DPRK “Collapse” Pathways: Implications for the Energy Sector and for Strategies Redevelopment/Support

Recommended Citation

"DPRK “Collapse” Pathways: Implications for the Energy Sector and for Strategies Redevelopment/Support", NAPSNet Special Reports, January 18, 2011, https://nautilus.org/napsnet/napsnet-special-reports/dprk-collapse-pathways-implications-for-the-energy-sector-and-for-strategies-redevelopmentsupport/

DPRK “Collapse” Pathways: Implications for the Energy Sector and for Strategies Redevelopment/Support

Special Report, January 18, 2011

Peter Hayes and David F. von Hippel

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This paper originally presented at the conference "The Korea Project: Planning for the Long Term," sponsored by the Korean Studies Institute, USC, and Korea Chair, CSIS. Held at the University of Southern California, Los Angeles, CA, August 20-21, 2010.

I. Introduction

Peter Hayes, Executive Director of the Nautilus Institute, and David von Hippel, Nautilus Institute Senior Associate, write, "Whether precipitated by war, coup, or simply continuing slow economic decline, it is incumbent on the international community to help to provide services and support to stabilize North Korea in the unlikely event of outright collapse. Fortunately, many of the measures that would be needed are the same as should be undertaken in the non-collapse pathways. Among the many likely needs of the North Korean population following a collapse—food, clean water, heath care, and economic development among them—the need to promptly provide the population with reliable and demonstrably improving access to energy services (heat, light, mechanized transportation, and so on) will be a key to stabilizing the country, meeting other post-collapse needs, and readying the North for eventual smooth (one hopes) integration with South Korea."

The views expressed in this article are those of the author and do not necessarily reflect the official policy or position of the Nautilus Institute. Readers should note that Nautilus seeks a diversity of views and opinions on contentious topics in order to identify common ground.

II. Article by Peter Hayes and David von Hippel

-"DPRK "Collapse" Pathways: Implications for the Energy Sector and for Strategies Redevelopment/Support"

By Peter Hayes and David von Hippel

1. Introduction

The prospect for the DPRK (Democratic People's Republic of Korea) and its leadership is bleak. Kim Jong Il's health is poor, so a succession is conceivable, albeit off unknown probability. There is little chance that the economic poverty of almost all North Koreans will change for the better. The external powers will continue to squeeze the DPRK with sanctions, especially the United States. Hyperinflation is in the cards in the aftermath of the currency redenomination failure. External aid will be minimal so long as the nuclear weapons issue remains unresolved.

This dismal future does not mean the DPRK is about to collapse. "Collapsists" have been arguing since the end of the Cold War that the DPRK "is about to collapse." Indeed, one notable expert and colleague, Aidan Foster-Carter, reissued his latest prediction in this vein on November 15, 2009, saying that the DPRK could "fall at any moment,"[1]—a claim no more persuasive than that made by Foster-Carter in 1992! [2] Many scenarios, including a persistent, slow recovery and gradual modernization of the DPRK, are possible.[3] Serial collapsists have the advantage that their prognostications are neither confirmed nor denied—they are what Karl Popper termed "unfalsifiable" statements. That is, the continued survival against all apparent odds of the DPRK is not regarded as refutation of the prediction and posing a longevity worthy of investigation and

explanation; and the only way to prove the prediction is to wait for the predicted outcome, at which time the prediction has a *post-ad hoc* character of truth after the fact. Thus, we should tread warily when it comes to claims about the prospective nature of collapse in the DPRK.

There is a reason, we suggest, that the DPRK has outlasted every other statist, personalized regime since the end of the Cold War. The DPRK is different, it is unique, and it represents a sample of one. It is hard to conduct authentic social science with a sample of one, especially from a distance. Moreover, this sample of one is intimately connected with and arguably inextricably linked with the status of United States policies. The two modern Korean states were born in war with each other; they have remained at war for nearly six decades; they are at war today. In our view, one cannot analyze the prospects for change in the DPRK without simultaneously analyzing the rates and types of change in US foreign and military policy.

Rather than outright collapse in the next decade, far more likely is either a "slow burn" by which we mean continuing slow degradation of the economy and consequent adaptation at local levels to tighter scarcity constraints; or a very slow recovery nurtured by economic reforms, buttressed by external support from and trade with China, and large-scale labor exports; or a faster recovery based on rapprochement with the ROK and the integration of DPRK state-owned-enterprises with the ROK's chaebols.

In an overall spectrum of possibility, we estimate that the non-collapse pathways dominate, covering roughly 95 percent or more of the policy spectrum. In this 95 percent plus range, the primary question is what support and reconstruction policies are available to avoid outright collapse, the outcome that is most likely to lead to loss of control of fissile material, nuclear warheads, people, and escalation to war via civil war or cross-DMZ war. Many, perhaps most, of the policy responses called for to deal with avoiding collapse are the same as will be needed in the case of outright collapse. [4] The main difference in the post-collapse pathways is greater scale and speed and therefore cost needed to re-establish stability rather than to merely maintain it. Perhaps there is an obvious lesson in economics of policy choice in that difference.

The biggest qualitative difference between non-collapse and collapse pathways will be in the military dimension after a DPRK collapse. Obviously, the highest velocity policy response in the case of DPRK collapse will be the moves by the ROK military (in particular, its special forces) to occupy and control key leadership posts, military bases, critical infrastructure, and transport chokepoints. How long this intervention would last is impossible to know in advance, but it could be held in place for many months or even years, depending on the degree to which local populations comply with the legitimacy of the occupying forces as against rebel against perceived injustices inflicted during the takeover. This particular policy response has its energy implications, both in its execution, and in its implications for energy sector reconstruction and immediate humanitarian assistance to the DPRK population. We will not cover, however, the military-energy aspects of establishing post-collapse control of the DPRK in this paper, although we will review the implications of how a war might be fought with the DPRK on post-war reconstruction.

In spite of these caveats, collapse is conceivable and should be addressed. Indeed, we have observed situations in the DPRK where the fabric of rural life was literally coming apart, and the demands on individuals and social units were beyond human endurance. By collapse, however, we have a specific meaning in mind, namely, the complete breakdown of central government in Pyongyang. In our view, such collapse is unlikely in the case of the DPRK in the short to medium-term. Given the number of interacting internal and external variables that affect the probability of DPRK collapse in the long-term (ten plus years), that probability is simply unknowable. Thus, we will concentrate largely on the short to medium- term in our analysis.

Whether precipitated by war, coup, or simply continuing slow economic decline, it is incumbent on the international community to help to provide services and support to stabilize North Korea in the unlikely event of outright collapse. Fortunately, many of the measures that would be needed are the same as should be undertaken in the non-collapse pathways. Among the many likely needs of the North Korean population following a collapse—food, clean water, heath care, and economic development among them—the need to promptly provide the population with reliable and demonstrably improving access to energy services (heat, light, mechanized transportation, and so on) will be a key to stabilizing the country, meeting other post-collapse needs, and readying the North for eventual smooth (one hopes) integration with South Korea. In this paper, we begin, in a largely qualitative way, the exploration of the implications of various DPRK "collapse" pathways for the energy sector of the North Korea, and for the approaches that the Republic of Korea (ROK) and other interested parties will need to take to rebuild and redevelop the DPRK energy sector, and in planning for same. The remainder of this paper is organized as follows:

- **Section 2** provides a brief background on the status of the DPRK energy sector, and on Nautilus Institute's approach to DPRK energy sector analysis in general, and to evaluating the impact of "collapse" pathways in particular.
- **Section 3** presents our illustration of four potential pathways that could lead to the collapse of the government of the DPRK, ranging from a quick collapse brought on by a "shooting war" or a West-friendly coup to a collapse from continued isolation and slow decline, which could take years or decades.
- **Section 4** describes our assessment of the implications of collapse pathways for the DPRK energy sector, and for provision of energy services (including energy supply and demand infrastructure) in the DPRK. For each collapse pathway, we identify key measures that the international community—including but hardly limited to the ROK and the US, would be obliged to or could take to help the DPRK transition toward eventual reunification with the ROK (whether official or *de facto* through economic integration).
- **Section 5** summarizes key overall lessons from our preliminary analysis of collapse pathways, focusing on near-term initiatives and planning efforts that the international community might carry out and support that would help to manage, smooth, and make easier the post-collapse transition for the DPRK populace, independent of how collapse actually occurs.

2. Background: The DPRK Energy Sector since 1990, and Nautilus Analytical Approaches

When the Soviet Union was dissolved in 1990, the DPRK lost not only its major supplier of crude oil and of parts for its power plants and factories, but also the markets for the bulk of the goods that its factories were designed to produce. The rapid economic and resource contraction, compounded by a series floods and droughts that affected both agriculture and energy production, plus economic isolation resulting from the international reaction to the DPRK's nuclear weapons program, resulted in a downward economic spiral of reduced energy availability and reduced industrial energy demand as the country's infrastructure fell into disrepair and markets dried up. By 2000 the DPRK's use of coal and production of electricity had fallen (by our estimates—see below) to almost a quarter of its 1990 levels, and overall energy end use had fallen to less than 40 percent of what it had been a decade before. Since this period, the DPRK's energy sector has been sustained primarily by an annual half-million tonnes of crude oil from China, modest imports of refined oil products, Korean tenacity and ingenuity that have kept some of its coal mines and aging power and coal production infrastructure running, and the substitution of wood and other biomass for subsistence energy use.

Much of the DPRK's major energy and industrial infrastructure dates to the 1950s, '60s, and '70s, with some, including major hydroelectric plants, dating to the 1920s Japanese occupation era.

Since 2000 there have been modest improvements in the DPRK economy and energy sector, with some power plant repairs, new small hydroelectric facilities, and new mining activity underwritten, in large part, by Chinese investment. Still, shortages of power, district heat, and coal persist, with blackouts even in Pyongyang, and much more tenuous power supply in other areas. In effect, the North Korean electricity system, though it is nominally a nationwide transmission and distribution grid, is in effect an patchwork of a few regional and some local grids, centered around major and smaller power plants. Most of the large thermal (almost all coal-fired) power plants and heating plants are only partially in operation due to damage of various kinds to one or more boilers/generating units, and/or to transformers, substations, or other parts of the transmission and distribution system. This means that even if large amounts of fuel or electricity were suddenly to be available to the DPRK, distribution of that energy would be problematic.

The combination of erosion in its energy system and industrial infrastructure, together with similar erosion in its transport infrastructure in many areas and lack of investment capital, means that the DPRK will not be able to reconstitute, or perhaps more accurately, redevelop, its energy system and economy in general without outside help. Rebuilding power plants—most of which, remember, were built with major components imported from the USSR or elsewhere—could not be done, at least for many years, using materials "made from scratch" in the DPRK because the industrial infrastructure to make the required power plant components either is no longer operating or, in fact, was never present in the DPRK. Similarly, decades of relative isolation have left the DPRK substantially without the capabilities in metallurgy, electronics, and other fields that would allow it to develop new industries. This means that the DPRK cannot redevelop its infrastructure sufficiently to develop a sustainable, peaceful economy without outside help.

Even for the DPRK economy to remain at its current "subsistence" level, help from other nations has been required. As noted above, the DPRK receives sufficient crude oil from China to keep one of its two oil refineries running, though at well below full capacity. This oil is paid for at market prices, but the DPRK runs an annual trade deficit with China. China could provide more crude oil to the DPRK, and has done so in the past (in some years during the 1990s), but the fairly constant flow of oil from China to the DPRK for the past decade or so suggests that China has determined the amount of oil that the DPRK economy needs to receive to fuel basic economic functions, and is providing that amount. This suggests to us that although China is willing to provide fuel to keep the DPRK economy (and society) from failing, it is unwilling, until the DPRK can afford the additional imports on its own, to provide sufficient assistance to actually redevelop the DPRK economy.

Hard data on virtually anything regarding the DPRK is hard to come by, and the energy sector is no exception. Given that some understanding of the DPRK energy sector has been (and still is) needed in order to allow the international community to effectively engage with the DPRK on energy issues (including those related to negotiations over the DPRK's nuclear weapons program, we have worked since 1994 to assemble and update a description and quantitative estimate of activity in the DPRK energy sector. Our approach in doing so has been to:

1. Obtain as much information as possible about the DPRK economy and energy sector from media sources, visitors to the DPRK, and other sources as available.
2. Using this available information, together with comparative analysis of energy supply and demand in other nations over time, tempered by our own judgment and that of colleagues, assemble a coherent and consistent picture of the DPRK energy sector, which we summarize in the form of an

"energy balance" (see Table 1 for an example balance for the year 2005 [6]).

3. Think about possible future paths for DPRK energy sector/economy, what changes (national, regional, global) might bring those paths about, implication of changes for end-use, infrastructure

Figures 1 and 2 show our estimates of the evolution of DPRK energy demand by sector and fuel, respectively. Note that 2008 estimates shown in these figures are preliminary only, as we are in the process of updating our DPRK energy sector analysis.

Figure 1: Estimated DPRK Energy End-Use by Fuel, 1990 - 2008

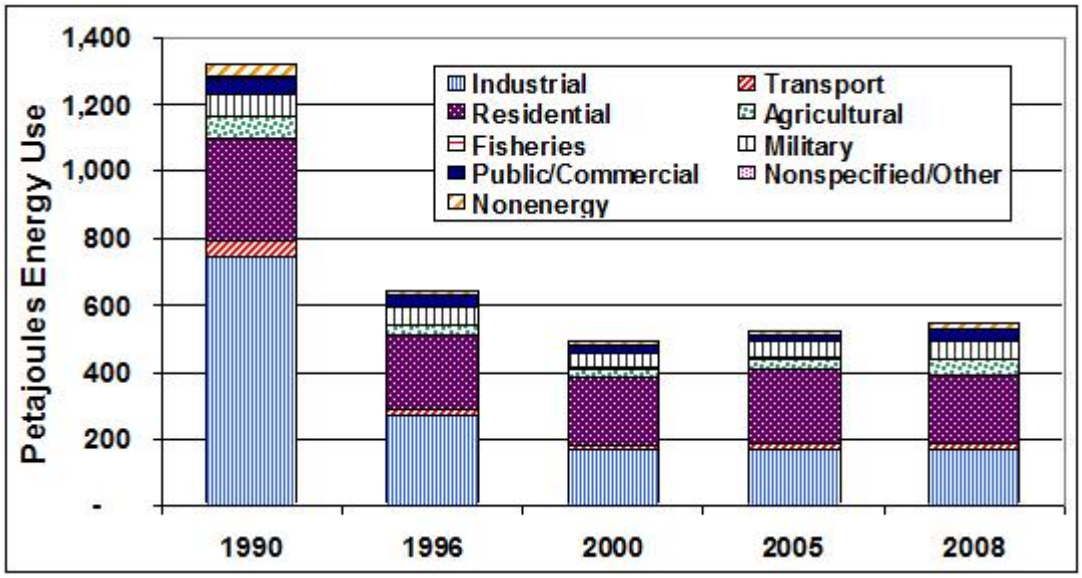


Figure 2: Estimated DPRK Energy End-Use by Fuel, 1990 - 2008

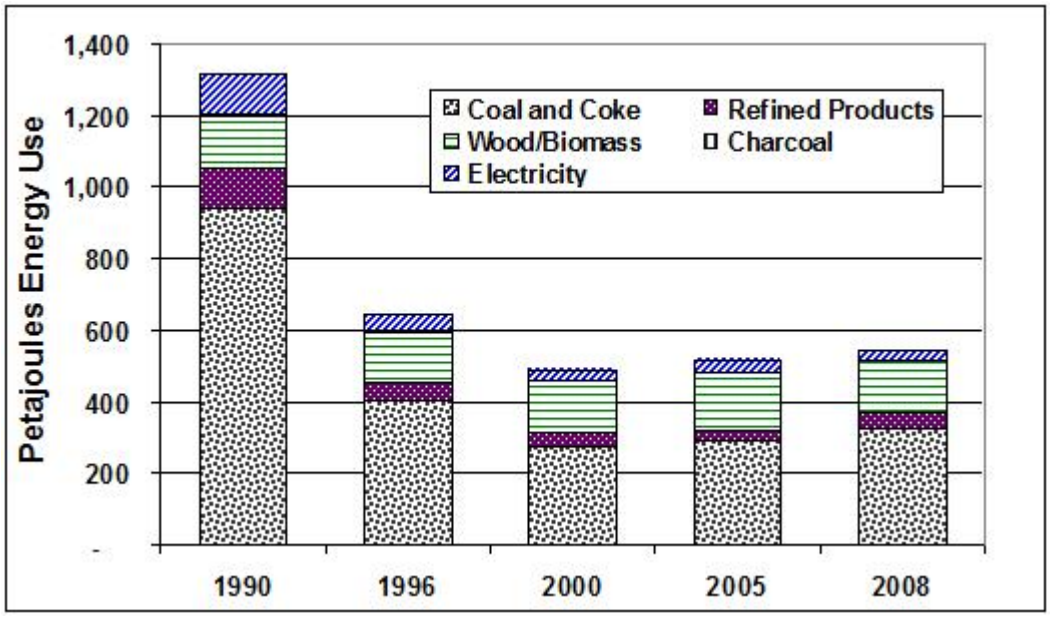


Table 1: Estimated DPRK Energy Balance, 2005 [6]

UNITS: PETAJOULES (PJ)	COAL & COKE	CRUDE OIL	REF. PROD	HYDRO/ NUCL	WOOD/ BIOMASS	CHAR-COAL	ELEC.	TOTAL
ENERGY SUPPLY	405	24	17	33	162	-	(0)	642
Domestic Production	480	1	-	33	150	-	-	665
Imports	5	22	17	-	12	-	0	57
Exports	80	-	0	-	0	-	0	80
Stock Changes	-	-	-	-	-	-	-	-
ENERGY TRANSF.	(117)	(24)	17	(33)	(4)	1	37	(121)
Electricity Generation	(88)	-	(5)	(33)	-	-	60	(66)
Petroleum Refining	-	(24)	24	-	-	-	-	(0)
Coal Prod./Prep.	(23)	-	-	-	-	-	(3)	(26)
Charcoal Production	-	-	-	-	(4)	1	-	(3)
Own Use	-	-	(1)	-	-	-	(4)	(5)
Losses	(6)	-	-	-	-	-	(16)	(21)
FUELS FOR FINAL CONS.	289	-	35	0	158	1	37	520
ENERGY DEMAND	289	-	35	-	158	1	37	520
INDUSTRIAL	150	-	8	-	0	-	14	172
TRANSPORT	-	-	9	-	1	-	4	14
RESIDENTIAL	94	-	3	-	118	1	4	220
AGRICULTURAL	8	-	1	-	25	-	1	35
FISHERIES	0	-	1	-	-	-	0	2
MILITARY	22	-	12	-	4	-	9	46
PUBLIC/COMML	14	-	0	-	4	-	5	23
NON-SPECIFIED			-					-
NON-ENERGY	2		1		6			9
Elect. Gen. (Gr. TWhe)	5.23	-	0.17	11.15	-	-	-	16.55

**Note: Gross terawatt-hours for coal-fired plants includes output for plants co-fired with coal and heavy fuel oil.*

Starting from the estimated 2005 energy balance shown above, we prepared (and are currently updating) future scenarios of energy-sector development for the DPRK, using the Long-range Energy Alternatives Planning energy/environment software tool or LEAP [7]. In our earlier work, as shown in Figure 3, we compared a "Redevelopment" path, implying significant opening of the DPRK economy to outside investment and assistance, but without significant emphasis on energy efficiency improvement, with a "Sustainable Development" path emphasizing energy efficiency and (to a lesser extent) renewable energy, and a "Regional Alternative" path also including DPRK participation in several types of regional energy infrastructure (for example, gas pipelines and electricity trading). An additional path modeled, the "Recent Trends" path, assumed that a substantial solution to the DPRK nuclear issue was not forthcoming, and recent trends in the DPRK economy continued.

Figure 3:

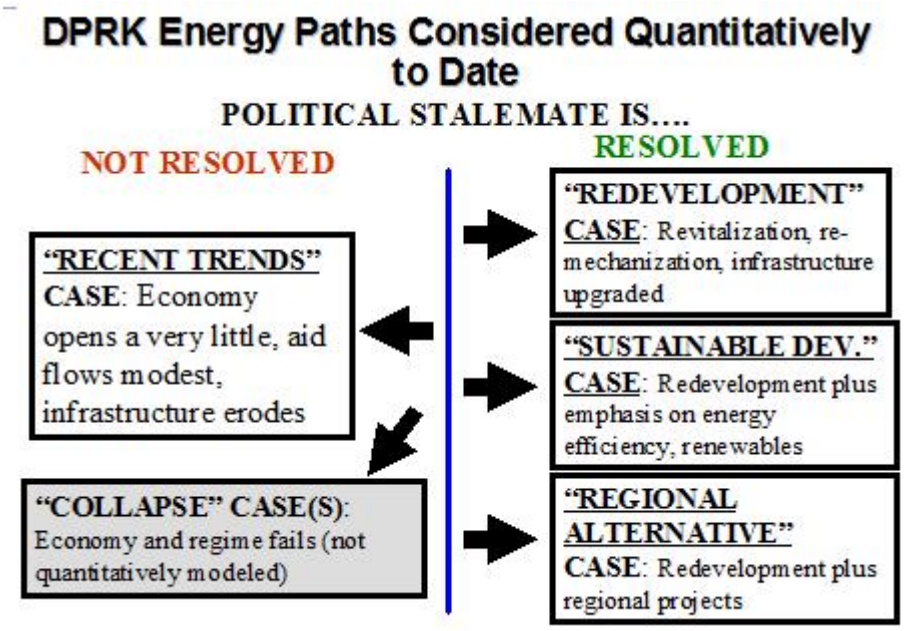


Figure 4 shows the results of energy use by sector in the DPRK under one of the paths described above, the "Redevelopment" path. Note that these are preliminary results using a 2005 base year. We are currently in the process of updating our overall analysis to a 2008 or 2009 base year, and will update our DPRK energy futures analysis as well.

Figure 4:

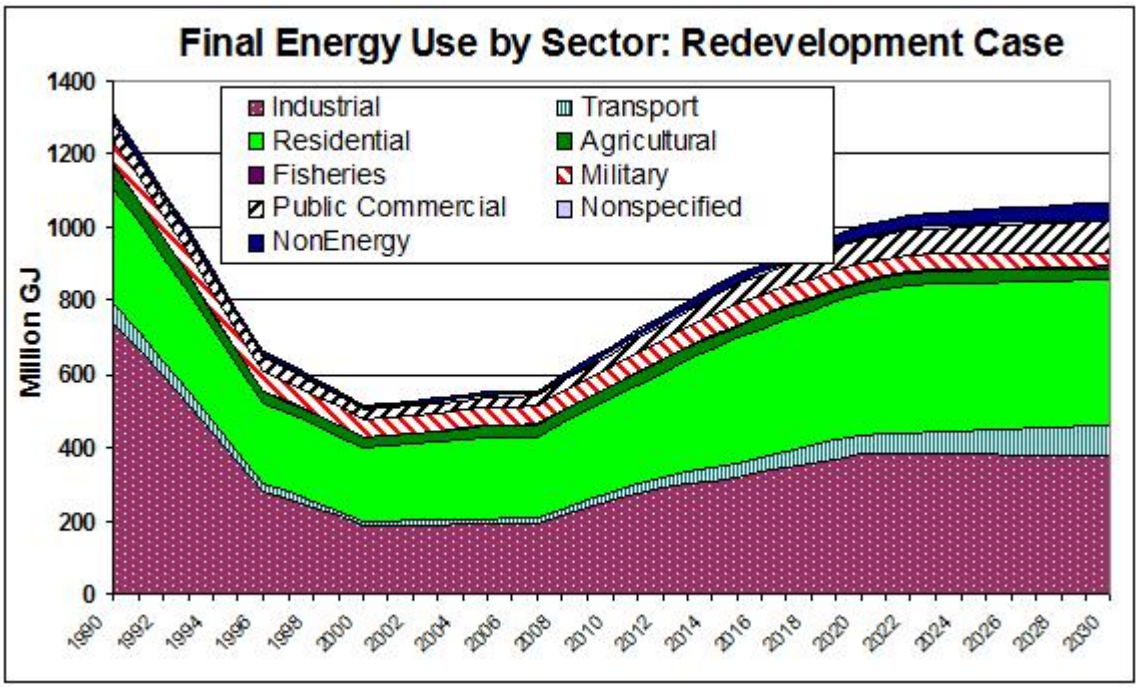


Figure 5 shows the results of energy use by fuel in the DPRK under the "Redevelopment" path. Note

the decline of biomass fuels use after about 2007, and the increased use of electricity, and later, gas, as these fuels become more available to North Korean consumers.

Figure 5:

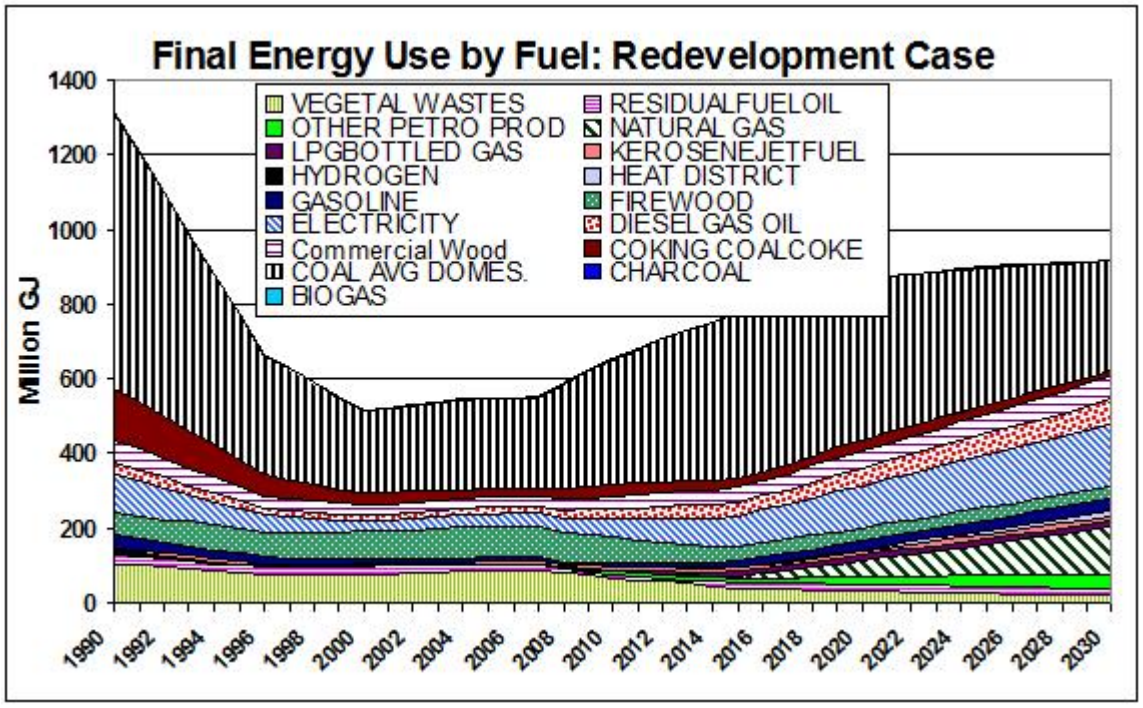


Figure 6 compares final electricity use (but not use of other fuels) by path. The "sustainable development case" (Blue diagonal stripes) is set up to provide the same energy services as the "redevelopment case" (green with dots), but with much more aggressive use of energy efficiency, which significantly reduces overall electricity demand. The "recent trends" case shown here is probably closest to the "slow collapse" path discussed later in this paper. Figure 7 shows the significant reduction in greenhouse gas emissions achieved in the sustainable development case and regional alternative case relative to the redevelopment case. Red and blue lines show the greenhouse gas emissions benefits of redevelopment approaches that emphasize energy efficiency and regional cooperation early-on. In the Recent Trends case a gradual economic improvement occurs, but without much assistance from outside, and as a result without much improvement in energy efficiency. The Recent Trends path also assumes that military energy use, which as of 2005 was less then 9 percent of DPRK total energy use, but slightly over a third of the DPRK's use of petroleum products and over half of all diesel oil and gasoline use, will continue indefinitely at near-current levels, while in the other paths, as a "peace dividend", a substantial shrinking of the DPRK military occurs, with a reduction in DPRK military energy use of over 50 percent (for example, in the redevelopment path) as a result.

The net costs of reductions in energy use in moving between the redevelopment path and the sustainable development or the closely-related regional alternative path may be relatively small or even negative, as illustrated in Figure 8. Redevelopment with greater energy efficiency costs more on the demand side, but saves money overall by reducing supply-side and resource costs. These results of our earlier work showed negative net costs (that is, net savings) for the Sustainable Development and Regional Alternative paths, relative to the Redevelopment path, even assuming future oil prices much lower than today's levels. We are continuing to update these analyses, but

expect that revised results will show the same general trends, reinforcing the conclusion that the least expensive way to redevelop the DPRK will be as an energy-efficient economy, and underscoring the benefits of a focus on energy-efficiency-related cooperation and assistance options as emphasized below and in our previous work.

Figure 6:

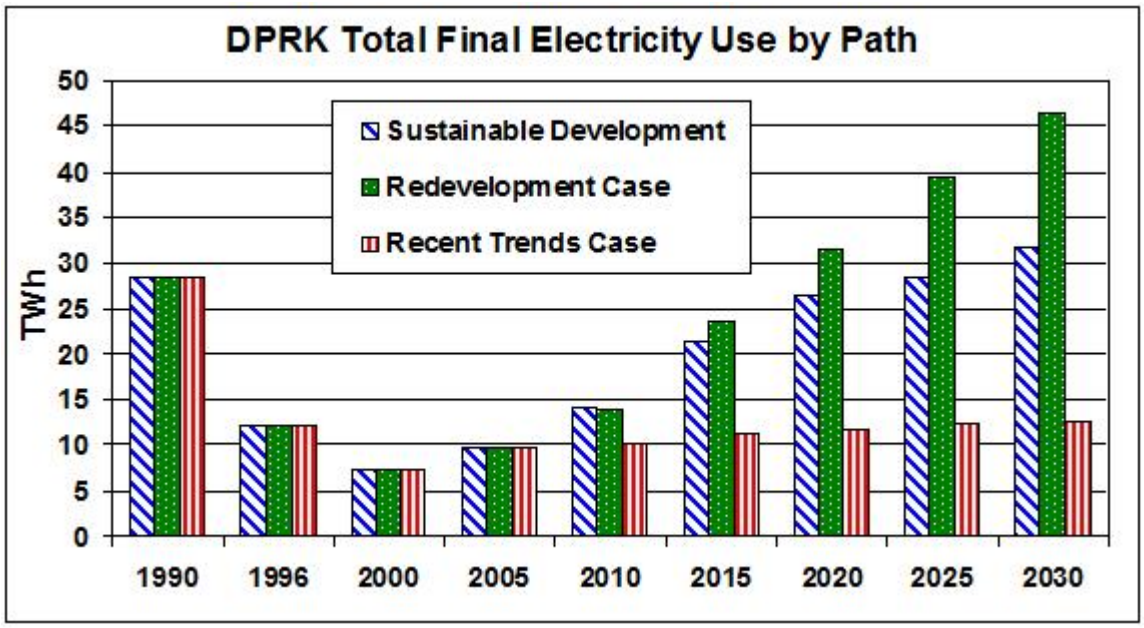


Figure 7:

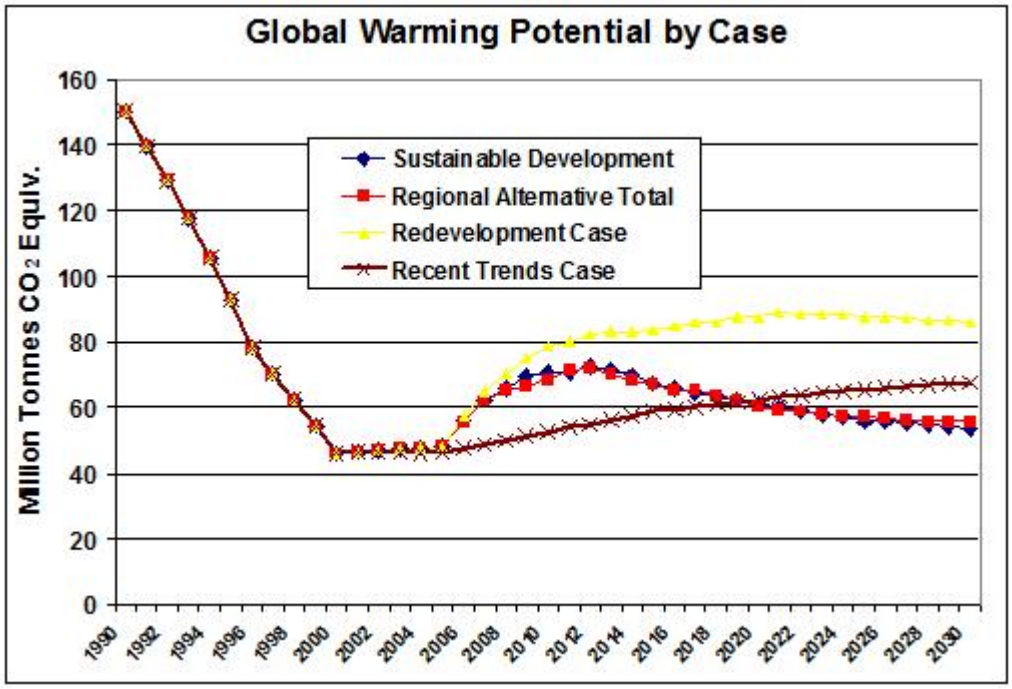
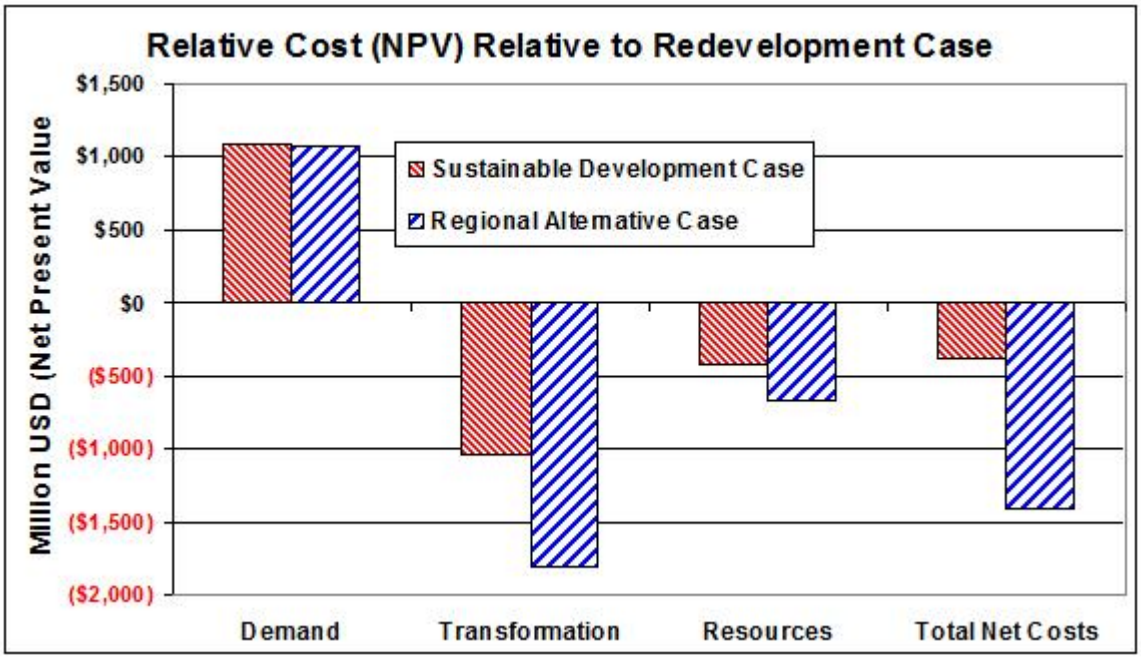


Figure 8:



Two light water nuclear reactors (LWRs) were being constructed on the East Coast of the DPRK near Kumho under the auspices of the Korean Peninsula Energy Development Organization (KEDO), until 2003 [9]. Though the construction of these reactors has since been suspended, reaching an agreement on resuming the LWR project has remained a political priority of the DPRK. As a consequence, the two LWRs were assumed to be installed are included in all of the cases shown in Figures 6 and 7 except the Recent Trends path. In these analyses, the first 1 gigawatt (GW) LWR unit was assumed to start generating electricity in 2013. If we were repeating the analysis today, we would assume that the LWRs would not be on line until 2018 or so, at the earliest, if they were included in the pathways at all.

3. Potential "Collapse" Pathways

3.1 Analytical Approach and Listing of Pathways Considered

Our general approach to the analysis of potential pathways of DPRK regime collapse is as follows. First, we define several significantly different, illustrative regime collapse pathways. We make no predictions about the relative likelihood of any of these paths, and freely admit that the four paths we illustrate have been chosen out of a universe of many possible options. The second step in the analysis is to think about the impacts of regime collapse, for each path, on the DPRK energy sector, and, by extension on energy and related infrastructure that supports the DPRK economy. Third, we consider how the ROK, the US, and the rest of the global community might or would need to respond to energy needs following each different type of collapse. Finally, we identify "robust" planning approaches that, if pursued now or soon, would prove useful in the event of any type of collapse pathway.

We consider four possible paths of regime collapse. These paths are described briefly below, and in more detail in the section that follows:

- **War:** A brief but very destructive war occurs between the DPRK and the ROK and its allies, precipitated by a military incident that rapidly escalates, and leads to essentially immediate unification
- **Regime Implosion Leading to New Authoritarian Regime:** A death or other event leads to regime replacement in the DPRK, with the new regime being modernizing, but leaning toward China and Russia for economic support, and away from the ROK and its Western allies.
- **Regime Change by Palace Coup Leading to ROK-installed Regime:** While not immediately leading to unification, this collapse path would lead to modernization that in turn would lead to at first de-facto economic unification, then, somewhat later, political unification with the ROK.
- **Slow Collapse Leading to Regime Change through Internal Conflict:** In this path, the Kim family and/or other leaders continue the current (largely) isolationist policies, which leads eventually, though perhaps not for many years, to the collapse of the DPRK state, with the ROK and its allies obliged to "pick up the pieces".

3.2 The "War" Path

The "War" path of regime collapse assumes that a shooting war between the DPRK and the ROK (and its allies), once set off by a military incident of some kind, quickly escalates. Given the proximity of DPRK artillery to the ROK border, we assume that this path results in considerable destruction in the Northern ROK (including the parts of the Seoul area close enough to the DMZ as to be within range of DPRK artillery and rocket fire—to the extent that DPRK ground-launched weapons capacity is not suppressed by ROK and US counter-fire), anfad also in considerable destruction in many areas of the DPRK, especially in areas associated with military installations, but perhaps sparing areas near the DPRK's northern borders (for reasons touched on below). Based on previous work (see text box below), our rough estimate is that the DPRK would not be able to sustain a conflict long (probably for weeks, or at most, a month or two) due to lack of fuel supplies. This assumes that China does not somehow step up fuel deliveries to the DPRK, which seems unlikely if the DPRK is seen as the aggressor in the conflict.

We assume that war leads to ROK (assisted by US and others) administration of the DPRK. We further assume that the ROK's administration of the DPRK is managed in such a way that significant dissatisfaction with the administration on the part of the North Korean population is avoided. This is a crucial assumption, as an insurgency related to popular local dissatisfaction with ROK administration of the DPRK would set DPRK rebuilding and redevelopment back years, as has been the case following the US wars in Iraq and Afghanistan. Would the DPRK population welcome ROK/US victors with open arms? Iraq/Afghanistan provide cautionary tales, but an analysis of that particular issue, though it has potentially significant ramifications for what types of energy infrastructure improvements will be possible/effective, is beyond the scope of this paper. Clearly, however, one of the lessons of Iraq is that the degree to which the administration quickly ramps up the provision of the essentials of life—food, clean water, health care, electricity, waste treatment, jobs—to the populace will play a huge role in how well the populace adapts to its new government.

How the war is prosecuted by the ROK/US side will have a significant bearing on the tasks needed to reconstruct the energy system. For example, will the ROK/US alliance choose to:

- Destroy power plants wholesale, or just render plants relatively temporarily unusable with surgical strikes on key, relatively easily-replaceable components?
- Destroy the DPRK's operating refinery, or just cut refined products supply lines?
- Destroy coal mines, or just cut power to them, rail lines from them?

DPRK Energy Supply during a War

Several years ago, we carried out a rough calculation that suggested that it would take about three months of DPRK refinery output, at current levels, to resupply the gasoline and diesel fuel that the military would use in the first month of an active conflict. By the end of the first month of conflict, it would take about two months of total refinery production plus imports (assuming current levels) of gasoline and diesel to operate for an additional month of war the DPRK military vehicles that we estimate might remain operable after the initial 30 days of conflict.

This calculation includes several simplifying assumptions, each with significant to considerable degrees of uncertainty. First, it assumes that 50 percent of DPRK military ground vehicles and armaments would be inoperable after 30 days of conflict, and that 90 percent of the DPRK's navy and 100 percent of its air force would be similarly inoperable or in deep storage. Given the superior firepower, particularly from the air, of the ROK/US alliance, these assumptions seem reasonable to us. Second, it assumes that the DPRK does not have many months of fuel stored in deep bunkers. Here, we have no direct information one way or another, but suspect that the relatively constant fuel shortages over the past decade and more have probably eroded stocks, at least somewhat. Third, it assumes that the one operating refinery continues to provide fuel at current levels, and that the second major DPRK refinery, at Sonbong on the DPRK's northeast coast (currently and recently inactive) is not reopened. The degree to which the currently-operating refinery, in the DPRK's northwest and connected by pipeline with China, maintains its output depends largely on the degree to which China continues supplying crude oil. Refineries are easy military targets, but it seems unlikely to us that the ROK-US forces would attack a facility so close to China. Whether China might increase or decrease the flow of crude oil to the refinery is an open question—our guess is that they might not do either. Reopening the Sonbong refinery would likely take much too long to help much in the event of a conflict, and it is unclear where the crude oil to fuel it would come from. Fourth, we assume that the current (mostly minor) sources of refined products would not increase or decrease much as a result of a conflict. If anything, it seems to us that it would be more difficult, not easier, to import oil by truck, train, or small tanker ship in the event of an armed conflict.

These caveats notwithstanding, the essential finding from our calculation is that the DPRK military would quickly—in a matter of weeks or certainly months—run short of fuel in any major armed conflict. With regard to the "War" path to regime change discussed in this paper, this finding has (at least) two implications. First, the major part of a war between the DPRK and the ROK and its allies is likely to be over, at least in terms of use of large fuel-using vehicles by the DPRK, within two or so months. Second, knowing that a war is likely to be brief, the ROK and its allies might be more inclined NOT to inflict difficult-to-reverse damage on major DPRK energy facilities.

We assume that, given that ROK/US air power superiority will provide control of the skies within days, the ROK/US military command can be prevailed upon to knock out energy infrastructure surgically. War planners will probably deem it necessary to knock out electrical grid to deny power to munitions and armaments factories and other military installations (although the latter will likely have their own power sources). Doing so by wholesale destruction of the transmission and distribution (T&D) grid and major power plants, however, would make it much harder to redevelop

the DPRK energy sector in a timely fashion, and probably isn't necessary. Targeting and destroying, for example, substations at power plants, which are already in very poor shape, will knock the power plants off line indefinitely, and be much easier to fix than would major damage to the power plants themselves. It seems unlikely that ROK/US forces would try to destroy or permanently disable the DPRK's one major operating (Northwest) refinery, as it is so close to China, but they might seek to bomb major rail and road links that would be used to provide fuel to the front, and possibly sink or disable some coastal tankers used to transport petroleum products, and/or target petroleum fuel depots. Disrupting the provision of power to DPRK coal mines would knock most coal production off line, but again, targeting rail links would be inflict damage that would be relatively easy (once the war ended) to fix, but still effective in reducing the DPRK's supply of fuel to the front lines of the war. Probably some war damage would be sustained in DPRK seaports, especially those that host submarines or Special Forces that use naval craft. Due to concerns about humanitarian impacts, plus effects on ROK water resources (rivers that flow across or near the DPRK/ROK border) and on China (for rivers in the northern part of the DPRK), we assume that ROK/US forces would avoid damaging hydroelectric facilities, at least the dams, but might, again, choose to knock hydropower stations off line (except probably, the several Supung and other power stations shared by the DPRK and China that are located along northern border rivers) by destroying key substations.

The descriptions of the "War" path above, and analysis of the energy implications of the War path provided below, assume that Russia and especially China stay out of the conflict. If they do not stay on the sidelines, at least in a military sense, the ROK/DPRK conflict becomes a very different and much more dangerous altercation, to say the least, with possible global consequences.

3.3 "Regime Implosion Leading to New Authoritarian Regime" Path

In the second path considered here, a new regime takes over from the Kim family as a result of the death of Kim Jong Il or his successor, or as a result of some internal coup. The new regime is authoritarian but modernizing, and is dominated by military and technocratic elements. Despite its modernizing elements, the new regime continues to spurn the ROK and the West. Rather, the modernizing approach implies much higher than recent rates of investment (from non-ROK, non-Western sources), and as a result energy infrastructure is rebuilt/redeveloped in close cooperation with China and Russia. For the most part, international governmental organizations and international financial institutions are also excluded by the new regime from the DPRK modernization process.

The elites of the new regime serve themselves by modernizing the DPRK economy enough to modestly improve the lot of the general population, but do so in the process of establishing businesses that mostly emphasize export of the DPRK's mineral and labor resources, with China and Russia as major partners. The elites of the regime operate the export companies, and thereby install themselves as a Korean equivalent of the Russian oligarchs of the 1990s. The ROK remains locked out of DPRK economy in the short and medium-term, but may in the longer term obtain regional network integration (via agreements on and construction of electricity interties and gas pipelines) by paying rent to the DPRK government for energy infrastructure and transport corridors through the DPRK to resources in Russia and markets in China and beyond.

3.4 "Regime Change by Palace Coup Leading to ROK-installed Regime" Path

In this path, following, for example, an act by Kim Jong Il or his successor that it considered the "last straw", a group of cosmopolitan younger DPRK diplomats and technocrats backed by young officers in the KPA takes power, and immediately establishes links with the ROK, the United States, and their allies. The result, initially, is an authoritarian regime that sympathetic to the ROK and the

West. The regime slowly, perhaps very slowly, installs elements of democracy in the DPRK, but focuses first on economic reforms. These economic reforms place emphasis on planning a DPRK economy that complements the ROK economy. For example, initially, economic reforms would likely emphasize development of the DPRK mineral resource base to help provide raw materials for ROK industry, and would utilize cheap labor in the DPRK to compete in industries (for example, textiles, and basic electronics) that have been moving out of ROK to lower-cost suppliers such as China and India. To fund these economic reforms, significant investment is drawn from the ROK, and probably from the US and elsewhere as well.

As with the China- and Russia-leaning elite in the "Regime Implosion Leading to New Authoritarian Regime" path, the new, ROK-leaning regime elites seek to serve themselves, but do so possibly by setting up ROK-style chaebol that they control, and that interface with/draw investment from analogs in the South. Such a regime might be amenable to large-scale virtual exports of DPRK labor via the internet, for example, for Korean language records processing for the insurance, medical, and telecommunications industries.

3.5 "Slow Collapse Leading to Eventual Reunification" Path

In this variant of "Regime Implosion", either Kim Jong Il or a successor from the Kim clique maintains control, or another regime (perhaps run by a "regent" governing the country in the name of a Kim successor) takes power. In either case, however, there is a failure to modernize or open the DPRK significantly to the outside world. Aided by continued isolation, the national regime's control over the country becomes progressively less effective due to continued erosion of energy and other infrastructure, and its inability to provide food and other essentials for the population as a whole.

As this erosion continues, possible situations between national control and total collapse of authority might include the effective fragmentation of the DPRK into "fiefdoms" run by powerful party or military (or criminal) leaders, perhaps supported individually by national neighbors (China, Russia, Japan?) or large foreign investors such as Chinese companies.

We assume that this scenario will lead to eventual reunification of the DPRK with the ROK. Control of information coming into North Korea would breaks down as the power of the central authority to impose order wanes [9], which, coupled with continued decline in living standards, leads eventually to disillusionment on the part of the majority of the population, internal conflict, civil disorder, and possibly even civil war in DPRK. A "Civil War" situation may be difficult to conceive of, given the lack of significant ethnic or religious divides in the DPRK, but a possible mechanism might occur in a "fiefdom" situation where rival warlords controlling (for example) different provincial areas, and using arms smuggled from different friendly nations/groups, begin to struggle for territory or power.

Overall, the process of decline under this path may be very slow, taking years or even decades to play out, but would likely end with a rapid collapse at the end stage that requires urgent intervention by the ROK and its allies (and possibly others on Northern borders to stem/support a flood of refugees leaving North Korea.

4. Implications of Collapse Pathways for the DPRK Energy Sector and for Provision of Energy Services in the DPRK

Each of the four "collapse" pathways outlined above has its own implications for how the DPRK energy sector will be affected. As such, each of the pathways implies different ways in which those in the international community with the wherewithal to help might provide or plan to provide energy

services to the DPRK population and economy in response to, or to soften the effects of, regime collapse. What follows are our initial thoughts on the energy sector and energy assistance implications of each of the paths described above.

4.1 "War" Path

As noted above, a major military conflict between the DPRK and the ROK (and its allies) would, depending significantly on the military strategy that the ROK/US alliance chooses to imply, eliminate considerable energy and industrial infrastructure in the DPRK, though much of it is already failing and/or obsolete. If a "surgical" military approach is used, the minimum short-term requirements to supply basic energy services to the DPRK and to start to build a peaceful DPRK economy would likely be:

- Replace virtually all substation equipment, including both equipment that was war-damaged and equipment that has simply become inoperable (or close to it) over time, as most substation transformers and related equipment are reportedly in poor condition.
- Establish emergency electricity generation, initially fueled with diesel oil or possibly liquefied petroleum gas (LPG, a mixture of propane and butane). This generation might take the form of power barges in coastal areas or where river transport is possible, and package diesel or portable combined heat and power plants in inland areas.
- Try to get major coal-fired power stations restarted, and restart or stabilize output from coal mines to supply them, while undertaking temporary transmission repairs sufficient to get electricity onto the local or regional grid on a semi-reliable basis.
- Ramp up petroleum products production in ROK refineries in order to substitute for whatever DPRK fuel production/transport capacity was destroyed in the war, with additional fuel provided to supply emergency generation facilities. ROK refining capacity is large enough that it could easily supply the ROK and the DPRK together today, though possibly not the both the ROK and DPRK at ROK per-capita levels of consumption. Given the status of DPRK fuels demand infrastructure, however, the DPRK wouldn't reach ROK levels of consumption for many years. As such, overall refined products supplies might not be a problem in a suddenly reunified Korea (though some products will be easier to supply than others), but the infrastructure to move supplies to where they are needed in the North—port facilities, rail facilities, and roads—will need upgrading even if they not damaged by war.
- Try to get major Hydro facilities restarted, including required transmission repairs and/or repairs to dams.
- Provide critical power and fuel for agriculture. The urgency of doing so will, of course, depend on the season in which the conflict occurs, but planning for supporting DPRK agriculture as much as possible will be a priority in any circumstance in order to reduce the quantity of food aid that will inevitably be required.

If a surgical military approach is NOT used by the ROK and its allies, supplying basic services and economy-building in the DPRK would be more difficult. For example, immediate replacement of most power plants would be needed, meaning more "triage" solutions to restart parts of energy facilities however possible, and more provision of emergency generation. Significant emergency civil engineering work will be also needed to shore up damaged infrastructure, repair ports, rail facilities, roads so that emergency supplies of refined products can be brought in.

A key complication of the "War" path is that it will somehow be necessary to rebuild/develop the DPRK at the same time as the considerable damage to the ROK infrastructure (and society) is being

repaired. This complication argues for the need for countries beyond the ROK and US to take a very active role in DPRK reconstruction, as a great deal of ROK rebuilding effort will necessarily be domestically focused. The need to support/rebuild both South and North Korea makes coordination, even in the midst of post-war chaos, even more necessary if citizens both south and north of the 38th parallel are to get needed services in a timely manner. All of these factors underline the need for detailed and coordinated pre-crisis planning [10].

In any post-war path there will be a need to quickly ramp up capacity-building for energy, environment-related, and other occupations. Capacity-building will be needed in part because trained people will be needed for reconstruction and redevelopment, but also because the North Korean population will need gainful, useful, peaceful employment. This is especially true for those officials and technicians associated with sensitive industries (for example, military industries and nuclear weapons programs) in today's DPRK. A key focus of early capacity-building efforts should be on providing skills and technologies that encourage the growth of local economies (for example, at the county level) that are capable, to a large degree, of providing essentials such as food and energy services for themselves. As concrete example, training should be provided for redeployment of scientists and technicians working at the Yongbyon nuclear weapons complex and military missile development/production programs so as to make sure their skills are directed toward productive and peaceful activities, rather than having their skills diverted to serving threatening states or organizations.

In the medium- and longer-term, several types of actions will be needed under a collapse via the "War" path:

- Plan for and start to build an integrated ROK/DPRK grid, probably starting with extending ROK grid into areas in the southern part of the (current) DPRK, and building local/regional grids in other areas for eventual hook-up to national grid.
- Make sure to replace damaged (or otherwise unserviceable) energy demand infrastructure with the most energy-efficient devices available, so as to lessen the requirements for new or rebuilt energy supply infrastructure.
- Make sure to choose energy-efficient devices for all of the new housing, commercial, and industrial developments that will be built as the North's economy and living standards start to gain on those of the South.
- Evaluate which industrial facilities need to be developed (or in rare cases, rebuilt), and plan for evolving supply systems for fuels (such as electricity, gas, heat) to serve the evolving economy. In this case, serving the "evolving economy" means, for example, putting supply systems where people will be, factoring in elements like re-mechanization of agriculture and shifts in economic composition toward the services sectors, and away from heavy industry, and probably toward cities and away from the countryside. That is, don't plan to necessarily put facilities where the people happen to be located now (or shortly after collapse) as they work in the planned economy and survival-level cottage industries.
- Work with the Russians to reconstruct--or, more likely, construct a new--Sonbong refinery, related port facilities, and the combined heat and power facilities associated with and serving the refinery and the local area.
- Work with the Russians to bring gas supplies and gas transmission and distribution infrastructure into and through DPRK to the ROK, and/or develop new liquefied natural gas (LNG) import, storage, and regasification facilities (again, with associated gas T&D facilities) somewhere near the 38th Parallel (for example, in or near Nampo in the DPRK). LNG facilities would likely be shared to serve both the North and South.

4.2 "Regime Implosion Leading to New Authoritarian Regime" Path

In the "Regime Implosion Leading to New Authoritarian Regime" Path, the technocratic regime would presumably assess the country's energy needs, and attempt to focus internally on energy infrastructure redevelopment, taking advantage of largely Chinese and Russian technical help. Energy infrastructure development would be focused on serving raw materials export industries, and as such might be focused on areas in the North and West of the DPRK, leading to somewhat geographically and sectorally unbalanced energy systems. For example, if the regime is focused on maximizing income from raw materials and labor exports, it might give limited attention to improving energy supplies to and infrastructure in urban areas (outside of areas where elites live) or to rural areas (outside of where minerals are found).

The ROK and West would be expected to have limited short and medium-term influence under this path. The main options the ROK and West might have to influence the DPRK energy sector might be to try and work through the Russians and Chinese to provide capacity-building, and thus affect patterns of change in DPRK energy infrastructure at the margin, and also to look for opportunities for joint ventures with Russians on regional infrastructure (for example, in electricity and gas networks, and on oil refining). Working through the Chinese and Russians, however, may be complicated by the bottom-line focus of Chinese and Russian trading companies operating in the DPRK, which may leave little room for modifications in approach that would help an eventually-reunified Korea. In general, the ROK and West could offer capacity-building on energy and related topics as a lever to start opening the DPRK economy to other influences, but how those overtures might be received by the new DPRK regime, under this path, is hard to predict.

In the longer-term, assuming an eventual gradual or sudden opening of the regime, the ROK/West will need to focus on providing energy infrastructure in areas and populations left underserved by export-oriented infrastructure.

"Regime Change by Palace Coup Leading to ROK-installed Regime" Path

The implications for the energy sector under the "Regime Change by Palace Coup Leading to ROK-installed Regime" path are similar in many ways to those under the "surgical strike" variant of "War" path, but with less DPRK destruction/dislocation to deal with, and without the need to rebuild infrastructure in the ROK.

As such, short-term needs under this path would include:

- Making a full assessment of the status of the North Korean electricity grid (T&D and generation) and other major energy and related infrastructure, including mines, refineries, rail facilities, and ports.
- Replacing virtually all electrical substation equipment, starting with failed and failing units.
- Establishing emergency electricity generation, initially with diesel or possibly LPG-power barges in coastal areas, and package diesel or combined heat and power plants in inland areas, focusing where power supply is particularly inadequate, in order to build social stability in those areas and stem out-migration.
- Where possible, applying quick repairs to keep the best of the major coal-fired power stations going for a few years while the national power grid is being replaced.

- Look for ways to upgrade existing hydroelectric facilities to improve their safety of operation, efficiency, and generation capacity.
- Ramping up ROK refined products production to supply currently unmet demand for transport fuels in the DPRK, plus diesel fuel needs for temporary generation.
- Providing critical power, fuel, and equipment for farming.

In the medium- and longer-term, one priority under this path will be to assess coal supply infrastructure to determine if any existing mines will be cost-effective to operate in the longer-term; and to shut down and abandon (and remediate) mines with poor prognosis. Poor prognosis for North Korean mines may be as a result of a damaged mining infrastructure that would be too difficult to repair, unsafe mining conditions, a poor resource base (in terms of coal quantity and/or quality), or simply poor mine economics (which could be a function of many factors, including all of the above, plus coal transport and other considerations). Even under this path, it would not make sense to abandon mines immediately as the regime changes, given the importance of coal to the existing infrastructure and the importance of the coal industry as an employer, but the coal mining sector should be reviewed soberly and shrunk if needed in favor of importing coal from major international low-cost producers if the assessment so indicates. A second major priority will be to evaluate which industrial facilities need to be developed, based in large part, on demand for DPRK-located facilities as indicated by willingness of private sector actors (in the DPRK, the ROK, and beyond) to invest. In addition, in the medium- and longer-term, plans need to be developed for evolving supply systems for fuels (electricity, gas, heat, and refined products) to serve the evolving Northern economy.

Again in the medium- and longer-term, under the path leading to an ROK-friendly regime, a key requirement will be to establish markets for fuels, and the regulatory authorities to oversee them, with an eye toward merging markets and regulatory authorities in a unified Korea. For markets, the DPRK could in fact lead the ROK into the world of “smart grids” and smart electricity meters. This could include, for example, widespread use of time-of-demand pricing, local generation, and renewable generation. Demand for electricity in North Korea under this path could be expected to increase rapidly, accompanied by an opportunity (not to be missed) to build a very modern, very high-efficiency supply and demand-side electricity sector. Hand-in-hand with this effort should go development of progressively tighter building energy efficiency regulations, and build human capacity to enforce building energy efficiency and other regulations, and to design and construct high-efficiency buildings.

As with other paths, it will be desirable to work with Russia, and possibly with China and other nations, to explore and extend regional electricity and gas grids, and to partner on a new Sonbong refinery. It will also be necessary to develop gas use infrastructure (demand-side and distribution) for all sectors, including electricity generation and combined heat and power, for a number of reasons, including reducing the greenhouse gas emissions in a unified Korea, and providing energy services as cleanly and efficiently (in terms of overall fossil fuel use) as possible. As in other paths, another priority will be to explore extending gas grids north from ROK, and building shared (North/South) LNG facilities.

Last, but certainly not least, this path will provide both the opportunity and need to do aggressive capacity-building on a vast host of topics, starting as soon as possible. This will mean sending the best North Korean students to the ROK, the United States, and elsewhere for study, and providing them with incentives to return to work in North Korea, but also, just as if not more importantly,

building up North Korean educational institutions at all levels.

4.4 "Slow Collapse Leading to Eventual Reunification" Path

In the "Slow Collapse Leading to Eventual Reunification" path, energy infrastructure continues to slowly decay, following the general pattern—albeit occasionally partially reversed by occasional isolated repair projects and new developments—over the last two decades. As infrastructure decays it continues to become more inefficient over time, and also loses capacity (for example, electricity generation capacity, transport capacity, heat production capacity, and so on) as the performance of individual units continues to decline, and as units fail altogether. In this path, scavenging for metals to sell for scrap may take an increasing toll on important energy infrastructure (such as T&D) systems and other infrastructure (such as rail lines) as well.
In the "Slow Collapse…" path, the DPRK's efforts to keep infrastructure running will continue, but will run up against diminishing returns due to a lack of replacement parts (for infrastructure originally manufactured outside the DPRK) and of outside expertise that can only be acquired with scarce foreign exchange dollars. Exceptions to the pattern of decaying infrastructure may be infrastructure that is required to support export ventures with outside investors, for example, Chinese companies, where outside investors have a vested interest in making sure that key infrastructure is operable.

From the perspective of the ROK and its allies, actions to usefully help to address DPRK energy sector and related needs in the short-to-medium term are limited. So long as a central regime hostile to the outside remains in power in North Korea, little can be done but to take advantages of the (likely) rare opportunities that occur for engagement and capacity building. As the central regime loses power, there may be more opportunities for small, local engagement projects addressing energy sector needs, but such projects will be difficult and potentially hazardous to carry out, and may more likely be the province of non-national groups such as non-governmental or international organizations. If an era of "fiefdoms" occurs during the slow collapse, arranging any type of regional project (electricity interties, gas pipelines, or rail interconnections) will be very difficult due to shifts in who is in charge or in power in areas transited by proposed infrastructure at any given time.

In the longer-term, when the collapse of the state is complete, with or without an interim "fiefdom" era, the types of measures required of the ROK and its partners following reunification-by-default are the same as in the "Regime change by palace coup" path, but with a significant difference. Continued degradation of energy infrastructure, leading (in part) to extreme scarcity and suppressed demand, is likely to make eventual reconstruction/redevelopment and recovery of North Korea a progressively larger and larger long-term issue for the ROK, with growing complexity and expense.

Also in the longer-term, relative to a more immediate collapse, the Slow Collapse path implies that full assessments of DPRK energy and related infrastructure will not be possible for some time. Full, on-the-ground assessments of infrastructure needs, energy demand, and other key factors that are needed to plan effective energy sector assistance will be stymied by lack of access for years. As a result, the countries and organizations that would need to step in to provide energy services and rebuild energy infrastructure under a collapse scenario will not be able to fully assess the slowly deteriorating situation until actual collapse occurs, at which point needs (for food, water, electricity, waste treatment, health care, jobs, and other essentials) will likely be more urgent than they would have been had collapse occurred sooner.

The lack of access to the DPRK for a full energy sector assessment means that planning for energy

sector support, and increasingly, as time passes, redevelopment, will need to continue to be informed by fragmentary information. This underlines the need for the international community to A) coordinate and share information on the DPRK whenever possible, B) use that information to formulate and regularly update plans for energy sector triage and rebuilding under a collapse scenario, even if collapse is long in coming, and C) provide resources to consistently support both A) and B). Gathering and making sense of energy sector information will require coordination by interested parties in data gathering and analysis. Considerable persistence and patience will also be required of those in the ROK and the international community who must prepare for DPRK regime collapse in keeping energy sector assistance and contingency plans updated, and remaining in readiness to effectively activate plans when needed.

5. Lessons from Collapse Pathways for Near-term Initiatives and Planning Efforts

Our initial consideration of the energy sector implications of potential DPRK regime collapse pathways suggests that there are a number of initiatives that the ROK, the United States, and the broader international community that is interested in the future of the Korean peninsula can undertake to be ready to assist in the event of a DPRK regime collapse. Possible initiatives include:

- Do capacity building on lots of topics whenever possible. It is cheap, useful, and necessary in any path, and has many ancillary benefits. Required capacity building topics include technical training in electricity generation, energy efficiency, oil refining, renewable energy, environmental remediation, waste treatment, reforestation, and other similar disciplines. In addition, training will be needed in running commercial enterprises, including economic analysis, building and operating regulatory and legal systems, and many other organizational topics. Ancillary benefits of capacity building include engagement on the individual and organizational level, opening minds to new ways of thinking, increasing the availability of competence and personal connections for application at key movements of transition, as well as availability of in-country trainers for to rapidly expand training as needed.
- Plan now for the wholesale rebuilding of the transmission and distribution system. Doing so will be necessary sooner or later An initial step might be to stockpile key components, such as transformers and substation switchgear, for rapid installation as needed
- Assess the ROK's current refining capacity versus the petroleum products needs of a reunified (in fact if not in deed) Korea. Start talking with Russians about possibility of rebuilding and expanding the Sonbong refinery so as to be ready to rapidly start a refinery project when conditions permit.
- In order to reduce the burden on energy supply infrastructure (including reducing the amount of new energy supply infrastructure needed), have the discipline to provide high-efficiency energy demand (and supply) devices when rebuilding the DPRK economy. Provide high-efficiency demand and supply devices rather than, for example, marketing secondhand appliances, industrial motors, power plants, automobiles, and other devices to the DPRK, so as to make sure that the DPRK has a better chance of "catching up" with technology in the South, yielding better outcomes from social, resource conservation, environmental, economic/infrastructure integration perspectives.
- Think through how markets for energy goods can be established so as to spur private sector investments.
- Plan integrated energy infrastructure/economic development demonstration projects, for example, on a county scale, and try to get some integrated projects implemented even before collapse.

- Network with other interested parties to provide the best assessment possible of DPRK energy sector status and needs, and collaborate on concrete plans so as to be able to swiftly and effectively address those needs when an opening occurs.

Finally, medium- and long-term regional energy projects such as a regional electric grid tie-lines and/or regional gas pipelines should be implemented in ways that provide China and Russia with some leverage over the reconstruction agenda should the DPRK collapse. This leverage may be needed, in part, to ensure that the ROK hands over all fissile material and nuclear weapons-related hardware and knowledge to the IAEA and/or to nuclear weapons states in the scenario where such hardware and knowledge is obtained/inherited by the ROK from DPRK sources after the collapse of the DPRK. Meanwhile, policymakers should focus on the measures needed to stabilize the DPRK to avoid collapse by the DPRK in the short- and medium-term.

III. Citations

[1] B. Bryan Kay, staff reporter: "Is Collapse of NK Regime Imminent?" Korea Times, November 15, 2009, at:
http://www.koreatimes.co.kr/www/news/nation/2010/08/120_55550.html
[2] Aidan Foster-Carter, "The Gradualist Pipe-Dream: Prospects and Pathways for Korean Reunification," in ed. A. Mack, Asian Flashpoint: Security and the Korean Peninsula, Canberra: Allen & Unwin, 1993, 159-175.
[3] J. Witt, Four Scenarios for a Nuclear DPRK, US-Korea Institute, Working Paper 10-01, February 2010, at: http://uskoreainstitute.org/bin/s/g/USKI_WP10-01_Wit.pdf
[4] We have outlined in detail appropriate policy options for this goal in, for example, von Hippel, D.F., and P. Hayes (2009), “DPRK Energy Sector Development Priorities: Options and Preferences”, forthcoming in the Asian Energy Security Special Issue of Energy Policy, and available as http://dx.doi.org/10.1016/j.enpol.2009.11.068; von Hippel, D.F., and P. Hayes (2007), Fueling DPRK Energy Futures and Energy Security: 2005 Energy Balance, Engagement Options, and Future Paths (Nautilus Institute Report, available as https://nautilus.org/fora/security/07042DPRKEnergyBalance.pdf); von Hippel, D.F., and P. Hayes (2007), “Energy Security for North Korea”, Science, volume 316, pages 1288 – 1289, June 1, 2007; von Hippel, D. F., P. Hayes, J. H. Williams, C. Greacen, M. Sagrillo, and T. Savage, 2008, “International energy assistance needs and options for the Democratic People's Republic of Korea (DPRK)”. Energy Policy, Volume 36, Issue 2, February 2008, Pages 541-552; and D. von Hippel and P. Hayes, DPRK Energy Sector Assistance to Accompany Progress in Denuclearization Discussions: Options and Considerations, produced as part of the project “Improving Regional Security and Denuclearizing the Korean Peninsula: U.S. Policy Interests and Options.”, organized by Joel Wit of Columbia University's Weatherhead Institute for East Asia and the U.S.-Korea Institute at the Johns Hopkins University School of Advanced International Studies, Washington, D.C., and available as https://nautilus.org/DPRKPolicy/vonHippel.pdf.
[5] See D.F. von Hippel and P. Hayes (2007), Fueling DPRK Energy Futures and Energy Security: 2005 Energy Balance, Engagement Options, and Future Paths (Nautilus Institute Report, available as https://nautilus.org/fora/security/07042DPRKEnergyBalance.pdf), for details on the 1990 through 2005 estimates provided in these figures, and for related information. Note that an update to this analysis is currently underway.
[6] Notes: 1 PJ is 1015 joules, approximately equivalent to energy in 24000 tonnes of oil equivalent (TOE), so a 642 PJ/y economy is the equivalent of about 15 million tonnes of TOE/yr. Based on this estimate, the approximately 22 million North Koreans used, as of 2005, about three times the energy of ½ million Washington DC residents, a comparison that is even more striking when one considers that Washington has little heavy industry, and the efficiency of energy use in Washington is much

higher than in the DPRK.
[7] The LEAP software tool is developed and maintained by Stockholm Environment Institute—United States. Please see http://www.energycommunity.org/ for information about the LEAP tool.
[8] Korean Peninsula Development Organization (2003), Korean Peninsula Development Organization Annual Report 2003. Dated December 31, 2003, and available from http://www.kedo.org/annual_reports.asp.
[9] Some would say that, due to the advent of cell phone usage in the Chinese border region and in Pyongyang, the control of information in the DPRK is breaking down already
[10] We assume that at least some significant planning for DPRK collapse has been undertaking by ROK government agencies, but if these plans have been reported in the public literature, we have not yet seen them.

IV. Nautilus invites your responses
The Northeast Asia Peace and Security Network invites your responses to this essay. Please send responses to: bscott@nautilus.org. Responses will be considered for redistribution to the network only if they include the author's name, affiliation, and explicit consent.

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