International Journal of Nuclear Security

Volume 1 | Number 1

7-9-2015

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Recommended Citation

Duchene, Matthew S. and Hall, Howard L. (2015) "Addressing Imbalances in US Nuclear Economic and Nonproliferation Policies," *International Journal of Nuclear Security*: Vol. 1: No. 1, Article 11.
Available at: http://dx.doi.org/10.7290/V7MS3QN3

International Journal of Nuclear Security, Vol. 1, No. 1, 2015

Addressing Imbalances in US Nuclear Economic and Nonproliferation Policies

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Abstract

Foreign civilian nuclear start-ups have an increasing number of international partners capable of supplying fuel cycle technologies. The desire to prevent the spread of dual-use enrichment and reprocessing technology by asking partner states to rely on international fuel markets is a major obstacle for US negotiating civilian nuclear trade agreements, leading to delays. US participation in emerging nuclear markets is being undercut by foreign competition, leading to decreasing economic competition and influence in international nonproliferation issues. It is therefore necessary for the US to reinvest and complete its domestic nuclear fuel cycle and modify its process for implementing civilian nuclear cooperation agreements with other states. By reducing delays in negotiations, having a larger stake in the uranium fuel supply provided to international markets, and outlining a clear waste policy, Washington will advance both its economic and nonproliferation goals.

I. A System Out of Balance

With more and more countries seeking to adopt and integrate nuclear technology into their energy infrastructures, the United States faces a delicate policy dilemma, requiring careful balance of both economic and geopolitical factors. On the one hand, the US government recognizes the benefits of nuclear energy as a low-carbon power source and the economic value of promoting the sale of US nuclear technology abroad. Both are strong incentives to expand civilian nuclear cooperation in foreign markets. But contrasting this open view is the nonproliferation objective of reducing the spread of the technology and knowledge necessary to operate sensitive nuclear fuel cycle processes – particularly uranium enrichment and spent nuclear fuel reprocessing (ENR).

The dual-use nature of ENR technology, which gives states the ability to produce fissile material either for nuclear fuel or weapons, makes it nearly impossible to firewall a peaceful nuclear power program from a nascent weaponization capability. Many states are content to use the international market for nuclear fuel but are reluctant to forego developing indigenous ENR technology in the interests of energy security. Independently operated ENR technology is arguably one of the most desirable capabilities for states looking to justify the expense of nuclear power in order to enhance domestic energy security.

At first glance, the United States' economic and nonproliferation objectives appear at odds with one another, and this is true in many instances. But it is also possible to advance both US civilian nuclear technology and nonproliferation through the same strategy. The two-part solution is almost entirely domestic: 1) reinvest in the US nuclear fuel cycle with the focus of providing international support to global markets, and 2) modify the process for implementing 123 Agreements—which Washington currently uses to negotiate bilateral nuclear cooperation with foreign countries while still guaranteeing certain nonproliferation reassurances. Achieving the first objective will create more alternatives for foreign governments to consider rather than develop their own ENR capabilities. Achieving both objectives will enable US nuclear industries to be more competitive in the world market.

II. The Nuclear Trade Paradox

Civilian nuclear cooperation is one of the principle tenants of the Treaty on Nonproliferation of Nuclear Weapons (NPT); it acknowledges the right of all states to peacefully use nuclear technology **[*1*]**. If this seminal agreement could be perfectly implemented, non-weapons states would only ever enter into civilian nuclear technology agreements with nuclear weapon states under the condition that their nuclear technology is never used to develop nuclear weapons.

Unfortunately, history is littered with examples of how the NPT is both a success and a failure at preventing the spread of nuclear weapons. The NPT has halted or eliminated a number of potential nuclear weapons programs since first entering into force in 1970. Many states have forsworn nuclear weapons in their territories and are successfully monitored through agreements with the International Atomic Energy Agency (IAEA). But weapons programs *have* spread to non-NPT signatories (e.g. India and Pakistan) as well as NPT signatories (e.g. North Korea). NPT's imperfections became especially evident after two distinct, eye-opening episodes in NPT-signatory Iraq: the discoveries of its surprisingly advanced nuclear weapons program in 1991 and then the lack thereof in 2003. These events show that the conditions set by the NPT, and its implementation and monitoring through the IAEA, are no longer a sufficient guarantee for the United States and many other governments to control the spread of nuclear weapons and their ENR precursor systems. Technology transfers of *any* nuclear fuel cycle process naturally give the recipient state a newly realized ability to advance nascent nuclear weapons production capability, but preventing the spread of ENR technology is the best way to prevent proliferation.

The US has a strong array of additional controls for restricting the spread of ENR technology. International control and inspection regimes – such as the Nuclear Suppliers Group (NSG) and the Australia Group – provide export control coverage by applying international standards for technology transfer. US civilian nuclear cooperation agreements – called "123 Agreements" after the governing section 123 in the Atomic Energy Act **[*2*]** – provide strong assurances to Washington and the international community that a state's declared, civilian nuclear infrastructure is not being surreptitiously used for military purposes. The IAEA takes responsibility for verifying the correctness and completeness of state-declared nuclear infrastructure. The United States and international community also have tools to restrict the spread of dual-use technology when conventional controls fail. International sanctions can curb attempts by states to circumvent these control mechanisms, as most recently demonstrated by the Iranian nuclear crisis.

Along with these efforts to restrict the transfer of nuclear technology, there are practical, economic reasons why the US promotes the spread of nuclear technology abroad **[*3*]**. The multi-billion dollar cost of building a nuclear power plant makes commercial participation in any capacity, ranging from supplying parts to consulting, an attractive business venture. Commercial nuclear power plants also require constant operational support, spare parts, and consultation over their lifetime – which can be sixty years or more.

The US nuclear industry is actively seeking participation in new foreign markets. Technology transfers and product sales cannot take place without a 123 Agreement, and the international competition is strong: the UAE is scheduled to complete its first of four nuclear reactors in 2017 under a South Korean led consortium **[*4*]**; Egypt **[*5*]** and Vietnam **[*6*]** will each build their first commercial reactors with Russian plant designs and building contracts; and China and Argentina are currently negotiating the construction of Argentina's next reactor **[*7*]**. Overall, the value of America's principal nuclear technology exports have remained constant over the past two decades, yet the percentage of global market share has decreased substantially (see Figure 1).

There are several factors stunting US growth in nuclear exports **[*8*]**, but because most foreign governments do not require companies in their countries to operate under a 123-type agreement, they are able to enter markets much earlier to compete for business[1]. Foreign, state-owned entities have a particular advantage over American commercial companies because they can offer additional perks to sweeten potential deals and are able to operate without the same nonproliferation restrictions applied by Washington **[*9*]**. Foreign competition also decreases the United States' global influence in nonproliferation areas. It limits opportunities for Washington to engage international partners on security and nonproliferation training, cooperative assistance, or help develop strong nuclear security polices.

[1] Some governments are indirectly burdened by US nuclear trade agreements. South Korean companies are, for example, constrained from developing ENR and thus from providing services to third parties based on those technologies. As of June 2015, the US and South Korea have renewed the 123 Agreement with a limited provision to allow South Korea to develop uranium enrichment.

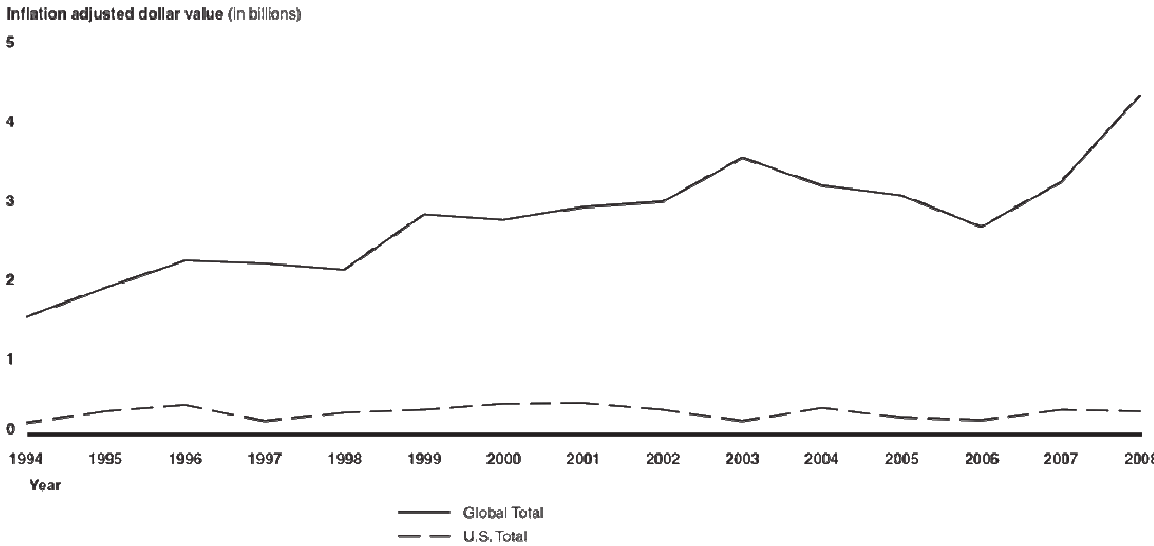

Figure 1. Value of US and Global Exports of Nuclear Reactors, Major Components and Equipment, and Minor Reactor Parts, 1994 through 2008, in 2010 US Dollars [*8*].

From an economic and nonproliferation policy prospective, it is in the best interests of the US government to expand its participation in the global nuclear marketplace. But US companies cannot participate in these new markets without an approved 123 Agreement, and the pace of negotiations for 123 Agreements is far too slow to give US companies a timely opportunity to expand into the market. In the case of Vietnam, negotiations for a 123 Agreement with the United States opened in 2010 but an agreement did not enter into force until October 2014. The process slowed because some insisted that the language in Vietnam's agreement should renounce ENR technology development known in the United States as a "gold standard" 123 Agreement **[*10*]**.

The United States did successfully negotiate a gold standard 123 Agreement with the United Arab Emirates in 2009. While praised at the time, Washington has not succeeded in implementing the same "gold standard" terms with other states. Even prior to the gold standard, no instance of weapon proliferation occurred because of a technology transfer made under a 123 Agreement **[*11*]**. Many states view ENR technology as part of their right under the NPT to produce civilian nuclear technology for peaceful purposes. Even if a prospective state has no intention of pursuing ENR, there is a natural political reluctance to give up this right.

The United States is not the gate-keeper of reliable, civilian nuclear technology. Uniform insistence on creating 123 Agreements that meet the gold standard is likely to be self-defeating. Other states like Russia and China are able and willing to provide the necessary technical assistance needed to start nuclear energy programs without such restrictions. The 123 Agreement with Vietnam did eventually include a non-binding political statement that Hanoi will refrain from pursuing ENR in lieu of the global fuel market. The global fuel market must therefore provide both a secure and economically viable alternative to states requiring steady access to nuclear fuel.

DOI: 10.7290/V7MS3QN3

III. Assuring Global Fuel Supplies

If Washington wants to discourage foreign governments from pursuing ENR programs, it needs to help provide this viable alternative. It is much easier to convince a state like Vietnam to pursue fuel on the global market if the US plays a larger role in guaranteeing a reliable supply of fuel.

While governments generally explore nuclear energy as a means to produce a reliable, secure source of electricity, they cannot guarantee the continuous supply of nuclear fuel that commercial nuclear power plants need. This presents tremendous financial, energy security, and economic risks. Plant outages cost operators millions of dollars per day in lost revenue and impact a state's economic productivity. Though related to the Fukushima accident and not to fuel supply constraints, plant outages in Japan are greatly impacting Japanese businesses **[*12*]**. Because of Ukraine's geopolitical tensions with its previous fuel supplier, Russia, Ukrainian utilities have now entered into fuel supply contracts with Westinghouse **[*13*]**.

For governments and utilities, guaranteeing a fresh fuel supply is a prerequisite to starting any new reactor project. Nuclear fuel cycle processes are high capital cost projects, particularly for inexperienced states, but the need to ensure adequate and uninterruptable fuel supplies propels research, development, and deployment (RD&D) strategies for the fuel cycle process. The economics of fuel supply lead many states – particularly those without significant landmass or with only a handful of reactors – to purchase their fuel from international vendors.

Iran stands as a modern exception. Tehran argues that it requires as many as 190,000 gas centrifuges to provide enriched fuel for its commercial reactor **[*14*]**, reasoning that its fuel supply is vulnerable to international pressures. Possessing this many centrifuges for a peaceful uranium enrichment program is a legitimate argument. In his February 15, 2015, testimony to Congress, US Secretary of State John Kerry correctly stated, "…a civilian power plant that's producing power legitimately and not a threat to proliferation, you could have as many as 190,000 or more centrifuges… So the key here is, is this a peaceful program, and are the measures in place capable of making sure you know it's peaceful?" **[*15*]**.

But assuming a state insists on developing and operating its own ENR facilities, as Iran does, then the problem is that even peaceful nuclear power programs require more enrichment capacities than what is necessary to produce highly enriched uranium (HEU) for weapons purposes. That makes it impossible to separate civilian ENR from latent nuclear weapons capabilities. Even the technical knowledge gleaned from the operation of a civilian process is in itself a substantial advance towards a weaponization capability. Therefore the US and the international community must not only consider how to monitor declared—and detect undeclared—ENR facilities, but they must also consider how to dismantle the fuel supply "vulnerability" argument.

Russia currently fuels Iran's Bushehr 1 nuclear power plant, with the provision that the spent nuclear fuel (SNF) will be repatriated after it is discharged from the reactor and cooled. Such fuel contracts prevent proliferation and operate in the spirit of the NPT because they eliminate Tehran's justification for pursuing an indigenous enrichment RD&D program on the grounds of energy security.

It is mostly in Washington's best interest to imitate such fuel supply agreements in other countries to take advantage of their obvious economic and nonproliferation benefits, but first America must resuscitate its own commercial domestic enrichment capability. The front end of the US fuel cycle has suffered gradual decay. The last US-owned commercial enrichment plant, the Paducah Gaseous Diffusion Plant, closed in May 2013, marking the first time since the Manhattan Project that the United States did not have access to a domestic enrichment capability. In 2013 American utilities alone required 12 million separative work units (SWU)[2] **[*16*]**. In 2015 the Nuclear Energy Agency (NEA) predicts that the US will have an enrichment plant capacity of only 4.3 million SWU **[*17*]** – requiring significant foreign enrichment. That being said, this figure is misleading because Urenco, a non-US enrichment company, controls all of that capacity. If the United States wants to guarantee a supply of nuclear fuel to countries that agree not to develop ENR, it needs to rebuild its own capability.

IV. Completing the Fuel Cycle

The United States' lack of capability to dispose of SNF also severely limits Washington's ability to influence what other states wish to adopt for their own programs. As a matter of policy, states investing in fuel cycle RD&D develop a comprehensive plan based generally on how it handles its SNF. States may use "open" or "closed" fuel cycles. "Open" fuel cycles are described as once-through fuel cycles where SNF is deposited in a long-term geological repository. In contrast, "closed" fuel cycles involve reprocessing SNF to recycle usable uranium and plutonium fuel back into reactors. Today a number of states that provide fuel contracts to foreign nuclear reactors—namely France, Russia, and the UK—use closed fuel cycles to reduce waste and recover valuable fuel and other transuranic isotopes.

While the United States boasts the largest commercial fleet of over one hundred operating nuclear power plants and a robust nuclear navy, it has yet to complete its domestic fuel cycle. The Nuclear Waste Policy Act of 1982 and its amendments sought to establish a long-term geological repository for SNF and other high level waste, but recent policy changes have postponed this effort indefinitely. There are also no plans to reprocess SNF in the United States, meaning the US has neither an open nor closed fuel cycle.

Despite previously enacted laws[3] and efforts to find a solution through the 2010 Blue Ribbon Commission (BRC)[4], there is no final disposition path for SNF in the US. The BRC issued a series of recommendations that called for the urgent adoption of an interim and permanent disposal solution for America's high-level waste **[*18*]**. The current political environment makes resolution of this issue unlikely, and the lack of resolution will continue to undermine US nonproliferation policy. Without its own completed fuel cycle, Washington will continue to negotiate from a weaker position when trying to convince other states to avoid pursuing reprocessing RD&D for their own fuel cycles.

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[2] SWU is a standard industry unit of measurement to quantify the amount of work performed to separate isotopes, such as uranium-235 from uranium-238.

[3] The Fuel Waste Disposal Act of 1982 established the repository at Yucca Mountain in Nevada. The Obama Administration sought to defund the Yucca Mountain project in 2009.

[4] The Blue Ribbon Commission on America's Nuclear Future was a committee of experts convened to research and issue recommendations for disposing of America's SNF.

DOI: 10.7290/V7MS3QN3

Having completed either an open or closed fuel cycle will strengthen longer term US goals for disposing of nuclear waste and convincing others to do so in a responsible manner. The US government rejected the reprocessing pathway in the 1970s, believing that other states would follow suit; but Washington cannot expect others to follow its example of rejecting reprocessing if it cannot demonstrate the viability of adopting an open cycle. Finland is presently the only state actively constructing a licensable long-term storage facility for high-level waste. This completed open fuel cycle demonstrates the reliability of the geological repository concept that others may follow.

Despite the United States' current position, other states have made the political decision to pursue SNF reprocessing. While current technology makes reprocessing economically unfavorable, other states have chosen, for various reasons, to absorb the expense. France, Japan, South Korea[5], and the UK have all adopted a closed fuel cycle policy because of their highly developed civilian nuclear power infrastructure, limited landmass for a geological repository site, and lack of indigenous uranium resources. Therefore, US policy makers must consider more than cost when dissuading others to forego SNF reprocessing. High-level waste reduction, trade deficits, and energy security are also factors. Thus if the US reexamines its position on civilian SNF reprocessing, with a goal of providing a national reprocessing capability to others, Washington would strengthen its nonproliferation goals. Doing so would eliminate the need for states with smaller nuclear programs to develop reprocessing or Yucca Mountain-scale geological repositories for themselves.

Other states with more limited generating capacity tend to seek agreements with some of the aforementioned states to allow them to reprocess their SNF. The BRC recommends this concept of a "take-away" arrangement, whether in an open or closed fuel cycle, as a desirable capability for the US to adopt:

> "Fuel 'take-away' arrangements would allow countries, particularly those with relatively small national programs, to avoid the very costly and politically difficult step of providing for waste disposal on their soil and to reduce associated safety and security risks…. The United States has implemented a relatively small but successful initiative to ship spent foreign research reactor fuel to US facilities for storage and disposal…. *A similar capability to accept spent fuel from foreign commercial reactors, in cases where the President would choose to authorize such imports for reasons of US national security, would be desirable within a larger policy framework that creates a clear path for the safe and permanent disposition of US spent fuel.*"
>
> **[*18*]**.

A completed US fuel cycle is necessary for the advancement of Washington's nonproliferation goals and objectives. Either completed fuel cycle will increase Washington's options for convincing others to forgo reprocessing. Future 123 Agreements may also allow for a take-away provision where the US would provide fuel to a state on the condition that the SNF be repatriated to the US. But even when this option is not available, Washington will be able to highlight its own SNF disposition strategy as a viable path forward for other states.

[5] South Korea is not currently reprocessing SNF but is seeking authorization from the US government to reprocess US origin uranium in the latest 123 Agreement negotiations.

V. Modify 123 Agreement Negotiations

Presently, 123 Agreements are a requirement for all US bilateral nuclear engagements, regardless of the scope or process. While designed to encompass all technologies in the fuel cycle, reduce the number of negotiating ambiguities, and avoid the hassle of creating multiple independent negotiating and confirmation processes, negotiating hurdles surrounding ENR issues adds substantial delays. The US can avoid these delays—which allow foreign competition to gain strong market positions over US companies —by modifying the process for adopting 123 Agreements.

Building and operating nuclear reactors are by far the most complex and costly undertakings in the nuclear fuel cycle. For most states starting a new nuclear power program, the initial focus is on reactor technology. Fuel supply considerations are a requirement, but fuel cycles are built around the necessary electricity generation. This gives the US room to create an initial, narrowly focused conditional agreement where US companies could supply states with bids for reactor designs and components. The concept of a "Limited-Scope 123 Agreement" can be negotiated in an abbreviated timeframe to allow US companies to make commercial light water reactor (CLWR) technology transfers. CLWRs are a low risk nuclear proliferation technology under IAEA safeguards. US export control regulations – informed by the NSG and US law – will prevent tech transfers outside of the scope of a Limited-Scope 123 Agreement.

US participation beyond this initial agreement is contingent on the adoption of a full 123 Agreement, giving negotiations time to address ENR issues. During this time US companies can draw new business, and Washington will not compromise its nonproliferation goals and objectives. This approach will also give Washington more opportunity to engage in extensive conversation with the partnering state's officials on nuclear issues including safety, regulation, and trade. This change needs to happen soon to avoid missed opportunities while ENR questions are still being resolved.

VI. Implementing Changes

Under present conditions and for nonproliferation and economic reasons, there may not be a better time for Washington to implement these changes to the US nuclear fuel cycle and how it approaches civilian cooperation. New commercial nuclear projects are continuing, even in the aftermath of the Fukushima-Daiichi nuclear accident. Sixty-eight reactors are currently under construction around the world [***19***]. People expect nuclear energy to play a major role in reducing carbon emissions while providing reliable baseline electricity generation.

The uranium enrichment market – presently saturated due to Germany's decision to phase-out nuclear energy and Japan's lengthy process for restarting its reactors – will rebound if future nuclear projects continue to expand. The US requires an independent enrichment capability under international agreements to provide fuel for its tritium production reactor. Further development of a US enrichment capability is justified to reduce the potential that foreign clients will seek an indigenous enrichment program.

As the BRC stated in its final report, the need for a long-term, high-level waste solution in the US is paramount. The US needs to act to implement a domestic waste solution and cannot miss the chance to craft a greater nonproliferation strategy while completing the fuel cycle back end.

DOI: 10.7290/V7MS3QN3

Implementing a waste disposal strategy is an incredibly difficult undertaking, but the cost of waiting will compound the already steep economic expenses and the number of missed nonproliferation opportunities.

Conditions are currently very favorable for Washington to invest in US fuel cycle development activities including the reconstitution of an enrichment capability and the completion of a formal waste policy. The industry requires modern fuel cycle service, and energy prices have fallen from their historic highs—reducing transportation and construction expenses. The presently strong US dollar increases the purchasing power for potential foreign design and construction assets.

There are other options for addressing the concerns of global fuel supply and disposing of high-level waste in states without fully developed fuel cycles through the adoption of multilateral fuel cycle facilities. A number of proposals made by the US and others[6] recommend that internationally owned and controlled facilities be established to guarantee the fuel supply for the international community. Proposals for international fuel banks are not new **[*20*]**, and they address critical concerns of states and nonproliferation advocates. However, such proposals cannot guarantee that all states will forgo construction or operation of their own ENR facilities. It will take time to bring about an international consensus on a single proposal and successfully implement an international fuel cycle regime. During such time, the US can still take advantage of the recommendations proposed here.

There are natural next-steps for the US government to consider in finding the right balance in advancing seemingly competing objectives. While policy balance amid bilateral relations does not have a one-size-fits-all solution, improvements as to how the US conducts its own domestic nuclear affairs and seeks engagements with others will allow its nonproliferation influence to grow abroad while supporting economic opportunities for businesses at home. Reinvestment in the domestic fuel cycle, rapid commercial engagement with foreign clients in non-ENR areas of the fuel cycle, and the possibility for supply guarantees and/or take-away assistance will reduce incentive and justification for the proliferation of dangerous ENR technology. There are no silver bullets in preventing the spread of nuclear weapons technology, but these recommended changes would improve the US policy balance between nuclear energy economics and nonproliferation.

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[6] See Nikitin, Andrews, and Holt for a comprehensive list and discussion of international fuel cycle proposals and concepts.

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