Managing Risks From a Nuclear Energy Revival

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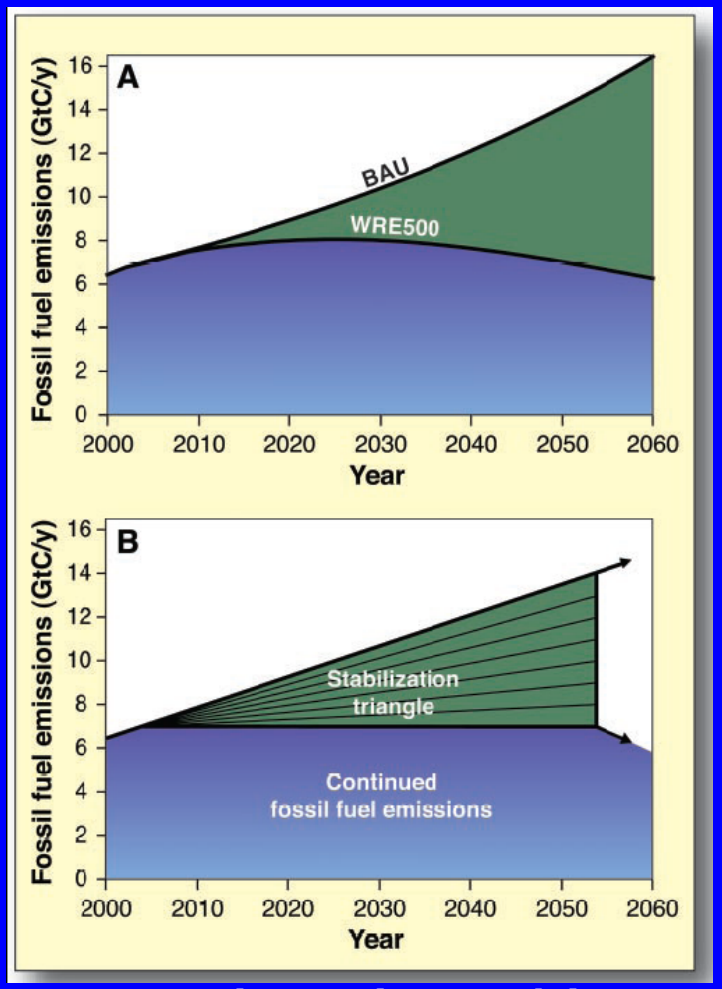
http://www.managingtheatom.org

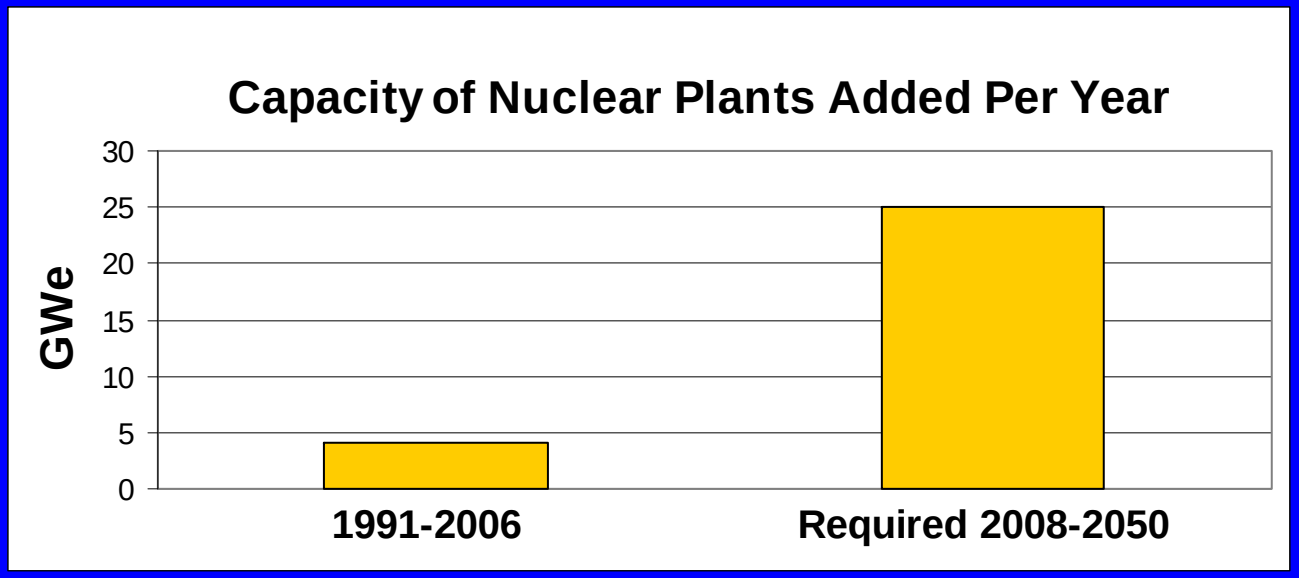
The energy-climate context

- *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



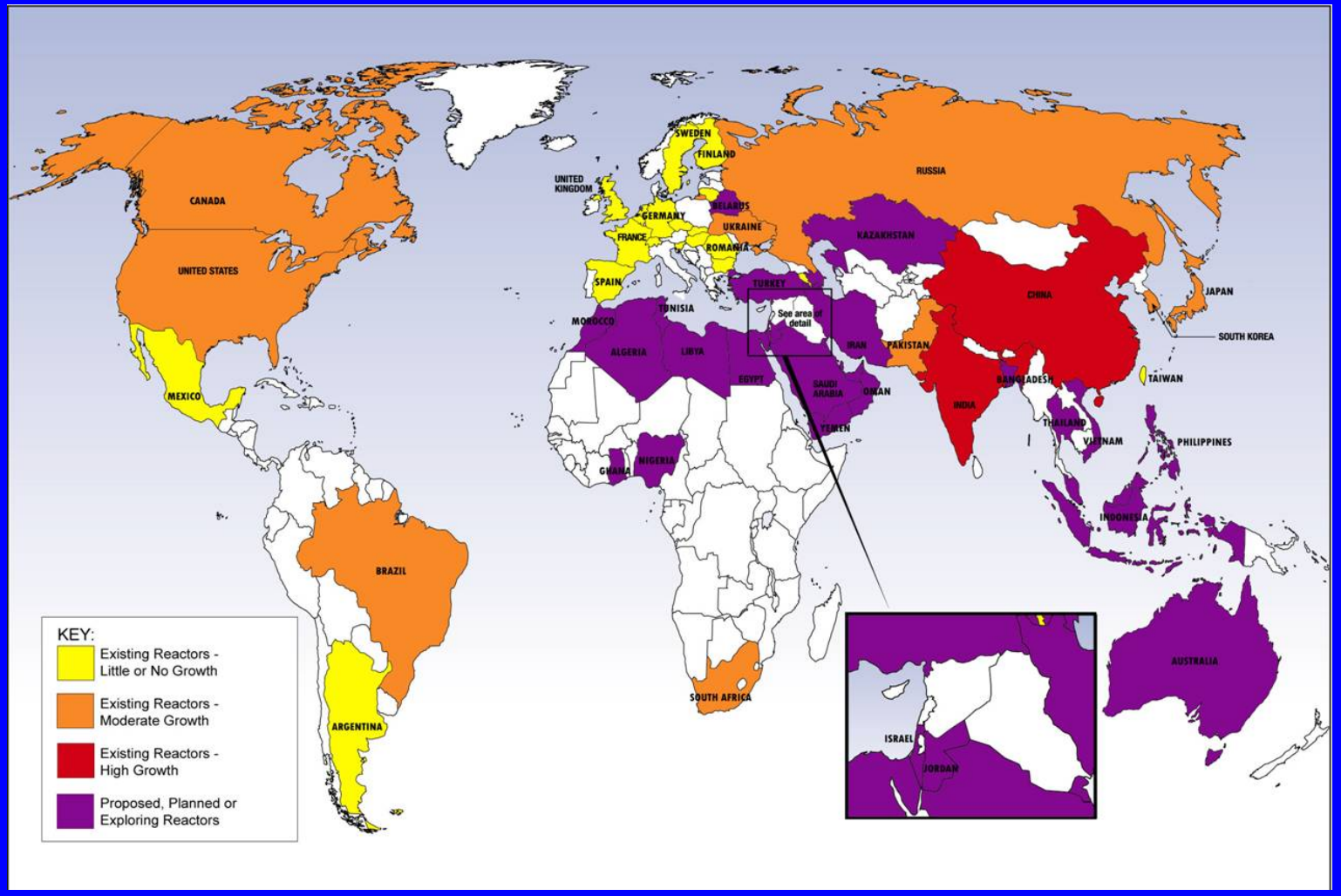
Source: Pacala+Socolow, "Stabilization Wedges," *Science* **305** 968-972 (2004)

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

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…

Potential risks from growth and spread of nuclear energy

- Accidents
  - Current per-reactor risks of Chernobyl-scale accidents must be further reduced for world of 1,000+ GWe
- Terrorism
  - Terrorists stealing nuclear material, making a nuclear bomb
  - Terrorist nuclear sabotage – “security Chernobyl”
  - “Dirty bombs” (mostly not from nuclear power)
- Proliferation
  - More states with nuclear energy facilities could lead to more proliferation risks
  - Particular problem for enrichment and reprocessing facilities – they offer technology to produce weapons material if desired

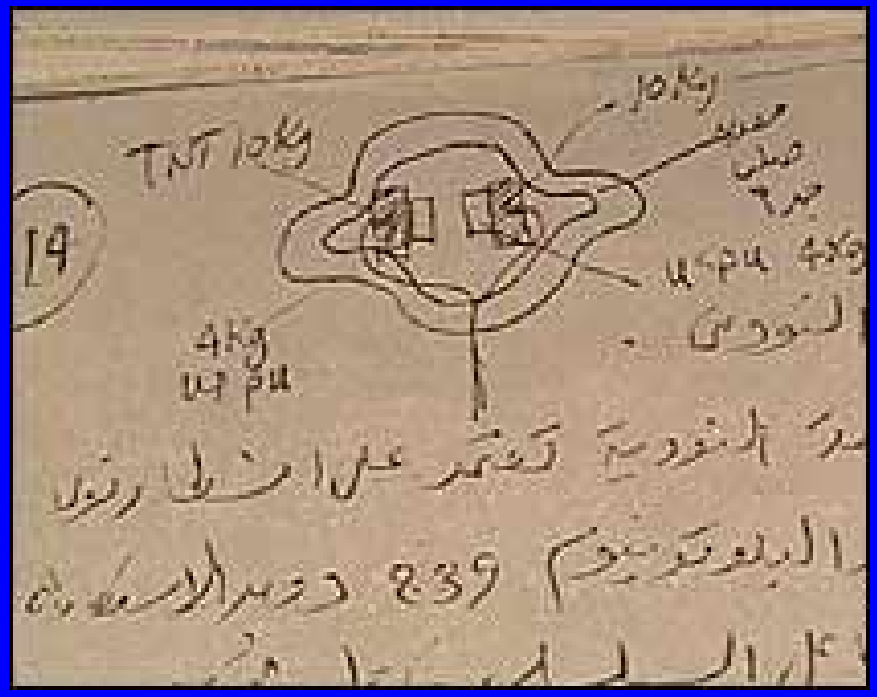
Reducing accident risks as nuclear energy grows and spreads

- Nuclear power today substantially safer than in the days of TMI, Chernobyl
  - *But*, continuing issues – Davis Besse provides compelling example
  - Highest risks likely to be from old, early-design reactors; reactors in newcomer states that have not yet built up effective regulations and safety culture; and reactors with poor safety culture generally
- To avoid increasing accident risks as nuclear energy grows and spreads requires strengthened institutional approaches:
  - Find and fix highest accident risks
  - Strengthen safety culture worldwide
- Current international safety regime entirely voluntary, needs to be strengthened (IAEA, WANO…)
- Commission of eminent persons: need effective global standards, IAEA safety review for all reactors

Safety culture matters: Davis-Besse vessel head hole

Source: FirstEnergy

Nuclear terrorism is a real danger



Source: CNN

- Terrorists are actively seeking nuclear weapons, some nuclear stockpiles are dangerously insecure (for details, see *Securing the Bomb 2008*)
- Al Qaeda has also considered sabotage of nuclear reactors
- Simple “dirty bombs” more likely, but far less devastating

Nuclear revival *need not* increase terrorist nuclear bomb risks

- Standard reactors do not use potential bomb material
  - Low-enriched uranium (LEU) fuel cannot be used to make a bomb
  - Plutonium in waste is 1% by weight in massive, intensely radioactive spent fuel assemblies – hard to steal and process
- Sufficient uranium to fuel rapid nuclear-growth for decades without recycling
- Large-scale reprocessing and recycling of plutonium would involve many tens of tons of weapons-usable plutonium being processed and transported each year, at many sites – increased risk of nuclear theft and terrorism
- Currently, reprocessing appears to be in decline, as utilities rely on cheaper dry-cask storage
  - Major exception: recent start-up of Rokkasho reprocessing plant in Japan

Reducing terrorist nuclear bomb risks – even with a nuclear revival

- Create fast-paced global campaign to prevent nuclear terrorism, focused particularly on effective nuclear security
  - Steps to build sense of urgency among leaders, nuclear managers
- Seek to ensure that *all* caches worldwide are protected
  - Against threats terrorists and criminal have shown they can pose
  - In ways that will work (includes strong security culture)
  - In ways that will last (sustainability)
- Establish effective global nuclear security standards
  - Can build from UNSC 1540 requirement
- Consolidate to smallest practicable number of sites
  - Expand facilities, materials covered, policy tools used
  - Seek to eliminate civil use of HEU
- Expand sustainability, security culture efforts

Sabotage risks and the nuclear revival

- With all the improvements in nuclear safety, probability of major release purely by accident may be less than probability of major release because somebody made it happen – that is, sabotage
  - If so, requires *dramatic* shift in industry culture, resources
- One major sabotage – "security Chernobyl" would doom any prospect for a stabilization wedge from nuclear
- *If* nothing else changes, increased numbers of nuclear reactors *would* increase sabotage risks
  - Creates more chances for security mistakes – for one or a few reactors to be vulnerable enough for terrorists to notice
  - As with safety and theft, risk dominated by small number of most vulnerable facilities – need new ways to find and fix them

Reducing sabotage risks

- Rapidly upgrade security for all high-consequence nuclear facilities and transports (esp. in high-threat countries)
  - Gain political-level agreement on this goal (e.g., through G-8)
  - Develop effective global standards for sabotage security (e.g., in revision to IAEA recommendations)
  - Add at least limited efforts to reduce sabotage risks to U.S. nuclear security assistance programs
  - Expand security-focused training, programs to strengthen security culture, exchange of best practices, peer reviews
- Ensure that all new reactors are designed and operated to protect them against demonstrated terrorist threats
- Work with “newcomer” states to ensure that infrastructure focused on “3 S’s” – safety, security, safeguards – established from the beginning

Security culture matters: Propped-open security door

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

Nuclear proliferation – bad news and good news

- 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
- Most nuclear weapons program have relied on dedicated military facilities – but civil sector has repeatedly been source for technology, expertise, cover stories…

Reducing 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***
- ***Stem the spread of enrichment and reprocessing***
- ***Toughen enforcement***
- ***Reduce demand***
- ***Keep our end of the bargain***

With the right policies, can hope that 20 years from now there will still be only 9 nuclear weapon states – or fewer. That should be the goal. Undue fatalism will lead us to fail to take the needed actions

The challenge of disarmament

- Non-nuclear weapon states will not support more measures that constrain *them* -- new fuel cycle controls, tougher enforcement, stronger safeguards, more stringent export controls – unless the nuclear weapon states also accept constraints on their nuclear postures
- Need to renew the fundamental NPT bargain: nuclear weapon states committed to pursue nuclear disarmament in good faith
- President-elect Obama should begin by recommitting to the vision, establishing a credible process to move toward ratifying the CTB, pursuing deep cuts and dealerting with Russia, and beginning to engage on steps toward building the conditions that would make disarmament possible…
- Need action before the 2010 NPT review to avoid another political disaster for the treaty, as at the 2005 review…

In short…

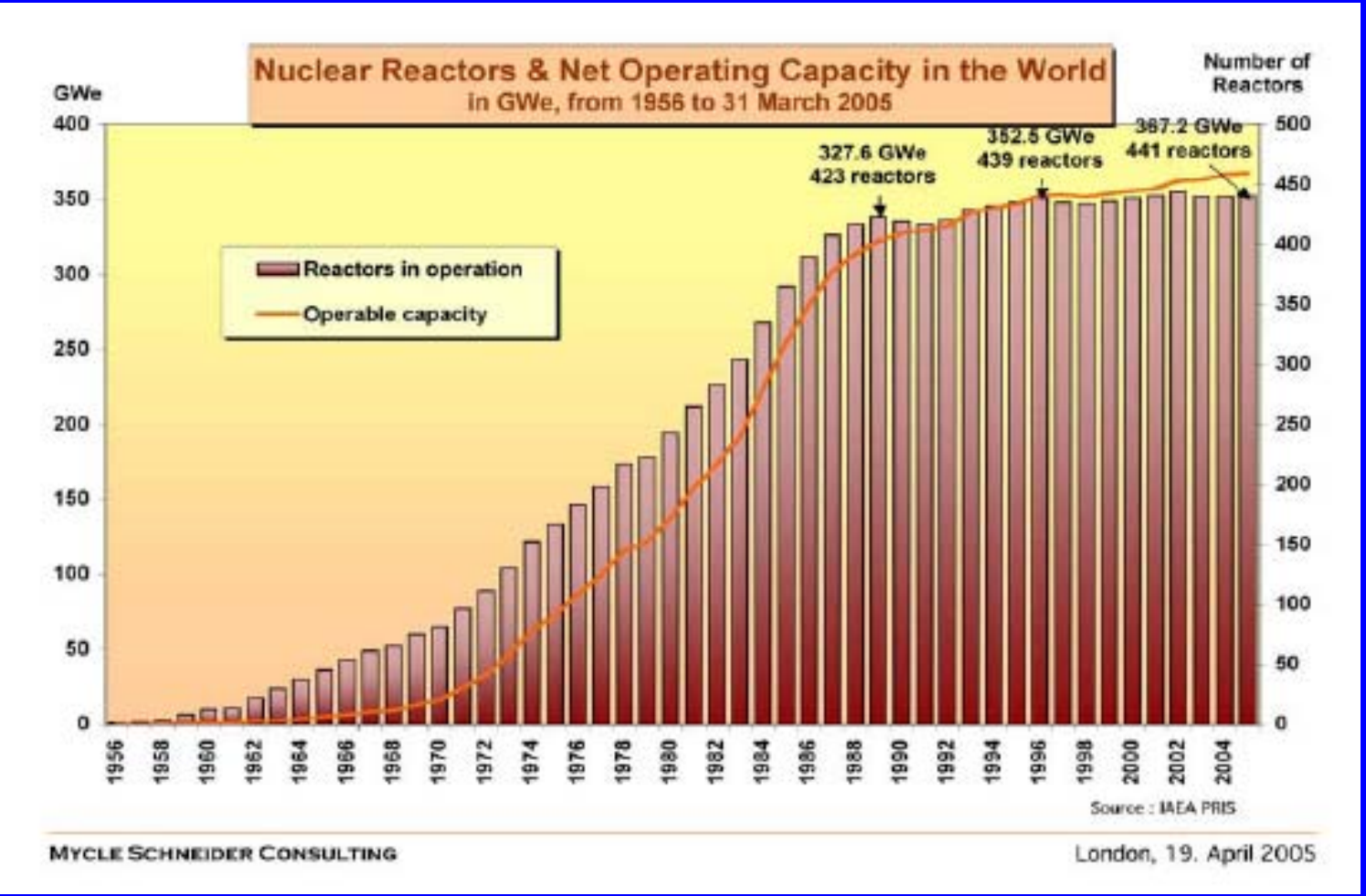
- Achieving a safe, secure, and peaceful nuclear revival will require major institutional innovations
- Avoiding major accidents, nuclear terrorism, or cascades of proliferation will be central to nuclear's ability to grow enough to contribute to mitigating climate change
- The "3 S's" – safety, security, safeguards – are key enablers for large-scale nuclear energy growth
- Major new nonproliferation steps are needed, but will not be agreed without major progress toward nuclear disarmament
- Hence, if we hope for a world in which the role of nuclear energy gets bigger, we need a world in which the role of nuclear weapons gets far, far smaller

Duplicate slides if needed

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



Expanding nuclear energy need not increase terrorist nuclear bomb risks

- Could have global nuclear energy growth with no use of directly weapons-usable nuclear material in the fuel cycle
  - Low-enriched uranium (LEU) fresh fuel cannot be made into a bomb without technologically demanding enrichment
  - Plutonium in massive, intensely radioactive spent fuel beyond plausible terrorist capacity to steal and process
- If scale of reprocessing, transport, and use of plutonium from spent fuel expands, nuclear energy contribution to nuclear terrorist risks would increase
  - Reprocessing converts plutonium into portable, not very radioactive, readily weapons-usable forms
  - With major exception of Rokkasho, current trend seems to be away from reprocessing (despite GNEP) – reduced operations at La Hague and Mayak, phase-out at Sellafield

How might nuclear growth and spread affect sabotage risks?

- Chance of major release caused by malevolent action may well be higher than chance from pure accident
  - Yet industry focus overwhelmingly more on safety than security
- Number of sabotage attempts likely to be driven by level of terrorist groups' interest, *not* number of reactors
- *But*:
  - More reactors in more places means more chances for security mistakes that could create a sabotage vulnerability – *unless* security measures strengthened as nuclear energy grows
  - Even more than with safety, small numbers of poorly secured plants can dominate total risk – terrorists more likely to choose them, and more likely to succeed if they do
- Highest likely current and future risks:
  - Older Soviet-design reactors with few redundant safety features
  - Reactors with minimal security measures (e.g., 0 armed guards)
  - Reactors in newcomer states with little nuclear security experience

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