Managing Risks From a Nuclear Energy Revival

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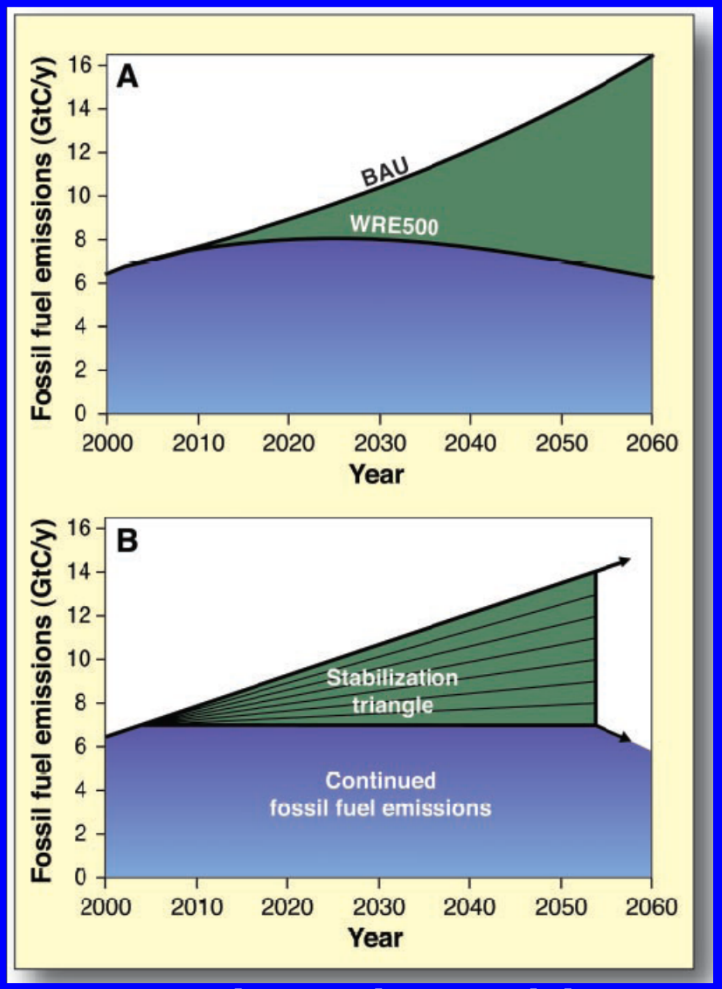
Nuclear revival in the near term and long term

- 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

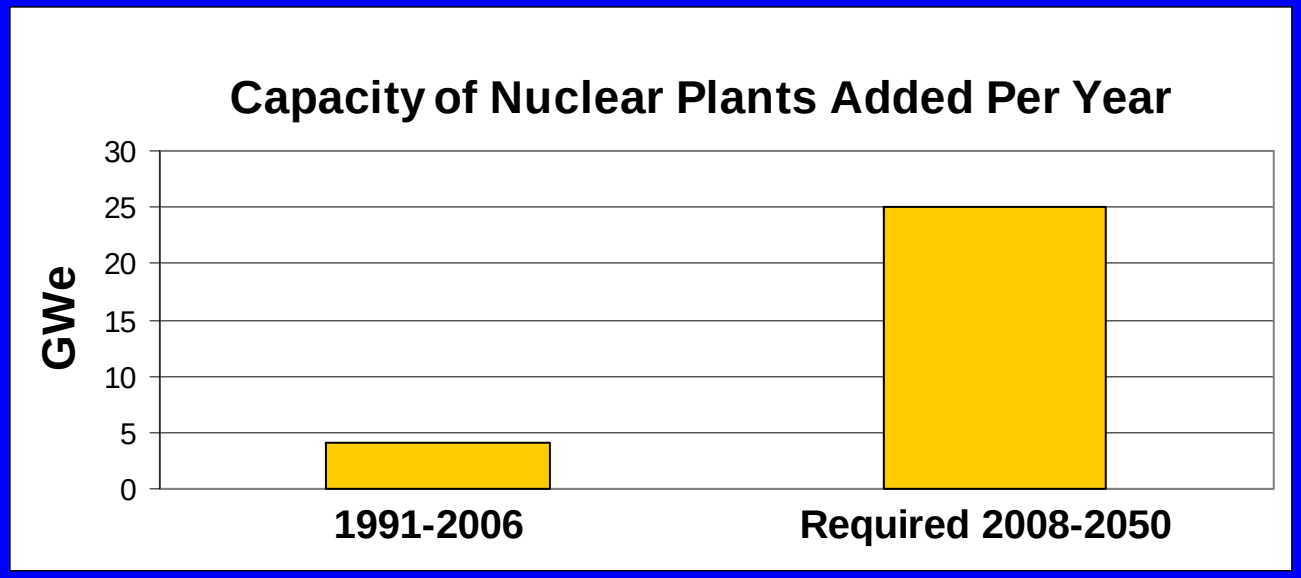
The energy-climate context

- *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



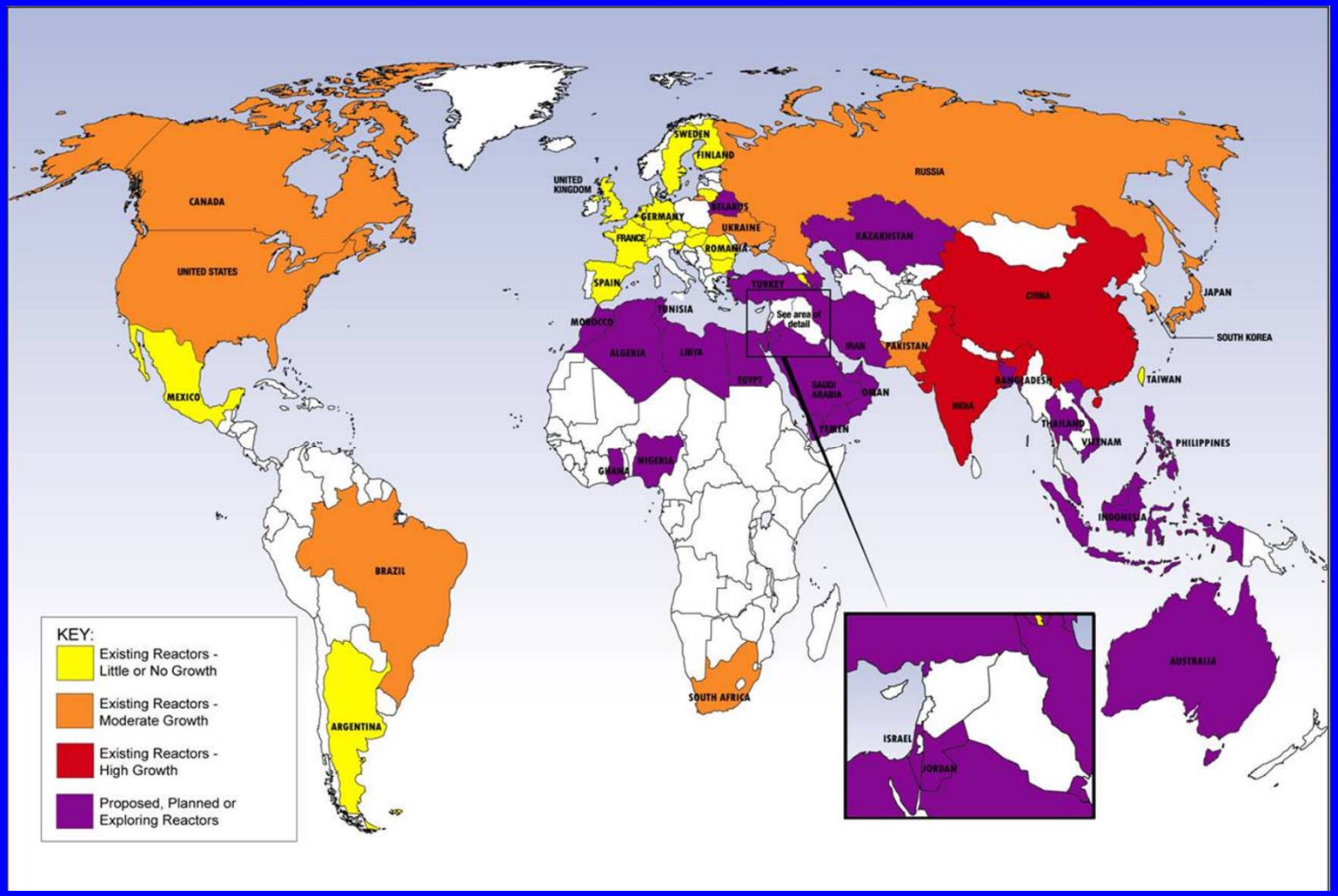
Source: Pacala+Socolow, "Stabilization Wedges," *Science* **305** 968-972 (2004)

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

Duplicate slides if needed

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

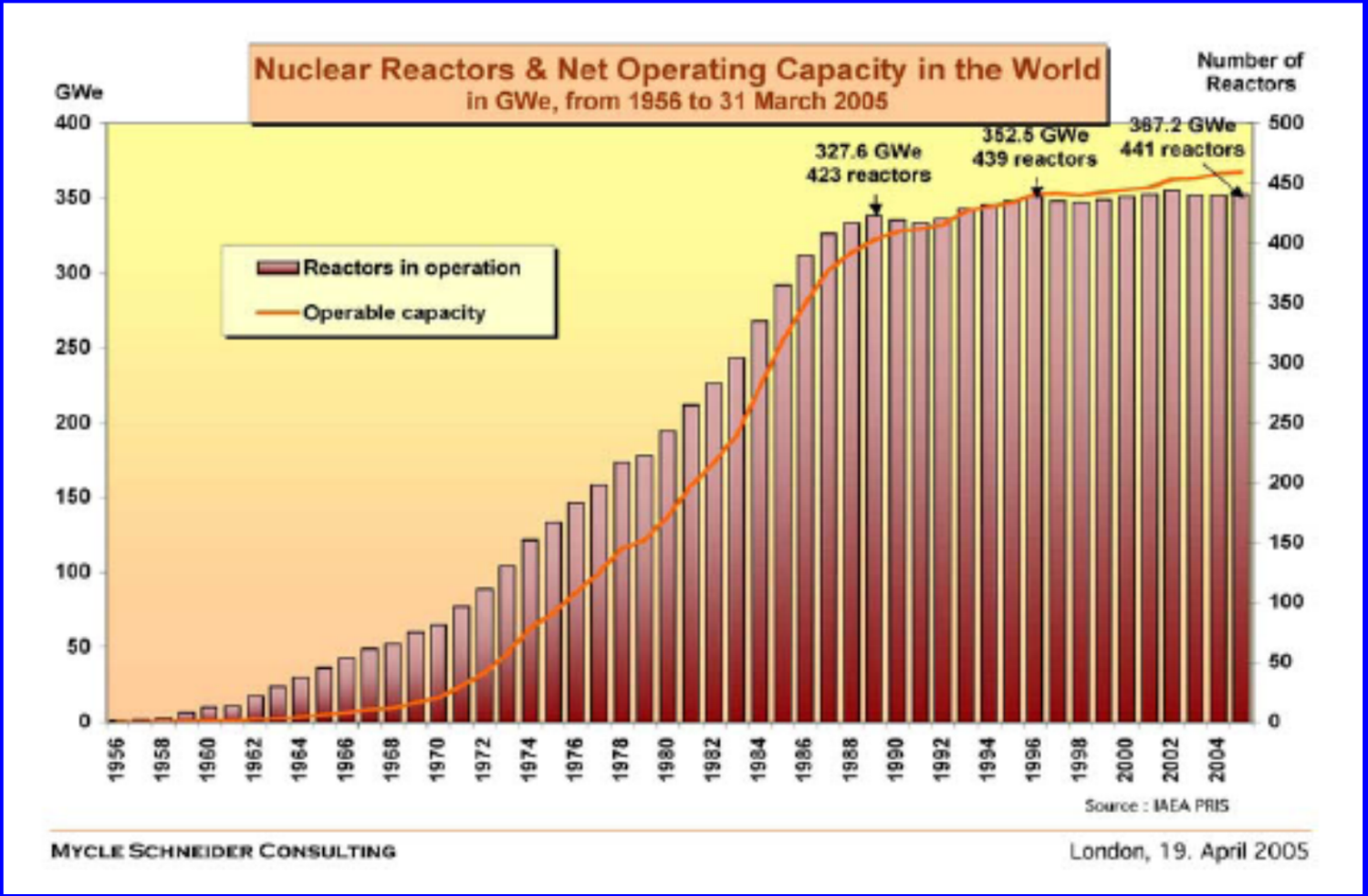
Issues that have to be addressed to enable substantial nuclear growth

- 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



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

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