Summary of “International Deployment of Commercial Capability in Nuclear Fuel Cycle and Nuclear Power Plant Design, Manufacture and Construction for Developing Countries: Final Report on Task 7”

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Summary of "International Deployment of Commercial Capability in Nuclear Fuel Cycle and Nuclear Power Plant Design, Manufacture and Construction for Developing Countries: Final Report on Task 7"

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I. Introduction

The following is a summary of the report, "International Deployment of Commercial Capability in Nuclear Fuel Cycle and Nuclear Power Plant Design, Manufacture and Construction for Developing Countries: Final Report on Task 7" by L. J. Droutman, et al, Westinghouse Corporation, which was prepared for the Union Carbide Corporation – Nuclear Division under Subcontract to the US Department of Energy (ORNL Sub-7494/4), and dated October 1979, and appeared as a NAPSNet Special Report on December 23, 2010.

This summary was prepared by David von Hippel, Nautilus Institute Senior Associate.

II. Summary by David von Hippel

The 1979 document, *International Deployment of Commercial Capability in Nuclear Fuel Cycle and Nuclear Power Plant Design, Manufacture and Construction for Developing Countries*, by a team of researchers from the Westinghouse Corporation's Nuclear Division, provides an assessment of the requirements for developing countries at different levels of technical sophistication to "acquire complete or partial independent commercial nuclear power capability". The report focuses on the various difficulties that a developing nation would need to overcome to acquire independent nuclear power capability, and assesses the likelihood that a country could be successful in doing so. This older report is germane today is that the Democratic People's Republic of Korea (DPRK), has recently revealed a surprisingly mature program for enrichment of uranium to produce (it claims) fuel for a domestically-developed fleet of small light-water nuclear power reactors (LWRs) [1]. The international community is currently considering how to respond to the DPRK's enrichment program, and to its plans for an apparently domestic reactor program. One (though certainly not the only) response would be for concerned nations to engage the DPRK to make sure that its nuclear energy program, as it develops, conforms to international norms and standards regarding safety, transparency, and oversight, and to do so by helping the DPRK in the process of developing its nuclear industry (obviously, with significant caveats as to DPRK behavior) [2]. This Westinghouse report, though written three decades ago and from the perspective of a "generic" developing country lacking the DPRK's rocky history with nations that could be potential commercial nuclear industry partners, nonetheless provides a useful and thorough, if not up-to-date, summary of the issues that the DPRK will face as it builds a nuclear industry. As such, it also provides the international community with clues as to leverage points where the DPRK will need, and perhaps be willing to make concessions to obtain, outside assistance in order to develop its program in a timely fashion.

Following a Summary section, the Westinghouse report provides an introduction to the premise and objectives of the study, describing the level of industrial development and nuclear aspirations for a fictitious developing country "X" with two sizes of electricity systems as of the start of nuclear sector development (assumed to be 1978), a "small" case of a country with a peak load of about 3000 electrical megawatts (MWe), and a "medium" case where the country's peak load is about 12,500

MWe. Coincidentally, the smaller case roughly corresponds to the size of the DPRK's total operable electricity generation capacity as of approximately 2009, by Nautilus estimates, while the medium case depicts a system somewhat larger than the reported generating capacity in the DPRK was as of about 1990. In each case, rapid (9 – 10 percent annually) growth in electricity demand is assumed. In the small case, in 20 years, nuclear power capacity grows to 5250 MWe, by which time nuclear power provides about 40 percent of national generation. The introduction also touches upon problems in assessing how a developing country will progress in acquiring a nuclear sector.

Most of the report is devoted to exploring, for each component of the nuclear fuel cycle, what would be required for a developing country to acquire a nuclear power industry. As such, each chapter provides a description of the component of the fuel cycle and related required activities to develop the component, materials requirements, personnel, supporting industries, time, and investment costs required for the component, and an assessment of the additional costs required if a truly independent industry to provide the component is assumed. The components of the nuclear fuel cycle covered in the chapters of the report are as follows: uranium supply (supply of uranium concentrates), uranium conversion to uranium hexafluoride, uranium enrichment, nuclear power plant construction, nuclear steam supply system production and regulation (by far the most extensive and detailed part of the report), nuclear fuel fabrication and design systems, reprocessing and mixed oxide fuel fabrication systems, nuclear waste storage options and arrangements. The report's conclusion summarizes the findings of the report, including the likelihood that a developing country could assemble an independent nuclear capability, and the factors that are likely to affect that likelihood, including a summary of "building blocks" toward an objective of commercial independence in nuclear power.

The key findings of the Westinghouse study, as summarized in the first chapter of the report, are many, but a selection of those most germane to the DPRK's current situation is as follows:

- Although the civil engineering associated with nuclear plant design is "extremely complex and difficult to master", it is not so different from that required for other large concrete works. A key difference, however, is the need for a larger number of experienced "first level supervisors" per craft laborer involved in the project, as well as an experienced top management team.
- Development of a regulatory capability must parallel nuclear technology development. Regulatory capability would (in the "Country X" example) be developed with substantial assistance from outside.
- Manufacturing of nuclear steam supply system components is complex and requires specialized skills and materials that would be difficult for a country to develop independently. A phased plan of licensing technologies and/or purchasing key components is more practical.
- Process computers and control systems are identified as not much of a problem for a country to obtain internationally, even as of 1979, but nuclear controls of adequate quality were considered difficult for a developing country to manufacture domestically.
- Nuclear systems engineering and project implementation capabilities require large staffs, and would be developed in stages over a period of 7 to 9 years, with outside assistance and with expatriate hiring, perhaps, at early stages.
- A nuclear training center with power plant simulators will be required, as well as a labor training facility.
- Domestic nuclear fuel fabrication is typically a fairly early step among the development of nuclear industrial capabilities (due to its "relatively higher volume and lower diseconomy of scale"), but its requirements are still very stringent and complex, requiring the use of sophisticated design tools and quality control.
- There are synergies between the overall level of industrial development of a country and the

country's ability to quickly develop nuclear power, but the "special quality and material requirements" of nuclear manufacturing limit the impact of such synergies.

Though the costs (even if inflated to current dollars) and perhaps other quantitative estimates provided in the report are certainly out of date, the volume nonetheless provides a sort of checklist against which observers of the DPRK nuclear power development program, and perhaps the North Koreans themselves, can assess in which areas the DPRK appears to have a good chance of achieving timely success in developing a nuclear fuel cycle, and in which areas substantial additional outside assistance will be needed if the DPRK is to build and operate nuclear power plants in the reasonably near-term future. Nuclear power development, especially if it is to be achieved (largely) independently, requires simultaneous progress on a number of industrial fronts, but some will take much longer than others. An assessment of the DPRK's situation with regard to each component of the nuclear system, based on an analytical structure like that provided in this report (as well as more recent compendia), would be expected to help to identify where outside assistance would be of most use to the DPRK in reaching its nuclear power development goals, and as a result what types of assistance are most likely to elicit desired behavior from the DPRK in terms of addressing the international community's nuclear weapons proliferation and other concerns regarding the North Korean nuclear program.

III. Citations

[1] See, for example, Siegfried S. Hecker (2010), A Return Trip to North Korea's Yongbyon Nuclear Complex. NAPSNet Special Report, dated November 22, 2010, and available as https://nautilus.org/publications/essays/napsnet/reports/a-return-trip-to-n-rth-korea2019s-yongbyon-nuclear-complex.

[2] See the January, 2011 Nautilus Special Report Online Engaging The DPRK Enrichment And Small LWR Program: What Would It Take?, by David von Hippel and Peter Hayes, which provides some initial thoughts on the forms that international engagement with the DPRK on their small LWR program might take.

IV. Nautilus invites your responses

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