Possible Energy, Economic, and Other Engagement/Assistance Activities to Combine with Yongbyon Decommissioning/Conversion

David von Hippel
The Nautilus Institute
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Introduction

Discussions are underway regarding the possible conversion of the nuclear facilities at the Yongbyon site in the DPRK to peaceful purposes. One key concept under discussion is the conversion of the IRT-2000 8 MWt research reactor at Yongbyon into a facility for production of medical isotopes. Below are some thoughts about energy- and economic-development-related activities that might be undertaken to complement conversion of the IRT, and, more generally, to equip the Yongbyon site to serve as a center for much-needed scientific and technical activities that could be disseminated nationwide. As such, these ideas propose ways of using the Yongbyon site, and its scientific/technical staff, as a locus and springboard for capacity building in a number of fields that the DPRK urgently needs in order to be able to develop a sustainable and peaceful economy. A selection of satellite photos of the complex are provided at the end of this memo for reference and to give a sense of the facilities involved.

The ideas below are divided into two categories. The first group are thoughts about how the energy and related infrastructure at the Yongbyon site, and its environs, would need to be rehabilitated/upgraded to provide the physical setting necessary to host centers of scientific and technical expertise in a number of areas, and , thereby, to retain and attract DPRK scientists and technicians (and those that would teach them) to Yongbyon. The second group of ideas describe development of potential centers of expertise in a number of fields with specific application to problems and opportunities at Yongbyon, but also with potential to address needs throughout the DPRK (and in some cases, beyond). Note that there is substantial linkage between the two groups, as some of the needed infrastructural improvements at Yongbyon also serve as pilot applications/models/demonstration facilities for measures that are the subject of training and dissemination activities by centers of expertise, and examples for the DPRK economy more broadly.

Infrastructure and Related Improvements to Enable Conversion of Yongbyon Site

- **Energy demand/supply assessment**. Researching and compiling (with local authorities and scientists/technicians) a thorough quantitative assessment of the energy demands at the Yongbyon site, and possibly in the broader region around Yongbyon as well, together with an assessment of the existing energy supply resources (coal, hydro, wind) and infrastructure (power supplies, fuel storage, mines, electricity T&D….). Note that this activity will need to be performed at some level in order to be able to plan and implement most of the suggested options below in a reasonably informed manner. The assessment itself should, by involving a team of DPRK scientists, engineers, and technicians to help to complete the necessary surveys and measurements, provide a "teachable moment" to start to build the capability to carry out such assessments wherever they are needed in the DPRK (which is essentially everywhere). As such, it will offer a first step in what will need to be a similar process

nationwide, as the DPRK figures out (with whatever outside assistance can be practically provided) how to modernize its energy system to support a sustainable economy.

- **District heating system rehabilitation**: Our understanding is that the 5 MW electric (equivalent) gas-cooled reactor at Yongbyon was also used to provide heat to buildings in the Yongbyon area, likely in the "Research and Housing" area adjacent to the reactor site. There is effectively an entire "village" of residential buildings associated with the Yongbyon site, and many (or all) of these may at least nominally have been supplied with heat from the reactor. With the 5 MWe reactor now partially decommissioned, it is likely that there is a heat deficit in the buildings formerly served with heat from the reactor. Though some of the buildings served with heat may have been related to plutonium separation or other nuclear activities that will theoretically be shut down, other heat users on the system will likely be administration buildings and residential buildings. Providing a replacement source of heat for these buildings will have humanitarian benefits, in terms of increasing the comfort of those who live and work in the buildings served by the system, and may also help in keeping nuclear technicians on-site by making it more attractive for them to stay. If and as the centers of expertise described below are built at Yongbyon, they will likewise need to be supplied with thermal energy, so the system should be designed so as to be expandable/scalable. Different possible sources of heat are possible, depending on the status of the existing heating system, what resources are realistically available locally, and fuel transport considerations. Options here include:
  - Providing one or a few diesel-engine generators that can both provide heat (by cycling radiator water through a heat exchanger to provide hot water for buildings) and power
  - Providing a boiler or generator (such as an engine-generator or microturbine) fueled with liquefied petroleum gas (LPG). An LPG tank for the complex could also supply gas to a small distribution network that could provide cooking fuel for residences, cafeterias, and clinics at the Yongbyon site.
  - Providing a coal-fired boiler, fueled with anthracite from a local mine. Yongbyon appears to be less than 40 km (as the crow flies) from the important Anju mining area; whether there are smaller coal mines nearby, we don't know, but the region as a whole has a number of major mines.

  Regardless of the heat source chosen, a number of rehabilitation/remediation steps will likely be required. Many of these can employ technicians from the Yongbyon plant, and some of them require nuclear-related expertise. These steps include:
  - Assessing the existing head supply and demand system in terms of layout, number of end users, capacity, and estimated requirements (to the extent not carried out as a part of the broader energy sector assessment suggested above).
  - Disconnecting heat supply lines from the 5 MWe reactor, and re-routing supply lines to wherever the new heat source is located.
  - Constructing a new building to house the new heat source, or adapting and refurbishing an existing building to serve as such.

- Assessing the existing heat supply lines, possibly all the way to the heat registers, for contamination with radiation, and replacing and safely disposing of lines found to be radioactive.
- Assessing the existing heat supply system for integrity and energy efficiency.
- Patching, sealing, re-insulating, updating, and replacing (if needed) elements of the existing heat supply network, including heating mains, feeder lines, radiators/registers, and valves and other controls.

The heating system rehabilitation activities described above, along with the green building, application of weatherization/energy efficiency measures, and local power development/T&D improvement activities described below, would also be first steps in a "training of trainers" initiative as a part of the Center for Energy Studies and Training concept described below. Scientists and technicians from the Yongbyon site and elsewhere in the DPRK would be involved in the heating rehabilitation system assessment, design, and replacement activities, and would also be responsible for monitoring and assessing the performance of the updated system, which would serve as a model and test bed for heating system upgrades that could be applied nationwide.

- **Development of new "green buildings" for use as clinics, schools, or for other purposes**: An activity that could involve and help to retrain technicians at the site might be to work closely with USDOE and possibly Chinese engineers and architects to design and build one or several highly energy-efficient "green building" incorporating, for example, solar passive or active heating, along with many energy efficiency measures. The idea is that the building would be a laboratory and showcase for building energy efficiency measures for the DPRK, and available for monitoring and study as a part of the Center for Energy Studies and Training. Functionally, it could also be integrated with the IRT's revised mission by, for example, serving as a clinic where those being treated with medical isotopes could come to stay and receive treatment, and/or to serve as a modern clinic for the researchers and other local residents at Yongbyon. Handling of the medical isotopes could involve technicians currently working in the nuclear weapons program.

- **Weatherization and energy efficiency in residential and administration buildings**: More generally, existing residential buildings on the Yongbyon site and in the adjoining village, as well as administration, laboratory, and other support buildings (child care centers, schools, and cafeterias, and similar facilities) should be "weatherized" with modern insulation, weatherstripping, and windows, plus fitted with energy-efficient lighting systems and with building control and monitoring systems (heat, electricity, and temperature sensors, meters, and recorders) to allow the buildings to also be energy efficiency "laboratories" to help to advance energy efficiency practices in the country as a whole. The buildings might well (almost certainly will) need to be largely rewired to take advantage of electrical system efficiency upgrades, which would provide an opportunity to wire the Yongbyon campus for telecommunications (especially computer networks) as well. The weatherization process would be preceded by assessments of energy-efficiency needs for the targeted buildings, which would again provide an opportunity for initial training of DPRK expert trainers-to-be who might help to staff a Center of Energy Studies.

- **Development of local power options and T&D system**: This option would begin with an assessment of the local electricity grid and power supply system, and, depending on the findings of the assessment, could include partial or wholesale rebuilding of the electricity distribution grid in the local area, replacement of existing substations or transformers, and possibly the addition of new power generation, either in the form of combined heat and power systems (as above) and/or with independent power systems, probably, judging from the terrain and the presence of a river nearby, a mini- or micro-hydro system, but possibly integrated with a small ridge-mounted wind-power system (and/or pumped-storage hydro system) as well (in part for demonstration/training purposes). Once again, energy supply assessment process, and the development of local power systems and T&D networks, can be expected to contribute to local and national expertise in these areas, and the new energy infrastructure set up as a result of this effort could/should be configured with sensors and other attributes so as to be used as pilot and demonstration systems for further training and study for researchers and technicians from throughout the DPRK.

- **Providing agricultural assistance for the local area**: The Yongbyon area would appear to have a number of agricultural fields nearby. Providing a combination of technical assistance, and improved implements (tractors and fuel, crop processing equipment, irrigation equipment) could help to boost local food production, which (depending on distribution) might help the complex to retain workers. Monitoring of agricultural soils and products for radiation, and remediation as needed, could also be a part of this type of assistance. Making sure that those based in Yongbyon have as much control as possible over their food security—by providing them with the wherewithal to produce their own food to the extent possible, would also be a goal (perhaps unstated) of this option.

- **Reforestation**: Reforestation efforts in the Yongbyon area to improve the local environment, help to reduce erosion (including, for example, protecting watersheds used for hydroelectric generation, or preventing flood damage to buildings and agricultural resources in the area), and, eventually, provide a sustainable source of fuelwood for local residents. Reforestation efforts could involve Yongbyon technicians and researchers both as laborers and for the long-term care and monitoring of reforestation efforts, including monitoring of soils and plants for radiation, and as such could lay the groundwork for the Center for Reforestation Studies concept described below.

Options for Conversion of Yongbyon Site as a Locus for National Centers of Expertise and for Incubating Economic Enterprises

The Yongbyon site has historically, for better or worse, been a center of expertise for nuclear weapons and nuclear power technologies in the DPRK. As such, the idea of continuing the tradition of the site as a center of expertise, but converting it to uses both peaceful and broadly practical for the rebuilding of the DPRK economy, has great appeal. A means to do so is to establish Centers of Expertise that use, to the extent possible, the skills of the people already at the Yongbyon site, and build upon both their expertise and measures that meet the day-to-day needs of the site itself (see above) to, ultimately, create institutions that can be used as an entry point for disseminating scientific and technical knowledge from outside the DPRK throughout the country, and can be a focus for original research for academic purposes and to develop ideas

with economic applications. Some of the types of Centers of Expertise that might be envisioned for the Yongbyon area are described below.

- **Center for Energy Studies and Training**: Nautilus Institute has been discussing a variant of this concept (a center focused on renewable energy and energy efficiency, to be located in Pyongyang) with DPRK colleagues for many years, and our colleagues have consistently shown a keen interest in the idea. This Center could be organized to serve as first, a place where scientists and technicians from Yongbyon and elsewhere in the DPRK would come to be trained in topics such as carrying out energy surveys and needs assessments, national energy supply-demand modeling, energy efficiency analysis methods and practices (including green buildings), renewable energy systems, modern transmission and distribution systems (including "smart grids"), and other topic relevant to a modern and forward-looking energy system. With initial training provided by experts from outside the DPRK (from China, the EU, Australia, and the US national labs and DOE, for example), the Center staff would then go on to train others in the DPRK and disseminate what they have learned, using the Yongbyon facilities upgraded as above as demonstration facilities, and to hone skills in monitoring and data analysis. A key goal of the Center would be to provide workers at the complex and others with alternative, sustainable employment possibilities by configuring the Center such that it could provide energy analysis and other services throughout the DPRK and beyond, perhaps first to assistance agencies (for example, an NGO wishing to rebuild a clinic), later directly to other organizations in the DPRK, and ultimately, possibly to export services to other countries. Another possibility is that one function of the Center could be as an R&D institute to develop or adapt designs for key energy efficiency and renewable energy devices to be manufactured in the DPRK, with a goal of establishing businesses in the DPRK to make such devices. This type of Center could eventually become the equivalent of a national laboratory, in the mold of the U.S. LBNL, PNL, or NREL, under and working with an appropriate DPRK Ministry. Models for this sort of Center exist in China and Eastern Europe, where U.S. organizations (including National Labs) worked with locals to establish them.

- **National Environmental Monitoring Center**: This Center could be a home to monitoring stations that are parts of international environmental monitoring networks, as well as to environmental monitoring of national concern. Examples of the former include monitoring of seismic activity (including, possibly, monitoring of seismic data to detect nuclear tests), monitoring of acid precipitation and other transboundary air pollutants, monitoring of atmospheric greenhouse gases and ozone, surveys of the number and health of migratory species of birds and other animals, and surveys/monitoring of the health of wetlands areas that extend across borders, such as the Tumen wetlands (probably in coordination with a branch Center in the Tumen area. Avian Flu could be a focus of research for the international programs of such as Center, and this and other issues could be expected to be excellent candidates for collaboration from international agencies (such as the UN Food and Agriculture Organization, the UN Environment Programme, the World Health Organization, and others) and national/regional agencies. On the national level, monitoring of surface and groundwater for chemical and biological pollutants, monitoring of urban and rural areas for air pollutants, and, for example, testing of devices (autos, stoves) for emissions characteristics could be a part of this Center's activities. The Center could also be the institution responsible for maintaining, for example, national pollutant and/or greenhouse gas

inventories. An Environmental Monitoring Center, focusing largely on monitoring and on international issues, could be either separate from, or a branch of, the Center for Environmental Management envisioned below.

- **Center for Environmental Management**: As one possible example, the Yongbyon site will need substantial environmental monitoring to determine where there are radiological and/or chemical hazards. In the (likely) event that hazards are found affected areas will require environmental remediation. The process of detecting radiological and toxic "hot spots", developing remediation plans, and cleaning up the affected areas, may be a set of services that Yongbyon scientific and technical staff can be trained to perform. If so, they could be set up with laboratory and other equipment such that they could, ultimately, develop the expertise to provide (eventually, for hire) toxics detection and remediation services in other areas of the DPRK (for example, at sites where military or non-military chemical manufacturing and storage has taken place, at decommissioned mines, or other areas. Given sufficient time and training, these detection and remediation services might earn export income, for example, by providing services to developing or reindustrializing countries.

- **Center for Reforestation Studies**: A Center focusing on reforestation and related geological and biological sciences could, in addition to monitoring reforestation and soil conservation efforts around Yongbyon (and thereby teaching relevant skills for reforestation efforts and analysis to local staff), serve in the following ways:
  - As a clearinghouse for monitoring data and analysis on reforestation efforts in the DPRK as a whole, including, for example, mapping of soil types.
  - As a center of expertise on the design and ongoing maintenance of reforestation efforts, perhaps in conjunction with forestry schools in the DPRK (and with the support of schools of Forestry in the United States, and elsewhere, for example).
  - As a facility for research on, and breeding and propagating of, trees and other plants most suitable for reforestation in the DPRK, including as a teaching center for both traditional plant care and breeding and modern plant biotechnology. Research in the Center might include, for example, research on the use of trees to remediate soils polluted with toxic materials and otherwise compromised land areas (in coordination with the Center for Environmental Management, for example).
  - As a nursery and seed bank for reforestation efforts, and perhaps (to help support the Center) commercial sales of trees for agriculture/forestry and for landscaping.
  - As a source of experts who could consult on reforestation efforts elsewhere in the DPRK.
  - As a Center of expertise on the global climate and regional acid rain dimensions of reforestation (again, in coordination with the Center for Environmental Management).
  - As a venue where DPRK staff could learn to interpret remote sensing data to evaluate trends in forest health (though this would need to be designed carefully to avoid concerns about military use).

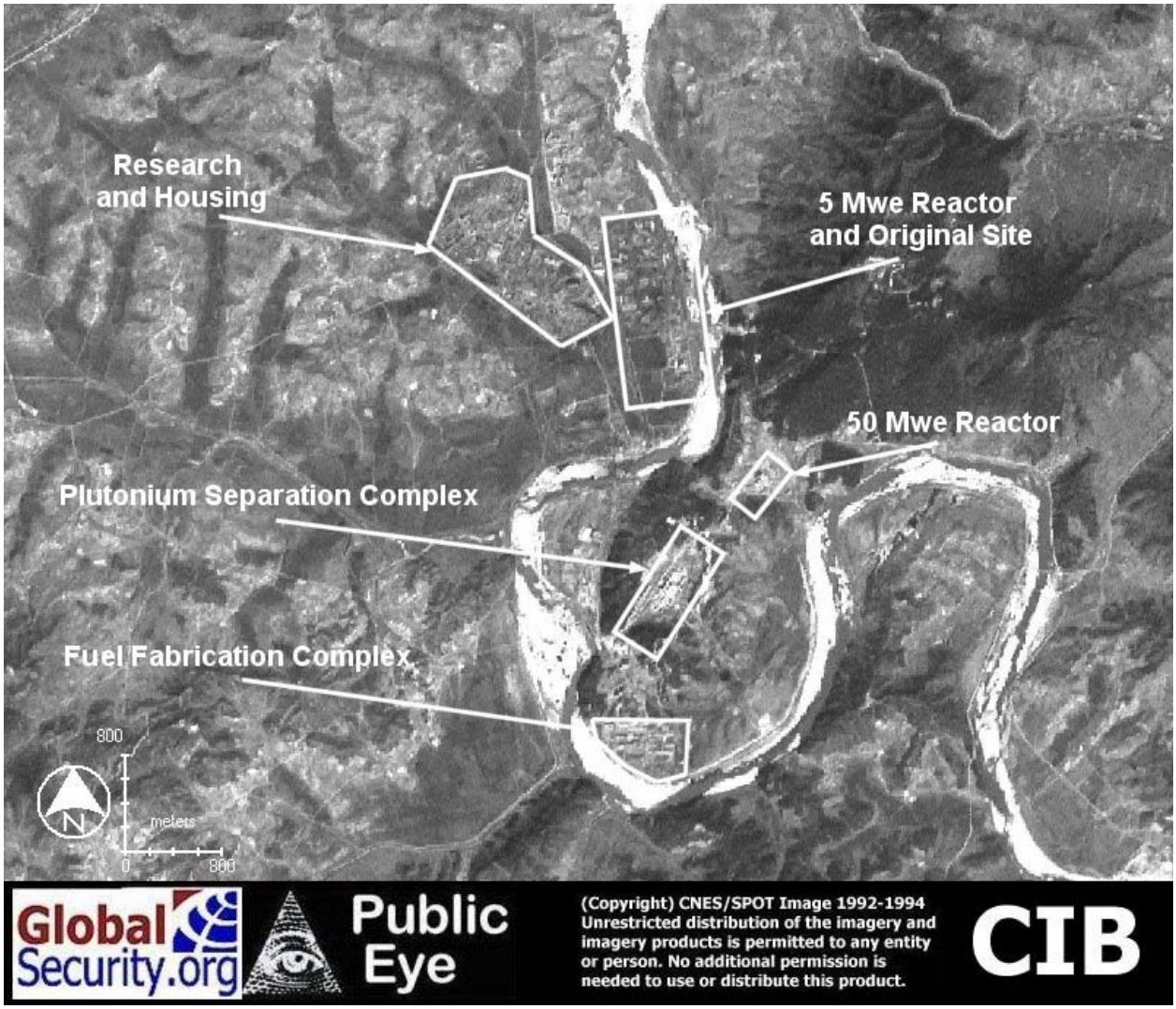
- **Center for Korean Anthropology**: There are important anthropological resources, including Neolithic cliff paintings, in the area near Yongbyon. It is possible that these and other sites, together with the expertise at Yongbyon in evaluation of isotopic composition (used for dating of anthropological artifacts) could serve as a rationale to assemble a Center for Korean

Anthropology that could collaborate with institutions in the ROK and internationally to forward the study of ancient Korea.

- **Incubators for Economic Development**: Each of the Centers above could serve to build on the skills that Yongbyon scientists and technicians already have to provide them (and others) with employment not just in research and development, but in providing scientific and technical services for hire in the DPRK and beyond, and, perhaps, doing light manufacturing to supply national and international markets. Such businesses could be "incubated" first within the Centers, then, if promising, "spun off" into independent for-profit or quasi-state businesses (on the China model that combines state and non-state investment in enterprises).

  As an example in addition to those discussed in connection with the conceptual "Centers" above, one could also see Yongbyon scientific and technical staff, given the proper training and provided with sufficient analytical equipment, servicing other industries inside the DPRK with, for example, chemical analysis for the mining and metallurgical industries, production of fine chemicals, biomedical analysis, or other services. There may be examples of such retraining of technical talent for other types of activities in Russia or East Germany, but we have not yet searched for such analogs to the Yongbyon situation.

  Another category of potential moneymaking endeavors that could be staffed by scientists and others now working at Yongbyon are in the area of information technology (IT), including computer programming and data management. There seems to be no particular reason why Yongbyon would have any particular advantage over other parts of the DPRK as a hub of information technology development (with the possible exception that it might be a place where high-speed internet access could be made available locally, without doing so nationally), but a significant amount of IT skill will be needed to support the Centers above, and demand from those Centers could be sufficient to catalyze the training of a critical mass (so to speak) of IT experts who could go on to sell their services to domestic and foreign organizations operating within and outside of the DPRK.



Satellite photo overview of Yongbyon area. Photos above and below from Global Security.org: http://www.globalsecurity.org/wmd/world/dprk/yongbyon-imagery.htm.

Satellite photo focusing on Research and Housing area

Satellite photo focusing on "**5MW Reactor Support Area", including the IRT-2000 building (in red oval, in upper left quadrant of this photo)**

Close-up of “Support Facilities” area

Close-up of IRT reactor area