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Structural Changes in Nuclear Energy: Proliferation and Security Risks

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"Risks of Civil Use of Nuclear Energy"

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What do

- New nuclear suppliers
- New nuclear recipients
- And emerging nuclear technologies

mean for proliferation and security risks?

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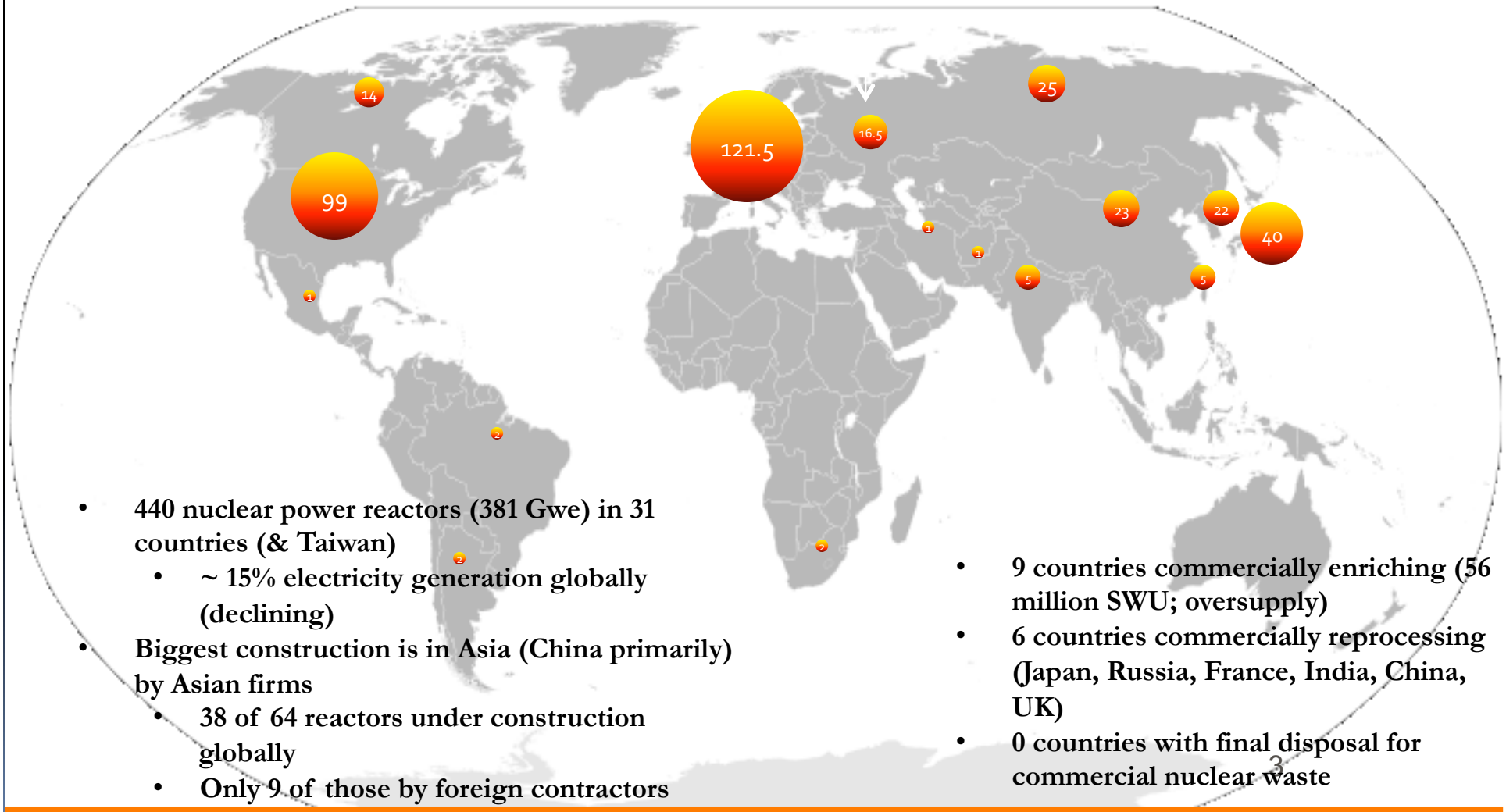
Reactor Capacities Today

(as of July 2015)



- 440 nuclear power reactors (381 Gwe) in 31 countries (& Taiwan)
  - ~ 15% electricity generation globally (declining)
- Biggest construction is in Asia (China primarily) by Asian firms
  - 38 of 64 reactors under construction globally
  - Only 9 of those by foreign contractors

- 9 countries commercially enriching (56 million SWU; oversupply)
- 6 countries commercially reprocessing (Japan, Russia, France, India, China, UK)
- 0 countries with final disposal for commercial nuclear waste

Fewer, Newer Suppliers

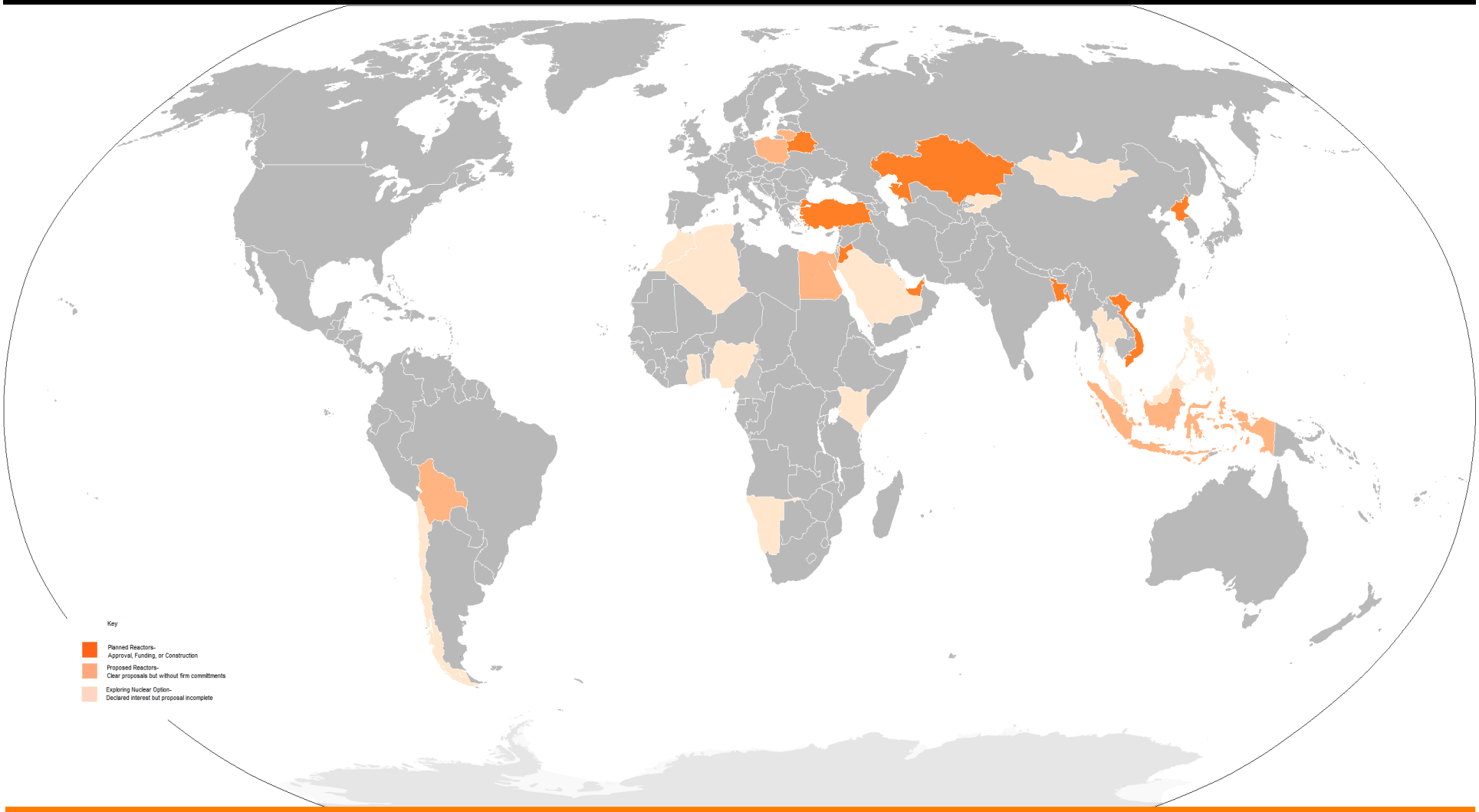
- With decline of nuclear power in OECD, so too a decline in OECD suppliers
  - Nuclear phase-outs in Belgium, Switzerland, Germany; Reduction in France; stalled nuclear in Japan
  - AREVA in severe financial distress; Japanese market uncertain; US sluggish
- While Russia, China, Korea ascendant
  - Russia's creative marketing (financial packages, SNF take-back offers, BOO) is attractive to newcomers. Russia is building 1/3 of npps now under construction abroad; is in one-half of countries that are now planning reactors
  - Korea entered market with 4 npps to UAE
  - China investing everywhere, with an eye to future sales

New Recipients

- 90% of current reactors in OECD countries but this is changing
- Nuclear power aspirant states in Southeast Asia, Africa, Middle East
- They will need significant safety, security and infrastructure support

Proposed "New" Nuclear States

as of July 2015



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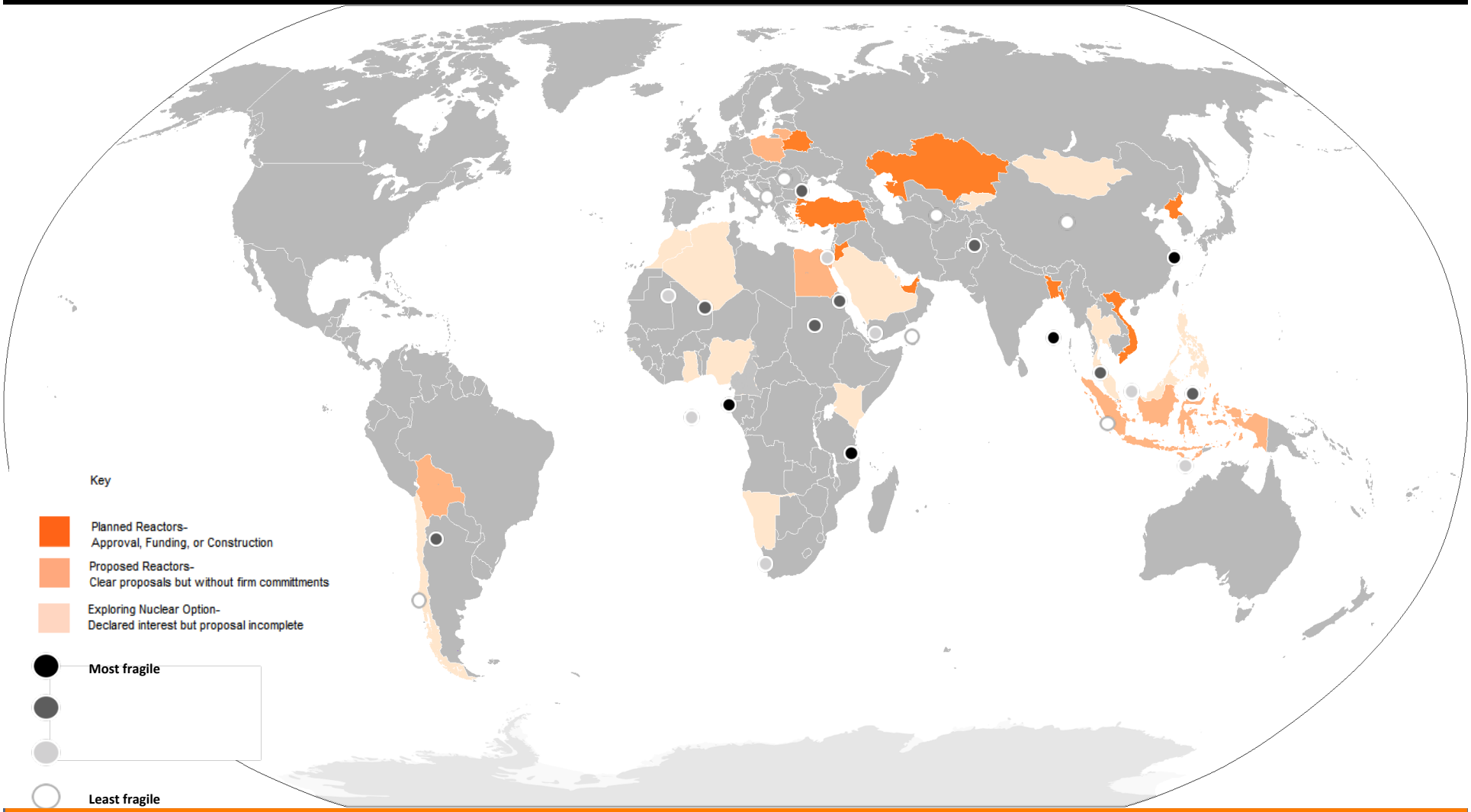
"New" Nuclear States and *Foreign Policy's* Fragile States Index 2015



Risks of New Suppliers/Recipients

- Demand by less-developed countries for comprehensive package (despite rhetoric about dependence)
  - Fuel services, waste management, even operations (BOO)
- Aggressive competition for markets where local know-how limited. Where will be pressure for high quality components, promotion of nuclear safety & security cultures, and design-in safeguards?
- New suppliers on restricting enrichment, reprocessing:
  - ROK: Supports NSG e/r criteria but wants itself to acquire enrichment to enhance competitiveness and pyroprocessing to condition SNF
  - China: Supports NSG e/r criteria but exports to Pakistan?
  - Russia: Take-back may/may not include reprocessing

Emerging Technologies & Risk

- Laser enrichment: If commercially viable, big incentives for proliferation: huge cost advantages, small footprint, impossible to "black box."
- Pyroprocessing: Will the "almost-green-light" to ROK in US peaceful nuclear cooperation agreement have wider implications?
- Fast reactors: GenIV "choice" for advanced countries. Can we agree not to breed plutonium?
- Small modular reactors: Depends on the kind (size, fuel, location, floating? LWR vs. PHWR?)

Other wildcards

- Additive manufacturing (3-D)
  - Risks are clearer in missile area but technology is moving fast (not sure re: tolerances for centrifuge rotors)
- Cyber/SCADA
  - Major vulnerability or more like Y-2K?
  - Nuclear power plants (especially aging ones) rely more on analog than digital systems & often have an "air gap" but associated systems may have internet connections

Conventional wisdom

- 1940s: Risks of nuclear technologies great enough to warrant proposals to internationalize control
- 1950s, 1960s: Uranium enrichment and spent fuel reprocessing too costly for all but a few countries
- 1970s, 1980s: Energy scarcity concerns spawned new enrichment, reprocessing but India's nuclear test highlighted risks of peaceful nuclear cooperation. Control supplies through Nuclear Suppliers Group
- 1990s: NSG controls were insufficient to stop Iraq, North Korea
- 2000s: Nuclear black markets aided Iran's acquisition of sensitive nuclear technologies. First serious consideration of nuclear terrorism

Today's conventional wisdom?

- 2010s: Concerned enough about nuclear security to host 4 summits, but no hard and fast rules on HEU minimization/ elimination, Pu stockpiling or restrictions on future nuclear energy that could affect nuclear security
- Enrichment with restrictions (limits on stockpiled uranium, production capacity) and enhanced monitoring *a la* Iran is acceptable (for a known risk)
- Spent fuel reprocessing in selected states is acceptable
- Efforts to minimize stockpiles of material still sovereign choice

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