# The Future of Nuclear Power: Lessons of Past Accidents

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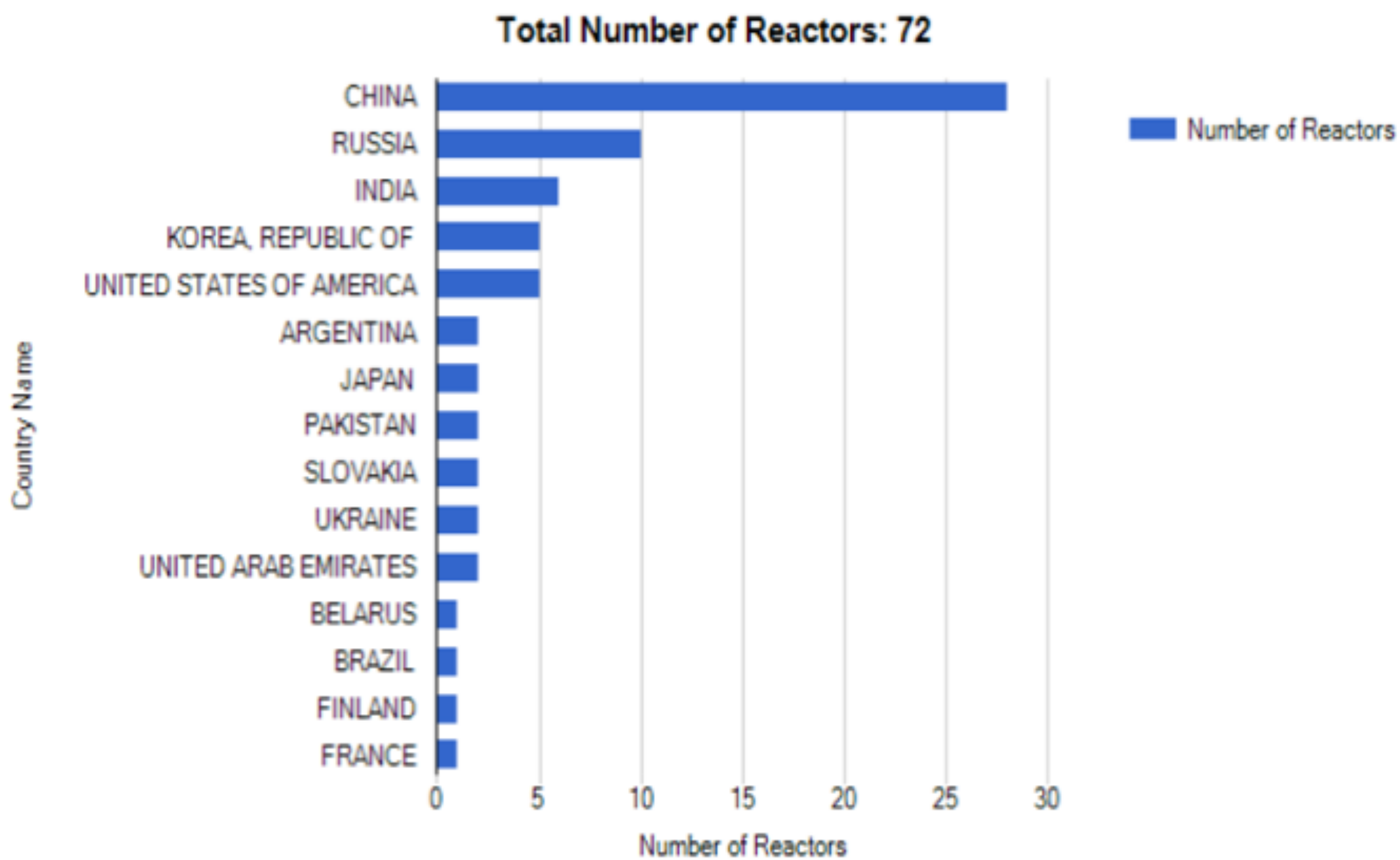
October 9, 2015

# Overview

- Importance of Nuclear Power Today
- The Three Mile Island Accident in 1979 and the impact on Emergency Preparedness
    - The Accident
    - The Impact
    - Changes to Emergency Preparedness
- Existing Emergency Preparedness regulations
    - planning standards
    - not dose based planning standards
- Accident Demonstrate Need for —
    - Enhanced Emergency Preparedness in the short term
    - New Concept of Safety Future of Nuclear Power
- Future of Nuclear Power: Economics Major Factor in the United States
    - Shutdowns and Decommissioning
    - status of new construction
- Conclusion

# Future of Nuclear Power

Only China is making major investments in nuclear plants



# Importance of Nuclear Power Today

- The nuclear power industry remains a viable electricity option today for four basic reasons:

1. countries wish to keep open the option to develop a nuclear weapons program

2. countries wish to have a fuel diversity among their energy options

3. countries lack their own domestic fossil or renewable fuel sources
   especially true in Japan

4. countries wish to abate air pollution, especially carbon dioxide
   especially true in the United States and Japan

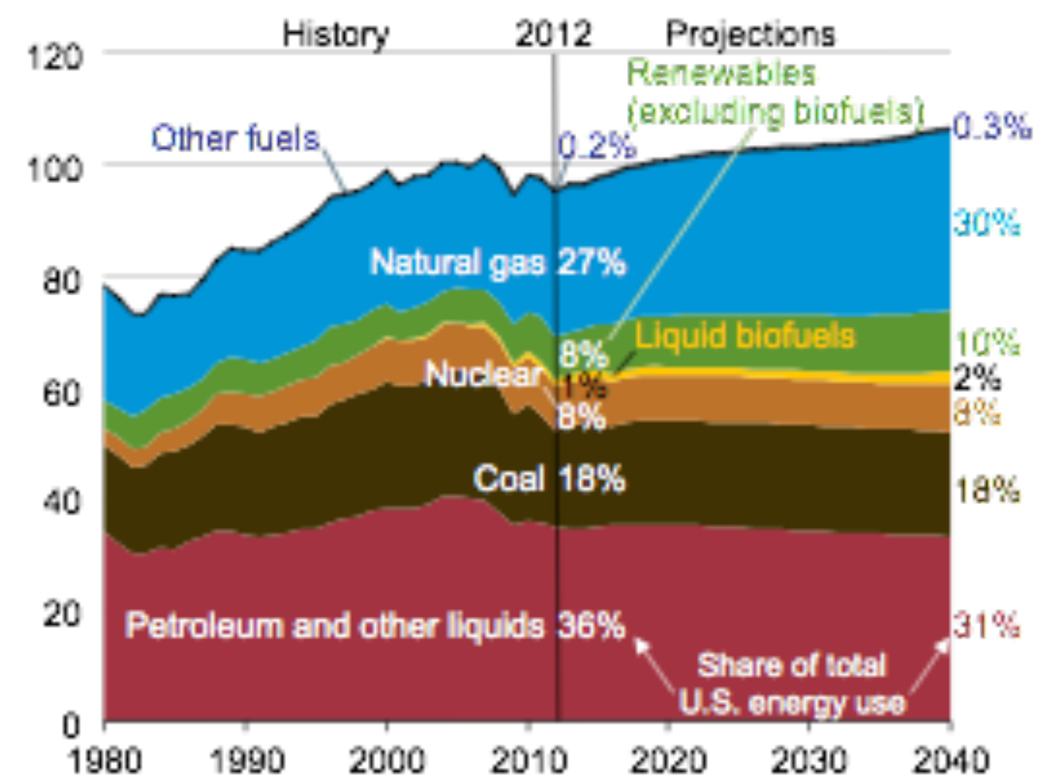
# Importance of Nuclear Power Today

- Energy and electricity play an increasingly important role in our lives

- Energy use is expected to grow over the next several decades

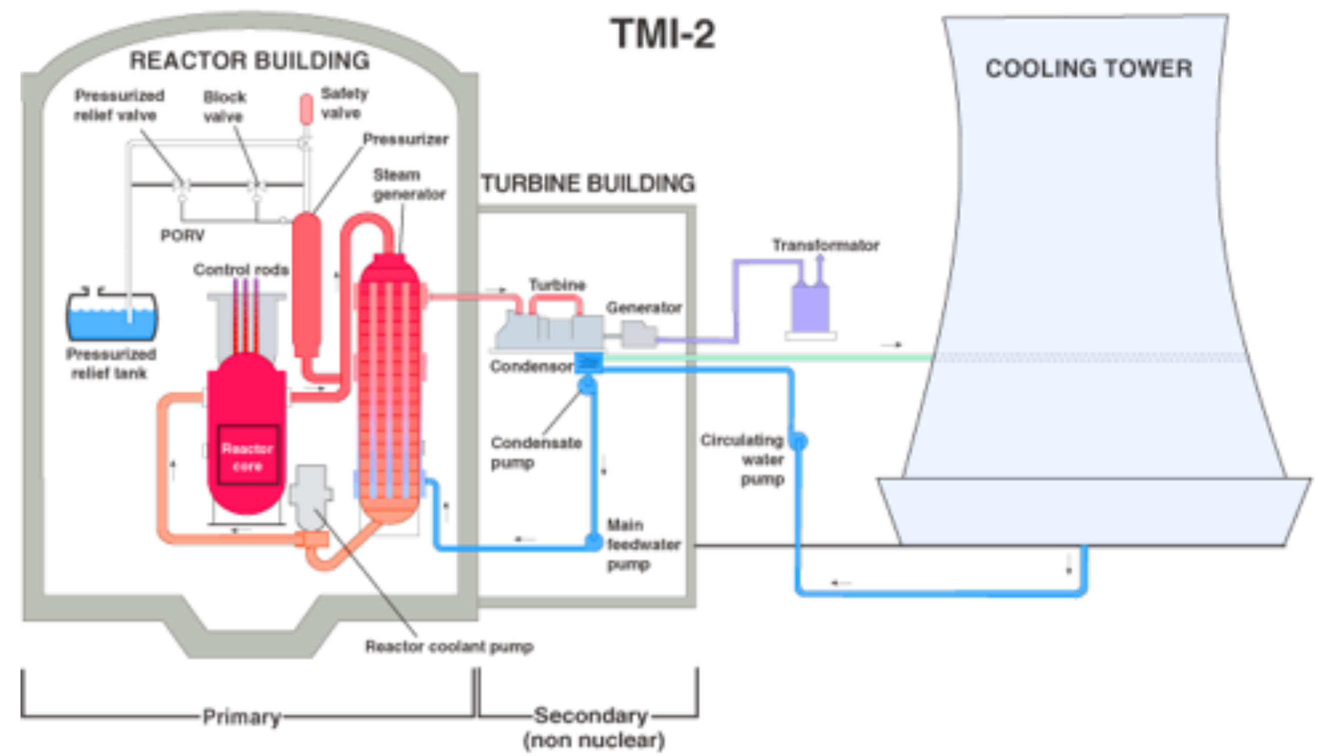
**Renewables and natural gas lead rise in primary energy consumption**

**Figure MT-9. Primary energy use by fuel in the Reference case, 1980-2040 (quadrillion Btu)**



# Major Accident: Three Mile Island

- The accident started when the ability to remove heat from the steam generators was lost on early morning March 28, 1979
- The fission reaction stopped but the decay heat still had to be removed
- The pressurizer relief valve lifted to allow the pressure to reduce because heat was going up
- The relief valve stuck open and water poured out of the value causing a loss of coolant accident, reducing water to cool the reactor fuel. **The control room indications showed the valve being closed**




- Misunderstanding the situation, the operators —
  - reduced water flow to prevent the pressurizer from going solid, **further reduction water to the core**
  - shut down the reactor coolant pumps because of vibrations from low pressure, **further reducing water to the core**
- The reactor fuel began to melt and interacted with the cladding to produce explosive hydrogen
- By 6am a separate valve was closed to prevent the loss of coolant, but there was significant steam in the system preventing proper cooling
- Adequate cooling restored by evening of March 28 **but no one knew the real extent of damage**

# Major Accident: Three Mile Island

- About half the fuel melted within the first day, but the containment remained intact.   No one really knew the condition of the core
- Contaminated gases were released to relief pressure in the coolant system to allow proper flow
  - through a series of miscommunications this led to an evacuation order PA Governor ordered women and children within 5 miles of the plant to evacuate
  - eventually extended to 20 miles
- the fuel melting lead to creation of hydrogen
  - combustion of hydrogen could have damaged the containment and allowed a greater release of radiation to the environment
  - by April 1 it was determined that there were not the correct conditions for a significant hydrogen explosion

# Major Accident: Three Mile Island

- There was a significant impact from the accident despite only limited amounts of radioactivity being released
- There was a moratorium on new plant licensing and temporary shutdown of similar reactor designs
- Significant changes to the nuclear regulatory system
    - NRC reforms
    - INPO created
    - FEMA established and Emergency Preparedness dramatically changed
- Decommissioning and fuel removal not complete until 1991 costing $1 billion

# Emergency Preparedness Program

- The most substantial changes from the accident were:
  - Executive Order establishing the newly established Federal Emergency Management Agency as the lead federal agency for offsite emergency response programs.
  - Transfer of some NRC authority over offsite emergency preparedness to FEMA.
  - Legal requirement for the NRC to make emergency preparedness a requirement of nuclear power plant licensing
    - For a plant to operate there must be reasonable assurance that an adequate plan exists
    - --> currently used 16 planning standards for emergency preparedness
  - New requirements for better training and response by the nuclear plants themselves
- The changes made within a few years of the accident are essentially the program in use today when it comes to emergency preparedness programs

# Emergency Preparedness - FEMA role

- The Federal Emergency Management Agency works closely with the NRC on this program
- Federal Emergency Management Agency (FEMA) is responsible for review state and local government offsite emergency preparedness programs.
- Ultimately a weakness in a state plan must be handled by the NRC, because the NRC has the authority over the nuclear power plant

# Emergency Preparedness - NRC role

- The NRC has the responsibility to license nuclear power plants.

- After Three Mile Island, the NRC must show with a reasonable assurance that an effective offsite and onsite emergency preparedness program exits

- The regulations specify 16 elements that an emergency preparedness program must contain — these are planning standards, not safety standard

# Emergency Preparedness — Planning Standards

1) Primary responsibilities for emergency response by the nuclear facility licensee and by State and local organizations within the Emergency Planning Zones have been assigned, the emergency responsibilities of the various supporting organizations have been specifically established, and each principal response organization has staff to respond and to augment its initial response on a continuous basis.

(2) On-shift facility licensee responsibilities for emergency response are unambiguously defined, adequate staffing to provide initial facility accident response in key functional areas is maintained at all times, timely augmentation of response capabilities is available and the interfaces among various onsite response activities and offsite support and response activities are specified.

(3) Arrangements for requesting and effectively using assistance resources have been made, arrangements to accommodate State and local staff at the licensee's Emergency Operations Facility have been made, and other organizations capable of augmenting the planned response have been identified.

(4) A standard emergency classification and action level scheme, the bases of which include facility system and effluent parameters, is in use by the nuclear facility licensee, and State and local response plans call for reliance on information provided by facility licensees for determinations of minimum initial offsite response measures.

(5) Procedures have been established for notification, by the licensee, of State and local response organizations and for notification of emergency personnel by all organizations; the content of initial and followup messages to response organizations and the public has been established; and means to provide early notification and clear instruction to the populace within the plume exposure pathway Emergency Planning Zone have been established.

(6) Provisions exist for prompt communications among principal response organizations to emergency personnel and to the public.

(7) Information is made available to the public on a periodic basis on how they will be notified and what their initial actions should be in an emergency (e.g., listening to a local broadcast station and remaining indoors), the principal points of contact with the news media for dissemination of information during an emergency (including the physical location or locations) are established in advance, and procedures for coordinated dissemination of information to the public are established.

(8) Adequate emergency facilities and equipment to support the emergency response are provided and maintained.

# Emergency Preparedness — Planning Standards

(9) Adequate methods, systems, and equipment for assessing and monitoring actual or potential offsite consequences of a radiological emergency condition are in use.

(10) A range of protective actions has been developed for the plume exposure pathway EPZ for emergency workers and the public. In developing this range of actions, consideration has been given to evacuation, sheltering, and, as a supplement to these, the prophylactic use of potassium iodide (KI), as appropriate. Evacuation time estimates have been developed by applicants and licensees. Licensees shall update the evacuation time estimates on a periodic basis. Guidelines for the choice of protective actions during an emergency, consistent with Federal guidance, are developed and in place, and protective actions for the ingestion exposure pathway EPZ appropriate to the locale have been developed.

(11) Means for controlling radiological exposures, in an emergency, are established for emergency workers. The means for controlling radiological exposures shall include exposure guidelines consistent with EPA Emergency Worker and Lifesaving Activity Protective Action Guides.

(12) Arrangements are made for medical services for contaminated injured individuals.

(13) General plans for recovery and reentry are developed.

(14) Periodic exercises are (will be) conducted to evaluate major portions of emergency response capabilities, periodic drills are (will be) conducted to develop and maintain key skills, and deficiencies identified as a result of exercises or drills are (will be) corrected.

(15) Radiological emergency response training is provided to those who may be called on to assist in an emergency.

(16) Responsibilities for plan development and review and for distribution of emergency plans are established, and planners are properly trained.

# NRC Siting Criteria

Relevant Siting Criteria for population and emergency planning

1. Every site must have an exclusion area and a low population zone
2. The population center distance must be at least one and one-third times the distance from the reactor to the outer boundary of the low population zone.
3. Site atmospheric dispersion characteristics must be evaluated and dispersion parameters established such that —
   (1) Radiological effluent release limits associated with normal operation...can be met
   (2) Radiological dose consequences of postulated accidents shall meet be met
4. Physical characteristics unique to the proposed site that could pose a significant impediment to the development of emergency plans must be identified;
5. Reactor sites should be located away from very densely populated centers. Areas of low population density are, generally, preferred. However, in determining the acceptability of a particular site located away from a very densely populated center but not in an area of low density, consideration will be given to safety, environmental, economic, or other factors, which may result in the site being found acceptable.

# NRC Siting Criteria

- NRC Safety Siting Requirements — largely irrelevant and meaningless
  - Design basis accident is assumed — not a severe accident
  - Postulated doses are still very large at the site boundary
    - It is assumed that emergency response activities would be needed for these postulated accidents
  - By regulation, applicants can always justify any site based on environmental, economic or other factors

# New Standard for Safety

- The Fundamental Problem is the potential for contamination outside the plant boundary during an accident
  - unique aspect of nuclear power plants
  - most large power plants only have the potential to harm workers during an accident
- Existing siting requirements are not sufficient to address the problem
- Every major accident has identified significant weaknesses in the emergency preparedness system

# New Standard For Safety

There needs to be a new standard for safety

After Fukushima and Three Miles Island, Safety must mean:

There can be no possible radiation release from a nuclear power plant that would cause harmful radiation exposure to a a member of the public.

# Future of Nuclear Power

- Two Major Drivers
  - Economics — nuclear is too expensive to compete
  - Safety — Need a new paradigm for safety and emergency preparedness
- These are interrelated:
  - Safety Needs —> Expensive Cost of New Reactors
  - Economic Pressures to Cut Cost —> Increased Risk of Safety Problems

# Future of Nuclear Power

There have been a number of recent or planned plant closures in the United States

- Vermont Yankee due to economic considerations
- Kewaunee due to economic considerations
- San Onofre unit 2 and 3 due to safety concerns
- Crystal River due to safety concerns
- Oyster Creek scheduled to shutdown in 2019

# Future of Nuclear Power

- To truly spur a nuclear revival, Vogtle and V.C. Summer needed to be built without a doubt on time and on budget
- How are they doing?
  - Vogtle is at least 3 years behind schedule with $1.5 billion in cost overruns
    - problems were largely the result of modular construction
  - Vogtle 3 is expected to come online in 2019
  - Vogtle 4 one year later
  - V.C. Summer is similarly behind schedule and over budget

# Future of Nuclear Power