users due to steel shortages on the other) have constrained the power output at thermal power stations. Also, the Institute for Coal Selection lacks equipment to determine the energy content of mined coal. Consequently, power station operators may not know the quality of fuel loaded into steam boilers at generation plants. The DPRK lacks a long range coal mining industry development programme and master plan for each coalfield and basin to determine the best allocation of investment resources in coal production in relation to projected consumption needs. Moreover, that coal which is produced is not cleaned before it is sent to consumers which imposes operating and pollution problems (from ash) for power plant operators. Perhaps 60 percent of the coal used in power plants is wasted in inefficient combustion.

It has been estimated that the equivalent of at least 6 million tonnes of coal is wasted in the whole country and that simply using high temperature waste heat rationally would increase electricity generating capacity by 400 MWe. Most of the industrial furnaces and ovens which vent exhaust gases at temperatures of more than 500o centigrade do not recover the heat for preheating fuel or other uses. Nor are piping or furnace walls insulated due to the lack of insulation materials. Almost no use is made of modern heat exchangers or simple heat pumps. Expansion Plans: The Government emphasises expansion of the power sector in its plans and allocated 3 billion won during the most recent (1987-1993) plan. It aimed to increase power capacity to 19,000 MWe and to generate 100 TWhe in 1993. These plans are ambitious and highly unrealistic.

To this end, the DPRK is building 12 new hydroelectric plants amounting to an additional 2,500 MWe (the largest is 800 MWe). The Government also plans to construct 4,000 MWe of thermal power plant ranging from 200-1600 MWe. As noted earlier, it also proposes to add a nuclear power plant the size of which is indeterminate. Finally, the Government intends to upgrade the transmission network by expanding it and introducing 330 KV transmission in the mid-nineties (to increase eventually to 500 KV). Institutional Weakness: The Electric Power Industry Commission (EPIC) is the key power sector institution which plans and develops power generation, transmission, distribution, and end use sales and has ministerial status in the Government. The organisation chart for EPIC is shown in Appendix 4.

Within EPIC, the Electric Power Dispatching Bureau is responsible for the Electric Power Production and Dispatching Control Center (EPPDCC) which in turn monitors and coordinates the functions of the power system with its fifty strong staff. EPPDCC is responsible for planning hydroelectric and thermal power plants; monitoring the status of generating units for efficiency and reliability of supply; monitoring the system flow of electricity at voltage levels at or above 110 KV; planning and implementing repair and maintenance of the system; responding to faults and contingencies in the power system; and collecting and storing data on system operation. It also supervises 11 regional power dispatching centers. It is supported by the Institute of Electric Power and Telecontrol in the areas of telecommunications and control, computer equipment, and software. Load Dispatch Difficulties: Given the complexity of the power system, EPPDCC requires instant access to accurate and salient information on 62 power plants, 58 substations, and 11 regional transmission and distribution dispatching centers. The system operators at EPPCDD, however, rely on phone or telex messages for status updates on the value of such parameters as voltage, current, active power, frequency etc. at a load center, or a drop in system frequency due to a fall in generation. Relatedly, if a transmission line is tripped out- of-service due to a fault, then the network configuration must be reconstituted immediately or whole sections of the system become isolated. The slow pace and unreliability of the information systems used by EPPDCC virtually ensure that the system operators cannot restore the system to working order. As of late 1992, EPPDCC operated one old desk top personal computer to collect and analyse system performance data, but it cannot handle the processing of planning and logging information.

Thus, the power system lacks an modern, automated, and computerised supervisory and monitoring capability that can support a load dispatching function in real time. The pilot project underway with UNDP support to rectify this deficiency covers four critical power plants and substations only, and will not resolve this problem at a system level. Vast End Use Energy Waste: In addition to the problems noted above, the consumption at point of end use of electricity is also very inefficient in the DPRK. The Government estimates that industries typically waste between 30 and 50 percent of energy supplied. In the building sector, many residential buildings are not insulated. Typically, heating is by hot water pipes embedded in the floor with a single on/off valve per apartment. The source of heat is centralised, and is linked to power plant waste steam output on a district basis. (Cooking is by bottled gas or kerosene with fuel stored on balconies) (21). Aside from dramatically increasing comfort levels in North Korean buildings, properly insulating walls and windows would reduce the demand for "waste" steam from power plants which could be used better on-site power plants to increase the generating efficiency (or reduce fuel usage) of electricity. The Government has recognised that large opportunities exist to reduce energy waste and has decided to establish a Centre for Rational Energy Use.

In short, the main characteristic of the DPRK's power sector is its extraordinarily wastefulness--waste in fuel production, waste in transmission and distribution, waste in end uses of electricity, and waste of scarce skilled labor. The DPRK's power sector is badly organised and managed. It cannot operate efficiently due to obsolete equipment and procedures. It is hard to imagine it operating effectively a modern nuclear power plant.

IMPLICATIONS FOR NUCLEAR POWER IN THE DPRK

From an economic perspective, the DPRK's priorities for public investment in increasing energy services obtained from its energy sector probably should be (in order of most to least important):

1. Improve energy efficiency in end uses, especially in large and centralised consumers such as industrial plants and buildings;

2. Reduce energy losses in generation, transmission, and distribution in the existing power system;

3. Increase the quality and quantity of domestic energy resources (coal and water storage);

4. Provide new energy service capacity based on integrated, least cost power planning which puts marginal supply options on an equal footing with marginal end use efficiency options.

5. Construct new generating capacity as needed after all the above priorities have been achieved. This analysis suggests that constructing a nuclear power plant in the DPRK is likely to be a high cost, low priority way to fulfil energy demands. The demonstration effect of the Japanese and South Korean nuclear power programs make it difficult to argue this case effectively with North Koreans--but the fact that these two countries have overinvested in a costly energy option should not disguise the fact that the DPRK can ill-afford to waste money on a nuclear power plant when many other options exist to supply energy services at far lower cost, faster, and with less risk. Indeed, continuing to divert a large fraction of North Korea's scientific and technological talent to a nuclear power program may worsen significantly the chronic and pressing problems of the conventional power sector described above. Technical Problems: In addition to the opportunity cost of foregone energy services that a nuclear power plant will impose on North Korea's economy, such a plant would also pose formidable technical challenges including: maintaining system reliability; following load patterns with a base load plant; safe operation; delay; and timing.

A nuclear power plant may also be technologically ill-suited for the DPRK power system. First, it is unclear whether a 1 GWe plant at Sinpo (or elsewhere) will be small enough to not threaten the power system's stability (crudely, no generating unit should exceed more than about 10-20 percent of the total system capability--or the available system reserve--or the operation of the whole system may be threatened due to unexpected outages) (22). Detailed review of the DPRK transmission system would be necessary to answer this question. Inspection of Table 3, however, indicates that the DPRK barely meets the reliability criterion--assuming that its total actual generating capacity of 10,000 MWe feeds into one national, highly interconnected transmission grid. Conversely, by the time that the DPRK might bring an LWR on-line, the grid may have grown enough to accomodate a large LWR.

Second, a nuclear power plant is usually operated as a baseload plant and cannot be quickly powered up and down to follow peak demand cycles. Ascertaining whether a nuclear Table 3: Relationship between installed capacity and size of plant

Installed Capacity Must Be At Least	To Accommodate A Single Plant of
850 MWe	100 MWe
3,300 MWe	300 MWe
9,200 MWe	600 MWe
20,000 MWe	1,000 MWe

R.J. Barber Associates, LDC Nuclear Power Prospects, 1975-1990: Commercial, Economic and Security Implications, ERDA-52 UC-2, p. 11-8.

power plant would be technically appropriate in relation to demand patterns would require access to data either as yet uncollected, or not released by the DPRK Government.

Third, it remains an open question as to whether a nuclear power plant could be operated safely and its output dispatched, given the parlous nature of the current power operating infrastructure described in the previous section. Admittedly, it would take 5-7 years (if South Korea were to be the supplier and architect-engineers) before an LWR could be built in the DPRK which would provide some time to train power system and nuclear plant operators. Nonetheless, the status of the current power system does not inspire confidence that safety and operational objectives would be achieved in a DPRK nuclear power program. Attempting to operate an LWR (especially a Russian LWR) in the DPRK may pose an environmental threat to domestic populations as well as to neighbouring states already sensitive to radioactive fallout issues in the aftermath of Chernobyl and Russian radwaste dumping in the Sea of Japan.

Fourth, transferring an LWR will take years--many years. The tasks of financing, site selection, power system upgrade, fuel cycle infrastructure, fuel supply contract, technology supply and architect-engineering contracts, training of operators and technicians, and actual construction and testing would all have to be completed before a nuclear power plant would deliver the first kWhe into the North Korean power grid.

A minimum of six years (assuming South Korean financing, and South Korean or Russian LWR technology) would be required, being one year to set up the deal, and five years to construct an LWR., (23) Given the difficulties of building a nuclear power plant in North Korea where basic legal and administrative barriers exist to the operation of foreign firms and in which the economic infrastructure is so poorly developed that an architect-engineering firm would have to import virtually all supplies and much of the requisite skilled labor force, a more reasonable estimate of the time to complete the plant might be 8-10 years.

Finally, a GWe-sized LWR will cost upwards of US$3 billion--money that the North Koreans do not and will not have in the foreseeable future, given their accumulated foreign debt of US$5 billion. If the North Koreans are serious about obtaining an LWR, then they must assume that they can persuade another state to provide financial guarantees to private financiers to bankroll the project, or to directly finance the transfer with a loan. Presumably, they have in mind that South Korea might finance either a Russian LWR, or a South Korean LWR as doing so may be cheaper than the political and military costs of responding to a North Korean nuclear weapons program. The DPRK may also calculate that obtaining external financing for an LWR on this scale might help it to revive its sagging credibility with foreign lenders still angry at its failure to reschedule its $5 billion debt.

V. CRITICAL ISSUES

Thus far in this paper, I have: 1) described the emergence of the LWR transfer issue in the context of the nuclear weapons issue; 2) compared the relative proliferation intensity of an LWR relative to an indigenous North Korean nuclear power reactor; and 3), demonstrated that North Korea probably will incur significant opportunity costs if it pursues a nuclear power program rather than cheaper and less risky ways to meet its energy needs. In this section, I turn to the concern which lies at the heart of the LWR transfer issue: why did the North Koreans raise this demand and is it sensible to meet it? North Korean officials often repeat a slogan in international meetings: "We mean what we say and we say what we mean." In reality, fathoming the North Koreans' intention has been the most difficult aspect of the past and on-going nuclear negotiations, and the LWR transfer issue is no exception.

In sum, the following conclusions can be drawn from the preceding four sections of this essay:

Conclusion 1: the North Koreans raised the LWR transfer issue to keep their options open by defining a face-saving exit from the NPT impasse that they have created and to create a battering ram with which to break down the US closed door policy on trade, investment and aid to the DPRK;

Conclusion 2: an LWR presents marginal advantages over the indigenous North Korean reactor in terms of relative proliferation intensity; but the critical issue is the implementation of full-scope safeguards and compliance with NPT obligations, not the relative technical characteristics of nuclear fuel cycles;

Conclusion 3: an LWR is probably an expensive way to meet North Korea's energy needs and may be dubious from an economic perspective. In any case, demanding an LWR along with abandonment of the DPRK's own reactors would delay the startup of its nuclear power reactor program by at least five years;

Conclusion 4: the DPRK is likely to insist that it retain its existing nuclear power program and operate it under safeguards while an LWR is transferred, in order to retain backstopping insurance against the whole deal going sour. Although the United States will find this stance difficult to accept, it may conclude that keeping the DPRK in the NPT with safeguards applied to its fuel cycle is better than having it outside the NPT without safeguards, especially if it judges that the actual transfer of LWR technology is unlikely to be completed in the lifetime of the Kim regime. The North Koreans who make decisions in Pyongyang know these facts will have drawn their own conclusions. The corollary of these conclusions is that they seek primarily to realise intangible benefits such as prestige, the impression of modernity, and symbols of external recognition of the durability of their rule; and possibly more tangible gains in terms of reopening trade and financial relations with the external world (see the epilogue below).

The critical issue is whether provision of an LWR will induce the North Koreans to abandon their reprocessing plant (and possibly their own reactors) and allow full-scope safeguards to be implemented. If so, then providing an LWR is a cheap way to preserve the peace and restore the nuclear non proliferation order in Northeast Asia. If not, then the transfer issue is simply a diversion introduced by North Korea to stall for time while they pursue a nuclear weapons program or seek other options.

Given that an LWR would not exist under the most optimistic scenario until after Kim Il Sung has passed from the scene, the abandonment of its 200 MWe reactor and reprocessing plant, and, by returning to the NPT fold, the resolution of outstanding ambiguity as to the North's residual nuclear weapons capability arising from past reprocessing, would be a major concession by Pyongyang. Indeed, the DPRK's current rulers would have no assurance that they would ever receive an LWR given the long lead times involved. It follows that however politically important an LWR transfer agreement might be to ensuring that full-scope safeguards are applied to the DPRK's nuclear fuel cycle, an LWR cannot substitute for other benefits sought by the regime which may have an immediate and tangible impact on its survival prospects. These include negative security assurances, an end to Team Spirit, and a general upgrading of US-DPRK relations.

By demanding that LWR technology be transferred, North Korea has set a high price for complying with the NPT. But in doing so, it has at least defined a specific way to resolve the standoff that might be acceptable to all parties and against which progress can be measured quite precisely. Striking this deal would also symbolise that the United States, and by implication, the rest of the world, recognises the political autonomy of the North Korean state.

It is difficult to be optimistic at this late stage in the endgame. North Korea has barely fulfilled the two conditions that it agreed to in Geneva--starting a serious dialogue with the IAEA to resolve the discrepancies identified by the IAEA as to past plutonium reprocessing, and entering into substantive talks with South Korea. Indeed, it has backtracked by asserting that compliance with IAEA safeguards should follow, not precede striking a deal to transfer an LWR--a position it knows to be a non-starter with the United States. It has also done nothing to date to resolve the outstanding issues with the IAEA and has refused to allow the IAEA to conduct uninhibited routine inspections (although it did offer to let inspectors refurbish monitoring equipment at the end of October).

Until now, the DPRK has been able to curb moves to increase pressure on it by allowing the international community to maintain the transparency of its current nuclear activities (24). However, the IAEA inspectors who went to North Korea at the end of August were unable to conduct even routine inspections, and were barely able to maintain continuity of monitoring at declared sites. Now that, as the IAEA puts it delicately, continuity of observation has been "damaged," the patience of the international community will be tested to the limit and time will run out for North Korea.

Shortly, therefore, we will know whether the LWR issue is simply another siren song to seduce the naive, or if it is a strategic commitment on the part of the DPRK intended to enable it to reenter the international community.

VI. EPILOGUE

Fortunately, "shortly" is an elastic word. It could be some time before the IAEA and the DPRK identify enough common ground to permit the United States and the DPRK to reconvene high level talks. Also, US national technical means can substitute for IAEA ground monitoring, at least for a time and to some extent.

In my October 19, 1993 interview with Kim Yong Sun in Pyongyang, he made a number of significant points relating to the LWR issue. "The LWR issue," he stated, "will be crucial to the success or failure of the next round of US-DPRK high level talks."

"If the LWR issue is solved successfully," he added, "then the DPRK will stay in the NPT. If not, then we have no alternative but to seek to supply energy from our own nuclear technology."

"The DPRK doesn't care where the LWR technology comes from, whether it is American, Russian, South Korean."

"But whatever the source," he said, "the arrangement must be made via an agreement between the DPRK and the United States." North Korea, he explained, fully understands that for the United States to provide LWR technology, for example, by allowing US LWR technology licensed to South Korean companies, to be exported to the DPRK will entail clearing away political and legal barriers that apply to all aid, investment, and trade between the two countries. Indeed, that is the major reason that the LWR issue is so important and why the high level talks will succeed or fail according to the way that the LWR issue is handled.

"It is crucial," he said, "that the next round of high level talks with the United States happen very soon. Only a comprehensive solution will work that declares that the United States and the DPRK will together bring about the LWR transfer. This could ease a lot of tension. If such a deal is made, the NPT issue will no longer be a big deal and it would contribute to the normalizing of relations between the DPRK and the United States."

Presuming that the immediate issues relating to the reactivation of routine inspections are overcome and US-DPRK high level talks are reconvened, what obstacles to and opportunities for cooperation arise with respect to the transfer of LWR technology to the DPRK?

In this epilogue, I analyse these obstacles and opportunities in a hierarchy starting with high and ending with low order questions. I conclude with some suggestions as to practical steps toward cooperating with the DPRK that would be entailed by LWR technology transfer, including roles that non governmental organisations can play. 1. The overarching quid pro quo US Objectives: Will the United States facilitate this transfer in return for merely reactivating routine inspections; or must the DPRK also allow special inspections to proceed? modified special inspections? dismantle its reprocessing plant? and allow it to be kept if inspected, but not insist that it be dismantled? dismantle its 200 MWe indigenous reactor? or allow it to be kept if inspected, but not insist that it too be dismantled? DPRK Objectives: Will the DPRK insist that the United States actually supply LWR technology (including the hardware)? commit to ensuring another supplier transfer the technology? merely facilitate discussions with another supplier? finance the transfer? over what time frame? and what will the DPRK give up in terms of fuel cycle capabilities that the United States wants dismantled and which represent fallback insurance if the LWR deal and related normalisation of relations go sour? What Does the DPRK Mean by "LWR Technology Transfer"? Does the DPRK mean the term to cover merely the supply of hardware, software, and peopleware required to plan, construct, operate and decomission an LWR in the DPRK? Or does it include equipping the DPRK with a full LWR fuel cycle facilities? And/or transfer of LWR manufacturing capabilities? In the rest of this paper, I assume that only the first, most narrow definition of transferral is under discussion with the DPRK. However, it is important to clarify this point at the appropriate time with the North Koreans. What Price is the US Willing to Pay to Keep the DPRK in the NPT?: Is the effort worth it for the United States? For the North Koreans, it is evidently necessary to transform their external political and economic relations if they are to commence the delicate process of internal reform, economic transition, and structural adjustment. The stakes for the North are regime survival. The nuclear lever is the only one available to it in which domestic and external factors converged.

But for the United States, the calculus is not so loaded in favor of an LWR transfer: a nuclear pariah state that is the exception that proves the rule of the NPT and forces allies back into US arms for extended nuclear deterrence may be preferrable to a creeping proliferator which retains residual nuclear options under the nose of the IAEA.

Conversely, the United States may be willing to pay a very high price to preserve the regional and peninsular peace, to keep the DPRK in the NPT in order to protect the 1995 NPT Extension Conference, and to avoid a chain reaction of Asian nuclear proliferation. (It should be noted that there appears to be relatively little technical advantage in terms of proliferation proneness of an LWR versus North Korean indigenous reactor technology; the issue is how to keep the DPRK in the NPT/IAEA system versus withdrawal rather than one versus another technology.) Is There a Better Alternative than an LWR Transfer? Is there another deal which makes more sense than LWR transfer? Should the United States propose instead to facilitate a major renovation of the DPRK energy sector, with particular emphasis on coal mines, power system, and boiler technology? Such a package deal would also entail overcome the same legal barriers; would be more in the US Government's purview; could be done incrementally in smaller, faster chunks; and would have a much bigger impact on the DPRK's prospects for economic survival, attracting foreign investment etc. Conversely, would the DPRK see this as a as losing face? as hooking up its economic train too fast and too much to an external locomotive? as foregoing its residual nuclear option to proliferate? 2 The difficulty of moving forward together but separately: Who Moves First? Can the two sides edge forward together toward normalisation of political and economic relations without admitting it? Or will the United States insist that the DPRK fulfil its IAEA/NPT obligations down to the last letter before any formal upgrading occurs and it commits to facilitating an LWR transfer? Conversely, will the DPRK accept US "concessions" (such as cancelling exercises, declarations of no first use, negative security guarantees, and the like) as surrogates for formal upgrading of relations, or will it insist that the two move strictly in tandem (creating problems for the United States with its allies)? Will it insist that the LWR transfer be realized before it reimplements full scope safeguards? 3 Political issues that arise include: Political and Ideological Opposition: Overcoming the political barriers in the United States and key allied states to allowing LWR technology to be transferred to a proliferation-prone state. In particular, the "non proliferation at all costs" school will have to be overcome as well as hardline hawks who relish the prospect of a confrontation with North Korea, their perfect adversary. The ROK's Reaction: Most important, how will the ROK react? What domestic political factors will come into play in Seoul that will affect the ROK's support or opposition to transferring LWR technology to the North? The IAEA's Role: Can the IAEA play a productive role in the transfer given its recent history with the DPRK? (It continued to assist the DPRK on non-politicized projects until very recently to keep the door open to Pyongyang.) Is a US Commitment Credible to the DPRK? Given the problems adduced above and below, is a US commitment to effect the transfer credible to all players in Pyongyang? Is this issue amenable to external inputs of any kind? 4 Obstacles to Transfer include: Obtaining Congressional Approval: Negotiating a deal that is acceptable to not only the DPRK, but to all parties that must be consulted and agreeable inside the United States, especially in Congress. The relevant acts are quite stringent in this regard, particularly with respect to the legal obligations of the Nuclear Regulatory Commission (25). The Legal Barriers: Skirting the thicket of legal barriers to allowing a strategic technology to be transferred to North Korea, including COCOM, the London Suppliers Group/Zanger List, Terrorism Act, Trading with the Enemy Act, Nuclear Non Proliferation Act, and many (twenty plus) other US laws; and, in the ROK--the only likely supplier of LWR technology to the DPRK (see below), what legal obstacles have to be overcome given its own nuclear export controls, both for ROK nuclear technology, and for US-licensed technology exports? Who Might Finance the Transfer? Financing the deal given that the DPRK is bankrupt and owes banks and creditors about $5 billion. The only conceivable source for the $2 billion+ that would be required is the ROK. The United States has virtually no manufacturing plant on line for making LWRs (although some components or parts of a second hand reactor from a US utility might be available cheap, or the BNPP in the Philippines) and even less political will to finance such an export., (26) Russia could supply the technology but not the finance, and it is difficult to conceive of barter trade on a scale that would meet the bill. Japan must resolve the reparations problem before the DPRK will entertain a specific deal like the LWR transfer. No-one wants France to be involved. What Role Might South Korea Play in the Transfer? That leaves South Korea. What kind of financing package might be involved? Apart from a major government-financed grant-in-aid, what kind of loan-cum-in-kind-repayment deal might be negotiable? Could the DPRK repay the loan in raw materials? by exporting electricity from the plant via a linked grid across the DMZ? Does the ROK actually have the full complement of LWR-related manufacturing capabilities that it claims? Building an LWR in the DPRK: Constructing an LWR in the DPRK would be a nightmare. There is almost no supporting infrastructure. Materials and services are of very poor quality, so all steel and concrete as well as every nut and bolt of machinery, plus all the supporting suppliers of incidental and routine goods and services for large scale power plant production, all of this and more will have to be imported. A ROK supplier will have advantages in this regard: its management, skilled and construction labor speak the same language as their compatriots; they have large stocks of the relevant nuclear-specific materials and items produced up to US nuclear engineering and manufacturing standards, plus a well developed set of supporting suppliers of goods and services. Time Horizon: DPRK decision makers may not fully realise the time required to plan, construct, and complete an LWR. The DPRK has never undertaken an industrial project on the scale and complexity of an LWR plant. Its industrial and construction culture is attuned to massively engineered, low technology, labor-intensive approaches that have no or negative bearing on nuclear power plant construction techniques. It will take at least 5-6 or more likely 8-10 years before the DPRK sees the first kWhe from an LWR. This time horizon is beyond the political lifetime of the current generation of gerontocrats in Pyongyang. It is not clear that the decision makers who will inherit this legacy will want to complete the project. If so, then the suppliers and financiers will incur additional risk of project non-completion and DPRK non-payment of the financing. The rulers-in-the-wings may also not thank the suppliers for locking them into a nuclear white elephant (the Aquino precedent is relevant here). Operation and Maintenance: North Korea's electric agencies are singularly ill-equipped to operate a nuclear power plant. Also, their grid may be technically inappropriate for a large (GWe) LWR due to the reliability criterion (density of interconnection and peak load relative to size of biggest generation unit). Although the performance of system operators can be upgraded during the LWR construction period, there are practical limits on what can be done in this regard, even in 5-6 years. Technical constraints include: deteriorating fuel supply, generation, transmission and distribution, and end use equipment; and almost non existent system control and dispatch capabilities in real time. Cultural and institutional constraints include organisational pathologies associated with forty years of command and control economics, standard operating procedures that are incompatible with safe and economic operation of an LWR etc. Uneconomic Front and Back End Fuel Cycle Facilities: Also, with only one LWR (which is all it could ever hope to obtain, whatever the pretensions of its Ministry of Atomic Energy Industry), the DPRK would not be able to operate economic front (uranium supply and fuel fabrication) and back end (storage except racked on the LWR site, and disposal) fuel cycle facilities. Perhaps it is best to assume that by the time an LWR comes on line, the two Koreas will be merging and South Koreans would staf and operate the DPRK's LWR; if there are still two separate states, perhaps South Koreans could be seconded to the North Korean nuclear agency. Until a couple of years ago, DPRK nuclear officials assumed that they could reexport the spent fuel to the former Soviet Union; now, they don't know what they will do with spent fuel any more than their ROK counterparts. Safety: There probably isn't much difference in the relative hazard of the indigenous DPRK nuclear reactor (higher chance of catastrophe with less technological isolation from the biosphere, but less curies of radioactivity in a smaller core) versus an LWR (less likely to crash with more barriers against release, but bigger load of radioactive materials). Training and technical assistance in site selection, operating procedures, radiation monitoring, and accident and emergency response procedures would be important aspects of a cooperative approach to an LWR program in the DPRK. Also, the DPRK would need to set up from scratch a sound regulatory framework including an independent nuclear regulatory agency. 5 Practical Cooperation with the DPRK

This list of obstacles to successful transfer is daunting. Equally, each obstacle represents an opportunity for possibile cooperation and dialogue with the DPRK, even if the final outcome is not a realised LWR transfer. I draw the following conclusions from the preceding sections.

Conclusion 4: Governments must play the primary role if a transfer is ever to be achieved. Only Governments can mobilize the requisite resources to address a number of the critical issues listed above.

Conclusion 5: Non governmental organisations have a role to play, but to be effective, they must enter the field only in areas where their flexibility, informality, and speed can help the negotiating parties to come to grips with and resolve critical issues. With a strategic approach aimed a key pressure points, NGOs can complement official work in all three capital cities involved in this question.

Conclusion 6: Governments are currently engaged in short term maneuvering and hard bargaining on other critical issues that will determine whether another round of high level talks take place this year. Very little hard work on the core issues involved in an LWR transfer has been undertaken within any of the Governments. All three Governments with most at stake in the DPRK nuclear issue must become much more informed about the potential for and obstacles to cooperation if the LWR issue is to become a practical plank of cooperation rather than another issue of contention.

Conclusion 7: NGOs have a comparative advantage in their ability to quickly address some of the critical issues that will face Governments (see below). They are unlikely to have much to offer in terms of defining legal and political barriers as legal counsel in the State Department and the Pentagon have already reportedly completed this analysis. Indeed, their main task may be to educate and restrain the more ideological anti-nuclear opponents who may take the US Government to court using NEPA, mobilize Congressional and media opposition in order to block the transfer, etc. Such educational meetings should be convened sooner rather than later, especially in Washington DC, and could be usefully undertaken by Carnegie Endowment; Nuclear Control Institute; Natural Resources Defense Council; etc.

Conclusion 8: In particular, NGOs could enter into dialogue with South Korean NGO and QANGO (quasi autonomous NGO) counterparts to clarify what reaction might be expected from Seoul to the ROK being the LWR supplier; and what issues and will arise and obstacles have to be overcome should it become the major source.

Conclusion 9: NGOs could also usefully enter into a dialogue with the DPRK Government to provide it with a better understanding of the critical economic, legal, and technological issues surrounding LWRs; in particular, they could address the relative economic and environmental performance of Russian versus US LWR technology. The Center for Energy and Environmental Studies at Princeton University; the Union of Concerned Scientists; the Federation of American Scientists could all supply such briefing missions at short notice. Such a mission could include some experienced Korean American nuclear engineers with construction experience in the ROK, likely from Bechtel or from Westinghouse companies.

Conclusion 10: NGOs could also explain to DPRK decision makers some of the opportunity costs and possible advantages of switching its demand from LWR to energy efficiency and energy supply technologies. The International Institute for Energy Conservation with its Thai office; or the International Energy Efficiency Initiative, with its Indian base in Bangalore, could play an important role in sending briefing missions to the DPRK on the latter issue.

APPENDIX 1: TEXT OF U.S.-DPRK NUCLEAR STATEMENT

The delegations of the United States of America (USA) and the Democratic People's Republic of Korea (DPRK) met from July 14-19, 1993, in Geneva for a second round of talks on resolving the nuclear issue.

Both sides reaffirmed the principles of the June 11, 1993 joint USA/DPRK statement.

For its part, the USA specifically reaffirmed its commitment to the principles on assurances against the threat and use of force, including nuclear weapons.

Both sides recognize the desirability of the DPRK's intention to replace its graphite-moderated reactors and associated nuclear facilities with light water moderated reactors. As part of a final resolution of the nuclear issue, and on the premise that a solution related to the provision of light water moderated reactors (LWRs) is achievable, the USA is prepared to support the introduction of LWRs and to explore with the DPRK ways in which LWRs could be obtained.

Both sides agreed that full and impartial application of IAEA safeguards is essential to accomplish a strong international nuclear non-proliferation regime. On this basis, the DPRK is prepared to begin consultations with the IAEA on outstanding safeguards and other issues as soon as possible.

The USA and DPRK also reaffirmed the importance of the implementation of the North-South Joint Declaration on the Denuclearisation of the Korean Peninsula. The DPRK reaffirms that it remains prepared to begin the North-South talks, as soon as possible, on bilateral issues, including the nuclear issue.

The USA and the DPRK have agreed to meet again in the next two months to discuss outstanding matters related to resolving the nuclear issue, including technical questions related to the introduction of LWRs, and to lay the basis for improving overall relations between the DPRK and the USA.

Source: Reuter's wire service, July 19, 1993.
(remaining appendices and figures are available in hard copy version of this paper. Please contact Nautilus Institute.)

APPENDIX 2: RELATIVE PROLIFERATION INTENSITY RANKINGS

Definition of ranking in factors

Source: J. Holdren, "Civilian Nuclear Technologies and Nuclear Weapons Proliferation," in C. Schaerf et al, New Technologies and the Arms Race, St. Martin's Press, New York, 1989, pp. 182-185; cited by permission of the author.

APPENDIX 3: ENERGY SECTOR FLOW CHART FOR DPRK

Source: Author's files

APPENDIX 4: DPRK ELECTRIC POWER INDUSTRY COMMITTEE (EPIC)

Source: Author's files

Figure 2. DPRK Annual and Daily Load Curves, 1989

Figure 3. Transmission and Distribution System

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