A Global Nuclear Renaissance?

Sharon Squassoni
Senior Fellow and Director, Proliferation Prevention Program

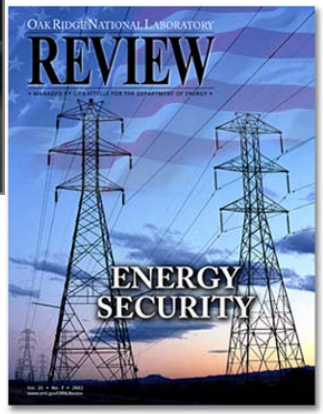
NEED Workshop,
Charlottesville, Virginia, July 27, 2010

CSIS | CENTER FOR STRATEGIC & INTERNATIONAL STUDIES | Proliferation Prevention Program

Forget the "renaissance"

- **"Nuclear Renaissance" is a U.S.-centric term. Asia continues to build; other areas just starting out.**
- **The cultural renaissance depended on patronage and took a few hundred years to root itself. Do we really want that for nuclear energy?**
  - Climate change & energy security point away from nuclear. Need cheapest, fastest, biggest diversity in resources. Better investment would be in efficiency and transformational technologies.
- **Without serious attention to reducing risks of nuclear energy, might get more than we bargained for.**
  - Regional tensions, latent proliferation?
  - Expansion of enrichment, reprocessing
  - Bigger nuclear material security risks

Instead, Nuclear Energy "Enthusiasm"



- Nuclear energy rebranded as "clean, green, secure"
- Since 2005, >30 non-nuclear states have announced plans for nuclear power; 50 interested?

Nuclear Energy Today

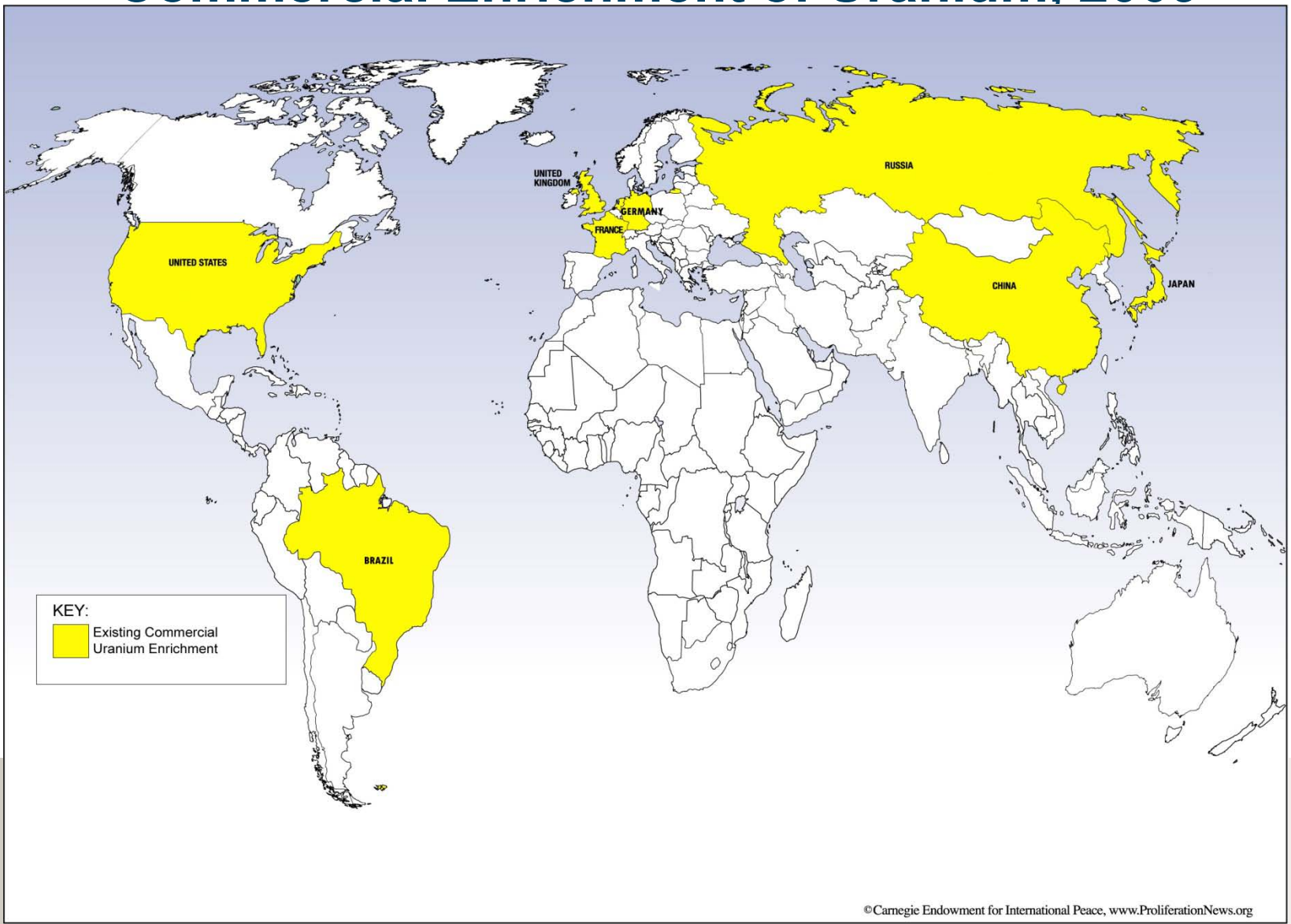
- **16% global electricity demand (and declining…)**
- **30 countries (and Taiwan) operating 439 reactors** (371 GW)
  - 80% in OECD
- **Construction: 61 reactors, 39 of which in Asia (not all are new)**
- **Enrichment: 9 countries hosting 50 million SWU**
- **Spent fuel separation: 6 countries**
  - UK phasing out, China phasing in
- **Waste: 0 countries with geologic repositories for spent nuclear fuel (SNF)**

Nuclear Energy Capacity Today

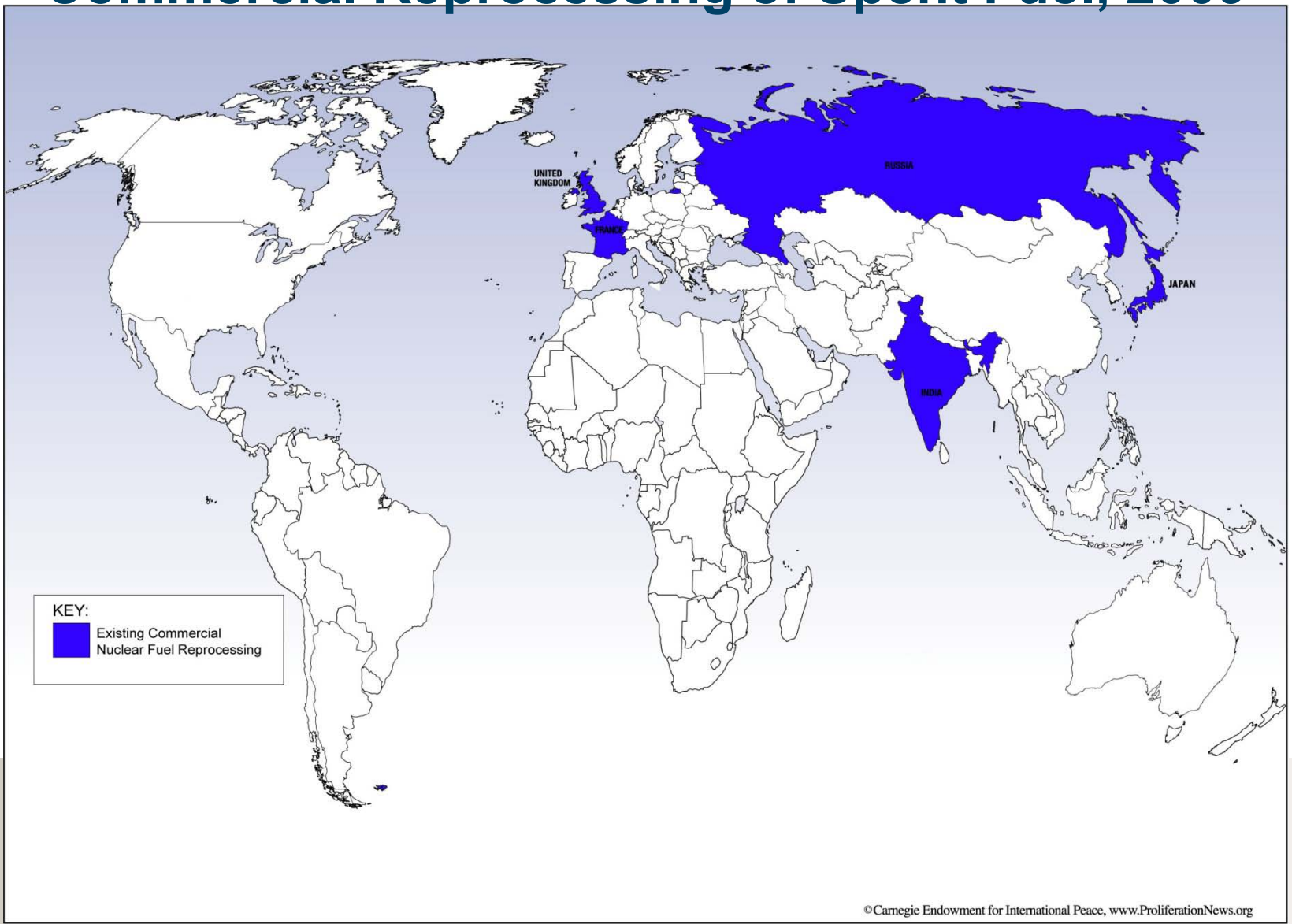
(Gigawatts electric, GWe)

©Carnegie Endowment for International Peace, www.ProliferationNews.org

Commercial Enrichment of Uranium, 2009



Commercial Reprocessing of Spent Fuel, 2009



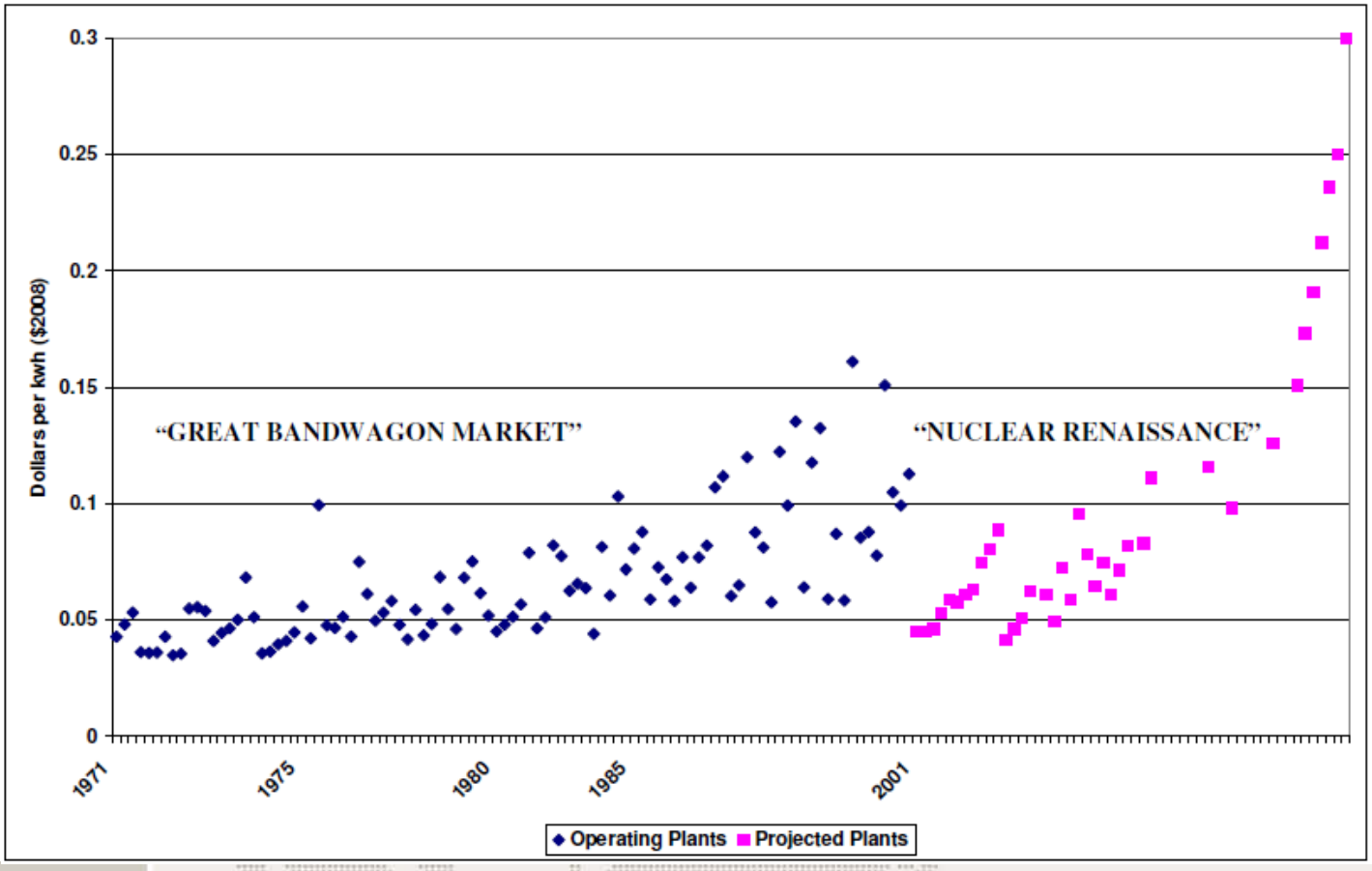
Nuclear energy decisions

- Energy economics
- National/international policies
- Forecasts rely on economics, but can't separate politics from energy decisions, particularly regarding nuclear energy

Caveats about "forecasts"

- Nuclear hard to fit in mold of economic models
  - So large-scale, never strictly an economic decision
  - Government decisions, public support are key
  - EIA does its projections off-line
- Timeframes disjointed
  - Nuclear takes 10-15 years to build from start to finish, so how accurate will economic growth forecasts be?
- Energy security, climate change frames require thinking out to 2030 and 2050
  - But this isn't what industries or utilities do
- Costs of new nuclear build unknowable

U.S. npp cost estimates (Cooper, Vermont Law School, 2009)



A word about climate change and nuclear power

- **How much can nuclear energy help?**
  - 40% of global CO_2 emissions from power sector; nuclear energy provides 16% of global electricity demand.
  - Nuclear's reduction in CO_2 emissions depends on what it displaces -- coal? wind? solar? hydro?

- **How urgent?**
  - Impact of climate change clearly visible
  - CO_2 emissions have risen faster in the past few years than anticipated (vs. rising gas prices)
  - Sustainable reductions path *(UN HDR 2007-2008)*
    - 2012 – 2015 – peak emissions
    - 2020 – 30% reductions
    - 2050 – 80% reductions

How Many Reactors for How Much CO2 Reduction?

Case	Target year	Total capacity	Nuclear % of CO2 reduction	Est'd build rate	Build rate w/ 10-yr lag
Alternative (WEO 2007)	2030	524 GWe	10%	7	7
Stabilization (WEO 2007)	2030	832 GWe	16%	22	25.5
ACT MAP (ETP 2008)	2050	960 GWe	6%	24	29
BLUE (ETP 2008)	2050	1280 GWe	6%	32	40
Princeton wedge	2050	1070 GWe	14.5% (NRDC: 6%)	25	33
MIT 1500 GWe	2050	1870 GWe	25%	45	60

Snapshot of IEA ETP Blue Scenario

- End-use fuel efficiency – 24%
- Renewables – 21%
- End use electricity efficiency – 12%
- End use fuel switching – 11%
- CCS power generation – 10%
- CCS industry and transformation – 9 %
- Power generation efficiency and fuel switching – 7%
- Nuclear -- 6%

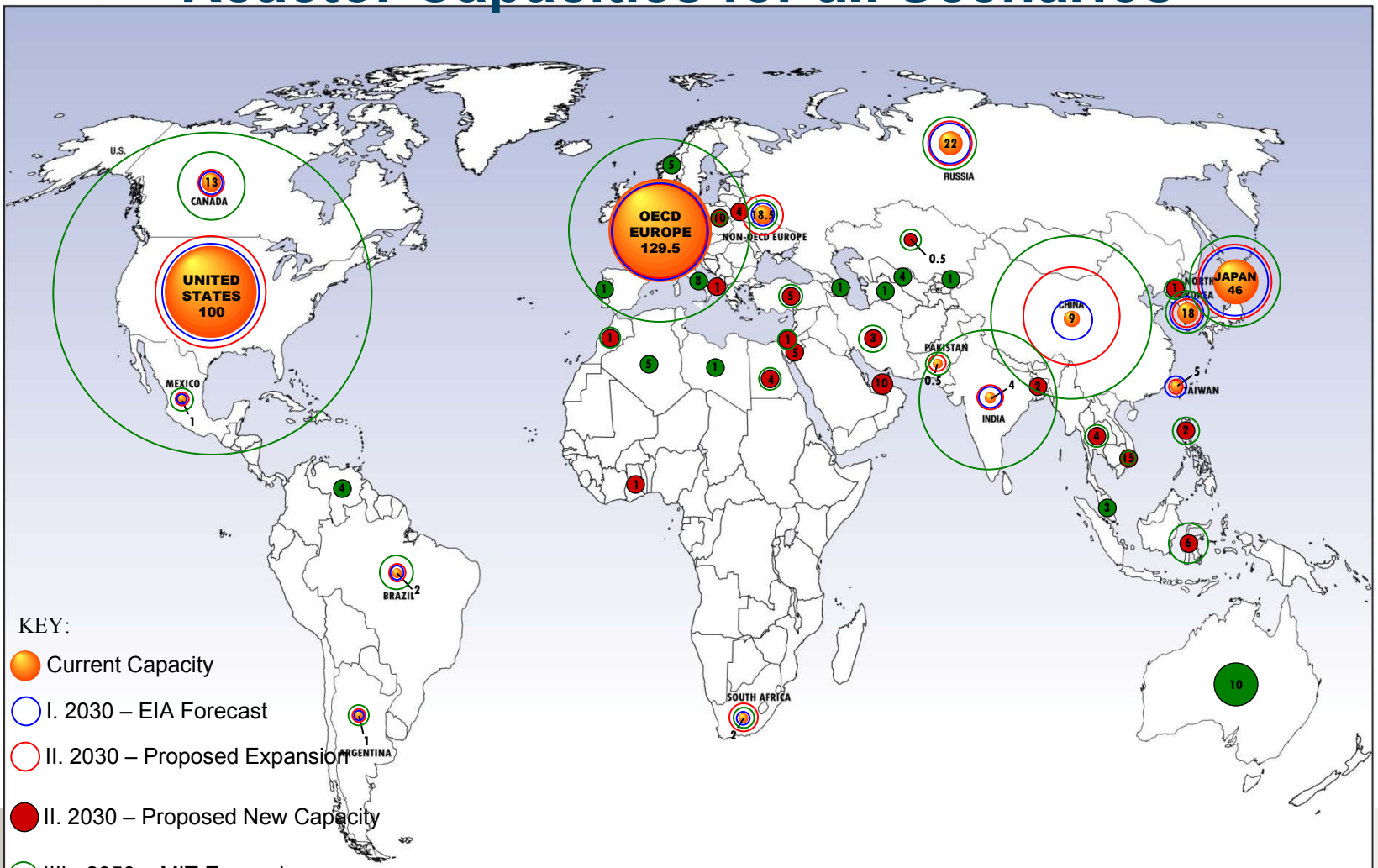
OF CO2 EMISSION REDUCTIONS

Nuclear Expansion Scenarios

Current Capacity: 370 GWe in 30 countries + Taiwan

- **Scenario I:** Realistic growth to 2030 (economic model EIA) +140 GW
- **Scenario II:** Wildly optimistic (states' plans) to 2030) +474 GW
- **Scenario III:** Fourfold increase (MIT's 2050 "high" scenario for 2050) +1300 GW

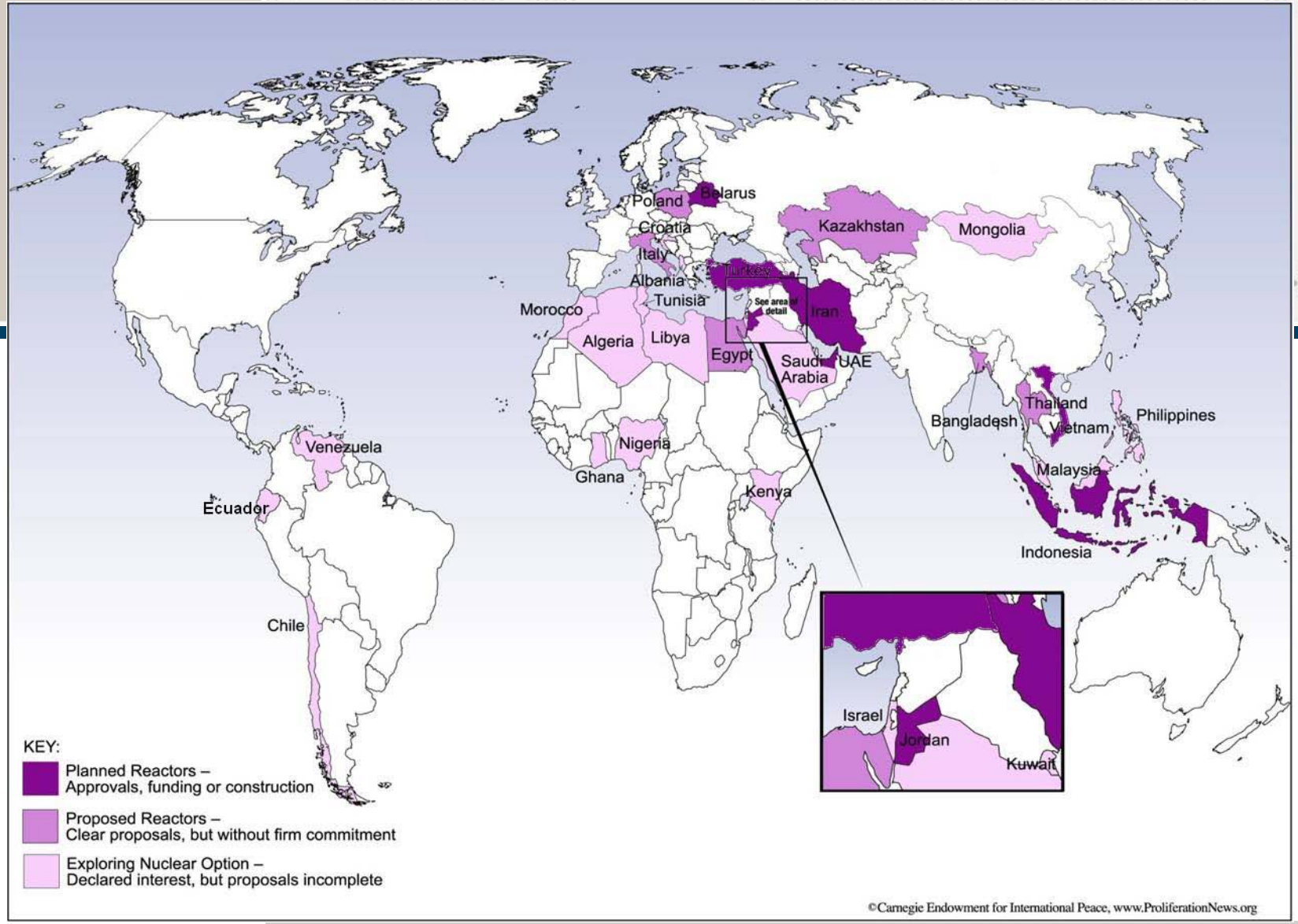
Reactor Capacities for all Scenarios*



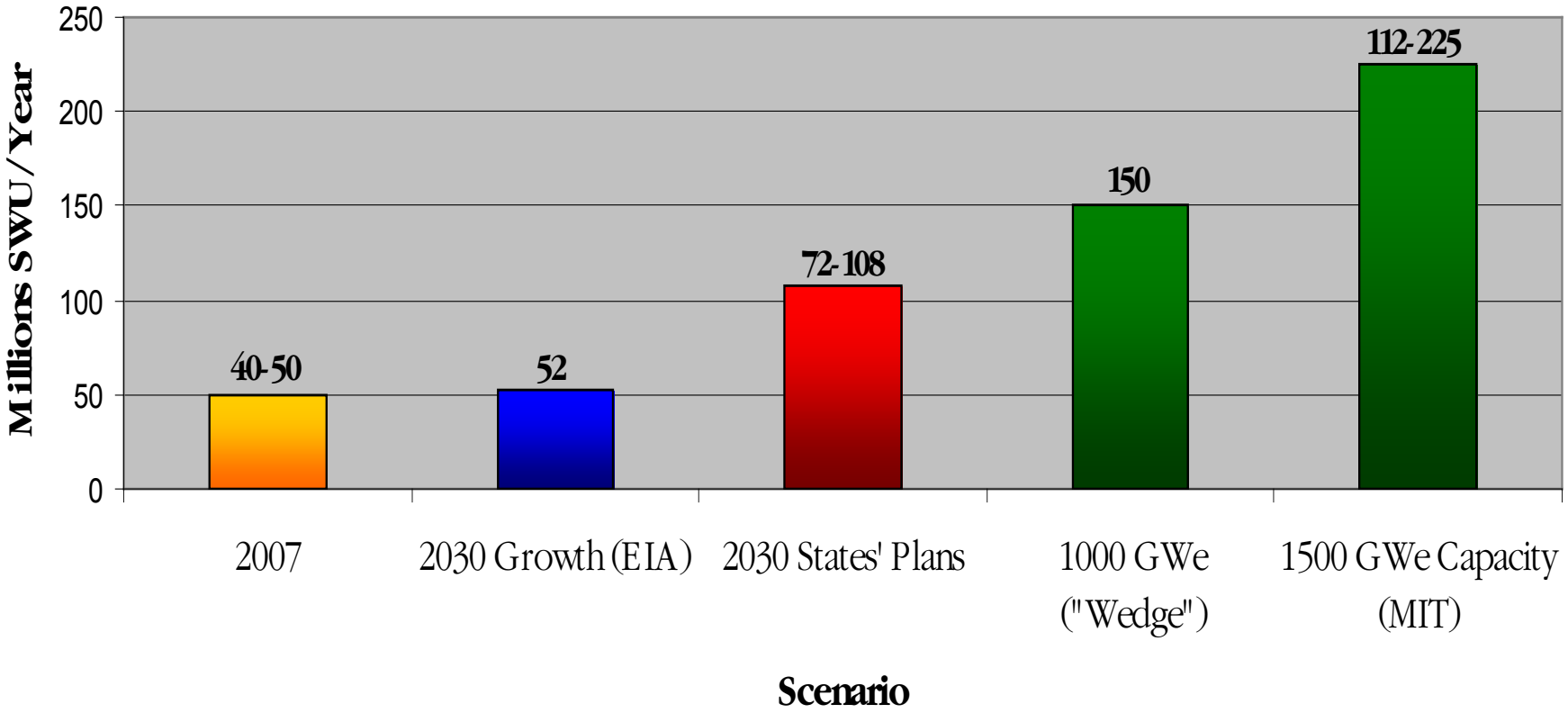
©Carnegie Endowment for International Peace, www.ProliferationNews.org

Proposed "New" Nuclear States

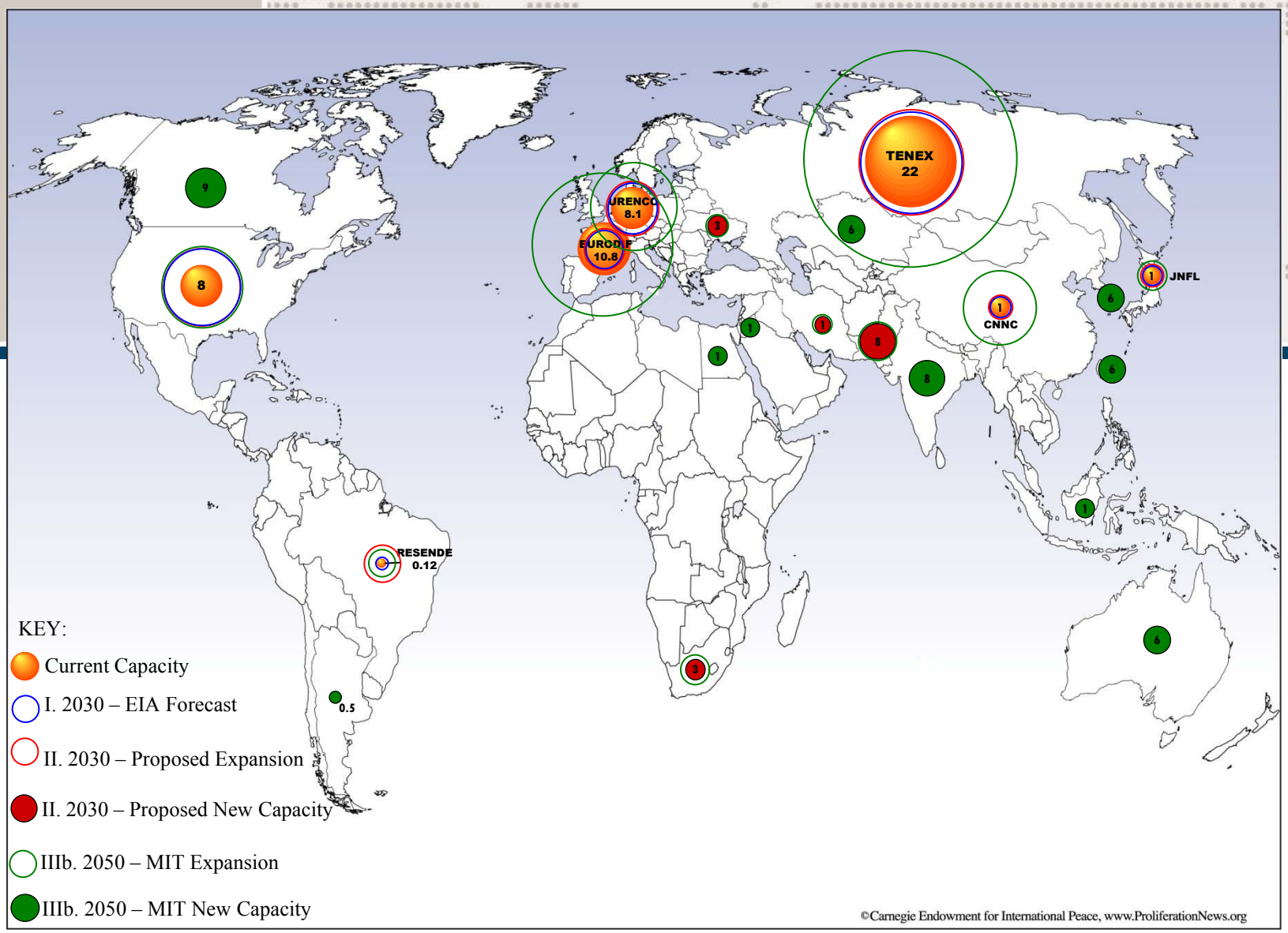
Proposals as of 2010



Enrichment Implications of Expansion

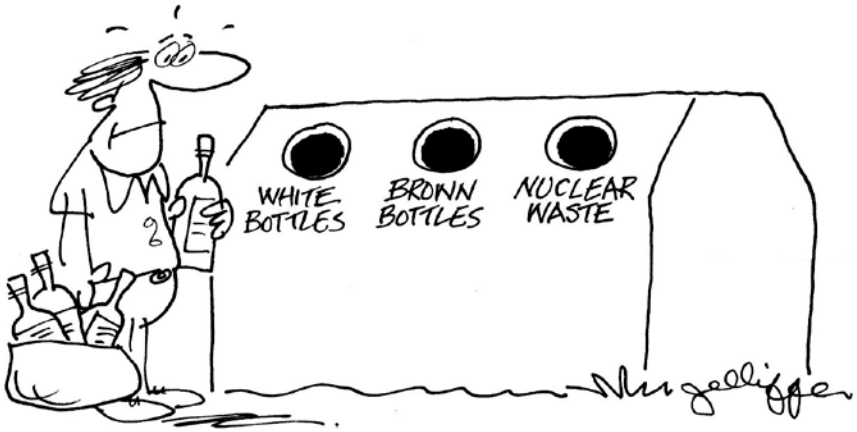


Enrichment Capacities for all Scenarios
(million SWU/year)



Spent Fuel Implications of Growth

- **1 GWe = 20 tons spent fuel/year**
- **"New" nuclear states will store SNF, or lease fuel**
  - More storage requires more safety, security measures
  - Fuel leasing = more transportation, greater safety, security measures
- **But, open or closed fuel cycle is a "choice."**
- Some advanced states still pursuing fast reactors, but no **need for uranium alternatives now, if ever. Recycling will continue to produce Pu.**



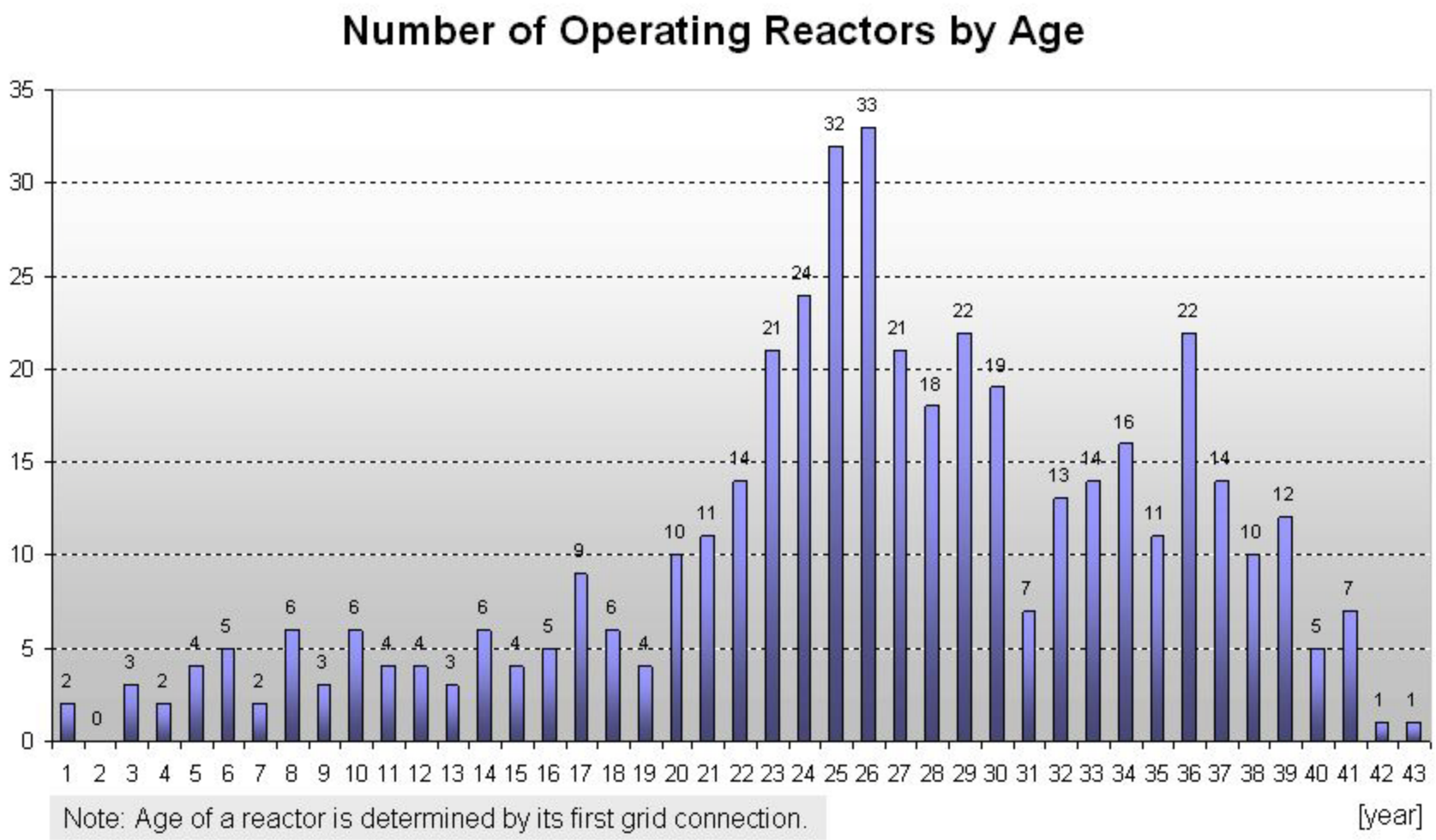
Major expansion could face industrial limits

Need to ramp up industry capacity

- No more than 10 reactors/yr connected to grid for last 20 years
- Bottlenecks for key components (heavy forgings, etc.)
- Skilled labor shortage
  - Not just engineers, but craft labor, qualified construction
- Management experience
  - Olkiluoto and Flammanville

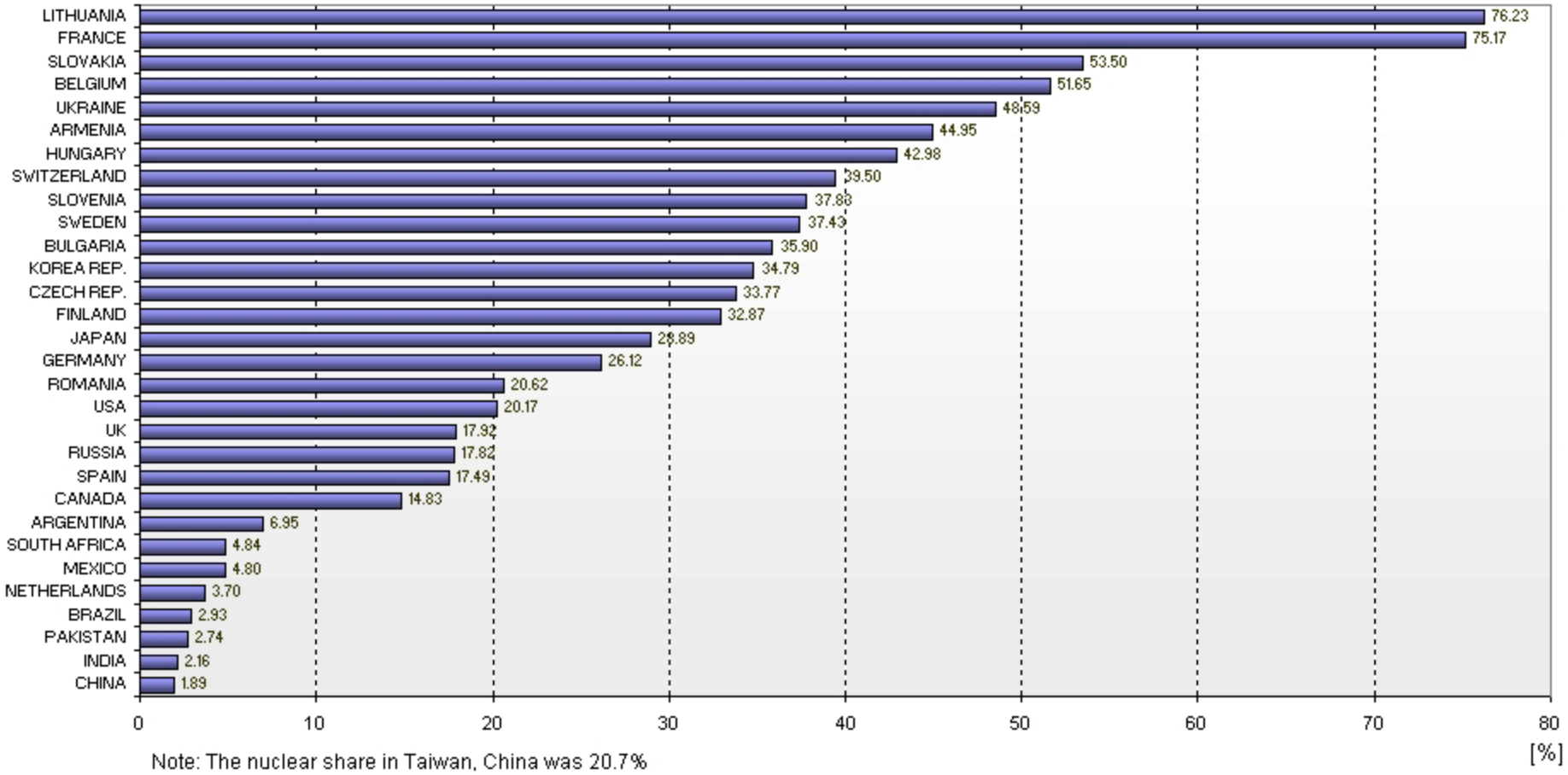
Need to replace aging reactors

- According to **World Nuclear Industry Status Report 2008 (Mycle Schneider & Antony Froggatt)**, **339 reactors will reach retirement age by 2030.** The IAEA's low growth scenario posits
  - Closing 145 units
  - Building 178 new units
  - Extending lives of 193 units beyond 40 years.



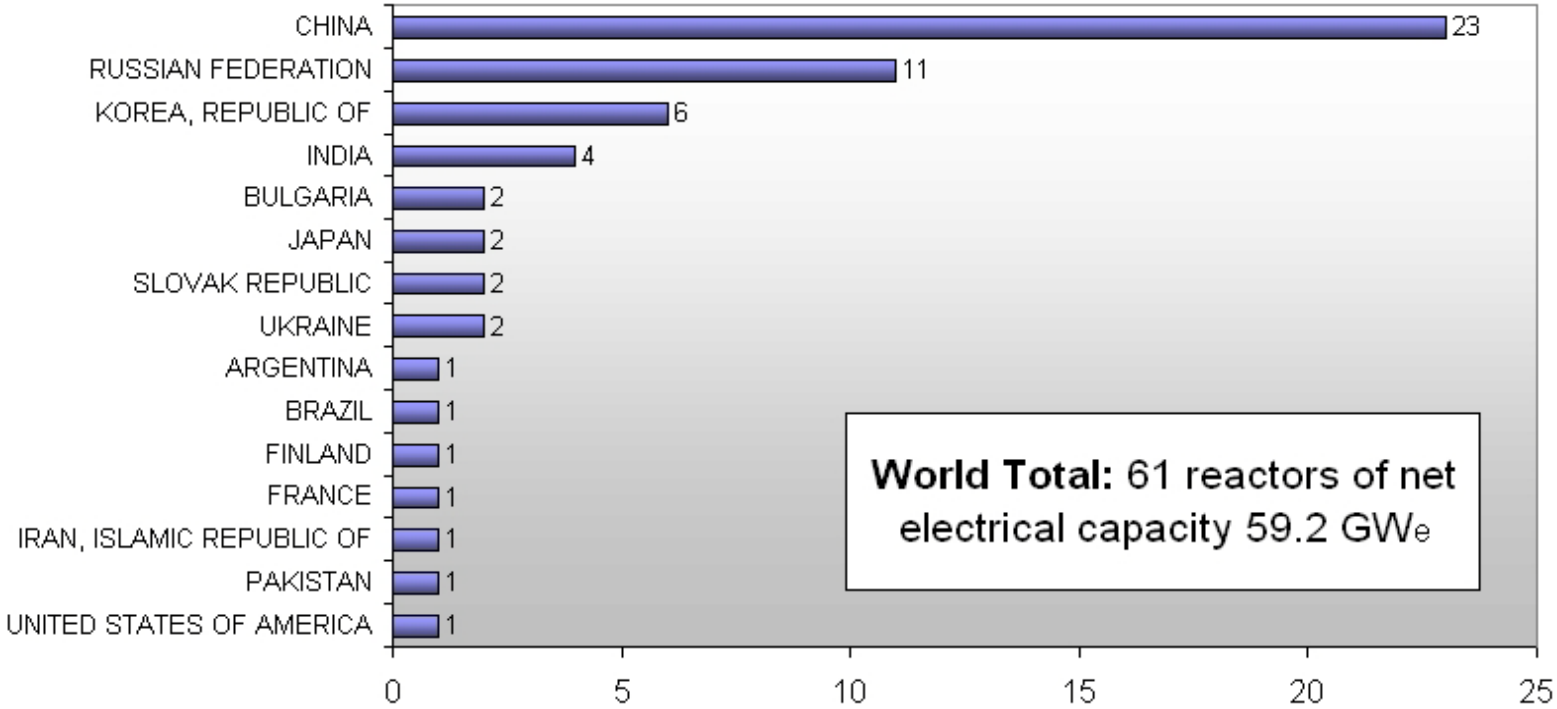
By 2050, how many still in operation?

Nuclear Share in Electricity Generation in 2009



Note: The nuclear share in Taiwan, China was 20.7%

Number of Reactors under Construction Worldwide



Note: The World Total includes also 2 reactors under construction in Taiwan, China.

And limits in new nuclear states

Physical, intellectual nuclear infrastructure

- Where are they in the IAEA process?
  - Knowledgeable commitment (Milestone 1)
  - Readiness to invite bids (Milestone 2)
  - Ready to commission and operate (Milestone 3)

Legal, financing, regulatory frameworks

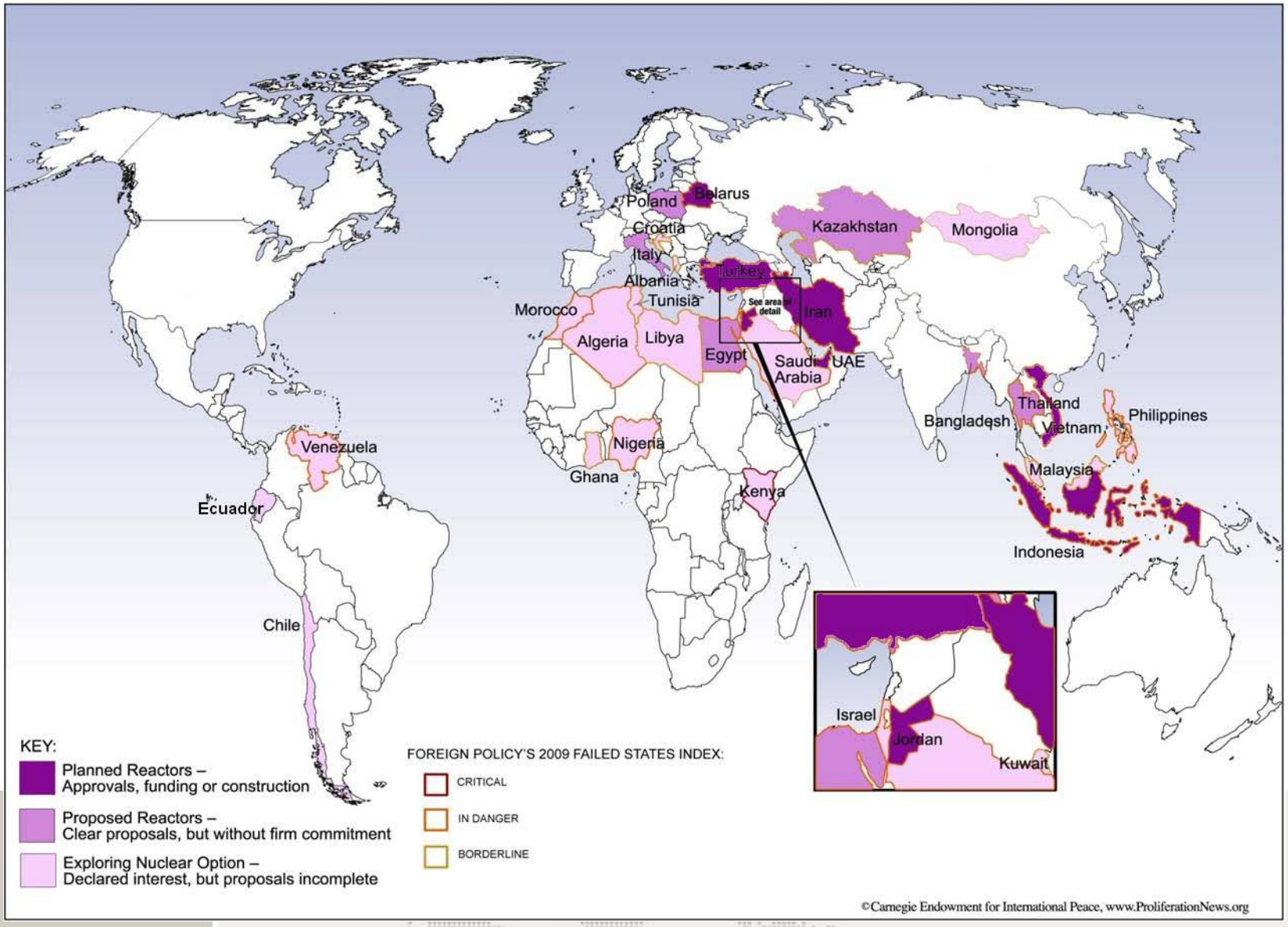
Safety, security cultures?

Funding?

Plans in the Middle East

Country	Plans	Date	Safeguards		Safety	Security	Liability
			INFCIRC/153	AP	(CNS)	(CPPNM)	
Algeria	2.4 GWe	2027	Y	Not in force	Y	Y	N
Bahrain	--	--	Y + SQP	Not in force	N	Y	N
Egypt	4 GWe	2022	Y	N	Y	N	Y
Iran	7 GWe	2020	Yes, but…	Not in force	N	N	N
Jordan	2 GWe	2025	Y + SQP	Y	Y	Y	N
Kuwait	--	--	Y + SQP	Y	Y	Y	N
Libya	1 GWe	2050	Y	Y	Y	Y	N
Morocco	2 GWe	2020-30	Y	Not in force	Not in force	Y	Y
Oman	--	--	Y + SQP	N	N	Y	N
Qatar	--	--	Y + SQP	N	N	Y	N
S. Arabia	--	--	Y + SQP	N	Y	Y	N
Tunisia	.9 GWe	2020	Y	Not in force	Y	Y	N
Turkey	4.8 GWe	2016-19	Y	Y	Y	Y	Y
UAE	5.6 GWe	2020	Y + SQP	Not in force	Y	Y	N

Nuclear Plans and Failed State Index 2009



Nuclear "enthusiasm": More than just numbers

- **New kinds of reactors**
  - Different choices for advanced vs. developing states
    - –Gen IV, grid-appropriate, nuclear batteries, floating reactors?
- **New suppliers?**
  - South Korea (UAE); China; India; Japan?
- **New locations**
  - Middle East, Southeast Asia, Africa
- **New capabilities**
  - o**Recycling techniques** + closed fuel cycles for more states?
  - oMore states with **uranium enrichment**?

Trends to watch for (1)

- **New kinds of reactors**
  - Will the advanced states succeed in commercializing fast reactors?
  - If they do, what is effect on less-advanced states' choices?
  - Will vendors supply what smaller countries need? Will smaller countries want what they need?
- **New suppliers**
  - Will Korea become the nuclear supplier powerhouse it wants to be?
  - Will new suppliers be as/less/more scrupulous in their technology transfer than current suppliers?
  - If one country steps forward to provide cradle-to-grave fuel services, will industry consolidate?

Spotlight on Asia

- Massive npp construction
- Enrichment, uranium production expansion
- Technology acquisition (reactors, forging)
- New commitment to export
- Uranium enrichment from China
- Seeks to export 80 npps in next 20 (30) years
- Spent fuel storage/disposal problem – pyroprocessing?

Trends to watch for (2)

- **New locations**
  - Will Middle Eastern states form regional fuel cycle center to gain access to enrichment, reprocessing? Or pursue separately?
  - How significant will growth be in Southeast Asia?

- **New capabilities**
  - Will suppliers succeed in making reprocessing more proliferation-resistant?
    - Debate about pyroprocessing and South Korea
  - Will efforts to multilateralize facilities go anywhere?
  - Will US efforts to get individual states to foreswear sensitive capabilities take root?

Contact information

Proliferation Prevention Program @ www.csis.org

ssquassoni@csis.org

202 775-3293