Preventing nuclear terrorism – in a world of expanding nuclear energy

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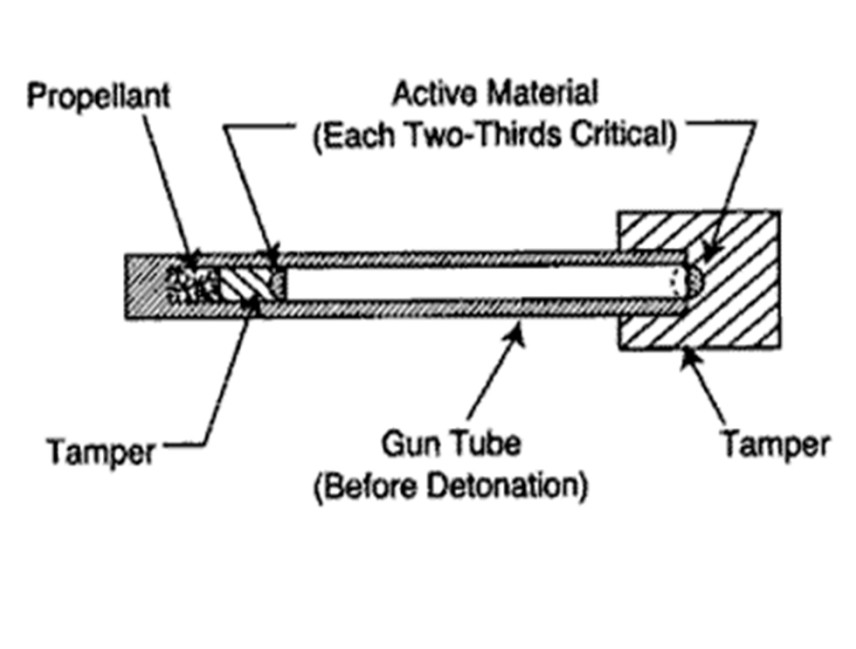
Nuclear terrorism remains a real and urgent risk

- Some terrorists are seeking nuclear weapons and materials
- Some terrorists could plausibly make a crude nuclear bomb if they got needed nuclear material
- ~ 20 real cases of theft or smuggling of HEU or plutonium (most recent March 2010)
  - Inadequate security measures to defeat demonstrated threats in many countries
- Devastating consequences – would reverberate worldwide
  - Even small probability enough to motivate action

Source: Block/AP

With nuclear material, terrorists may be able to make crude nuclear bombs

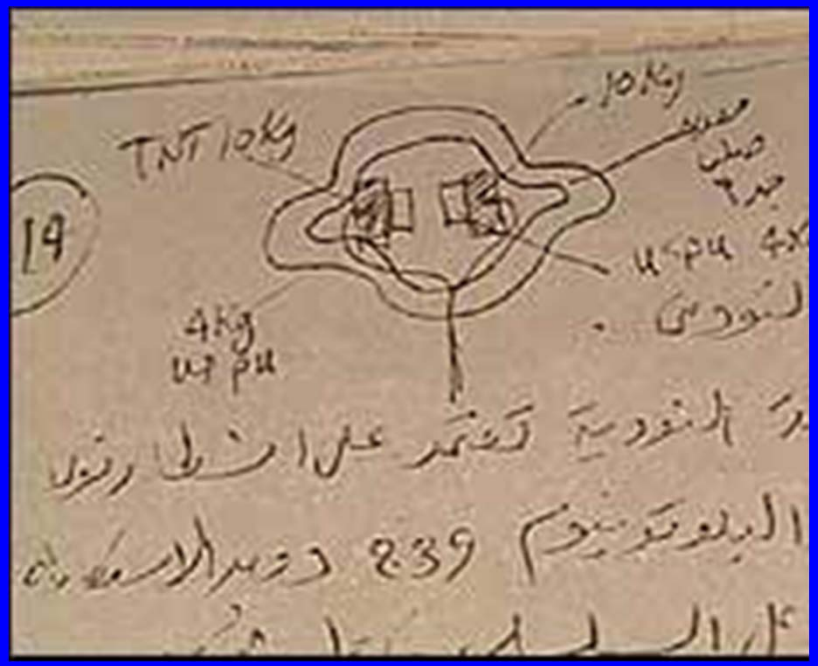
- With HEU, gun-type bomb – as obliterated Hiroshima – very plausibly within capabilities of sophisticated terrorist group
- Implosion bomb (required for Pu) more difficult, still conceivable (especially if they got help)
  - Doesn't need to be as complex as Nagasaki bomb



Source: NATO

Terrorists are seeking nuclear weapons

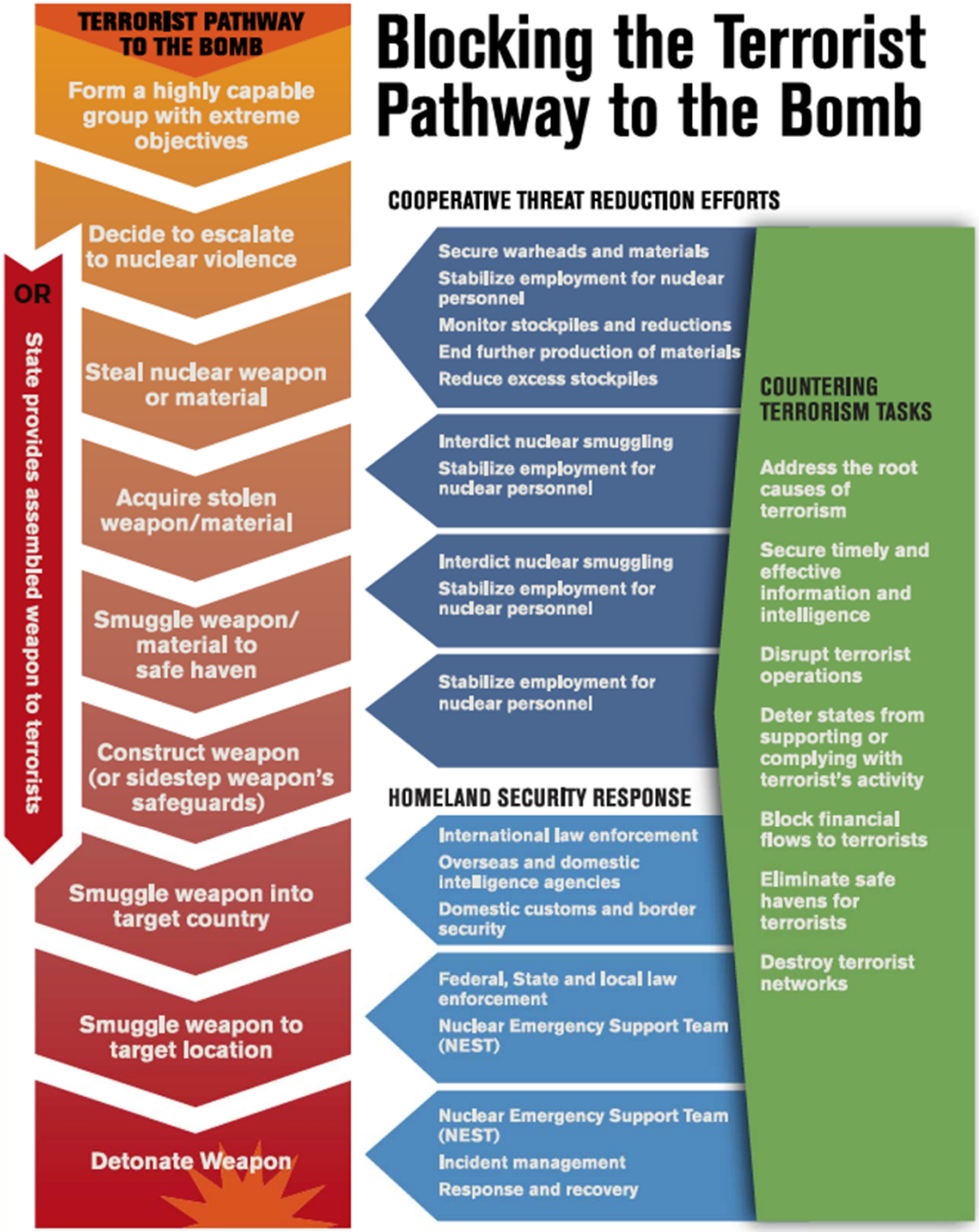
- al Qaeda has repeatedly sought to get nuclear bomb materials, recruit nuclear expertise
- Focused nuclear program reported directly to Zawahiri
- Progressed as far as carrying out explosive tests in the Afghan desert
- Sought and received *fatwa* authorizing use of nuclear weapons in 2003 – Zawahiri elaborated on argument in 2008
- Japanese terror cult Aum Shinrikyo sought nuclear weapons in 1990s



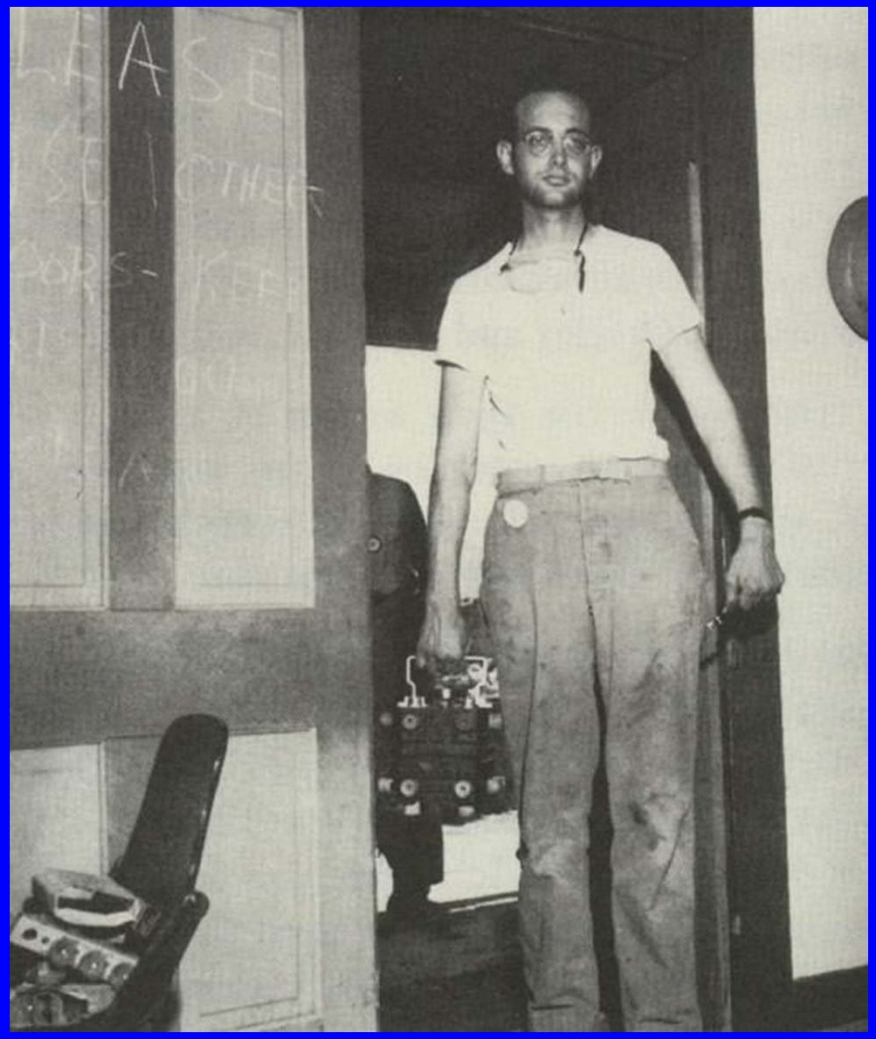
Source: CNN

Blocking the Terrorist Pathway to the Bomb

Source: Bunn, Securing the Bomb 2010: Securing All Nuclear Materials in Four Years (2010)



Nuclear material is not hard to smuggle – plutonium box for first-ever bomb



Source: Los Alamos

Major nuclear security progress – but more to be done

- Dozens of sites with dramatically improved security
- Dozens of sites with all potential nuclear bomb material removed
- Nearly all planned comprehensive upgrades in Russia and former Soviet Union completed
- But many weaknesses remain, in many countries
  - Protection against only modest threats
  - Lack of on-site armed guards
  - Limited insider protection

Source: Department of Defense

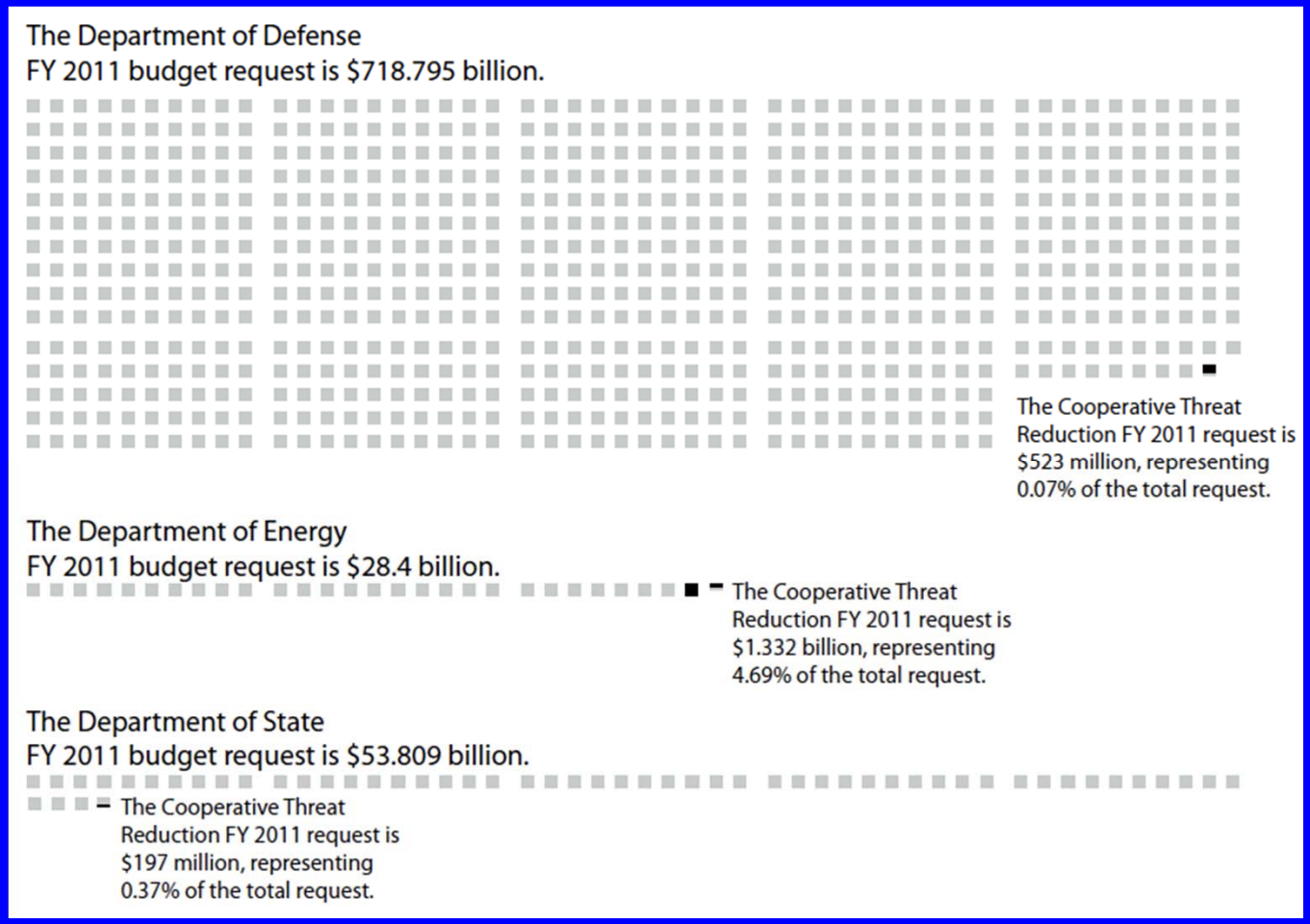
Seizing the opportunities from the nuclear security summit

- Summit raised the issue to presidents and prime ministers in an unprecedented way
  - Major contribution to building the sense of urgency and commitment around the world
  - Agreement on securing all vulnerable material within four years
  - Many significant commitments (e.g., Ukraine's commitment to eliminate all HEU by the end of 2012)
  - Agreement to hold another summit in 2012, regular meetings between, helps hold countries' feet to the fire
- Challenge now is moving from words to deeds
  - Need intensive diplomacy to convince countries to toughen security rules, convert research reactors, eliminate stocks where possible
  - Unfortunate funding constraint: FY2010 < FY2009, FY2011 on continuing resolution until late winter (at least) – slows pace
  - Huge obstacles: complacency, sovereignty, secrecy, bureaucracy, politics between states…

What can be done in the four-year effort – and beyond

- By end of 2013 (ambitious targets)
  - Drastically reduce number of countries with weapons-usable nuclear material on their soil
    - » ~50% reduction may be possible
  - Reduce number of locations where weapons-usable nuclear material exists (~20-30% reduction may be possible)
  - Ensure all HEU and Pu worldwide has at least a "baseline" level of protection – e.g., secure against modest group of well-armed, well-trained outsiders (>1 team), and/or one well-placed insider
  - Ensure beyond-baseline security in a few countries with especially large threats (e.g., Pakistan)
  - Get countries to launch programs to strengthen security culture
- After end of 2013:
  - Forge common understanding on effective global nuclear security standards (e.g., as interpretation of UNSC 1540 obligation)
  - Phase-out of civilian HEU, end accumulation of separated Pu

Cooperative threat reduction is a tiny portion of overall spending



Source: Author's estimates, described in Securing the Bomb 2010

Belief in the threat – the key to success

- Effective and lasting nuclear security worldwide will not be achieved unless key policymakers and nuclear managers around the world come to believe nuclear terrorism is a real threat to *their* countries' security, worthy of investing their time and resources to address it
- Steps to convince states this is a real and urgent threat:
  - Intelligence-agency discussions – most states rely on their intelligence agencies to assess key security threats
  - Joint threat briefings – by their experts and our experts, together
  - Nuclear terrorism exercises and simulations
  - "Red team" tests of nuclear security effectiveness
  - Fast-paced nuclear security reviews – by teams trusted by the leadership of each country
  - Shared databases of real incidents related to nuclear security, capabilities and tactics thieves and terrorists have used, lessons learned

Security culture matters: Propped-open security door

Source: GAO, Nuclear Nonproliferation: Security of Russia's Nuclear Material Improving, More Enhancements Needed *(GAO, 2001)*

North Korea and Iran are likely small parts of the nuclear terrorism problem

- Nuclear security:
  - North Korea has only a few bombs' worth of plutonium in a tightly controlled garrison state – theft very unlikely
  - Iran has not begun to produce weapons-usable material – has only a small amount of HEU research reactor fuel
- Conscious state transfer:
  - Regimes bent on maintaining power unlikely to take the immense risk of providing nuclear bomb material to terrorist groups who might use it in a way that would provoke overwhelming retaliation
  - Transfers to other *states* – who are likely to be deterred from using nuclear weapons – a very different act
- High-level "rogues" within states
  - If stocks of weapons-usable material grew, could an "A.Q. Kim" sell without detection?
- State collapse:
  - Could have worrisome "loose nukes" scenario

Spread of nuclear power <u>need not</u> increase terrorist nuclear bomb risks

- Most nuclear reactors do not use nuclear material that can readily be used in nuclear bombs:
  - Low-enriched uranium fuel cannot be used to make a nuclear bomb without technologically demanding further enrichment
  - Plutonium in spent fuel is 1% by weight in massive, intensely radioactive fuel assemblies
- Reprocessing (separating plutonium from spent fuel) could increase risks, requires intensive security and accounting
  - Poor economics, few additional countries pursuing – South Korea and China major current issues
  - Reprocessing does <u>not</u> solve the nuclear waste problem – should not be seen as the "answer" to the U.S. Yucca Mountain problem
- Power reactors <u>do</u> pose potential targets for sabotage
  - Sabotage would mainly affect countries in region, global nuclear industry
  - As with nuclear theft, strong security measures can reduce the risk

For further reading…

- Full text of Managing the Atom publications at:
  - http://www.managingtheatom.org
- A major web section we maintain for the Nuclear Threat Initiative, *Securing the Bomb:*
  - http://www.nti.org/securingthebomb
- Includes hundreds of pages of analysis, links, and databases, and our most recent reports:
  - *Securing the Bomb 2010* (April 2010)
  - "Funding for U.S. Efforts to Improve Controls Over Nuclear Weapons, Materials, and Expertise Overseas: a 2009 Update" (June 2009)
- *For regular e-mail updates from Managing the Atom, write to* atom@harvard.edu

Backup slides if needed…

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Hiroshima -- result of a gun-type bomb

Source: U.S. Army

What should the mission be?

- Achieve effective and lasting security for all nuclear weapons and stocks of plutonium and HEU worldwide within four years – while consolidating to the minimum number of locations
  - Effective = provides high-confidence protection against demonstrated terrorist and criminal capabilities
    - » Not only installed systems but effective security culture
  - Lasting = countries can and will sustain effective security with their own resources (and have effectively enforced regulations in place that require the necessary measures to be maintained)
  - All = not just in Russia and the former Soviet Union, not just in developing countries, but in all countries – global problem, and wealthy developed countries also an issue
  - Consolidating = reducing number of weapons and materials sites wherever possible, especially removing material from the most vulnerable, difficult-to-defend sites (such as civilian research reactors)

Some highlights of the FY2011 nuclear security request

- GTRI:
  - $559 million (+$225M, 67% boost from last year)
  - Will fund accelerated HEU removals, reactor conversions, some additional security upgrades at HEU-fueled reactors and for radiological sources
- CTR:
  - New $74.5M line for "Global Nuclear Lockdown"
  - Will fund regional nuclear security "centers of excellence", dealing with irradiated HEU naval fuel in Russia, some sustainability in Russia
- MPC&A:
  - +$25M for expanded upgrades in Russia, non-FSU countries

At least these amounts – and probably more – will be needed to have any hope of achieving the four-year goal

Goal/Program		FY09 Approp.	FY10 Approp.	FY11 Request	Change from FY10 Approp.	
Total, Improving Controls on Nuclear Weapons, Material, and Expertise		**1,315**	**1,290**	**1,684**	**394***	**31%**
Securing Nuclear Warheads and Materials		**756**	**707**	**1,018**	**+311**	**+44%**
Material Protection, Control, & Accounting (excl. SLD) [1]	Energy	280	300	325	+25	+8%
Nuclear Weapons Storage Security - Russia	Defense	16	22	10	-12	-56%
Global Threat Reduction Initiative	Energy	395	334	559	+225	+68%
Nuclear Weapons Transportation Security - Russia	Defense	59	46	45	-1	-2%
International Nuclear Security	Energy	6	6	5	0	-7%
Global Nuclear Lockdown	Defense	0	0	74	+74	NP**
Interdicting Nuclear Smuggling		**300**	**425**	**421**	**-4**	**-1%**
Second Line of Defense (part of MPC&A budget line)	Energy	175	272	265	-7	-3%
Export Control and Related Border Security Assistance	State	46	54	62	+8	+14%
WMD Proliferation Prevention	Defense	69	84	80	-4	-5%
International Counterproliferation [2]	Defense	10	14	14	0	0%
Stabilizing Employment for Nuclear Personnel		**81**	**94**	**94**	**0**	**0%**
Global Threat Reduction Program	State	62	70	72	+2	+3%
Global Initiatives for Proliferation Prevention	Energy	15	20	18	-1	-7%
Civilian Research and Development Foundation [3]	State	4	4	4	0	0%
Monitoring Stockpiles and Reductions		**33**	**36**	**34**	**-1**	**-4%**
HEU Transparency Implementation	Energy	17	18	18	0	0%
Warhead and Fissile Material Transparency	Energy	16	18	17	-1	-7%
Ending Further Production		**141**	**25**	**0**	**-25**	**-100%**
Elimination of Weapons Grade Plutonium Production	Energy	141	25	0	-25	-100%
Reducing Excess Stockpiles		**1**	**1**	**113**	**+112**	**11,200%**
Russian Plutonium Disposition	Energy	1	1	113	+112	11,200%
Cross-Cutting Initiatives		**3**	**3**	**3**	**0**	**0%**
WMD Terrorism	State	2	2	2	0	0%
Coordinator for Threat Reduction	State	1	1	1	0	0%

Required budgets depend on strategy – but substantial funds will be needed

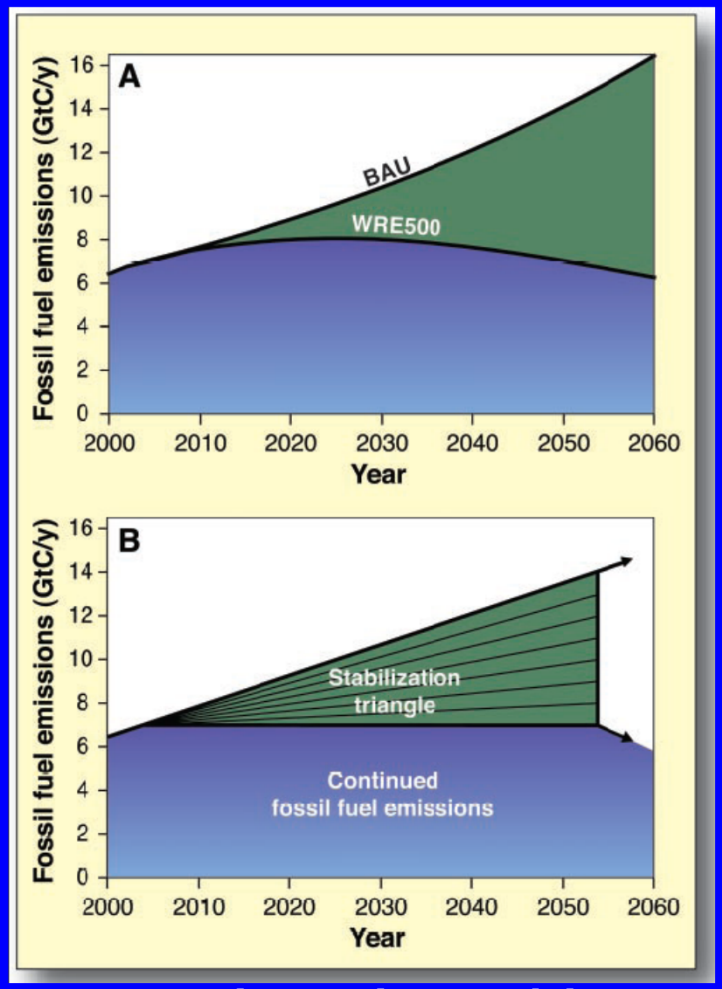
- Different approaches involve different U.S. costs
  - U.S.-funded security upgrades worldwide would be expensive
  - But for many countries, approach will be convincing them to upgrade nuclear security themselves
- *But*, to do more, faster, will cost more money
  - Paying for more reactor conversions
  - Paying for more HEU and plutonium removals
  - Paying for upgrading sites to higher standards of security
  - Paying for upgrading more sites
  - Offering incentives to convince sites to convert/shut down/give up their HEU
  - Expanding cooperation on regulations, sustainability, security culture to more countries

Nuclear revival in the near term and long term

- Near term: modest growth and spread
  - Only a few reactors a year being connected to grid in last decade
  - Growth likely to speed up somewhat, but stay modest for now
  - Cheap natural gas (incl. shale gas) will limit growth
  - Few countries interested in enrichment and reprocessing
- Long term: massive growth and spread possible, potentially in context of disarming world
- So: in near term, need to:
  - Address proliferation risks that already exist, independent of nuclear revival
  - Build foundation of strengthened controls (especially on sensitive aspects of fuel cycle) for the longer term

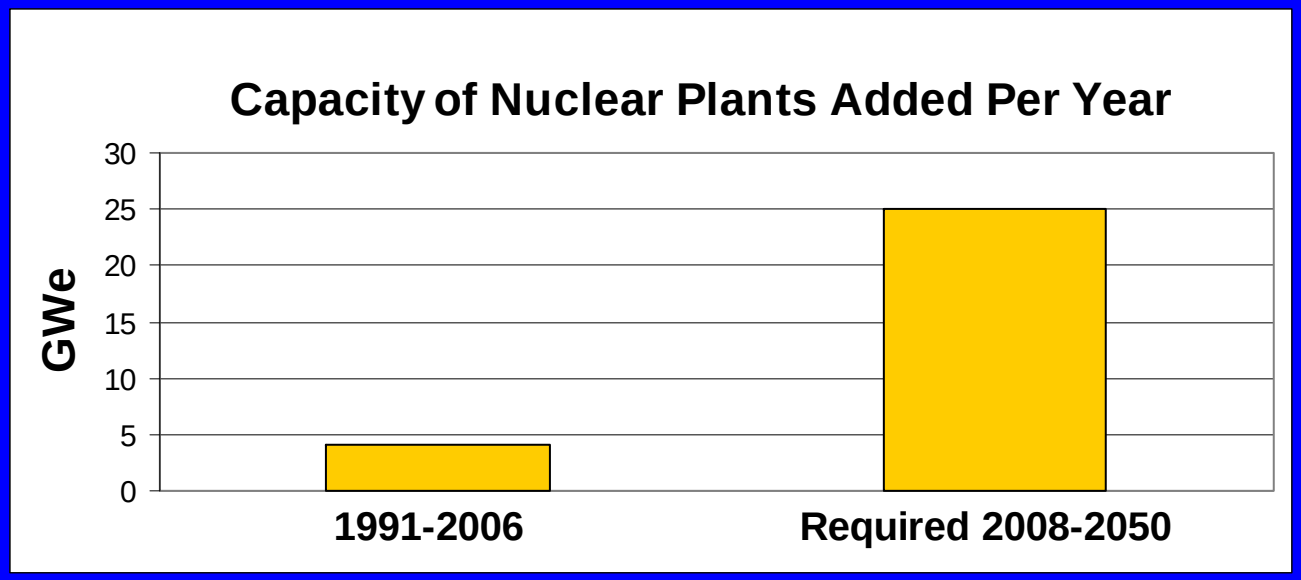
The energy-climate context

- *Dramatic* nuclear growth required for climate contribution large enough to be significant
- To provide *one* of seven "wedges" needed to stabilize CO2 at 500 ppm, nuclear would have to add 700 GWe of capacity by 2050 – and replace 369 GWe of existing capacity
- 2 wedges – as in Stern report – may be unobtainable
- Latest science suggests 10-15 "wedges" may be needed



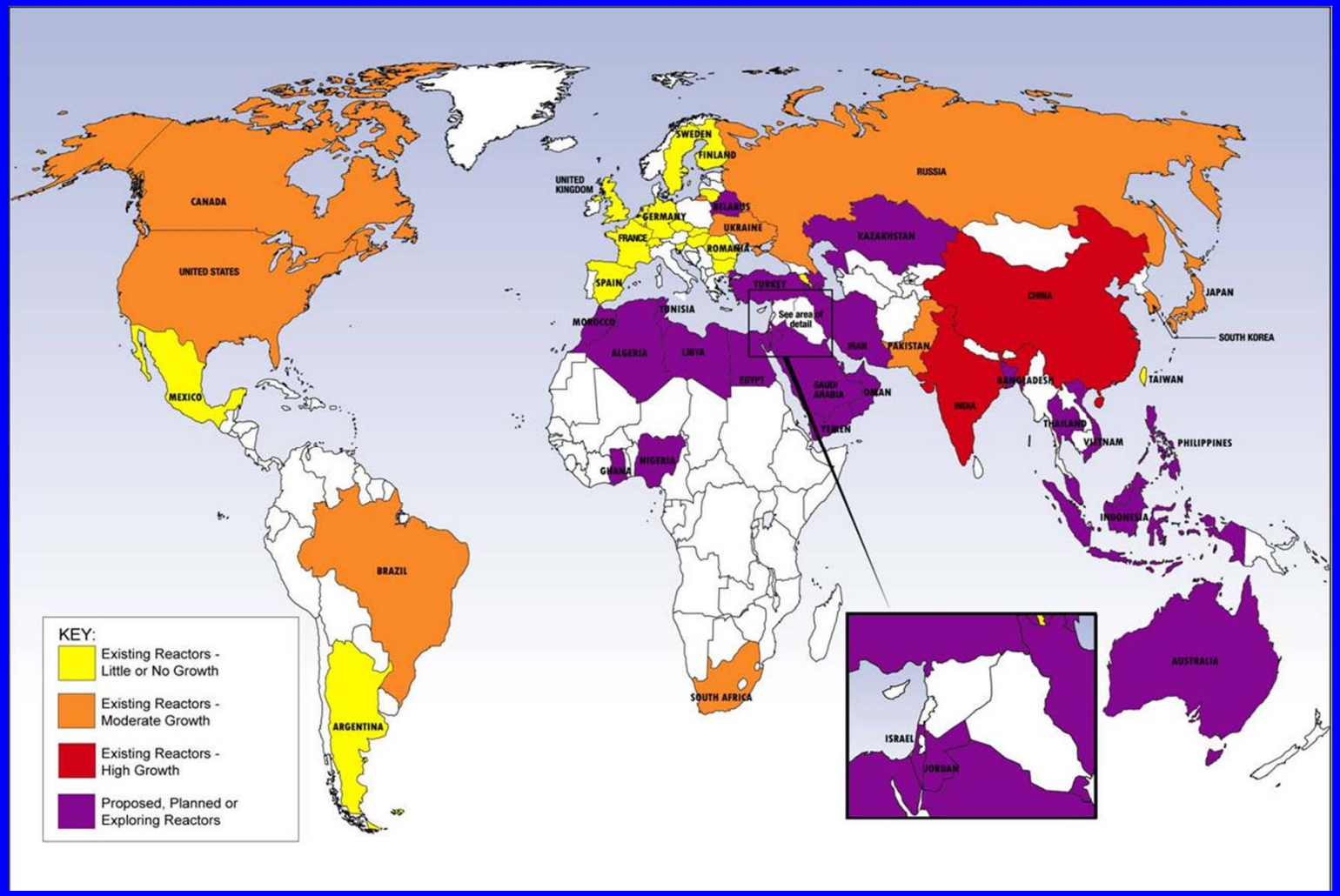
Source: Pacala+Socolow, "Stabilization Wedges," *Science* **305** 968-972 (2004)

For nuclear stabilization wedge, huge increase in construction needed



- Need to shift from 4 to 25 GWe/yr
- Nuclear must become dramatically more attractive to governments and utilities than it has been
- Any major disaster, from accident or terrorism, would doom any realistic prospect for major nuclear contribution to the climate problem

Large-scale nuclear growth implies nuclear spread – the picture so far



Source: Sharon Squassoni, Carnegie Endowment for International Peace

Proliferation and nuclear energy: how strong a connection?

- Today's light-water reactors, under IAEA safeguards, pose modest (though not zero) proliferation risks
- Only a few states that do not have enrichment or reprocessing want to build such facilities – for now
- All states with nuclear weapons have built dedicated military facilities to produce weapons material
- *But*, all nuclear weapons programs since nuclear energy was broadly established have had major inputs from civil sector
  - As source for open or covert technology acquisition
  - As means to build up expertise, infrastructure
  - As "cover" for purchases whose military purpose would otherwise be clear
  - As bureaucratic power base for nuclear advocates

Reducing existing proliferation risks – lessons of proliferation crises

- ***Engage the hard cases***
- ***Beef up nuclear security***
- ***Strengthen nuclear safeguards***
- ***Take new steps to stop black-market networks***
- ***Reduce the risks posed by enrichment and reprocessing***
- ***Toughen enforcement***
- ***Reduce demand***
- ***Keep our end of the bargain***

Getting support for strengthened nonproliferation measures – important to the future of nuclear energy – will not be possible without progress on disarmament. Hence, a world with far greater reliance on nuclear energy probably implies far less reliance on nuclear weapons.

Some longer-term measures

- Control of sensitive nuclear activities needs to be rethought if we are serious about deep nuclear reductions, possibly someday to zero
  - Purely national control of (a) stocks of nuclear material equivalent to thousands of bombs; (b) facilities capable of producing thousands of bombs' worth of material per year will likely no longer be acceptable
  - Need to move toward some form of international/multinational ownership/control
  - Need far-reaching verification measures, for all sensitive nuclear activities (military and civilian – in weapon states as well)
- In a world with far more nuclear energy, will need to:
  - Satisfy fuel cycle needs without spread of nationally-controlled enrichment and reprocessing facilities
  - Develop, deploy more proliferation-resistant systems (e.g., "nuclear battery" reactors with small staffs, sealed cores, "cradle to grave" fuel services)

A vision…

- A world with a greater nuclear contribution to energy needs, with reduced rather than increased risks
- A world with greatly expanded transparency, verification, and multinational control over nuclear activities
- A world in which nuclear weapons and weapons-usable nuclear materials have been dramatically reduced
- A world in which the vast majority of states have joined together to support measures that reduce both the demand for nuclear weapons and the supply of technologies helpful to a nuclear weapons program
- A world in which all nuclear weapons, weapons-usable nuclear materials, and high-consequence nuclear facilities are effectively secured against terrorists and thieves

Preventing nuclear proliferation

- Global nuclear nonproliferation regime is under severe stress – Iran, North Korea, the A.Q. Khan network, the global spread of technology, potential growth and spread of nuclear energy, disputes over disarmament, India deal…
- *But*, the regime has been both successful + resilient
  - 9 states with nuclear weapons today – 9 states 20 years ago
  - More states that started nuclear weapons programs and verifiably gave them up than states with nuclear weapons – nonproliferation succeeds more often than it fails
  - Every past shock has led to parties introducing new measures to strengthen the system
  - All but 4 states are parties to the NPT, and believe it serves their interests
- With right policies today, can hope to have only 9 states with nuclear weapons 20 years from now – or fewer

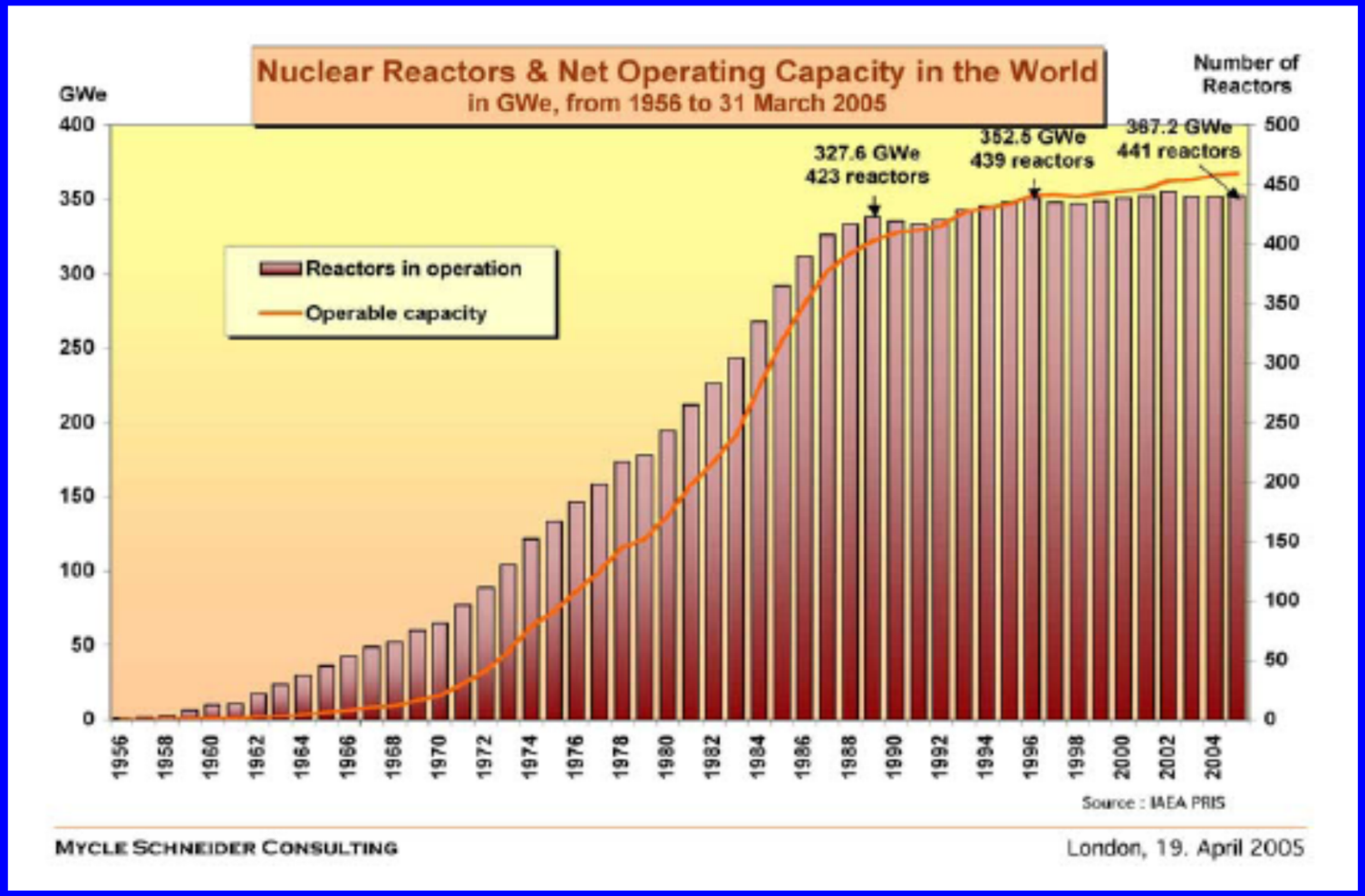
Issues that have to be addressed to enable substantial nuclear growth

- Factors affecting whether governments and utilities *want* to build nuclear power plants:
  - Economics
  - Safety
  - Security & terrorism
  - Proliferation
  - Waste
  - Assurance of supply
  - National pride & prestige
  - Weapons options, regional balancing
  - Public perceptions of above
- Also constraints on whether governments and utilities *can* build nuclear power plants at desired pace:
  - Production capacity (e.g., steel containment vessels), personnel, infrastructure (e.g., regulations, grids), capital availability…

The dangers of complacency

- Most companies in the nuclear industry have as much demand as they can handle, see no need for new action on safety, security, nonproliferation, disarmament
- Most states unwilling to agree to new measures that involve the slightest compromise of their prerogatives
  - U.S. refusal to even discuss “13 steps” agreed in 2000
  - Negotiators of amendment to physical protection convention reject any binding nuclear security standards or reviews
  - “Committee of 25” collapses without agreeing on a single measure to strengthen safeguards
- Financial crisis, Iraq, Afghanistan, the Middle East, all shrink the attention senior policy-makers are likely to give
- *But*, both Obama and McCain have endorsed the vision of disarmament, called for near-term steps in that direction – new administration will create new opportunities

A fragile revival? TMI + Chernobyl stopped nuclear growth



The scale of the control problem…

- Making roughly 15 kilograms of highly enriched uranium (HEU) for one bomb requires ~ 3500 units of enrichment work
  - Current global *civilian* enrichment capacity enough to produce material for >13,000 weapons/yr – would have to triple for stabilization wedge on once-through fuel cycle
- Making one bomb from plutonium requires ~ 4-8 kilograms of plutonium
  - Current global *civilian* plutonium separation ~ 20 t/yr, enough for > 3,000 weapons/yr (capacity is larger, but underutilized)
  - Nuclear stabilization wedge with plutonium fuel cycle (mix of fast reactors and thermal reactors) would require reprocessing ~835 tonnes of plutonium and minor actinides/yr – amount needed to produce ~140,000 bombs
- Controls must prevent diversion of 1 part in 10-100,000, *and* limit the spread of the technology – daunting challenge

Addressing safeguards challenges

- Convince states to give IAEA resources, information, authority, personnel, technology it needs to do its job
  - Provide substantial increase in safeguards budget
  - Press for all states to accept Additional Protocol, make this condition of supply
  - Limit spread of fuel-cycle facilities
  - Provide information from intelligence, export control (denials, inquiries, etc.), other sources
  - Reform IAEA personnel practices to attract, retain best-qualified experts in key proliferation technologies
  - Reinvest in safeguards technology, people (e.g., “Next Generation Safeguards Initiative”)
  - Adopt philosophy of “safeguards by design” for new facilities
  - Develop technologies and procedures to safeguard new fuel-cycle technologies before deploying them

How strong a nuclear revival? Near term vs. long term

- Near term: modest growth, some spread
  - Past decade: ~ 4 reactors connected to grid/yr
  - ~2% of total capacity additions (< renewables)
  - Major construction in China, India, Russia
  - A few reactors in "newcomer" states
  - Low gas prices may continue for many years (shale gas) may suppress all capital-intensive electricity production
  - Few states interested in enrichment, reprocessing
- Long term: potential for huge growth, drastic spread
  - Only readily expandable low-carbon baseload electricity source
  - Future technologies may reduce costs, make nuclear more suitable for more of world's population, more different energy uses
  - Growth to 3-5 times current deployment by 2050 *possible* – not clear if this is likely
  - More states may want enrichment and reprocessing
  - Potential move toward deep nuclear reductions/disarmament

What should the mission be?

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“Steady as you go” budgets will not be enough

- FY2010 request prepared before four-year nuclear security plan could be fleshed out – clearly insufficient
- Achieving the four-year goal will require increased effort:
  - Security upgrades at more sites in more countries
  - Expanded efforts to strengthen security regulation, security culture
  - Removing a wider range of materials from a wider range of facilities
  - *Incentives* to convince states and operators to give up their material
  - Expansion to shut-down of underutilized research reactors as a complement to current focus on conversion
- *But*, the United States should not be paying for upgrades everywhere – in countries like Japan or Belgium, the focus must be on convincing them to upgrade security themselves

Providing the resources needed

- Nuclear security is affordable: large reduction in nuclear terrorism risk can be purchased for ~1-2% of one year's defense budget, spread over several years
- Congress should ask the administration for an assessment of total funds required, by year, to meet the four-year goal – then increase current budget request to match
- Because unexpected opportunities arise, difficult-to-plan incentives are often required, Congress should provide flexible pool of ~$500 million to be drawn on as needed

Given the high stakes and modest costs, Congress and the administration must act to ensure that this effort is not slowed by lack of money

Other key areas for resources

- Helping states implement effective controls required by UNSC 1540
  - Expanded programs to strengthen criminal laws, upgrade export controls, border controls, transshipment controls in many countries
  - Modify mandate for 100% scanning of containers into systems-level approach – with "red teaming" to probe vulnerabilities – to make it as difficult as we cost-effectively can to get nuclear weapons and materials into United States by *any* routes
  - Intelligence support – particularly understanding security arrangements, insider and outsider threats, for nuclear stockpiles around the world
  - Fund non-government analysis – small investments can lead to large returns in improved program effectiveness

Only small fraction of U.S. nuclear spending goes to prevention

- Carnegie study: *Nuclear Security Spending: Assessing Costs, Examining Priorities*
- ~$52 B in total U.S. nuclear spending in 2008
- ~10% for all programs related to preventing the spread of nuclear weapons to hostile states or terrorist groups

Prevention spending can be increased substantially without affecting overall expenditures significantly

The challenge

- Lugar Doctrine: war on terrorism will not be won until every nuclear bomb and cache of bomb material everywhere in the world is secure and accounted for to stringent and demonstrable standards

On the day after a nuclear terrorist attack, what would we wish we had done to prevent it?

Why aren't we doing it now?