EXPORTING NUCLEAR SAFETY

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Thesis

Nuclear power will necessarily increase world-wide.

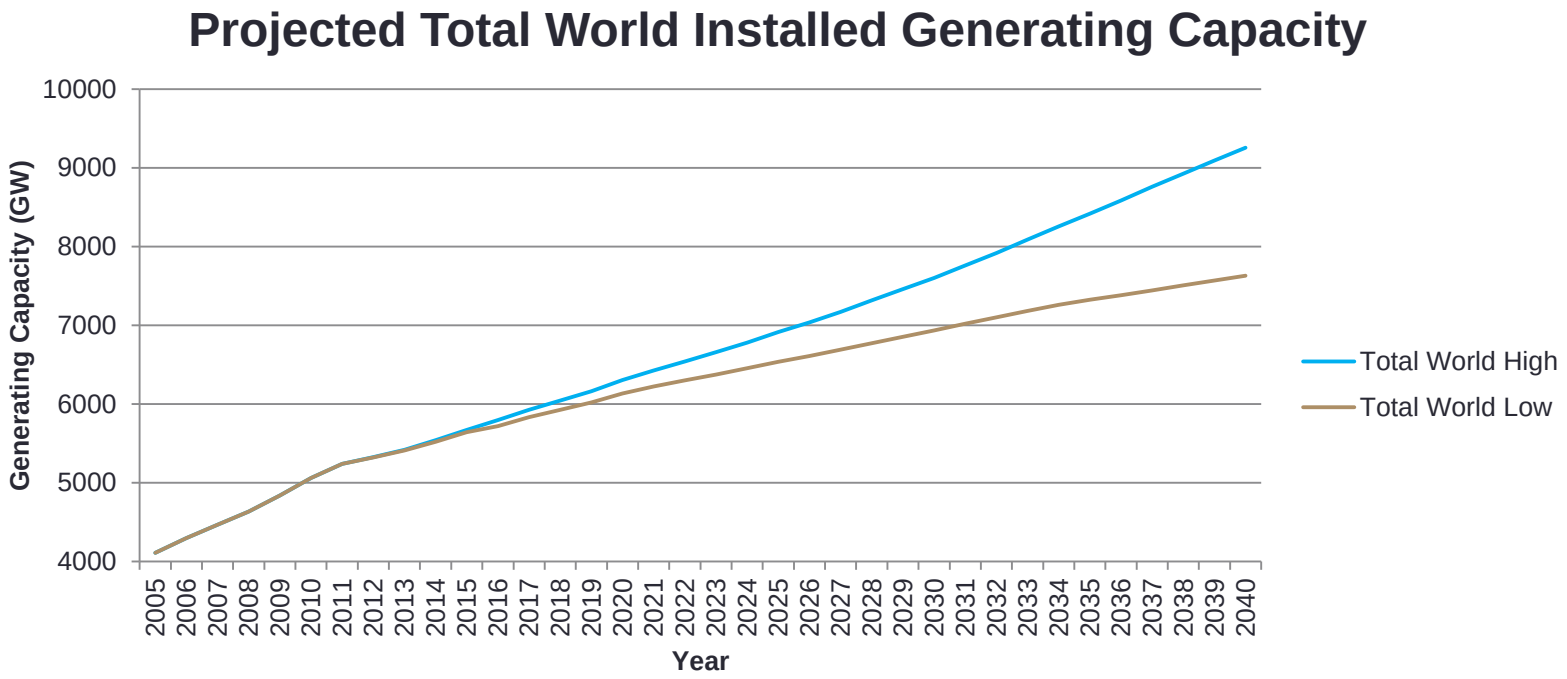
This presents both opportunities and proliferation risks.

The U.S.'s ability to influence the development of safe, efficient, and secure nuclear power world-wide depends on its domestic success.

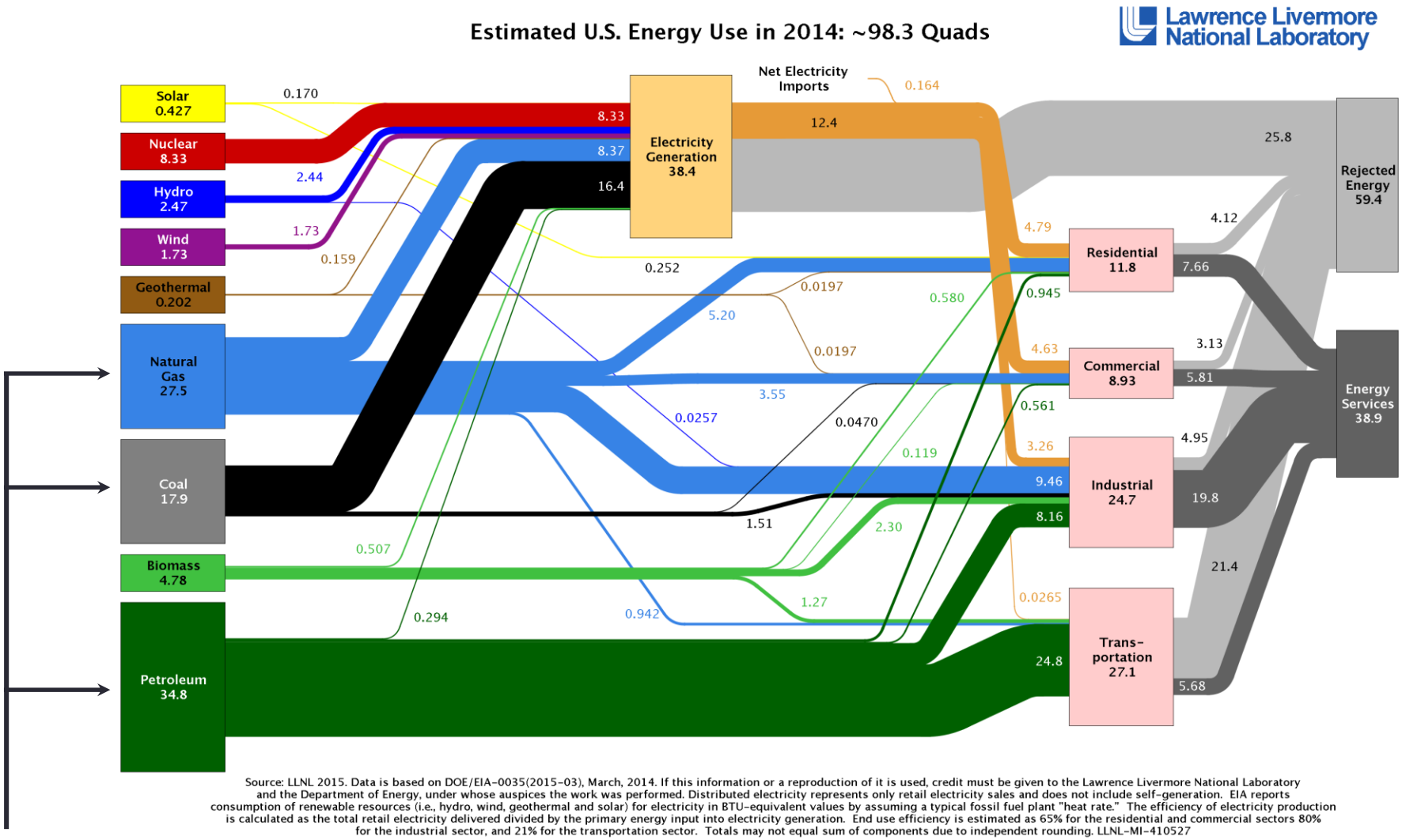
"U.S. nuclear exports also increase the transparency of the importing country's nuclear programs, thus indirectly supporting our nonproliferation policies. When we export U.S. technology, we are also exporting our safety and security cultures."
—Hon. R. Gottemoeller, Undersecretary of State for Arms Control and Int'l Security

World Energy Demands

- DOE/EIA's International Energy Outlook 2013, 2040 holds:
  - $141/barrel oil
  - 56% energy demand growth
- USAID intends to add 30GW to Africa
  - ~75% of New York's 2015 power capacity



2014 U.S. Energy Consumption



Source: LLNL 2015. Data is based on DOE/EIA-0035(2015-03), March, 2014. If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. Distributed electricity represents only retail electricity sales and does not include self-generation. EIA reports consumption of renewable resources (i.e., hydro, wind, geothermal and solar) for electricity in BTU-equivalent values by assuming a typical fossil fuel plant "heat rate." The efficiency of electricity production is calculated as the total retail electricity delivered divided by the primary energy input into electricity generation. End use efficiency is estimated as 65% for the residential and commercial sectors 80% for the industrial sector, and 21% for the transportation sector. Totals may not equal sum of components due to independent rounding. LLNL-MI-410527

80.7%

One quad is equivalent to 33.434 gigawatt-years.

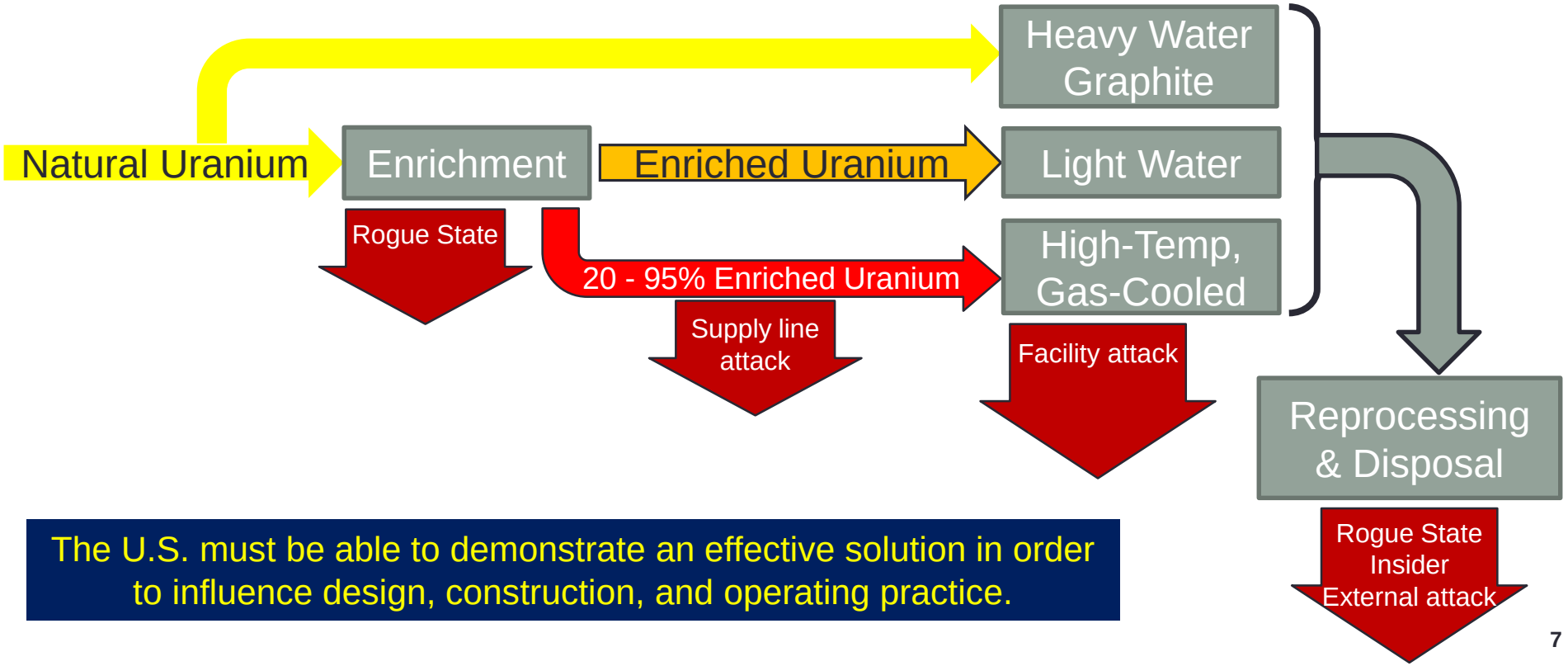
Nations Will Turn to Nuclear Power

- Japan
  - Nuclear power shuttered in 2013, responding to Fukushima
  - 11 Aug 15—Sendai power plant restarted; PM Shinzo Abe citing economic need
- Germany
  - Nuclear power provided 22.6% of electric power prior to Fukushima
  - Planning to phase out nuclear by 2022
  - Still dependent on coal; committed to cutting emissions by 40%
  - Major economic impacts—possible 60% energy price hike by 2020
- India
  - Goal of tripling nuclear power capacity by 2020 (currently 5.78GW)
  - Developing thorium cycle reactors to use indigenous fuel supply

Underlying trend: the global economy needs nuclear power.

A Global Need for Power Drives a Global Security Problem

- Increased fuel demand will require greater enrichment capacity
- Expanded capabilities to produce Pu-239 and U-233
- Increased logistics exposure, physical security risks



The U.S. must be able to demonstrate an effective solution in order to influence design, construction, and operating practice.

Instruments of Power

- Diplomacy, Information, Military, Economics
- Economic ties lead to spheres of influence
  - "… participation in the Marshall Plan was open even to governments in the Soviet orbit—a hint taken up in Warsaw and Prague and just as quickly squelched by Stalin."—Kissinger, *Diplomacy*
- Energy supplies are the fundamental economic power
  - 1973: The OPEC Oil Embargo "acutely strained a U.S. economy that had grown increasingly dependent on foreign oil"
  - Current events: European dependence on Russian oil and natural gas
    - Development of alternate supplies

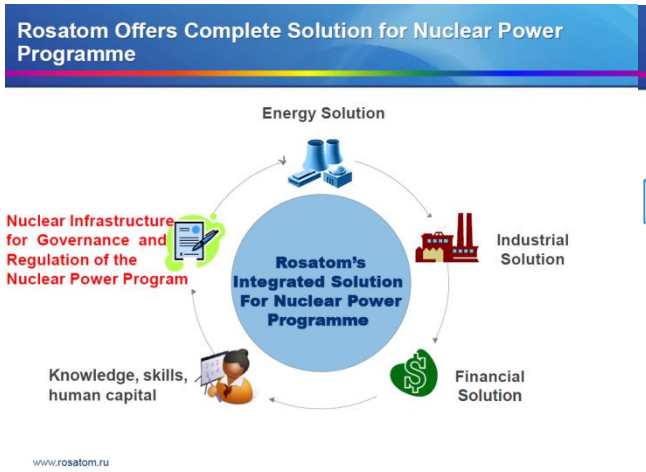
AP

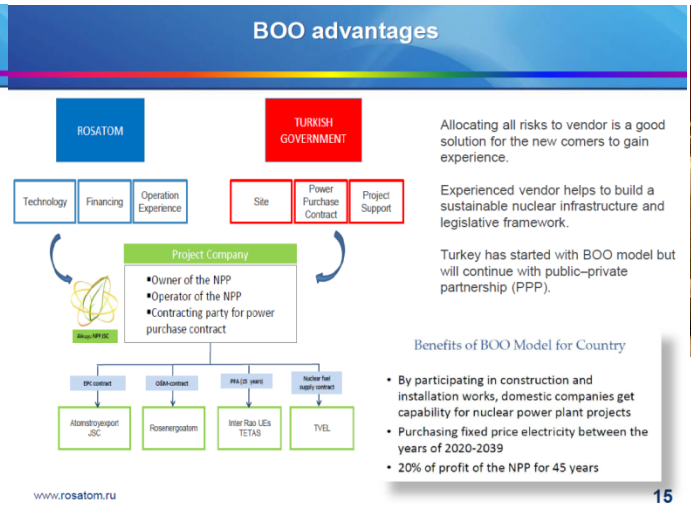
International Competition: Rosatom

- Russian State Atomic Energy Corporation
  - Run by Sergey Kiriyenko, overseen by V. Putin
  - Aggressively marketing nuclear power projects world-wide

ROSATOM

"We offer good terms, and we use the latest technology, so if anyone had forced our partner to turn down the contract (I believe this could have been done), this would have been very detrimental to the national interests of Hungary itself." –Vladimir Putin, 5 May 15





Mr. Kiriyenko and Mr. Putin, 5 May 15. The transcript is functionally an advertisement.

Slides from "Developing the National Nuclear Infrastructure: Role of the Supplier Country, Lessons Learned." A. Sitnikov, Rosatom Overseas, April 2014.

U.S. Commercial Efforts Overseas

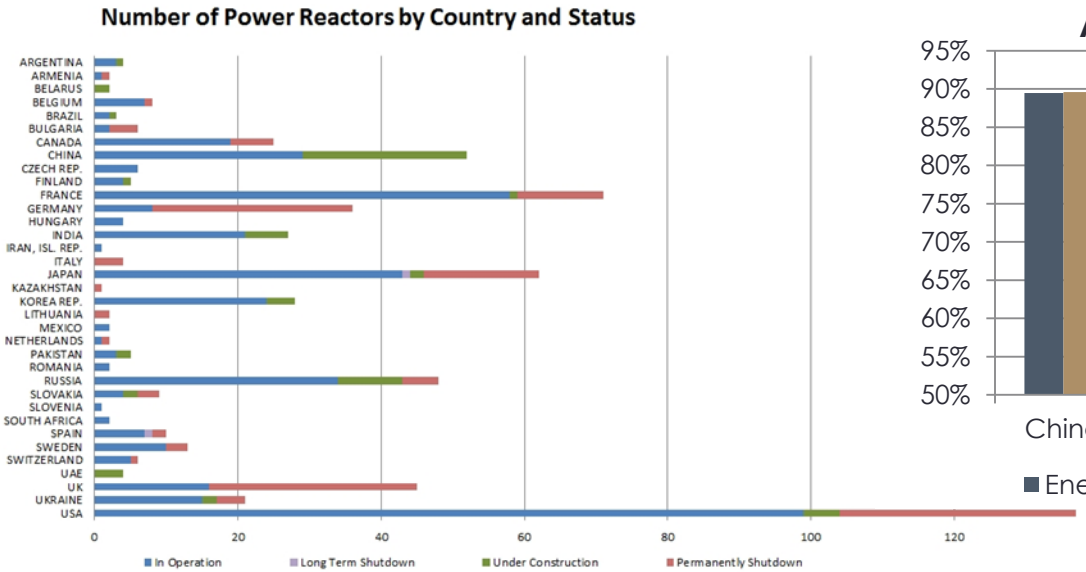
- Westinghouse
  - Spain—Technology sharing agreement
  - Bulgaria—expanding operations in Bulgaria, Westinghouse AP1000 selected for Kozloduy 7
  - Haiyang, China—8 AP1000 units in three phases; Sanmen County, China—2 AP1000 units
    - 2013—partnership formed with China's State Nuclear Power Technology Corporation, focus on development of the Westinghouse Small Modular Reactor
- Babcock & Wilcox
  - Design and delivery of the steam generator for the HPR1000, Guangxi, China
- TerraScale Power
  - Agreement with China National Nuclear Corporation to work on development of a Travelling Wave Reactor, signed 23 Sep 15
- India-US Civil Nuclear Agreement
  - Formally signed 8 Oct 2008
  - GE & Westinghouse have sites to build reactors

Assessment: some engagement, not driven by over-arching national policy.

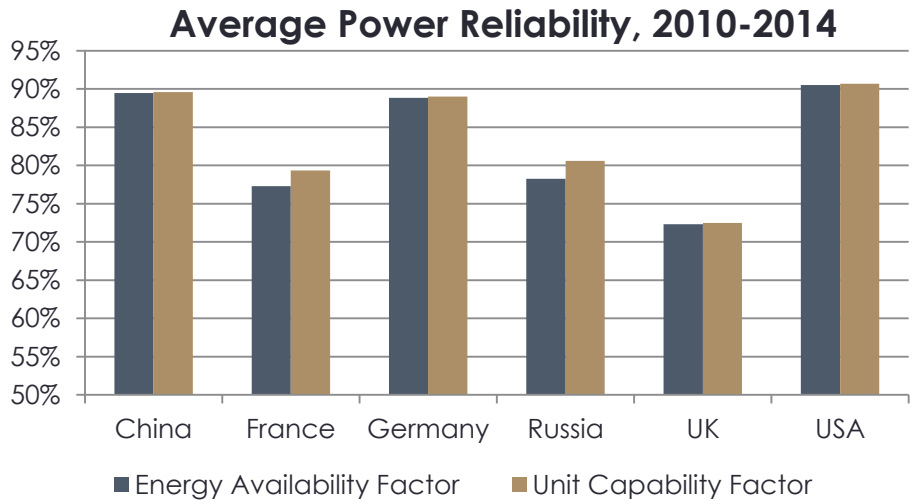
The U.S. industry is losing ground in its ability to promote proliferation-resistant nuclear technology and practice.

Snapshot of the U.S. Nuclear Industry

- Current Major Reactor Contractors:
  - Bechtel—Babcock & Wilcox: mPower
  - General Electric-Hitachi: Advanced Boiling Water Reactor (ABWR), Economic Simplified Boiling Water Reactor (Fermi-3 design)
  - Westinghouse: AP1000, Small Modular Reactor (SMR)
- New Builds: 4 underway, 7 license applications w/ target dates



Graphic from the IAEA Power Reactor Information System



Data from IAEA's Reference Data Series, 2015 ed.

Future of the U.S. Nuclear Industry

- Nearly 50 R&D companies, $1.3B private investments, however…

- Nuclear Regulatory Commission Chairman's View
  - Inability to assess non-Light Water Reactor designs for 5 years minimum
  - $800 million average to build and test new designs
  - "Operating Reactors—Down slightly, New Reactors—Down significantly" by 2020, per NRC internal study

"Faced with a long funding path and licensing their technology in the United States, many developers of next-generation nuclear reactors have said they will likely test their machines in other countries, including China."
—R. Martin, MIT Technology Review, 13 Oct 2015

Future of U.S. Nuclear Industry (cont.)

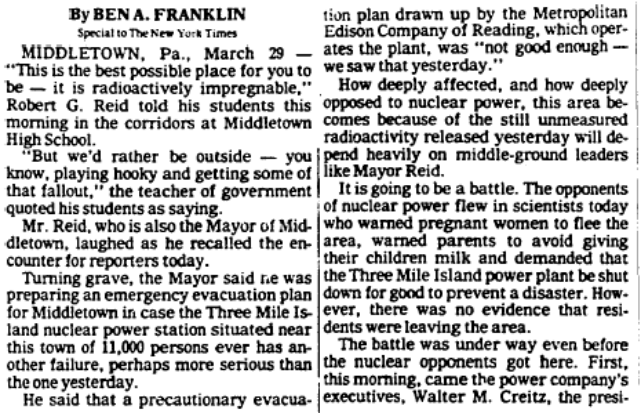
- Department of Energy Initiatives to Address the Problem
  - $452M earmarked for SMR development
    - Cost-sharing programs with mPower (B&W, TVA, Bechtel) and NuScale
    - Objective: commercial operations by 2022
  - Argonne and GE/Hitachi Nuclear Energy—Power Reactor Innovative Small Module (PRISM) fast reactor design risk modeling
  - Westinghouse—Competing in DOE's Advance Reactor Industry Competition for Concept Development with lead-cooled fast design

- White House Summit on Nuclear Energy, 6 Nov 15
  - Strong support for nuclear from the environmental direction
  - PB FY16: $900M for DOE to support R&D
  - $12.5B in loan guarantees for "innovative nuclear energy projects"

New design and manufacturing presents opportunities to build in safety and security for export.

Traditional Obstacles Remain

- Nuclear waste disposal
  - Reprocessing
  - Yucca Mountain
- Public Opinion & Opposition
  - Profoundly poor communication by nuclear professionals
  - Overstated risks
  - Tendency to conflate nuclear reactors with weapons
- Legal Hurdles
  - "An environmental coalition (Beyond Nuclear, Citizens for Alternatives to Chemical Contamination, Citizen Environment Alliance of Southwestern Ontario, Don't Waste Michigan, and Sierra Club Michigan Chapter) officially intervened against the COLA on March 9, 2009 and have vowed to continue to resist the proposed new atomic reactor. The intervention's three dozen filed contentions has likely delayed Fermi 3's groundbreaking by several years." –Beyond Nuclear press release



By BEN A. FRANKLIN
Special to The New York Times

MIDDLETOWN, Pa., March 29 — "This is the best possible place for you to be — it is radioactively impregnable," Robert G. Reid told his students this morning in the corridors at Middletown High School.

"But we'd rather be outside — you know, playing hooky and getting some of that fallout," the teacher of government quoted his students as saying.

Mr. Reid, who is also the Mayor of Middletown, laughed as he recalled the encounter for reporters today.

Turning grave, the Mayor said he was preparing an emergency evacuation plan for Middletown in case the Three Mile Island nuclear power station situated near this town of 11,000 persons ever has another failure, perhaps more serious than the one yesterday.

He said that a precautionary evacuation plan drawn up by the Metropolitan Edison Company of Reading, which operates the plant, was "not good enough — we saw that yesterday."

How deeply affected, and how deeply opposed to nuclear power, this area becomes because of the still unmeasured radioactivity released yesterday will depend heavily on middle-ground leaders like Mayor Reid.

It is going to be a battle. The opponents of nuclear power flew in scientists today who warned pregnant women to flee the area, warned parents to avoid giving their children milk and demanded that the Three Mile Island power plant be shut down for good to prevent a disaster. However, there was no evidence that residents were leaving the area.

The battle was under way even before the nuclear opponents got here. First, this morning, came the power company's executives, Walter M. Creitz, the presi-

From "Nuclear Foes See Grave Risk in Pennsylvania Mishap, but Utility Aides are Unalarmed," New York Times, 30 Mar 1979

The Path Forward

- U.S. nuclear industry must remain relevant:
  - New, proliferation-resistant reactor technology
  - New, proliferation-resistant means for dealing with nuclear waste
- Overcoming public misperceptions:
  - Communicating the advantages of nuclear power to the populace
  - Addressing sources of fear
  - Removing unnecessary legal hurdles to nuclear development
- Establishing an overarching policy position for global nuclear power

Goal:
Apply American-origin nuclear power technology and practice to meet world energy needs, prevent proliferation, and influence global industry.

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