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China's Nuclear Fuel Cycle: A Case Study of FMCT Verification

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China's current position

"China values the role of the Conference on Disarmament (CD) in Geneva, and supports efforts in the CD to reach a comprehensive and balanced program of work, so as to enable the CD to start substantial work on such issues as the Fissile Material Cut-off Treaty (FMCT), prevention of an arms race in outer space, nuclear disarmament and security assurance to non-nuclear-weapon states."

---White Paper on China's National Defense in 2008, Jan.2009, Beijing

Evolution of China's policy

- On December 16, 1993, the UN General Assembly adopted a resolution which called for the negotiation of "a non-discriminatory, multilateral and internationally and effectively verifiable treaty banning the production of fissile material for nuclear weapons or other nuclear explosive devices"

- On October 4, 1994, U.S. Secretary of State Christopher and Chinese Foreign Minister Qian issued a joint statement in which they promoted the "earliest possible achievement" of a treaty prohibiting the production of fissile material for use in nuclear weapons.

- Supported Shannon Mandate, 1995 .

- In May 1995 at the NPT extension conference, the Parties adopted a principles and objectives document that called for the "immediate commencement and early conclusion" of FMCT negotiations.

Evolution of China's policy

- **A linkage with PAROS, around 2000**

---the Conference on Disarmament in Geneva should not emphasize the importance of only the FMCT negotiations to the neglect of the issues of nuclear disarmament and the prevention of an arms race in outer space, and should, at the minimum, give equal attention to all three issues by carrying out its substantive work in a balanced manner." --- In 2000 China's defense white paper

- **China agreed FMCT negotiation in 2003; However, US : an unverified FMCT in 2004 blocked a restart**

- **Obama new administration to resume FMCT negotiation. China will support and its major concerns should be addressed.**

China's participation would be essential

- A primary goal of an FMCT will focus on 8 target states(5 +3)

- Without China's participation in the FMCT, India will not sign it – and Pakistan will not sign unless India does. Both South Asian countries and Israel are believed to be continuing to produce fissile materials for their military stockpiles.

- Like the other four acknowledged nuclear weapon states, China is believed to have stopped producing HEU and plutonium for weapons, ---However, Beijing's willingness to participate in FMCT negotiation could be dependent on addressing its major security concerns.

China's major concerns

- **China's serious concerns on US Space weapons program and missile defense programs**
  - China could be the target
  - Neutralize China's strategic nuclear deterrent; More freedom to encroach on China's sovereignty(including Taiwan affair)
  - would damage the whole nuclear arms control and disarmaments regimes, damage strategic stability and international security.

China's major concerns (cont)

- China maintains that the global missile defense program will be detrimental to strategic balance and stability, undermine international and regional security, and have a negative impact on the process of nuclear disarmament. China pays close attention to this issue.

  --white paper on China's National Defense in 2008, Jan.2009, Beijing

Why related to an FMCT?

---China's one option—to build more ICBMs to neutralize MD and space weapons programs

---A need for more weapons -- a need for more fissile material --so China might keep open to production.

China's position on an FMCT

- **Ban "future production", not including past stocks**
- **Wants an *verifiable* FMCT**
- **Prefers to a focus verification approach**
- **Less intrusive approach at former military nuclear facilities**
- **Against abuse of on-site challenge inspection**

China's major facilities under an FMCT verification

Reprocessing plant	
Jiuquan reprocessing plant	Previous military; Shutdown; Operated 70s-84?
Guangyuan reprocessing plant	Previous military; Shutdown; Operated 70s-91?
A pilot reprocessing Plant at Lanzhou	Civilian purpose; 50-100MT/yr, ready operation
Proposed commercial reprocessing plant	Civilian purpose; 800 MT/yr; planned commission in 2020
Enrichment plants	
Lanzhou GDP	Previous military; 300kSWU-kg/yr; Shutdown; Began operation in 1963; HEU production ended in 1987
Heping GDP	Previous military; 150-590k SWU-kg/yr; Shutdown. Began operation in 1974; HEU production ended in 1987
Hanzhong CEP (At Shaanxi)	Civilian purpose (LEU); 500 kSWU-kg/yr. IAEA safeguards
Lanzhou CEP	Civilian purpose (LEU); 500 kSWU-kg/yr

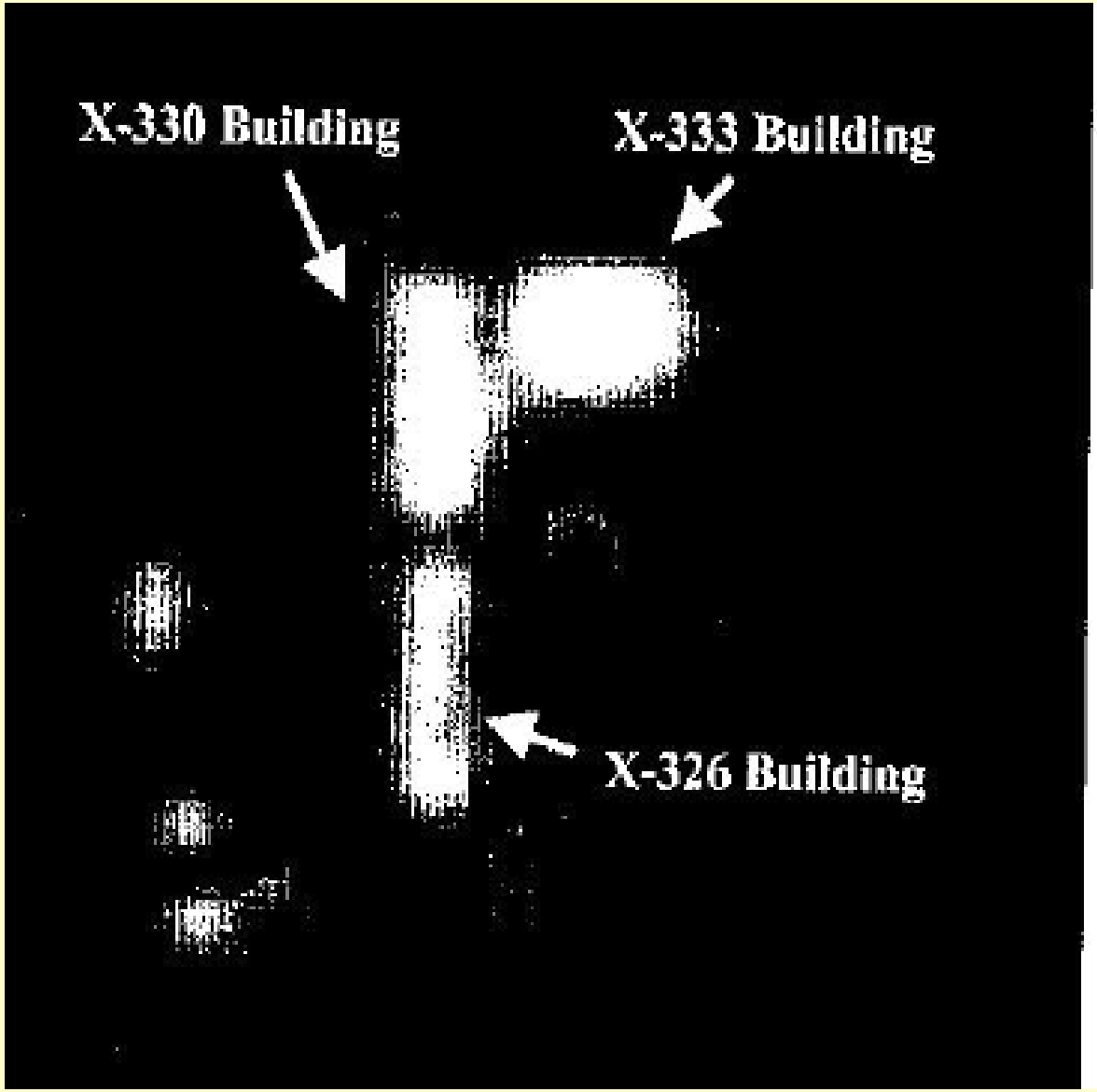
Enrichment facilities and verification

- Two GDPs for HEU production ---shut down: should be easy to monitor .
- Two CEPs for LEU, civilian purpose—should no problems to apply IAEA safeguards

---hot roof of processing building would be detected by satellite thermal imagery.

---vapor plume from cooling towers could be seen.

----see, Hui Zhang & Frank von Hippel, Using Commercial Imaging Satellites to Detect the Operation of Plutonium-Production Reactors and Gaseous-Diffusion Plants, Science & Global Security, vol.8, no.3, 2000.



Landsat-5TIR image (March 12, 1994) over Portsmouth GDP process buildings

Transparency measures and verification of status Lanzhou GDP shutdown

Off-site verification	On-site verification	Non-permissions
Satellite remote sensing: •VNIR : tower plume •TIR: the hot roof; warm plume from the tower.	Site visual observation : •outside the cascade building: no plume from the cooling towers, no treatment of cooling water, no electrical service •Inside the building: not hot, not noisy! Continuous surveillance monitor and tamper-proof seal: •seal the high-voltage disconnect switches; •seal the valves on the supply and return headers of the recirculating Cooling Water system; •seal the inlet and outlet block valves for the cascade piping; •put vibration and or/temperature sensors on the process equipment.	Industrial secrets: The diffusion barrier technology information. On-site Sampling?

Case study : Uranium-enrichment gaseous-diffusion plants

- the major concerns:-- the diffusion barrier technology information that most countries take it as industrial secrets. However, this would be easily protected by some prevent measures.

- Environmental sampling?-- release the composition of the feeds, products and tails of uranium, which could provide information to further estimate the amount of HEU produced by the plant. Whether each target state would take such information sensitive? However, sampling is not needed to confirm the GDP shutdown status.

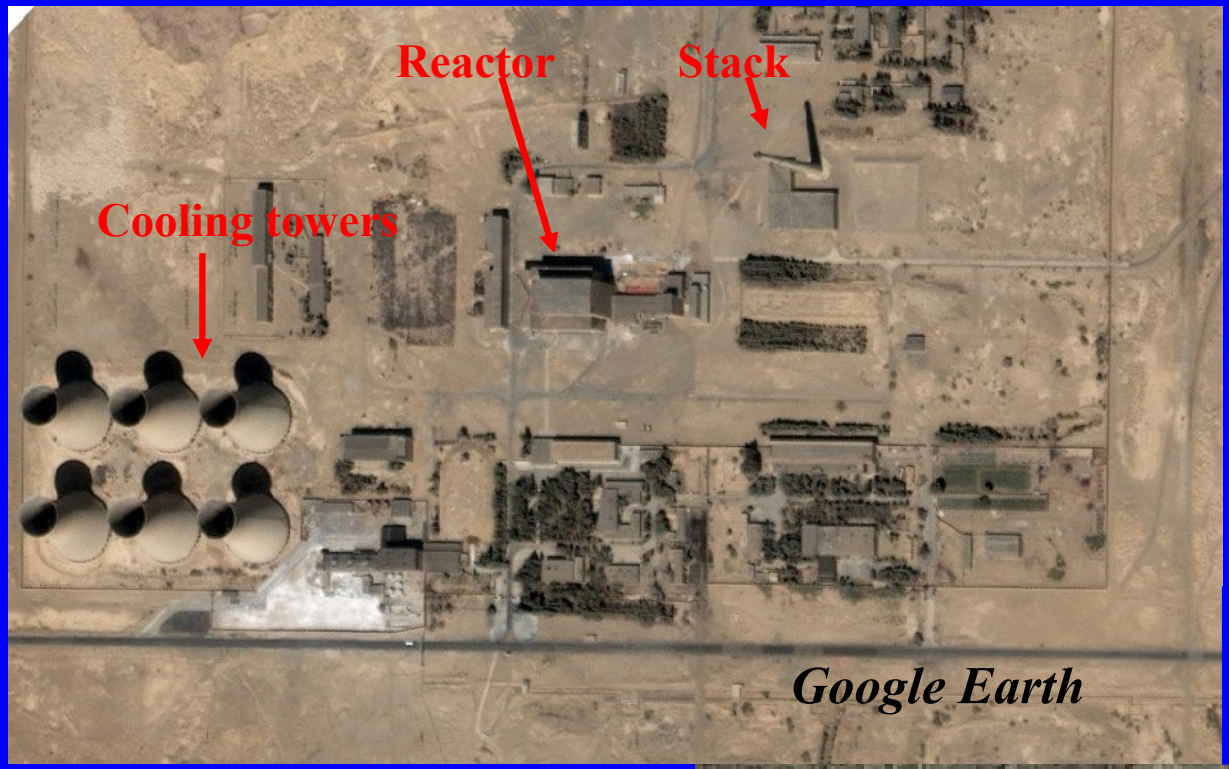
❖ **Chinese non-weapon uses of HEU are very limited**

--- nuclear-power submarines fueled with LEU

---several research reactors

---Tritium production reactor

➢ **Support HEU phase-out proposals?**



Top: Jiuquan Pu production reactor. 6 cooling towers clearly seen. ---If operating, would see vapor plumes over towers.

Bottom: Ikonos image of Russia's Tomsk-7 Pu-production reactor, July10,2000.

Source: Hui Zhang & Frank von Hippel, Eyes in the Sky, Bulletin of the Atomic Scientists, July/Aug.2001

Verification of the shutdown status of China's reprocessing plant

Off-site verification	On-site verification	Non-permissions
1.Off-site sampling: Kr-85 2.Satellite remote sensing: •VNIR: activity level	1.site environmental sampling: •product stream (glovebox) •waste stream (HLW tanks) 2. visual observation: •no activity at the railroad cask portal;etc 3. Continuous surveillance monitor and tamper-proof seal: •Outside the canyon building: monitoring the waste stream Etc. •Inside the building	•Information of production quantities, production rate. • the inventory of sludge HLW, total radioactive of Sr-90 and Cs137.

Some possible concerns about on-site inspections at Jiuquan Pu production complex

- **On-site visit: estimate the physical size of the cooling tower—thus the reactor power**

---e.g. using the size (estimated from satellite image) --can estimate the upper bound thermal power less 650 MWe.

---In any way, the satellite will (already) see it. However, only the size--still a wide range.

- **On-site sampling: could reveal information of burn-up, Pu isotopic composition, the irradiation time, and discharge time, reprocessing time.**

---All should be not sensitive.

---However, if takes Pu isotopic composition sensitive, sampling could not allowed. Need others measures.

Protecting National Security Interests

- Sensitive nuclear facilities and activities, e.g.

<u>Collocated sites</u> ---conducting sensitive activities, such as,

- the processing of plutonium and HEU produced in the past into metal,
- the fabrication of weapons components ,
- the finial assembly of weapons.

---Some sensitive information, e.g., chemical composition information from these activities might be divulged through sampling and analysis around the facilities.

Therefore, need approach, which would build confidence that no secret facilities exist while protecting national security secrets.

Manages Access Mechanism

- **For most cases of managed access situations, simple procedures would be sufficient, E.g.**

  ---the undeclared facilities and activities would be detected by sampling around the site (without accessing to the appropriated control security fences) through their signatures in the effluents such as fission products from reprocessing and HEU from enrichment activities.

- **In some locations, should take measures to prevent overt or covert sampling, E.g**

  --at the fissile material manufacturing facilities, chemical composition information could be divulged through sampling and analysis.

- **In some cases where it will be essential for inspectors to have access areas with classified activities, should apply appropriated measures to protect sensitive information, E.g**

  --at the nuclear weapons assembly facility, weapons component etc might be vulnerable to the visual access. ---Thus need measures including shrouding and masking of sensitive equipments or other obvious method to prevent the visual access.

China's plans on reprocessing

Status

---Since mid 80s-90s early, China has selected a closed fuel cycle strategy to reprocess it spent fuel.

---A pilot reprocessing plant has been built in early 20s.

---A larger commercial plant is under consideration.

Proposed motivations

---Full use of uranium resources; Reducing cost of mining, milling and enrichment uranium

---Provide MOX fuel ; Development of FBR;

---Energy security concerns;

---Reduce the waste repository volume

---minimizing the radioactive toxic, disposal of radwast safely;

---Reducing the burden of spent fuel at reactor pools

A multi-purpose reprocessing pilot plant

Purpose (commercial):

R&D of future reprocessing technologies for LWR-MOX or FBR; reprocessing spent fuels from research reactors,….

Located at Gansu province

Capacity: 50 tHM/a--- 100tHM/a

Development:

the project approved in July 1986; Start construction in July 1997, first reception of spent fuel from Daya bay reactors in Sept. 2003 , conducted water test in Oct.2004, now ready to operate.

A commercial reprocessing plant

---Located at Gansu province
---Capacity up to 800 tHM/a
---preliminary work started (site selection,etc) ;
Planned commission around 2020

---In addition: A MOX fuel fabrication plant planned in commission by 2020

❖For those commercial reprocessing facilities, should be easier to accept the IAEA safeguards.

An estimation of cost of a focused approach

---as the Alternative B in the 1995 IAEA study and Option 2 in 1996 BNL study

- **verify declared inventories of separated plutonium, HEU and U233 in store;**
- **verify complete material balance at declared reprocessing plants, MOX, HEU and U233 conversion and fuel fabrication plants;**
- **verify complete material balance at declared uranium enrichment plants;**
- **verify status of decommissioned, shut down facilities and facilities under construction.**

Case 1: a focused approach (reference scenario) ---as Alternative B in 1995 IAEA study. PDI value as 1996 BNL Option Two.
---production facilities as shown in the tables
---cost per PDI: Considering the IAEA safeguards operation budget in 2004 --- about $70 million and the inspection effort was 9063 PDI---
Assuming: $7,700/PDI

Case 2: Case 1 plus known former military plutonium production reactors. only 4% increase)

Case 3: as Case 1, and excluding those facilities already under international safeguards.

Case 4: as Case 1 , and assuming 1) more facilities shutdown --two Russian military reprocessing plants at Seversk and Zheleznogorsk; two UK reprocessing plants; French and U.S. GDPs replaced by CEP. 2) exclude those facilities already under international safeguards.

Case 5: the minimum approach (as Alternative A in 1995 IAEA study. PDI value as 1996 BNL Option Three.

An estimation of verification cost for several cases (in 2004)

Cases	PDI	Cost($ Million
Case 1	16, 500	127
Case 2	17,100	132
Case 3	12,000	90
Case 4	10,000	80
Case 5	7,000	50

Is the FMCT verification cost (around $100 million per year) too expensive?

--- modest, compared to its security benefits

- An effective FMCT would make an important contribution to nuclear disarmament, the nonproliferation regime, and the prevention of nuclear terrorism.
- comparable to another important treaty of nuclear arms control—CTBT. The budget of the CTBTO Preparatory Commission for 2004 is $94.5 million.
- Much smaller than the operational cost savings realized by the target states through shutting down their production facilities for fissile material.

  ---E.g. the U.S. spent about $2 billion per year on plutonium production for weapons from 1984 through 1993.

Conclusion

- Given all China's previous military production facilities of fissile materials would be closed, verifications of their status should be easy.
- For China's new civilian CEPs and reprocessing facilities, should be easier to accept IAEA safeguards.
- For China's participation of a verifiable FMCT, technical challenges would be much less than political ones.
- China's willingness to an FMCT negotiation would be increased--- if its major security concerns be addressed including US space weapons and missile defense programs.