Summary Report of the East Asia Energy Futures Project Activities and Accomplishments

2001 to 2002

Nautilus Institute for Security and Sustainable Development

[Revised Draft, 5/14/2002, D. Von Hippel]

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1. Background, Project Goals, and Report Contents

The East Asia Energy Futures project, coordinated by the Nautilus Institute for Security and Sustainable Development, is an ongoing cooperative research venture with partners from the countries of Northeast Asia, including China, the Democratic Peoples' Republic of Korea, Japan, the Republic of Korea, the Russian Federation (the Russian Far East), and Taiwan.

1.1 Summary of Energy/Environmental Situation in NE Asia

Recent economic growth in the Asia-Pacific region in general, and in many of the economies of Northeast Asia in particular, has been spectacular for most of the 1990s. Along with this growth has come a vast expansion in the need for energy services, and an expansion in the demand for the fuels that help to supply these services. Future projections suggest that the growth of fossil fuel use in Northeast Asia, and in China in particular, is likely to not only have major consequences for local and regional financial and fuels markets, as well as local and regional pollution, but will have global dimensions as well. Energy-related local and regional pollution are already facts of life in many areas of Northeast Asia. Rapidly increasing growth of fossil fuel use in Northeast Asia will have ramifications for global energy and capital markets, and will have profound impacts on global greenhouse gas emissions. How the countries of the region choose to supply the energy needs of their populations will therefore have impacts well beyond the region. The sum of these impacts defines the degree of energy security or insecurity of the countries of the region.

In addition to considerations of required energy supply and demand, and of the environmental implications of energy transformation and use, energy security, broadly defined, also plays a profound role in shaping the relations between nations in Northeast Asia, as well as the relations of nations in the region with nations outside the region. Nowhere is this more evident than in the Democratic People's Republic of Korea (DPRK), where the energy security of the nation has been seen as a key to peace and stability in the Korean peninsula, and in the region as a whole.

What has been lacking, until this project, has been a forum for energy experts from all of the countries of the region to meet, informally and in an unofficial capacity, to discuss openly and in a targeted fashion the energy situations in their countries, and to work together to evaluate the energy efficiency costs and benefits--again broadly construed--of different ways of meeting the energy needs of the region. The East Asia Energy Futures project has provided and provides such a forum, and as such constitutes a unique resource in the engagement of the countries of Northeast Asia on the topic of energy security.

1.2 East Asia Energy Futures Overall Project Goals

The overall goal of the East Asia Energy Futures project is to identify policy options to increase regional energy security and to engage the DPRK through the analysis of demand-driven energy paths. These energy paths are used to identify key national, regional, or global policies that contribute toward enhancing energy security—considered in the broad sense—in the

Northeast Asia region. In working toward that goal with a group of collaborating researchers key sub-goals, particularly in the past year, have been:

- To strengthen the network of regional energy researchers assembled by Nautilus.
- To develop, apply, and share transparent energy paths analysis tools, techniques, and data among the members of the regional research network and other interested groups.
- To propose plausible alternative energy futures for the countries included in the project and for region as a whole.
- To contribute toward the understanding of the full ramifications (effects) of national and regional energy choices.
- To suggest modes of national, regional, international cooperation and action to enhance the energy security of the region, and to place project results in the hands of key decision-makers.

In addressing the goal and sub-goals identified above, the East Asia Energy Futures project has worked towards the following milestones:

- Development of a set of alternative future energy "paths"—detailed quantitative projections or scenarios of energy supply and demand over the next two decades or more—for each country in the Northeast Asian region individually, as well as for the region as a whole;
- Development and assembly of accurate and comprehensive national energy data sets that can be shared with other researchers; and
- Establishment of clear and open means of communication between regional energy researchers, Nautilus staff, and others, in order to work collaboratively on national and regional energy scenarios analysis.

1.3 Summary of Prior East Asia Energy Futures and Related Activities

In the first phase of the East Asia Energy Futures project, which was carried out from approximately 1996 to 2000, Nautilus staff, with funding from the W. Alton Jones Foundation and the US Department of Energy (1999 through 2002), complied energy data sets for Japan, China, Republic of Korea (ROK), Democratic People's Republic of Korea (DPRK), Hong Kong, and Taiwan, and carried out partial analyses of baseline energy paths using the LEAP (Long-range Energy Alternatives Planning) software tool. The energy databases thus created were also used for analysis carried out in other Nautilus energy projects, including the Energy, Security and Environment in Northeast Asia (ESENA) Project and the Pacific Asia Regional Energy Security (PARES) Project[1]. In the PARES project, Nautilus used LEAP and the LEAP Japan

[1] Some of the Nautilus research efforts that have drawn upon national energy databases created during the first phase of the Asia Energy Security project include D. F. Von Hippel, P. Hayes, and N. Kraft (1997), East Asia Energy Futures: Towards Least-Cost Energy Investment in Northeast Asia, Progress Report, March, 1997; T. Suzuki, D. F. Von Hippel, K. Wilkening, and J. Nickum (1998), Pacific Asian Regional Energy Security: Frameworks for Analysis and Japan Case Study. Synthesis Report for Pacific Asian Regional Energy Security (PARES) Project, Phase I; D.F. Von Hippel and P. Hayes (1998), "Two Scenarios of Nuclear Power and Nuclear Waste Production in

data set in collaborative work with Japanese and US partners in order to develop and evaluate alternative energy paths for Japan. The methodology for the analysis of the energy security impacts of different energy paths developed during the PARES project has been adapted for use in the collaborative phase of the East Asia Energy Futures project covered by this report. In June of 2000, a workshop was held in Beijing, convened by Nautilus and its partner organization in China (the US/China Energy and Environment Technology Center of Tsinghua University, Beijing, China), that included participants from throughout Northeast Asia. The workshop included several days of lectures and discussion in which different national and international perspectives of the energy situation in Northeast Asia were discussed, followed by a week in which the training of working group participants in the energy security analysis techniques was initiated.

1.4 Contents and Coverage of this Report

This purpose of this report is to provide a brief summary of the activities and accomplishments of the East Asia Energy Futures project over the past year, the current status of the project, and plans for future project activities. The remainder of this report is organized into the following sections:

- **Section 2** summarizes the activities carried out under the East Asia Energy Futures project during the past project year.
- **Section 3** describes key lessons that Nautilus has gleaned from the East Asia Energy Futures working group process.
- **Section 4** presents initial results and plans for updated work on alternative energy futures in the DPRK, and implications of those futures for energy and security policy in the region and beyond.
- **Section 5** presents a very brief summary of the results, to date, of "business as usual" energy paths analyses from each of the country teams.
- **Section 6** provides an overview of future plans for the East Asia Energy Futures project.

Attachments to this report provide brief descriptions, prepared by the members of the regional working group, of their experience with and thoughts about the East Asia Energy Futures project to date, and the tools and methods learned and used as a part of the project.

2. East Asia Energy Futures Project Activities During the Past Year

2.1 Working Group Development

Nautilus staff have been active in the past year in continuing to support and develop the East Asia Energy Futures Working Group. This process has included making contractual arrangements for the participation of working group members, providing direction to the Working Group in development of their data sets and energy paths, providing direction in the development of inputs to the Training Workshops, providing support in the use of the LEAP

Northeast Asia". Pacific and Asian Journal of Energy, Volume 8, No. 1, 1998, pp. 23 - 50; and D.F. Von Hippel (1999), Modeling of Clean-Coal Scenarios for China: Progress Report and Initial Results.

software by Working Group members, and identifying additional participants or observers to join the Working Group. As of this writing, the Working Group includes teams from:

China (Prof. Zhang Aling, Prof. Wang Yanjia, Mr. Guo Baolei)

The DPRK (Different team members have attended different workshops, but members in attendance have included Eng. Kim Jae Suk, Kim Il Bong, Chang Il Kim, Kwan Ho Kim, Song Bung Kim, Yong Ii Ri)

Japan (Prof. Tatsuhiro Suzuki, Mr. Oda Junichiro, Mr. Takuro Kiuchi)

The ROK (Prof. Euisoon Shin, Mr. Hoesoek Kim, Dr. Chung Woojin)

The Russian Far East (Dr. Victor Kalashnikov, Dr. Alexander Ognev, Mr. Roman Matveev)

Other participants and observers from the region have been involved in the two workshops described below, but have not as yet been active in the Working Group.

2.2 Training and Information Sharing Workshops

During the period covered by this report, two East Asia Energy Futures workshops have been held for the purpose of sharing information and background about the energy systems of the countries of the region, and to provide training in methods of the analysis of energy paths and their energy security impacts. The first of these workshop (actually the second East Asia Energy Futures project workshop) was held in Berkeley, California in February of 2001. The second workshop, originally scheduled for October of 2001 and originally to have been held in Beijing, was delayed and shifted to Berkeley, in part due to travel concerns resulting from the terrorist attacks of September 11. The second workshop was held in Berkeley from January 28 to February 1, 2002.

2.2.1 Berkeley East Asia Energy Futures Workshop, February 2001

An East Asia Energy Futures Framework Meeting (the Second East Asia Energy Futures Workshop) was held in February 2001 at Nautilus Institute offices in Berkeley, California. The goals of the Workshop were to elaborate a common research framework for developing *national* energy paths and to discuss a set of common analytical tools for generation and evaluation of energy paths. The analytical and conceptual approach elaborated in this meeting was also developed to ensure that the activities of the workshop could serve also as a foundation for energy paths analysis at the *regional* levels in subsequent phases of the project.

The 2001 Workshop began with two days of presentations and discussion. The first day focused on presentations and discussions of the current energy situations and key research questions in energy planning as determined by each country, as well as discussions on comprehensive regional energy paths. The second day of the workshop focused on identifying and elaborating the means to support energy paths development in the East Asia Energy Futures project, and how to evaluate energy paths in a quantitative way. As such, this second day of the workshop highlighted the analytical tools used to quantitatively support the energy paths analysis.

The common research framework used in ongoing and future phases of the East Asia Energy Futures project is designed to draw on aspects of the energy security framework developed and used as a part of another Nautilus project, the PARES project (as noted above). The research framework also is designed to provide broad research directions as what kind of scenarios might be prepared and evaluated by each country group, to prepare and evaluate. Common analytical tools and methods used in this project include the LEAP 2000 energy planning software, outlines for data collection and final reports, sample/initial data sets assembled by the Nautilus Institute, documents that provide guidance on building consistent data sets for each scenario, and guidance on approaches and methodologies for data collection. Many of these tools and approaches were discussed in detail during the 5-day LEAP 2000 software training that followed the Framework Meeting.

2.2.2 Berkeley Workshop, January 2002

On the first day of the January 28 to February 1, 2002 East Asia Energy Futures workshop, participants from the countries involved in the East Asia Energy Futures project presented, in the context of updates on the status of their national energy and energy policy situations, summaries of the status of their LEAP modeling efforts, including their LEAP national energy data sets and BAU energy paths. The second and third days of the workshop were devoted to qualitative discussions on alternative national and regional energy paths and more general "scenarios". One of these days was devoted to a "scenario exercise", facilitated by a team from the Global Business Network, to get participants thinking about the future of energy security in the Northeast Asia region. The first three days of the workshop therefore provided the context for a following training session, in which the participants could continue with detailed technical discussions about LEAP data collection, BAU path elaboration, and the implementation of alternative paths within the modeling structure.

The final two days of the third East Asia Energy Futures workshop were devoted to "hands-on" work with the LEAP (Long-range Energy Alternative Planning system) software tool, the common analytical tool being used for the quantitative energy paths analysis throughout the project. Issues related to modeling energy security impacts of different energy paths within and outside of a LEAP framework were also discussed, as were plans for future analytical activities under the project. The final two days of the workshop were largely designed to help participants finish up business-as-usual (BAU) paths work, and to begin work on designing and implementing "alternative" energy paths within the modeling framework.

Prior to the workshop, Nautilus staff suggested that the final two days of the workshop be used for discussions and training on:

a) LEAP data collection/interpretation, including the collection methodology, key data sources and key data gaps, problems encountered in gathering data, concerns of the country team regarding data availability and quality, and other topics relevant to the data collection effort.

b) BAU energy path design and assumptions, including the central data sources, the overall assumptions about demographics and economics in your country in the future, assumptions with regional implications, preliminary results, and reasonableness of BAU paths.

c) Other problems and concerns related to assembling and using LEAP dataset

These topics formed the core of workshop discussions. Using a projection device connected to a computer, participants and Nautilus staff looked through each group’s draft LEAP dataset (and back-up material such as data development workbooks) in detail together and discussed specific energy data and model structure issues. In doing so, group members freely helped each other with problems encountered, discussed different approaches to energy database development and use. The LEAP energy modeling system's characteristics—particularly its transparency and ease-of-use—made it easy for all participants to appreciate the approaches taken by the various groups, and to assist others with specific issues. The new "LEAP2000" version of the software improves upon earlier generations of modeling tools, particularly in providing intuitive and familiar ways to edit data and review results. This characteristic significantly helped the participants from various academic backgrounds and cultures understand and discuss together various end-use energy data structures and issues.

2.3 Work on LEAP Databases/Business as Usual Energy Paths

Following the 2002 Workshop described above, Working Group members were tasked with completing (and documenting) the base year databases within the LEAP modeling structure, and with preparing "business-as-usual" energy paths for their country. The interpretation of "business-as-usual" suggested by Nautilus was left rather open, but the overall guidance was for the Working Groups to describe paths that fit the trend of recent energy sector development and energy sector policies in their country. Some Working Groups chose to develop BAU paths based largely on existing government plans for the sector, while other groups chose to describe paths that departed somewhat from official plans.

Project communications between Working Group members and Nautilus staff have been active during this period of database and BAU path development. Working Group members have sent questions on implementation of their data sets in LEAP to Nautilus staff via e-mail, and responses have been provided and well-received, with most responses shared with all of the Working Groups.

At present, several groups have complete or nearly complete base year data sets and BAU energy paths, while some groups have some "data gaps" remaining to be filled. The status of each data set, and a brief presentation of interim results, is provided in section 5 of this Report.

3. Key Lessons from East Asia Energy Futures Working Group Process

3.1 Value of Collaborative Efforts Focused on a Commonly-used, Transparent Tool

The 2002 Berkeley workshop marked the third time that the core group of East Asia Energy Futures Working Group participants had been brought together for LEAP training, and the second time that the group had worked together with the new "LEAP2000" Windows™-based version of the software (all of the groups worked with the software in their own countries between the second and third workshops). The third workshop was the first instance, however, in which country teams brought their own data sets to work on and share with Nautilus staff and other project participants, and Nautilus staff were struck by several aspects of how the workshop proceeded:

- Though participants had exhibited a high degree of interest and concentration in earlier training workshops, their evident increase in "ownership" and their enthusiasm in working on their own country data sets was quite gratifying to see.

- The openness with which participants shared both their views and their data was also gratifying. Given the choice of having individual discussions with Nautilus staff about their own data sets, or of walking through their data sets in front of the whole group, participants chose the latter, which was both, in the view of Nautilus staff, more effective for all concerned and also a highly significant measure of trust in each other and in the project.
- Participants accepted suggestions from Nautilus staff and from other group members quite willingly and gratefully, and many participants had become sufficiently facile with the software to teach Nautilus trainers a trick or two.
- There is clear enthusiasm on the part of the participants for continuing with the project. In many of the participating countries, this project represents the only instance of this type of "bottom-up" energy analysis being carried out. Even more importantly, the project also represents the only regional group working collaboratively on detailed energy futures and regional energy security analysis. The level of comfort with each other shown during this third East Asia Energy Futures workshop makes it crucial to keep the group intact and working toward the project goals.

3.2 Value of Long-term Commitment to Working Group

The openness and camaraderie and enthusiasm described above is the direct result of a long-term, consistent, and patient approach to the building of relationships between researchers and with Nautilus staff. The types of relationships forged during this project are both immensely valuable and rather difficult to achieve. This is particularly true for relationships with and between researchers and organizations in Northeast Asia, where decades (and in some cases, much longer) of tension and often conflict between countries, plus a history of strong government control, mean that the barriers to collaborative work are indeed formidable in practice. Continuity in attention and in funding are and will be required to keep the Working Group active, and resource whose value continues to increase (see below) with time will be squandered if the East Asia Energy Futures Working Group is not maintained.

3.3 "Spinoffs" to other Regional Collaborative Efforts

The East Asia Energy Futures Working Group network of researchers, and the national databases prepared and maintained by the national Working Groups, offer a significant resources not only for continuing East Asia Energy Futures activities, but also for other analytical, policy-driven studies at both the national and regional levels. Examples of such "spinoff" applications, both ongoing and proposed, include:

- The **Northeast Asia Power Grid Interconnection Project**, which has brought together representatives of the countries of the region for a focused study of one of the elements of regional energy sector cooperation considered by the East Asia Energy Futures Working Group, namely regional power grid interconnections. The relationships developed as a part of the East Asia Energy Futures project—in the Russian Far East, the DPRK, the Republic of Korea, and China—have been instrumental in making this project a reality. The Northeast Asia Power Grid Interconnection Project includes a series of regional workshops and a collaborative multi-national "prefeasibility" study to assess the costs and benefits of regional grid interconnection. Issues relating to the use of the nuclear reactors being built by the

Korean Peninsula Energy Development Organization (KEDO) in the DPRK are also being discussed as part of this project.

- A **Northeast Asia Nuclear Fuel Cycle Project** is under active discussion by Nautilus and several members of the East Asia Energy Futures Working Group, led by members from Japan. This project would use the national databases and energy paths assembled in the East Asia Energy Futures work to look at the costs, benefits, and overall energy security implications of various arrangements for storage and disposal of wastes from nuclear power reactors in the region.

[In addition to the regional collaborations described above, one intent of the East Asia Energy Futures project has been that databases and energy sector models built by each of the country Working Groups be available for the researchers that built it, in collaboration with others in their country, to use on energy futures-related studies in their own countries. Such applications are already beginning, as is noted in the reports from the participating East Asia Energy Futures teams (provided as attachments to this Report).

4. DPRK Energy Sector Analysis

During the last seven years, Nautilus Institute has prepared a number of studies that have attempted to analyze energy supply and demand patterns, and future paths or "scenarios" of energy supply and demand, in the Democratic Peoples' Republic of Korea[2]. As the United States, the Republic of Korea and the DPRK, as well as other nations in the region, continue to struggle with issues relating to relations between the countries, the status and prospects of the DPRK energy system, the engine of the DPRK economy, is an increasingly important key to the long-term security of the region. One of the many difficulties faced by those tasked with charting a course for relations between the Koreas and the US is that so little is known—both inside the DPRK and out—about the DPRK energy system in its entirety. Nautilus Institute therefore proposes to integrate the consideration of DPRK energy futures with the East Asia Energy Futures project work. A brief discussion of illustrative results of DPRK energy paths analysis by Nautilus is provided below, along with a discussion of some of the DPRK-related elements that Nautilus proposes to include in future East Asia Energy Futures work.

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[2] Examples include an assessment of the degree to which energy efficiency measures could result in improved performance of the DPRK energy sector (Von Hippel, D. F., and P. Hayes, The Prospects For Energy Efficiency Improvements in the Democratic People's Republic of Korea: Evaluating and Exploring the Options. Nautilus Institute Report, December, 1995); a review of the demand for and supply of heavy fuel oil in the DPRK as of 1996, with demand scenarios for the year 2000, prepared for the Korean Peninsula Energy Development Organization (KEDO); research focusing on the DPRK electricity system, updating our estimate of the status of the DPRK energy sector to 1996, and elaborating and evaluating energy scenarios for the DPRK to 2005 (D.F. Von Hippel, and P. Hayes, Demand and Supply of Electricity and Other Fuels in the Democratic Peoples' Republic of Korean (DPRK), Nautilus Institute (prepared for Northeast Asia Economic Forum), 1997); and a discussion of the rural energy crisis in the DPRK, and of measures that might be taken to rebuild rural energy and agricultural infrastructure in the country (J. Williams, D.F. Von Hippel, and P. Hayes, Fuel and Famine, Rural Energy Policy Options in the DPRK, Nautilus Institute, March 2000).

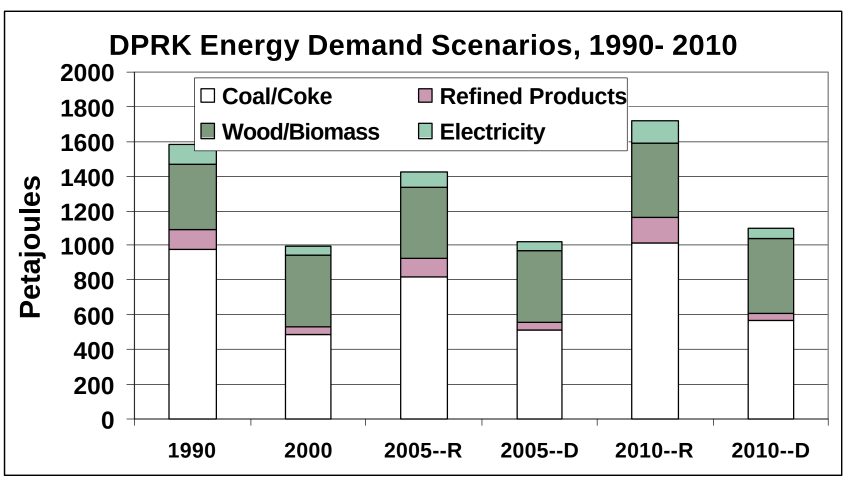
4.1 Illustrative DPRK Energy Scenarios for 2005 and 2010

To say that the future energy demand and supply situation in the DPRK is uncertain is a vast understatement. Energy consumption in the DPRK has been contracting virtually throughout the 1990s. The text that follows presents an updated version of two scenarios ("Continued Decline" and "Rebuilding") for the DPRK energy sector, based on previous Nautilus Institute work. These scenarios are indicative only, should be considered only initial indicators of the results of work in progress. The "Continued Decline" scenario assumes that the economy of the DPRK is not materially rebuilt over the next decade, but largely continues its stagnation, with only the most modest economic reforms and with international aid and austerity the main factors in maintaining the DPRK economy near its current levels. The "Rebuilding" scenario implicitly assumes a major breakthrough in relations with the ROK (and probably the United States as well), resulting in some investment in the industrial and energy infrastructure in the DPRK from outside the country and much increased foreign development aid. The "Rebuilding" scenario also assumes, however, that the DPRK government essentially maintains its integrity. If the current DPRK government loses power, rapid reunification of North and South Korea may result, which probably means very large, very fast changes for the DPRK energy sector, providing that the unified Korea can obtain internal and external financing for infrastructure reconstruction in the North.

4.1.1 Future Energy Demand in the DPRK

Figure 1 shows estimated final energy demand by fuel type in the DPRK for the two scenarios described above. In Figures 1, and 2, and in Table 1, "2005--D" and "2010--R" refer to year 2005 and 2010 results for the "Continued **D**ecline" and "**R**ebuilding" scenarios, respectively[3]. The rebuilding scenario show much greater use of fossil fuels and electricity than the decline scenario, with the highest growth being in the highest quality fuels—petroleum products and electricity.

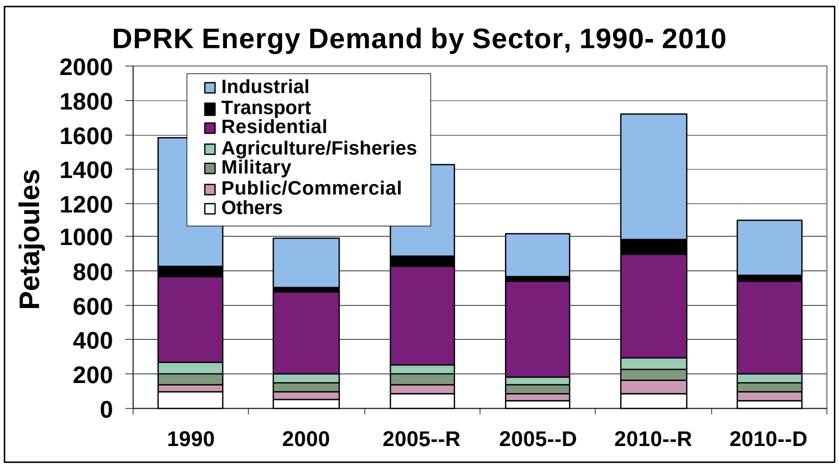
Figure 1:



[3] The energy units in Figures 18 through 20 are petajoules, or 10^{15} Joules. One petajoule is equal to about 23.9 thousand tonnes of oil equivalent.

Energy demand by sector under the two scenarios in the DPRK, as illustrated in Figure 2, is different for all sectors by 2005 and 2010, but the major difference between the two scenarios is resurgence in the industrial and transport sectors. There is some resurgence in the public/commercial sector as well. Rebuilding of the industrial sector in the DPRK will, however, mean more than just restarting existing industries, as those industries were initially designed to serve markets that do not now exist. Probably the first industries to be rebuilt in the DPRK will be those that produce raw materials with international markets, such as production of the refractory mineral magnesite, of which the DRPK has considerable reserves.

Figure 2:



4.1.2 Future Fuels Supply in the DPRK

The pattern of energy supply by fuel under the two scenarios for development of the DPRK energy sector is shown in Table 1. Coal will probably continue to be produced primarily domestically under both scenario, and crude oil and refined products will continue to be imported. In the "Rebuilding" scenario, imports for oil will likely to continue to come from China, augmented by imports from Russia and perhaps from the Middle East or elsewhere. The higher value for primary energy supplies from "Hydro/nuclear" in the 2010--R and 2010--D columns reflects the start-up, possibly sometime around 2007 to 2009, of the nuclear reactors being built by KEDO in the DPRK.

Table 1:

Scenarios for Primary Energy Supplies by Fuel in the DPRK (PJ)						
	1990	2000	2005--R	2005--D	2010--R	2010--D
Coal/Coke	1,356	739	1,149	705	1,350	757
Crude Oil	111	43	111	38	216	47
Refined Products	27	32	42	31	(13)	14
Hydro/Nuclear	77	21	53	32	135	94
Wood/Biomass	386	412	420	413	435	431
TOTAL	1,956	1,246	1,774	1,220	2,123	1,342

4.2 Future East Asia Energy Futures Activities Related to Assessment of Energy Paths for the DPRK

Nautilus Institute plans to continue with the analysis of the DPRK energy situation and Energy Paths within the framework of the ongoing East Asia Energy Futures project. This work is expected to include:

- Updating of Nautilus' Estimated DPRK energy supply/demand balance, and the detailed energy analysis that is used to produce the balance estimate, to a base year of 2000. This will be done by assembling all relevant recent materials on the DPRK economy and energy system, interviewing recent visitors to the DPRK, and using the calculation tools prepared for previous work to derive an estimated quantitative picture of the DPRK energy situation as of 2000.
- Using the update prepared as above to update Nautilus' LEAP data set for the DPRK.
- Considering the current political and economic directions in the region and the status of the DPRK energy sector as of 2000, revising the existing energy paths in the LEAP DPRK energy model, and assembling new paths for analysis as applicable.
- Deepening the LEAP skills of the DPRK Working Group by encouraging their continued participation in East Asia Energy Futures workshops, and also by sending missions to Pyongyang to work with DPRK teams in learning and using the East Asia Energy Futures energy security analysis methodologies. It is expected that these sessions will provide an opportunity for Nautilus to share its work on DPRK energy paths with DPRK counterparts, to obtain insights on that work from DPRK experts, and to put the lessons learned through the energy paths analyses before DPRK policymakers.
- Working with the other East Asia Energy Futures colleagues in the Working Group to integrate the DPRK energy paths analysis—either that prepared by Nautilus, work done by DPRK colleagues and shared with the East Asia Energy Futures group, or some combination of the two—into the composite regional picture to be formed by the collaborative work of the Group as a whole. This work is expected to help point the ways in which regional (and other international) approaches can help to contribute to a solution to DPRK energy-sector problems.
- Evaluating the results of DPRK energy paths analysis, including the analysis of regional energy paths with DPRK components, for their implications for future regional energy security, and for their implication for US policy toward the DPRK. A part of this work will include identifying and describing in quantitative terms potential engagement approaches that the United States and its partners in the region might use to constructively help the DPRK work toward a sustainable energy sector, and to build trust and confidence among the nations involved.

5. Summary of Business-As-Usual Path Interim Results

This section provides a brief description, and summary results, of each of the four LEAP data sets (China, Japan, Republic of Korea, and Russian Far East) developed by East Asia Energy Futures country Working Groups, and of a DPRK data set developed by Nautilus.

5.1 China

The China East Asia Energy Futures Working Group has prepared a relatively extensive data set for China. The China data set includes detailed end-use treatment of the Residential sector (with urban and rural households treated separately), and the Transport sector is divided by type of vehicle/vessel for passenger and freight transport. The industrial sector is divided into three major categories--manufacturing, mining and quarrying, and construction. Manufacturing is further split into 11 subsectors, most of which use physical quantities of output of key products (such as cement for "non-metal mineral") as driving variables. The Commerce and Agricultural sectors use square meters of floor-space and value added, respectively, as driving variables, and aggregate fuel use (by fuel type) over all activities.

The Transformation portion of the data set compiled by the Chinese team includes "modules" for Transmission and distribution, electricity generation, heat supply, gas making, coking, briquette making, biogas making, coal washing, oil refining, oil extraction, and coal mining. Electricity generation includes 12 power plant types. No costs have been entered for transformation equipment.

The China data set appears to be reasonably complete. Additions that might be considered include more notes on data derivation and assumptions throughout the data set (there are some notes in use in the demand and resource portions of the data set), addition of a natural gas production module, and addition of costs, particularly for transformation processes and resources. Also, it is not clear how the heat output from combined heat and power production in the electricity generation module is to be reflected. At present, no growth in either oil or coal extraction capacity is included in the BAU path.

Figure 3 shows the China Working Group's current BAU path demand by sector. The transport sector is shows the most rapid increase in energy demand, and overall growth in end-use fuels consumption averages about 2.4 percent annually from 1999 to 2030—considerably lower than historical rates in China in all but the last few years. Table 2.provides a breakdown of demand by fuel. Growth is highest for transportation fuels, LPG, and electricity, while biomass use declines. Use of raw coal continues to grow at about 2.5 percent annually, though washed coal use grows faster.

Table 3 shows the considerable change in the fraction of China's energy that will be supplied by imports in the coming years. This value is inflated by the limits placed on coal mining and oil extraction capacity, but a considerable increase in China's import dependence does seem likely.

Figure 3:

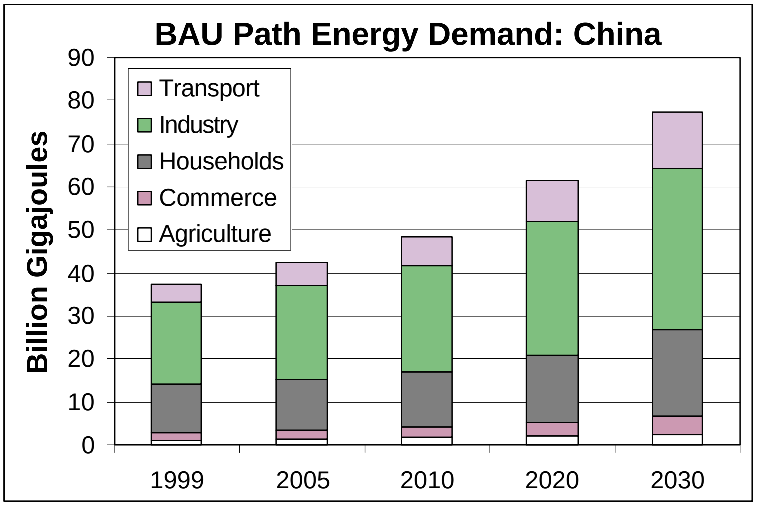


Table 2: BAU Case Energy Demand in China by Fuel

Units: billion gigajoule						%/yr growth
Fuel	1999	2005	2010	2020	2030	1999-2030
Biogas	0.04	0.12	0.28	0.76	1.94	13.34%
Biomass (unspecified)	5.95	4.83	4.03	2.76	1.77	-3.84%
Briquette	0.16	0.17	0.17	0.13	0.06	-3.11%
Cleaned coal	0.34	0.38	0.44	0.54	0.65	2.11%
Coke	2.83	3.02	3.46	4.34	5.22	1.99%
Coke oven gas	0.33	0.37	0.43	0.58	0.74	2.64%
Crude Oil	0.87	0.87	1.01	1.28	1.55	1.88%
Diesel	2.66	3.36	4.01	5.28	6.65	3.00%
Electricity	3.84	4.46	5.19	6.77	8.36	2.54%
Gasoline	2.25	3.06	3.87	5.6	7.94	4.15%
Geothermal	0.01	0.01	0.01	0.02	0.03	3.61%
Heat	1.19	1.45	1.72	2.32	2.97	2.99%
Heavy Oil	1.22	1.38	1.58	1.97	2.39	2.19%
Kerosene	0.23	0.33	0.43	0.67	0.93	4.61%
LPG	0.46	0.73	1.14	2.28	4.49	7.63%
Natural Gas	0.64	0.59	0.69	0.94	1.2	2.05%
Other Petro products	1.25	1.35	1.44	1.63	1.81	1.20%
Other coking products	0.05	0.05	0.06	0.07	0.09	1.91%
Other gas	0.36	0.4	0.48	0.65	0.83	2.73%
Other washed coal	0.33	0.42	0.5	0.69	0.89	3.25%
Raw coal	12.08	14.77	17.09	21.8	26.33	2.55%
Refinery gas	0.19	0.2	0.21	0.23	0.25	0.89%
Solar	0.02	0.03	0.04	0.05	0.07	4.12%
Sum	37.3	42.34	48.28	61.34	77.19	2.37%

Table 3: Fuels Supply in China, BAU Path (Billion Gigajoules)

	1999	2005	2010	2020	2030
Primary Requirements	47.40	53.68	60.73	74.62	91.11
Indigenous Production	45.00	48.22	49.68	50.41	50.80
Imports	2.40	5.46	11.05	24.22	40.31
Exports	1.72	2.13	2.43	3.01	3.53
Fraction of Requirements as Imports	5.1%	10.2%	18.2%	32.5%	44.2%

5.2 Japan

The Japan East Asia Energy Futures Working Group is also relatively extensive. The Japan data set includes detailed end-use treatment of the Households sector, with cooling, hot water supply, cooking, and "motive energy & other" (electrical appliances and other uses of electricity) included as separate categories. "Motive energy & other" includes an extensive listing of types of appliances. The services sector uses square meters of building area as the driving activity, and is broken down into electric and non-electric fuels use. Industry subsumes agriculture and forestry, fishing, construction, mining, and manufacturing. Manufacturing is divided into nine industrial subsectors. Output, in trillion Japanese Yen, is used as a driving activity in the construction subsector and in all of the manufacturing subsectors. An index is used for the agriculture and forestry, fishing, and mining subsectors. Transport is divided into passenger and "portage" (freight) categories, and by vehicle/vessel type for each category. Passenger and freight kilometers are used as driving activities.

The Transformation portion of the data set compiled by the Japanese team includes "modules" for Electricity generation, transmission and distribution, heat supply, gas making, coking, briquette making, biogas making, coal washing, oil refining, coke production, and municipal gas production. Electricity generation includes 13 power plant types, and dispatch is by a system load curve. Future capacity additions have been specified for gas production and for electricity generation, but not for oil refining or coke production. No costs have been entered for transformation equipment.

The Japan data set appears to be reasonably complete on the demand side, but there may be more work to do on the transformation side. Additions that might be considered include notes on data derivation and assumptions throughout the data set, addition of natural gas and oil production modules (though domestic oil and gas production in Japan is limited), addition of an LNG imports module, and addition of costs, particularly for transformation processes and resources. Also combined heat and power production does not yet appear to be treated on either the demand or transformation side. Domestic resource estimates do not appear to be reflected in the data set as yet

Figure 4 shows the Japan Working Group's current BAU path demand by sector. The services sector is shows the most rapid increase in energy demand, and overall growth in end-use fuels consumption averages a reasonably modest 0.6 percent annually from 1999 to 2025. Household sector demand declines after 2010. Table 4.provides a breakdown of demand by fuel in Japan. Growth is highest for heat, natural gas and electricity, LPG, and electricity, while use of many solid fuels declines.

Figure 4:

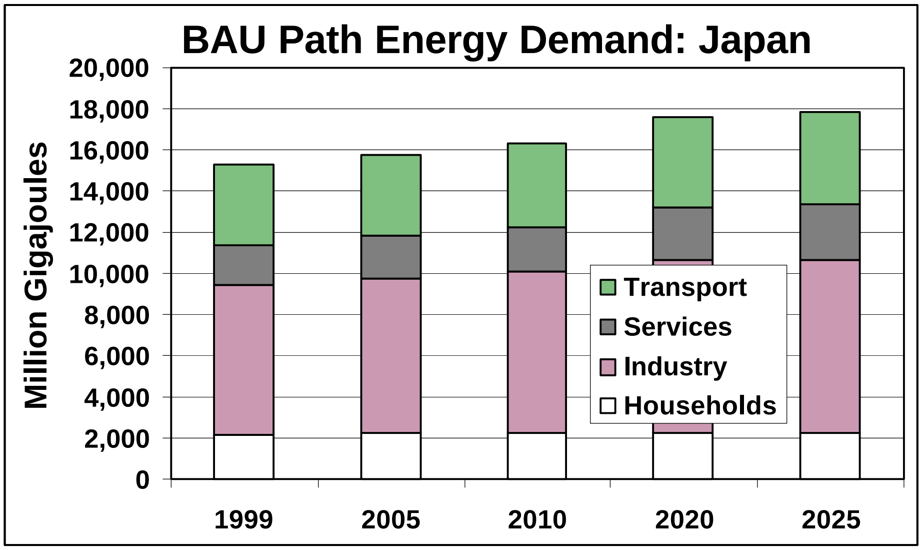


Table 4: BAU Case Energy Demand in Japan by Fuel

Units: million gigajoule

Fuel	1999	2005	2010	2020	2025	%/yr growth 1999-2030
Biomass (unspecified)	97	89	82	71	63	-1.64%
Coal (anthracite)	24	24	24	24	23	-0.13%
Coal (bituminous)	298	280	268	244	223	-1.10%
Coal (lignite)	372	409	437	484	479	0.98%
Diesel	1,661	1,690	1,742	1,830	1,834	0.38%
Electricity	3,394	3,639	3,875	4,305	4,462	1.06%
Gasoline	2,011	1,991	2,046	2,301	2,387	0.66%
Heat	20	28	37	56	65	4.68%
Jet Kerosene	169	195	215	248	261	1.68%
Kerosene	1,109	1,094	1,086	1,069	1,061	-0.17%
LPG	821	857	899	993	1,036	0.90%
Metalurgical Coke	971	894	836	732	655	-1.51%
Naphtha	1,586	1,770	1,929	2,264	2,325	1.48%
Natural Gas	1,005	1,127	1,242	1,459	1,552	1.69%
Petroleum Coke	114	122	128	137	134	0.63%
Residual Fuel Oil	1,563	1,487	1,444	1,327	1,241	-0.88%
Solar	31	32	33	33	32	0.10%
Wood	5	4	3	2	2	-4.14%
Sum	15,250	15,730	16,322	17,577	17,835	0.60%

The Japan BAU path as it currently stands shows all of Japan's energy resources as being imported, though there is some domestic energy production (wood, solar, biomass). Even with these changes factored in, little in the BAU path changes Japan's near-total energy import dependence.

5.3 Republic of Korea

The data set compiled by the ROK East Asia Energy Futures Working Group describes energy demand in the ROK in a fairly detailed manner, but is not quite as complete in its description of fuels transformation. The residential sector is divided up into cooking, heating, lighting, and electric appliances end-uses. The cooking and heating end-uses are further divided by (non-electric) fuel share, lighting is divided by type of bulb, and appliances includes 14 types of electric appliances—including some appliances used for the other end-uses. Residential sector data includes costs for most end-uses. The ROK transport sector is divided into "household vehicles" (private vehicles), mass-transit vehicles (including taxis), and freight vessels and vehicles. The industrial sector covers agriculture and forestry, mining, construction, and manufacturing. Manufacturing is not further divided into subsectors. Each of the categories under the industrial sector is modeled as an overall average energy intensity (per unit of economic output) that is broken into fuel shares. The commercial sector is described as seven subsectors, with square meters of floor-space as the driving activity. The "other services" sector is divided into four subsectors, with number of organizations as the driving activity. The ROK demand data set is linked to environmental effects data in TED (used to produce the global warming potential estimates presented in the ROK Team's Attachment to this Report. The notes feature of LEAP seems to have been used in many parts of the data set, but many of the notes seem to have originally been written in Korean, and may require a Korean version of Windows to be legible.

The ROK data set includes transformation modules for electricity transformation and distribution, electricity generation, district heating, and town gas transmission and distribution. The electricity generation module includes nine different plant types. Electricity and heat are both produced by the electricity generation module, a load curve is used to dispatch plants, and costs and auxiliary fuel use (plant "own-use") for generation plants are provided. Resource estimates have been entered for some renewable and fossil fuels. The ROK team has also entered import costs for several primary resources.

The ROK data set appears to have good coverage on the demand side, and includes more data on costs and environmental performance than other data sets. The modeling of the important manufacturing sector in the ROK data set could benefit by the addition of detail. Other additions that might be considered include more notes on data derivation and assumptions throughout the data set, addition of coal mining, town gas production, and LNG imports modules, and addition of costs for non-electric transformation processes. Also, the ROK data set uses a shorter time-line (2000 to 2015) than the other data sets; the timeline should probably be lengthened to 2020 (at least).

Figure 5 shows the ROK Working Group's current BAU path demand by sector. The commercial, other services, and transport sectors show the most rapid increase in energy demand with growth on the order of 4.5 to 5 percent annually, while the industrial and residential sectors grow more slowly (on the order of 2 percent annually). Overall growth in end-use fuels consumption averages 3.2 percent annually from 2000 to 2015, considerably less than during the 1980s and most of the 1990s. Table 5 provides a breakdown of demand by fuel in the ROK. Growth rates are highest for heat, town gas, transport fuels, and butane (LPG), and electricity, while the use of solid fuels, heavy fuel oil, and electricity grow more slowly. As in Japan, indigenous production of fuels provides a tiny fraction (less than one percent, excluding nuclear fuel) of total primary fuel requirements. Additional interim results of the ROK BAU energy path can be found in the ROK section of the Attachments to this Report.

Figure 5:

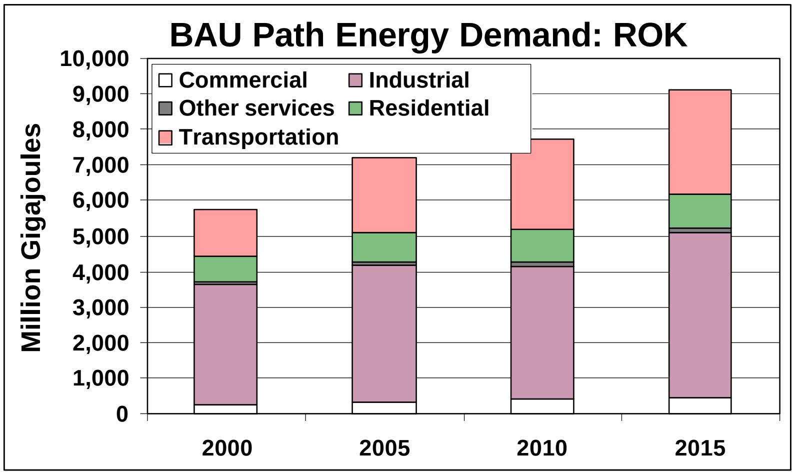


Table 5: BAU Case Energy Demand in the ROK by Fuel

Units: million gigajoule					%/yr growth
Fuel	2000	2005	2010	2015	1999-2030
Bunker A	40	49	57	67	3.44%
Bunker B	14.0	17.3	19.8	23.5	3.51%
Bunker C	745	877	914	1,119	2.75%
Butane	144	251	302	362	6.32%
Coal (anthracite)	32.3	30.7	24.1	29.5	-0.60%
Coal (bituminous)	662	753	719	892	2.01%
Diesel	675	1,015	1,228	1,425	5.11%
Electricity	738	882	921	1,084	2.60%
Gasoline	351	560	667	740	5.11%
Heat	74	115	152	168	5.63%
JA-1	168	279	344	419	6.28%
Kerosene	356	325	258	291	-1.34%
Naphtha	1,236	1,407	1,343	1,666	2.01%
Propane	121	135	137	160	1.88%
Solar	1.3	8.2	16.1	17.0	18.70%
Town Gas	372	504	614	674	4.04%
Sum	5,728	7,207	7,715	9,134	3.16%

5.4 The Russian Far East

The Russian Far East East Asia Energy Futures Working Group got a slightly later start than some of the other groups and, as indicated in the RFE section of the Attachments to this Report, encountered significant difficulty finding recent energy data (especially demand-side data) for their region of Russia. The data set the RFE Working Group has compiled to date is, however, nearly complete. Household demand data is divided between urban and rural residents, and further into the cooking, lighting, appliances, space heating, hot water, and electric heating and air conditioning. The transport sector is divided into passenger and freight modes, and into the various types of vehicles and vessels used for transport. The "Commercial" sector is divided into agriculture and industry, each of which uses an average energy intensity, indexed, respectively, to hectares of crop area and industrial output in rubles, with shares for each relevant fuel.

The Transformation portion of the RFE data set includes an Transmission and Distribution modules for electricity and heat, as well as modules for electricity generation, oil refining, coal mining, natural gas extraction, centralized heat production, and crude oil extraction. The electricity generation module includes 23 types of generators. Costs for transformation processes are not yet included in the data set. Reserves and yields are provided for a number of primary energy resources, and costs are provided for natural gas resources.

The RFE data set would benefit by additional detail, particularly for the industrial sector, on the demand side, but the statistical information needed to provide such detail might be simply unavailable. Data on costs and environmental performance of both demand- and supply-side devices and processes have not yet been entered. Additional resource cost data are also needed. More extensive use of the "notes" feature is also recommended.

Figure 6 shows the RFE Working Group's current BAU path demand by sector. The industrial sector shows the fastest relative growth, followed by the agriculture and transport sectors, with household energy use growing rather slowly. Overall growth in end-use fuels consumption averages 2.3 percent annually from 2000 to 2020, following a considerable contraction in energy use during the 1990s. Table 6 provides a breakdown of demand by fuel in the RFE. Growth rates are highest for use of natural gas, oil products, and transport fuels, and while the use of solid fuels (wood and coal) grows relatively slowly.

Figure 6:

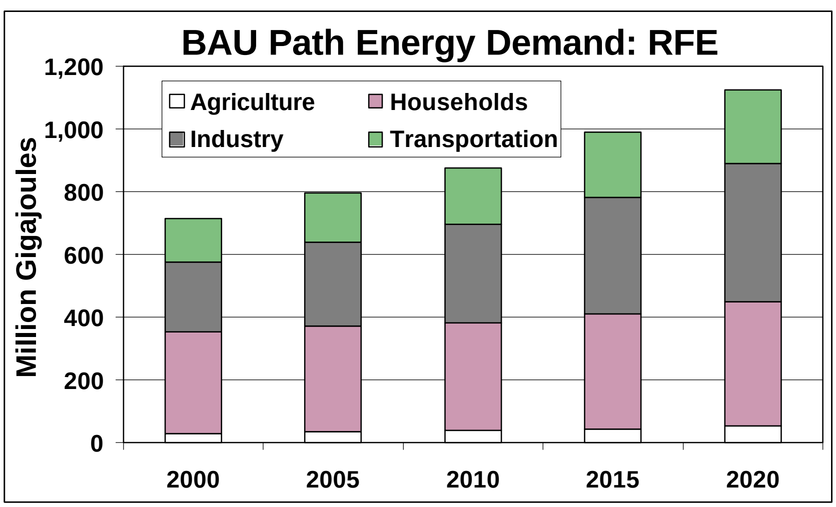


Table 6: BAU Case Energy Demand in the RFE by Fuel

Units: million gigajoule						%/yr growth
Fuel	2000	2005	2010	2015	2020	1999-2030
Coal (bituminous)	147	156.3	162.4	176	192.9	1.37%
Diesel	129.6	150.1	173.8	201.4	233.6	2.99%
Electricity	77.4	88.3	101.1	117.2	135.8	2.85%
Fuel Oil	38.2	45.1	53.1	62.7	74	3.36%
Gasoline	21.6	24.6	28	31.8	36.3	2.63%
Heat	210.6	232.4	251.8	282.3	319.8	2.11%
Jet Kerosene	25.4	28.5	32	35.8	40.2	2.32%
LPG	1.4	1.4	1.4	1.5	1.5	0.35%
Natural Gas	18.8	22.2	26.4	31.3	37.1	3.46%
Wood	45.2	47.1	47.4	50.2	53.8	0.87%
Sum	715.2	796	877.3	990.1	1,125.00	2.29%

A major assumption in the RFE data set is that large increases in exports of coal and especially natural gas begin between 2005 and 2010, resulting, by 2020, in exports that are nearly half of total fuel requirements (including exports) and thus only slightly less than internal energy demand in the RFE.

5.5 The Democratic Peoples' Republic of Korea

Nautilus Institute staff prepared an illustrative set of three energy paths for the DPRK. The starting point for the preparation of these paths was Nautilus' DPRK energy sector analyses, prepared in 1995 through 1997[4], and previous "Recovery" and "Decline" path projections to the year 2005. The paths presented here are subjective, illustrative updates of paths prepared in previous work taking into account changes in the DPRK since 1996, and Nautilus' informal assessment of current prospects for change. The work presented here is **NOT** based upon actual quantitative analysis of recent DPRK data. As noted above and below, an analysis of year 2000 energy demand and supply in the DPRK, and a revised paths analysis will be topics of research in the coming months.

For the illustrative DPRK presented here, three primary paths were investigated: "**Recovery**", "**Continued Decline**", and "**Sustainable Development**". The "**Recovery**" Path is built upon the following assumptions:

- With some political and economic opening, coupled with increased foreign aid, the DPRK economy starts to rebuild in approximately 2003.
- Industrial production increases, particularly in the lighter industries; and there is increased demand for transport.
- There is an increase in household energy use, with trends toward using more electricity, LPG, and kerosene in homes.

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[4] See footnote 2.

- There is a considerable increase in commercial sector activity, and a relatively small increase in military sector energy use.
- Refurbishment of electric transmission and distribution infrastructure takes place, coupled with refurbishment of existing hydro plants, building of new hydro capacity, the re-starting and expansion of the DPRK's east coast refinery, and partial retirement of coal-fired electricity generating capacity.
- Modest improvements in energy efficiency take place.

Driving assumptions for the "**Continued Decline**" Path include:

- No significant economic or political opening occurs, and the DPRK undertakes only modest rapprochement with the United States and the ROK.
- Though the DPRK economy doesn't really decline relative to 2000, it continues stagnating. Foreign aid and domestic policies keep the economy going at a low level, but there is little (if any) growth in per-capita energy use.
- Existing (operating) energy infrastructure is maintained just enough to keep it operating.
- There is no significant increase in energy efficiency.

The third path evaluated, the "Sustainable Development" path, is based on and provides the same energy services as the "Recovery" path, but also assumes:

- There is aggressive implementation of energy efficiency measures to reduce coal and electricity use per unit of energy service delivered.
- There is a more rapid phase-out of existing coal-fired power plants, the addition of an LNG terminal and a Gas combined-cycle power plant in about 2011, and the addition of an IGCC (integrated gasification combined-cycle) plant in 2015.
- Wind power development occurs, along with hydro plant refurbishment and the construction of new (including small) hydroelectric plants.

All three of the paths summarized above assume that the nuclear power plants (approximately 2 GW of light water reactor capacity) being built by KEDO in the DPRK will be on line in 2007, operate reliably, and primarily export power (to the ROK or China). No assumptions made about nuclear waste disposition arrangements.

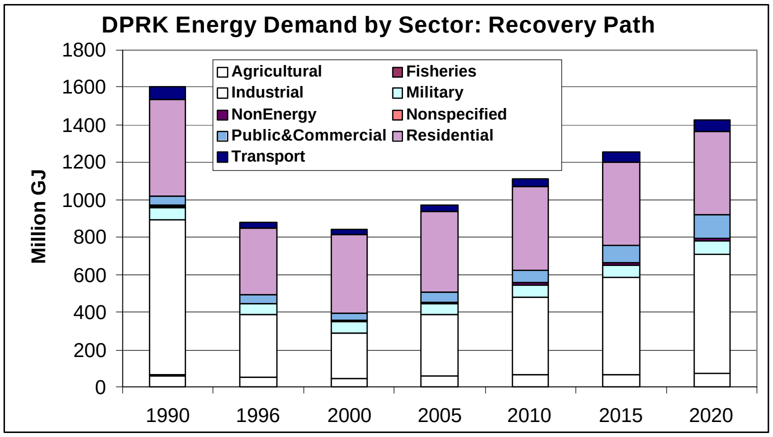
The results of the "**Recovery**" path analysis include the following:

- Overall fuels demand returns to about 90 percent of year 1990 demand by 2020, and the share of demand provided by oil products and electricity increase.
- Primary fuel requirements rise nearly to 1990 levels by 2020, with coal requirements lower than 1990 levels, but oil, hydroelectric, and nuclear (starting in 2007) energy use higher than in 1990.
- Electricity output is about 50 percent higher in 2020 than in 1990, but much of the increased output is exported energy from the KEDO reactors.

- In terms of environmental performance, the GWP (global warming potential) of air pollutant emissions, and the emissions of carbon dioxide (CO_2) and nitrogen oxides (NO_x) are about 15 percent lower in 2020 than in 1990, and sulfur oxides SO_x emissions are 25 percent lower.

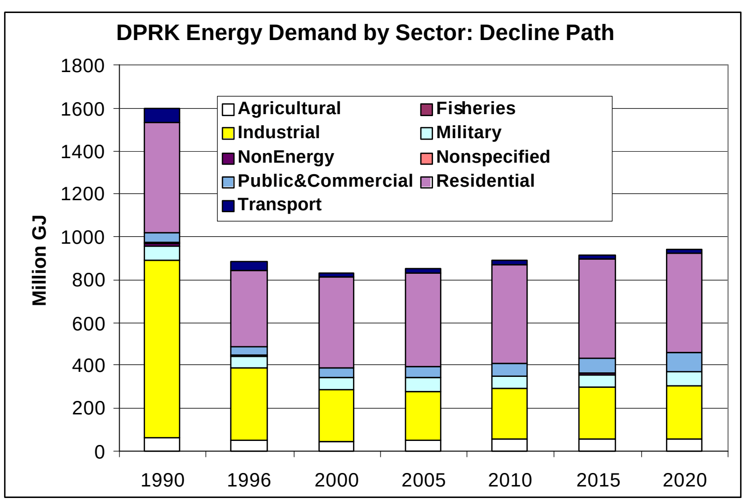
Energy demand in the DPRK under the Recovery path is shown in Figure 7.

Figure 7:



In the "**Decline**" path, overall fuels demand rises gradually after 2000 to about 60% of 1990 demand by 2020, but nearly half of that total is accounted for by biomass fuel use. Industrial demand for fuels remains low. The share of oil products in the DPRK sector, as well as the share of electricity, are lower in 2020 than in 1990. Primary fuel requirements reach 62 percent of 1990 levels by 2020, but coal attains only 40 percent, and oil only 47 percent of 1990 levels of consumption. Electricity output in 2020 under the "Decline" path is less than in 1990, and 35 percent of electricity output is exported. On the environmental side, the overall GWP in 2020, as well as emissions of CO_2, NO_x, and SO_x, are 60 or more percent lower in 2020 than in 1990. Figure 8 shows DPRK energy demand by sector for the "Decline" path.

Figure 8:



The "**Sustainable Development**" variant of the "Recovery" path results in overall fuels demand rising gradually after 2000, but to only about 70% of "Recovery" path levels by 2020. Relative to the "Recovery" path, the "Sustainable Development" path yields substantial reductions in industrial, residential, and public/commercial sector energy use by 2020. Shares of oil products and electricity rise in the "Sustainable Development" path, but primary fuel requirements are only 65 percent of "Recovery" levels by 2020, and only 60 percent of 1990 levels. Coal and oil use are 42 and 134 percent of 1990 levels by 2020, respectively. Electricity output higher in 2020 than in 1990 in the "Sustainable Development" path, but output of electricity for domestic use is lower that in 1990. The GWP of pollutant emissions and total CO_2 emissions are half of 1990 levels, and 60 percent of "Recovery" levels by 2020. Figure 9 shows the difference in sectoral consumption over time between the "Sustainable Development" and "Recovery" paths. Figure 10 illustrates the difference in overall fuels demand between the three paths over time.

Figure 9:

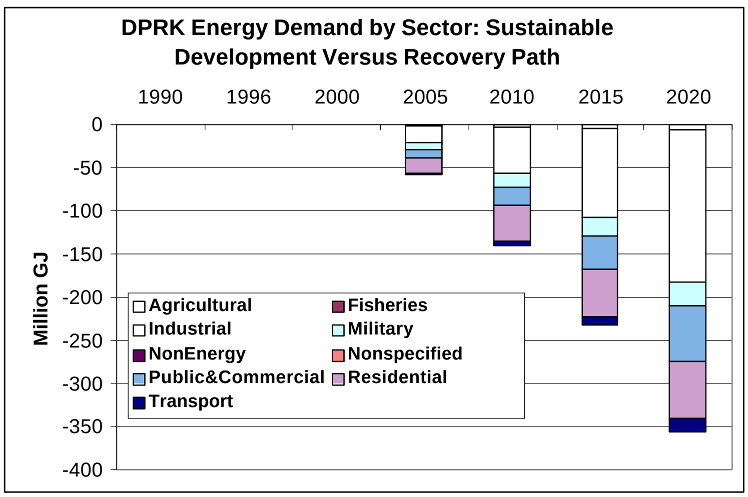
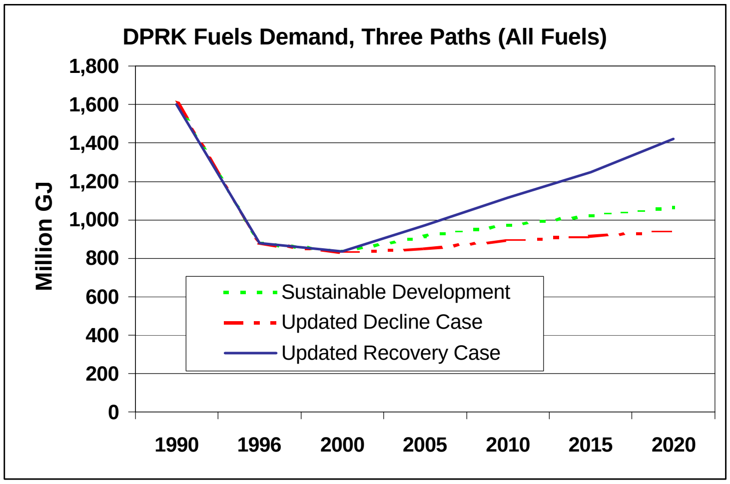


Figure 10:



The next steps on the DPRK energy paths analysis will include:

- The review and analysis of DPRK energy sector and economy information since 1996.
- The preparation of a year 2000 energy balance for the DPRK.
- A reconsideration of existing paths based on the new year 2000 energy balance, and on thoughts about the future as developed during Nautilus workshops and in conversations with colleagues in the region and elsewhere.
- The addition of costs (for demand devices, supply infrastructure, and resources/imports) in order to evaluate the relative outlays needed to achieve different energy paths.
- Debugging of the DPRK data set, and iteration of the analysis, as required, based on new data and insights.

These tasks overlap somewhat, of course, with the project plans described in section 4 of this report. As noted, Nautilus hopes to be able to work with DPRK colleagues as much as possible on this energy paths work, both as a means to obtain the best information possible on the DPRK energy sector, and as a means of engaging DPRK planners and officials in learning more about the possibilities for the DPRK energy economy.

6. Next Steps in Project

Over the next (approximately) two years, the following activities are planned for the East Asia Energy Futures project:

- **Finish, Review and Revise BAU Paths**. National Working Groups, and Nautilus (in the case of the DPRK) will continue working on LEAP data collection and analysis for national BAU paths. Nautilus staff will review the submitted BAU-path data sets for consistency and to identify any errors or structural problems. Any outstanding issues regarding the data sets will be discussed with participants, and the BAU-paths data sets for each country will be revised as necessary.

- **Develop *National* Alternative Paths**. Based on broad guidelines for *national* alternative energy path development provided by Nautilus, national Working Groups participants will work on alternative path data sets for several months. Nautilus will convene a workshop at which participants can discuss and receive ideas on alternative national energy path development and evaluation. Elements of *regional* energy paths might also be discussed at this workshop.
- **Evaluate *National* BAU and Alternative Energy Paths**. Using a suggested summary list of methods for analysis of the energy security costs and benefits of alternative *national* energy paths, Working Group members will prepare evaluations of the relative impacts on energy security of the BAU or Alternative paths for their countries. When *national* alternative paths work in each of the participating countries is complete, a fifth East Asia Energy Futures meeting will be held to present evaluations of the relative energy security aspects of the alternative *national* paths.
- **Regional Paths Integration**. Country teams will prepare BAU and alternative paths for each nation that reflect regional cooperation on selected energy issues (based on cooperation strategies defined and agreed upon earlier). Cooperation strategies could include, depending upon the interest and inclination of the Working Group, regional integration of electricity and/or gas transmission grids, regional approaches to development of renewable sources of energy, regional approaches to energy efficiency, and/or regional cooperation on nuclear waste issues. Energy paths including regional cooperation will be assessed to determine their costs and benefits (including energy security benefits) relative to paths where countries develop their energy systems independently. A workshop will then be held to discuss the results of regional paths integration. Nautilus and participants from the region will prepare a report that presents the results of the national and regional paths evaluations, underscores lessons for energy policy in the region, and offers ideas for next steps in energy-sector cooperation in Northeast Asia.

The activities identified above will be accomplished through a combination of workshops, long-distance (e-mail and telephone) interactions between Nautilus and the Working Group, and selected missions by Nautilus staff to the region. Expected dates for workshops have not yet been set, but Fall of 2002, late Spring of 2003, and Fall or Winter of 2003. Long-distance (e-mail) communication with Working Group members from all countries has already proven a highly effective method of assisting country teams with modeling issues, including the transfer of data sets for Nautilus review, and the transfer of modified data sets back to the national teams by Nautilus staff. Missions to the region by Nautilus staff will be used as an opportunity to focus on the training and energy paths development needs of a subset of country teams (probably one or two) where such assistance would be most useful. As noted above, Nautilus expects that one or more training/assistance/energy paths development missions to the DPRK is/are highly likely to be important parts of the East Asia Energy Futures project.

Attachments: Country Interim Reports

The Attachments that follow provide country reports submitted by each of the country Working Groups participating in the East Asia Energy Futures project. Country teams were asked by Nautilus to prepare brief descriptions of the process they used in compiling their LEAP data sets to date, of any difficulties they have had in developing their base year data and their BAU energy paths, their thoughts about the East Asia Energy Futures project as a whole, and any non-East Asia Energy Futures projects for which they planned to build on their experience in the East Asia Energy Futures project. The reports provided by each of the Working Groups (China, Japan, the Republic of Korea, and the Russian Far East) are presented below, with minimal editing and reformatting. The DPRK team did not submit a report, but the leader of the DPRK delegation to the 2001 Berkeley workshop expressed his gratitude at having been included in the project, and his team's appreciation for the training provided and for the opportunity to interact with colleagues from the region.

Report of the China East Asia Energy Futures Working Group

LEAP database of East Asia Energy Futures project China area is prepared by Prof. Yanjia Wang, Prof. Aling Zhang, and Baolei Guo, which lasts more than half a year. This database covers Resource, Demand and Transformation data of almost all the sectors and processes in energy system. To prepare this dataset, we have referred to many data sources including yearbooks of various years, reports and papers from other researchers. Specifically, they are:

1. **China Statistical Yearbook**, various years, SSB, which is an annual statistical publication, covering very comprehensive data series and selected data series in historically important years, reflecting various aspects of China's social and economic development.
2. **China Energy Statistical Yearbook** (1991-1996, 1997-1999), compiled by Department of Industry and Transport Statistics, National Bureau of Statistics, P.R.China, published by China Statistics Press, covering infrastructure capital investment of energy industry, energy production and energy consumption.
3. **China Electricity Statistical Yearbook**, various years, compiled by State Power Corporation, in cooperation with China Power Enterprises Association, and the Department of Power under the State Economic&Trade Commission.
4. **Almanac of China 's Water Power** (1995-1997).
5. **Yearbook of China Transportation&Commnication (prime Edition) 1986-2000,** an annual supervised by the State Development Planning Commission, sponsored by China Communication and Transportation Association and jointly prepared and published by the relevant departments of the Ministry of Railway, Ministry of Communications, Ministry of Information Industry, Civil Aviation Administration of China, China Petroleum and Gas Pipeline Bureau and Military Transport Sub Department of the General logistic Department of P.L.A.
6. **White Book of China New Energy and Renewable Energy 1999**, compiled by SDPC China, published by China Plan Press, 2000, Beijing.

7. **Climate Change: China Case Study**, a report from China researchers on climate changes in China, published by Tsinghua University in 2000.
8. **China Energy Data book**, from LBNL, David Fridely.
9. *The Role of Renewable Energy Options in China's Present and Future Energy System*, GU Shuhua (an authority in the field of new energy and renewable energy) and LIU Wenqiang.
10. China Steel Industry statistical yearbook
11. The Tenth five-year plan of China
12. The Development plan of China New Energy and Renewable Energy (officially published)
13. etc.

Besides, we have got an insight into the development through personal communication with experts. Some data are also from early LEAP datasets.

Our BAU pathway is defined as: In DEMAND, BAU scenario represents the change of activity level (for example, the urban and rural household), and, with little or no change in average energy intensity, while in TRANSFORM, most of the BAU are based on the plan of the state, though sometimes assumptions are also made. By inputting the useful data into LEAP, we get the BAU results. To 2030, the final energy demand will double its present value, if biomass energy is taken into account. The Transport sector energy demand in DEMADN is found to be increasing the fastest, which is more than three fold its 1999 value. A fast energy demand increase is also found in Commercial sector. Primary energy requirements, as the calculation result shows, will also double to the year 2030.

So far, we haven't yet created the TED of China. Maybe it has to be done in the time to come.

I [Mr. Guo] have written a proposal on East Asia Energy Futures-China Case Study as a degree thesis. LEAP is the tool I use for analysis. I find that LEAP is quite a powerful analysis tool and the workshop I took part in was also quite useful and motivating.

The East Asia Energy Futures project is significant for Northeast Asia as a whole since there exists large potential for cooperation. The report will be of great help to the decision makers of all the countries concerned and will promote the cooperation among countries, leading to the prosperity and sustainability of regional economy.

During the project, we have good work schedule and organization. Open and constructive discussions are carried out. Most importantly is that it provides an opportunity for researcher from different countries and regions to sit around the table and talk about the same thing beneficial to the whole region.

REPORT OF THE ROK EAST ASIA ENERGY FUTURES WORKING GROUP:

ROK'S BAU PATH: SUMMARY REPORT

1. SOURCES OF DATA USED

BOOKS & REPORTS

KEEI (2001), *Yearbook of Energy Statistics*, Korea Energy Economics Institute.

KEPCO (1997), *The Status of Generation Facilities 1997*, KEPCO.

KEPCO (2000), *Survey on Electricity Consumption Characteristics of Home Appliances*, KEPCO.

MOCIE (2000), *Energy Consumption Survey, Ministry of Commerce*, Industry and Energy.

MOCIE (2001), *Statistics on Electricity*, The Office of Energy Industry Supervisor, MOCIE.

MOCE & KEEI (2000), *Study on Strategies to Address the United Nations Framework Convention on Climate Change and the Kyoto Protocol*, MOCIE & KEEI.

OPM (2002), "The 2nd Synthetic Measures for UNFCCC," Executive summary, Office of Prime Minister.

WEBSITES

Industrial Information Network (http://www.iin.co.kr)

Korea District Heat Company (http://www.kdhc.co.kr)

Korea Gas Corporation (http://www.kogas.co.kr)

Korea Electric Power Corporation (http://www.kepco.co.kr)

Korea Energy Economics Institute (http://www.keei.re.kr)

Korea National Statistical Office (http://www.nso.go.kr)

Korea Petroleum Association (http://www.petroleum.co.kr)

Korea Transportation Database (http://www.kotb.or.kr)

Ministry of Commerce, Industry and Energy (http://www.mocie.go.kr)

Ministry of Construction & Transportation (http://www.moct.go.kr)

Office of Prime Minister (http://www.opm.go.kr)

Stat-Korea (http://www.stat.go.kr)

2. RESULTS OF ROK'S BAU PATH

ROK BAU PATH

A. The Basis

- MOCIE’s official documents which suggest ROK’s long-term policy strategies
- KEEI’s research reports supporting MOCIE’s decision making process
- KEPCO’s long-term electricity supply plan

B. Major considerations

- Expansion of town gas utilized by the residential sector
- Introduction and expansion of energy-saving fluorescent bulbs
- Wide application of minimum energy efficiency standards and manufacturers’ voluntary efficiency improving efforts
- Increase of market penetration of expensive electric appliances such as air conditioners, dish washers, and PC.
- Increase of passenger and freight travel demand
- Other autonomous energy efficiency improvements

<u>RESULTS OF BAU SCENARIO SIMULATION</u>

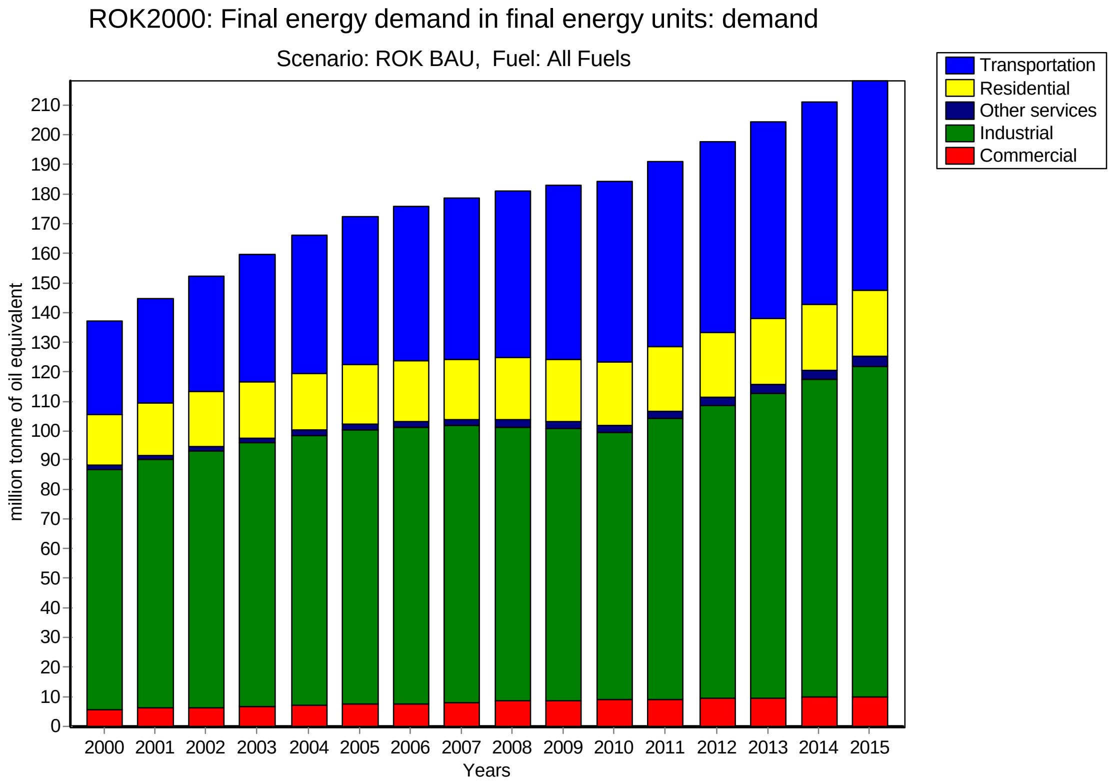
- The Industrial sector will remain as the largest energy-consuming sector: Oil products use of manufacture industry and its role in Korean economy is the central driver of final energy demand.
- Energy use of the transportation sector will continue to increase until 2010: The number of household vehicle will continue to increase, but the increasing rate will be decreasing.
- Town gas consumption of the residential sector will be increasing: The stable and sufficient supply of natural gas will be the central consideration in energy security.
- Carbon dioxide emission of transportation and industrial sector will take about 95% of total emission. (transportation 35%, industrial 60%)

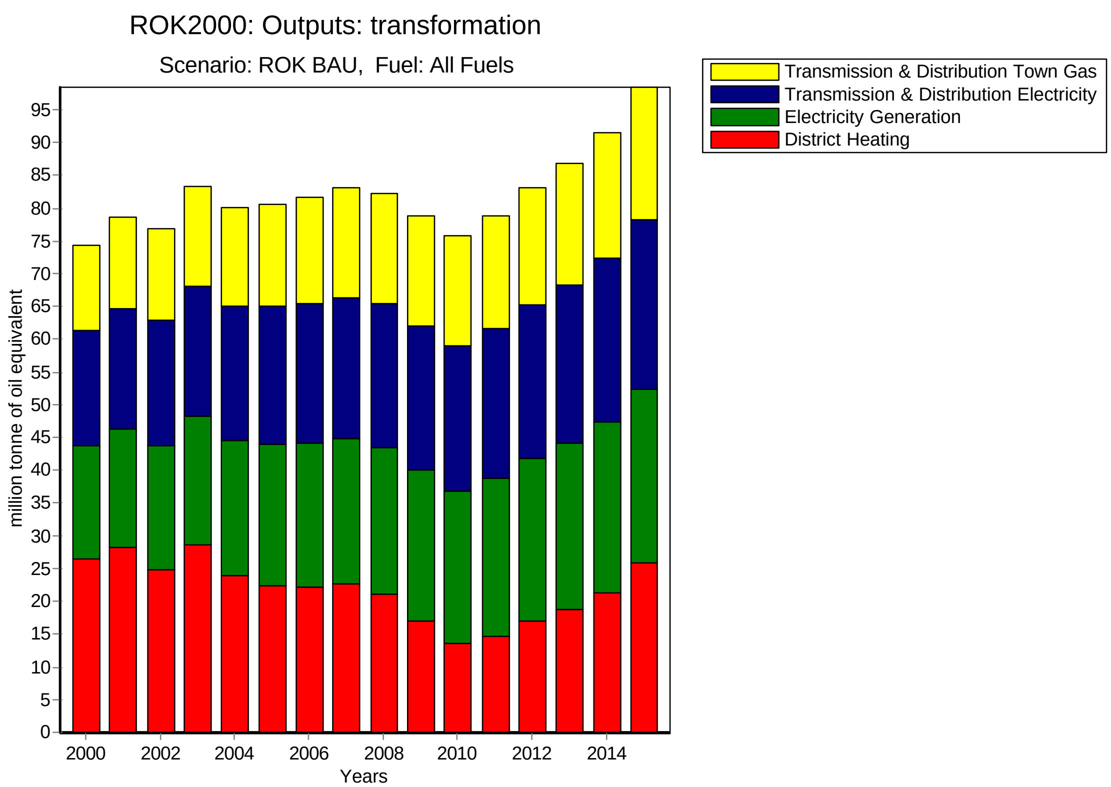
BAU PATH: MAJOR SOCIO-ECONOMIC INDICATORS

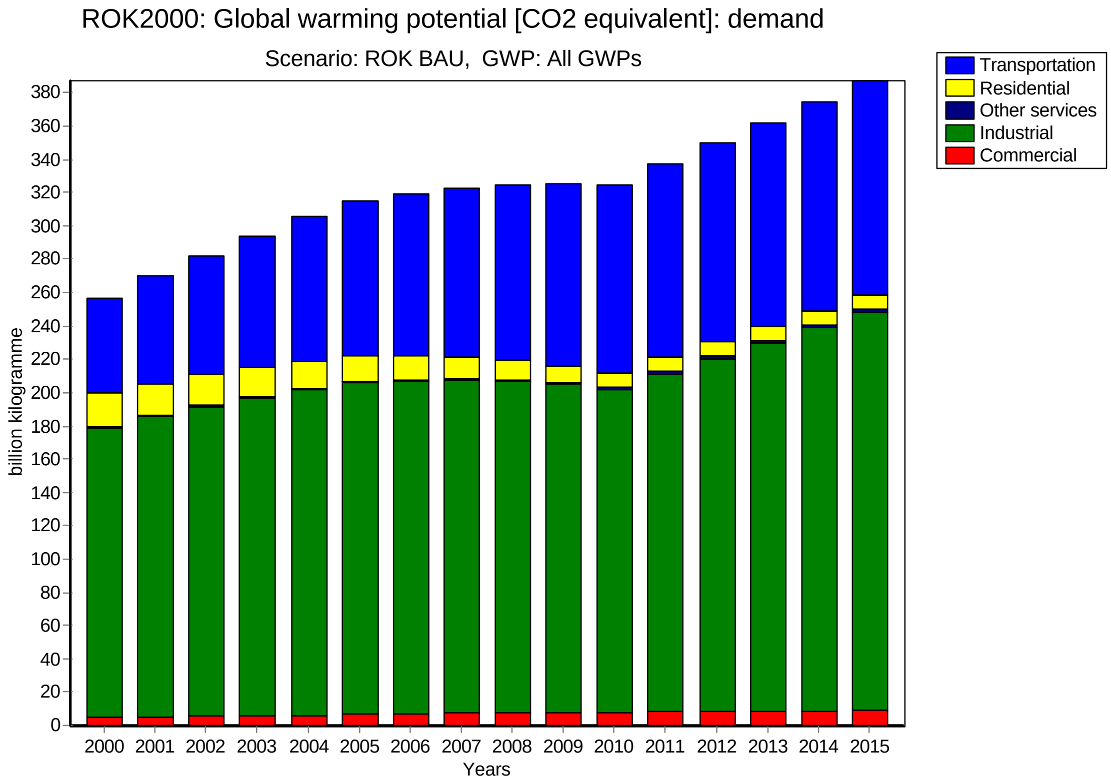
	UNIT	2000	2005	2010	Annual Avg. Grw Rate	
					2001-2005	2006-2010
GDP	1995 B Won	476269	622300	794200	5.5	5.0
Population	Million	47.3	49.1	50.6	0.8	0.7
Households	Million	14.3	16.2	17.4	2.0	1.4
TPE	M TOE	192.9	235.8	275.1	3.9	2.0
TPE/Pop.	TOE	3.87	4.80	5.44	3.1	1.6
TFE	**M TOE**	**150.1**	**182.8**	**209.1**	**3.5**	**1.8**
Industrial	M TOE	84.1	95.3	105.7	2.6	1.5
Transport	M TOE	30.9	41	47.8	4.8	2.2
Residential	M TOE	20.0	25.1	29.5	3.7	1.9
Commercial	M TOE	12.4	17.9	22.1	5.5	2.1
Public & etc	M TOE	2.6	3.4	4.0	3.9	1.5

RESULTS OF ROK BAU SENARIO

	UNIT	2000	2005	2010	Annual Avg. Grw Rate	
					2001-2005	2006-2010
TPE	M TOE	258.5	298.4	295.2		
TFE	**M TOE**	**136.8**	**172.1**	**184.3**		
Industrial	M TOE	81.2	92.8	90.3		
Transport	M TOE	31.3	50.0	60.9		
Residential	M TOE	17.2	19.9	21.5		
Commercial	M TOE	5.6	7.6	9.1		
Public & etc	M TOE	1.5	1.9	2.5		


ROK2000: Final energy demand in final energy units: demand
Scenario: ROK BAU, Fuel: All Fuels
Transportation
Residential
Other services
Industrial
Commercial
million tonne of oil equivalent
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
Years


ROK2000: Outputs: transformation
Scenario: ROK BAU, Fuel: All Fuels
Transmission & Distribution Town Gas
Transmission & Distribution Electricity
Electricity Generation
District Heating
million tonne of oil equivalent
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
2000
2002
2004
2006
2008
2010
2012
2014
Years



3. EXPERIENCES WITH LEAP MODELING

DATA GATHERING

- In Korean case there are fairly well sorted statistics which describe the behaviors and modes of energy-consuming activities in the residential sector.

- There were some inconsistency between transportation related indicators and statistics from different organizations. My dataset has based on National Statistical Office's report.

- The detail description of energy consumption activity in industrial and commercial sector is partially possible, but I think we'd better use 'aggregate energy intensity' branches rather than stick to incomparable and immoderately sorted statistics on the sectors. We can improve the function of 'aggregate energy intensity' branches in the sectors by expanding the industry division.

OTHER COMMENTS

- There are some mis-specified parts in transformation branch. I have not identified the problems, but my learning by doing process is keep going.

- In the new Korean electricity market environment the generation of each plants would be determined based on various cost variables such as capita, O+M, and fuel costs. Therefore to capture and describe the real electricity market performance, LEAP need to be modified to introduce equilibrium concept and method.

- We are going to assess the cost and environmental impacts of LFG-fired generation project that has been announced by MOCIE in 2001. For this we are gathering LFG related data on technical aspects of LFG-fired generation. This project will deliver the first assessment report by the end of May.

EAST ASIA ENERGY FUTURES GROUP REPORT: RUSSIAN FAR EAST

Our brief report on the Russian Far East LEAP model development contains information on the following basic positions:

- short description of the major types of data sources which we used in preparing the base year and BAU LEAP data sets for the Russian Far East;
- short description of the results of BAU simulation;
- thoughts on the experience of collecting and LEAP data processing;
- benefits of LEAP software and prepared data set for the Khabarovsk Economic Research Institute where we work.

Short description of the major types of data sources

The major types of data sources are conditioned by the East Asia Energy Futures project methodology, which determines total structure of data set:

- Energy Demand Data set
- Energy Supply Data Set
- Driving Variables Data set

We use the major sources of information as follows:

1. **Official materials**
    - 1985, 1990 Fuel and Energy Balance for the Far East. Moscow. 1987. 1992.
    - The Energy Strategy of Russia over the period up to 2020. Moscow. Ministry of Energy of the Russian Federation. 2001.
    - Forecasting of population of Russia up to 2016. Moscow. Russian State Committees of Statistic. 2001.
2. **Books and reports**

- Y. Sinyak. Energy Efficiency and Prospects for the USSR and Eastern Europe. CRIEPI Report. 1990.
- E. Medvedeva, V. Nikitin. Energy consumption and living standards. Novosibirsk, 1991.
- A. Bestchinsky, Y. Kohan. Economic problems of electrification. Moscow. 1983.
- Comprehensive Program of Energy Development of East Siberia and Far East up to 2020. Irkutsk. 2000.

3. **WWW resources**

- World Energy Council: www.worldenergy.org/wec-geis/
- World Bank Group: www.worldbank.org/data/coutrydata/
- U.S. Department of Energy: www.eia.doe.gov
- Lawrence Berkeley National Laboratory: www.lbnl.org

4. Useful energy data from Nautilus's disk (especially about Northern countries, such as Sweden, Norway, Canada etc.)

5. **Personal communications**

- Far Eastern Representation of JSC "Unified Power Grid of Russia" (Khabarovsk)
- Ministry of Energy of the Russian Federation (Moscow)
- Melentiev's Energy Systems Institute (Irkutsk)
- Forecasting Institute of Russian Academy of Sciences (Moscow)
- Energy Departments of territorial administrations of the Russian Far East
- Economic Research Institute (Khabarovsk)

A summary description of the results of BAU path developed

So far the attempts to obtain a set of essential quantitative results for BAU path using the LEAP model have failed. The main problem is due to difficulties in obtaining and specifying data to be included in the LEAP model. The main result as yet consists in defining framework for

BAU and Alternative paths of energy development for the RFE, which involves determining key parameters of energy development:

- assumptions on economic growth and population growth in the region;
- main essential attributes of energy security in the RFE;
- key variables that are meaningful for energy policy in the region (environmental objectives, energy efficiency policy, development of renewables, access to advanced technologies, international energy cooperation in NEA);
- specification of key parameters of the RFE energy development for the two paths– BAU and Alternative.

Yet another important result obtained – is preparation of provisional BAU LEAP data set though additional efforts are still required. The most important result for us is specification of 2000 current accounts, particularly for the DEMAND sector in terms of final energy consumption subsectors.

Thoughts about experience of collecting data and LEAP simulation

In our view, operating with a LEAP model has a strong side – an ability to self-educate the experts involved in the analysis. Although the LEAP model is relatively simple and flexible, it strictly structures the analyzed energy system, calls for a clear specification of the research problem and for clear understanding for the experts of the approaches for dealing with it.

The structural property of the LEAP model, indicated above, requires a well-developed database on energy balance, for both present and future time periods.

At the current stage, the most complex for us is collecting data on the Demand sector and, in some extent, on Centralized Heat subsector. The problem in Russia and the Russian Far East is that statistical registration of the final energy consumption by sectors has stopped by 1990. Possibility of using statistical recent trends has been lost. The great changes in Russia and the Russian Far East have occurred in the volume and structure of consumption during 10 years, because of profound economic recession and changes in the structure of economy and energy consumption.

To implement a reliable specification of the Demand sector dataset, the following additional help can be obtained from:

- conducting surveys on energy use in individual subsectors of the Russian Far East;
- international energy assessments and surveys which could be used as comparative analogues and, possibly, as future energy consumption models in the Russian Far East.

Another problem that is essential for our team is costs data for each module of LEAP and, in particular, for demand sector.

Benefits of LEAP software

Having LEAP software, compiling a comprehensive database for BAU and Alternative energy paths of the RFE, the results of the analysis based on the LEAP model appear to be valuable and helpful for the Khabarovsk Economic Research Institute FEB RAS. Here the following benefits for the ERI FEB RAS can be named:

- as far as we know so far nobody has used LEAP models and LEAP methodology in the RFE and in Russia. That means that using the LEAP model is a unique phenomenon for the region;
- we are sure that the results obtained based on the LEAP model will be called for by policy-makers;
- using the LEAP model and working under the international East Asia Energy Futures project gives access to advanced international experience of energy research, effective mutual information exchange.

Except the East Asia Energy Futures project managed by the Nautilus, we are planning to use LEAP software and prepared dataset in implementation of the project "Energy Development of the Khabarovsk Territory".

EAST ASIA ENERGY FUTURES GROUP REPORT: JAPAN

1. Data sources and references

Japan's energy economics data probably are more reliable and better organized than energy data of other countries in Asia. There are not large discrepancies in data among data sources, so that the choice of the data source doesn't significantly affect reliability of data or LEAP research results. However, energy statistics in Japan use different methodologies or premise to calculate the data from methods that IEA uses[5]. I [Mr. Oda] kept this difference in mind and used the following data sources. A&B are past statistics and C&D are for future projections.

A. Economic Data and Modeling Center (EDMC), **EDMC 2001 Handbook of Energy and Economic Statistics in Japan**. Edited by EDMC and the Institute of Energy Economics, Japan (IEEJ), and published by the Energy Conservation Center, Tokyo, Japan, 2001. This data book covers and sorts well various categories of energy economics data. I used this data source most frequently.

B. **Japan Energy Statistics**, 2000, Agency of Natural Resources and Energy, Economic Data and Modeling Center, IEEJ, published May 2001. I created an Excel data sheet using the data of the years 1990, 1993, 1995, and 1999 from this book, and analyzed the 10-year energy trends.

C. **Energy Outlook**, Ministry of Economy, Trade and Industry (METI), Advisory committee for energy and resources, July 2001.

   METI reviews Japan's energy policy every several years. The 2001 version of the **Energy Outlook** is the latest edition of this review. In this outlook, although economic growth is projected to continue at a growth rate of 2.0% annually until the year 2020, growth in energy consumption and CO_2 emissions are at very low levels. In the outlook, METI made some unrealistic assumptions: 1) Energy conservation will be implemented drastically (which is contrary to the current trend). 2) There will be no siting difficulties for nuclear power plant construction. 3) Energy prices will be stable at very high levels. 4) Agriculture and the construction materials industry will grow steadily. Although these assumptions are not consistent with the current trends, I used them as reference figures.

D. **Economics and Energy projections to the year 2025**. Tsuneaki Hattori, CRIEPI (Report # Y99018) May, 2000

   Since the base year is 1997 for this report, the analysis in it was done based on older data. However, the author conducted very detailed socioeconomic analysis and made energy projection for the relatively longer term (through 2025), so I used this as one reference.

[5] For instance, IEA statistics data use net heating value (or low heat value), on the other hand, Japanese statistics uses high heat value. Generation efficiencies of the primary electricity generation are different. In 1999, fuel consumption in all geothermal, hydro and nuclear power generation was counted at the efficiency of oil-fired electricity generation (38.1%), so that the heating value was 2,250 kcal/kWh.

2. Assumptions for BAU scenario

I used METI's data [document C] for the base year and projections data for Japan's BAU scenario that I presented at the third EAEF meeting this February. For this report, I developed a different BAU scenario using different base data. GDP growth rate is 0.5% annually until the year 2005, 1.5%/yr from 2006 to 2020, and 1%/yr from 2021 to 2025. These rates are lower than the rates projected in [C] and [D], but still higher than the current trend (~0% at best). However, I chose these rates because current depression is not likely to last over the next decade and I would like to avoid underestimation of future energy consumption, too.

Energy conservation will continue as the same rate as 1990s. Refrigerators and televisions tend to be bigger and the number of them per household will increase (ownership ratio), but at the same time the per unit electricity consumption of these home appliances will decrease because they will become more energy efficient through technological innovation. Therefore, the energy consumption for these appliances per household will decrease. Conversely, the number of air conditioners, electronic high-tech toilets, dishwashers/dryers, dryers (clothes), and personal computers will increase much faster than the speed of efficiency improvement, so that total energy consumption per household will increase. In the transportation sector, the fuel economy of family cars is improving. However, since other factors[6] that increase the fuel consumption will become dominant, fuel consumption per household will increase very substantially. In the LEAP data set, I assumed that number of hybrid cars, which have twice the fuel efficiency of normal cars, will increase, but that total energy consumption for the cars will be increasing continuously.

For energy end-uses, consumption of low H/C [Hydrogen to Carbon] fuels such as coal, heavy oil and cokes will be decreasing. In their place, the use of high H/C fuels such as natural gas will increase. In non-transportation sectors, clean electricity use at the end-use level will be increasing.

For the generation sector, electricity generation in the year of 1999 was 943 TWh. This value will be 1197 TWh in 2020, with an average growth rate is 1.1 % per year. Primary energy consumption in the electricity sector was 5265 TWh (18954 PJ) in 1999, and will be 6251 TWh (22503 PJ) in 2020.

3. Data collection

I used time series of data from 1970 to 1999; in particular, I sorted and analyzed data for the years between 1990 and 1999 very carefully. Even though energy efficient technology has been improved, overall energy consumption tends to continuously increase, because of higher activity levels, the increase of the ownership rate, increases of appliances' size, the

[6] Some of those factors to increase the fuel consumption are an increase of activity (# of people x km), increase in vehicle weight and size, decrease in # of passenger per vehicle, increase of driving speed, increase of traffic jam.

use of high-speed appliances, the increase of the average time that an appliance is used annually, etc, This trend is clear especially in the residential sector. This trend has been continuing since 1986, when energy prices declined. In the industrial sector, energy consumption per unit of activity had been decreasing dramatically until 1986 because energy efficient technology was improved. However, energy consumption has been slightly increasing since 1986 and there has not been significant energy efficiency improvement since then. In the transportation sector, energy consumption was stable until 1986, but it has been increasing since then.

The increase of energy prices, which could be done by taxation, is not helpful. High energy prices decrease consumers' real income. Japan's industry wouldn't be competitive internationally if the energy tax isn't used efficiently. In addition, if the energy tax is used unfairly for some special usage, it could just produce other vested interest groups.

4. Japan's scenario analysis by LEAP

When people discuss how the Japan's BAU path should be or would be, the results strongly depend on what energy source people like. This tendency becomes very strong especially when we discuss alternative energy sources. Those who advocate nuclear energy argue that nuclear energy is economically reliable and has little environmental impacts, that radioactive waste is just a social problem, and that nuclear energy could contribute to improve national energy security, so as a consequence we must keep a significant share of nuclear energy source.

On the other hand, those who do not agree with the nuclear development argue that nuclear development is currently economical only because the government bears a large potion of the financial burden and protects the nuclear industry. They argued that if there's no governmental protection, it's not clear whether nuclear energy is an economical energy source. In addition, they also argued that it's not yet clear how much the financial burden would be to manage and dispose of the radioactive waste. Since vested interests are strongly involved in nuclear power development, nuclear energy cannot be discussed fairly.

Those who advocate renewable energy technologies argue that if Japan has a well-designed energy policy and a system to implement the renewable energy technologies, then the policy could lead to the mass consumption and mass production of the currently expensive renewable energy technologies, and once a mass market of the system is achieved, the system cost will go down.

Those who don't believe feasibility of large deployment of renewable energy sources argue that even we increase the renewable energy production, other generation technologies such as combined cycle gas turbine could be improved significantly, so that renewable energy sources won't be a competitive technology in the future. They also argue that Japan is a small island and that potential for renewable energy sources are in any case very limited.

5. Effectiveness of LEAP method for the Northeast Asia energy scenario analysis

It is very interesting if LEAP can be used to quantitatively analyze and compare two cases: each country in Northeast Asia optimizes the national energy security individually, or all countries collaboratively try to optimize the energy security regionally. I'd like to suggest that the following four issues be considered carefully.

A. Gas pipeline and electric power grid development

In the NE Asian region, there are two large natural gas reserves (resources), in Far East Russia (FER) and in the west part of China. If natural gas could be transported from these areas to the East coast of China, Korea and Japan using gas pipelines or long distance power grid connections, regional energy systems would be largely different.

B. Nuclear power development

Nuclear development has been considered an important option for contributing to the improvement of energy security, but it might worsen the energy security situation. If each country individually tries to develop its nuclear technological capability, especially sensitive technologies such as reprocessing and plutonium fuel cycle, and conducts less collaboration among regional countries regarding regional energy security, the situation might deteriorate the mutual trust among countries and then worsen regional energy security.

C. Economic growth

Household income is affected by the level of economic growth, which would therefore have a large impact on energy consumption.

D. Energy price

The level of energy prices would largely affect the level of energy conservation. If energy prices are kept high, whether prices are stable or not, it could be an incentive for natural gas development in FER and Western China.

6. Overall thoughts about the EAEF project

In the Northeast Asian region, it is very difficult to analyze or compare energy systems quantitatively because each country has different politics, economics, social systems and culture. This is why an intense one-week discussion on energy security and other EAEF activity would be really precious. The following issues are my thoughts about the project.

A. Regarding energy data collection, Republic of Korea might have the best-organized energy data, followed by Japan. China doesn't have a complete set of energy data and also the data quality wasn't really good. It seems very difficult for Russia to collect data because Russian colleagues said that all things are not totally open in Russia.

B. Significant differences exist between Japan and other countries as to the kinds of energy problems encountered. Neither the Republic of Korea nor China groups really have a doubt about their governments' energy policies. The only crucial energy problem that China faces is "drastic increase of energy consumption." On the other hand, many questions are raised against Japanese government energy policy. In particular, its decision making process and increasing lack of trust in government is evident.

Although there are still strong political tensions in some parts of the Northeast Asian Region, there is large potential for the region to sustain its relatively high economic growth. Therefore, we should expect a large increase in energy imports from outside the region. This means that the NE Asian region will have significant impacts on the world energy situation and on world energy markets. The EAEF project provides a rare opportunity for researchers from different countries in this (problematic) region to collaboratively discuss and analyze the energy and environmental aspects of energy demand and supply in the region. I hope the project will be continued and further developed.