Nuclear Energy in South Asia

Recipe for Hope or Disaster?

Stephanie Cooke

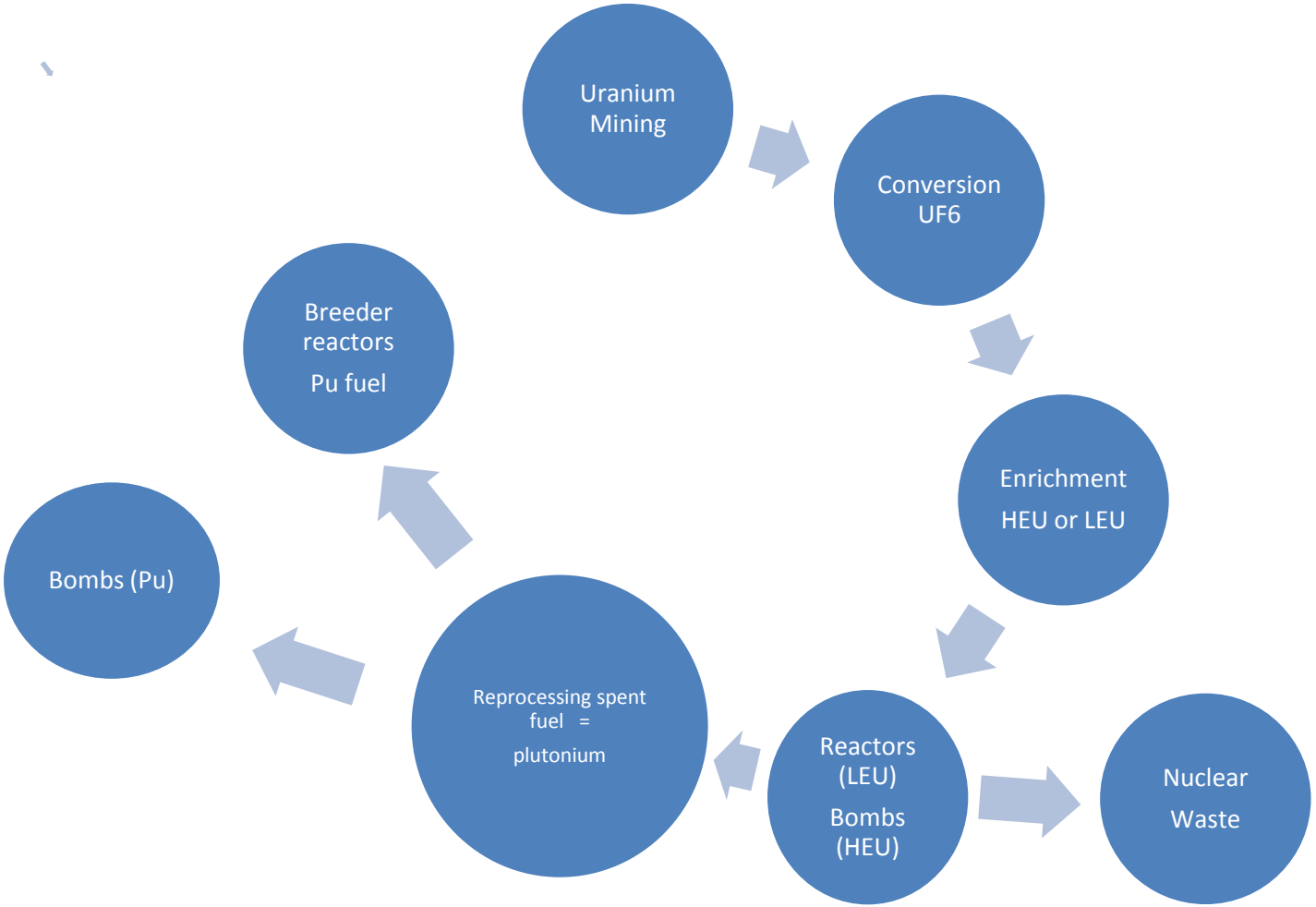
View of recent nuclear test site at Pokhran in Rajasthan

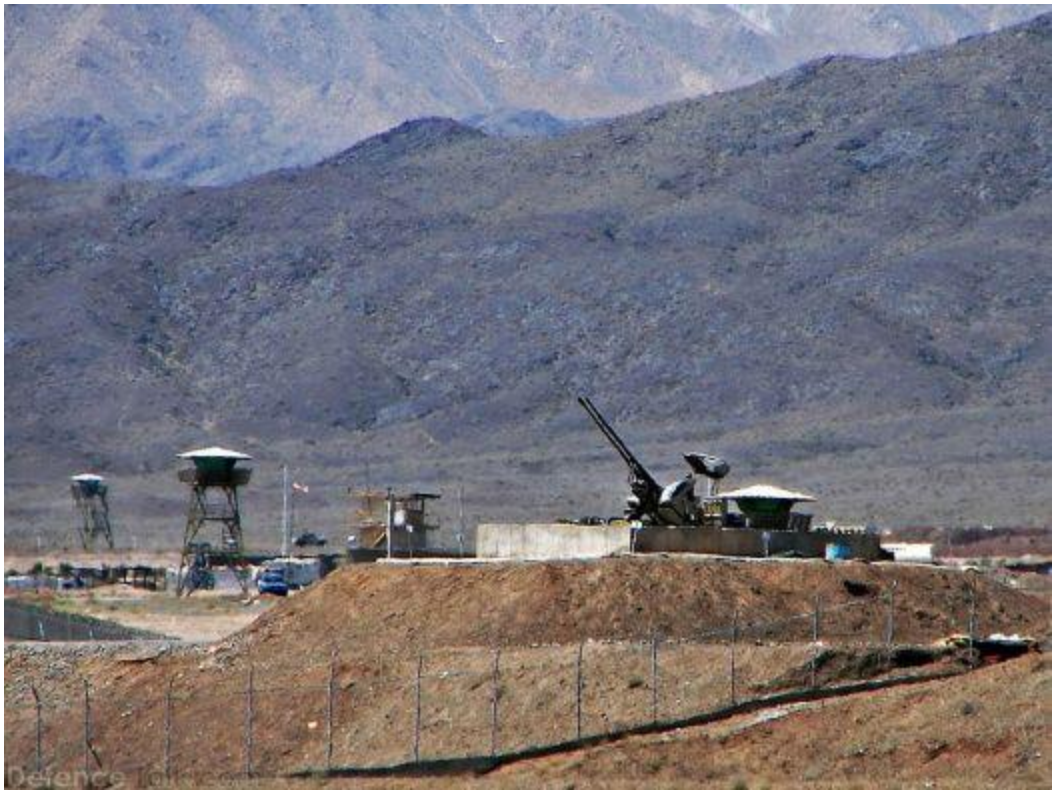
High and low-yield weapons tested

Attack on Indian Parliament December 2001

Atoms for Peace

Nuclear Fuel Cycle





High Stakes in Iran

Anti-aircraft artillery guarding Natanz

Cosmic Rays!

Khrushev with Bhabha in Bombay

Early Indian Nuclear Forecasts

- 1962 — 20-25,000 MW by 1987
- 1969 — 43,500 MW by 2000
- 1984 (after NNPA) — 10,000 MW by 2000

- 2010 ACTUAL — 4,560 MW (19 reactors)

CIRUS

- Reactor supplied by Canada
- Heavy water and reprocessing plant supplied by US
- Result: “peaceful nuclear explosion” 1974

Non-Proliferation Treaty (NPT)

Weapons states – 'legitimate'

- United States
- USSR
- China
- Britain
- France

Weapons states – 'illegitimate'

- Israel
- India
- Pakistan
- S. Africa (since abandoned)
- N. Korea

Estimated cumulative weapon grade Pu production (kg) through 2006

India

- CIRUS 234
- Dhruva 414

- Total consumed 131
- Total available 500 = @ 100 weapons

Pakistan

- Khushab (50MWt) 92

Estimated cumulative civilian reactor grade Pu production (kg) 2006

India

- Unsafeguarded 11,500
- Safeguarded 6,800

4-20 kg/one weapon

Pakistan

- Unsafeguarded none
- Safeguarded 1200

Pakistan

A.Q. Khan

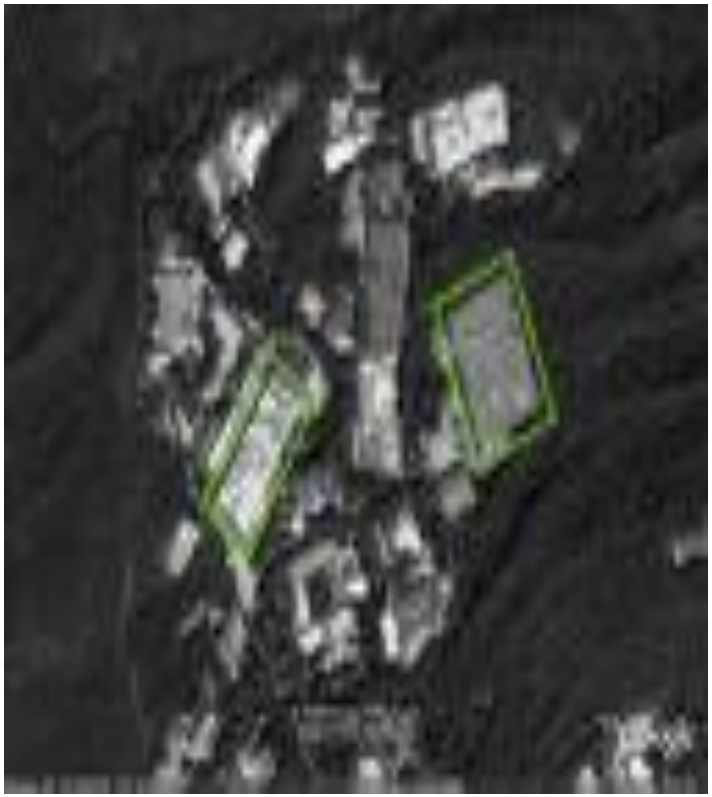
Kahuta Enrichment Plant

Highly Classified

Centrifuge Technology

Uranium Enrichment Centrifuges

Kahuta



Estimated cumulative enriched uranium production (kg)

India

- 460-700 (45-30% enrichment)
- Assumed swu capacity = 4100

Pakistan

- 1400 (90% enrichment)
- 120 kg consumed in tests, leaving estimated stockpile of 1300 kg – enough for about 65 weapons
- Assumed swu capacity 20,000
- 12 kg/bomb

Estimated Weapons Stockpiles

- India 70-90
- Pakistan 60-70

- Source: International Panel on Fissile Materials

US-India Nuclear Deal 2005

Lifts restrictions on US nuclear exports to India

Uranium Shortages (reactor capacity factors 32-70%)

- "…we were desperate…If this agreement had not come through we might have as well closed down our nuclear reactors and by extension our nuclear program," Indian official to BBC.

US-India Deal:
What to do with all that uranium…?

Use domestic output for further weapon-grade plutonium production – in unsafeguarded reactors.

New Forecasts!

- 20 GW by 2020 (or 40, depending)
- 470 GW by 2050 (with heavy breeder component) = 35% if projected demand

Breeder reactors

Positives

- Produce or “breed” more fissile material than they use.

Drawbacks

- 50-80% more expensive to operate than conventional reactors
- Unique risks – greater potential for catastrophic accidents
- Proliferation potential
- Breeders shut down in France, Germany and Japan. Russian breeder has had repeated sodium leaks and fires. US ended breeder program in early 1980s.

India’s Renaissance So Far?

New Deals!

- Contract with Areva for 300 tons of uranium (December 2008)
- Atomstroyexport agrees to supply 4 more reactors (December 2008)

Hungry for Business

- Areva (France)
- Westinghouse (Toshiba US-Japan)
- GE-Hitachi (US-Japan)
- Atomstroyexport (Russia)

What's the Hold-Up?

- High and rising reactor capital costs
- Siting requirements
- Indian demands for blanket reprocessing rights
- Western demands for liability scheme

Newbuild capital costs

$6-$10 billion per reactor

Global Renaissance by 2030

- 288 units = net increase of 145

  Asia 40%

- 62% jump in nuclear generation capacity – from 371 GWe to 600 GWe

- Europe largest number of closures (46%)

Asian Renaissance
2009

- 54,615 MWe under active construction globally

  43% in China (21 reactors out of 41 total)

- 14,836 MWe construction started

  83% in China (10 reactors out of 12 total)

A Closer Look

new reactors under construction

- China 21
- Russia 9
- S. Korea 6
- India 3
- France 1
- Finland 1

- US 0

other points

- Two projects in Europe: massive delays and cost overruns

- 9-10 reactors under construction worldwide: started 1972-1986

US Renaissance

Lead projects delayed	Reasons
VC Summer (South Carolina Electric & Gas) – 2016, 2019	Westinghouse AP1000 licensing delays
Vogtle (Georgia Power) 2016, 2017	
Calvert Cliffs 3 (Unistar – Maryland) 2015	Areva - long battle with state regulators
South Texas Project (NRG Energy, Toshiba, CPS Energy) 2016,2017	Unexpected cost increase, legal battle between project partners

US Nuclear Overall

- 104 operating reactors
- Applications submitted for 28 new reactors and plans announced for 10 more
- Six units suspected; four delayed

US Capacity Additions to 2030

- Natural gas 53%
- Renewables 22%
- Coal-fired 18%
- Nuclear 5%

Source: EIA Annual Energy Outlook 2009

US Electricity Demand Forecast

- 26% increase 2007-2030 (1% per year)
- From about 4,000 billion kWh to 5,000 billion kWh
- Nuclear contribution decreases from 19% to 18%

Source: EIA Annual Energy Outlook 2009

Constraints

- High capital costs
- Skills shortages
- Infrastructure capacity constraints

The Risks

- Proliferation – countries that want nuclear power are in volatile regions (Middle East, Africa and Asia)
- Increased number of nuclear fuel plants
- Safety -- inexperienced regulators, skills shortages, reduced quality control
- Waste – where to put it for 100,000 – 1 million years? (US repository now 50 years off.)

India's Nuclear Challenges

- Securing affordable newbuild – costs keep rising. Where will the financing come from?
- Attracting capital for local infrastructure development to support nuclear industry
- Siting – securing land from unwilling landowners
- Coping with multiple, unfamiliar reactor designs – both from a regulatory and operational standpoint
- Improving safety
- Enacting insurance legislation to satisfy western vendors
- Confronting waste and decommissioning issues

Hope or Disaster

- Risks of nuclear conflict between India and Pakistan as both increase fissile material production
- Risk of nuclear terrorism (witness Kaiga?)
- Risk of accidental nuclear war or catastrophic nuclear plant accident