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SETTING THE STANDARD

Nuclear Decontamination & Decommissioning

Rome, Italy
March 20 -21, 2018

Sargent & Lundy LLC

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Presenters

Edward Martin

James McIntyre

- Quality Services Managers with Sargent & Lundy of Chicago, Illinois of the United States
- Extensive Nuclear Industry experience

Edward Martin

Quality Services Manager - Sargent & Lundy

- 50 years of electric industry experience.
- Extensive nuclear power plant experience from construction to operations to decommissioning.
- Various Quality roles at Exelon Nuclear from 1967 to 1998. Joined Sargent & Lundy in 1998.
- Quality Manager for a number of D&D projects.

James McIntyre

Quality Services Manager - Sargent & Lundy

- 32 years of nuclear power plant experience from construction to operations to decommissioning.
- Various Quality roles at Exelon Nuclear from 1985 to 1999. Joined Sargent & Lundy in 1999.
- Executive Committee Chairman of ASME Nuclear Quality Assurance (NQA) Committee.

State of the Nuclear Industry
“Decontamination & Decommissioning – Are We Ready”

Tuesday, March 20 (1000 – 1115)

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State of the Nuclear Industry "Decontamination and Decommissioning Are We Ready"

- Reactor Decommissioning Options
- Worldwide Status of Decontamination & Decommissioning
- Costs and Finances
- Other Considerations

State of the Nuclear Industry
“Decontamination and Decommissioning Are We Ready”

Reactor Decommissioning Options

- Immediate Dismantling/Early Site Release/Decontamination
  – Trojan (US) and Greifswald (Germany)
- Safe Enclosure/Safstor
  – TMI 2 (US) and Dresden 1 (US)
- Entombment
  – Chernobyl (Ukraine) and Piqua (US)

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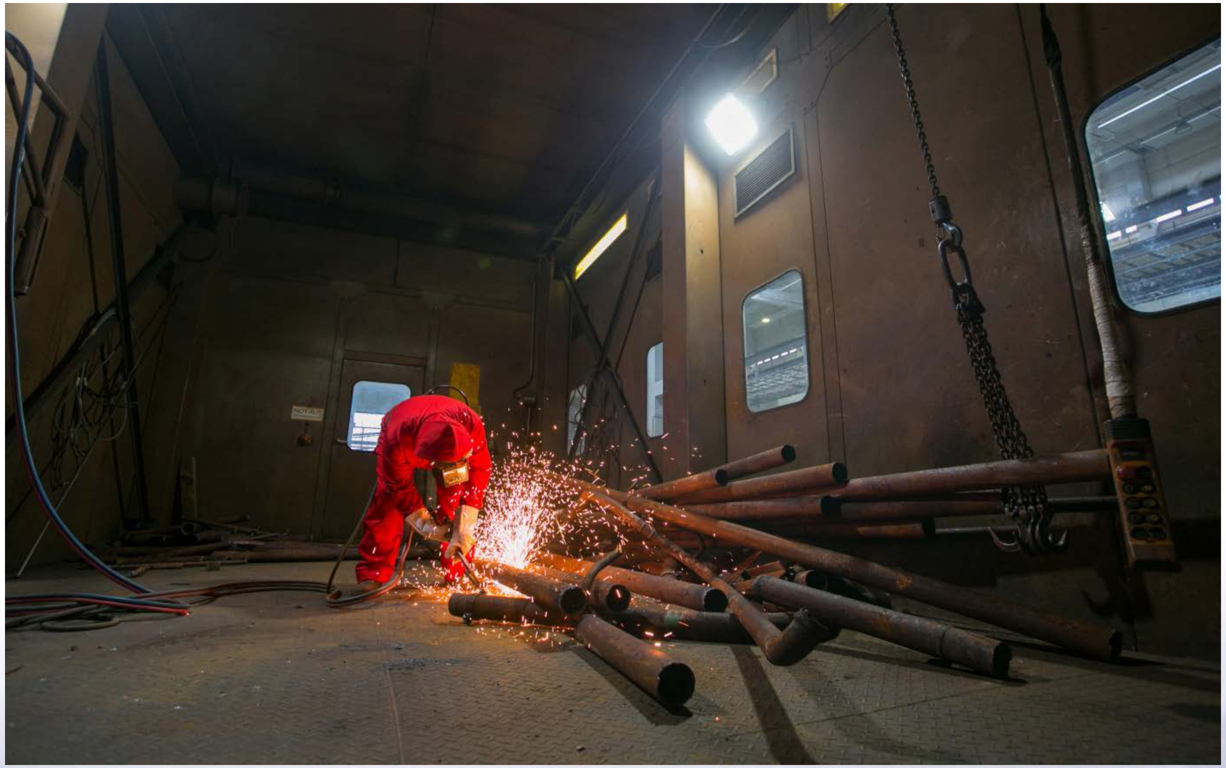
Immediate Dismantling/Early Site Release/Decon

- Allows for the facility to be removed from regulatory control relatively soon after shutdown
- Final dismantling or decontamination activities may begin within a few months or years depending upon the facility
- Equipment, structures, and portions of the facility containing radioactive contaminants are removed or decontaminated to a level that permits release of property and license termination

Greifswald

1990 - Upgrade to new safety standards too costly.
1995 - Decommissioning began



Source: Bloomberg News

Trojan

1993 – D&D begins
2006 - Cooling tower demolition

Source: CBS News

Immediate Dismantling/Decon Benefits and Concerns

Benefits

- Prevent cost escalations
- Experienced facility personnel available
- Regulatory uncertainty minimized
- Site available for reuse

Concern

- Higher radiation rates and increased waste

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Safe Enclosure (SAFSTOR)

- Deferred dismantling
- Postpones the final decommissioning for a longer period, usually 40 to 60 years
- Nuclear facility is placed into a safe storage configuration during this time in which the radioactivity is allowed to decay before dismantlement commences

SAFSTOR

Dresden Unit 1 in SAFSTOR

Source: Exelon

SAFSTOR Benefits and Concerns

Benefits

- Reduced quantity of radioactive material to be removed during decontamination phase
- Lower radiation exposure rates
- Potential technology enhancements

Concerns

- Extended maintenance and monitoring and potential costs
- Public perception

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Entombment

- Place the facility in a condition that allows the remaining material to remain on-site indefinitely
- Radioactive contaminants are permanently encased on site in structurally sound material such as concrete with the goal of preventing a release of radioactive material
- Facility is maintained and monitored until the radioactivity decays to a level that would permit restricted release of the property

Entombment

Piqua- demonstration plant ceased operation in 1966 and containment entombed.

Source: U.S. Department of Energy

Entombment Benefits and Concerns

Benefit

- Monitoring cost savings over SAFSTOR

Concerns

- Nuclear leakage and public perception
- Longer term of liability
- Long term monitoring required

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Status of the Industry

- Plant Status
- Forecast Going Forward

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Status of the Industry - 2017

Three reactors were permanently closed in 2017:

- In Germany, Gundremmingen-B was closed in December as part of the country's nuclear phase-out policy.
- South Korea and Sweden both shut down their oldest units - Kori-1 and Oskashamn-1.

In addition, two more Japanese reactors, Ohi-1 and -2 were officially closed after the operator abandoned plans for restart and lifetime extension.

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Reactor Status*

In Operation	Shutdown/Under Decommissioning	Fully Decommissioned
448	166	15

* Per IAEA PRIS Database

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Decommissioned Reactors in United States

- Big Rock Point
- Fort St Vrain
- Haddam Neck
- Maine Yankee
- Pathfinder
- Rancho Seco
- Shippingport
- Shoreham
- Trojan and
- Yankee Rowe

Per NEI Report of August 2016

Reactors in Decommissioning in U.S.

- Crystal River 3
- Dresden 1
- Fermi 1
- Fort Calhoun
- GE Vallecitos
- Humboldt Bay
- Indian Point 1
- Kewaunee
- La Crosse
- Millstone 1
- Peach Bottom 1
- San Onofre 1,2,3
- TMI 2
- Vermont Yankee
- Zion 1, 2

Per NEI Report of August 2016

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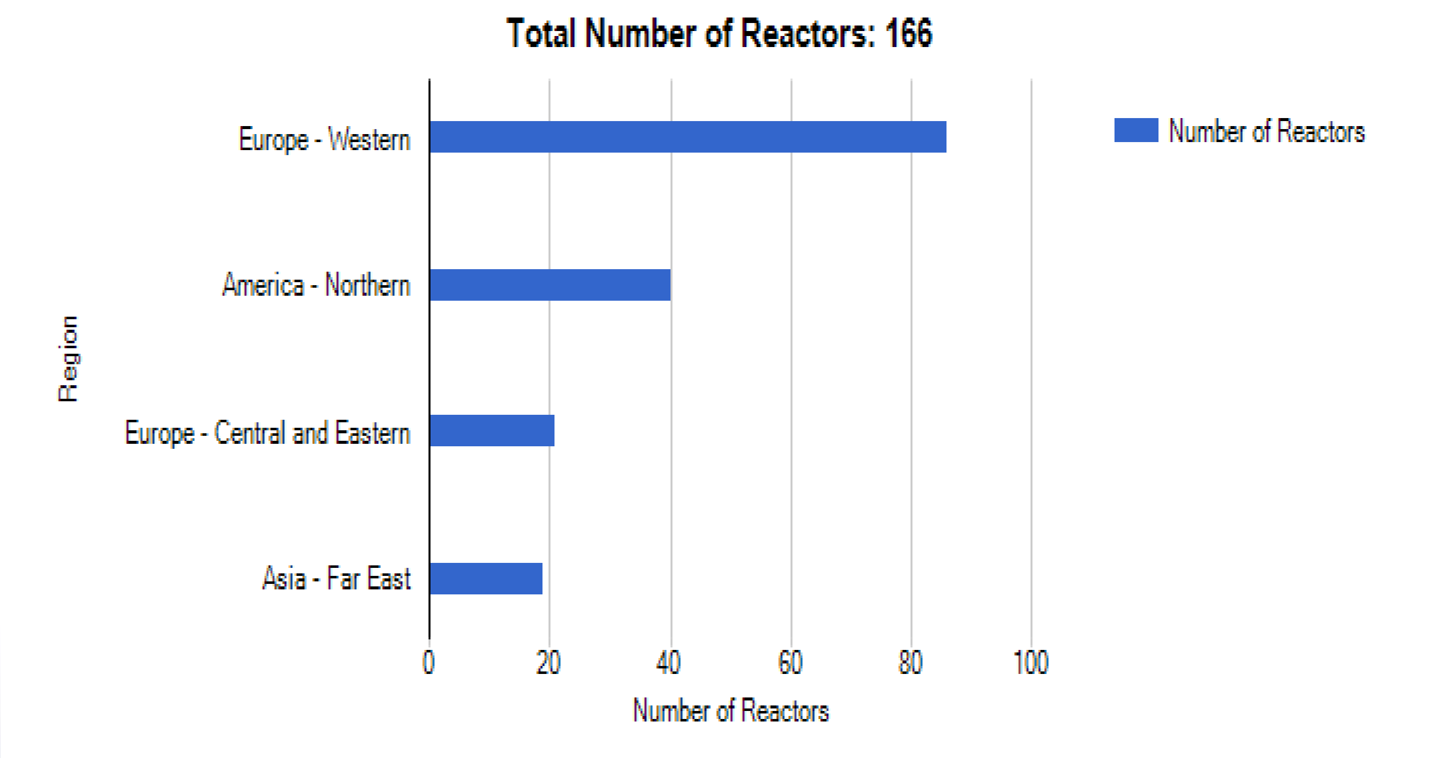
“Decontamination and Decommissioning Are We Ready”

Shutdown/Under Decommissioning by Region



Source: IAEA PRIS Data

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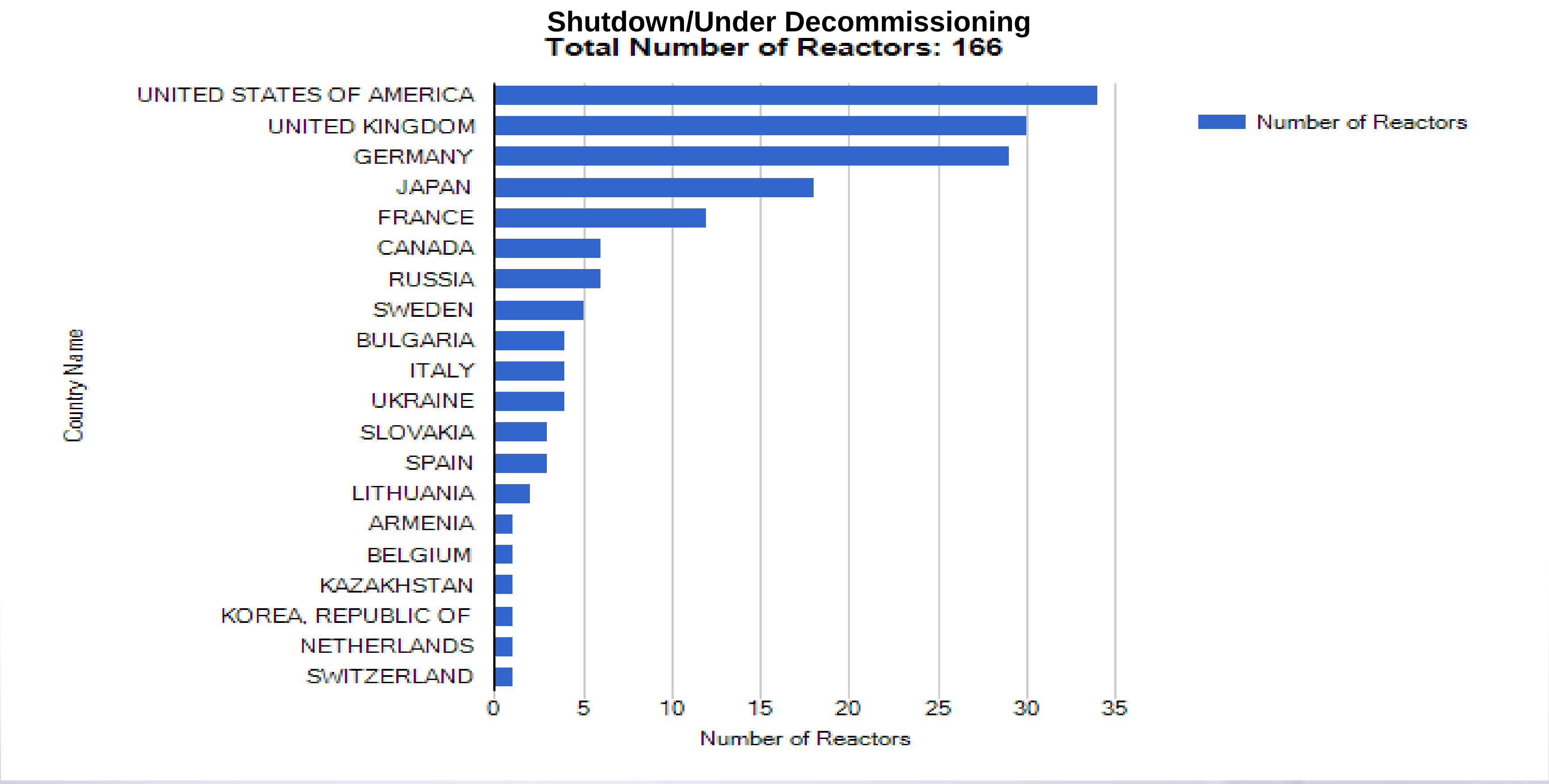
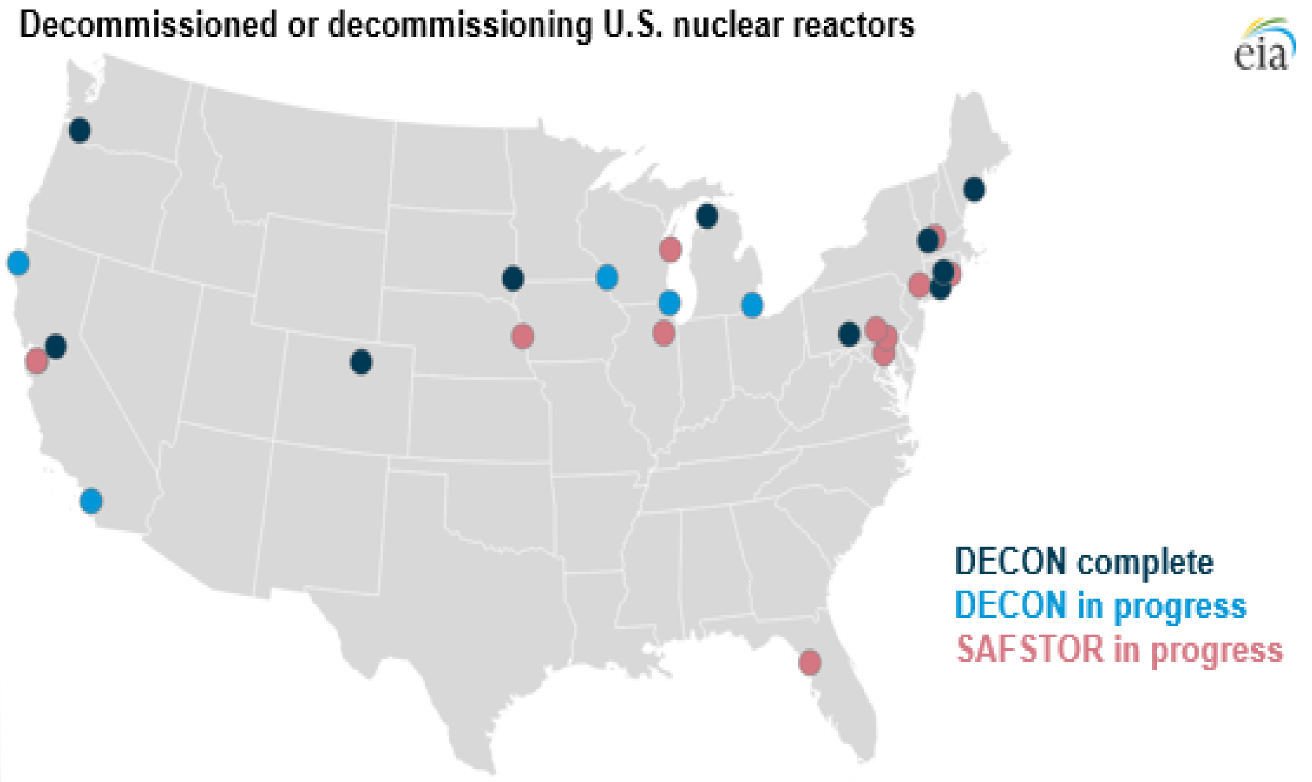


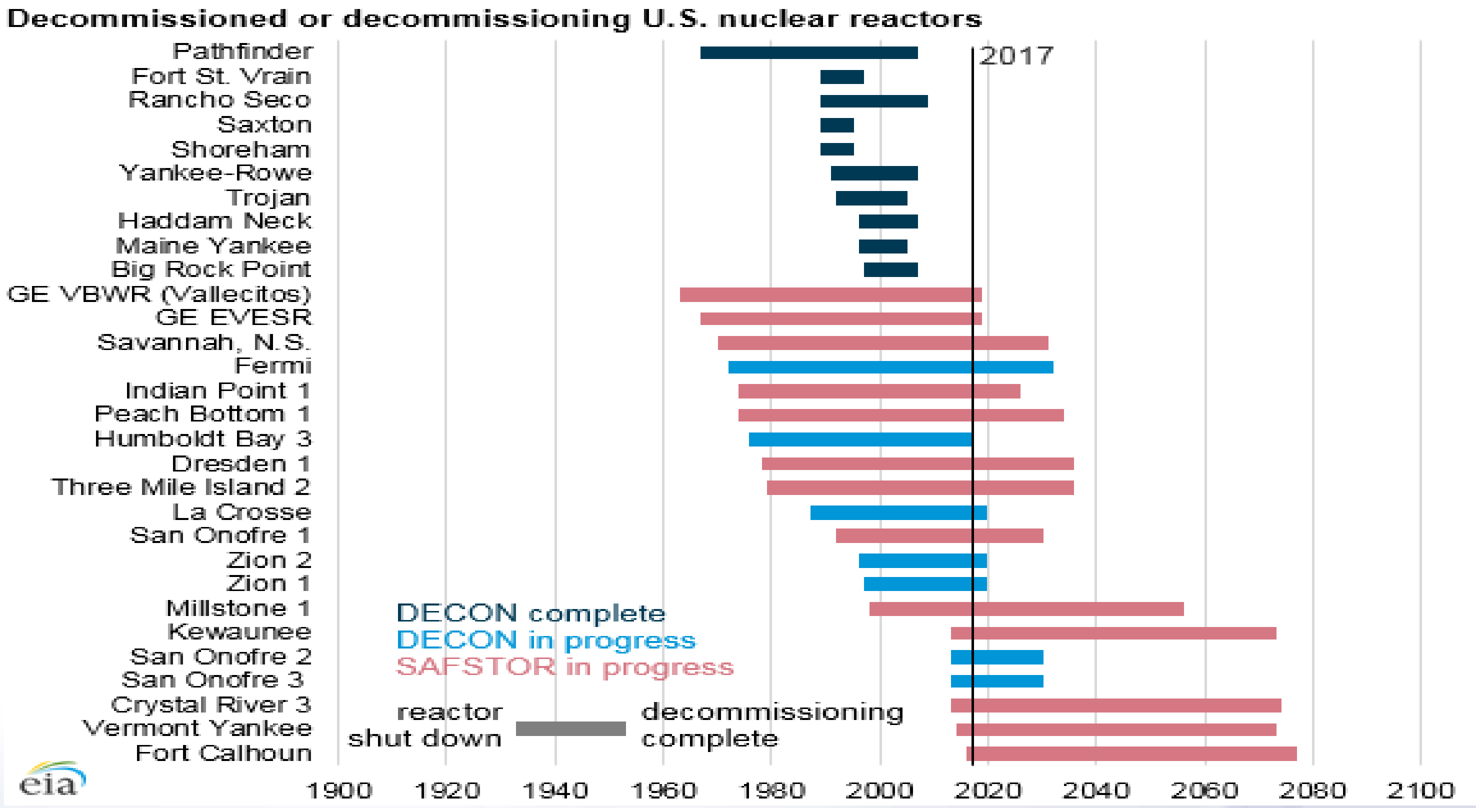
Source: IAEA PRIS Data

State of the Nuclear Industry
United States Plant Status



Source: U.S. Energy Information Administration, based on Nuclear Regulatory Commission and IAEA Power Reactor Information System

State of the Nuclear Industry
United States Plant Status



Source: U.S. Energy Information Administration, based on Nuclear Regulatory Commission and IAEA Power Reactor Information System

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“Decontamination and Decommissioning Are We Ready”

- **Non-European Forecast***

Country	Potential Shutdown Before 2030
United States	5
Canada	14
Korea	9
Japan	23

*** Based on Organisation for Economic Co-Operation and Development Data – Assume shutdown after 60 years operational time in United States and 40 years all others**

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- **European Forecast***

Country	Potential Shutdown Before 2030	Country	Potential Shutdown Before 2030
Russia	23	United Kingdom	15
Germany	8	Belgium	7
Spain	7	Sweden	4
Switzerland	4	Finland	2
France	1**		

*** Source: IAEA PRIS Database. Based on Organisation for Economic Co-Operation and Development Data – Assume shutdown after 40 years operational time**

**** Due to license extension**

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- Costs and Finances
  - Costs and future estimates
  - Financing methods
    - Prepayment
    - External sinking funds
    - Surety fund, letter of credit or insurance

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- **Costs and Future Estimates**
  - Labor, energy, and waste material transportation and disposal are the primary components of decommissioning costs.
  - 2016 cost estimate in United States for the 99 operating and 11 non-operating nuclear reactors was 91 billion USD (approximately 74 billion Euro). This is approximately 827 million USD (668 billion Euro) per reactor.
  - On a per KW breakdown the cost estimate is approximately $800 to $850/KW (647 to 687 Euro)

Source: Callan Institute 2017 Nuclear Decommissioning Funding Study

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- **Financing Methods**
  - Prepayment: Money is deposited in a separate account to cover decommissioning costs even before the plant begins operation. Funds can only be withdrawn for decommissioning purposes.
  - External sinking funds: Money built up over the years from a % of the electricity rates charged to consumers. Proceeds placed in fund outside utility control.
  - Surety fund, letter of credit or insurance: Products purchased by the utility to guarantee that decommissioning costs will be covered even if the utility defaults.

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Funding in United States

53 billion USD (43 billion Euro) has been set aside as of 2016.

The U.S. regulations require:

- Determination of the minimum decommissioning funds assurance
- Annual adjustment to account for inflation
- Reporting on fund status every 2 years during operation and every year when plant is within 5 years of end of operating life
- Site specific decommissioning cost estimate within 2 years of shutdown
- Limited use of funds to legitimate decommissioning expenses.

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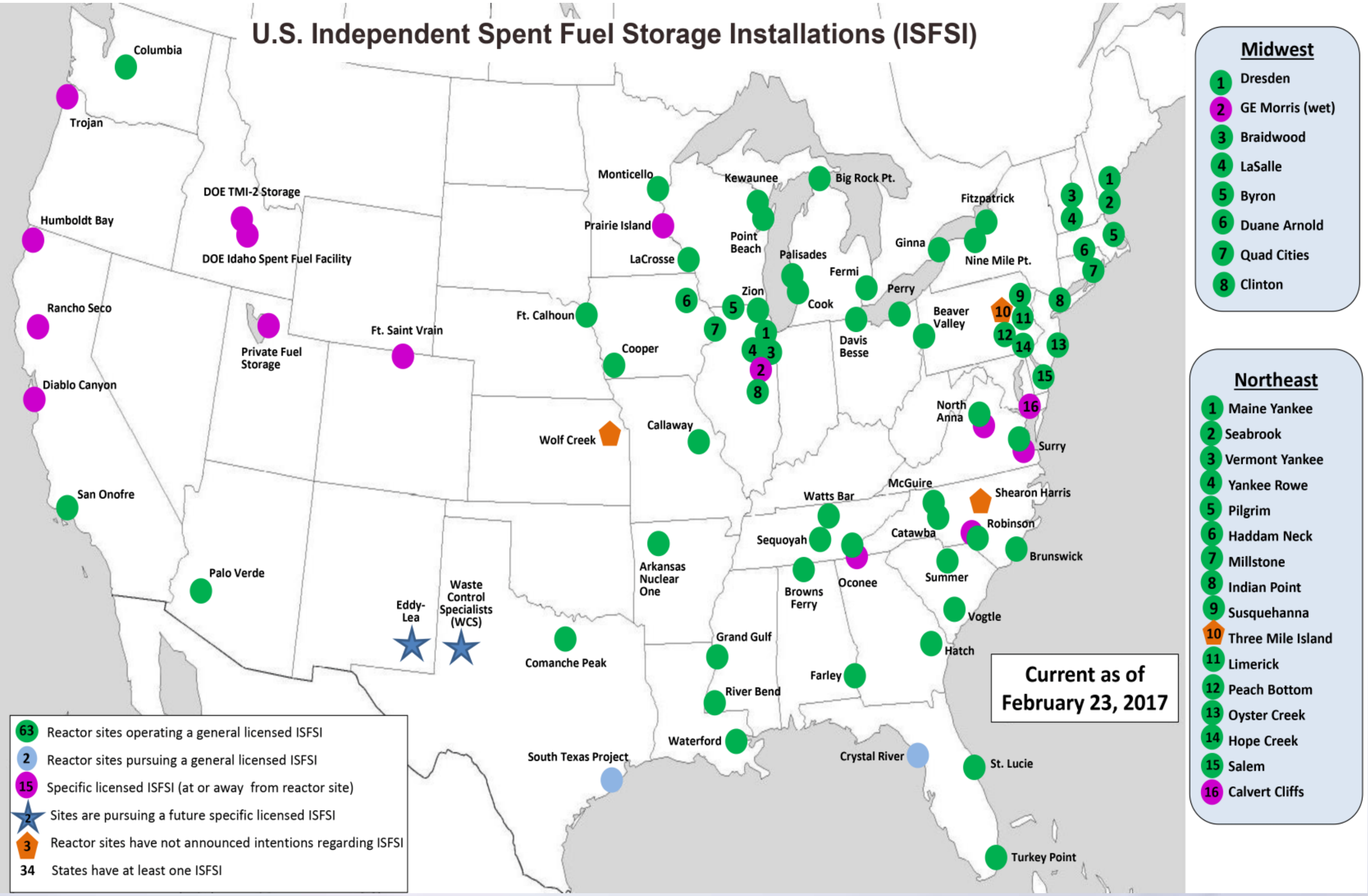
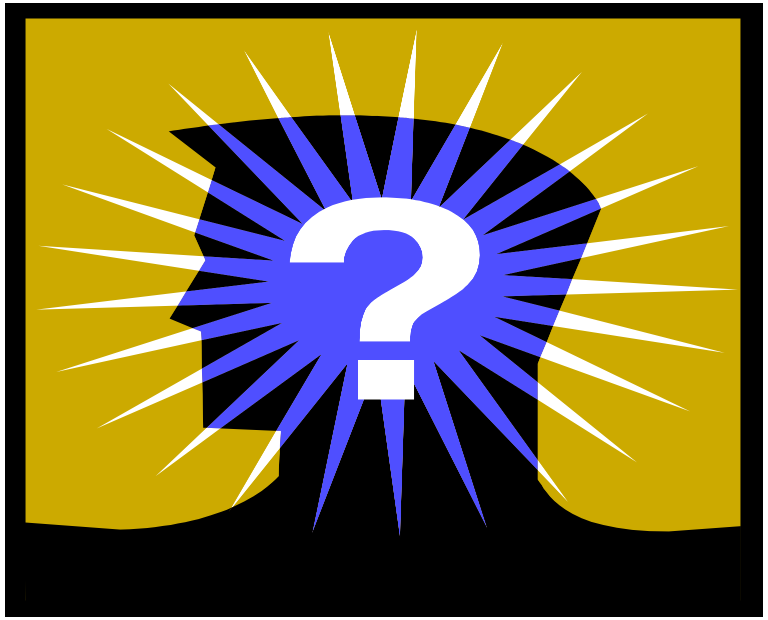
- **Additional Considerations**
  - Spent fuel storage
    - Methods
    - Technology
    - Costs
  - Public perception and participation
  - Recycling and reuse of materials
  - Others?

ISFSI Locations in the U.S.



QUESTIONS



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