

# Analysis on Essential Factors for Successful Denuclearization

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## Abstract

In order to maintain nuclear nonproliferation regime based on the Treaty on the Non-Proliferation of Nuclear Weapons, it is indispensable for non-nuclear weapon states that have acceded to implement the treaty in good faith. From this perspective, the purpose of this study is to discover ways to lead successful denuclearization of countries that have engaged in nuclear weapons-related activities. After investigating the history and analyzing the characteristics of denuclearization of eight countries, which have already achieved or whose denuclearization are currently pursued, namely South Africa, Iraq, Libya, Ukraine, Kazakhstan, Belarus, the Democratic People's Republic of Korea, and Iran, we then derived eight denuclearization factors, which are essential to consider for leading successful denuclearization. Such factors are: (a) Motivation for nuclear development (motivation for maintaining inherited nuclear weapons in the cases of Ukraine, Kazakhstan and Belarus's denuclearization), (b) Progress of nuclear development, (c) Domestic and international circumstances at the time of denuclearization, (d) Incentives for denuclearization, (e) Effect of sanctions, (f) An international framework for denuclearization, (g) Denuclearization methods, and (h) Verification methods and a verifier of denuclearization. Finally, we concluded the relationship and combination of the above eight factors for successful denuclearization as follows: First, in order to encourage a country's decision for denuclearization, it is necessary to provide it with any incentives for its denuclearization, such as security assurance, especially from nuclear weapon states, and sanction relief and financial support, while considering the domestic and international circumstances surrounding them. Second, upon a nation's decision for denuclearization, under an international consensus framework involving nuclear-weapon states, irreversible denuclearization methods should be promptly implemented in accordance with its progress of nuclear development. Simultaneously, in a parallel with denuclearization, and except for nuclear weapons verification that should be completed by nuclear weapon experts in nuclear weapon states, the International Atomic Energy Agency verifies and monitors its denuclearization, principally based on verification methods which have already been implemented under the Comprehensive Safeguards Agreement and Additional Protocol.

## Introduction

Under the nuclear nonproliferation regime based on the Treaty on the Nonproliferation of Nuclear Weapons (NPT), non-nuclear weapon states (NNWSs) are enjoying peaceful use of nuclear energy, while faithfully accepting International Atomic Energy Agency (IAEA) Safeguards. However, some countries have clandestinely engaged in nuclear weapons-related activities or happened to inherit nuclear weapons. Denuclearization of such countries is indispensable for maintaining a nuclear nonproliferation regime, for strengthening NPT as an important norm for such a regime, and consequently for promoting peaceful use of nuclear energy under the NPT. Specifically, the process of denuclearization involves the following: (1) the dismantlement and disposition of nuclear weapons or nuclear explosive devices, (2) the disposition and/or removal of nuclear weapon-usable material such as highly enriched uranium (HEU) and plutonium (Pu), (3) the disablement, destruction, disposition and/or removal of nuclear weapon and/or nuclear weapon usable material-related facilities, equipment and components, and/or (4) the curtailment of certain nuclear activities. Regarding nations believed to require denuclearization, in order for the international community to discover ways for leading their successful denuclearization, we conducted a case study and factor analysis of eight countries which have already achieved or whose denuclearization are currently pursued.

In our study, we first selected eight states, namely South Africa, Iraq, Libya, Ukraine, Kazakhstan, Belarus, the Democratic People's Republic of Korea (DPRK), and Iran, and investigated their denuclearization history, together with analyzing their main denuclearization characteristics (Chapter 1). Secondly, we derived eight denuclearization factors that are essential to consider for leading successful denuclearization (Chapter 2). Finally, we analyzed the relationship and combination of the above eight denuclearization factors for the international community to lead successful denuclearization (Chapter 3).

Extant research has extensively studied denuclearization history and suggested methods for denuclearization. However, we could not find studies like the present one that derived denuclearization factors then analyzed the relationship and combination of those factors for leading successful nuclearization.

# 1. Denuclearization history of eight countries and their characteristics

## 1.1 Brief description of eight countries

Table 1 in Chapter 1.1 briefly describes the progress of nuclear development, and denuclearization methods of eight countries for our case studies. Chapters 1.2 to 1.7 outline the history of denuclearization and their main characteristics.

Table 1 Brief description of eight countries

Category	Country	Progress of nuclear development	Denuclearization methods
Achieved denuclearization	South Africa	Produced six HEU-type nuclear explosive devices	Abandonment of six nuclear explosive devices
	Iraq	Pursued uranium enrichment activities and HEU-type nuclear weapons without success	Destruction and removal of nuclear facilities and related items
	Libya	Obtained centrifuge components from nuclear black market, but failed to even assemble centrifuge machine	Removal of nuclear-related items
Inherited nuclear weapons but transferred them to Russia	Ukraine	Inherited nuclear weapons with the collapse of the Soviet Union	Transfer of nuclear weapons to Russia
	Kazakhstan		
	Belarus		
Denuclearization is currently pursued	DPRK	Already conducted nuclear tests and estimated to possess nuclear warheads	Agreed in the US-DPRK Agreed Framework (1994) and Six-Party Talks (2005 and 2007); however, no progress has been made so far
	Iran	Already possesses ability to produce HEU	Restrictions on nuclear capabilities under the 2015 Joint Comprehensive Plan of Action (JCPOA)

## 1.2 South Africa

### 1.2.1 History of denuclearization

South Africa launched full-scale nuclear weapons activities from 1970s. The reasons behind such activities were its isolation from the international community due to its apartheid policy and national security concerns during the Cold War period, confronting the Cuban military force over Angola around 1975. South Africa succeeded in HEU production by utilizing its own-developed vortex tube process as well as manufacturing a total of six HEU-type nuclear explosive devices by 1989.

Against the backdrop of the easing of the Cold War, the Cuban military force withdrew from Angola in 1988 and the national security environment surrounding South Africa was intensively improved. Mr. Fredrik Willem de Clark, who became president in 1989, recognized that maintaining the apartheid policy which was heavily criticized globally and related governance system would be impossible, and that drastic political and social changes would soon be inevitable. In 1990, President de Clark ordered the dismantlement and disposal of six nuclear explosive devices and related facilities. Upon the completion of the above activities, South Africa joined the NPT as an NNWS and a Comprehensive Safeguards Agreement (CSA) with the IAEA came into force in 1991. In March 1993, President de Clark announced its past nuclear weapon-related activities as well as the completion of their disposition. South Africa actively cooperated with the IAEA's verification activities and in September 1993, IAEA concluded "the amounts of HEU which could have been produced by South Africa's pilot enrichment plant are consistent with the amounts declared in South Africa's Initial Report."<sup>1</sup>

### 1.2.2 Main characteristics of denuclearization

First, being different from other states' denuclearization, South Africa's abandonment of own-developed and own-made HEU-type nuclear explosive devices can be termed "self-contained denuclearization." Only South Africa has achieved denuclearization in this way. Second, South Africa's denuclearization was indirectly linked to the abolishment of the apartheid policy as well as consequent drastic changes of its political and social systems accordingly. As mentioned in 1.2.1, the apartheid policy isolated South Africa from the international community. In order to alleviate this isolation, South Africa needed to abolish apartheid and as a result, shift from white supremacy

to the establishment of a new government based on democratic election participated in by all races. In such circumstances, the pros and cons of possessing nuclear explosive devices might have been deeply reconsidered,<sup>2</sup> together with a backdrop of the easing of the Cold War. Third, after the completion of its “self-contained denuclearization,” South Africa abided by NPT procedure and was also quite cooperative with the IAEA’s verification, providing IAEA with “anywhere, anytime access within reason.”<sup>3</sup> South Africa’s exemplary attitude showed the importance of NPT as the core of a nuclear nonproliferation regime and also contributed to South Africa’s return to the international community from solitude.<sup>4</sup>

## **1.3 Iraq**

### **1.3.1 History of denuclearization**

Iraq, led by President Saddam Hussein, focused more on clandestine HEU production and HEU-type nuclear weapon-related activities especially after Israel’s airstrike on an Iraqi research reactor (Tammuz-1) in June 1981. President Saddam Hussein’s ambitions, which not only ensured his strong dictatorship in Iraq but also established regional hegemony by acquiring the first nuclear weapon in the Arab region against Israel. This is said to have led him to conduct clandestine nuclear activities.<sup>5</sup>

However, Iraq could not achieve the production of either HEU or HEU-type nuclear weapons at all. Defeated in the 1991 Gulf War, Iraq had to accept abandoning its Weapons of Mass Destruction (WMD) program under the UN Security Council Resolution 687 (UNSCR 687).<sup>6</sup> In addition to CSA-based activities in Iraq, the IAEA was authorized by the UNSCR 687 to verify and monitor Iraq’s denuclearization, with the support and cooperation of the United Nations Special Commission on Iraq (UNSCOM), established by the UNSCR 687 and backed up mainly by the United States. The IAEA’s intensive inspections and verifications activities, carried out in 1991 and 1992, revealed the details of Iraq’s clandestine nuclear programs. On the other hand, UNSCOM’s verification on the Iraqi WMD program other than nuclear had not progressed smoothly, due to lacks of Iraq’s cooperation to UNSCOM (from UNSCOM’s perspective) and of UNSOCOM’s behaviors which were not necessarily internationally neutral (from Iraqi perspective). The United States, which had been frustrated by this situation, started the Iraq War in 2003 and destroyed the regime of Saddam, who was executed in 2006 in Iraq.

### **1.3.2 Main Characteristics of denuclearization**

First, defeated in the Gulf War, Iraq had to accept the abandonment of its WMD program including nuclear weapons, by UNSCR 687. This can be called “inevitably accepted denuclearization” and clearly contrasts South Africa’s “self-contained denuclearization.” Second, the IAEA was empowered by UNSCR 687 to verify Iraq’s undeclared nuclear activities including visits to Iraqi undeclared sites; these additional verification procedures and later came to fruition as a model additional protocol (INFCIRC/540). Third, the UNSCR 687 included a strict condition on sanctions relief to Iraq in which no countries were allowed to import oil from Iraq until the UN Security Council concluded that Iraq completed the abandonment of its WMD program. This condition completely differs from the one in JCPOA in which sanctions would be gradually lifted in accordance with Iran’s compliance with the JCPOA (See Chapter 1.7). This strict condition on Iraq, together with the fact that Iraqi oil exports were partly allowed under certain conditions, also contributed to reducing its incentives for cooperation with UNSCOM’s verification activities.

## **1.4 Libya**

### **1.4.1 History of denuclearization**

Libya, led by Colonel Muammar Gaddafi, clandestinely carried out nuclear development from the 1980s and obtained centrifuge components from a nuclear black market. At that time, Libya was isolated from the international community through sanctions due to its terrorist activities. The same as President Saddam Hussein of Iraq, Gaddafi’s ambitions, ensuring a strong dictatorship in Libya and establishing regional hegemony by acquiring the first nuclear weapon in the Arab region against Israel, led him to conduct secret nuclear activities.<sup>7</sup>

Libya, however, could not advance its nuclear program, not only due to a lack of Libya’s nuclear knowledge and technical ability but also necessary foreign nuclear assistance owing to international sanctions imposed on the nation. In March 2003, about the same time as the Iraq War, information on Libya’s underground WMD program was informally transmitted to UK intelligence officials then to the US government. The US and the UK governments initiated secret negotiations with Libya on how to deal with the latter’s WMD program. During the negotiation, the US clearly insisted to Libya that the US’ economic sanctions that had severely damaged its economy would never be lifted, unless Libya abandoned its WMD program. In September 2003, an inspection of the German-flagged BBC-China heading to Libya with uranium centrifuge-related items clearly revealed Libya’s clandestine activities. Faced with this undeniable fact, Gaddafi decided to abandon its WMD program in December, in exchange for lifting sanctions. Upon this decision, the US and UK governments immediately started removing Libya’s uranium enrichment-related equipment and components, in tandem with the IAEA’s verification activities. Most of Libya’s denuclearization activities were completed by March 2004. On the other hand, completely unrelated to this denuclearization, Gaddafi’s regime collapsed, and he was killed in 2011 during Libya’s civil war.

## **1.4.2 Main Characteristics of denuclearization**

First, the US and the UK-led denuclearization of Libya, precisely removing sensitive centrifuge-related items and information out of Libya, in addition to the IAEA's verification, was smoothly completed within just four months (December 2003 to March 2004). This was made possible by careful preparation and cooperation among the US, UK, and IAEA, including clarification of necessary denuclearization work and schedule and precise division of roles among them. In addition, Libya was quite cooperative with the IAEA's verification by offering unlimited access to any site at its borders, although it has not yet concluded an AP with the IAEA. This smooth progress of denuclearization of Libya was later referred to as the "Libya model" as a successful example of denuclearization. Second, lifting sanctions was quite successful in return for Libya's denuclearization, since economic sanctions to Libya have severely damaged its economy. Third, the outbreak of the Iraq War in 2003 and the miserable end of Saddam Hussein who forced a WMD project, resulted in Gaddafi finally deciding to abandon his WMD program.

On the other hand, even after denuclearization, Gaddafi himself maintained his position as the dictator of Libya, but he and his government were overthrown by the US and Europe through military intervention in the wake of the subsequent democratization movement in Libya. Despite Gaddafi's abandonment of the WMD program, he failed to obtain assurance of his dictatorship from the international community. This fact might be interpreted as a negative message regarding denuclearization, whereby if Gaddafi did not abandon his nuclear program, he could have used the program as a symbol of his authority and potentially maintained his dictatorship.

## **1.5 Ukraine, Kazakhstan, and Belarus**

### **1.5.1 History of denuclearization<sup>8</sup>**

With the collapse of the Soviet Union in December 1991, nuclear weapons deployed during the Soviet era were left behind in Ukraine, Kazakhstan, and Belarus. Initially, those countries clearly expressed their intentions of transferring such weapons to Russia by the Alma-Ata Declaration on December 1991.<sup>9</sup> However, they withdrew the Declaration in April 1992 and insisted they would join the First Strategic Weapons Reduction Treaty (START-I) as equal successors of the Soviet Union at par with Russia.<sup>10</sup> However, Kazakhstan and Belarus later decided to be placed under the Russian nuclear weapons umbrella by the Collective Security Treaty,<sup>11</sup> while the US and Russia separately provided Ukraine with security assurance. In May 1992, Russia, Ukraine, Kazakhstan and Belarus signed the Lisbon Protocol to the START-I and they committed not only assuming obligations under the START-I, but also joining the NPT as NNWS in the shortest possible time. In December 1994, the US, UK, and Russia signed the Budapest Memorandum of Security Assurance, which provided security assurance to Ukraine, Kazakhstan, and Belarus after their joining the NPT (China and France provided security assurance to those three states separately). Upon the signature of the Memorandum, START-I and its Lisbon Protocol came into effect on the same day. In response, Ukraine, Kazakhstan, and Belarus transferred all nuclear warheads to Russia and they were consequently disposed of in Russia under the START-I. The US Congress passed the Soviet Nuclear Threat Reduction Act of 1991 (commonly known as the Nan-Luger Act) and provided financial support for the dismantlement and disposal of WMD in the former Soviet Union countries.<sup>12</sup> Verification of the removal and disposal of nuclear warheads was carried out by the US under START-I.

### **1.5.2 Main Characteristics of denuclearization**

First, for Ukraine, Kazakhstan and Belarus, provided security assurance and economic assistance by NWSs were the two most important incentives for their denuclearization. However, in this context, Russia's annexation of Ukraine's Crimea in 2014 was a clear violation of the Budapest Memorandum of Security Assurance in 1994 and it is concerned that such Russia's violation would be a negative factor for future denuclearization. Second, the US's tactful strategy simultaneously achieved both denuclearization of Ukraine, Kazakhstan and Belarus, and Russian's disarmament under the START-I. Third, the importance of the US's Nan-Luger Act and its denuclearization program should also be noted. By this Act, from 1991 to 2012, the US invested \$1 billion annually to the Nan-Luger Program in the form of budget, funds and business.<sup>13</sup> Such investment was used for economic assistance, transfer and disposition of WMD, prevention of nuclear proliferation of scientists who previously engaged in WMD-related activities by transferring them into peaceful research. Such comprehensive and nonproliferation-considered financial and technical assistance for denuclearization could be one of good reference for future denuclearization.

## **1.6 DPRK**

### **1.6.1 History of denuclearization**

The DPRK's nuclear development began in the 1950s with the support of the Soviet Union, against the backdrop of the Korean War and nuclear threats by the US.<sup>14</sup> Therefore, the primary reason for DPRK's nuclear weapons program is for ensuring its national security, while showing legitimacy of domestic governance system.<sup>15</sup>

The Yongbyon Nuclear Research Center is the core of the DPRK nuclear development. According to information by the Nuclear Threat Initiative, which was last updated on May 29, 2012: “the Yongbyon Nuclear Research Center is also the site of North Korea’s 5MWe Reactor and 50MWe Reactor, and a new experimental 25-30 MW(e) light-water reactor, as well as pilot scale and full scale fuel fabrication facilities, the Radiochemistry Laboratory used for reprocessing, and three waste storage facilities known externally as Building 500, Declared Waste Storage Facility, and Undeclared Waste Storage Facility.”<sup>16</sup> The DPRK has conducted a total of six nuclear tests by 2017, the first of which was held in October 2006. According to an interview with Dr. Siegfried Hecker in an article of the *38 North*, dated April 30, 2021, the current most likely number of the DPRK’s nuclear weapons is 45 and he said, “My current estimate is that North Korea has a plutonium inventory in the range of 25 to 48 kilograms. Based on what we have learned about reactor characteristics, including from my visits to the Yongbyon nuclear complex, North Korea can produce at most six kilograms per year at full operation. My inventory estimate is based on production estimates, production losses and estimates of amounts expended in nuclear tests.”<sup>17</sup>

Table 2 below shows some brief background, contents, and results of the four past agreements on the DPRK’s denuclearization.

Table 2 Past agreements on DPRK’s denuclearization<sup>18</sup>

The Joint Declaration of the Denuclearization of the Korean Peninsula <sup>19</sup> (1991)	
Background	<ul style="list-style-type: none"> <li>• Collapse of the Soviet Union</li> <li>• Russia and China approaching South Korea</li> <li>• Removal of US nuclear weapons from United States Forces Korea (USFK)</li> </ul>
Agreement	<ul style="list-style-type: none"> <li>• Not to test, manufacture, produce, receive, possess, store, deploy, or use nuclear weapons</li> <li>• Not to possess nuclear reprocessing and uranium enrichment facilities</li> </ul>
Results	<ul style="list-style-type: none"> <li>• DPRK’s refusal of IAEA’s request for a special inspection</li> <li>• DPRK’s withdrawal from NPT</li> <li>• DPRK withdrawal from IAEA’s membership</li> </ul>
The Agreed Framework (1994)	
Background	<ul style="list-style-type: none"> <li>• Impossibility of gaining support from the former Soviet Union due to collapse of the Union</li> <li>• Slumping of food production and famines in the DPRK</li> </ul>
Agreement	<ul style="list-style-type: none"> <li>• DPRK would freeze all activity at Yongbyon and allow IAEA inspectors to monitor the facility in exchange for: <ul style="list-style-type: none"> <li>✓ Two light-water reactors in DPRK by 2003 (KEDO<sup>20</sup> nuclear plant project)</li> <li>✓ Supply of 500,000 tons of heavy fuel oil annually until one light-water reactor was completed</li> </ul> </li> </ul>
Results	<ul style="list-style-type: none"> <li>• Upon disclosure of DPRK’s program to enrich uranium for nuclear weapons (2002), the following actions were taken between the US and DPRK: <ul style="list-style-type: none"> <li>✓ US suspension of supplying heavy fuel oil</li> <li>✓ DPRK suspension of freezing its nuclear facilities</li> <li>✓ Suspension of KEDO Project</li> <li>✓ DPRK order to leave IAEA inspectors out of the country</li> <li>✓ DPRK’s second declaration of withdrawal from NPT</li> </ul> </li> </ul>
Six-Party Talks	
Background	<ul style="list-style-type: none"> <li>• DPRK concerns about military invasion against the backdrop of the Iraq War in 2003</li> <li>• China’s persuasion of DPRK to join negotiation table</li> </ul>
Agreement	2005 Joint Statement <sup>21</sup>
	2007 Joint Statement <sup>22</sup>
	<ul style="list-style-type: none"> <li>• Agreed verifiable denuclearization of the Korean Peninsula in a peaceful manner</li> <li>• DPRK would abandon its all-nuclear weapons and existing nuclear programs as well as returns to the NPT, in exchange for:</li> </ul>
	<ul style="list-style-type: none"> <li>• US will lead disablement activities and provide the initial funding for those activities</li> <li>• DPRK agreed (1) to disable all existing nuclear facilities subject to abandonment under the September 2005 Joint Statement, (2) to provide a complete and correct declaration of all its nuclear programs and (3) not to transfer nuclear</li> </ul>

	<ul style="list-style-type: none"> <li>✓ Security assurance</li> <li>✓ Energy assistance</li> <li>✓ Peaceful use of nuclear energy</li> <li>• Agreed to take coordinated steps in line with the principle of “commitment for commitment, action for action”</li> </ul>	<p>materials, technology, or know-how, in exchange for:</p> <ul style="list-style-type: none"> <li>✓ Economic and energy assistance</li> <li>✓ Removing the designation of the DPRK as a state sponsor of terrorism</li> <li>✓ Terminating the application of the Trading with the Enemy Act with respect to the DPRK</li> <li>• US lifting freezes of DPRK’s bank accounts in Banco Delta Asia (BDA)</li> </ul>
Results	<ul style="list-style-type: none"> <li>• No progress had been made due to DPRK opposition that its accounts in the Macau-based BDA were frozen under US financial sanctions</li> </ul>	<ul style="list-style-type: none"> <li>• No progress had been made</li> <li>• DPRK failed to adhere to the agreement despite the initial funding having been provided</li> </ul>

As mentioned in the background of the Six-Party Talks, the DPRK has been greatly influenced by China’s behavior, since its trade heavily depends on China (DPRK’s trade dependence with China in 2019 was 95.2%, which was the highest ever).<sup>23</sup> Therefore, whether international sanctions on the DPRK would be effective depends on China’s serious cooperation with the sanctions.

## 1.6.2 Main characteristics of denuclearization

First, as shown in Table 2, the international community has repeatedly negotiated with the DPRK on denuclearization and, in certain agreements, the DPRK promised to freeze and/or abandon certain nuclear activities and facilities under pre-agreed conditions. However, its denuclearization has not been achieved so far. It seems that the international community has been doing the same thing repeatedly from the very beginning, but during that circle, the DPRK has enjoyed promoting nuclear activities. In this context, any irreversible methods that could lead to future denuclearization need to be pursued. Second, the DPRK had agreed to denuclearize in the event of its own security crisis and worsening economic and social conditions. In that sense, for the DPRK, the denuclearization had been an important bargaining chip for diplomatic negotiations. Therefore, it seems that the DPRK would not seriously face its denuclearization without a very large reward from the international community. Third, given China’s great influence on DPRK politically and economically, its presence in the denuclearization negotiation with the DPRK is necessary, so working closely and in step with China on this issue is imperative.

## 1.7 Iran

### 1.7.1 History of denuclearization

Iran became isolated from the international community in the wake of the Iranian Revolution in 1979 and the subsequent Iran–Iraq War from 1980. During the war, Iran was attacked with chemical weapons by Iraq and such attacks, together with international isolation, are said to have led to Iran’s covert nuclear activities from the late 1980s to 1990s, including acquisition of uranium enrichment centrifuge technology and components from nuclear black market.<sup>24</sup> In 2002, an Iranian dissident revealed the existence of Iran’s undeclared nuclear facilities. In October 2003, through the negotiation with the UK, Germany, and France (EU3), Iran agreed to cooperate with the IAEA, sign an AP to Iran’s Safeguards Agreement, and temporarily suspend uranium conversion and enrichment activities (Teheran Agreement). Although Iran continued uranium conversion experiments, it faced renewed sanctions threats; Iran again agreed with EU3 to continue the temporary suspensions in November 2004 (Paris Agreement). The IAEA’s verification afterward revealed Iran’s secret acquisition of centrifuge machines and related drawings from Pakistan’s nuclear black market.<sup>25</sup> When the Iranian conservative-hardline President Mahmoud Ahmadomejad took office in 2005, he overturned the Paris Agreement and resumed uranium enrichment activities. Negotiations between Iran and E3/EU+3, which added the US, China, and Russia, were initiated subsequently. In 2013, moderate-conservative Hassan Rouhani became president and expressed his determination to promote dialog with the international community. After agreeing to the Joint Plan of Action in 2013, Iran and E3/EU+3 finally agreed to the JCPOA in 2015, which was approved by UNSCR 2231. The JCPOA put various restrictions on Iran’s nuclear activities with the aim of increasing the time required for Iran to obtain the nuclear materials needed to produce a single nuclear weapon for more than a year. Such restrictions include those on uranium enrichment capacity (enrichment level, amount of enriched uranium stockpile, number of centrifuges), R&D activities, redesign of Arak heavy water reactor, and ban on weapon-grade plutonium production, together with Iran’s provisional application of AP. In addition, in accordance with Iran’s compliance with the JCPOA, sanctions based on UN Security Council resolutions would be lifted accordingly.

### 1.7.2 Main characteristics of denuclearization

First, in order to maintain Iran’s breakout time for more than a year, and in accordance with its current nuclear development and capabilities, the JCPOA imposes various restrictions on Iran’s nuclear activities, without denying its peaceful use of nuclear energy. In this respect, the JCPOA is a careful, well-considered and tailor-made denuclearization method. Second, sanctions imposed on Iran would be lifted in accordance with Iran’s compliance with the JCPOA and sanctions will be re-imposed in case of non-compliance. Such a gradual (step-by-step) and compliance-based denuclearization method is more acceptable to Iran, unlike the method in Iraqi denuclearization in which sanctions would not be lifted at all unless all WMD were disposed of in Iraq. Third, the JCPOA was agreed on by all NWSs and approved by the UN Security Council. It means that the JCPOA was well accepted by the international community and originally it could expect broad international cooperation, although, as an exception, ex-US President Trump withdrew America from the deal.

## 2. Eight denuclearization factors essential to consider for leading successful Denuclearization

### 2.1 Eight denuclearization factors

Based on denuclearization history and the characteristics of eight countries, we derived eight denuclearization factors that are essential to consider for leading successful denuclearization as follows: (a) Motivation for nuclear development (motivation for maintaining inherited nuclear weapons in the denuclearization case of Ukraine, Kazakhstan and Belarus), (b) Progress of nuclear development, (c) Domestic and international circumstances at the time of denuclearization, (d) Incentives for denuclearization, (e) Effects of sanctions, (f) International framework for denuclearization, (g) Denuclearization methods, and (h) Verification methods and verifiers.

### 2.2 Details of eight denuclearization factors

Table 3 below shows details of eight denuclearization factors, together with countries to which such details apply most.

Table 3 Eight denuclearization factors

Denuclearization factors		Countries	
(a) Motivation for nuclear development/ motivations for maintaining inherited nuclear weapons	National security concern	South Africa, Ukraine, Kazakhstan, Belarus, Iran, DPRK	
	Isolation from the international community	South Africa, Libya, DPRK	
	Establishing regional hegemony by acquiring the first nuclear weapon in the Middle East against Israel	Iraq, Libya, Iran	
	Establishing and maintaining a dictatorship	Iraq, Libya, DPRK	
	Political bargaining chip	Ukraine, Kazakhstan, Belarus, DPRK	
(b) Progress of nuclear development	Possess nuclear weapons/nuclear explosive devices	Independent development	South Africa, DPRK
		Inherited	Ukraine, Kazakhstan, Belarus
	Not yet to possess nuclear weapons, but possess facilities/equipment related to nuclear weapon-usable material (HEU, Pu)	Possess production facilities	Iran
		Possess R&D facilities	Iraq
(c) Domestic and international circumstances at the time of denuclearization	International circumstance	Possess production components	Libya
		War/use of military force	Iraq
		Changes in the security environment	South Africa, Ukraine, Kazakhstan, Belarus, DPRK

		Iraq War and collapse of Saddam Hussein's regime	Libya, DPRK, Iran
	Domestic circumstance	Suffer political, social, and/or economic exhaustion	South Africa, Libya, DPRK, Iran
		Change in political system/change of leader	South Africa, Iran
(d) Incentives for denuclearization	Provide security assurance		Ukraine, Kazakhstan, Belarus, DPRK
	Lifting sanctions		South Africa, Iraq, Libya, DPRK, Iran
	Return to the international community		South Africa, Libya
	Financial support		Ukraine, Kazakhstan, Belarus
	Energy assistance		Same as above, DPRK
	Securing employment of nuclear scientists		Ukraine, Kazakhstan, Belarus
(e) Effects of sanctions	Suffered from sanctions		Libya, Iran
	Necessarily suffered from sanctions		South Africa, Iraq, DPRK
(f) International framework for denuclearization	None		South Africa
	United Nations (Based on UN Security Council Resolution)		Iraq
	Multi-state framework including NWSs		Libya, DPRK, Iran
	US-Russia arms control treaty (START-I)		Ukraine, Kazakhstan, Belarus
(g) Denuclearization methods	Nuclear weapon	Removal/transfer	Ukraine, Kazakhstan, Belarus
	Nuclear explosive device	Dismantlement /disposition	South Africa
	Nuclear weapon usable material	Removal/transfer	Libya, Iraq, Kazakhstan, Belarus
		Keep as own stockpile	South Africa, Belarus
	Facilities, equipment, and components related to producing nuclear weapon usable material	Limitation of ability	Iran
		Freezing	DPRK
		Distraction/Disposition	Iraq
		Removal	Libya
(h) Verification	Methods	Based on CSA with IAEA	South Africa, DPRK (Agreed Framework)
		Based on CSA and AP (including similar to AP methods and provisional application of AP)	Iraq, Libya, Iran
		Based on US-Russia arms control treaty (START-I)	Ukraine, Kazakhstan, Belarus
	Verifier	IAEA	South Africa, Iraq, Libya, DPRK (Agreed Framework), Iran
		US	Ukraine, Kazakhstan, Belarus

### **3. Relationship and combination of the eight factors**

Based on the case study in Chapter 1 and eight denuclearization factors described in Chapter 2, we analyzed their relationship and combination for the international community to lead successful denuclearization, as follows.

First, in order to lead a country's decision to conduct denuclearization, it is essential to provide it with incentives for denuclearization, while considering the nation's motivation for nuclear development, progress of nuclear development, and domestic and international issues affecting the country. Among various incentives for denuclearization, security assurance by NWSs is one of the most effective incentives, on the condition that NWSs continue to grant it. Otherwise, it could be a good excuse to drive the country toward re-nuclearization. Another effective incentive is sanctions relief. It will be difficult to stop nuclear development solely with sanctions. However, if sanctions can have a direct impact on national security and its economy, along with its politics and society, and without loopholes, it could serve as an effective incentive for denuclearization. Moreover, lifting sanctions could be more favorable to the nation if nuclear development is not as advanced as in Libya. In addition, gradual sanction relief, such as that adopted in the JCPOA, is considered effective, rather than the "all or nothing" method adopted in Iraq's denuclearization case, which might reduce the country's incentives for denuclearization. Furthermore, in general, the more the nation has advanced its nuclear program, the more varied and specifically made-to-order incentives for denuclearization would be required, as shown in the DPRK's denuclearization history. In this context, as to financial support, a long-standing and comprehensive support program such as the US' Nan-Lugar Program could be a good reference, in case denuclearization requires a great deal of expense, not only including the removal of nuclear weapons but also various hard and soft infrastructure developments.

Secondly, regarding various practical denuclearization works, especially as to international framework for denuclearization, an international consensus framework involving NWSs, especially the US and Russia, is indispensable for successful denuclearization as shown in various denuclearization cases. This is due to the fact that from a nuclear nonproliferation viewpoint, nuclear weapons and sensitive materials, equipment, and components could be removed only to NWSs. As to denuclearization methods, as shown in Libya's case, rapid action would be necessary to avoid overturning the political decision for denuclearization, while considering a country's progress of nuclear development and domestic and international circumstances. For this purpose, careful preparation including identification of denuclearization works to be completed, schedule, division of roles among related countries, etc., is required. In addition, as mentioned in 1.6.2 (DPRK denuclearization), irreversible denuclearization methods need to be explored.

Lastly, as to verification methods and verifier, except for nuclear weapons verification that should be completed by nuclear weapon experts in NWSs, the IAEA would be an appropriate verifier utilizing the same verification methods implemented under CSA and AP. The IAEA already has verification experience in Iraq, Libya and Iran based on CSA with them and verification methods and technique under the AP were actually established for detecting undeclared nuclear activities based on the verification experience of Iraq's clandestine nuclear activities.

### **4. Conclusion**

To summarize the above relationship and combination of eight denuclearization factors, it can be concluded as follows: In order to encourage a country's decision for denuclearization, it is necessary to provide it with any incentives for its denuclearization, such as security assurance, especially from NWSs, and sanctions relief and financial support, while considering the domestic and international circumstances surrounding them. Upon its decision for denuclearization, under an international consensus framework including NWSs, irreversible denuclearization methods should be promptly implemented in accordance with its progress of nuclear development. At the same time, in parallel with denuclearization, the IAEA verifies and monitors its denuclearization, principally based on verification methods already implemented under CSA and AP, although NWSs need to be involved in the verification process, if the country in question has already possessed nuclear weapons.

The above conclusion is expected to be helpful for the international community to consider leading successful denuclearization. In the near future, we will especially focus on (g) denuclearization methods and (h) denuclearization verification methods, and verifiers, and analyze what specific methods are more effective and suitable, while referring decommissioning methods of the nuclear fuel cycle facilities from a nonproliferation viewpoint.

### **Acknowledgment**

This study was carried out as a part of policy research studies conducted by Policy Research Office, Integrated Support Center for Nuclear Nonproliferation and Nuclear Security (ISCN), JAEA from 2018 to 2020. We would like to express our sincere appreciation to those who cooperated in our research and provided us with various valuable advice.

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