The Overview of an Adaptive Cooperative Threat Reduction Proposal for the Denuclearization of the DPRK: Non-Governmental Perspectives

Yong Soo Hwang

Department of Nuclear Fuel Cycle Policy Development, Korea Atomic Energy Research Institute (KAERI), Daejeon, South Korea

ABSTRACT
The DPRK is unique in that it has voluntarily suggested to work on the denuclearization even though still disputing the exact meaning of denuclearization. Since the political regime of the DPRK will remain stable, the entire denuclearization processes are different from those after the collapse of the Soviet Union. Even though the denuclearization of the DPRK is a difficult issue, it is the task that the global society as should tackle together with North-East Asian countries. There are many political, financial, and technical issues at this moment. In this paper, these issues are summarized and certain practical measures such as energy solutions, facility management, and related upgrading of infrastructure are proposed.

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Introduction

One of the most challenging issues in the denuclearization of the DPRK is about how to take care of staff members who are currently involved in the critical WMD mission (CWMDM) such as the development of weapons-grade fissile materials, nuclear weapons, missiles, submarines, and chemical and biological weapons. It is essential to propose a comprehensive package to give the staff members stable and decent job opportunities to prevent the proliferation of WMDs around the world. Also, since these staff members are core components of the DPRK society, taking care of them is a key to stabilize the DPRK society in the course of the denuclearization processes. In addition, these staff members are highly educated and well-trained human resources to serve as a basis for future economic prosperity of the DPRK.

Therefore, it is urgent to develop a new, comprehensive and tailor-made cooperative threat reduction (CTR) program that aims to target human resource management in the DPRK while significantly assisting the future economic development of the country. Since the situation in the DPRK is quite unique, a CTR for the DPRK needs a special name, that is, an Adaptive Cooperative Threat Reduction (ACTR).

To accomplish this mission, the author suggests the creation of a small-scale non-governmental working group comprising participants from the Republic of Korea.
(ROK), the United States and other concerned states. The ROK has the unique knowledge about the DPRK society. In addition, the United States has profound and accumulated experiences attained through its CTR program for the former Soviet Union countries and others in the Middle East (NTI 2019). The existing non-governmental entities such as Asia Pacific Leadership Network (APLN) can be a major player in creating such an international working group.

Such a group can begin to develop a draft of detailed action plans on the step-by-step implementation of the ACTR programs. The draft version is expected to be carefully reviewed by the DPRK to ensure that the final version reflects their preferences. During this process, active participation of key partners is needed. Potential participants include neighboring states such as the People’s Republic of China (PRC), Japan, the Russian Federation (RF), as well as international organizations such as the European Union that contributed to the creation of the Korean Peninsula Energy Development Organization (KEDO) and other global nuclear negotiations. The proposed non-governmental working group can be transformed to an international entity later on, if needed, when all the concerned parties such as the DPRK, the ROK, the United States, other neighboring states and international bodies finally sign a Comprehensive Agreement for the Denuclearization (CAD) of the DPRK.

**Overall Vision of the ACRT**

As discussed among key experts in the invaluable occasion of the Agreed Framework in 1994, the proper management of all the different levels of the staff members who are now working in CWMDM is a challenging issue. To prevent any potential development for nuclear weapon systems and sensitive ballistic missile technologies in the future, there should be considerable efforts to limit access to very sensitive special nuclear materials (SNMs), a couple of hundred core experts, and core components to build them. This mission is assumed to be powerfully led by the United States and other concerned P-5 states in association with active cooperation of the DPRK and the International Atomic Energy Agency (IAEA). Thus, the context of that mission will not be within the scope of the tasks of the proposed ACTR.

Still, there are more than twenty to thirty thousand staff members\(^1\) who are believed to work in CWMDM such as the acquisition of SNMs throughout the full operation of front and back end nuclear fuel cycle facilities including mining and refining of uranium; production of yellow cake; conversion to UF4 and UF6; fuel manufacturing; operation of two critical reactors such as the IRT-2000 and the 5 MWe Magnox type reactors; reprocessing and storage of used nuclear fuel; enrichment of U-235; production of tritium and final separation of it from targets; taking care of the stockpile of weapons-grade SNMs; assembling of nuclear bombs and high explosive components; testing of nuclear bombs; upgrades of existing designs; and the stewardship of nuclear bombs as the final product.

Also, there are other staff members working on the design of various sets of missiles in short-, intermediate- and inter-continental ranges; production of efficient fuel flight systems; and development of critical guiding components, post boosting vehicles, re-

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\(^1\)Personal communication with Siegfried Hecker at Stanford University, after the 73rd EAF Seminar at Plaza Hotel Seoul, 19 September 2019.
entry systems and much lighter carbon fiber for airframes, along with the development of submarine systems in the DPRK. Frankly, we do not have comprehensive information over these huge networks of WMD industries in the DPRK. However, based on the current knowledge and potential future studies to identify the actual capacity of the DPRK programs, we can hopefully acquire good knowledge to take care of all the concerned staff members in these sectors and the facilities that will be fully managed through full implementation of the CAD.

In practice, the level of knowledge among staff members in the DPRK’s CWMDM is considered to be very different. Therefore, the author recommends to develop a tailor-made approach to find optimum options for successful job transfer. The critical components that we need to bear in mind for the design of the ACTR program are:

1. To fully respect the needs of the DPRK that has had a strong ambition to achieve an economic quantum jump for its prosperity through the entire process of denuclearization, and to implement comprehensive measures to take care of its staff members,
2. To practically assist a peaceful and complete denuclearization of the DPRK, and
3. To actively contribute to trust-building processes among concerned parties to further strengthen a CAD system and eventually establish a North-East Asia Peace Regime (NEAPR) among the ROK, the PRC, and Japan in association with the United States and the Russian Federation in the future.

To accomplish the three ambitious goals, the author proposes the following specific but closely inter-connected missions for the ACTR programs:

1. **Provision of step-by-step energy solutions** to meet the demand from the DPRK through short-, mid-, and long-term approaches,
2. **Development of a comprehensive work package to manage key critical facilities** in Yongbyon at first, followed by programs for other cases, and
3. **Assisting the upgrade of critical transportation infrastructures** such as railway systems, road networks, harbors, and key airports to assist actions for denuclearization.

Surely, there will be many other critical components to accelerate denuclearization in the DPRK such as cooperative environmental monitoring. In this paper, however, the author will focus only on the most critical issue, that is about how to manage staff members in the CWMDM of the DPRK especially with a view to achieving energy supply.

**Energy Solution**

Energy solution is one of the factors in a major package that can act as a practical incentive for the DPRK to join the negotiation table for a CAD. The sustainable supply of energy in a step-by-step approach is essential for the economic development of the DPRK. There are two key areas that we have to work on to develop action plans;

1. The development of electricity generation systems, and
2. The development of grid networks to deliver energy throughout the DPRK.
Through the step-by-step implementation of this energy solution, it would substantially contribute to the creation of many decent job opportunities for the DPRK staff members now in the CWMDM.

It is expected that there would be the following demands from the DPRK for energy supply.

(1) Strong benefits of the energy solution will cover DPRK’s actual demand from industries to supply electricity and other types of energy.
(2) The DPRK will not significantly rely on foreign natural resources, but accomplish energy independence as much as possible.
(3) Many decent and stable job opportunities will be created for the staff members now in the CWMDM.

We need a careful and profound study to propose optimum solutions satisfying the above requirements. Unlike the previous case of the Agreed Framework, it is essential to immediately deliver the package to let the DPRK enjoy the real benefits of the energy solution. This will act as a critical incentive for the DPRK to sincerely join the table for negotiation and to initiate a trust-building process in the immediate future.

**Current Status**

Since the collapse of the former Soviet Union, the DPRK has experienced an energy crisis. Even critical industrial facilities such as Kimchaek Steel Factory have suffered an unstable supply of energy and materials indispensable for producing steels. Figure 1 is an indication of the energy crisis in the DPRK. Even though the Kim Jong Un Administration has tried hard to introduce numerous small-scale hydro- and the diesel battery-power stations across the region, the DPRK is still experiencing a significant deficiency of electricity supply.

![Figure 1. The current status illustrating the issues on electricity supply in the DPRK](http://www.nknews.org)
Figure 2 illustrates the deployment of newly introduced power stations in Huichon and Taechon areas in the North West region of the DPRK. The total national capacity of electricity generation is believed to increase by around 2 GWe as of 2019 (Hayes 2019). The currently installed capacity is still below 10 GWe. Given that the Shin-Gori Unit 4 in the ROK can generate 1.4 GWe, the level of the installed capacity in the DPRK can be regarded as very limited. Moreover, traditionally, the major section of DPRK’s industry is heavy industry that consumes a significant amount of electricity.

There is another pressing issue over electricity supply in the DPRK. The annual capacity factor of the actual operation of power plants has been very low after the collapse of the former Soviet Union. Since most of the installed power stations are outdated, the annual capacity factor is believed to stand at a low of 35% (Hayes 2019). If the current capacity factor can be multiplied, the actual amount of the annual electricity generation could reach around 3 GWe. It literally matches the level of the annual electricity production from two APWR units in Shin-Kori Nuclear Complex in the ROK.

Therefore, in order to overcome the current energy dilemma in the DPRK, we should focus on the following:

1. To increase the installed capacity to solve the current dilemma and to meet potential demand from the future economy development, and
2. To enhance the annual operational capacity by upgrading existing facilities with reasonable financial resources.

**Immediate Approach**

There would be many practical solutions to solve the difficulty in electricity generation in the DPRK. Quite recently, many famous high rising buildings have been built in the Pyongyang area. Mainly due to the harsh international economic sanctions, many of
them lack insulation such as weather strips that protect people from heat waves or cold winds. The ROK has a full range of knowledge to properly install necessary components, systems, and structures to enhance the energy efficiency of these buildings and many other traditional facilities in the DPRK. Many practical approaches can be implemented within months or so through close cooperation between two Koreas.

In addition to the proposal to enhance the energy efficiency of the buildings, we should work on the development of a critical approach to supply electricity and energy to remote areas in the DPRK to support valuable mines. Traditionally, the DPRK is famous for abundant natural resources such as steel, rare earths, magnesium, and so on. For the continuous commercial operation of these mines, many of the mining sites require a stable energy supply. The stable operation of these mines is a critical component of the DPRK economy to earn a significant amount of hard foreign currency through export and to provide stable jobs for local communities. Unfortunately, it will be impossible to immediately supply the needed electricity through existing nationwide grid network.

However, an entirely different approach can be implemented to solve this challenging dilemma through the combined use of small-scale renewable energy generation such as windmills, and the so-called micro-grid network that is now in popular in California in the United States. It might be expensive to introduce such a system to the DPRK. In addition, it might also require constant on-site maintenance to continuously operate small-scale windmills in remote areas of the DPRK. However, the new system will surely deliver an immediate energy solution to make a continuous operation of key valuable mines possible. If this action plan is successfully implemented, it would serve as a good example to bring about an immediate impact of the energy solution for the DPRK and to further solidify the trust-building processes.

Certainly, other energy supply solutions can be added to this new approach. One of the possibilities is to revive a heavy oil supply network with much more emphasis on the assurance of supply.

**Intermediate Approach**

The effect of the immediate approach will be great if it is carefully implemented with full support from the ROK and the United States. However, it cannot solve the entire energy dilemma in the DPRK. For this purpose, I propose other practical step-by-step approaches – both intermediate and long-term ones.

The first goal of the intermediate approach is to carefully review the energy efficiencies of existing fossil fuel-fired power stations in the DPRK. There are many prominent fossil fuel-fired power stations in the DPRK such as Pukchang, Pyongyang, and 616 Unggi stations. Some of them were originally designed to use heavy oil from the former Soviet Union. Unfortunately, since the collapse of the Soviet, the operation of these facilities has been significantly hampered. The stations such as the 616 Unggi have now been converted, not to use oil anymore, but to use indigenous coal instead. Some may claim that these facilities are outdated. But the author is confident that, through well-designed renovations, we can significantly enhance energy efficiencies of these facilities in a timely

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2 Personal communication with S. Hecker at Stanford University, Palo Alto CA, 30 April 2019.
3 Personal communication with J. Whang and C. I. Moon, Internal Discussion in APLN, Seoul, 17 December 2019.
manner so that they can serve as a basis of stable energy supply system in the DPRK at least for the foreseeable future.

The ROK has developed mature technologies to fully enhance energy efficiencies of its coal-fired stations. One of the key national laboratories in the ROK to take a leading role for the immediate approach is the Korea Institute of Energy Research (KIER) in Daejeon, the Korean Mecca for energy efficiency and renewable energy solution development. Through active cooperation between the two Koreas, comprehensive upgrades of old turbine systems can be accomplished within a relatively short period of time. Also, there is a great opportunity of open, joint cooperation to significantly reduce air pollution from the operation of coal-fired stations in the downtown of big cities such as Pyongyang.

Unfortunately, these upgraded stations cannot be connected to the existing nationwide electricity grid network for the time being. But they can still serve actively for local communities through somewhat isolated local-grid networks. Eventually, through a newly-built nationwide grid network, these facilities could be connected to the national electricity system.

**Ultimate Approach**

Eventually, there must be a final solution to meet the future strong demand to support the economic development in the DPRK. In designing the ultimate approach, detailed studies are necessary. Through the previous Agreed Framework, the supply of two units of PWRs from the ROK to Sinpo Complex through the KEDO was the sole practical solution. Unfortunately, the KEDO project was terminated without any tangible outcome even though the site is well preserved by the DPRK as illustrated in Figure 3. Even after the failure of the KEDO Project, all the six party members still recognized the importance of the peaceful use of nuclear energy in the DPRK, and decided to support the need as depicted in the September 2005 Beijing Joint Agreement (NCNK 2005).

For the DPRK, the option for the commercial use of nuclear energy has many prominent advantages. Firstly, the DPRK operates uranium mines such as Pyongsan even though the quantity of natural uranium in the ores might be not so great. Also, there are some phosphate mines in the DPRK adequate to produce fertilizers. The key by-

Figure 3. Recent view of the old sinpo site [Combination of personal information with Google earth illustration].
product of the phosphate ores is uranium at a level of couple of hundreds ppm. Due to the cheap labor cost, these mines in the DPRK have a certain value to provide domestic uranium resources for the potential peaceful application of nuclear energy (Hecker 2019). Of course, there should be a certain security assurance measure for the international society to prevent all feasible activities to assist any clandestine military actions while encouraging peaceful commercial activities.

The potential revitalization of the nuclear option can contribute to the creation of significant amount of new job opportunities in the DPRK. In the ROK, several hundreds of highly trained additional staff members are recruited to operate one new nuclear power station. However, when we begin to operate one new unit in the ROK without any good operational record, we actually need more than a thousand experts per each reactor for safe operation.

Another advantage of the nuclear option in the DPRK is that the burden of cost for fuel supply is significantly low compared to other energy options. Therefore, once the facilities are successfully installed, then the financial burden to supply fresh nuclear fuel would be not so significant at all, compared to other large-scale energy options for the DPRK.

**Understanding the Importance of the Indigenous Resources in the DPRK**

Through the history of its energy supply, the DPRK has accumulated valuable lessons on the importance of indigenous energy resources, especially when the heavy oil supply chain from the former Soviet Union was completely destroyed. In that sense, even though there is a concern from the Western society over the revitalization of electricity generation from nuclear energy, the DPRK may still prefer to exercise nuclear energy option. How to solve this issue is a very delicate matter to be discussed through candid dialogues among all the concerned states in the negotiation table. If there is a good political solution to allow electricity generation through nuclear options while fully ensuring nuclear non-proliferation and security without any violation in the future DPRK, the detailed action plans to materialize peaceful application of nuclear energy while fully discouraging any potential attempt on enrichment and reprocessing (EnR) can be developed.

The active application of fuel leasing can be a practical cornerstone for the DPRK case. Firstly, the ores extracted from Pyongsan can be used under a multilateral nuclear agreement. The ROK procures the ores for manufacturing fresh nuclear fuel for its domestic nuclear program to financially support the continuous operation of the mine and to preserve valuable jobs in that local area (Hecker 2019). At the same time, other states such as Russia and China can also purchase the ores and ship them to their domestic enrichment facilities. The low-enriched uranium from the corresponding enrichment service is used to fabricate fresh fuels in these countries or sent to the ROK for fuel fabrication at Korea Electric Power Corporation – Nuclear Fuel in Daejeon. These fuels are then sent to the DPRK to operate its reactors. Within 1 year from the discharge from the reactors, the spent nuclear fuel stored in special transportation casks is shipped out via existing railway network to the hosting states such as China and Russia for enrichment (Hwang 2019b). At this moment, there are four railway connections between the DPRK and China, and one between the DPRK and Russia. If a very long-distance transportation is needed, then the combination of maritime transport with
railway can also be considered. This fuel leasing option can be a solution to practically eliminate the chance of potential EnR in the DPRK while completely dismantling all open and clandestine enrichment facilities and current radiochemical laboratory facilities in Yongbyon.

Some might argue that the supply of two units of one GWe PWRs proposed through the KEDO project, and the possible new proposal to supply new systems such as 1.4 GWe APWRs are too big for the DPRK to match up with the current and future nationwide grid network in a timely manner. Also, some might claim that the active technology development in small and modular reactors such as System-Integrated Modular Advanced Reactor (SMART) developed by Korea Atomic Energy Research Institute (KAERI) is nowadays more adequate for the electricity supply in the DPRK (Hwang 2019b). If the DPRK strongly demands the deployment of many small-scale power plants across its territory, the implementation of SMARTs could be a viable option. The full spectrum of feasible options for ultimate energy supply solution should be carefully reviewed, taking into account of nuclear non-proliferation and security concerns.

If the DPRK is more interested in other options than the nuclear one, its preference should be fully respected. Therefore, a possible research team should be responsible for:

(1) carefully examining all the spectrum of the pros and cons of feasible options, and
(2) identifying optimum solutions through active and consistent consultations with core states such as the DPRK and the United States.

An additional comprehensive research is strongly needed to identify fundamentals on the development of global cost-sharing system to support energy solutions and corresponding action plans.

**Grid Network System Development**

Recently, there have been many keen suggestions to introduce the so-called regional energy solution in the North-East Asia. For example, Masayoshi Son, the founder and the CEO of SoftBank Group in Japan proposed an ambitious approach to install an integrated network of solar power generation systems in Mongolia in association with supergrid networks covering Mongolia, North-Eastern parts of the PRC, two Koreas and Japan. Also, Russia proposed a solid idea on the pipeline network of liquid gas from Siberia to the entire North East region. These projects are good for the construction of mutual economic ties in the region and trust-build.

However, to really implement these ambitious plans, a significant amount of time and effort will be required. Therefore, there is no pragmatic silver bullet to solve the current energy dilemma in the DPRK in a timely manner. In reality, a practical solution for the DPRK should be composed of a well-designed step-by-step approach. For this mission, I propose to introduce the combination of the following options:

(1) The so-called micro-grid network for key remote areas with valuable financial assets such as the mines by which the DPRK can earn hard foreign currencies through the export via their proper operations (Hayes 2019), and
(2) The independent conventional, non-micro-grid local-grid networks to support power generation and to distribute electricity to neighboring countries.

It is when the ultimate energy supply approach is completed with the fleets of noticeably large-scale stations that a real nationwide grid network is available in a timely manner. In practice, the introduction of such a nationwide grid network would require comprehensive and detailed action plans and global investment on a significant scale. It is one of the core tasks for regional partners and the international community to figure out an eternal energy solution in the denuclearization process of the DPRK.

**Decommissioning and Decontamination (D&D) of the Nuclear Installations**

**Yongbyon First**

The proper decommissioning and management of old nuclear facilities in the DPRK and the follow-up activities to manage all kinds of radioactive wastes will be a real technical and financial challenge. However, it can serve as a good opportunity for the creation of decent and sustainable jobs for staff members in CWMDM of the DPRK. The ROK, the United States, and the other neighboring states along with many critical international parties can assist comprehensive technology training and waste management through the D&D process.

We do not fully understand the entire spectrum of nuclear facilities in the DPRK. For example, we do not have solid information of conversion facilities to produce UF$_4$ and UF$_6$. Also, we do not have clear pictures of the full enrichment capacity of the DPRK. In addition, we do not have any knowledge on the stewardship of warheads and stockpiles of weapons-grade materials. The lack of information will cause uncertainties in our work plans. However, we can still develop a solid scheme to handle all the key facilities by reducing uncertainties throughout careful future analyses.

There are more than 300 buildings in Yongbyon for nuclear activities. Figure 4 is a birds eye view of the Yongbyon Atomic Energy Research Complex (AERC) that has accommodated many different nuclear installations from 1964 on (Bermudez and Cha 2018). The AERC firstly introduced the IRT-2000 from the former Soviet Union. It is now believed to have been upgraded to an 8,000 kW reactor. Each key section of the Yongbyon complex is specialized for specific missions such as

1. Reactor operation,
2. Reprocessing, and
3. Uranium enrichment and tritium separation (Hwang 2019a).

The comprehensive plan to manage the Yongbyon AERC will require significant time and financial resources.

Firstly, three reactors – the IRT-2000, the 5 MWe Magnox, and the experimental light water reactor (ELWR) – that are now still under construction will require careful management schemes. The IRT-2000 still uses 36% HEU, far exceeding a 20% limit set by the IAEA. There is a strong demand to immediately shut down the reactor to stop the use of HEU. However, the IRT reactor has served as a hub to supply radio-isotopes for industrial and medical applications in the DPRK. The DPRK will need to seek a new
means to assure the stable supply of these isotopes. After the 9/11 incident, the US National Nuclear Security Administration has worked hard to develop non-radioactive substances for industrial and medical applications. At least for the moment, however, it is essential to introduce a new isotope generation reactor that can enrich nuclear fuels to only less than 20%, to replace the existing IRT-2000 at the Yongbyon AERC. The ROK has accumulated profound experiences through the operation of Hanaro research reactor at the KAERI in Daejon, the export of a new research reactor to Jordan, and the current endeavor to construct a new specialized reactor to produce valuable radioisotopes for medical and industrial applications in the South-Eastern part of the country. The proper planning in association with the tailor-made training for the operation of a new reactor such as a new Hanaro reactor should be done through close cooperation among concerned parties (Hecker 2019).

One of the well-known purposes of the Magnox reactor in the Yongbyon AERC is simply to produce weapons-grade plutonium by reprocessing a 50 tone spent nuclear fuel in a nearby radiochemistry laboratory. Also, it is believed that it has served as a hub to produce tritium to make a booster bomb in the DPRK. The target materials composed of Li-6 produce tritium by properly slowing down incident neutrons through the careful operation of a reactor and additional features such as special claddings. The continuous operation of the 5 MWe Magnox reactor can produce enough tritium to make a booster bomb. The DPRK announced that it had successfully tested a booster bomb in its 4th nuclear test in January 2016, even though there is a certain doubt over the successful explosion. The results from the 6th and the latest test conducted in September 2017

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4 Personal communication with J. Whang and Y. Hwang on unpublished scientific estimations, Suwon, 18 December 2017.
certainly indicated that the DPRK successfully detonated either a booster or a hydrogen bomb. What is critical for the complete denuclearization is to fully frustrate the production of tritium in the 5 MWe Magnox reactor and possibly in the IRT as well as to crack down on any potential transfer of tritium and deuterium through black market\(^5\).

The demolition of the 5 MWe reactor inevitably would produce a by-product: radioactive graphite blocks. After decommissioning, graphite needs to be safely disposed in a deep repository in the future. Having assistance from the United Kingdom and France that have learned significant lessons to manage contaminated graphite is highly recommended. In addition, special containers are necessary to store discharged spent fuel from the 5 MWe reactor\(^6\). An internationally concerted effort is also desirable for the timely delivery of proper storage casks. Japan and the United States can contribute to this purpose through ongoing projects.

How to take care of the ongoing ELWR Project is another issue. The comprehensive safety inspection with the potential addition of a cooling water supply system will be needed to ensure the safe operation of the new system when the international community decides to support the commercial operation of this new reactor.

Many of the key buildings in the radio-chemistry laboratory area are relatively open to the outside world through previous inspections occasionally carried out by the IAEA. Still, some buildings have been updated, which would require further studies for verification and remedial actions in the future. The real issue for this area is the proper inspection of extracted plutonium, and the management of wastes in the Building 500. It is believed that this building contains high-level liquid wastes.

All waste streams need to be carefully inspected to identify the exact amount of extracted plutonium. Of course, there will be independent inspection of the 5 MWe reactor with full records on the reactor operation history and proper radio-isotope samplings from graphite blocks inside a reactor. In practice, the IAEA will be responsible for the verification.

Primarily, the ACTR missions can be responsible for the proper management of all waste streams in this building. Solidifying complicated liquid wastes into stable vitrified glass forms and any other solid form is a technical challenge because there are many different origins of liquid wastes in this building. It may come from:

(1) The operation of traditional PUREX reprocessing facilities and
(2) The early implementation of chemical de-cladding (Whang and Baldwin 2005).

The United States has learned many of costly but valuable lessons in the Hanford site where very troublesome liquid wastes have been solidified for a long time. A special international team would be necessary for the proper management of accumulated wastes in this section. It is also highly likely that some radioactive wastes have been dumped advertently and inadvertently onto nearby grounds in this area. In fact, this is not unique for the DPRK. Some states made similar mistakes in the initial stages of weapon development. To decontaminate land, principles such as the Green Field Approach and the Brown Field Approach should be properly introduced. The Green

\(^5\)Personal communication with S. Hecker at Stanford University, Palo Alto CA, May 2015..
\(^6\)Personal communication with J. Bermudez at CSIS, Longmont CO, 10 January 2020.
Field Approach is ideally recognized to completely clean up the Yongbyon site. But it requires a bigger budget, and it takes a longer time than the case of the Brown Field Approach. In the Brown Field Approach, some key parts of the site will be cleaned up well. However, certain hot spots at the site that may require significant time and financial resources for complete cleanup will be cleaned only up to a certain level and controlled to limit the access of the general public. We need detailed studies to choose an optimum option under a financial constraint, for the cleanup of the concerned areas in Yongbyon. The experiences in the United Kingdom and the United States are essential to pave a way to pragmatic remedial actions.

All the enrichment-related buildings in the Southern part of the Yongbyon AERC are strongly recommended to be completely demolished in a timely manner. Even though some people might claim that the complex is financially valuable asset for commercial enrichment in the future, it does not indeed make any sense at all. The American Centrifuge Plant (ACP), a leading enrichment facility located in the United States, is based on the 10th generation centrifuge technology. It has experienced a series of difficulties so that the opening of this new facility has been indefinitely postponed.

Practically, the 8th generation centrifuge facility in Russia is the best facility of enrichment in the world. The URENCO enrichment facility in the Western Europe based on the 7th generation technology has experienced difficulties in its competition against Russians in the global free market. The Yongbyon Uranium Enrichment Plant (UEP) is based on the 2nd generation centrifuge technology supplied by Pakistan (Hwang and Lee 2016), so that there is no financial benefit at all to operate the UEP for commercial service. Also, the operation of the enrichment facilities with centrifuge cascades does not provide significant job opportunities.

Some might claim that the UEP can serve as a new hub to produce valuable and stable nuclides in the future. But, closing any potential route for enrichment would be the top priority for stakeholders in the negotiation table for a CAD. Therefore, the entire shutdown of the UEP facilities in the Yongbyon AERC should be surely pursued.

In addition to the UEP buildings, there are certain facilities in that area to extract tritium from irradiated Li-6 targets. The new facilities with five special hot cells will be decommissioned immediately after verification.

**Other Facilities Outside Yongbyon**

In the previous section, I discussed the timely management of the facilities in the Yongbyon AERC. Of course, we will eventually need to develop comprehensive plans to manage other known nuclear facilities and clandestine ones. However, I strongly recommend our initial focus be on the development of action plans over the Yongbyon AERC. As already pointed out in this paper, the Yongbyon AERC accommodates hundreds of buildings covering many key features of the production of weapons-grade materials. By implementing the step by step approach, we can accumulate valuable experiences to manage many other sites later on, while trying to implement confidence-building measures closely with the DPRK. In addition, we will be able to acquire more information to fully recognize the real capacity of the DPRK through the implementation of the proposed Yongbyon AERC-first plan. We can also develop an entire map to
dismantle DPRK facilities not just in relation to nuclear weapon development but to all the other WMD development from the cradle to the grave later on.

**Contribution to Human Resources Management**

As illustrated in the previous section, the proper management of facilities in the Yongbyon AERC requires significant efforts of the DPRK and concerned international stakeholders. The proper management of facilities throughout a transition period followed by comprehensive D&D implementation along with the proper management of all kinds of radioactive wastes will serve as a great opportunity to create many decent job opportunities for the DPRK staff members who are now in CWMDM. To create more attractive job opportunities, the international society should provide specialized training programs so that the DPRK staff members can be fully qualified to serve as a fundamental workforce for international joint efforts to manage concerned facilities in the future.

**Upgrade of Transportation Systems**

To support the installation of new energy systems and the upgrade of existing facilities requires the solid renovation of transportation network in the DPRK. Since the immediate approach in our proposal for energy supply is targeting the installation of renewable energy stations in remote locations of the DPRK, the development of solid transportation routes will be a key to its successful implementation. Such a transportation network is also necessary to manage and dismantle the Yongbyon AERC and other WMD facilities around the DPRK. It will require specific schemes to assist the transportation of both heavy non-radioactive and radioactive materials.

In practice, what we need to do is to develop a comprehensive program to upgrade the transportation systems in the DPRK. In this connection, the potential introduction of a high-speed railway system has been hotly debated in the ROK. But, in this paper, I will focus only on the upgrade of heavy freight transportation system in the DPRK, which will be comprised of railway, road, and air to transport, for example, heavy materials to and from Yongbyon.

Critically important special nuclear materials can be transported from the Yongbyon AERC by special vehicles to nearby Panghyon Airport in Kusong, and then by air to the outside world. If needed, two prominent airports, Panghyon in Kusong and Kalma in Wonsan, can be designated as a hub for international air transportation (Hwang 2020). In reality, many other materials will possibly be transported by railway and road networks. There is a roadway connection between Kusong and Yongbyon via Taechon. But the railway system in the DPRK is outdated with only small-scale bridges or tunnels available. These bridges and tunnels are typical weak points in developing heavy freight railway transportation. To rely on railway transportation, we will need a systematic upgrade of existing nationwide railway network. Figure 5 illustrates an overall view of the existing transportation routes around Yongbyon. Even though this map does not explicitly indicate bridges and tunnels, a detailed map, if any, would show such weak points in the system.

If we move heavy freights from western part of the DPRK to Yongbyon, one of the practical starting points will be Wonsan harbor. Starting from Wonsan, there is a good railway connection via Kowon, Suncheon, Jeongju, Kusong, to Yongbyon. However, this
route passes through inland high mountain areas where small-scale tunnels and bridges need to be upgraded.

To upgrade these transportation systems with limited funding will be a key challenge for the ACTR program development in the future. It will require careful consultations and on-site investigations in the DPRK with the active participation of international experts. The same is true for road transportation. We can easily recognize solid highways between

(1) Kaesong and Pyongyang,
(2) Wonsan and Pyongyang, and
(3) the Chongchon-Kang area and Pyongyang (Hwang 2020).

But other road routes are outdated, waiting for further systematic upgrades in the future.

The solid upgrade of the nationwide transportation infrastructures in the DPRK will require another huge step by step project. When implemented, it will also create many new job opportunities for the staff members now in CWMDM.

**Conclusions: Rome Was Not Built in a Day**

Even though the importance of the denuclearization of the DPRK has been recognized for many decades, we still need to construct a comprehensive package for its effective implementation as early as possible. In this paper, I have summarized new ideas over the ACTR approach. I strongly propose to make joint international efforts especially by non-governmental actors to solicit key ideas without any political constraints to prepare a draft ACTR action plan. I would like to name it as a “Pre-ACTR Proposal”. Through consultations among concerned parties, the basis of the ACTR programs can be developed. After a series of review by international expert groups, they can be presented to global and regional stakeholders. For this mission, it is important to clearly define the

![Transportation networks around Yongbyon](image)
roles and responsibilities of the ACTR program right from the beginning. Its critical core will be:

1. It should **not lead but assist** the successful implementation of international denuclearization efforts *by proposing practical solutions to temporarily manage and eventually decommission key WMD facilities in the DPRK*, and
2. It should systematically **support the peaceful job transition of many staff members, who are now in CWMDM of the DPRK with different levels of skills, to descent and stable civilian positions**, while promoting the economic development of the DPRK and supporting the actual denuclearization of the DPRK.

To complete this mission, we should try to understand the real capacity of the DPRK WMD business. It will be a hard task to do so with only limited open-source information. Still, we can do our best to overcome the difficulty and to develop a comprehensive ACTR package in a timely manner.

The development of the ACTR package through the active participation of global civilian actors is very important not only to develop effective action plans but also to create really solid confidence-building measures among sensitive stakeholders. Rome was not built in a day. Our new approach for the ACTR program development will inevitably face many trials and errors throughout detailed studies. Still, the transparent approach respecting the real needs of the DPRK and other concerned parties is a key to success. For this reason, I would strongly emphasize the importance of a pragmatic step by step energy solution in this paper. Our effort for energy supply will produce immediate as well as ultimate benefits in a timely manner. This will be a real mechanism to build trust and to consistently support time-consuming denuclearization processes as a whole.

In this short paper, I have briefly introduced how to manage the Yongbyon AERC. To this, we can add in the near future fundamental ideas to manage other nuclear facilities such as the ones for missile development. Finally, I would like to emphasize the importance of urgent studies to develop the fundamentals of a peace regime in North-East Asia. The peace in North-East Asia cannot be achieved in a single day. The denuclearization of the DPRK is only a beginning toward a regional peace regime. To promote eternal peace in this region, a comprehensive package to achieve a peace regime in this region should also be discussed in the future.

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**Disclosure Statement**

No potential conflict of interest was reported by the author.
Notes on Contributor

Dr. Yong Soo Hwang is a principal researcher for the Korea Atomic Energy Research Institute (KAERI) in the ROK. He served as a senior vice president of KAERI between 2018 and 2019. He also worked as a director general of KINAC, the national laboratory for nuclear non-proliferation and security between 2014 and 2016; as a visiting fellow at CSIS in Washington, DC between 2010 and 2012; and as an advisory member for the Director General of the IAEA to develop the Multilateral Nuclear Agreement (MNA) between 2004 and 2005. He also joined the Nuclear Safety and Security Commission, ROK’s nuclear regulatory body, as an advisory member who specialized in nuclear control between 2013 and 2015. He is a member of Asia Pacific Leadership Network (APLN) since 2016. He has worked on DPRK issues, nuclear fuel cycle technology development, and public and stakeholder engagement for many years. He received his BS degree at the Department of Nuclear Engineering in Seoul National University in 1983, and MS and PhD at the Department of Nuclear Engineering in University of California, Berkeley in 1985 and 1991 respectively.

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