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# Facing the Reality of Iran as a De Facto Nuclear State: Centrifuge Enrichment and the IAEA February 24, 2012 Safeguards Update

In various papers since 2008, this author has outlined how Iran's growing centrifuge enrichment program could provide it with the ability to produce Highly Enriched Uranium (HEU) for nuclear weapons.[2] On February 24, 2012 the International Atomic Energy Agency (IAEA) published its latest safeguards update. This update shows that not only has Iran's centrifuge enrichment effort continued to be unimpeded by Western counteraction but that it has undergone a significant expansion. In particular Iran has made good on its announcement of June 2011 that it would triple its production of 19.7% enriched uranium by beginning enrichment operations at the well-protected Fordow facility. At its main enrichment facility at Natanz, Iran increased its production of 3.5% enriched uranium by an additional 15%, meaning it has doubled production since 2009—this is in stark contrast to the popular perception that cyber-attacks have crippled Iran's enrichment effort. I estimate that Iran could produce enough HEU for a nuclear weapon in one and one half months to three and two-thirds months and might be able to produce enough HEU for three nuclear weapons in just six months if it were to decide to quickly do so (See Appendix 1).

Iran's rapid progress has changed the perception of the problem of Iran's nuclear program, even for those who disagree with my current assessments. It is now obvious that even if my assessments are not true at this moment, they soon will be. For example, Olli Heinonen at the Harvard Belfer Center and former deputy director general of the IAEA has estimated that if Iran were to now make an all-out effort, it could produce enough HEU for a nuclear weapon in just six months. However, due to Iran's rapid progress in producing 20% enriched uranium, by the end of 2012 Heinonen estimates that Iran could produce this HEU in just one month.[3]

It was just last fall that David Albright of the Institute for Science and International Security was promoting the cheery notion that sanctions had capped Iran's nuclear program and that with its increasingly unreliable centrifuges, Iran's enriched uranium production had reached its maximum and was beginning to decline. Clearly this is not the case and no longer is there any pretense that direct sanctions on Iran's nuclear program will stop Iran from being able to produce the HEU for nuclear weapons.

This does not mean that most analysts (including those in the U.S. government) are willing to accept my view stated last September that Iran is in fact so close to having a nuclear weapon that

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[2] My most recent report is: Gregory S. Jones, "Iran's Efforts to Develop Nuclear Weapons Explicated, Centrifuge Uranium Enrichment Continues Unimpeded, The IAEA's November 8, 2011 Safeguards Update," December, 6, 2011, http://npolicy.org/article.php?aid=1124&rid=4

[3] Olli Heinonen, "The 20 Percent Solution," *Foreign Policy*, January 11, 2012.

it is already a de facto nuclear weapon state.[4] Rather the focus has shifted to the non-nuclear components that would be needed to detonate Iran's HEU and implausible claims that it will take Iran one to three years to develop a "deliverable" nuclear weapon. In addition, most observers still cling to the hope that somehow Iran can be stopped from acquiring nuclear weapons. The methods that they foresee for stopping Iran are either some form of military strike, the effects of sanctions, diplomacy or some combination of these elements. As we will see, none of these methods holds much promise.

**Non-nuclear Weapon Components**

As I have pointed out in prior writings,[5] the viewpoint that it will take Iran years to develop the non-nuclear components required for a nuclear weapon is hard to square with the actual historical experience of the nuclear weapon states. It is well-known that for past nuclear weapon programs, the key impediment was the need to acquire the fissile material (HEU or plutonium) for the weapon. The production of the non-nuclear components needed to detonate the fissile material was relatively easy and the development of these components was usually done in parallel to the more costly and time consuming effort to produce fissile material. After all the non-nuclear components of a nuclear weapon rely on conventional high-explosive technology and any country advanced enough to acquire nuclear weapons has a military large enough to have substantial high-explosive expertise.

The U.S. in 1944 was able to develop an implosion type nuclear weapon (the type that Iran would produce) in just 11 months and this should be considered an upper bound on the time that Iran would require. Though today Iran would not have the talent and resources available to the Manhattan Project, it would be starting from a far better position than the U.S. did. In 1944, no one knew whether or how the implosion method could work. Today it is not only well known that such weapons work but also there are descriptions of such weapons and pictures showing their general construction. Additionally, knowledge of explosives as well as computing power are far superior today than they were 68 years ago when the U.S. undertook this effort.

Moreover, Iran would not be starting from scratch. As the IAEA described last November, prior to 2004, Iran was assisted in developing "a multipoint initiation system that can be used to initiate effectively and simultaneously a high explosive charge over its surface" by "a foreign expert" who "worked for much of his career with this technology in the nuclear weapon programme of the country of his origin."[6] According to press reports, this "foreign expert" is a Russian named Vyacheslav Danilenko. The IAEA has been told "by nuclear-weapon States that the specific multipoint initiation concept is used in some known nuclear explosive devices."

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[4] Gregory S. Jones, "No More Hypotheticals: Iran Already Is a Nuclear State, *The New Republic*, September 9, 2011, http://www.tnr.com/article/environment-and-energy/94715/jones-nuclear-iran-ahmadinejad

[5] Gregory S. Jones, "Iran's Efforts to Develop Nuclear Weapons Explicated, Centrifuge Uranium Enrichment Continues Unimpeded, The IAEA's November 8, 2011 Safeguards Update," December, 6, 2011, pp. 10-13, http://npolicy.org/article.php?aid=1124&rid=4 and Gregory S. Jones, An In-Depth Examination of Iran's Centrifuge Enrichment Program and Its Efforts to Acquire Nuclear Weapons, August 9, 2011, pp. 23-25, http://npolicy.org/article.php?aid=1092&rid=4

[6] *Implementation of the NPT Safeguards Agreement and relevant provisions of Security Council resolutions in the Islamic Republic of Iran*, GOV/2011/65, November 8, 2011, Annex, pp.8-9.

This "multipoint initiation system" will allow Iran to manufacture sophisticated nuclear weapons and Iran is now in a position to build nuclear weapons that are significantly lighter, and have a smaller diameter than the cruder nuclear weapons that are typical of countries' early efforts. In 2003 Iran had already conducted at least one full-scale test of its multipoint initiation system with the hemispheric shape required for a nuclear weapon and sized to be used as a missile warhead. Furthermore, since that time Iran has continued to test this system but it is now using scaled down versions and employing a cylindrical geometry. Such geometry is not directly applicable to a nuclear weapon but according to the IAEA such tests would still allow Iran to improve and optimize the multipoint initiation design. As a result I estimate that Iran could develop the non-nuclear components for a nuclear weapon is just two to six months.

A common mistake is to assume that Iran's production of HEU and its production of the non-nuclear components for its nuclear weapons would need to occur in series. However, it is clear from the published accounts of the U.S, British and Chinese nuclear weapons programs that this development tends to occur in parallel instead. William Penney, who led the British effort to develop nuclear weapons, outlined the process. According to the official British history:

> "He said that the manufacture of an atomic bomb of present design fell naturally into two parts: firstly the production of the active material and secondly the ordnance part, that is, the manufacture and assembly of the components causing the explosion of the active material. The second part of the work could be begun and *completed* without the need to use fissile material at any stage."[7] [Emphasis added]

Therefore not only can the production of the fissile material and the non-nuclear components of a nuclear weapon occur in parallel, the production of the non-nuclear components can occur first. This fact was demonstrated by U.S. experience in World War II. The non-nuclear components of the Hiroshima nuclear weapon were on the cruiser *Indianapolis* and sailing across the Pacific Ocean while some of the HEU components for the weapon were still being manufactured. The fact that the IAEA has provided information showing that Iran is currently developing the non-nuclear components for nuclear weapons even though Iran does not yet have any HEU further reinforces this point.

Though some have indicated that Iran might be able to develop a nuclear weapon in a year or less, they estimate that it could take Iran two to three years to develop a "deliverable" nuclear weapon i.e. one that could be fitted as a warhead to a ballistic missile. There are several problems with this estimate. First, Iran does not need to use ballistic missiles to deliver its nuclear weapons. Vehicle delivery of bombs (up to now all conventional) has become quite common in the region and many such attacks have been carried out on U.S. forces. Vehicle delivery of a nuclear weapon against U.S. forces could have a devastating effect and would have the advantage of making it more difficult to attribute the source of the attack.

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[7] At the time the memo was so highly classified that Penney had to type it himself. See: Margaret Gowing, assisted by Lorna Arnold, *Independence and Deterrence: Britain and Atomic Energy, 1945-1952*, Volume I, Policy Making, St. Martin's Press, New York, 1974, p.180.

Second, Iran already possesses and has tested a multipoint initiation system that has been sized for a ballistic missile warhead. Therefore Iran's first nuclear weapon will probably already be small and light enough to fit on a ballistic missile. One should note however, that given the antimissile systems of Israel and the U.S., it is not clear that even if Iran can deliver nuclear weapons by ballistic missiles, that this will be Iran's preferred nuclear weapon delivery mode.

Recent U.S. Government statements on how quickly Iran could build a nuclear weapon should it decide to do so have also indicated that the time required has been declining. But given the now widely held assessment that Iran can produce enough HEU for a nuclear weapon in a matter of months, the U.S. Government assessments are still surprisingly long and are inconsistent as well. Media reporting, in particular that of CBS News has further complicated the situation. On December 19, 2011, CBS News broadcast an interview with U.S. Secretary of Defense Leon Panetta conducted by Scott Pelley:[8]

**Pelley:** So are you saying that Iran can have a nuclear weapon in 2012?

**Panetta:** It would probably be about a year before they can do it. Perhaps a little less. But one proviso, Scott, is if they have a hidden facility somewhere in Iran that may be enriching fuel.

**Pelley:** So that they can develop a weapon even more quickly…

**Panetta:** On a faster track…

**Pelley:** Than we believe…

**Panetta:** That's correct.

This interview caused quite a stir, since it was the first time that someone from the U.S. Government had given a public statement to the effect that Iran could produce a nuclear weapon in less than one year. Prior to that time, there was the belief that Iran was at least several years away. But a month later Panetta seemed to be saying something different in an interview that CBS News broadcast on "Sixty Minutes" on January 29, 2012. Again the interview was conducted by Scott Pelley.[9]

Narration by Pelley: "We were surprised to hear how far he thinks Iran has come."

**Panetta:** The consensus is that, if they decided to do it, it would probably take them about a year to be able to produce a bomb and then possibly another one to two years in order to put it on a deliverable vehicle of some sort in order to deliver that weapon.

At first glance in this second interview it seems that Panetta is just backtracking as well as making the rather dubious assumption that Iran would first produce a nuclear weapon and only then start to work on a means of delivery. But the reality is more complicated. When one

[8] Transcript from: http://www.cbsnews.com/8301-18563_162-57345322/panetta-iran-will-not-be-allowed-nukes/
[9] http://www.cbsnews.com/8301-18560_162-57367997/the-defense-secretary-an-interview-with-leon-panetta/?tag=contentMain;cbsCarousel

watches the video of these interviews,[10] it becomes clear that these are the *same interview* that has simply been edited differently. I find it disconcerting how easily the same interview can be edited to provide a quite different sense of how quickly Iran could produce a nuclear weapon and disappointing that a news organization as distinguished as CBS should have done so. It would be of great value for CBS to publish an unedited version of this interview so that Panetta's real view of this matter could be determined.

James Clapper, the Director of National Intelligence, has presented the Assessment of the US Intelligence Community to a Congressional Hearing on January 31, 2012. In part this statement said:[11]

> "We assess Iran is keeping open the option to develop nuclear weapons, in part by developing various nuclear capabilities that better position it to produce such weapons, should it choose to do so. We do not know, however, if Iran will eventually decide to build nuclear weapons…
>
> Iran's technical advancement, particularly in uranium enrichment, strengthens our assessment that Iran has the scientific, technical, and industrial capacity to eventually produce nuclear weapons, making the central issue its political will to do so. These advancements contribute to our judgment that Iran is technically capable of producing enough highly enriched uranium for a weapon, if it so chooses."

A few comments are in order. The first sentence contradicts itself since if Iran is developing various nuclear capabilities that better position it to produce nuclear weapons then it is doing significantly more than just "keeping open" the option to develop nuclear weapons. Rather Iran is either further developing the option or exercising it.

Absent any concrete time estimates, many of these statements are devoid of meaning. After all, any country (Belize for example) has the "scientific, technical, and industrial capacity" to *eventually* produce nuclear weapons. For Belize the time required would be many decades but for Iran it is presumably a good deal shorter. With the repeated use of the word "eventually," this Intelligence Assessment gives the impression that Iran is many years away but when pressed on this issue at Congressional Hearings in February, Clapper said that Tehran could produce a nuclear weapon in one or two years.[12] Not only is this estimate much more immediate than the term "eventually" implies but it is not consistent with Panetta's one year (or perhaps less than one year).

Panetta's has also placed a great deal of reliance on a semantic distinction that upon further examination turns out to have no significance. This relates to the question of whether Iran is

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[10] Available at the same locations as the transcripts.
[11] James R. Clapper, "Unclassified Statement for the Record on the Worldwide Threat Assessment of the US Intelligence Community for the Senate Select Committee on Intelligence," January 31, 2012, pp. 5-6.
[12] Associated Press, "Panetta says Iran enriching uranium but no decision yet on proceeding with a nuclear weapon," *The Washington Post*, February 16, 2012.

developing a nuclear weapons capability or a nuclear weapon itself. On January 8, 2012 he said:[13]

> "Are they [Iran] trying to develop a nuclear weapon? No. But we know that they're trying to develop a nuclear capability. And that's what concerns us. And our red line to Iran is do not develop a nuclear weapon. That's a red line for us."

But what is the difference? To build a nuclear weapon, Iran (or any country) needs sufficient fissile material (in Iran's case HEU) and the non-nuclear components to detonate the fissile material. Iran is developing both of these elements. How is this not developing a nuclear weapon?

In addition, as was discussed above, *any* country is "nuclear capable" in the sense that given enough time it can build a nuclear weapon. Yet most discussions (and not just those of U.S. Government Officials) use "nuclear capable" without reference to any time element and thus render the term meaningless.

A related factor is the oft repeated statement that Iran has yet to decide to build a nuclear weapon. The implication seems to be that Iran cannot be building a nuclear weapon if it has not decided to do so. But many current nuclear states had nuclear weapons programs before there was a specific decision to build a nuclear weapon. And these nuclear weapon programs helped to enable a decision to build nuclear weapons by allowing countries to get close to acquiring nuclear weapons before any explicit decision was required. As I have written before:[14]

> "Though Iran's leadership may have not yet specifically decided to develop nuclear weapons, the U.K., France, India and Nazi Germany at one time all had nuclear weapons programs before their governments had decided specifically to produce nuclear weapons. The U.K., France and India all went on to make such a decision and have produced nuclear weapons. This underscores the point that as Iran moves closer to having a nuclear weapons capability, it becomes increasing likely that Iran will make the decision to produce nuclear weapons."

**Military Strike on Iran**

The possibility of an Israeli military strike to "take out" Iran's enrichment facilities has been much in the news lately. Though not explicit, there seems to be a general view that this would be a one-time strike, similar to the ones that Israel carried out on nuclear reactors in Iraq in 1981 and in Syria in 2007. Concerns have been raised about the progress of the Iranian program and whether with its partial move of its centrifuge enrichment activities to the underground site near Qom, Iran may be entering a "zone of immunity" whereby the Iranian centrifuge enrichment program can no longer be successfully attacked in a single strike.

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[13] "Face the Nation transcript: January 8, 2012," http://www.cbsnews.com/8301-3460_162-57354647/face-the-nation-transcript-january-8-2012/

[14] Gregory S. Jones, "An In-Depth Examination of Iran's Centrifuge Enrichment Program and Its Efforts to Acquire Nuclear Weapons," August 9, 2011, p.35, http://npolicy.org/article.php?aid=1092&rid=4

In fact, attacking centrifuge enrichment facilities is quite different from attacking single nuclear reactors and Iran's enrichment program is already well into a zone of immunity with regard to a single air strike. At its main enrichment facility at Natanz, Iran has somewhere between 32 and 52 cascades operating in parallel.[15] An air strike on Natanz that scored multiple bomb hits would shut down the entire facility. But the majority of the cascades would be undamaged and not able to operate only due to damage to piping and the loss of utilities. It would only take a few months of repairs before these undamaged cascades were back in operation. Even for the cascades that suffered bomb hits, the majority of the centrifuges would still be undamaged. Iran could pull out the undamaged centrifuges and use them to build new cascades. It would only take four to six months before Iran would have returned to close to full production.

A further problem is Iran's current stockpiles of about 3,000 kilograms of 3.5% enriched uranium and 67 kilograms of 19.7% enriched uranium. These stockpiles represent years of centrifuge plant operation but would be very difficult to destroy by air attack. The combined volume of these two stockpiles is less than one cubic yard—making them very easy to hide or protect.

It is small wonder that U.S. officials when discussing possible attacks on Iran's centrifuge enrichment program have begun to talk of bombing campaigns rather than single strikes.[16] By bombing Iran's facilities every few months, it would be possible to keep Iran's enrichment facilities shutdown. Such a campaign would also have the advantage that the question of whether U.S. large bunker-buster bombs can actually penetrate and hit Iran's underground enrichment facility near Qom would largely be moot. No matter how deep and well protected a bunker is, it is always possible to collapse the entrance tunnels and cut off the utilities from the outside.

There are two problems with such an air bombing campaign. First, Iran could respond by dispersing its centrifuges. Indeed centrifuge enrichment with its many parallel cascades would be ideal for such dispersal. The U.S. would be able to find and bomb some of these dispersed enrichment sites but many would continue in operation undetected. Second, such a prolonged bombing campaign would run a serious risk of turning into a large-scale war with Iran. Though no doubt the U.S. would eventually win such a war, I think that given the financially-exhausted and war-weary condition of the U.S. that such a war would be ill-advised.

**Sanctions**

A key element of U.S. policy is to impose increasingly severe sanctions on Iran. The latest round of sanctions are designed to significantly affect Iran's overall economy by making it more and more difficult for Iran to export its oil. However, these sanctions are not authorized by the United Nations but rather imposed unilaterally by the U.S. and the EU. The reason for this is that despite the IAEA's revelations last November of Iran's efforts to develop the non-nuclear components for a nuclear weapon, both Russia and China have refused to support any additional

[15] Iran has declared to the IAEA that it has 52 cascades in operation but its enriched uranium production is only equivalent to about 32 cascades operating at full capacity.
[16] Joby Warrick, "Iran's underground nuclear sites not immune to U.S. bunker-busters, experts say," *The Washington Post*, February 29, 2012.

sanctions against Iran. Indeed both countries have continued trading with Iran and China continues to purchase oil from Iran.

Nor are China and Russia the only countries that have not adopted these sanctions. India with its important economy has actually increased its purchases of Iranian oil as has South Korea. India has gone so far as to change its tax code so as to facilitate a method of payment that involves using rupees rather than dollars. Pakistan and Turkey have also continued trading with Iran. Pakistan has even proposed deals based on a straight barter arrangement. Japan has cut back on its oil purchases but is expected to ask the U.S. for an exemption from a requirement to eliminate all Iranian oil purchases.

With all of these important economies not complying with the sanctions on Iran, it is not clear that the sanctions will be enough to compel Iran to change its current policies. Even if they can, the real problem is that Iran can resolve all of its outstanding issues with the IAEA but due to the laxity of IAEA safeguards, Iran can still maintain its drive towards the production of nuclear weapons.

**Diplomacy**

Many have continued to hope that negotiations with Iran could provide a means to prevent Iran from obtaining nuclear weapons. But no one has outlined how any realistic agreement with Iran can achieve this goal.

President Obama has said that the U.S. will not allow Iran to obtain nuclear weapons. But as I have written elsewhere, Iran has no need to actually produce a nuclear weapon unless it wants to test or use such a weapon.[17] Therefore it is likely to be many years before Iran does so. The real issue in the near term is not preventing Iran from obtaining nuclear weapons but rather stopping Iran from moving ever closer to being able to build nuclear weapons.

Similarly, President Obama has said that Iran must "make a decision to forsake nuclear weapons" but since many U.S. Government officials have said that Iran has not yet made a decision to produce nuclear weapons, the Iranians can argue that they have already complied with this requirement.

Iran has outstanding issues with the IAEA regarding its nuclear weapons development program. But most of these issues relate to events from 2003 and before. Though it would be domestically politically difficult for Iran, if it were to admit to these prior transgressions, it would be able to end its disputes with the IAEA while not having to give up any of its current centrifuge

[17] "That's not to say that I expect Iran to divert nuclear material from IAEA safeguards anytime soon. After all, why should it? It can continue to move ever closer to the HEU required for a nuclear weapon with the blessing of the IAEA. Iran would only need to divert nuclear material from safeguards when it would want to test or use a nuclear weapon. Recall that the U.S. was unable to certify that Pakistan did not have nuclear weapons in 1990, but it was only in 1998 that it actually tested a bomb. Similarly, though it could be many years before Iran becomes an overt nuclear power, it needs to be treated as a de facto nuclear power simply by virtue of being so close to having a weapon." Gregory S. Jones, "No More Hypotheticals: Iran Already Is a Nuclear State, *The New Republic*, September 9, 2011, http://www.tnr.com/article/environment-and-energy/94715/jones-nuclear-iran-ahmadinejad

enrichment program.  Indeed give the laxity of IAEA safeguards, Iran could go on to produce HEU with the blessings of the IAEA.

Most of those who believe that Iran's nuclear weapons program can be stopped diplomatically have suggested that in order to reach an agreement, Iran should be allowed to keep its centrifuge uranium enrichment program.  Those who hold this view realize that this poses a risk of allowing Iran to obtain the HEU needed for nuclear weapons but they believe that with the proper controls, this risk can be obviated.  In particular, it is often suggested that Iran be limited to producing uranium with an enrichment of less than 5%, reduce its stockpile of 19.7% enriched uranium to zero by exporting all of this material and that Iran's future enrichment program be limited to that which can be justified by its peaceful nuclear needs.  However, Iran's current enrichment facilities are very small compared to those needed for most peaceful nuclear activities (say providing fuel for a single nuclear power reactor) and such an agreement would provide Iran with the justification for greatly expanding its current enrichment facilities.  These greatly expanded facilities would provide Iran easy access to the HEU needed for nuclear weapons.

For example, even if Iran produced only 4.1% enriched uranium and expanded its enrichment capacity by a factor of 20, it would only produce about 15 metric tons of enriched uranium per year.  This amount would still be less than that needed to fuel a single large power reactor yet, using batch recycling, these enrichment facilities could produce enough HEU for a nuclear weapon in just two weeks or enough HEU for five weapons in just five weeks.(Appendix 2)  One might argue that it would take Iran a very long time to expand its enrichment facilities by a factor of 20 using its own resources but it should be remembered that such a diplomatic agreement would serve the function of legitimizing Iran's enrichment activities.  This would lead to the removal of sanctions that are designed to prevent Iran from importing the materials needed to build additional centrifuges and in addition Iran might receive assistance to expand its enrichment facilities (from say China or Pakistan) as part of normal nuclear commerce.

As it is, Iran appears to be laying the groundwork to make such an agreement impossible and to present the P5+1[18] with a lose-lose situation.  In the middle of February 2012, Iran announced a set of three advances in its nuclear program--that it had manufactured and installed a fuel element using 20% enriched uranium into the Tehran Research Reactor (TRR), that it had increased the number of centrifuges operating at Natanz from 6,000 to 9,000 and that it had successfully developed more advanced and efficient centrifuges than the type that Iran currently uses.  This announcement was generally met with derisive comments to the effect that these advances were not that special and that the Iranian Government was playing to its domestic audience.

At the same time Iran indicated that it was interested in restarting negotiations with the P5+1 regarding its nuclear program.  Some observers were puzzled by this seemingly schizoid behavior.  Others were so eager for negotiations that they didn't care about any contradictory indications including Iran's assault on the British Embassy just last November.  However, very few seem to have recognized the significance of the two events together.

[18] The U.S., UK, France, Russia, China and Germany.

By announcing its nuclear advances, Iran is throwing down markers for negotiations. By loading a 20% fuel element into its research reactor, Iran can now argue that it has a legitimate need to produce such enriched uranium and that it will not stop its production. By claiming to have 9,000 centrifuges in operation, Iran is establishing a base below which it will refuse to go. And by claiming a have finished developing advanced centrifuges, Iran is putting itself in a position to be able to significantly upgrade and expand its current uranium enrichment capacity.

This then is the P5+1's no-win situation. It can either refuse in negotiations to allow Iran to keep its centrifuge enrichment facilities in which case Iran can break off the talks, claiming that the P5+1 are being unreasonable. Iran can use this claim to help to break sanctions by playing to on-the-fence countries such as India. Or if the P5+1 should be so foolish as to agree to allow Iran to keep its current enrichment facilities, then Iran will have legitimized these facilities and its ability to quickly to produce the HEU for nuclear weapons whenever it decides to do so.

The only negotiated solution that would prevent Iran from quickly being able to produce HEU would be for Iran to permanently shut down its enrichment facilities and export its stockpiles of enriched uranium. By saying that the P5+1 must accept continuing Iranian uranium enrichment, advocates of a negotiated solution are essentially admitting that no satisfactory negotiated solution is possible.

**Non-Proliferation After Iran**

If in fact Iran is already a de facto nuclear weapon state, where should the U.S. go from here with regards to its non-proliferation policy? The key will be to learn from our failure with Iran and prevent additional countries from acquiring nuclear weapons. This will require a two prong approach.

First, as President Obama has indicated, Iran's de facto nuclear status will motivate a number of other countries to try to emulate Iran's success. The U.S. needs to take decisive action to head off these efforts on a county by country basis as soon as the first steps towards acquiring the fissile material for nuclear weapons are detected. Taking early action runs counter to normal government instincts, which is to try to "kick the can down the road" and avoid taking any unpleasant actions unless it has to. The lack of early action has been a hallmark of U.S. non-proliferation policy since the Reagan Administration and has facilitated Pakistan, India, North Korea and now Iran to acquire the fissile material required for nuclear weapons.

Yet as we saw with Libya, early action can be quite effective. Many believe that Gaddafi made a mistake by giving up a nuclear weapons program but the fact of the matter is that he had no choice. His effort was discovered early, before Libya had even begun to enrich uranium and Gaddafi had no other option.

Second, there needs to be a change to the IAEA's safeguards regime, so as to prevent countries from acquiring the fissile material needed for nuclear weapons with the IAEA's approval. Some in the U.S. Congress have called for military action against Iran if it starts to enrich uranium to levels greater than 20%. But under current IAEA rules such Iranian actions would be perfectly acceptable as long as Iran declared the activity to the IAEA. Similarly, the IAEA permits non-nuclear weapon states to produce pure compounds of plutonium by reprocessing spent fuel. Informally the IAEA does require that the country carrying out these activities provide some rationale as to how these activities are related to some peaceful nuclear activity but the rationale does not have to be very plausible. For example, a country can say that it is stockpiling the plutonium for use in a breeder reactor even if it is now more than 40 years since such reactors were first supposed to come into operation and that such reactors are still decades away.

Much of providing the proper rationale involves learning to play the game properly. As was discussed above, Iran got itself into trouble by conducting clandestine nuclear activities prior to 2004. More recently Iran did a better job and explained that its production of 20% enriched uranium was required to produce research reactor fuel. This activity which is generally agreed to be carrying Iran close to the possession of the fissile material for a nuclear weapon, has not caused the IAEA to say that Iran is violating safeguards even though Iran is currently producing more 20% enriched uranium in one month than the research reactor uses in one year.

The U.S. Government has recognized this problem and in its Nuclear Cooperation Agreement with the United Arab Emirates, it requires the UAE to not possess facilities that can engage in uranium enrichment or the reprocessing of spent fuel which could produce plutonium, HEU or U-233 (another material that can be used to produce nuclear weapons). However, the U.S. administration has discovered the drawback to attempting to handle this problem though its bilateral nuclear cooperation agreements. In the face of competition from Russia and France, the U.S. has proposed nuclear cooperation agreements with Vietnam and Jordan that lack these provisions. Only if the issue is approached by the IAEA will there be uniform standards without commercial pressures undercutting non-proliferation.

Furthermore, even the standards for the UAE are not enough. Non-nuclear weapon countries need to be prohibited from possessing any materials or facilities that can quickly provide fissile material for nuclear weapons. This includes prohibiting not only enrichment and reprocessing facilities but also separated HEU, plutonium or U-233 and HEU, plutonium or U-233 that is contained in unirradiated reactor fuel (such as HEU fuel for research reactors or mixed oxide fuel for power reactors).

The IAEA does not have the legal authority to prohibit countries from possessing such materials or facilities but it does have the responsibility to safeguard these materials and facilities. As I have discussed elsewhere,[19] IAEA safeguards are supposed to be more than just an accounting system but rather provide "timely warning" of diversion of nuclear materials. However, the IAEA cannot safeguard these facilities and materials in a timely warning sense. The IAEA needs to admit this fact and make clear that any such facilities and materials in non-nuclear weapon states are not being effectively safeguarded. This issue is significantly larger than just Iran and would include Japan, Germany, the Netherlands and Brazil at a minimum. It will be up to these countries to explain why they need to continue to possess these materials and facilities given that they cannot be effectively safeguarded. Given the state of nuclear power in a post-Fukushima world, this could be difficult.

[19] Gregory S. Jones, An In-Depth Examination of Iran's Centrifuge Enrichment Program and Its Efforts to Acquire Nuclear Weapons, August 9, 2011, pp. 16-23, http://npolicy.org/article.php?aid=1092&rid=4

The U.S. needs to urge the IAEA to be clear about what materials and facilities it can effectively safeguard and which it cannot. At the same time the U.S. needs to take early action to ensure that any countries that attempt to follow Iran's successful path are prevented from gaining access to the fissile material required for nuclear weapons. Otherwise, the number of nuclear-armed countries will continue to grow until the catastrophe of nuclear use occurs. Just one nuclear weapon detonated in a city could kill hundreds of thousands—roughly 100 times as many people than were killed on 9/11.

## Appendix 1

## Detailed Analysis of the IAEA February 24, 2012 Safeguards Report and Methods Whereby Iran Could Produce HEU for Nuclear Weapons

### Iranian Centrifuge Enrichment of Uranium

Iran has three known centrifuge enrichment facilities. Iran's main facility is the Fuel Enrichment Plant (FEP) at Natanz. The basic unit of Iran's centrifuge enrichment effort is a cascade which originally consisted of 164 centrifuges but Iran has now modified the majority of the cascades by increasing the number of centrifuges to 174. (All centrifuges installed up to now have been of the IR-1 type.) Each cascade is designed to enrich natural uranium to 3.5% enriched uranium. As of February 19, 2012, Iran had installed a total of 54 cascades, 30 of which each contain 174 centrifuges and the remaining 24 cascades each contain 164 centrifuges. This results in a total of 9,156 centrifuges. Of these 54 cascades, 52 (containing 8808 centrifuges) were declared by Iran as being fed with uranium hexafluoride and therefore were producing 3.5% enriched uranium though the IAEA has indicated that not all of these 8,808 centrifuges may be operational.[20] Indeed given the amount of enriched uranium that was actually being produced at the FEP, it seems likely that Iran's declaration was simply a negotiating ploy so as to be able to claim it has this number of centrifuges in operation and that the real number of centrifuges in operation was significantly less.

Iran began producing 3.5% enriched uranium at the FEP in February 2007 and as of February 4, 2012 Iran had produced a total of 3,685 kilograms (in the form of 5,451 kilograms of uranium hexafluoride). Since 666 kilograms of this enriched uranium has already been processed into 19.7% enriched uranium (see the PFEP and FFEP below) and a further 21 kilograms was converted into uranium dioxide for use as fuel in the TRR, Iran's current stockpile of 3.5% enriched uranium is 2,998 kilograms. Iran's current production rate of 3.5% enriched uranium is about 115 kilograms per month.[21] This production rate represents about a 15% increase from 2011 when the production rate was about a steady 100 kilograms per month and represents about a doubling of the rate since 2009 (see Table 1). From the production rate of 3.5% enriched uranium, it is easy to calculate that the FEP has a separative capacity of about 5,000 separative work units (SWU) per year.[22]

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[20] "Not all of the centrifuges in the cascades that were being fed with $UF_6$ may have been working." *Implementation of the NPT Safeguards Agreement and relevant provisions of Security Council resolutions in the Islamic Republic of Iran*, GOV/2012/9, February 24, 2012, p.3.

[21] To avoid problems with the fact that the length of a month is variable, we have adopted a uniform month length of 30.44 days.

[22] Assuming 0.4% tails. A Separative Work Unit is a measure of the amount of enrichment a facility can perform. The SWU needed to produce a given amount of enriched uranium product can be calculated if the U-235 concentration in the product, feed and tails are known.

**Table 1**
**Average Iranian Production Rate of 3.5% Enriched Uranium**
**Late 2008 to Early 2012**

| IAEA Reporting Interval | Average 3.5% Enriched Uranium Production Rate (Kilograms Uranium per Month) |
|---|---|
| 11/17/08-1/31/09 | 52 |
| 2/1/09-5/31/09 | 53 |
| 6/1/09-7/31/09 | 57 |
| 8/1/09-10/31/09 | 57 |
| 11/22/09-1/29/10 | 78 |
| 1/30/10-5/1/10 | 81 |
| 5/2/10-8/6/10 | 80 |
| 8/7/10-10/17/10 | 95 |
| 10/18/10-2/5/11 | 88 |
| 2/6/11-5/14/11 | 105 |
| 5/15/11-8/13/11 | 99 |
| 8/14/11-11/1/11 | 97 |
| 11/2/11-2/4/12 | 115 |

Iran also has the Pilot Fuel Enrichment Plant (PFEP) at Natanz, which is used to test a number of more advanced centrifuge designs. These are usually configured as single centrifuges or small ten or twenty centrifuge test cascades. However, Iran has installed a cascade of 164 IR-2m centrifuges and though this cascade appears ready to begin to produce enriched uranium, it has yet to do so. Iran has also installed 58 IR-4 centrifuges in a separate cascade but has not yet begun feeding them with uranium hexafluoride.

In addition, there are two full cascades each with 164 IR-1 type centrifuges at the PFEP. These two cascades are interconnected and are being used to process 3.5% enriched uranium into 19.7% enriched uranium. In February 2010, Iran began producing 19.7% enriched uranium at the PFEP using one cascade. It added the second cascade in July 2010. As of February 11, 2012, Iran had produced 64.5 kilograms of 19.7% enriched uranium (in the form of 95.4 kilograms of uranium hexafluoride) at this facility. Iran's production rate of 19.7% enriched uranium at the PFEP has been fairly steady over the past year and is currently about 3.05 kilograms per month. The centrifuges at this facility are each producing about 0.9 SWU per year.

Finally, Iran has constructed an enrichment facility near Qom. Known as the Fordow Fuel Enrichment Plant (FFEP), Iran clandestinely started to construct this plant in violation of its IAEA safeguards. Iran only revealed the existence of this plant in September 2009, after Iran believed that the West had discovered the plant.

Iran has installed two sets of two interconnected cascades at the FFEP (each cascade contains 174 centrifuges, IR-1 type) in order to produce 19.7% enriched uranium from 3.5% enriched uranium as is being done at the PFEP. The first of these two sets began production on December

14, 2011 and the second set began operation on January 25, 2012. As of February 17, 2012, Iran had produced 9.3 kilograms of 19.7% enriched uranium (in the form of 13.8 of uranium hexafluoride) at this facility. This facility is producing 19.7% enriched uranium at the rate of 6.45 kilograms per month. As with the centrifuges at the PFEP, the individual centrifuges at the FFEP are producing about 0.9 SWU per year.

With the start of these two sets of interconnected cascades at the FFEP, Iran has made good on its announcement in June 2011 that it would triple its production rate of 19.7% enriched uranium. Currently Iran is producing a total of about 9.5 kilograms of 19.7% enriched uranium per month. As of mid-February, Iran had produced a total of about 74 kilograms of 19.7% enriched uranium. Since Iran has converted about 7 kilograms of this uranium into a uranium oxide compound for use as fuel in the TRR, Iran's current stockpile of 19.7% enriched uranium is about 67 kilograms.

Iran has installed the piping and centrifuge casings for an additional 2088 centrifuges (12 cascades) at the FFEP. Iran has informed the IAEA that these additional cascades when completed will be used to produce either 3.5% or 19.7% enriched uranium without specifying how many cascades will be producing which type of enriched uranium. This opens the possibility that Iran could further increase its rate of 19.7% enriched uranium. Given Iran's current rate of production rate of 3.5% enriched uranium at the FEP, Iran could run two additional sets of two interconnected cascades to produce 19.7% enriched uranium without the need to drawdown its stockpile of 3.5% enriched uranium. If Iran were to construct and start to operate these two additional sets of cascades then its overall production rate of 19.7% enriched uranium would be about 16 kilograms per month.

**Iranian Options for Producing HEU**

Given that Iran currently has an enrichment capacity of 5,000 SWU per year at the FEP and stockpiles of about 3,000 kilograms of 3.5% enriched uranium and 67 kilograms of 19.7% enriched uranium, Iran has a number of options for producing the 20 kilograms of HEU required for a nuclear weapon.

The most straightforward method Iran could use to produce HEU would be batch recycling at the FEP. In this process, no major modifications are made to the FEP but rather enriched uranium is successively run though the FEP in batches until the desired enrichment is achieved. In the past I have calculated that Iran could use a two-step process to produce HEU. In the first step, 3.5% enriched uranium would be enriched to 19.7% enriched uranium. Iran has already demonstrated this step by producing 19.7% enriched uranium at the PFEP and FFEP. In the second step, 19.7% enriched uranium would be enriched to 90% enriched uranium. My calculations for this second step rely on work by Glaser which demonstrated that by reducing the flow through the cascade, it was possible to achieve the production of 90% enriched uranium from 19.7% enriched uranium in one step without a significant loss of separative capacity.[23] This process is illustrated for Iran's current situation in Table 2.

[23] Alexander Glaser, "Characteristics of the Gas Centrifuge for Uranium Enrichment and Their Relevance for Nuclear Weapon Proliferation", *Science and Global Security*, Vol. 16, 2008. In particular see Table 3 on p.16.

**Table 2**

**Time, Product and Feed Requirements for the Production of 20 kg of HEU by Batch Recycling at the FEP (5,000 SWU per year total)**
**(The Second Step is Based on Glaser's Analysis)**

| Cycle | Product Enrichment and Quantity | Feed Enrichment and Quantity | Time for Cycle (Days) |
|---|---|---|---|
| First | 19.7%<br>91.2 kg | 3.5%<br>1,080 kg | 32 |
| Second | 90.0%<br>20 kg | 19.7%<br>153.2 kg* | 11 |
| Total | | | 47** |

* Includes 67 kilograms of 19.7% enriched uranium that Iran has already stockpiled.
**Includes four days to account for equilibrium and cascade fill time.

Two steps are required. In the first step, Iran needs to produce 158.2 kilograms of 19.7% enriched uranium (including 5 kilograms for the plant inventory in the second step). However, since it has already produced 67 kilograms of 19.7% enriched uranium, Iran needs only to produce an additional 91.2 kilograms. This step requires 1,080 kilograms of 3.5% enriched uranium as feed but Iran's current stockpile well exceeds this figure. In the second step, the 19.7% enriched uranium is further enriched to the 90% level suitable for a nuclear weapon. Using Iran's currently operating centrifuges at the FEP, the batch recycling would take about one and one half months.

As was stated above, this calculation depends on Glaser's published calculations of the effectiveness of reduced cascade flow so that uranium can be enriched from 19.7% to 90% in one step. I am not the only analyst who has relied on Glaser's work, as both Levi[24] and the International Institute for Strategic Studies[25] have based their calculations on Glaser's calculations. However, as I wrote in my last paper, questions have been raised about the validity of Glaser's work and I have had to examine methods whereby Iran could produce the 20 kilograms of HEU required for a nuclear weapon without relying on Glaser's calculations.[26]

Iran could still produce HEU by batch recycling at the FEP but the process would require three steps. Each pass would produce the feed required for the next cycle, which would include the plant inventory (in this case, 2 kilograms for each cycle). Iran would need to produce sufficient

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[24] Michael A. Levi, "Drawing the Line on Iranian Enrichment," *Survival*, Vol. 53, No. 4, August-September 2011, pp.180-181.
[25] *Iran's Nuclear, Chemical and Biological Capabilities, A net assessment*, an IISS strategic dossier, The International Institute for Strategic Studies, London, February 2011, p.73.
[26] Gregory S. Jones, "Iran's Efforts to Develop Nuclear Weapons Explicated, Centrifuge Uranium Enrichment Continues Unimpeded, The IAEA's November 8, 2011 Safeguards Update," December, 6, 2011, p.5, http://npolicy.org/article.php?aid=1124&rid=4

19.7% enriched uranium from 3.5% enriched feed, then further enrich this 19.7% enriched uranium to 55.4% enriched uranium and finally enrich the 55.4% enriched uranium to 86.3% enriched uranium. I have increased the amount of HEU required from 20 kilograms to 21 kilograms to keep the quantity of U-235 in the product about the same.

The results for the first step can be found using separative work calculations but for the other two steps a SWU calculation would not produce accurate results. Since the plant at Natanz is designed to produce 3.5% product from natural uranium, its cascade is more tapered than is optimal for the upper stages of an enrichment plant designed to produce highly enriched uranium. As a result, some of the SWU output of the plant cannot be utilized during the latter cycles of the batch production process. The plant is restricted by the flow at the product end of the cascade. Therefore the time required per cycle is then determined by the amount of product required and the amount of product the plant can produce per day and not by a SWU calculation.

The results (Table 3) show that this method of batch recycling would take just under 5 months in contrast to the one and one half months required in Table 2. In addition Iran would need to start with 3,840 kilograms of 3.5% enriched uranium, much more than the 1,080 kilograms required by the calculations in Table 2 and significantly more than the 3,000 kilograms that Iran currently possesses. At current production rates it would take about seven months before Iran would possess enough 3.5% enriched uranium to start the batch recycling process.

**Table 3**

**Time, Product and Feed Requirements for the Production of HEU by Batch Recycling at the FEP (5,000 SWU per year total)**
**(Does Not Rely on Glaser's Analysis)**

| Cycle | Product Enrichment and Quantity | Feed Enrichment and Quantity | Time for Cycle (Days) |
|---|---|---|---|
| First | 19.7%<br>325 kg | 3.5%<br>3,840 kg | 114 |
| Second | 55.4%<br>68.4 kg | 19.7%<br>390 kg* | 18 |
| Third | 86.3%<br>21 kg | 55.4%<br>66.4 | 6 |
| Total | | | 144** |

* Includes 67 kilograms of 19.7% enriched uranium that Iran has already stockpiled.
**Includes six days to account for equilibrium and cascade fill time.

Iran, however, has additional options for producing the HEU required for a nuclear weapon. As was stated above, in addition to the FEP, Iran is producing 19.7% enriched uranium at the PFEP and recently tripled its production of 19.7% enriched uranium by starting two sets of two interconnected cascades at the FFEP. Iran can use its 19.7% production capacity to carry out the final step of the three step batch recycling process. The results are shown in Table 4.

As in the previous case, the times for the second and third steps are determined by the cascade product production rate and not by SWU calculations. The total time required is about three and two-thirds half months, which is over a month shorter than the prior case where all three batch recycling steps were carried out at the FEP. In addition, this method has the advantage of reducing the required amount of 3.5% enriched uranium feed from 3,840 kilograms to 1,640 kilograms, which is smaller than Iran's current 3,000 kilograms stockpile and therefore could be carried out today if Iran so desired.

**Table 4**

**Time, Product and Feed Requirements for the Production of HEU by Batch Recycling at the FEP (5,000 SWU per year total)**
**Final Step at PFEP and FFEP**
**(Does Not Rely on Glaser's Analysis)**

| Cycle and Enrichment Plant | Product Enrichment and Quantity | Feed Enrichment and Quantity | Time for Cycle (Days) |
|---|---|---|---|
| First<br>FEP | 19.7%<br>139 kg | 3.5%<br>1,640 kg | 37 |
| Second<br>FEP | 55.4%<br>39.2 kg | 19.7%<br>223 kg* | 10 |
| Third<br>PFEP & FFEP** | 89.4%<br>20 kg | 55.4%<br>39.0 kg | 64 |
| Total | | | 111** |

* Includes 67 kilograms of 19.7% enriched uranium that Iran has already stockpiled and 19 kilograms of 19.7% enriched uranium from the tails of the PFEP and FFEP.
** Plant inventory is 0.2 kilogram.
***Includes six days to account for equilibrium and cascade fill time.

If Glaser's calculations are incorrect, the only way that Iran could currently produce the HEU for a nuclear weapon in just two months would be to use batch recycling at the FEP combined with a clandestine "topping" enrichment plant. Since Iran continues to refuse to implement the Additional Protocol to its safeguards agreement, the IAEA would find it very difficult to locate a clandestine enrichment plant—a fact that the IAEA has continued to confirm.[27] While this has

[27] "While the Agency continues to verify the non-diversion of declared nuclear material at the nuclear facilities and LOFs declared by Iran under its Safeguards Agreement, as Iran is not providing the necessary cooperation, including by not implementing its Additional Protocol, the Agency is unable to provide credible assurance about the absence of undeclared nuclear material and activities in Iran, and therefore to conclude that all nuclear material in Iran is in peaceful activities." *Implementation of the NPT Safeguards Agreement and relevant provisions of Security Council resolutions in the Islamic Republic of Iran*, GOV/2012/9, February 24, 2012, pp.10-11.

been a theoretical possibility since 2007, its salience increased with the discovery in September 2009 that Iran was actually building such a clandestine enrichment plant (the FFEP near Qom).

In this case, the clandestine enrichment plant could be designed as an ideal cascade to enrich 19.7% enriched uranium to the 90% enriched uranium needed for a nuclear weapon. By starting from 19.7% enriched uranium this clandestine enrichment plant need only contain about 1,400 IR-1 type centrifuges to be able to produce the 20 kilograms of HEU required for a nuclear weapon in just two months. Furthermore since Iran already has a stockpile of 19.7% enriched uranium, the production of the 19.7% enriched uranium at the FEP and the 90% enriched uranium at the clandestine enrichment plant could be carried out *simultaneously*.

The results of this process are shown in Table 5. As can be seen, the production of the 19.7% enriched uranium needed (including 0.5 kilograms for the plant inventory at the clandestine plant) to produce 20 kilograms of HEU at the clandestine enrichment plant now requires only 325 kilograms of 3.5% enriched feed. Since the cycle time at the FEP is shorter than that at the clandestine enrichment plant and the cycles are carried out simultaneously, the time required at the FEP has no impact on the overall time required to produce the HEU.

**Table 5**

**Time, Product and Feed Requirements for the Production of HEU by Batch Recycling at the FEP (5,000 SWU per year total)**
**Final Step at 1,400 Centrifuge Clandestine Plant (0.9 SWU per centrifuge-year)**
**Cycles Carried out Simultaneously**
**(Does Not Rely on Glaser's Analysis)**

| Cycle and Enrichment Plant | Product Enrichment and Quantity | Feed Enrichment and Quantity | Time for Cycle (Days) |
|---|---|---|---|
| First<br>FEP | 19.7%<br>27.5 kg | 3.5%<br>325 kg | 12** |
| Second<br>Clandestine | 90.0%<br>20 kg | 19.7%<br>106.8 kg* | 63** |
| Total | | | 63*** |

* Includes 67 kilograms of 19.7% enriched uranium that Iran has already stockpiled. Processing the tails of the clandestine plant at the PFEP and FFEP produces an additional 12.8 kilograms of 19.7% enriched uranium.
** Includes two days to account for equilibrium and cascade fill time.
*** Cycle times *not* additive since cycles are simultaneous.

Further, since Iran would have a substantial quantity of 3.5% enriched uranium left over (about 2,700 kilograms), Iran could continue the process and produce additional HEU. An additional 20 kilograms of HEU would require 1,109 kilograms of 3.5% enriched uranium feed, so with its current stockpile Iran could produce a total of about 68 kilograms of HEU, which is enough for about three nuclear weapons. Since the clandestine enrichment plant has been sized to produce about 10 kilograms of HEU per month, Iran could produce enough HEU for a nuclear weapon at successive two month intervals.

Nor is batch recycling of enriched uranium the only pathway for Iran to produce the fissile material required for nuclear weapons, though it is the process that allows Iran to produce HEU most quickly. Iran could produce HEU at a clandestine enrichment plant designed to produce 90% enriched uranium from natural uranium feed.

A clandestine enrichment plant containing 3,800 centrifuges (0.9 SWU per centrifuge-year) could produce around 20 kilograms of HEU (the amount required for one nuclear weapon) each year using natural uranium as feed. Since this option does not require any overt breakout from safeguards, the relatively slow rate of HEU production would not necessarily be of any concern to Iran. Such production could be going on right now and the West might well not know. A clandestine enrichment plant would need a source of uranium but Iran is producing uranium at a mine near Bandar Abbas.[28] Since Iran has refused to implement the Additional Protocol to its IAEA safeguards, this uranium mining is unsafeguarded and the whereabouts of the uranium that Iran has produced there is unknown. A significant drawback to this stand-alone clandestine enrichment plant is that it requires many more centrifuges than would the 1,400 centrifuge clandestine plant discussed above. It is not clear whether Iran could provide this number of centrifuges to a clandestine plant and the larger any clandestine enrichment plant is, the more likely it is that it will be discovered.

Iran then, has a number of methods whereby it could produce the HEU required for a nuclear weapon. If Glaser's previously published calculations are correct, then batch recycling at the FEP alone could produce enough HEU for a weapon in just one and one half months. If Glaser's calculations are incorrect, then the most threatening cases are those involving clandestine enrichment plants. If Iran were to produce 19.7% enriched uranium at the FEP and simultaneously enrich 19.7% enriched uranium to HEU at a clandestine enrichment plant, then it could produce a weapon's worth of HEU in two months and enough HEU for three weapons in six months. Alternatively, Iran might build a stand-alone clandestine plant to enrich natural uranium to HEU. Such a plant would only produce enough HEU for one weapon a year but since the plant could go undetected for many years, Iran could produce a sizable stockpile before detection.

If Glaser's calculations are incorrect, and one does not want to posit the existence of a clandestine enrichment plant, then the fastest way Iran could produce HEU would be to carry out batch recycling at the FEP and the final enrichment step at the PFEP and FFEP. In this fashion, Iran could produce sufficient HEU for a weapon in about three and two-thirds months which is longer than the one and one half months that would be required if Glaser's calculations are correct. Clearly, it would be helpful to resolve the uncertainties regarding Glaser's calculations. However, even if these uncertainties are not resolved, it is obvious that clandestine Iranian enrichment facilities pose a serious threat.

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[28] *Implementation of the NPT Safeguards Agreement and relevant provisions of Security Council resolutions in the Islamic Republic of Iran*, GOV/2011/7, February 25, 2011, p.9.

## Appendix 2

### Limiting Iran to Producing and Stockpiling Less Than 5% Enriched Uranium Does Not Prevent Easy Access to HEU

As was discussed in the text, many who propose a diplomatic solution with Iran have suggested that Iran should be allowed to continue to enrich uranium as long as this activity is subject to proper controls. In particular, they propose that Iran should not enrich uranium to more than 5% and that Iran's current stockpile of near 20% enriched uranium should be removed from Iran. Further, they propose that the size of Iran's enrichment effort be determined by the needs of Iran's peaceful nuclear program.

But Iran's current enrichment effort is quite small compared to those needed for most peaceful nuclear activities such as providing fuel for a single nuclear power reactor. A diplomatic solution could provide Iran with the justification for greatly expanding its current enrichment facilities as well as removing sanctions. Under these circumstances, Iran might receive assistance to expand its enrichment facilities (from say China or Pakistan) as part of normal nuclear commerce. These greatly expanded facilities would provide Iran easy access to the HEU needed for nuclear weapons.

For example, even if Iran produced only 4.1% enriched uranium[29] and expanded its enrichment capacity by a factor of 20 (100,000 SWU/yr), it would only produce about 15 metric tons of enriched uranium per year. This amount would still be less than that needed to fuel a single large power reactor yet, using batch recycling, these enrichment facilities could produce enough HEU for a nuclear weapon in just two weeks. This process is shown in Table 6.

**Table 6**

**Time, Product and Feed Requirements for the Production of 20 kg of HEU by Batch Recycling at a Centrifuge Enrichment Plant Designed to Produce 4.1% Enriched Uranium (100,000 SWU per year total) (Does Not Rely on Glaser's Analysis)**

| Cycle | Product Enrichment and Quantity | Feed Enrichment and Quantity | Time for Cycle (Days) |
|---|---|---|---|
| First | 20.2%<br>304 kg | 4.1%<br>1,990 kg | 7.5 |
| Second | 60.2%<br>69.5 kg | 20.2%<br>274 kg | 1.7 |
| Third | 90.0%<br>20 kg | 60.2%<br>39.5 | 0.5 |
| Total | | | 16* |

*Includes six days to account for equilibrium and cascade fill time.

[29] With tails of 0.2%.

In the first step, 4.1% enriched uranium is processed into 20.2% enriched uranium. In the second step, this uranium is processed into 60.2% enriched uranium and the third step completes the process by producing the 20 kilograms of 90% enriched uranium needed for a nuclear weapon. Each step produces not only the material needed to be processed in the next step but the material needed for the plant inventory which in this case is 30 kilograms per step.

Instead of just producing enough HEU for one nuclear weapon, Iran could produce enough HEU for five nuclear weapons (100 kilograms) in a single batch recycling campaign. This process would take about five weeks and is shown in Table 7. This process would require starting with 6,090 kilograms of 4.1% enriched uranium but since the plant will be producing about 15,000 kilograms per year, it would not be hard for Iran to stockpile this quantity of enriched uranium.

**Table 7**

**Time, Product and Feed Requirements for the Production of 100 kg of HEU by Batch Recycling at a Centrifuge Enrichment Plant Designed to Produce 4.1% Enriched Uranium (100,000 SWU per year total)**
**(Does Not Rely on Glaser's Analysis)**

| Cycle | Product Enrichment and Quantity | Feed Enrichment and Quantity | Time for Cycle (Days) |
|---|---|---|---|
| First | 20.2%<br>929 kg | 4.1%<br>6,090 kg | 23 |
| Second | 60.2%<br>228 kg | 20.2%<br>899 kg | 5.6 |
| Third | 90.0%<br>100 kg | 60.2%<br>198 | 2.5 |
| Total | | | 37* |

*Includes six days to account for equilibrium and cascade fill time.