Safety, Security, Safeguards: Enabling Nuclear Energy Growth

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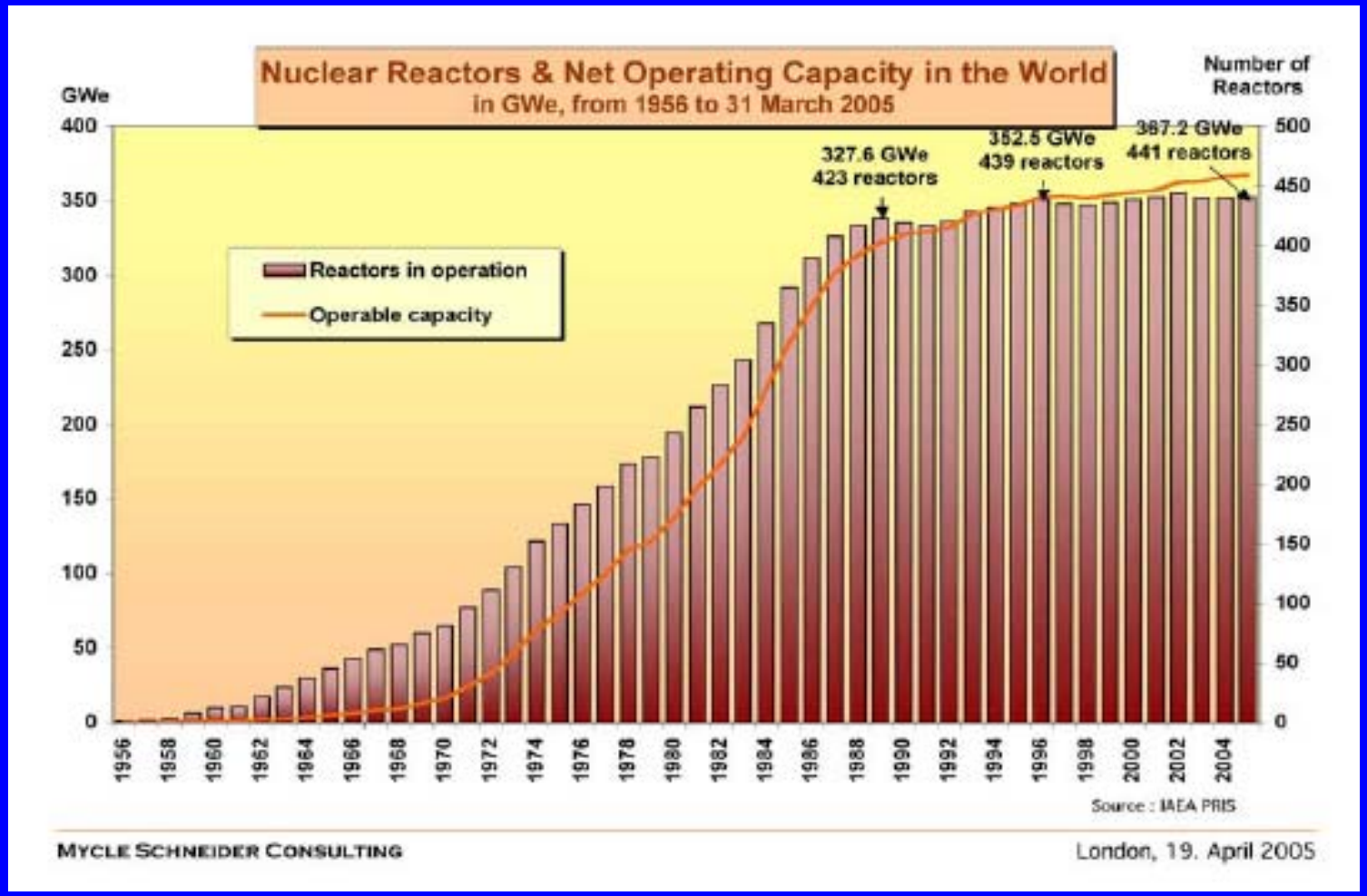
Some questions

- How fragile is global nuclear energy growth?
- How would growth and spread of nuclear energy affect:
  - Risk of major accident
  - Risk of terrorist nuclear bomb
  - Risk of nuclear sabotage
  - Safeguards challenges
- What are the most important steps to reduce these risks and challenges, and how could states be convinced to take them?

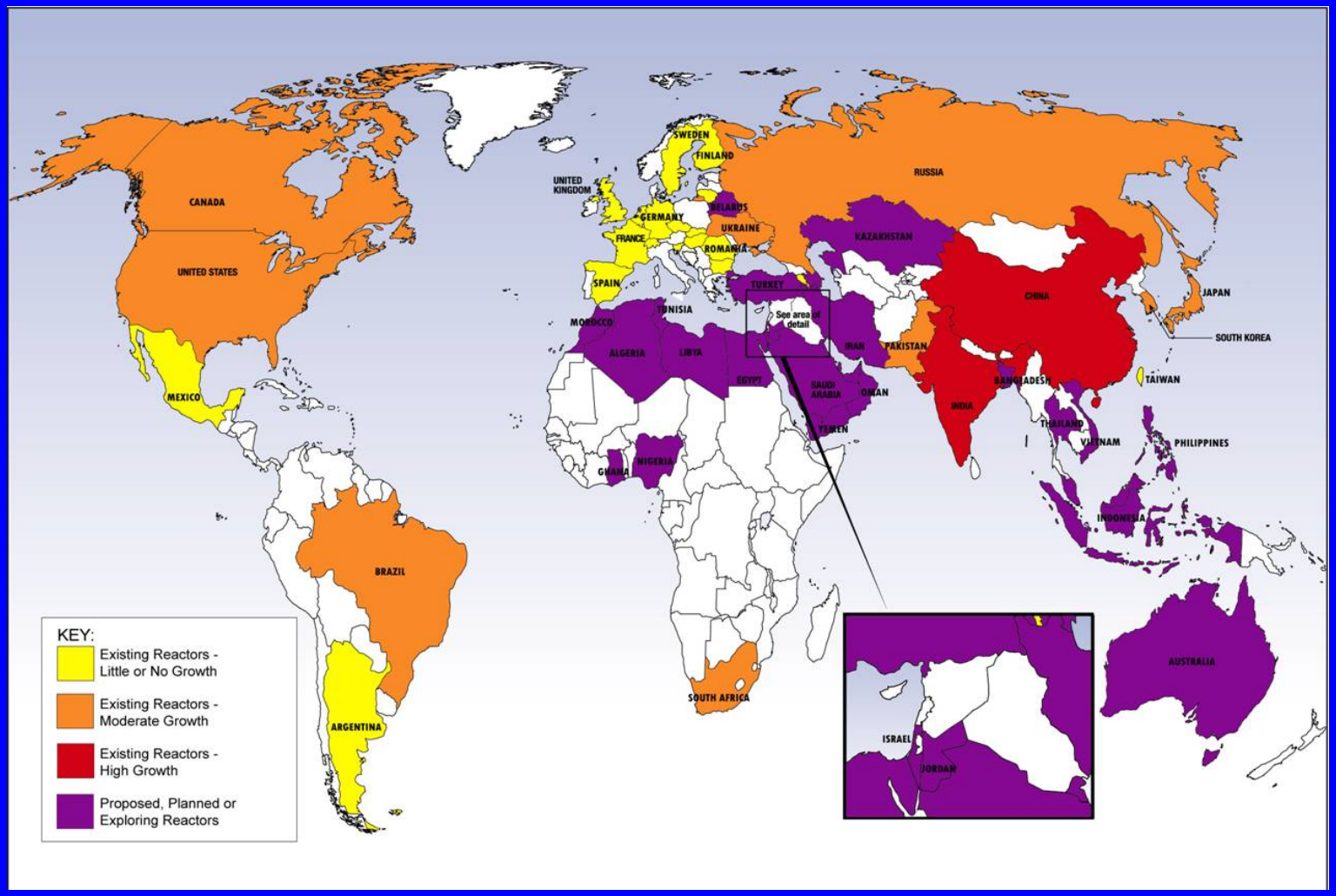
A fragile renaissance? TMI + Chernobyl stopped nuclear growth



How fragile, against what, until what else changes?

- Would another TMI – a major core damage accident with no significant release of radiation – end nuclear growth?
  - What if it occurred *after* major climate disasters?
  - Can we get to the point such events are seen as an unfortunate occasional part of doing business, as major aircraft accidents are?
  - What about a sabotage *attempt* that did not cause a major radioactive release?
- How would major proliferation affect nuclear demand?
  - If Iran becomes an established nuclear weapon state, others in the region seen as seeking to follow, how does that affect nuclear energy decisions elsewhere?
- What impact would terrorism not directly from civil industry have?
  - Terrorist nuclear bomb with material stolen from military stockpiles?
  - Radiological “dirty bomb” with material from, e.g., hospital?

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



Source: Sharon Squassoni, Carnegie Endowment for International Peace

How might nuclear growth and spread affect accident risks?

- More reactors means more risk – *unless* per-reactor risks are reduced in parallel with nuclear growth
  - If 1/20,000/reactor-yr, 40-year probability of major accident = 8% for 430 plants, 20% for 1100 plants
  - But if additional plants $1/10^6$/reactor-yr, probability *declines* as reactors added, old reactors phase out
- Even small numbers of high-risk reactors can dominate risk
  - 40-year risk from 20 1/1000/reactor-yr plants is 55%
- Likely highest current and future risks to be addressed:
  - Old-design plants without modern safety features (esp. Soviet-designed)
  - Plants with poor operator safety culture
  - Plants in "newcomer" states – no experience yet in ensuring safe operations, regulations – so *spread* important
  - Plants in extremely rapid growth states – safe construction, operation, regulation may not be able to keep up

Expanding nuclear energy <u>need not</u> 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

How might nuclear growth and spread affect safeguards challenges?

- Light-water reactors require few inspections, large growth in these represents modest extra burden, *but*
  - Inspections should be improved to preclude undetected removal of enough fuel pins for a bomb
  - Reactors in many more countries will mean more work for state-level assessments
- Enrichment and plutonium recycling <u>would</u> pose increased challenges
  - Likely more plants – possibly more in non-nuclear-weapon states
  - Larger flows => greater challenges in ensuring enough for a bomb is not diverted
  - Larger number of plants, in more countries, suggests larger number of sources for potential technology leakage to black market – hence greater risk of difficult-to-detect covert facilities
  - Proposed "proliferation-resistant" recycling approaches mean more radioactive material that is more difficult to measure – new technologies, approaches may be needed

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

Reducing accident risks

- Undertake an intensive effort to find and fix or shut down the highest-risk facilities worldwide
- Develop more stringent + comprehensive global safety standards – and higher standards for new reactors
- Expand, strengthen international safety peer reviews
  - More resources for more IAEA reviews
  - More pressure on states to have IAEA reviews at all key facilities
  - Reform of WANO – review standards and approaches more similar across regions, outside-region reviewers included
- Intensive work with “newcomer” states to establish effective safety measures (training, regulation…)
- Expand programs to promote, review safety culture worldwide

Safety culture matters: Davis-Besse vessel head hole

Source: FirstEnergy

Reducing terrorist nuclear bomb risks

- 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

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)*

A WANO-like organization for nuclear security?

- World Association of Nuclear Operators (WANO)
  - Exchanges data on safety incidents, best practices
  - Organizes international peer reviews
  - Essentially all power reactors worldwide participate
  - Information kept confidential within industry
- Possible World Institute of Nuclear Security (WINS)
  - Could exchange best practices, unclassified information on threats and how to address them
  - Ultimately, the operators are the key to nuclear security – need an organization focused on them
  - Nuclear Threat Initiative, Institute for Nuclear Materials Management, working with nuclear community to establish

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

In short…

- Large-scale growth and spread of nuclear power <u>need not</u> lead to large increases in risks of accident or terrorism, or in safeguards challenges
- *But* avoiding such large increases will require major policy actions and institutional innovations not yet in place
- Taking these steps is likely to be crucial to nuclear energy gaining the acceptance needed to provide a significant portion of the low-carbon energy needed in the 21st century
- Hence, the "3 S's" – safety, security, safeguards – are key enablers for large-scale nuclear energy growth