U.S.NRC

United States Nuclear Regulatory Commission

Protecting People and the Environment

Power Generation

Ronaldo Jenkins

Electrical Engineering Branch Chief

Office of New Reactors (NRO)

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Agenda

- Overview – Design Considerations
- 10 Code of Federal Regulations (CFR) 50
  - 10 CFR 50, General Design Criteria 17 & 18
  - 10 CFR 50.36 (Technical Specifications)
  - 10 CFR 50.49 (Environmental Qualification)
  - 10 CFR 50.63 (Station Blackout)
  - 10 CFR 50.65 (Maintenance Rule)
- Trends & Related Operating Experience

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Energy flow of Power Plant

E1=Energy consumed,

El1=Electricity generated,

El2=Internal use,

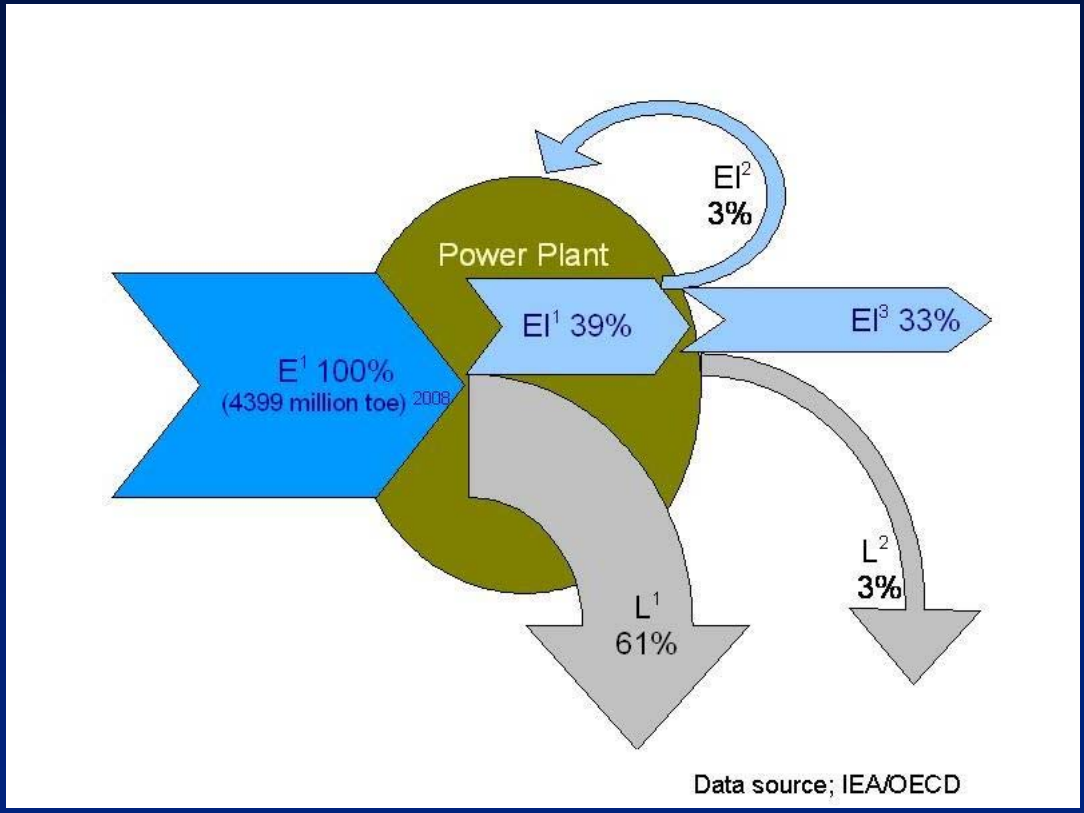
El3=Electricity for consumption,

L1=Processing Loss,

L2=Transmission Loss.

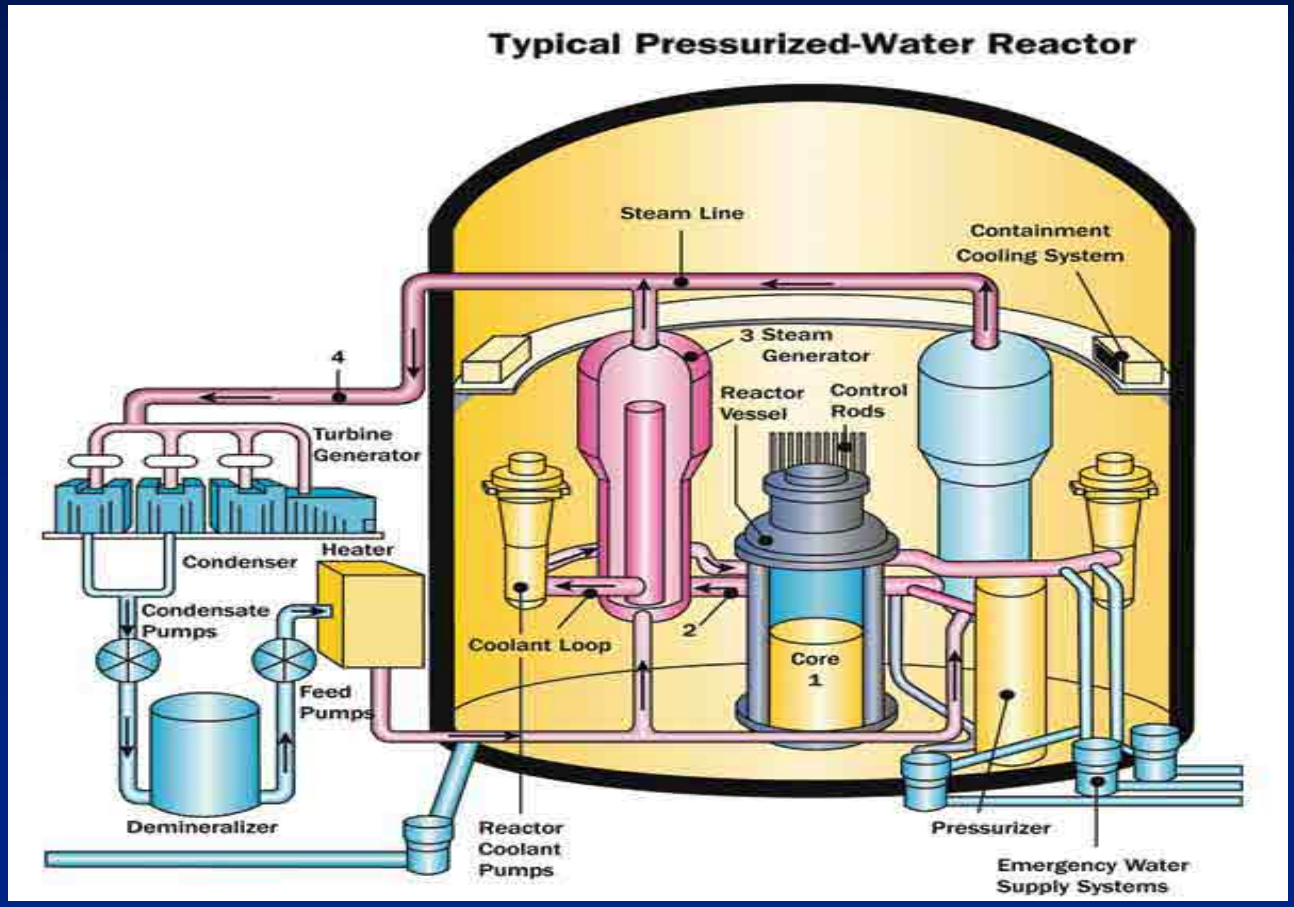
(Result of year 2008)

toe = tons of oil equivalent



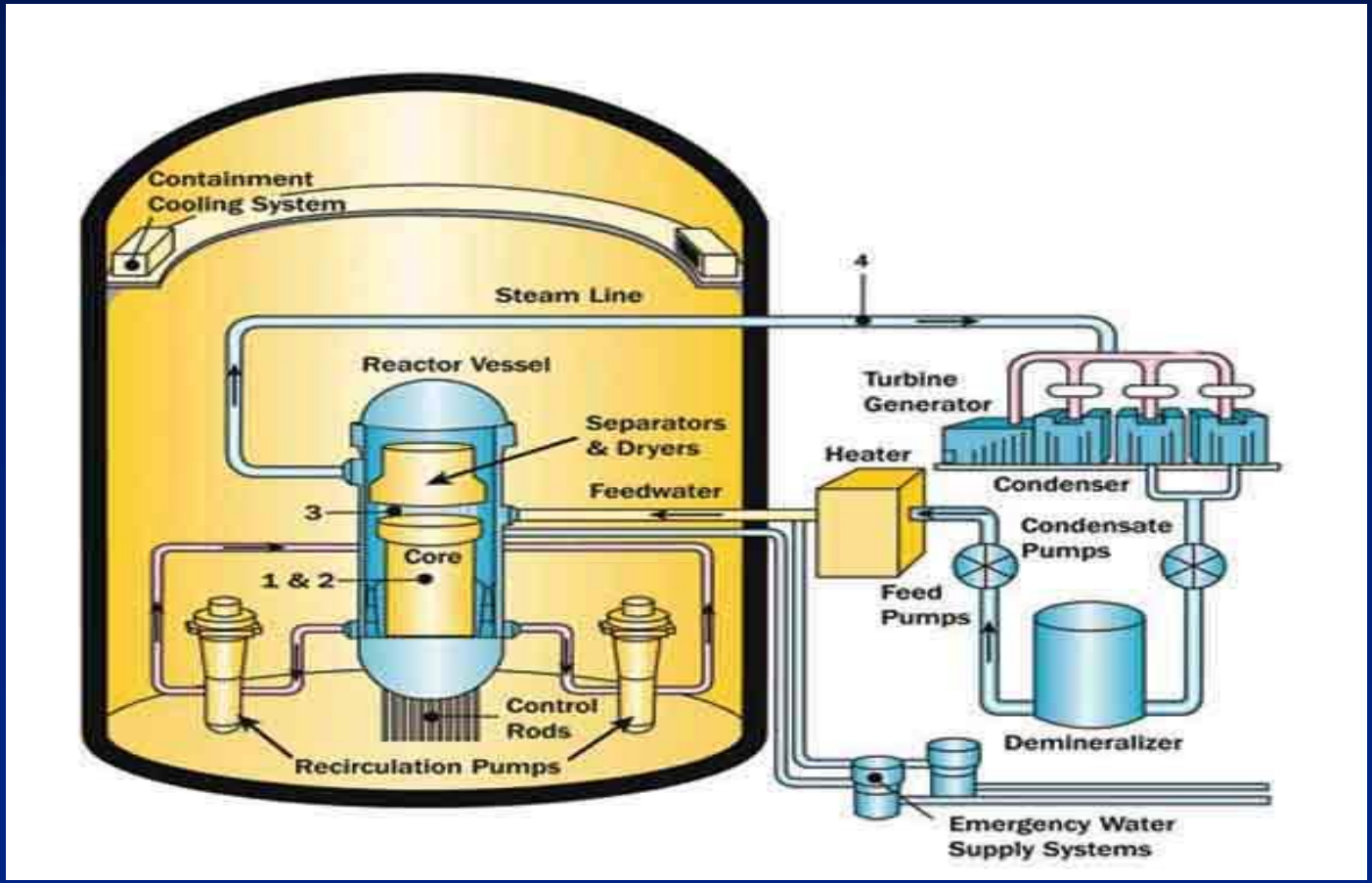
U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Pressurized Water Reactor (PWR)



U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Boiling Water Reactor (BWR)



U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

For Power Generation, What Do PWRs and BWRs Have In Common?

- A Nuclear Power Plant (NPP) shares the same key characteristics as a fossil (e.g., coal, oil) power plant. Power Generation requires
  - Thermal to electric power conversion (3:1 typical efficiencies)
  - Water source for cooling
  - Electrical equipment for control of voltage and current

- NPP differs due to the provisions necessary to protect the public from radiological risks

ANSWER: ROTARENEG ENIBRUT (spelled backwards)

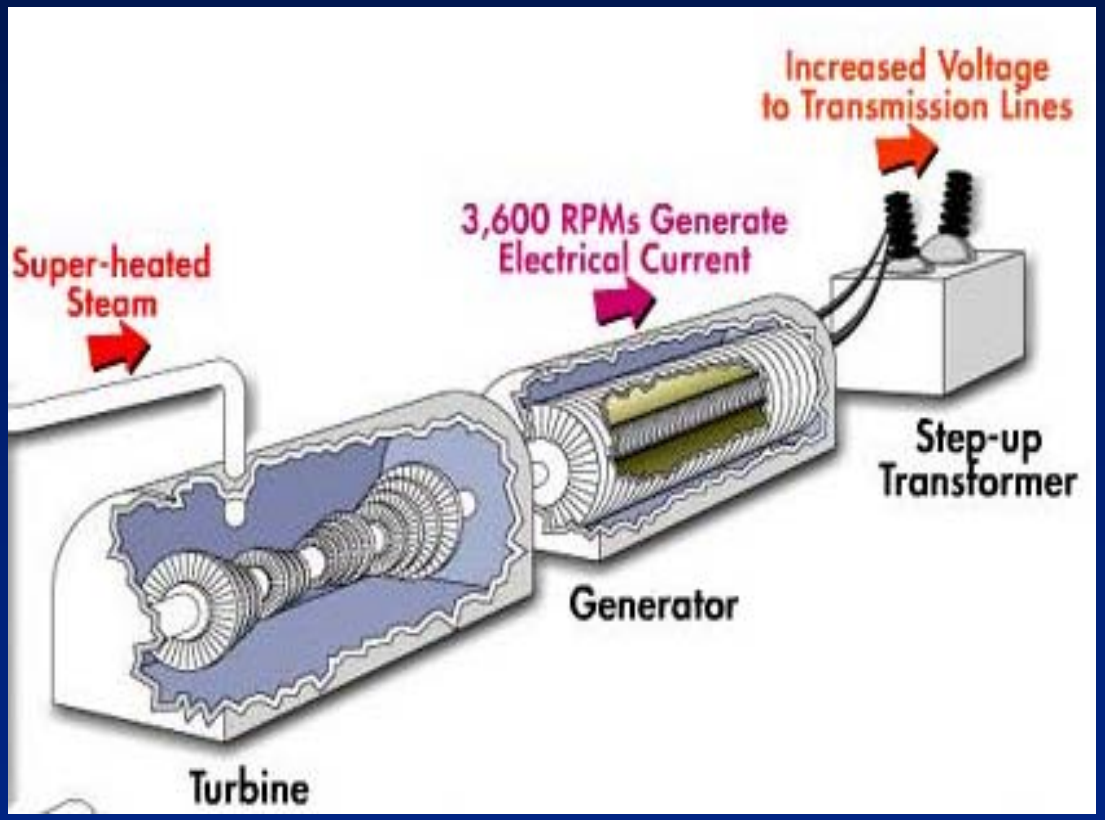
U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

TURBINE GENERATOR TAKES

SUPER-HEATED STEAM FROM

REACTOR TO DRIVE TURBINE

TO GENERATE ELECTRICITY



U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Calvert Cliffs Nuclear Power Plant

Location: Lusby, MD (40 miles S of Annapolis, MD) Region I

Operating License: Issued - 07/31/1974

Reactor Type: Pressurized Water Reactor

Electrical Output: 873 MWe

Reactor Vendor/Type: Combustion Engineering

Containment Type: Dry, Ambient Pressure

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

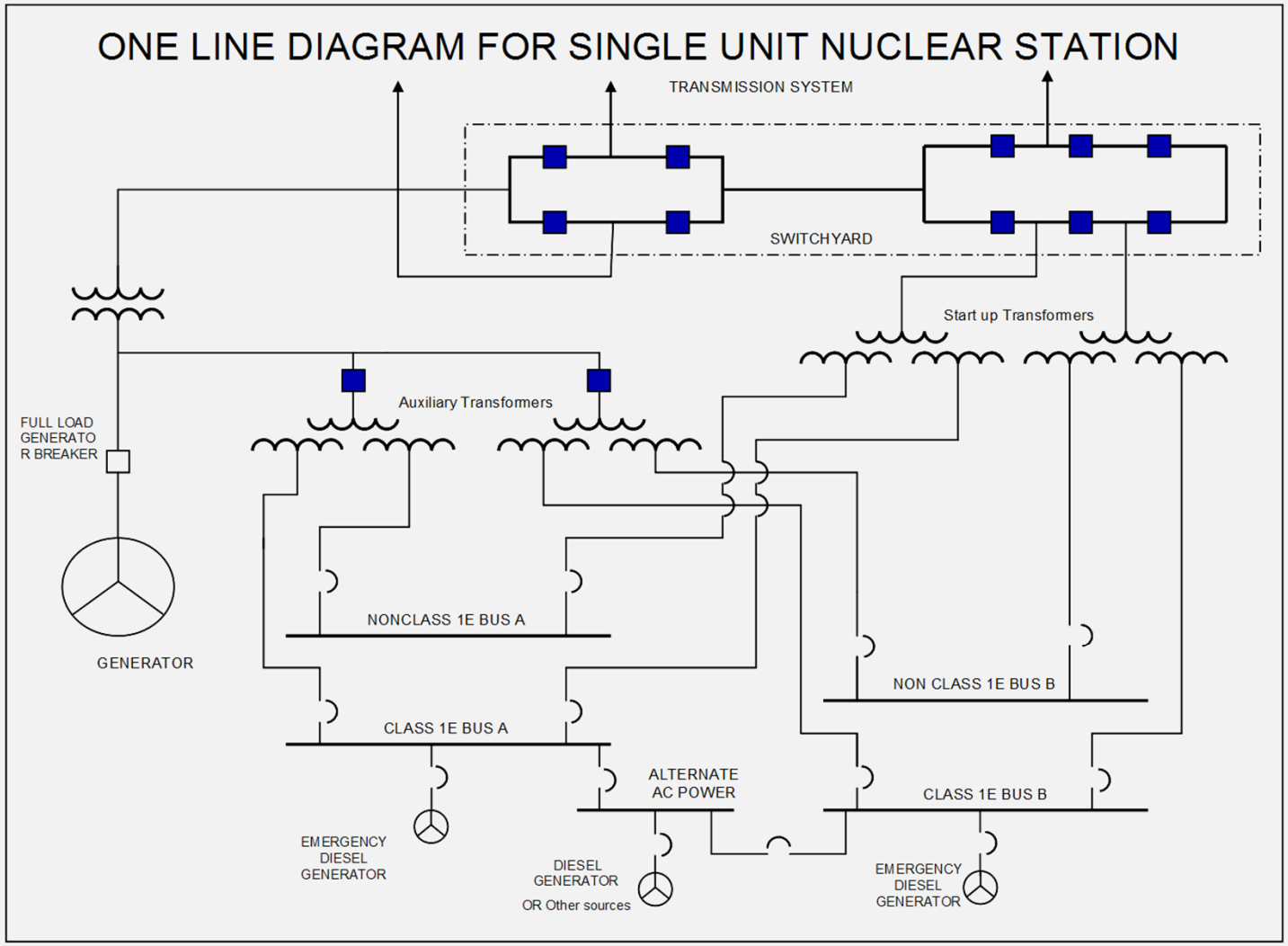
How The NRC Regulates

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Regulations

- 10 CFR 50 GDC 17, Electric Power Systems
  - Two independent sources of AC power of sufficient capacity and capability to assure that (1) fuel design limits and design conditions are not exceeded as a result of anticipated operational occurrences (2) core is cooled and containment integrity and other vital functions are maintained
  - Onsite power sources together should meet single failure
  - Provisions to minimize loss of electric power coincident with or as result from loss of generation, loss of grid, or loss any onsite source

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment



U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

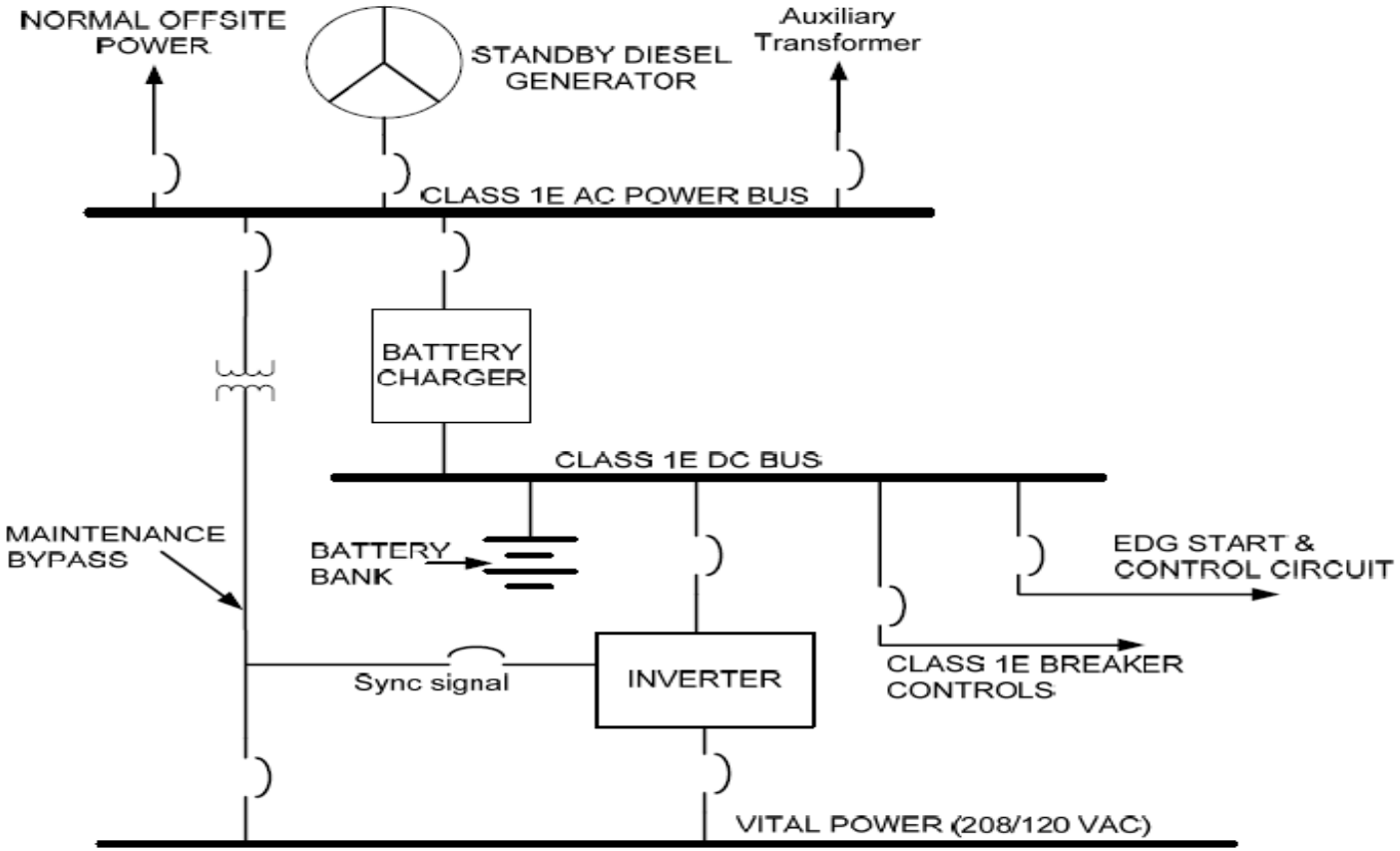
Regulations (Cont'd)

- General Design Criteria 18, Inspection and Testing of Electric Power Systems

  - ❖ Electric power systems important to safety must be designed to permit appropriate periodic inspection and testing of important areas and features...

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Simplified CLASS 1E Power System



U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Regulations (Cont'd)

- 10 CFR 50.36, Technical Specifications, constitute the limiting conditions for operation necessary to maintain the plant within safety limits. Includes
  - Surveillance Requirements
  - Administrative Controls
  - Allowed Outage Time limiting the time that equipment can remain in an inoperable state
  - For example, 72 hours limit that 1 of the 2 Emergency Diesel Generators can be inoperable else the plant must begin its shutdown procedure

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Regulations (Cont'd)

- 10 CFR 50.49, Environmental Qualification of Electric Equipment Important to Safety for Nuclear Power Plants

  - After the Three Mile Island Accident, the NRC required that licensees qualify certain equipment to remain operable during and after a design basis accident
  - Equipment must be tested for harsh environmental conditions (i.e., radiation, thermal)
  - Focus is on post accident monitoring and mitigation

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Regulations (Cont'd)

- 10 CFR 50.63, Loss of All Alternating Current Power

Each light water-cooled NPP must be able to withstand for a specified duration and recover from a Station Blackout [SBO] (loss of all ac power both onsite and offsite sources) depending on

- Redundancy of emergency onsite power sources
- Reliability of emergency onsite power sources
- Frequency of loss of offsite power
- Probable time to restore offsite power

Alternative ac sources were installed to deal with a SBO event

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Regulations (Cont'd)

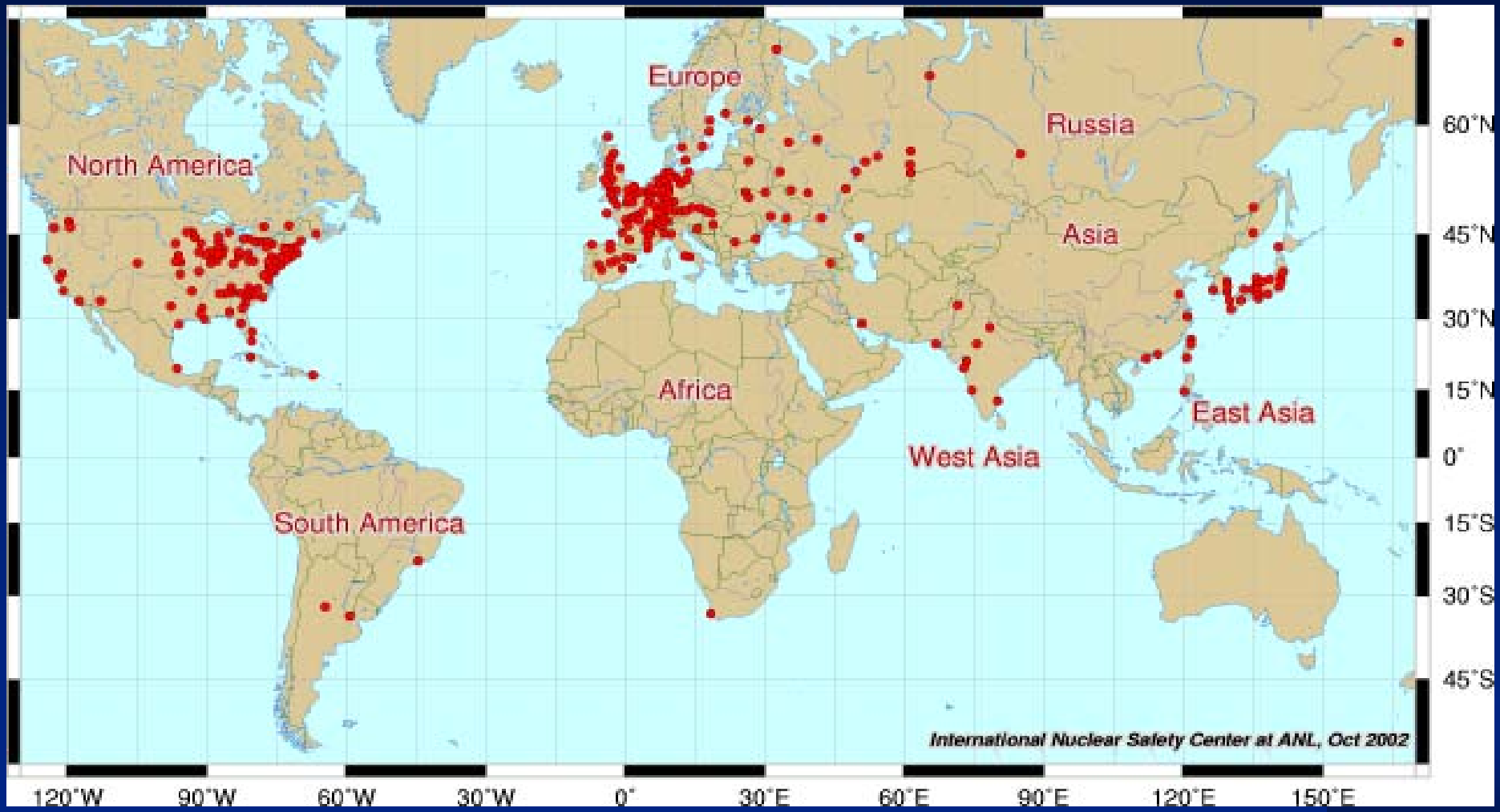
- Maintenance Rule (10 CFR 50.65) requires licensees to manage the increase in risk that results from the proposed maintenance activities (including corrective and preventive maintenance, post-maintenance testing, surveillance, etc.,)

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

INDUSTRY TRENDS AND RELATED OPERATING EXPERIENCE

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

World Nuclear Power Plants



U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Worldwide Nuclear Power Reactors

- There are 440 nuclear power reactors in 31 countries.
- 30 more reactors are under construction.
- They account for 16% of the World's electricity
- They produce a total of 351 gigawatts (billion watts) of electricity
- Each country is planning their own course of nuclear plant increase or decline

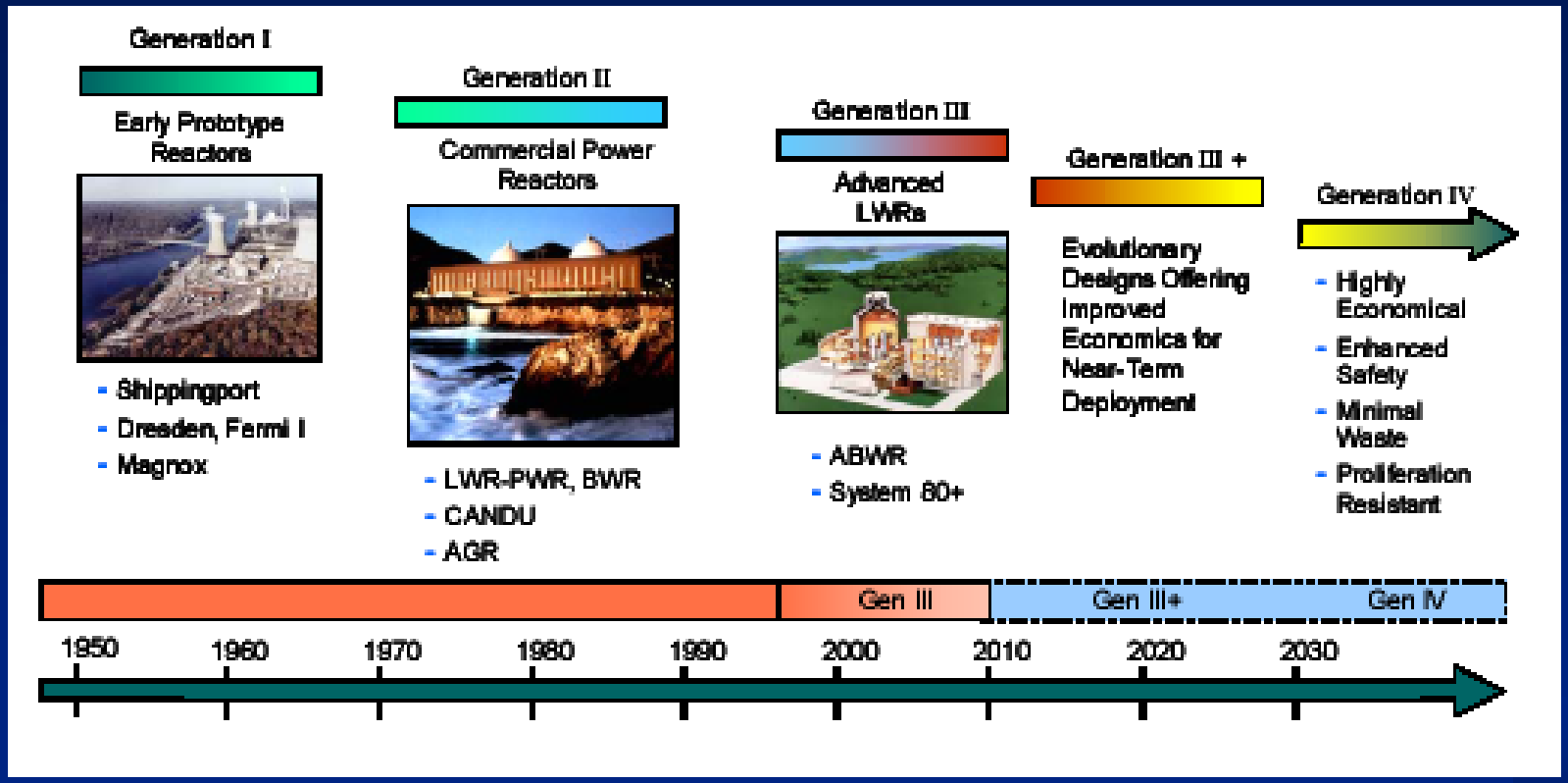
U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

US Nuclear Power Generation

- In the US, 20% of our electricity is produced by nuclear power. There are 104 nuclear power reactors in operation.
- A typical reactor produces about 1,100 million watts (megawatts) of electricity which is enough to power one million homes
- Each reactor's production is equivalent to 15 million barrels of oil or 3.5 million tons of coal a year.

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Future of Nuclear Power Generation



U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Fukushima

- March 11, 2011 Great East Japan Earthquake and Tsunami
- Tsunami rendered critical safety systems inoperable at several units at Fukushima Daiichi site
- NRC formed Near-Term Task Force to review NRC processes and regulations for possible improvements
- Task Force report issued July 12, 2011

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Fukushima

BEFORE

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Fukushima

DURING

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Fukushima

DURING

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Fukushima

AFTER

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Units 3 and 4 (after explosions)

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Fukushima-Daiichi Accident Aftermath

- NRC Task Force Recommendations
  - Clarify Regulatory Framework
  - Ensure Protection of Critical Structures, Systems, and Components
  - Enhance Mitigation Capabilities
  - Strengthen Emergency Preparedness
  - Improve Efficiency of NRC programs
- For Power Generation –renewed focus on SBO