

CHANGES IN THE NORTH KOREAN ECONOMY AND IMPLICATIONS FOR THE ENERGY SECTOR: Is North Korea Really Short of Energy?

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Introduction

In preparing this paper I have drawn on experiences as an economic analyst many years ago in CIA's Office of Economic Research where I worked on the North Korean and Chinese economies, and more recently as an economist in the Chief Economist's Office at the Commerce Department where I worked on issues related to GDP accounting and economic growth. At CIA, around 1980, I submitted to my boss what I thought was a nice research paper on the North Korean economy, looking at each of the industrial sectors and estimating output in each; looking at exports and imports and estimating its balance of payments; and looking at the central government budget and estimating military and other government expenditures. My boss said "great paper but you haven't said anything about their GDP. I said "Pyongyang doesn't publish reasonable data, how can I possibly estimate their GDP?" He gave me three more months to give it a try. I put some US dollar figures on each of the final outputs, made some guesses at services and military spending, added some other items and ended up with \$9 billion or so. So I put an even \$10 billion, \$1,000 per capita, in a general summary at the beginning of the paper. My boss now liked the paper but said, "can't we make this look a little more exact-like add a decimal point or something". I said no, I was only comfortable with a figure between \$5 and \$15 billion and insisted on staying with the 10. The next year he asked me for an update and I gave him \$10 billion again. So he put in another table that North Korea had zero percent growth that year. I objected (you can see why my career there was short lived) and said I

thought the country's economy grew about 5%. So he stuck \$10.5 billion on the chart and we had the beginnings of our CIA series-you can see the latest such estimate in the CIA World Factbook-by now they have grown North Korean GDP to \$40 billion.

Right about then I switched to working on the Chinese energy account and drafted a paper that was published by the Joint Economic Committee of Congress entitled "China: Energy and Economic Growth" . At this point China's largest export earner was crude oil and my paper suggested that fairly soon China would regret such exports as it would need to become a large oil importer unless it found a lot of oil in their South China Seas explorations. China didn't find that oil and by 1990, even faster than I had thought, China was a net importer of oil and has been ever since. Contrary to some analysts I did not argue that lack of energy would be a constraint on economic growth, arguing that since the country consumed very large amounts of primary energy given its low level of economic output, much savings could accrue with the market oriented economic system that appeared to be developing. The socialist pricing system had encouraged wasteful use of energy by pricing coal and oil cheaply while pricing energy intensive products, such as petrochemicals and fertilizers, very high. The result in China was thousands of incredibly inefficient and small fertilizer plants-I calculated, for instance, that just the electricity used to produce a ton of fertilizer in these plants, if priced at world prices, was worth more than the fertilizer produced. All of the naphtha, coal, capital and labor inputs were totally wasted and China's GDP would increase if the plants were simply shut down. At the time China had set a goal of quadrupling GDP while only doubling use of primary energy by 2000. Given the wasteful initial use and taking into account the fact that China was beginning its move to allow prices to be set by the forces of supply and demand, I thought it was possible on the energy account for China to make such a plan-allowing an energy elasticity to GDP growth of 0.5.

Electricity, on the other hand was another matter. I thought insufficient power output would be a hindrance to China's growth due to the enormous capital requirements needed for power production, and that the latent consumer demand coming up from near zero would stress the system. Almost everywhere in the world electricity demand rises at least as fast as GDP and it was hard to see how China could come up with the capital to quadruple power output in a twenty year period. Moreover, it was hard then to imagine a China with refrigerators in every home, let alone air conditioners in many of them. I turned out to be wrong in this. What I hadn't figured was the huge productivity gains and the higher profits and savings that would accrue to the economy as market forces began to dominate, making enormous investments in electric power production both necessary and possible. We see results of that investment even this month with the completion of the Three Gorges hydropower project.

In this paper I'd like to make some observations about North Korean energy and economic growth, using lessons from China 25 years ago, and elsewhere. The dates I think are appropriate. North Korean economic policy adjustments of mid-2002 -when the regime allowed money and markets to push out the centrally planned supply mechanism-are similar to those taken by Hua Kuo Feng and Deng Xiao Ping in 1978. I'll get to this at the end of this paper but I think Pyongyang is now in quite a bit of trouble since it hasn't adopted the follow-on steps allowed by Deng Xiao Ping in letting the cooperative farming system collapse over the next three years. This collapse released a burst of productivity growth in China that has not stopped since. North Korea in contrast, four years after the so called "reforms" is still firmly a socialist state, not allowing any semblance of private property. By allowing markets to operate it has succeeded in improving distribution of production but it is also getting massive inflation-the productivity boost from private activity is nowhere to be seen.

I argue that inflation in North Korea is a good thing, indicating that the state ownership system is not being sustained and that it is possible, even likely, that the system will soon crumble and North

Korea will start on a path to private farm and small scale industry development. If so, the need for primary energy and electric power will be interesting things to watch, and even participate in as investors or as aid providers. But I hasten to say we are not in that position yet. Extreme care must be taken to make sure that external aid, whether it is food or energy, is not prolonging the country's agony.

Data and Information About North Korea

Immediately frustrating to anyone beginning the study of the North Korean economy is a near total absence of formal data. Kim Chong-il's regime provides its own public and the rest of the world much less information than even China provided in 1978 and far less than Kim Il-sung's regime provided up through the 1980s. The regime also generally prevents any private survey activity although exceptions occur-one of the most important exceptions is the work done by Nautilus a few years ago in looking at village energy use. The lack of information dissuades most economists from studying the economic dilemmas that this government finds itself in and makes investment, either by North Koreans or foreigners, a highly speculative activity. The following describes what limited data is available:

From North Korea:

The annual spring budget submission by the Premier and other State ministers, carried on radio and television and printed in the media, is the only consistent vehicle for the provision of economic data. Absolute figures generally are not provided but percent changes are sometimes given for such aggregations as industrial output, electric power and coal output. Government income and expenditure figures are given in some detail in North Korean won and in percent changes. Unfortunately, no inflation measure is provided to gauge the real growth of these nominal series.

Pyongyang's New Year's press articles and speeches give some indication of how previous year's economic plans were met or not met. Long term plan goals used to be announced on these occasions and these offered specific volume based goals for a score or so industries. Since the planning system failed a dozen or so years ago, longer range goals are not announced.

Monthly publications, such as Economic ---, carry a few interesting articles but are essentially void of useful data.

Other North Korea media publish anecdotal figures for particular factories and farms.

From International Agencies:

North Korea is a member of many UN agencies that require information sharing and it does occasionally provide these agencies with reports containing economic data, especially when such data is required to gain access to aid. The UNDP, for example, has maintained an office in Pyongyang for many years but rarely manages to garner economic data from the government and share it with the public, either North Korean or foreign. Once or twice UNDP has provided snippets of interesting data showing what North Korea claims is GDP growth and GDP per capita income, measured in US dollars. The last I know of this was in 1999. The data seemed reasonable-a per-capita income of about \$-- was indicated, half the level of the early 1990s. But no explanations were given about how the data was derived was made available. The use of the term "GDP" was surprising given what I would assume to be a much different account system in North Korea-as I discuss later.

Population data also has been provided UN agencies in some detail as has food production and nutrition data to the World Food Program and the Food and Agriculture Organization. Health data

has been provided the World Health Organization. Most of this type of data can be found in the North Korea page of the World Bank's International Development Indicators, even though North Korea is not a member state.

Some of the most useful data on North Korea can be found in the trade data of all the countries with which it trades. This "mirror" data can be gathered by looking at each partner country-for instance taking Japan's exports to North Korea as North Korean imports from Japan. This data has enormous detail in it and can be acquired separately by reporting country, making some adjustments to account for freight, or it can be collected via the UN Direction of Trade compilation of world trade. Since North Korea trades with relatively few countries, it may be easiest to use a service such as Global Trade Atlas to look at about ten key countries. A problem with this, however, is the fact that South Korea considers its now rather extensive trade with the North as domestic trade and this data must be obtained separately from the South Korean government. Another problem is errors in recording data-sometimes foreign country customs officials place their typically much larger trade with South Korea in the North Korea column. Lastly, this of course does not capture illegal trade or, in many cases, military trade that partner countries wish to obscure.

From South Korea

South Korea considers North Korea as part of itself and thus makes rather heroic efforts to estimate economic data for the North. Most of this is compiled by the Bank of Korea (the entity that creates South Korean National Income and Product Accounts) from data provided by South Korean intelligence agencies.

This Bank of Korea data is by far the most comprehensive data available on North Korea and the most widely used, both for the level of GDP and its annual growth rate. Most useful for energy analysis is the inclusion of volume output data of key products and extensive exports and imports data. A fairly complete set of energy data also is provided.

The main problem with this BoK data is that it is "too good to be true". Unless South Korean intelligence has amazing access to North Korean statistics-and is willing to expose such access with the world-the data that is inputted into the Bank of Korea NIPA framework are likely educated guesses at best. Since there is no corroborating information, we are left to take the data something as a black box. Given the lack of alternatives, the media and many scholars takes the BoK figures for granted. Even I will misuse this data somewhat in this paper.

For analytical purposes, however, some thought should be given to whether using this data is a good practice or not. Energy to GDP relationships, for instance, may look reasonable only because the BoK uses a reasonable model to estimate them. Surprises, or unique insights are unlikely to be found. Moreover, since North Korea won is not of any real monetary value, the North Korean output estimates are developed using South Korean prices to value various outputs. Then the data is converted to US dollars at the South Korean won's exchange rate in order to undertake international comparisons. This may make sense for South Korean users but not for other users since use of three different currencies in this way introduces a large distortion into annual growth rates. This can be seen easily in the following two graphs of North Korean GDP growth; one using the real growth as measured in constant South Korean won; the other using real growth using constant US dollars. In 2000 in particular, we can see that the estimate that North Korean GDP grow xx percent is very misleading. The real growth figure was estimated at xx percent but when translated to a rising South Korean won, the figure rose to xx%. This year with the South Korea won rising again, a similar problem will occur.

Another issue with the data is that it is provided by the BoK, at least in detail, is only on a GDP

production basis and not the more common GDP expenditure basis. This reduces the analytical value of the data when trying to understand economic growth since key concepts such as consumption and investment are not available.

Lastly, extensive use of South Korean data gets the Pyongyang off the hook. Every effort should be made to encourage, even demand economic data from North Korea before engaging them in business activities. This is not just an international issue, after all. How can we expect North Korean citizens to take advantage of their own investment opportunities when their government doesn't give them access to necessary information.

Other Data Sources

The CIA World Factbook has useful data on North Korea but the estimate of GDP, as mentioned earlier, is not reliable. Just last year the estimate was raised from \$30 billion to \$40 billion even though the growth rate is said to be only 1 or 2 percent. As the Factbook's footnote clearly states, the figure is essentially a placeholder in a system that tries to add up the whole world's GDP and changes to that. It especially warns not to take growth rates from data published in two different years. So for our purposes of anticipating energy output and demand, these figures do not seem useful.

Some of the most useful information, though rarely data, is now being provided by aid groups and other visitors to North Korea. As with press reporting, this information generally falls into the category of anecdotes which have merit but can hardly be used to justify large investments. Anecdotal information can, however, be very valuable in detecting if and how well markets are operating-probably the most important thing that we need to know about the North Korean economy at this point. Probably for that reason foreign access to markets is restricted but there are many refugees who can provide extensive market data that is quite helpful in this regard. Any many traders in China go back and forth into North Korea and, of course, have accurate and timely information on supply and demand conditions.

Historical data is available from the Japanese colonial period on much of the geography and geology of North Korea. Japan considered the northern part of Korea as rich in minerals and metals and invested heavily in these industries, rail transportation, and hydroelectric power plants to service its East Asian Empire. Many if not most North Korean industrial establishments are still based upon these original Japanese built factories and mines. Additionally up through about 1980, North Korea was proud of its industrial accomplishments and published a fair amount of annual output data. As the economy faltered, however, less and less data was made available.

What Information is Missing?

The economic information gaps that we observe in North Korea are different from those found in similarly poor countries of Africa, the Middle East, and Latin America. In those countries researchers generally have good access to the economy but the governments have often failed to develop useful and reliable sets of economic statistics needed to guide the private sector, government, and foreign businesses. In North Korea it is quite the opposite situation. The government has a large system to collect economic data, as is required in any planned economy. Presumably the regime collects large amounts of input and output data from all of its state-owned farms and factories. Even though the planning system obviously is not working, we might assume that each layer of the party and government continues to collect and report upward all kinds of statistics. This is suggested, moreover, in the anecdotal information that is reported in the media and in the annual budget presentations. Reliability of such data is open to question-in China the Maoist government placed much of the blame on its weak response to the famines that ravaged the

country in the 1950s and 1960s on exaggerated output data. But in North Korea, the system is probably much tighter with severe punishment dolled out to falsified information-at least that is my suspicion.

The problem then is not a lack of data but the fact that data is not made public. According to the state philosophy, such information is only the government and Workers Party's business-just as internal data in a privately held company is kept secret. In North Korea, the state and the Party make all the important decisions internally so it sees no need in publishing data.

An immediate challenge then to those who want to work with North Korea is to force a change in this philosophy. As long as Pyongyang insists on such secrecy, development aid or investment will be impossible to justify to foreign taxpayers and shareholders.

The next step in understanding what information gaps exist in North Korea is to ask the question of how such information will be used? I argue below that the information required by the state planners is so vastly different than the data needed by foreign investors or development aid agencies that before any headway can be made a large and open discussion with the North Korean government is necessary. And if the information is needed for development type assistance, first priority needs to be given to insure that North Korean citizens have at least equal if not privileged access to any data that emerges. Without that development agencies simply help to perpetuate the slave-like system that has enveloped North Korea. I note, moreover, that according to the World Bank, one of the key things the South Korean government got right in its 1963 economic reforms that transformed the country was the creation of a credibly independent economic statistical system, providing accurate data to government policymakers, domestic businesses and foreign investors alike. Good news and bad news was freely dispensed. Without such a start for North Korea, any kind of aid or investment is likely to be fruitless at best.

Socialist Planning Data Requirements

In theory, North Korea's socialist planned economy requires an excellent understanding by the planners of what inputs are needed in order to generate a given set of final outputs. The planning agency is thus likely to have an extensive input-output matrix so that if say Kim Chong-il orders that 10,000 housing units be built in the next plan period, enough cement and steel are produced to support the construction. Then in second order plans, in order to produce that amount of cement and steel, how much intermediate goods-coal, gypsum and iron ore etc. are needed. In theory many iterations are needed to solve the plan and they thus become enormously complex. Invariably these plans break down and certain cheating occurs-trade between factors begins to fill in gaps. In the Soviet and Chinese systems, lots of cheating occurred, keeping their systems alive for many years. Marxist ideologs never like such cheating since it encouraged speculation and undermined the reporting of data essential to the planning mechanism-and gave power to those who were most successful at trading. But at least the trades kept the factories operating when the plan failed to deliver essential inputs.

It is clear that the planning system never worked well in North Korea and broke down completely around the time of Kim Il-sung's death. Factory-to-factory trade probably was much better controlled in North Korea than in other socialist states, and when inevitable planning gaps appeared, it seems that Kim Il-sung himself was the only person who could command enough authority to move resources. When he died no one could and the entire economy suddenly ceased to operate. North Koreans and many South Koreans argue that it was the loss of Soviet aid that caused the collapse. No doubt that contributed but it begs the question-why was North Korea dependent on Soviet aid? And if Russian factories had to begin to compete for markets, why could not North Korean factories compete as well?

The issue is important because I sense that what North Korea seeks from South Korea and international agencies is a replacement of the aid that the Soviets and Chinese gave them-aid that they can use to insert into holes in the planning matrix and thus try to crank up the planning mechanism again. They can't be blamed for trying since they seem to have had a lot of success in doing so.

Put it another way, the government of a socialist planned economy is always trying to fill in bottlenecks that develop when insufficient inputs are available to meet plan objectives. Foreign trade is designed to import these shortage items when needed. Exports are designed only to earn the funds needed to buy the essential inputs, not to generate employment or to increase national savings as in most development minded economies.

This may help to explain why North Korea, when negotiating with foreign investors and aid providers, focuses narrowly on the provision of specific goods-for example electricity or corn-since their data shows they are in need of that specific commodity. If offered something else, say potatoes, they might not be able to match a specific line item in their planning mechanism, and thus refuse them

This may also help explain North Korean demands for nuclear fueled electric power plants. Such plants are almost self-contained units with less need for inputs, such as coal or oil or even very much labor. Whereas officials in market economies like to count as "multipliers" all the jobs that are required to service a new plant, in North Korea such "multipliers" are seen as a burden, a drain on resources and large complications for planners. An offer of a new coal fired plant, for example, is difficult for planners to deal with since they have to figure out how to arrange for the all the mining of the coal and transportation to the power plant. In a centralized system like is North Korea, there are very few people around to make such decisions.

Another result from this kind of planning is that self-sufficiency (juche philosophy in North Korea) of actors is greatly valued since it avoids the complexity of planning. This is even more true when the planning system breaks down and everyone is on their own-like in a market economy except one in which money and markets don't operate. North Korea's self-sufficiency essentially eliminates the most basic economic concept of the division of labor, forcing everyone or at least every small production unit to be self-sufficient in everything. So small units each want to generate their own electricity, for example, no matter how inefficiently. In recent years we see a great deal of attention paid to small hydro-power turbine/generators, for example, which obviate the need to plug into a centrally planned, and thus broken power grid, but which probably use up a large amount of scarce capital in the process. As encouraged by Nautilus, wind mill type units also may fit this need-becoming highly desired for the same reasons.

This is meant to point out how different North Korea is from almost any other country that investors or aid providers are used to dealing with. In any decentralized market economy where prices rule the decision-making process, a shortfall in supply automatically results in a rise in price and, in a profit driven world, creates an inducement for millions of investors to create more of that now higher priced commodity, and for millions of consumers to use less. Rather than a few decision makers, in an economy the size of North Korea's there may be hundreds of thousands.

In a much more dynamic and ultimately more efficient process than is central planning, different kinds of economic data are needed to guide economic decision-making than the relatively simple, and static, input-output relationships used by the central planner.

These differences are captured in the different ways market economies collect and analyze economic data compared to the way strict socialist countries-of which North Korea and Cuba may now be the

last ones standing-handle their data. Lets use the UN's system of National Income and Product Accounts (NIPA), including the important GDP, GNP and Balance of Payments concepts, as an example. GDP data is typically produced according to the UN System of National Accounts in three parallel and exactly equivalent accounts; production based accounting, expenditure based accounting, and income based accounting. By definition, each of these accounts ends up with the same figure for final production, final income, or final expenditure, known almost universally as GDP. The purposes of each set of accounts is different.

Production based accounting

Production based accounting is closest in nature to the socialist system of accounts since data is collected on all the inputs and outputs of an economy and the relationships of how much of one product goes into making another is tabulated. This is important for productivity analysis and for some business decision-making but generally, at least in the US system, this production based accounting is the least noticed. The data typically is produced several years after the more relevant expenditure and income data are produced.

The important thing for us to understand is that the widely used South Korean Bank of Korea estimates of North Korea's GDP essentially follow this production based concept. This is understandable since it best fits the requirements of a socialist planned economy; moreover, with limited data this is conceptually much easier to estimate-as I tried back in 1980. China also continues to use production based GDP as its main accounting system although estimates made through an expenditure based system are available and likely will soon begin to become the dominant system published by China's State Statistical Commission.

I focus on this issue since this type of data is also often used by energy forecasters, tempted by the relationships one can easily see as between power demands and economic growth. A typical question asked of such analysis might be "how much electricity, and thus how much coal, oil, nuclear, and hydropower inputs, will be needed for North Korea if it is to quadruple GDP in the next twenty years-just like China did." I expect that kind of thinking is a major part of this conference. Using formulas based on a particular technologies, such an answer can be derived rather easily and exactly. Plans are then set to build the needed production capacity and to provide the needed capital, labor and fuel inputs. For the planner, money, interest rates, fuel prices and even electric power prices are all almost irrelevant to the process.

A shortcoming of such a system, however, is that it is static, dependent on a preconceived and top-down notion of what an economy "should" produce and typically on old and unchanging coefficients of how much and what kind of inputs are required for any given output. Complex products and complex relationships among inputs and outputs quickly overwhelm any such system's ability to create a workable plan. Bottlenecks are inevitable in which large power plants are constructed with no fuel to power them and thus they sit idle, or when the power that is generated doesn't have the transmission system to effectively distribute the power. In this sense it is important to remember, as I show below, that North Korea is not short of electric power generating capacity. It is producing far below past peak output levels and even with depilated equipment, probably far below current capacity. In fact one might argue that the last thing it needs right now is a new coal fired power plant.

Expenditure based accounting

Ever since the Great Depression of the 1930s, market oriented economies have focused on expenditure based accounting; the familiar $GDP = C + I + G + X$ formulation [where C=Consumption, I=Investment, G=Government expenditure, X=net exports] that Keynesian

economics made famous. The emphasis on aggregate demand is designed to help the policymaker and the investor understand what is happening between consumption and investment and whether fiscal policy changes, interest rate changes, or exchange rate changes are needed to shift the balance from one to the other. Too much consumption eventually leads to inflation and too little investment to drive growth; too much investment erodes profits and ultimately is not self-sustaining, leading to recession while depriving current generations of a reasonable standard of living. So the balance between these relationship is critical to the health of a modern market economy and this kind of accounting can show them clearly. Meanwhile trends are easily observed and forecasts can be made by solving econometric models which may include hundreds of behavioral equations. Prices for goods, services, labor, capital, resources, and foreign currencies are all the critical moving factors. Relationships between energy use and GDP growth can be observed and forecast. The job is not easy due to the number of moving parts-price changes alone are unpredictable and prediction often wrong. But the results of inaccurate forecasts are minimized by the force of the markets-if insufficient refining capacity is built--as appears to be the case in the United States, for instance, at present-refined product prices will rise, reducing demand while rewarding importers or firms that do go ahead and expand capacity.

This expenditure based accounting makes little sense in a command economy where the consumption and investment relationship is dictated by the state. So we should be surprised if North Korean policymakers hold any such data or models or even concepts in mind. While economic growth in the planned system is created by constraining consumption and devoting a large share of resources toward investment; in a market system growth is dependent on millions of consumers and investors deciding how much capital and labor inputs they want to provide at the going price. Ultimately, according to modern growth theory, long-term per-capita growth is driven by technology advancement which enhance the productivity with which labor and capital are employed. Aggregate growth at some particular rate may be forecast or even targeted but never planned. The planned system can and often does manage to target and obtain a certain set of specific output results-for instance ten million tons of steel, ten-thousand automobiles, or 1 million square meters of housing. One of sits failing however is in fixing fixed prices to each of these outputs-not considering the tendency for the value of a product to decline as it becomes more abundant.

It is important for economic and energy analysts to understand the different kinds of analytical questions that can be asked on one accounting system versus the other. An analogous analytical question to the one that was posed above for a planned economy regarding what amount of electricity is needed to provide a certain level of economic growth might be "Will an investment of \$10 billion in a nuclear power plant be profitable-in other words will the cost of borrowing the capital to build the plant pay itself back at the going interest rates and anticipated electricity prices." An even better question is not whether it is simply profitable but whether it is the most profitable use of the \$10 billion investment. The answers will have to take into account a potentially rapidly growing economy but one with lots of idle power capacity, lots of coal resources, a high cost and return on capital, and an apparent current shortage of electricity production but a price system that values the power output very cheaply. The answer clearly is not at all obvious, requiring much more data then we have to even make a satisfactory guess. I might speculate that a far better return on capital would be to spend it on improving coal mines in order to get coal to currently idle plants. And then to prioritize the power output so that its first use goes to pumping water out of coal mine and transporting the coal to the plant. An answer for the longer-run might be to put funds into mine-mouth coal power plants to avoid all of the training of coal that occurs in North Korea. Another type of question that can be handled with the expenditure accounting system much better than the production side accounting might be: "With predicted supply growth of electricity estimated at 10 percent per year based on current investment plans, what will be the equilibrium price of electricity in North Korea in ten years and will that price support investment in a large non-ferrous metals

smelting operation". My guess is that one would yield a positive answer and that billions of dollars would then be forthcoming to develop North Korea's decrepit metals industry.

Clearly educated guesses are not enough to drive the development of an economy. But one can see that the questions asked of this later system are more operational and interesting than are input-output coefficients. A much fuller slate of choices can be developed and more efficient outcomes will result.

Following is how the two accounting systems would project data, following the Bank of Korea's model for the North Korean economy. BOK shows North Korea's GDP as follows:

GDP (2004) =

With regard to energy usage, this system might be able to tell us how efficiently energy is used to make certain products-maybe KEEI has already done some work on that. For instance, how much electricity do they use in the Ham hung fertilizer plant? I wonder whether that as in China in the 1980s, shutting down the plant and saving the power for other uses might be the most economical thing to do.

On an expenditure basis such data might show something like:

GDP (2004) = \$20 billion = \$10 billion private consumption + \$10 billion government consumption + \$1 billion investment - \$ 1 billion net exports.

From this expenditure based system we would be able to identify how energy is ultimately used: for instance, how much electricity is used for final consumption by consumers-used that is directly by consumers and indirectly in the products they consume, how much is used in investment projects, and how much used by the government. I'm pretty sure this kind of accounting would identify the shortage in North Korea not as electricity but as personal consumption generally-after all people don't have enough food to eat, and far too much government consumption. Investment, moreover, will be seen to be very small and on a net of depreciation basis, probably negative. No doubt the government would like to increase investment but after decades of squeezing consumption to essentially a subsistence level, there is no more squeeze left. It is no wonder then the economy doesn't grow, and insufficient electricity is a symptom and not the reason for stagnation.

My point in this is that the question "what information is missing" can be answered quite differently depending on what one wants to do. Filling in a gap in the socialist plan is relatively easy to do; all one has to do is trust Pyongyang to give data on the sector and on available inputs and expected outputs. Most likely North Korea has that kind of data available, and the answer is "give us a certain amount of fertilizer, or electricity, or a nuclear power plant". Deciding what is the optimal or even beneficial investment or aid project, on the other hand, is far more difficult. North Korea itself probably does not have the statistics or the analysis needed to help answer the question. But as outsiders, it important for us at the start to ask the right questions.

Observations about North Korea's Energy Sector

Even without much data we can come to some basic understandings about North Korea's energy sector. Important mystery's and key questions remain that I will look into just a bit.

Basic Understandings

1. North Korea was built as energy intensive economy. Historically and probably through the 1980s, the energy sector and especially electricity production, was quite large in comparison to the rest of

the economy. When built in the 1920s, the Supung hydropower plant on the Yalu River, at 700MW was the largest in Asia and even now is a substantial plant, with output divided with China. Later the Pukchang power plant built with Soviet aid, at 1,600 MW is also a very large coal powered plant even by world standards-although its 16x100 MW generators are outdated technology. Coal and hydropower over the years thus fueled the development of an energy intensive metallurgical and chemical based industry, taking advantage of the country's large mineral and metals deposits.

Through the 1980s, North Korea thus produced and consumed more energy per unit of GDP than would most countries, probably appropriate given its resource base. South Korean data show that as late as 1985, both North and South Korea consumed about 1.3 or 1.4 tons of oil equivalent energy per-capita even though South Korean incomes levels were probably twice North Korea's. This suggests North Korea's use of energy per given amount of final product was about two times South Korea's.

By 2002, according to the South Korean data, North Korean per-capita use had fallen in half to 0.8 TOE (tons of oil equivalent energy) whereas South Korean energy use per capita had soared to 4.4 TOE, almost all imported. This does not mean, necessarily, that North Korean consumers had less energy to use then before-the collapse of the metals industry since 1994 has reduced demand for electricity quite substantially.

2. North Korea's agriculture sector, whose collapse caused massive famine in the mid 1990s, is a heavy user of energy. Irrigation of rice paddies is powered by tens of thousands of electric irrigation pumps, used primarily in the month of May, as paddy rice is transplanted, creating a major load problem for the power system. Coal based chemical fertilizer is heavily used in the depleted soils. Diesel and other transportation fuels is used, thought probably modestly, to transport the grain to urban markets.

3. North Korea probably has large coal resources, especially anthracite, but production has fallen sharply in the past decade.

The Premier said in March of this year that coal output rose by 10 percent in 2005 in perhaps the beginning of a turnaround in coal production. This output increase allowed an 11 percent boost in electricity output and a 10 percent increase in industrial output. This one to one relationship of coal to power to overall industry is reasonable but also suggests that coal and power are not the bottleneck usually cited; if so a 10 percent increase in coal would allow a larger percent increase in industrial output. Nevertheless, if true, 2005 was a relatively good year.

North Korea has no coking quality bituminous coal needed for its steel industry-at least needed when the steel industry was alive. So it trades anthracite coal for coking coal with China. Anthracite briquettes make up the bulk of the country's home heating systems. Yet home heating appears to be very inadequate for the population in a very cold country. Difficulties of the provision of coal to the power plants and to chemical plants has been a major cause of the country's industrial collapse since 1994-see Mysteries.

3. North Korea has no oil or gas and few imports Another fact about North Korea is that it, like South Korea, has no petroleum or natural gas reserves. For thirty years Pyongyang has boasted of oil reserves in the northeastern corner of the Yellow Sea, and even under the city of Pyongyang, but nowhere have commercial reserves been proven and exploited. North Korea acquires most of its petroleum needs by pipeline from China to a Chinese built refinery south of Sinuiju. The crude (approximately 700,000 tons per year) is apparently a gift from the people of China but the volume has shrunk in recent years as China finds better use of the oil for itself. Imports of petroleum products have risen and are probably cash purchases. Crude oil imports from Russia and the Middle

East have essentially stopped, and the US gift of 500,000 tons of heavy fuel oil per year ceased in 2002.

As an outgrowth of an intense Japanese development of North Korean industry just before and during World War II, during a period in which Japan itself was starved for oil, the industry that developed was creative in using coal as feedstock in many applications that normally would have used oil, giving rise to a reasonably self-sufficient and coal oriented North Korean fertilizer and textile industry.

Oil use is thus limited and mostly given to transportation fuels and one French built petrochemical plant. The large amount of heavy oil given by the US in exchange for North Korea abandoning nuclear weapons programs was used directly in power plants to help the coal burn.

4. Other than food, electricity is seen as North Korea's most important shortage. As noted above, power output is claimed to have risen 11 percent in 2005 and by 50 percent since 2002. A level of output was not given for 2002 so we do not know what to make of the 50 percent increase-possibly a combination of a very bad year in 2002 and a substantial recovery from that low point. Anecdotal information suggests some improvement in power availability in cities. Whether this is a result of higher output or a result of shifting allocations from the apparently dormant metallurgical industry, is not clear.

North Korea makes announcements of many new small hydropower plants and one medium sized unit having been construction this year. But investment generally in the system is not at all apparent-for instance in machinery export data from Europe and Japan, the most likely sources of electric generating equipment. Imports of machinery from Japan are at the lowest levels in several decades.

North Korea raised its set price for electricity from 0.035 won per kWh in 2002 to xxx won per kWh, in a general resetting of fixed prices and the allowance of market prices for food and other consumer items. This important reform of the price system however has led to massive inflation and the electricity price is not incredibly cheap in comparison to market based prices for other goods. For example, in the US a kilogram of rice can buy about 7 kWh of electricity. In North Korea, at this set price of electricity and a market price of rice, one kilogram of rice can buy 722 kWh of electricity. In other words electricity is essentially a free good if one can obtain it. If one can't obtain it, almost no amount of money can buy it. This likely makes for incredibly inefficient use. [One can imagine enterprising farmers developing a "pumped storage" system using their irrigations pumps to pump water into reservoirs above their small hydropower plants when power is on and free, releasing the water and driving the hydro generators when the power is off. Meanwhile, electric trains sit idle on the tracks as the farmers pump their water.]

Mysteries

Does North Korea still have the coal and other mineral and metals resources that would suggest that big investment projects in these areas make sense-or, as many South Koreans assert, has the country used up these resources? It is clear that North Korea has mismanaged its mining industry and that output has fallen sharply in all areas in the past decade. But the mystery relates to whether the country has done an adequate job of exploring for new resources. If not, as is likely, undeveloped resources might be larger than expected.

Why does North Korea not prioritize its coal, electricity, and transportation uses to unblock the most obvious bottlenecks? It asserts, for instance, that power output is down because of a downturn in coal output, and that coal output is down because of a downturn in power output, needed to pump

water out of mines. It would seem to be a rather simple issue to resolve-giving top priority of electricity output to the mines so that coal output, and electrified train transportation, can go directly to the power plants. But for a decade, Pyongyang has not managed to do this. In there anyone in charge?

Does North Korea intend to reform its system along Chinese lines-introducing a "market socialist economy" or is intent on simply adjusting its socialist system to try to meet its new challenges. Price movements and inflation suggest the former; new ration systems and continued restrictions on private ownership suggest the later.

Questions

In closing, I leave the following questions that energy economists, development agencies, and especially North Korean policymakers need to consider.

Does North Korea's economy need to be so energy intensive? It is easy to understand how it became this way and it is easy to understand how hard it is to change. But this also may suggest that struggling to provide more energy will only cause the economy to provide the energy to inefficient uses, avoiding the country's real comparative advantages.

*If energy is in such short supply, why doesn't North Korea import petroleum, like most other East Asian countries, and develop the export industries to pay for it?*The answer is not lack of foreign exchange. Like any other country, North Korea can export if it wants to. In fact its labor costs as exemplified in the Kaesong Industrial Zone, are probably the lowest in the world - the \$65 per month wages given by South Korean firms is apparently changed at an extremely disadvantageous rate to the workers, making their real incomes almost nothing more than the food and housing given to them by the government.

Does the electrified irrigation system make any sense in a modern economy? And other uses of electricity in this way, causing problems with peak loads and extensive distribution issues.

Does the coal based chemical industry make sense? If the coal instead were used in power plants would the return be higher, allowing export industry to develop and importing petrochemicals, like most countries.

Where do the country's natural comparative advantage now lie? In Japan's closed empire, clearly its advantage were heavy industry, chemicals, and machinery-all fed by hydro power. Nearly a hundred years later, has anything changed?

Do big projects make sense? North Korea imported hundreds of large plants in the 1970s and 1980s from generous European and Japanese governments and failed to make payments on almost any of them. The country is thus bankrupt in terms of arranging new credit, except from newly generous South Korean sources. Given the problems illustrated above with the breakdown of the planning system and the incomplete development of a market system, is it reasonable to undertake more large plants that, like their predecessors, end up a white elephants?

What small projects provide the best examples?

In contrast to failed large projects, aid agencies report considerable success with small pilot projects and small investments. The key in these projects appears to be able to import devices such as gasoline generators and their own trucks, avoiding as much as possible dependency on the country's dilapidated energy and transportation infrastructure.

How to encourage rational pricing of electricity, coal, gasoline, and diesel?

At least in theory, a planned system that works can obtain a certain rationality in the distribution of resources. It is clear, however, that a broken but still powerful planned system combined with a largely illegal market system can create very bad allocations of resources. Free and un-metered electricity in a country whose electric trains stop for hours for lack of power, makes no sense unless there is a master planner who shifts the power allocations at will, turning off the consumers and giving it to the trains at just the right time. Since Kim Il-sung died, North Korea does not have that kind of master planner and power distributions are erratic at best. If given more free power, Pyongyang is likely to waste it even more, perhaps pouring the kilowatts into trying to resurrect obsolete electric furnaces as the Kim Ch'aek steel mill.

Is North Korea really short of energy?

It's a lot like asking is the United States short of gasoline? Everyone claims that higher gasoline prices suggest such a shortage yet giant SUVs dominate our highways. We take for granted North Korea's assertions that it lacks energy and indeed it is obvious to visitors that lights and elevators don't work and that electric trains shut down in the middle of the countryside. But if energy is so short in supply, we should ask our North Korean interlocutors, why then is it so cheap? If they respond it is the planned system that allocates our energy and our prices, ask for the data and the plan itself. One of the most hopeful signs for the North Korean economy may not be offer of 2,000 MW of free electric power from South Korea, but a little announcement in the North Korean press a few months ago that an electric meter factory is under construction and that electricity will soon be metered.

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