Nuclear proliferation and nuclear terrorism

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Nuclear energy can electrify the world

Nuclear Share of Electricity - NEI 2010



Or, it can destroy the world



"A factor of millions" by splitting the nucleus

"A Report on the International Control of Atomic Energy". Acheson-Lilienthal Report, March 28, 1946

• It is further recognized that atomic energy plays so vital a part in contributing to the military power, to the possible economic welfare, and no doubt to the security of a nation, that the incentive to other nations to press their own developments is overwhelming.

• The development of atomic energy for peaceful purposes and the development of atomic energy for bombs are in much of their course interchangeable and interdependent.

Nuclear Fuel Cycle



Two paths to the bomb

Uranium-235 (Produced by enrichment)

- Uranium ore (0.7% U-235, the fissile isotope, the rest is U-238)
- Enrich uranium in U-235, typically > 90% (HEU)
 - Gas centrifuge, for example
- A few tens of kg required for a hypothetical bomb
- >20% HEU is weapons usable



Gun-type assembly method

Plutonium-239 (Produced in reactors)

- Uranium ore to fuel rods or reactor targets
- Irradiate U-238 in reactor to make Pu-239
- Separate (extract) Pu-239 from spent fuel
- Pu-239 metal, typically >93% Pu-239 for bombs
- < 10 kg required for a hypothetical bomb</p>
- Reactor-grade Pu (> 19% Pu-240) can be used for bombs, but is less desirable



Fielding a nuclear weapon



Terrorists may be able to field an improvised device.

Nuclear tests established nuclear weapons capabilities

Date of first test		<u>Country</u>	
1945	(July 16)	United States (Pu)	
1949	(Aug. 29)	Soviet Union (Pu)	
1952	(Oct. 3)	UK (Pu)	P-5
1960	(Feb. 13)	France (Pu)	
1964	(Oct. 16)	China (U)	
1968	(1970) NPT – Nu	clear Nonproliferation Treaty	
1974	(May 18)	India ("peaceful") (Pu)	
1979	(Sept. 22)	Enigma (South Africa/Israel?)	
1979 1998	(Sept. 22) <mark>(May)</mark>	Enigma (South Africa/Israel?) India (Pu) and Pakistan (U)	

Why they built and keep nuclear weapons

Reasons	US	SU/ Rus	UK	FRA	CHIN	ISR	IND 1974 1998	PAK	NK
Nat'l security	XXX	XXX	ХХ	хх	ХХХ	ХХХ	x xx	ххх	XXX
Inter- national	ХХ	ххх	х	ххх	х	X	xx xx	хх	ххх
Domestic	X	X	x	X		X	x xxx	XXX	XX

Nuclear weapons programs









P.W. Botha, South Africa





Assad – Syria?

Nuclear Walmart

A.Q. Khan's black market



Urs Tinner, Swiss family connection







Gotthard Lerch, German connection

Qaddafi built and bought Libya's nuclear capabilities



Iraq tried both routes to the bomb



Israeli's destroyed Osirak reactor in 1981

... but started a war and lost it all





South Africa built bombs, then destroyed them



North Korea and Iran Different paths to the bomb

What a difference the regime makes

The Shah < 1979

Ahmadinejad - now

Iran develops the "nuclear option"

- 1950s 60s: U.S. "Atoms for Peace"
- 1970s to 1979: Grand nuclear power plans and covert bomb ambitions (with Israel, South Africa)
- Ayatollahs abandon, then go covert in mid-1980s
- 1990s: Iran goes shopping, steps up covert program
- 2002 12: Program discovered, admitted, and continuous cat-and-mouse game with Europeans

Iran does not have the bomb or fissile materials. Yet, sufficient enrichment progress and other programs to prepare it for breakout. It has the "nuclear option."

Known Iran Nuclear Installations

- Bushehr reactor: 915 MWe, operational (Russian fuel)
- Natanz enrichment plant (discovered 2003)
 - Previously undeclared enrichment facility at Qom (2009)
 - STUXNET virus invades Natanz centrifuge facility
- Esfahan: Uranium conversion
- Arak: 40 MW heavy water reactor (2012?)
 - Laser uranium enrichment experiments milligrams
- Esfahan Nuclear Fuel Research & Production Center: 3 research reactors, other facilities
- Parchin military complex high explosives and other work
- Vigorous missile program
 http://www.iiss.org/publications/strategic-dossiers/irans-ballistic-missile-capabilities/

Dialogue with Iran

Civilian - military divide: Is it a wide gap or a fine line?

Iranian Embassy, The Hague, Aug. 1, 2008 Sec. W.J. Perry and Sig Hecker with Iranian officials

How did North Korea get the bomb?

- Soviet "Atoms for Peace" 1950s & 1960s
- Going solo, but under civilian cover 1970s to 1992
- Freeze: Agreed Framework 1994 2002
- Bomb production: Jan. 2003 July 2007
- First test, Oct. 2006; Second test: May 2009

North Korean bomb – 50 years in the making. Civilian cover followed by breakout.

How do we know anything about North Korea?

- It is reputed to be the last Stalinist state a black hole
- However, we have satellites overhead imagery
- They invite people in
 - Tourists
 - News media KCNA and Western (Pyongyang AP)
 - Track II people like me

Therefore we know a lot more than most people think

Visiting the North Korean nuclear complex

Jan. 2004 Yongbyon

Aug. 2005 Pyongyang

Nov. 2006 Pyongyang

August 9, 2007, Yongbyon Feb. 14, 2008, Yongbyon Feb. 27, 2009, Pyongyang
Aspecific message for each visit

Tell American skeptics we shut down the reactor

August 9, 2007, Yongbyon

North Korea's nuclear program

Nuclear weapons

- Plutonium: 24 to 42 kg (~4 to 8 bomb's worth)
- Most likely simple, not confident to mount on missiles
- 2006 test partial success; 2009 likely successful

Missile program

- Three long-range missile tests one a total failure, two partially successful. Fourth a failure.
- Musudan road-mobile missile Oct. 2010 parade

Uranium enrichment

- Showed me a small industrial scale enrichment facility
- Likely to have HEU, not sure of extent of program

North Korea has the bomb, but not much of a nuclear arsenal – yet.

S.S. Hecker, Daedalus, Winter 2010, pp. 44-56.

Source: DigitalGlobe

Dec 03 2010 Source: DigitalGlobe

Experimental Light Water Reactor

Newly roofed Turbine

<u>Generator</u>

Hall

3-D Model Reactor containme

structure

Port for maintenance and replacement of equipment

Designation of the local division of the loc

LWR Reactor Dome

IBW I

- States

 MUL2 Gness Spot Images linnyts © 2012 GeoEve Images © 2012 Depital Stoke © 2012 Geogles

SC"CTOLES" STATS" CONSECT 2 Alloy 20'00

03 February 2012; Image Credit: DigitalGlobe

Uranium Enrichment Centrifuge Facility Building Exterior 1 3-D SketchUp Model

Blue Roof Centrifuge Hall

ARGAN

Main Gate to Fuel Fabrication Facility

2nd Floor: Control Room and Recovery Room?

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** A * ** ** ** ** ** ****

Road to Building 4

A CONTRACTOR CONTRACTOR

19/46 15/59 /v 125/45/00 DE F www. 120 ft

Liye als 7 fei ft

Google earth

- Not in the near future not voluntarily
- Must make the price of keeping weapons be greater than the benefits of giving them up
- China holds the key to the price U.S. and ROK hold the key to benefits
- We must understand why DPRK wants weapons security, domestic and international reasons

http://cisac.stanford.edu/publications/can_north_korea_nuclear_crisis_be_resolved

North Korea: Space launch failed - Now what?

Contain the threat for now

 Pyongyang defied international sanctions – but we have few options – no good ones.

• Our typical response is ineffective – we should focus on what's important – missiles pose little threat without a warhead.

 Focus on risk – 3 no's – no more bombs, no better bombs, no export.

- No nuclear test close the tunnel
- Stop uranium enrichment get into YB centrifuge facility
- Take irreversible steps to shut down plutonium production
- Work with China on stopping nuclear imports and exports

Policies are complicated by leadership transition in North, domestic politics in South and the U.S.

Nuclear terrorism presents very different challenges

 Nuclear detonation – a real WMD; massive, devastating, no analogue

-Radiological dispersal device – "dirty bomb." A weapon of mass "disruption"

-Radiological sabotage – nuclear facilities. Radiation release concerns

The greatest nuclear terrorism threats today

Pakistan

North Korea

Iran

HEU research reactors

Kazakhstan

Russian nuclear complex

Based on the likelihood of HEU or Pu being diverted or stolen and getting into the hands of terrorists

How can terrorists get a nuclear bomb?

Steal or divert a bomb

• Steal or divert components and assemble

 Steal or divert nuclear materials and build a bomb

The most likely nuclear threat is a "dirty bomb"

- Radiation sources are everywhere key ingredients of medicine, commerce and agriculture
- "Orphaned" sources present a serious challenge
- IAEA found 110 countries have inadequate regulatory control
- Other suitable radioactive materials (spent fuel, nuclear waste) are plentiful

A dirty bomb is a weapon of mass disruption, not destruction

- Disruption can be devastating and expensive
- Much can be done to reduce supply protect and dispose
- Much can be done to prepare and limit the disruption

Kim Jong-un: Third in the Kim family dynasty

They are real people

Time is not on DPRK's side

Over 1 million cell phones now

The winds of change are on our side

Pyongyang subway

Where there is swoosh, there is hope

BACKUP SLIDES

India's path to the bomb

- Aug. 1948. Homi Bhabha and the Indian Atomic Energy Commission
- Ambitious three-phase nuclear energy plan
- 1974 "Peaceful" nuclear explosion (Smiling Buddha)
- International sanctions (led by United States)
- June 9, 1988. Rajiv Gandhi's rejection of nuclear weapons
- 1998 nuclear tests (declaration of nuclear weapon status)
- Oct. 2008. U.S. India nuclear deal (123 agreement)

The deal was highly controversial in both countries. Can it bring India inside the nonproliferation tent?

Pakistan's path to the bomb

- Began in 1972 following war with India loss of E. Pakistan
- Meeting of PM Zulifkar Ali Bhutto with his nuclear establishment
- Bomb was going to rebuild Pakistan's strength, heal its wounds, buttress its pride, and ensure better results in future wars.
- Contracted with Belgium and France for Pu reprocessing facility
- 1974 India test tightened export cooperation for Pakistan as well
- 1976 A.Q. Khan returns to Pakistan to lead uranium effort
- Pakistan solicited financial help from Libya and Saudi Arabia
- U.S. imposes sanctions on and off. China aids Pakistan program
- Pakistan achieved rudimentary nuclear capability by 1987

Pakistan's path to the bomb (cont.)

- 1990s Pakistan lost whatever hesitation it may have had about proliferation and the spread of nuclear technologies
- Pakistan follows India with six nuclear explosions in 1998
- The A.Q. Khan proliferation ring becomes a nuclear "Walmart"
- Nuclear capability played large role in Pakistani Kashmir adventurism.
- Pakistan counts on nuclear weapons to repel India
- Nuclear weapons have become enormous part of national pride

There was no magical moment or action that could have been taken to cause Pakistan to abandon its nuclear program

George Perkovich, Carnegie Endowment for International Peace

- I. NWS no transfer nuclear weapons or control - not assist, encourage, or induce NNWS to manufacture or otherwise acquire nuclear weapons II. NNWS – not to receive transfer of NWs III. 1) NNWS – accepts safeguards to prevent diversion 2) All – agree not to provide FM, equipment or material 3) Safeguards yes, but avoid hampering economic and technological development IV. 1) All have 'inalienable' right for research, production, and use of peaceful uses of nuclear energy 2) All will facilitate in fullest exchange of equipment, materials, and information for peaceful uses (esp. developing world) V. All – potential benefits made available to NNWS (nondiscriminatory) VI. All – pursue negotiations in good faith on effective measures relating to cessation of the nuclear arms race at an early date and to nuclear disarmament, and on a treaty on general and complete disarmament under strict and effective int'l control
 - X. All have right to withdraw (national sovereignty)

Three pillars – nonproliferation, right to energy, disarmament

Why does Iran want nuclear weapons?

Let's take a look at its neighborhood

Why does Iran want nuclear weapons?

- Gain a greater role in the Middle East and Islamic leadership
- As a deterrent to U.S. aggression and U.S. influence in Gulf
- To counter Israel's nuclear weapons capability
- For domestic consumption shore up the Islamic regime
- To gain international prestige
- Hedge against Saudi Arabia

Negotiation Option: Prospects Are Poor

- Carrots and sticks are not proving enough
- Positive incentive ("soft power") is lacking
- Neither side trusts the other
- Ahmadinejad has threatened Israel's existence
- Israel has stated it will not accept a nuclear Iran

We have had no feet on the ground. We understand little about internal dynamics. We missed opportunity in 2003. We don't understand the motivations of our partners.

Military Option: Prospects Are Poor

- Iran is three times the size and population of Iraq and much better armed
- War could be prolonged, involve Israel, other Middle East countries
- Iranian missiles can reach Israel, Saudi Arabia
- May not be able to destroy all nuclear facilities

We cannot rule out that Israel may conduct surgical strike if nuclear weapons capability seems imminent

Strategy to prevent nuclear Iran

- Make it more attractive to give up the bombs and more costly to keep them
- \cdot U.S. holds the key to the benefits
- China and Russia hold the key to the costs
- U.S. must develop risk-based policy and speak with one clear voice
- Ú.S. must understand what China and Russia want, and develop a common strategy

What are the nuclear security threats?

- Nuclear attack currently, a low threat
 - Concerns in event of miscalculation or instability
 - Greater threat if many more bombs
- Miscalculations, instability or accidents possible
- Uranium enrichment (HEU) low unless lots of HEU
- Export materials or technologies very serious
 - Centrifuge technologies may be attractive
 - HEU export bigger threat than plutonium

Peace & Prosperity

War & Disaster

Iran's nuclear program under the cover of civilian nuclear power

- 1960s U.S. "Atoms for Peace" research reactor and hot cells
- 1974 Germans start commercial LWRs at Bushehr
- 1980s 1990s: China supplies nuclear-related technologies
 - Iran shops globally for nuclear infrastructure
 - A.Q. Khan supplies centrifuge technologies (P1 and P2)
 - and possibly weapons design
- Mid-1990s: Iran links up with Russia
 - Public Bushehr commercial nuclear power deal
 - Mikhailov Amrollahi secret nuclear cooperation protocol
 - Other fuel cycle acquisition attempts
- Late 1990s on: Iran scales up enrichment program & other facilities
 - Major sites at Natanz and Kalaye
 - Potential weapons sites at Parchin and Lavizan-Shian
 - Develops complete uranium ore to HEU infrastructure
- 2002: IAEA begins investigation after secret nuclear facilities revealed
- 2003-2005: Iran "temporarily" suspends enrichment cat & mouse game
- 2006 Iran resumes enrichment activities, continues dialogue IAEA not able to declare Iran has no weapon program UNSC issues resolutions
- 2012 Iran continues both enrichment and dialogue

Public view of Iran's centrifuge facility (4/8/2008)

Status of Natanz

2010 Status of Natanz

- 8856 centrifuges installed (end of August 2010)
 - 3772 fed with UF6, 2.8 tons of LEU produced
 - STUXNET virus slowed progress; then the Stars virus (2011)
- Progress slower than anticipated
- Eventual goal is 50,000 centrifuges
- 3000 IR-1 centrifuges could produce ~ 40 kg HEU per year

A secret centrifuge facility discovered near Qom - 2009

Satellite Imagery Narrows Qom Enrichment Facility Construction Start Date (sometime in 2006)

D. Albright, ISIS

40 MW_{th} Heavy water reactor construction at Arak

U.S. supplied 5 MWt Tehran Research Reactor

- Operating since 1967
- Provided research and training
- Very small plutonium extraction performed in past

Iran has 40-yr history of nuclear research