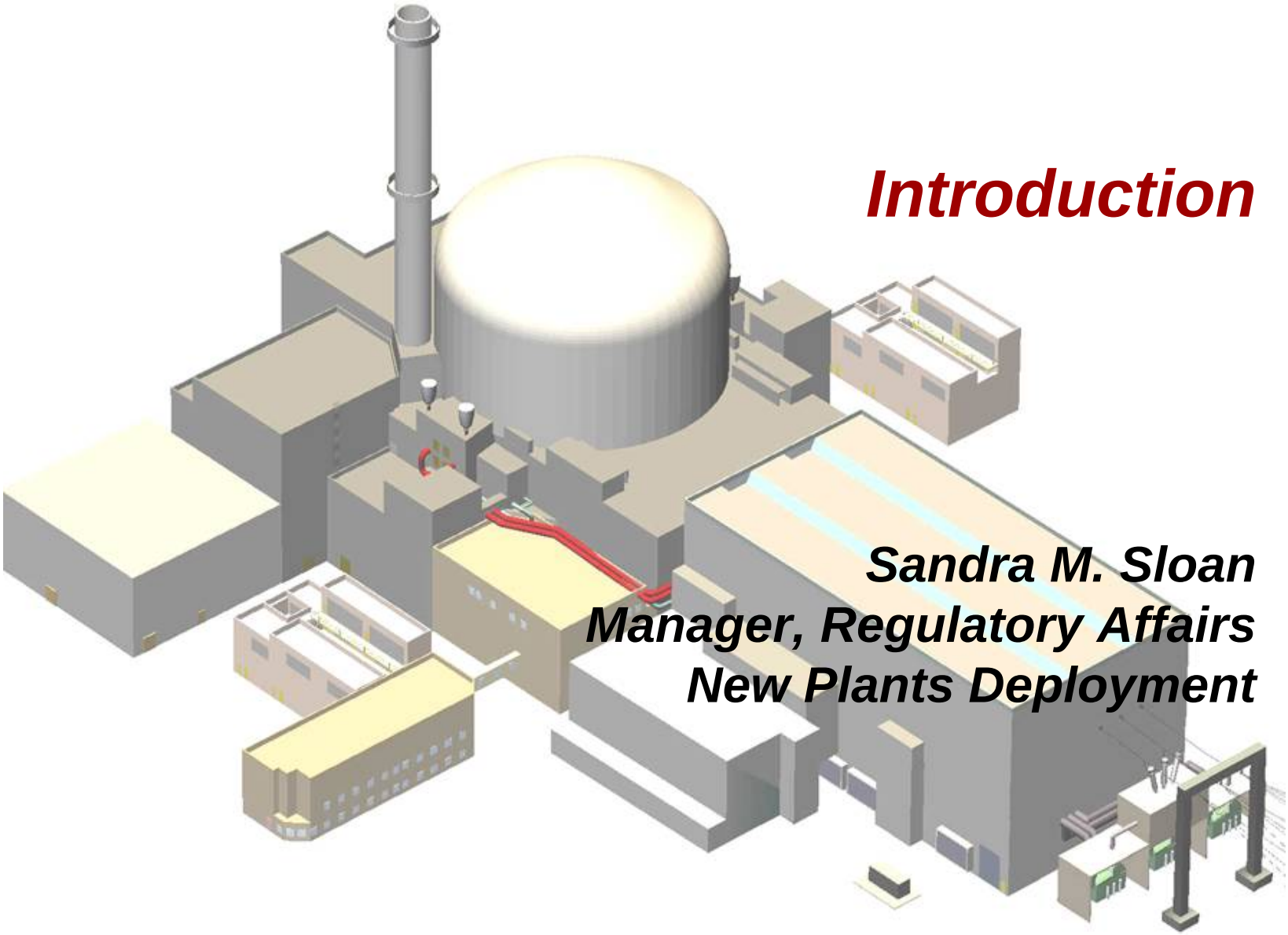
U.S. EPR Pre-Application Review Meeting:
Electrical Systems, Fire Protection and Train Separation Requirements Overview

AREVA NP Inc. and the NRC
June 20, 2006

Introduction



Sandra M. Sloan
Manager, Regulatory Affairs
New Plants Deployment

Meeting Objectives
Electrical Systems Overview

- Describe the approach for the design of electrical systems for the U.S. EPR
- Provide an overview of U.S. EPR electrical design
- Obtain early NRC feedback concerning the electrical system design strategy
- Discuss upcoming activities associated with the U.S. EPR electrical design

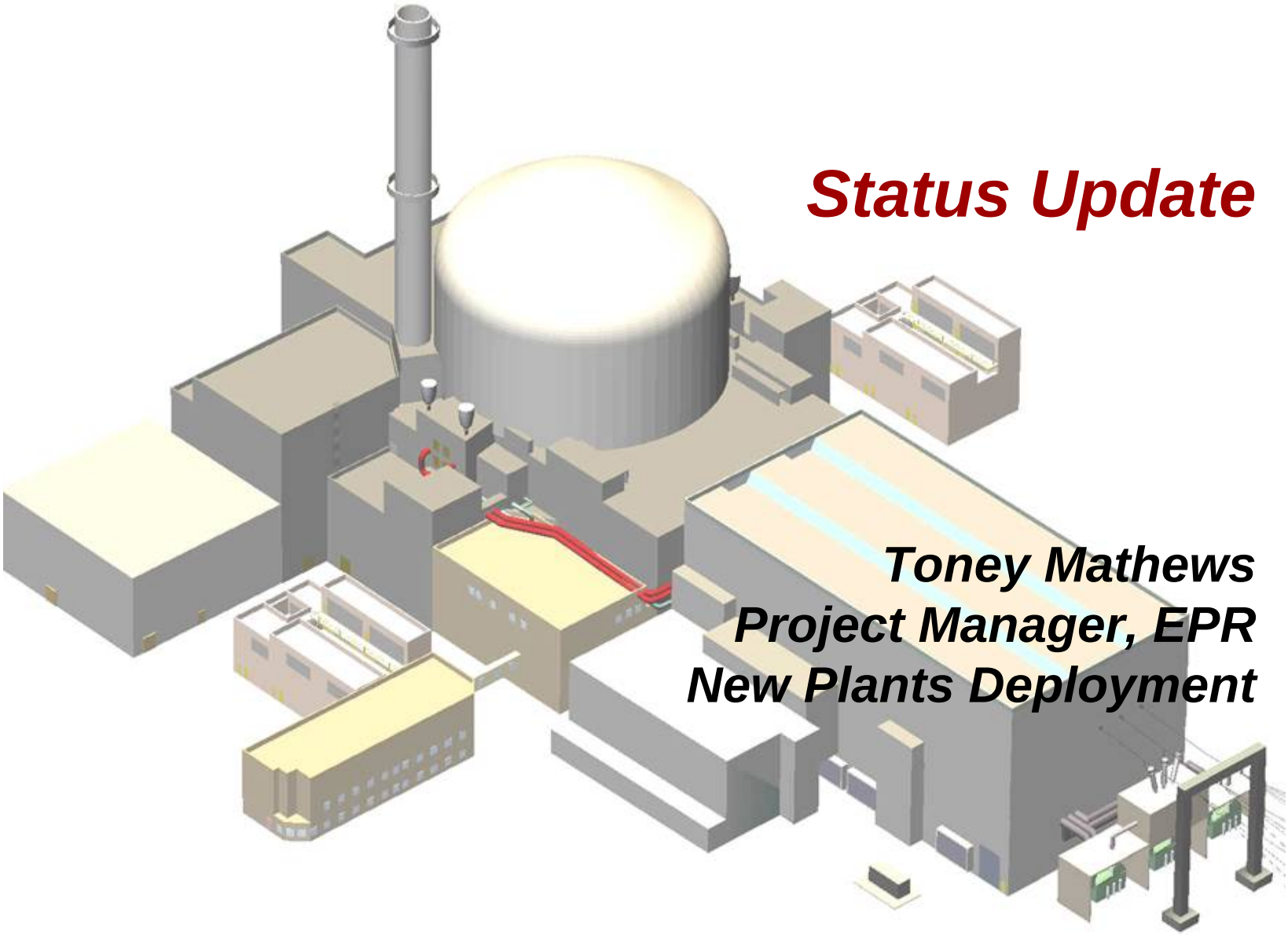
Meeting Objectives
Fire Protection & Train Separation

- Provide an overview of the U.S. EPR design features to meet NRC requirements for Fire Protection
- Describe the defense-in-depth design for Fire Protection
- Provide an overview of the inherent safe shutdown design features
- Obtain early NRC feedback associated with the U.S. EPR Fire Protection strategy

Outline

- U.S. EPR status update (Mathews)
- U.S. EPR electrical systems overview (Grundman)
- U.S. EPR fire protection and train separation (Redmond)
- Next steps (Sloan)

Status Update



Toney Mathews
Project Manager, EPR
New Plants Deployment

Current Activities

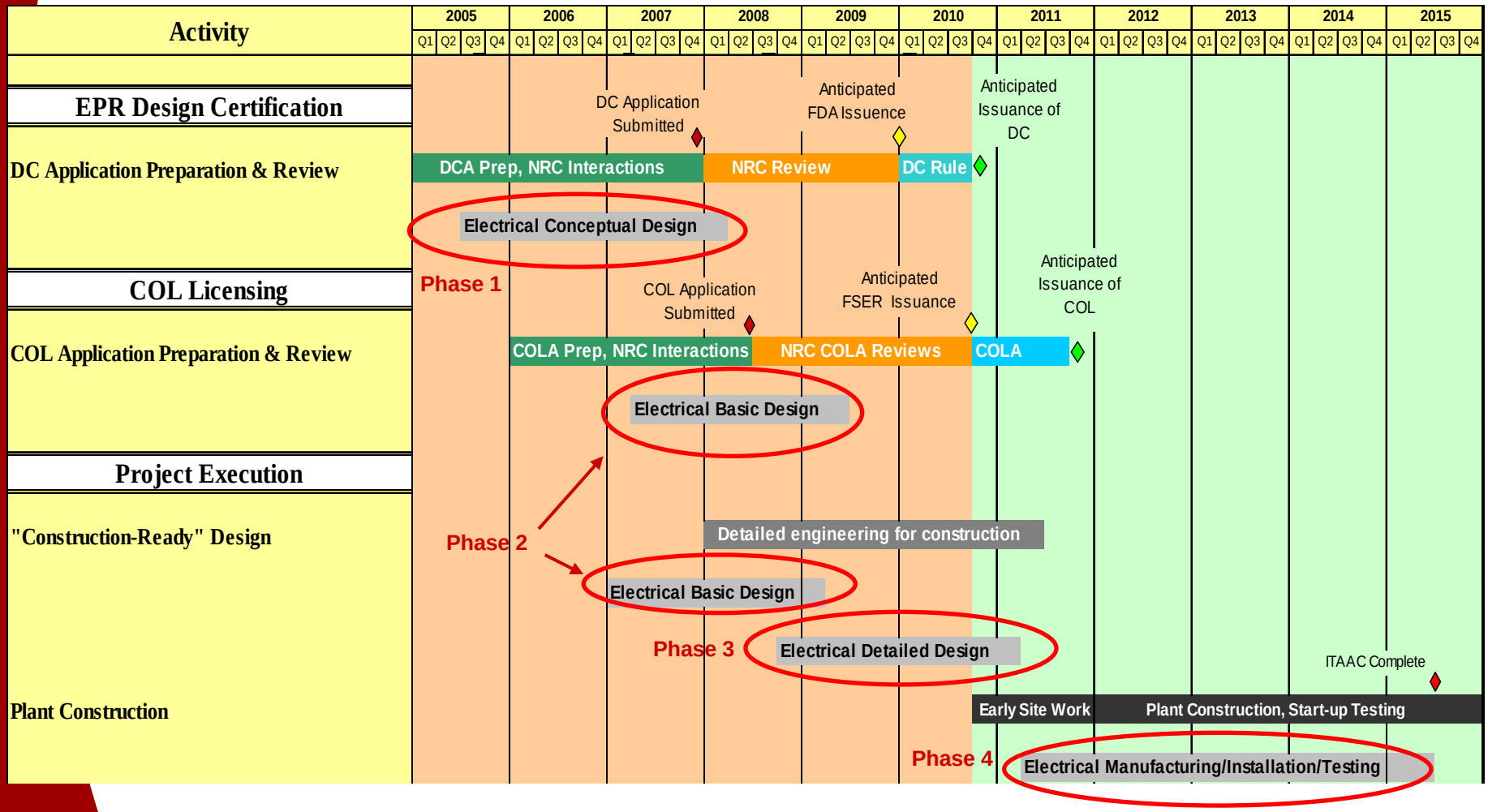
- **OL3 reference plant**
  - Under construction in Finland
  - 2009 commercial operation
  - Design freeze on electrical load list
  - Cable penetration and cable tray specification issued
  - Main generator rotor has been fabricated

- **U.S. EPR deployment**
  - DCD development for December 2007 submittal
  - COLA development for June 2008 submittal
  - Design continuum development
  - Electrical licensing and design basis reconciliation
  - Electrical global competence team oversight

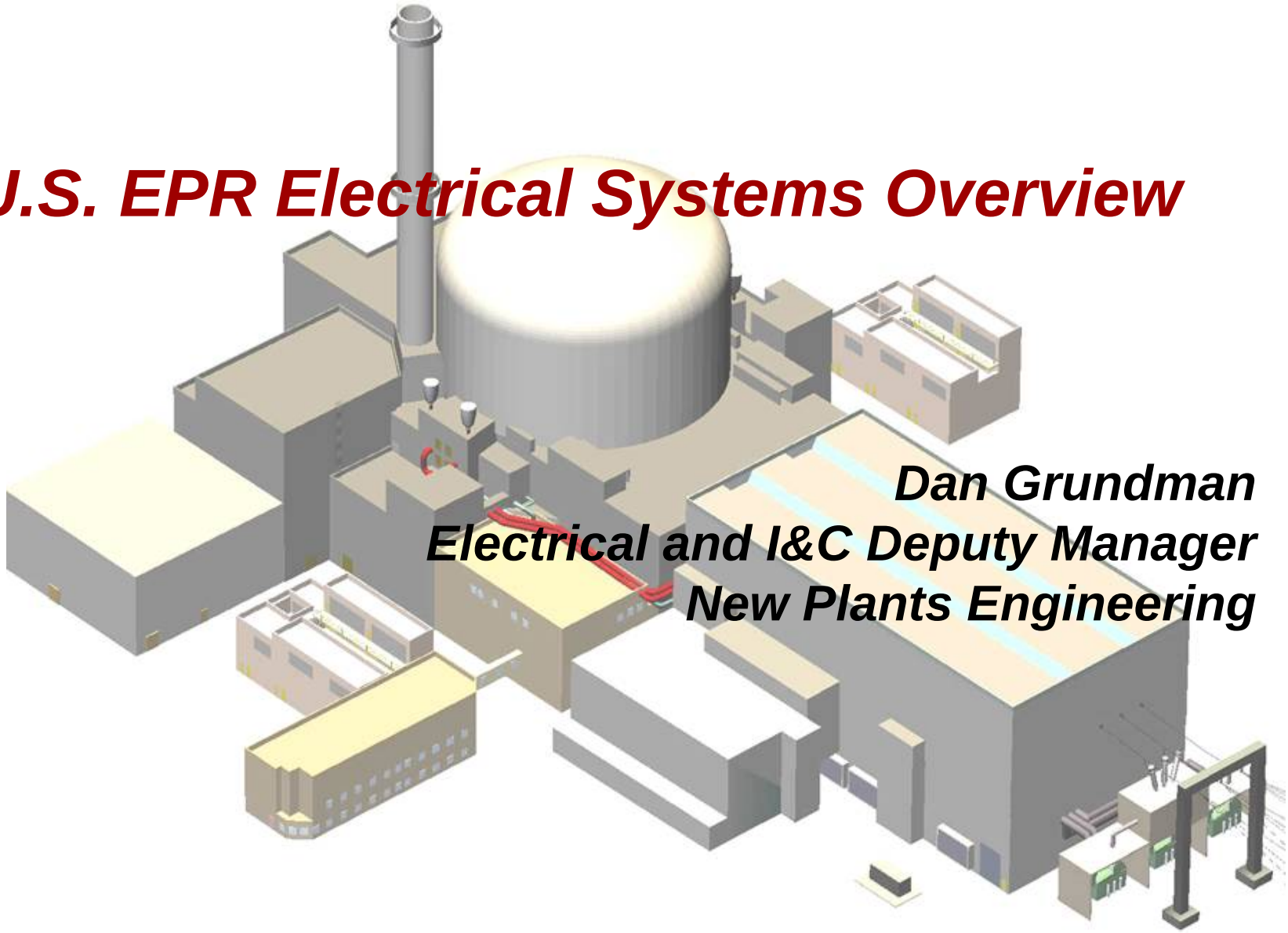
Planned Activities

- **Electrical Design Process**
  - **Phase 1 – Conceptual Design**
  - **Phase 2 – Basic Design**
  - **Phase 3 – Detailed Design**
  - **Phase 4 – Manufacturing/Testing/Installation**

Planned Activities - Timeline



U.S. EPR Electrical Systems Overview



Dan Grundman
Electrical and I&C Deputy Manager
New Plants Engineering

U.S. EPR Electrical Systems Topics

- Electrical – goals and objectives
- Electrical design approach
- Major differences between OL3 and U.S. EPR
- Conceptual single line diagram
- Offsite power system
- Onsite AC power system (Non-Class 1E)
- Onsite AC power system (Class 1E)
- Onsite UPS power system (Non-Class 1E)
- Onsite UPS power system (Class 1E)
- ETAP® analysis

U.S. EPR Electrical Systems Goals and Objectives

Improved Electrical Safety, Performance and Reliability

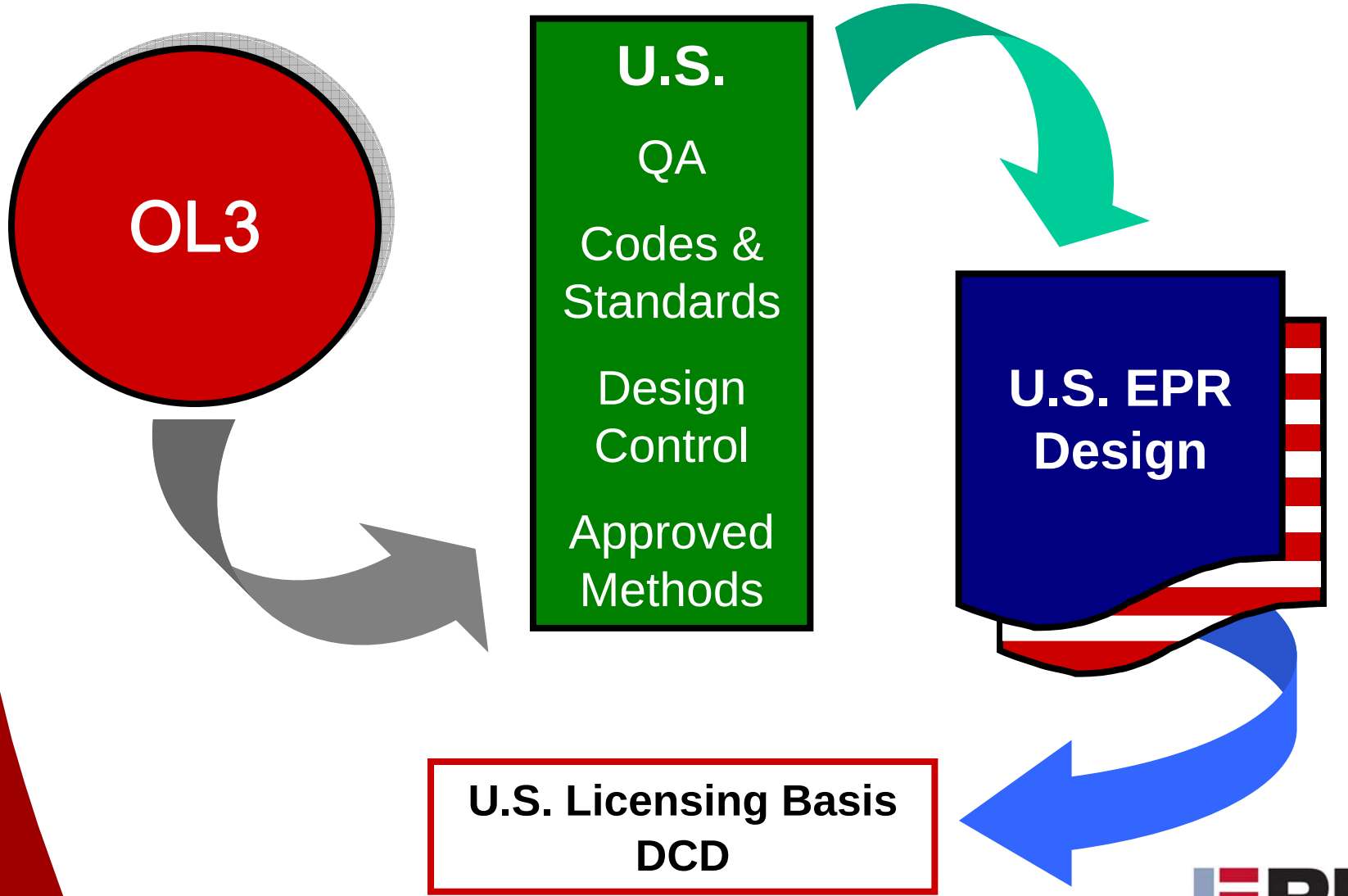
- Improved safety/reliability
  - Ensure preferred power source is available to support safety system operation
  - Ensure emergency power sources are available when needed
  - Minimize single point vulnerabilities which could cause unit trip or loss of preferred power source
- Improved maintainability
  - On-line testing and diagnostics
  - On-line maintenance
- Support advanced plant PRA goals
- Support advanced plant staffing goals
- World-wide standardization to maximum extent possible
- Acceptance by international regulatory authorities

EPR Electrical Systems Design Approach

- OL3 comprises the base plant design
- Systematic process is being applied to prepare the design for U.S. deployment
  - Conversion to U.S. design codes & standards
  - Compliance with NRC regulations and QA requirements
- Industry operating experience addressed in the design certification process
- Use of global competence team to develop and implement worldwide EPR electrical design concepts
- Recent EPR electrical design experience is factored into the U.S. EPR with the implementation of a rotational electrical engineering position

Standardization is a design goal

EPR Design Conversion



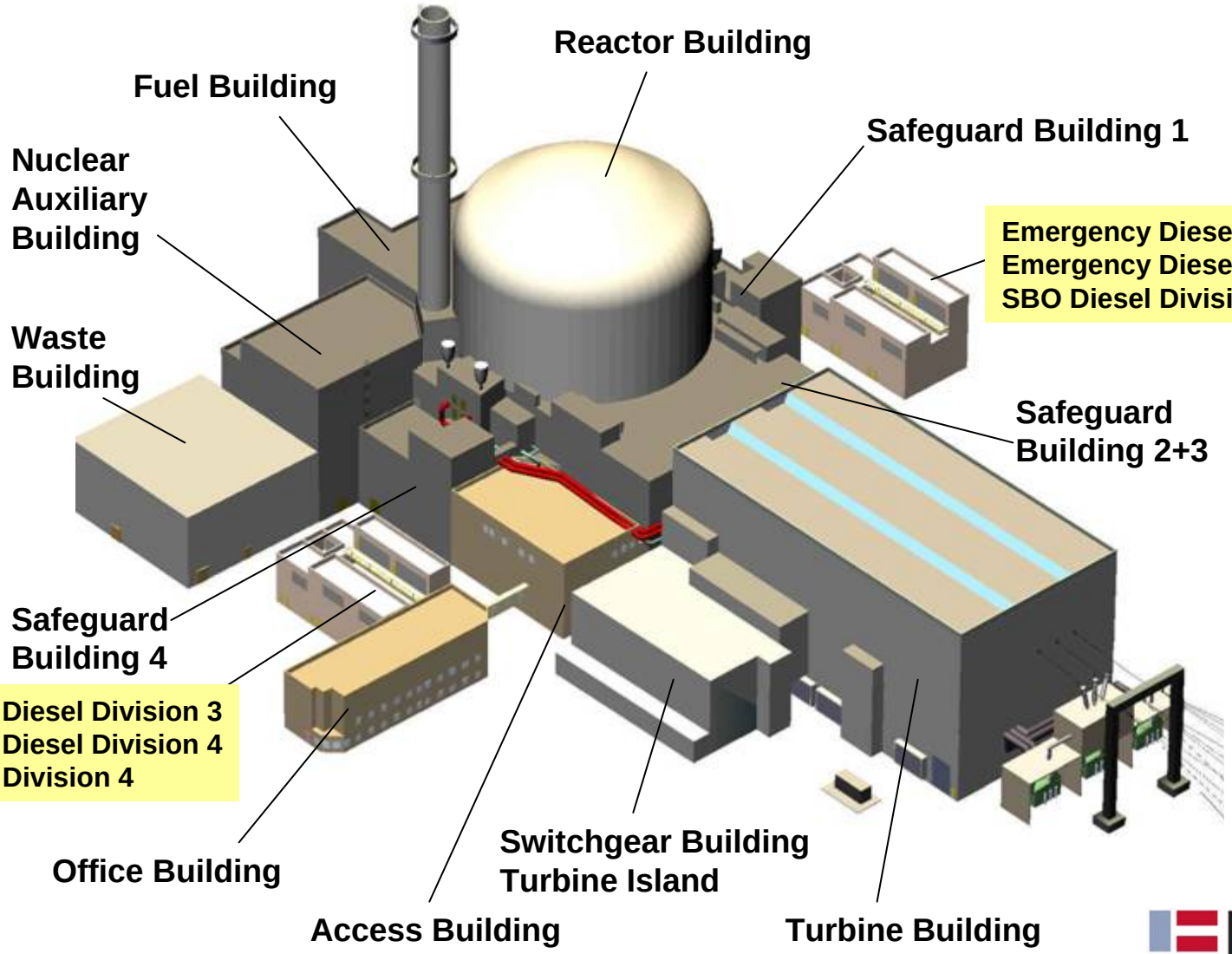
Major Differences between OL3 and U.S. EPR Electrical Design

	OL3	U.S. EPR
Voltage	10kV, 690V	13.8kV, 4.16kV, 480V
Frequency	50 Hz	60 Hz
Regulatory Guidance/Standards	IEC, STUK	IEEE, NRC

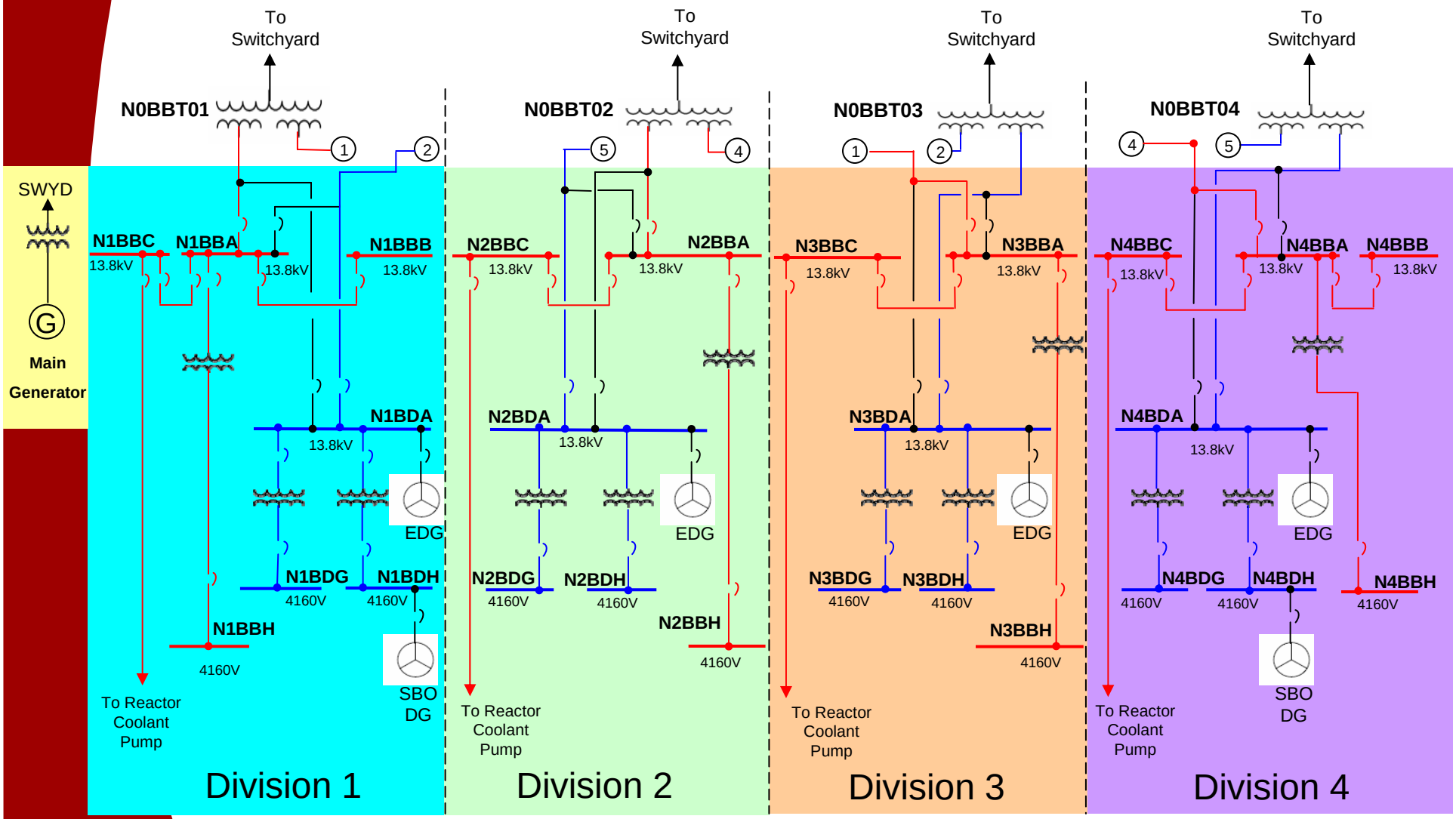
Standard Review Plan (NUREG 0800) Correlation with U.S. EPR Electrical Systems

Standard Review Plan	U.S. EPR Electrical System
Section 8.2 “Offsite Power System”	1) Preferred Power Supply (PPS) 2) Switchyard (SWYD)
Section 8.3.1 “AC Power Systems (Onsite)”	1) Emergency Power Supply System (EPSS) 2) Emergency Diesel Generators (EDG) 3) SBO Diesel Generators (SBDG)
Section 8.3.2 “DC Power Systems (Onsite)”	1) Class 1E UPS (EUPS)
Section 8.4 “Station Blackout (Future)”	1) SBO Diesel Generators (SBDG)

EPR General Plant Layout



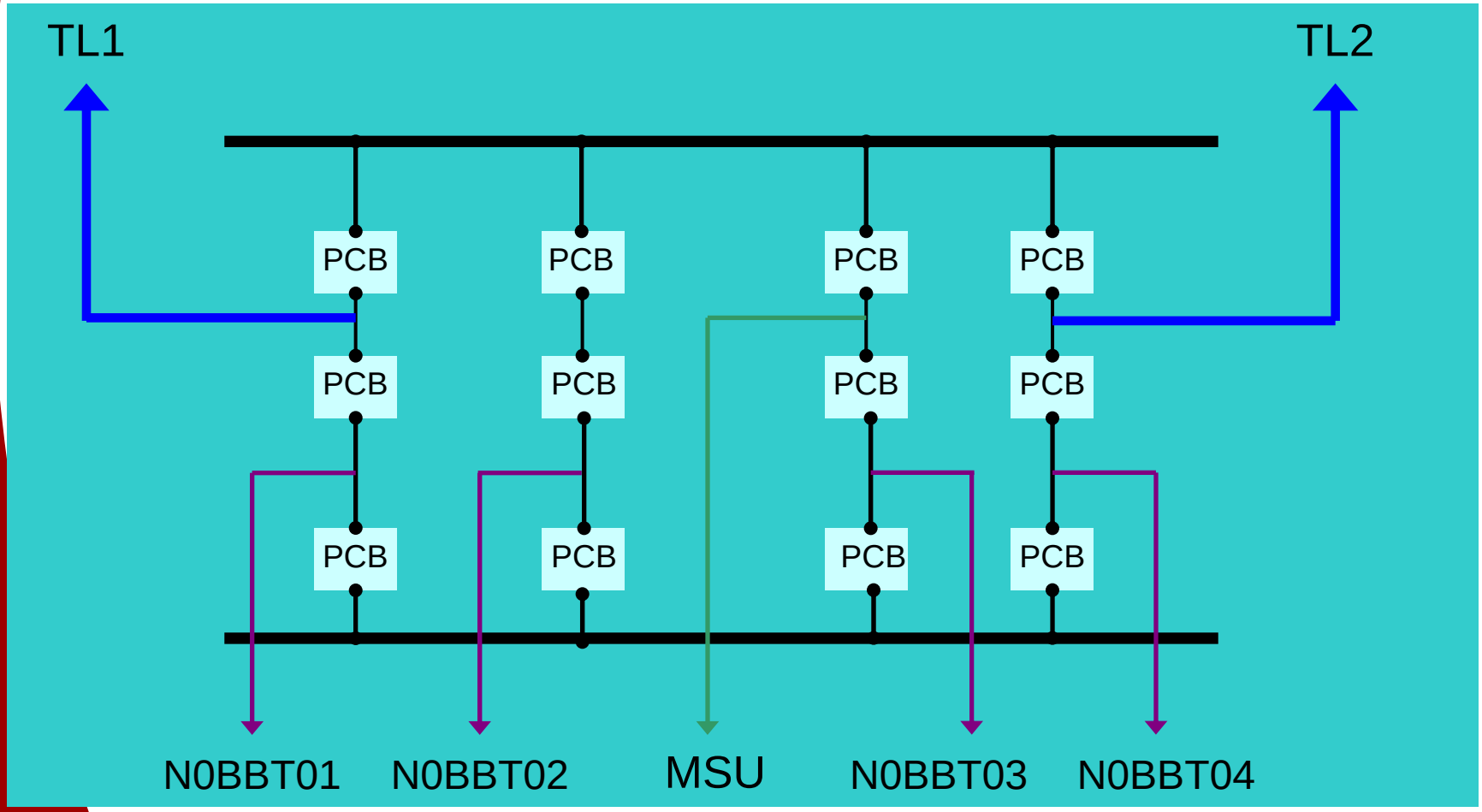
Conceptual Single Line Diagram



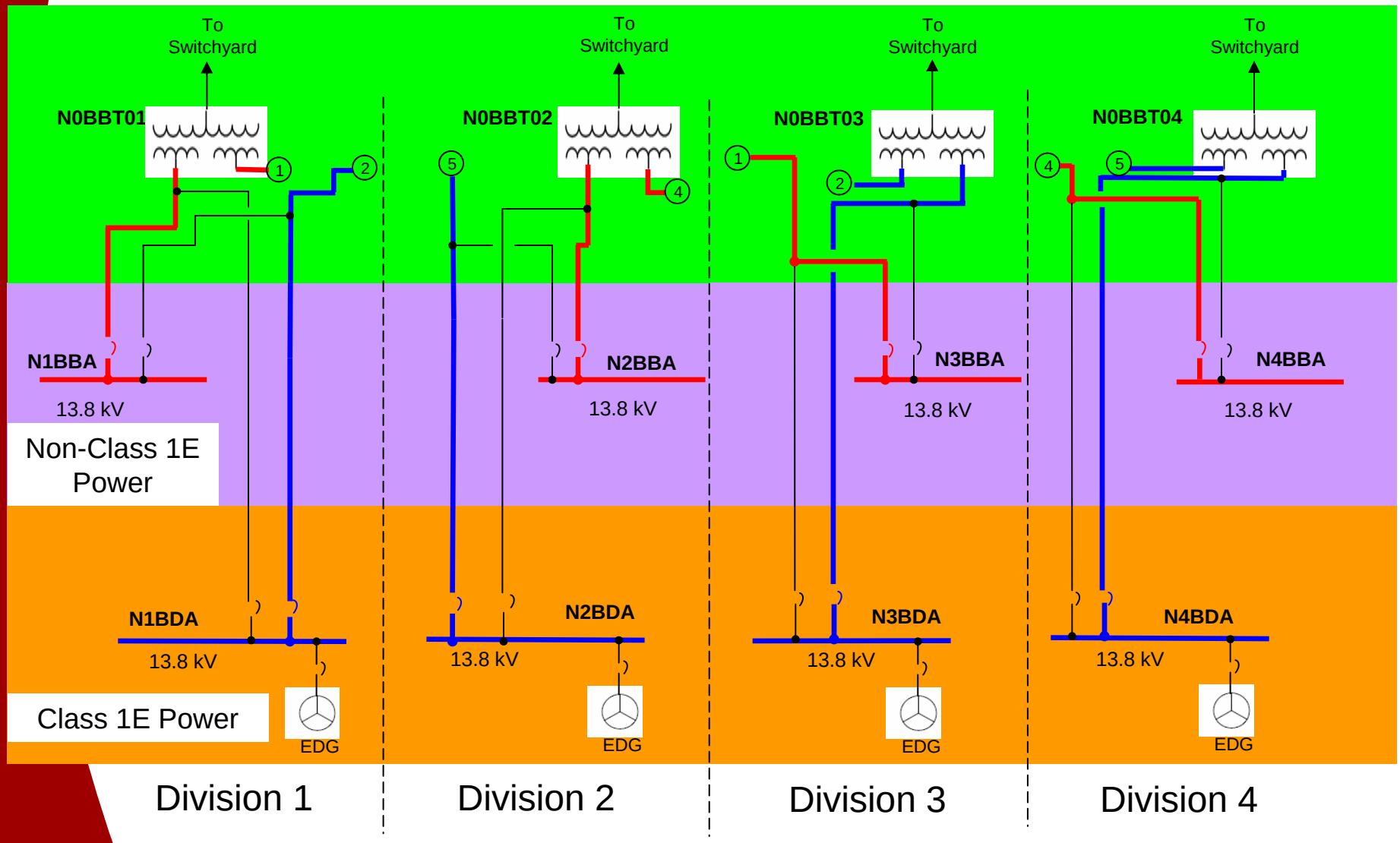
Offsite Power System

- **The offsite system is comprised of two physically independent circuits (in accordance with GDC-17) connecting the transmission network (grid) to the onsite distribution system**
- **Each redundant safety division is supplied directly from both offsite power sources with no intervening non-safety buses**
- **The U.S. EPR electrical design group is actively involved in the industry issues involved with grid reliability including NRC GL 2006-02 "*Grid Reliability and the Impact on Plant Risk and the Operability of Offsite Power* "**

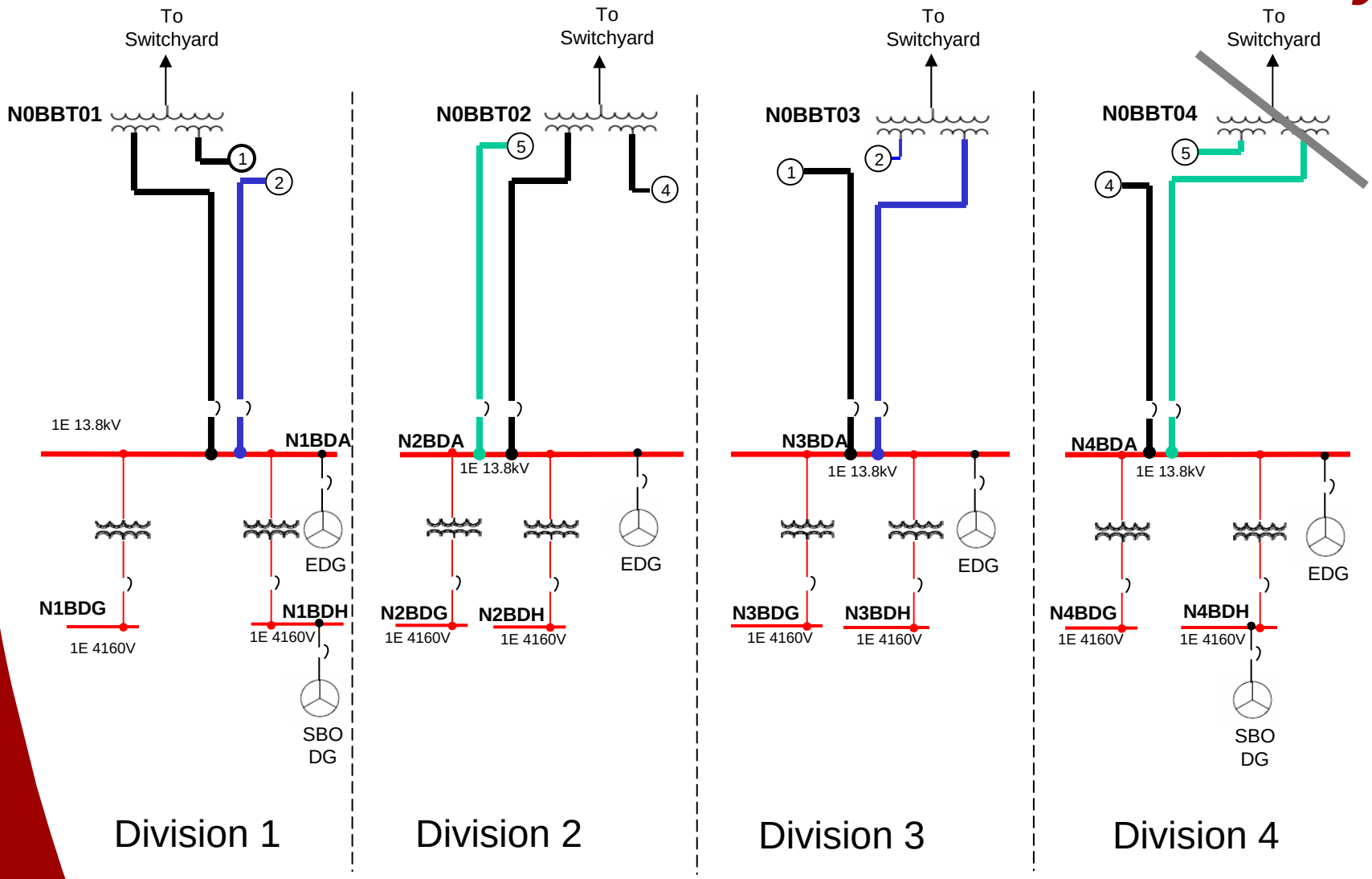
Typical U.S. Switchyard Configuration
Breaker and ½ Scheme



Offsite Power Interface SLD



Offsite Connection Reliability



Loss of Auxiliary Transformer (N0BBT04)

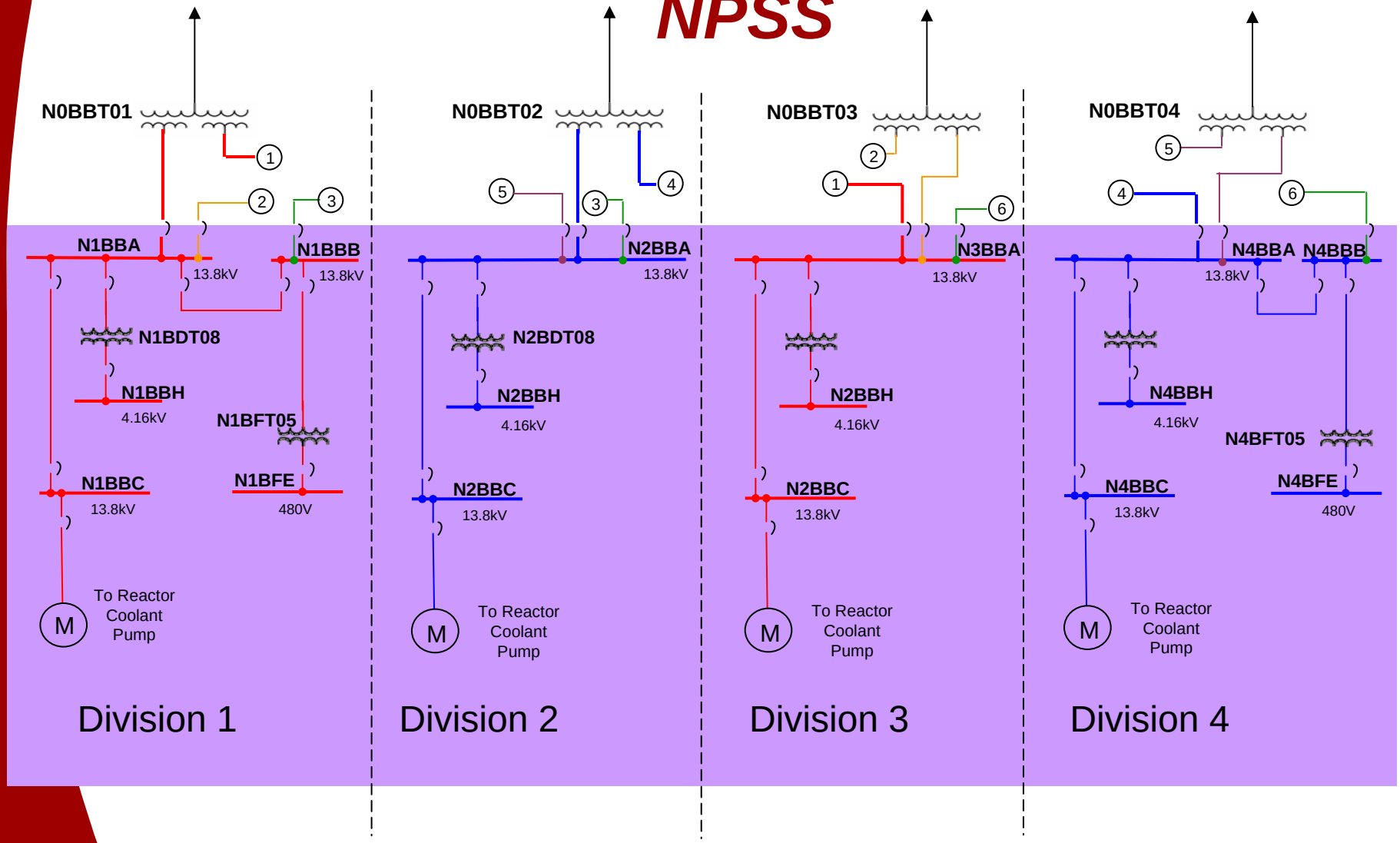
Onsite AC Power (Non-Class 1E)

Normal Power Supply System (NPSS)

- Four train bus concept with two maintenance buses capable of being supplied from two sources
- Turbine generator capable of a load rejection (grid) and still maintain house load operation (island mode)
- Largest electrical loads consists of reactor coolant pumps, feedwater pumps, condensate pumps
- Investment protection power supply for a backup power source to supply critical loads (turbine lube oil, UPS, etc) during a loss of offsite power
- No bus transfers required at plant startup or shutdown

Significantly improved reliability

Onsite AC Power (Non-Class 1E) SLD NPSS



Onsite AC Power (Class 1E)

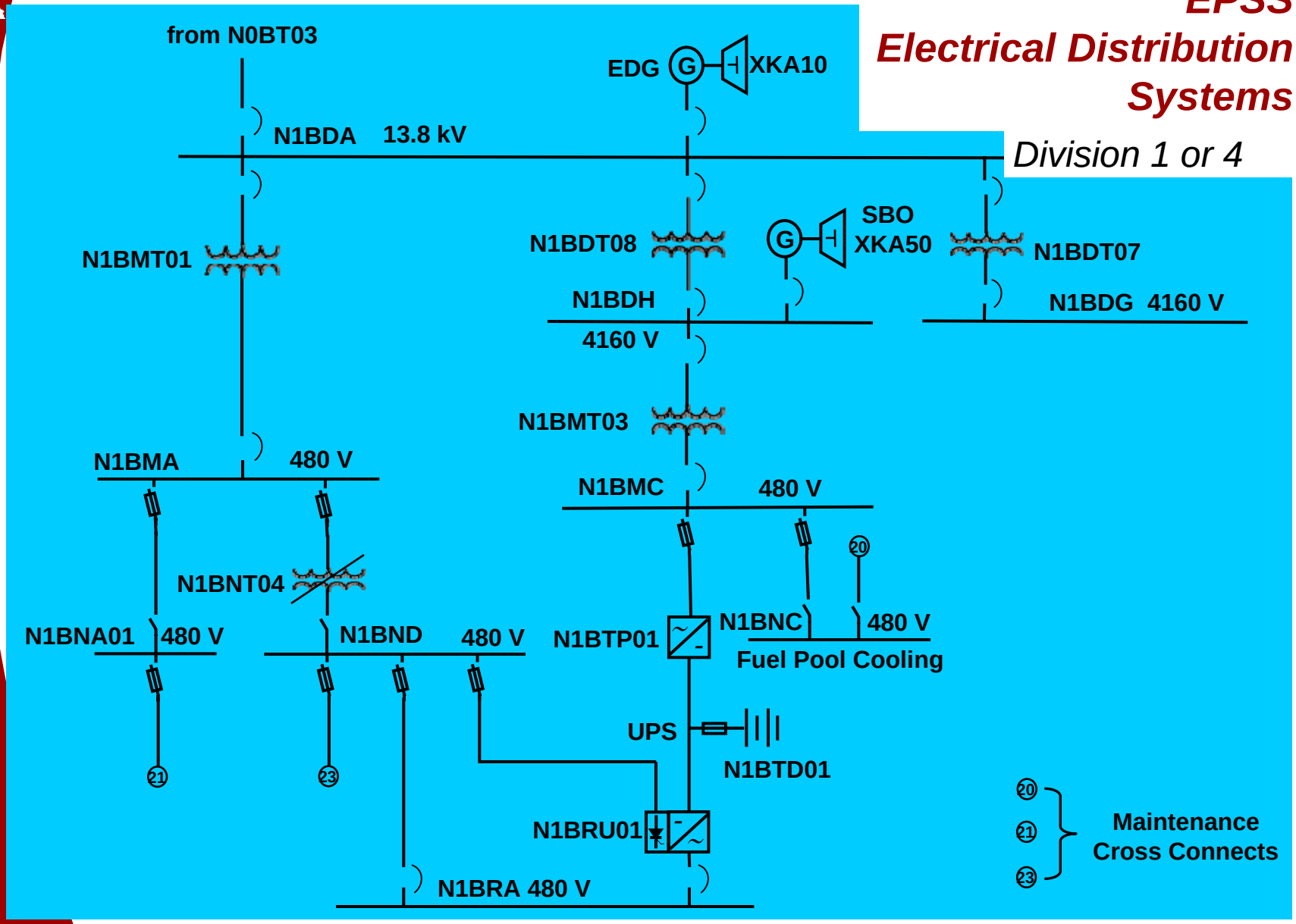
Emergency Power Supply System (EPSS)

- Four division concept with four redundant emergency diesel generators
- Four 480V fast regulating transformers for voltage sensitive loads, i.e. containment isolation valves
- Divisional electrical cross connects are used to enhance the flexibility and reliability of performing on-line maintenance and outage maintenance

Increased flexibility, reliability and design margin

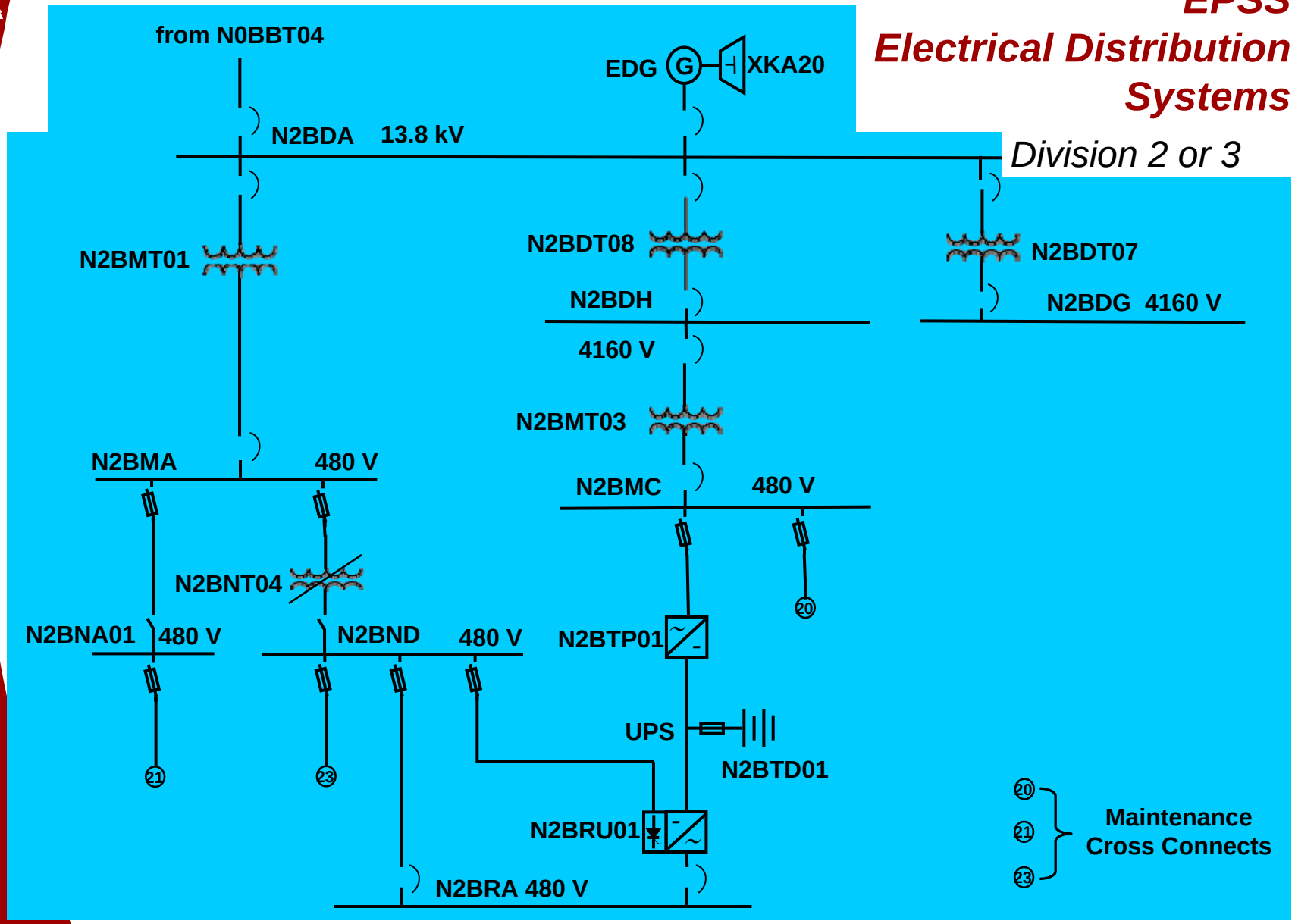
EPSS
Electrical Distribution Systems

Division 1 or 4

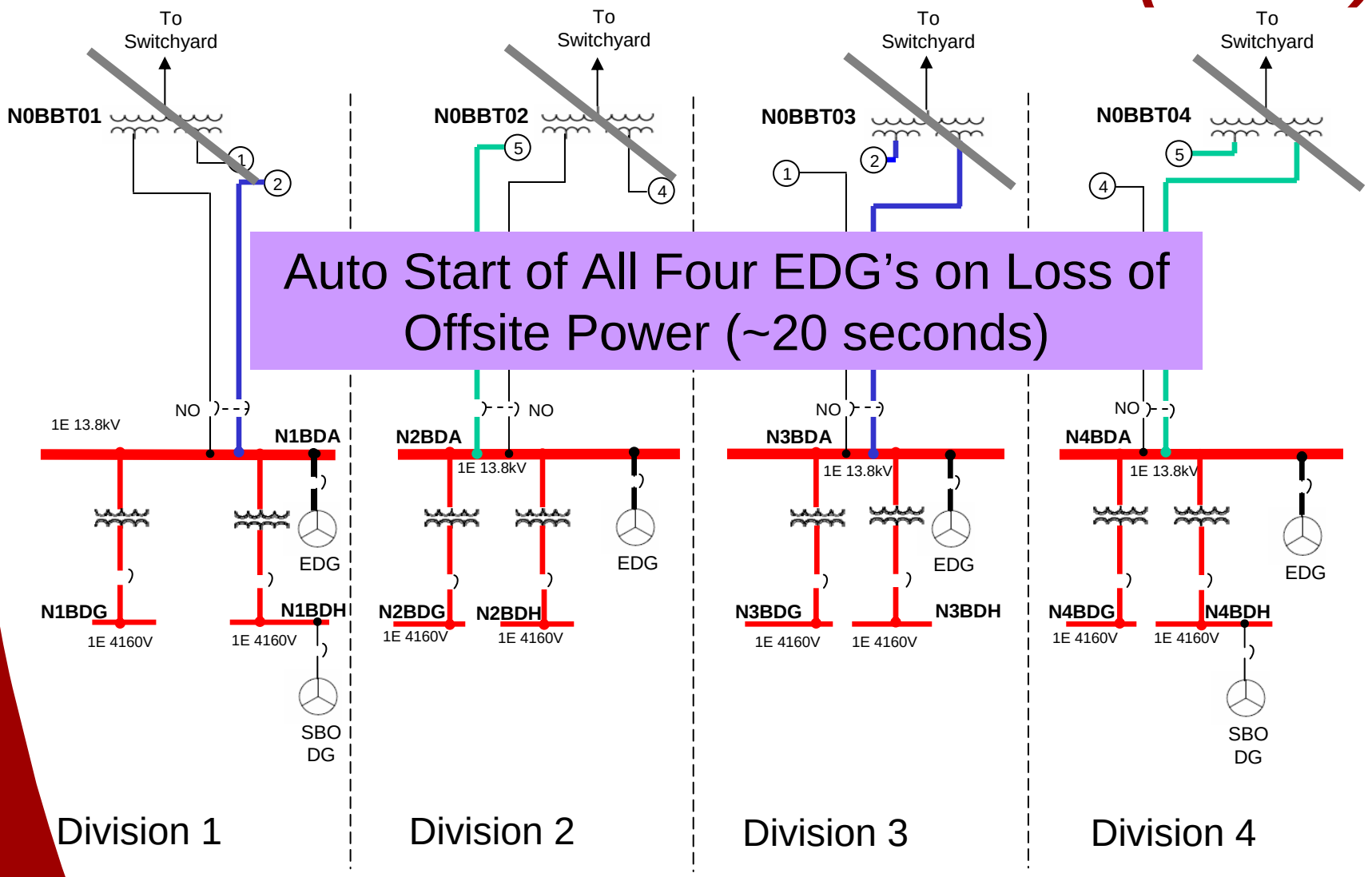


EPSS
Electrical Distribution Systems

Division 2 or 3



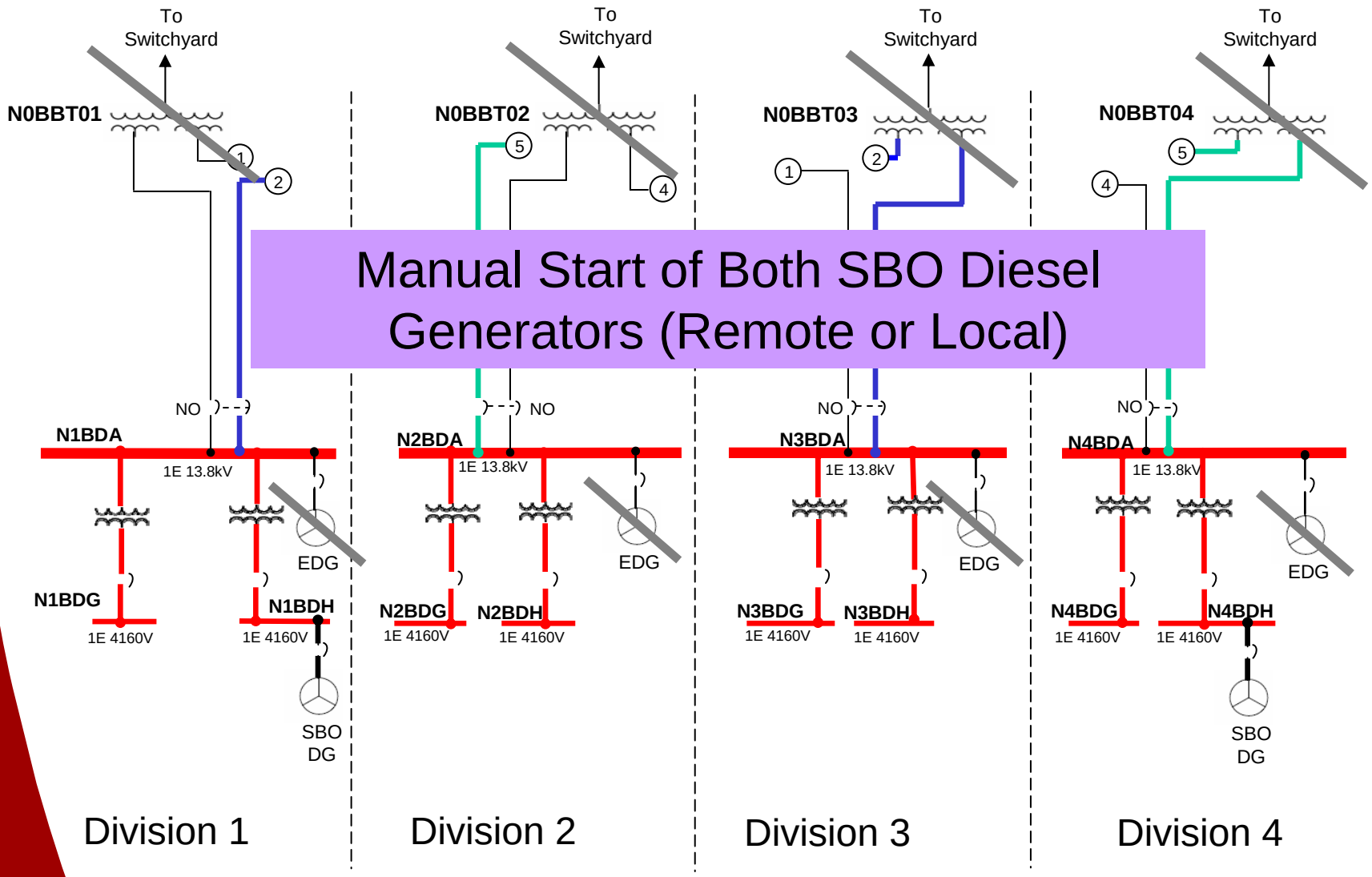
Loss of Offsite Power (LOOP)



Station Blackout (SBO)

- Two SBO Non-Class 1E diesel generators (division 1 & 4) which are credited as Alternate AC sources (AAS) for station blackout event
- SBO diesel generators can be started and controlled either from the control room or locally

Station Blackout

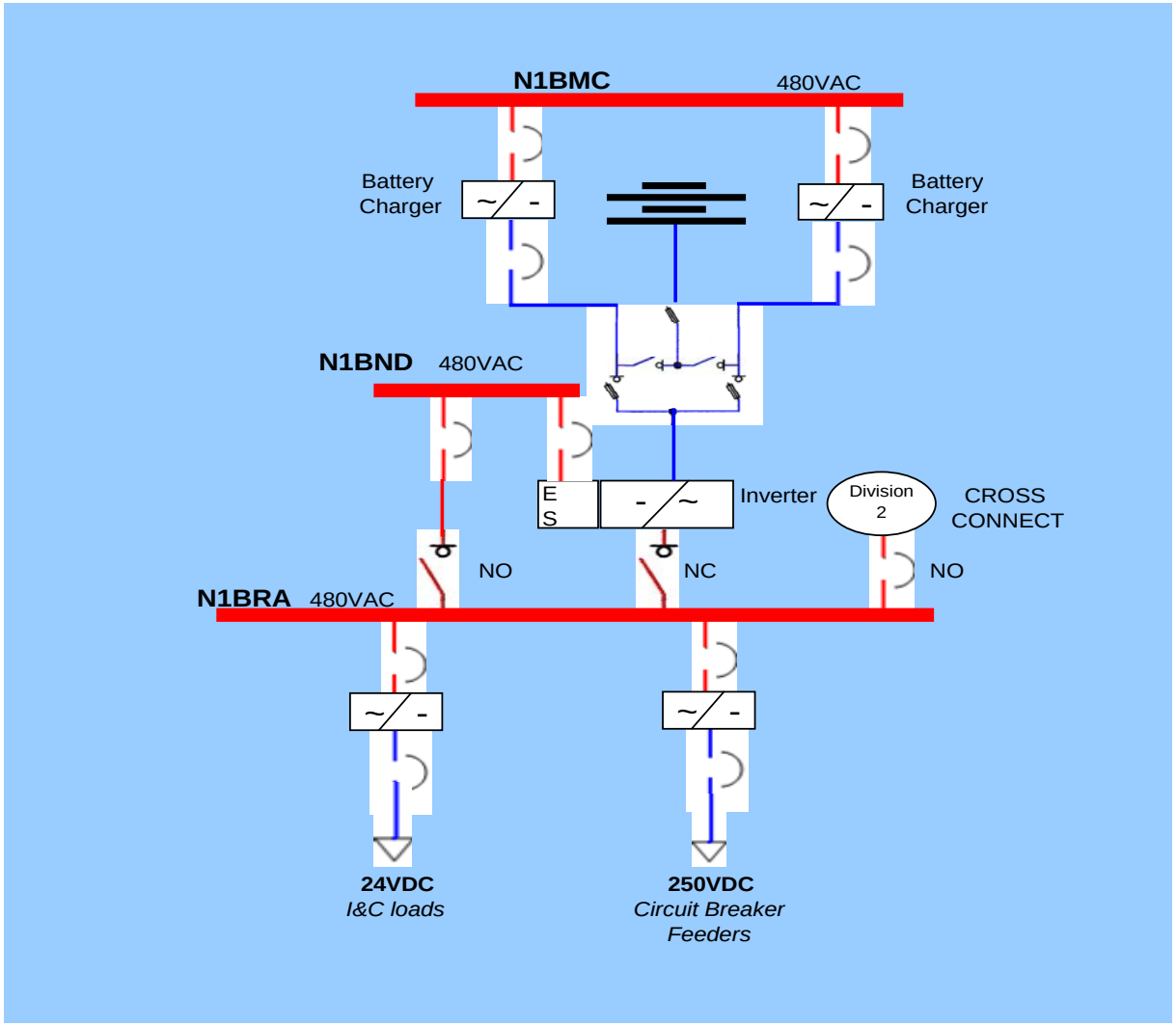


Manual Start of Both SBO Diesel Generators (Remote or Local)

Onsite DC Power (Class 1E UPS)

- **DC/UPS system is an evolutionary design feature:**
  - **Motor operated valve loads are AC loads fed from the bus on the output of the 480VAC inverter, which is supplied from the battery**
  - **DC loads (I&C, switchgear control power, etc) are supplied downstream of UPS inverters by multiple 480VAC/250VDC and 480VAC/24VDC converters**
- **Advantages vs conventional DC system:**
  - **Better reliability**
    - **A backup source of power is available to safety significant loads from the 480VAC fast regulating transformers in the event of a failure of the normal inverter, battery or charger**
    - **Safety significant loads are fed from a regulated power source vs. one in which voltage decays as the battery is discharged**
  - **Four fewer battery systems (24VDC)**
  - **24VDC converters located close to the loads minimizes large diameter DC cabling runs**

Onsite Class 1E DC/UPS SLD Division 1

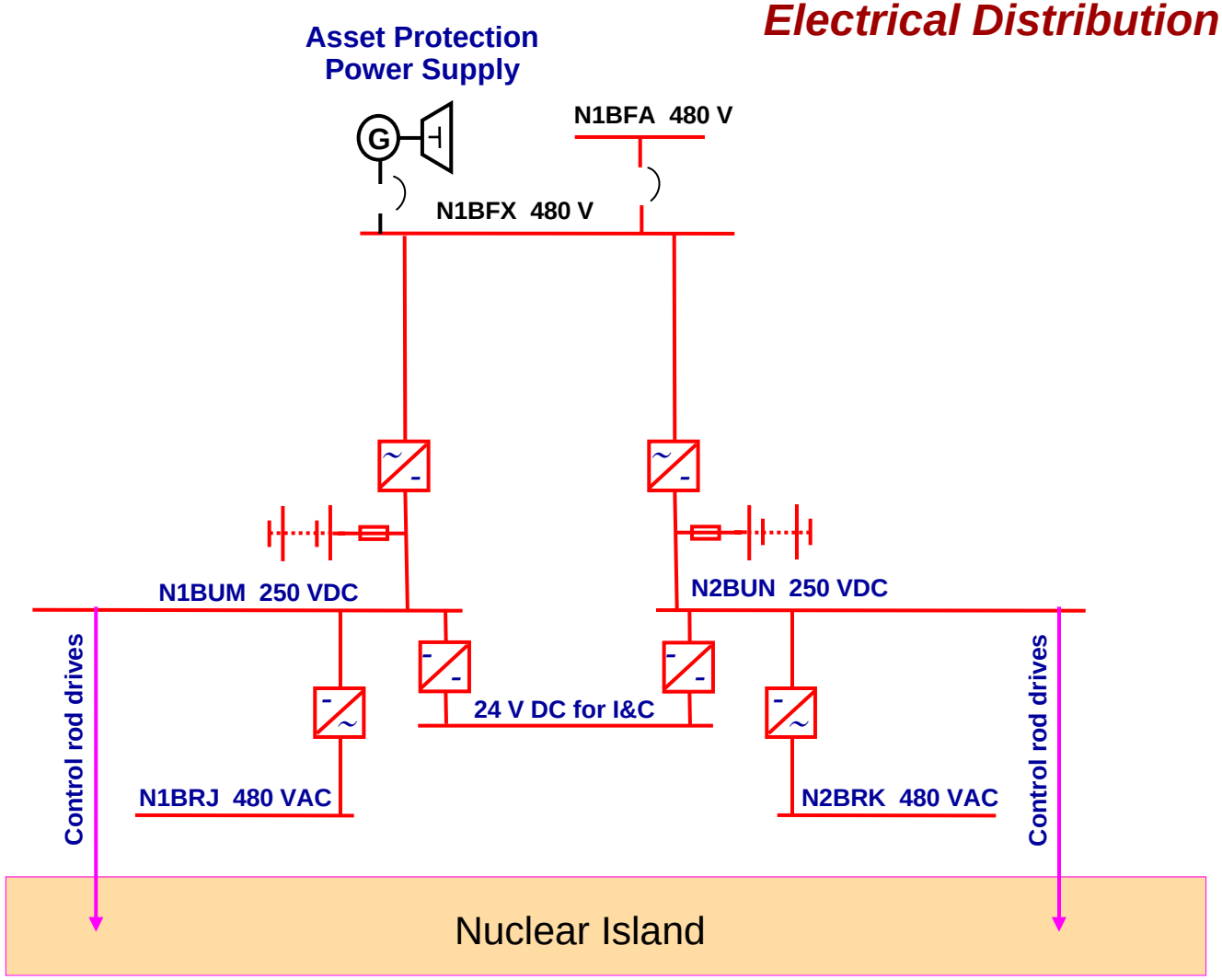


Non-Class 1E – UPS

- Two 250 VDC batteries, each supported by two 100% battery chargers
- 24 VDC I&C power is supplied from dual converters
- Power supply for the CRDM's
- Power supply for critical non-safety loads for asset protection (turbine generator lube oil pumps, etc)

Non-Class 1E Uninterruptible Power Supply

Electrical Distribution Systems



Electrical Systems Analysis

- **ETAP® studies will be developed to verify the adequacy of the conceptual design**
- **Load flow, short circuit and dynamic analyses of the electrical system will be developed to:**
  - Verify the adequacy of the diesel generator size and diesel generator loading
  - Develop equipment specifications for transformers, switchgear, circuit breakers and MCCs
  - Dynamic transfer analyses to validate transfers to back up sources of power on a loss of a normal source
  - Determine requirements needed to assure off-site power system voltage adequacy

Summary

- **The U.S. EPR electrical systems design uses insights gained from the design of OL3 and incorporates world-wide operating experience**
- **The U.S. EPR electrical systems are being designed to meet applicable NRC requirements**
- **AREVA NP Inc. will provide sufficient information in the DCD and supporting documentation to allow the NRC to make the necessary finding with regard to safety**

Robust, reliable electrical design

Fire Protection and Separation Requirements

Joe Redmond
Manager, Electrical & Fire Protection Design and Analysis

Meeting Objectives
Fire Protection and Separation

- Provide an overview of the U.S. EPR design features to meet NRC requirements for Fire Protection
- Describe the defense-in-depth design for Fire Protection
- Provide an overview of the inherent safe shutdown design features
- Obtain early NRC feedback associated with the U.S. EPR Fire Protection strategy

Topics

- Fire Protection Defense-in-Depth
- Applicable Regulatory Requirements for U.S. EPR
- Planned Approach for U.S. EPR
- Elements of the Fire Protection Program
- Fire Protection Design Approach
- Fire Protection Systems and Design Features
- Safety Train Separation
- Multiple Redundancy of Safety Systems
- Control Room Considerations
- Containment Considerations

Fire Protection Defense-in-Depth

- Minimize the potential for fires and explosions
- Rapidly detect, control, and extinguish fires
- Ensure that fire will not prevent the performance of necessary safe shutdown functions and will not significantly increase the risk of radioactive releases to the environment
- Failure or inadvertent operation of fire protection systems will not adversely impact the ability of SSC important to safety to perform their safety functions

U.S. EPR Fire Protection Criteria

- **NUREG-0800, Standard Review Plan 9.5.1**
  - **Appendix B addresses supplemental review criteria for Advanced Reactors**
  - **Appendix D addresses review criteria for fire PRAs**
- **SECY-90-016 and SECY-93-087**
- **10CFR52.47(a)(1)(v)**
- **Regulatory Guide 1.189**

Fire Protection Regulatory Environment

- NFPA 804
  - Applicable to new reactors
  - Deterministic
  - Appendix B of NUREG 0800 cites NFPA 804
  - Not endorsed by rulemaking
- NFPA 805
  - Applicable to existing reactors
  - Not applicable to new reactors
  - NRC approved new risk-informed performance-based option - 10CFR50.48(c)
- NFPA 806 is under development
  - Applicable to new reactors
  - Risk informed / performance based
  - Scheduled for approval in fall of 2007
  - NRC endorsement unknown

AREVA is monitoring latest fire protection regulatory developments

Planned Approach for U.S. EPR

- U.S. EPR will use existing deterministic guidance (NUREG-0800, SECY 90-016 and SECY 93-087) to demonstrate compliance with NRC requirements, including Regulatory Guide 1.189
- Any deviations from existing deterministic guidance for fire protection will be based on risk-informed, performance-based analysis methods following guidance provided in NFPA 806

Elements of the U.S. EPR Fire Protection Program (FPP)

- Comprehensive identification and analysis of fire and explosion hazards
- Organization and staff positions responsible for FPP management and implementation
- Fire prevention program
- Automatic detection and suppression systems
- Manual fire suppression capability
- Building design features minimize the threat of fires
- Safe shutdown analysis demonstrates that the plant can achieve and maintain safe shutdown in the event of a fire
- Probabilistic risk/safety analysis (PRA) specific to the U.S. EPR design that identifies relative fire risks and vulnerabilities

U.S. EPR Fire Protection Design Approach

- OL3 comprises the base plant design
- Systematic process is being applied to prepare design for U.S. deployment
  - Conversion to U.S. design codes and standards
  - Compliance with NRC regulations and QA requirements
- Insights gained through operating experience will be incorporated into the U.S. EPR fire protection design
- U.S. based employees assigned to support OL3 to develop and implement standardization in worldwide EPR fire protection design concepts

Standardization is a design goal

U.S. EPR Fire Protection Systems and Design Features: Fire Detection and Alarm

- **Fire detection systems will be installed in all areas of the plant that contain or present an exposure fire hazard to SSCs important to safety.**
  - **Fire Detection and Alarm Systems will comply with the applicable requirements established by NFPA 72 (National Fire Alarm Code)**

U.S. EPR Fire Protection Systems and Design Features: Water Supply Systems

- **Fire pumps, water supply and fire mains will be sized and arranged to ensure that:**
  - **100% capacity will be available assuming a single active failure of a fire pump or a water supply or line break with the fire main**
  - **U.S. EPR water supply systems will comply with applicable NFPA codes of record:**
    - **NFPA 20 (fire pumps)**
    - **NFPA 22 (water tanks)**
    - **NFPA 24 (fire mains)**

U.S. EPR Fire Protection Systems and Design Features: Automatic Fire Suppression

- **Automatic fire suppression systems will be installed as specified to:**
  - **Fire Hazards Analysis**
  - **Provide protection of redundant systems or components necessary for safe shutdown**
- **U.S. EPR automatic fire suppression systems will comply with applicable NFPA codes of record:**
  - **NFPA 13 (sprinkler systems)**
  - **NFPA 15 (water spray systems)**
  - **NFPA 2001 (clean agent systems)**

Due to spatial separation and four train shutdown design, the U.S. EPR is expected to require less automatic suppression than existing plants

U.S. EPR Fire Protection Systems and Design Features: Manual Fire Suppression

- **Manual firefighting capability will be provided throughout the plant to limit the extent of fire damage**
  - **Standpipes and hose stations will be able to reach any location that contains, or could present, a fire exposure hazard to equipment important to safety**
  - **Outside hydrants will provide effective hose stream protection for any onsite location where fixed or transient combustibles could jeopardize equipment important to safety**
- **U.S. EPR will comply with the applicable codes of record for manual fire suppression systems:**
  - **NFPA 10 (fire extinguishers)**
  - **NFPA 14 (Standpipes and hose systems)**
  - **NFPA 24 (fire hydrants)**

U.S. EPR Fire Protection Systems and Design Features: Building Design

- **Building layout**
  - SSCs important to safety will be designed and located to minimize the probability and effect of fires and explosions by utilizing passive fire barriers to subdivide the plant into separate fire areas or zones
  - Structural fire barrier designs will be based on NFPA 251/ASTME 119 fire endurance test protocol
  - Fire door designs will be in accordance with NFPA 80
- **Materials of construction**
  - Noncombustible and heat resistant materials will be used wherever practical throughout the plant
  - NFPA 221 will be used as guidance for specifying requirements for the design and construction of fire walls and fire barrier walls

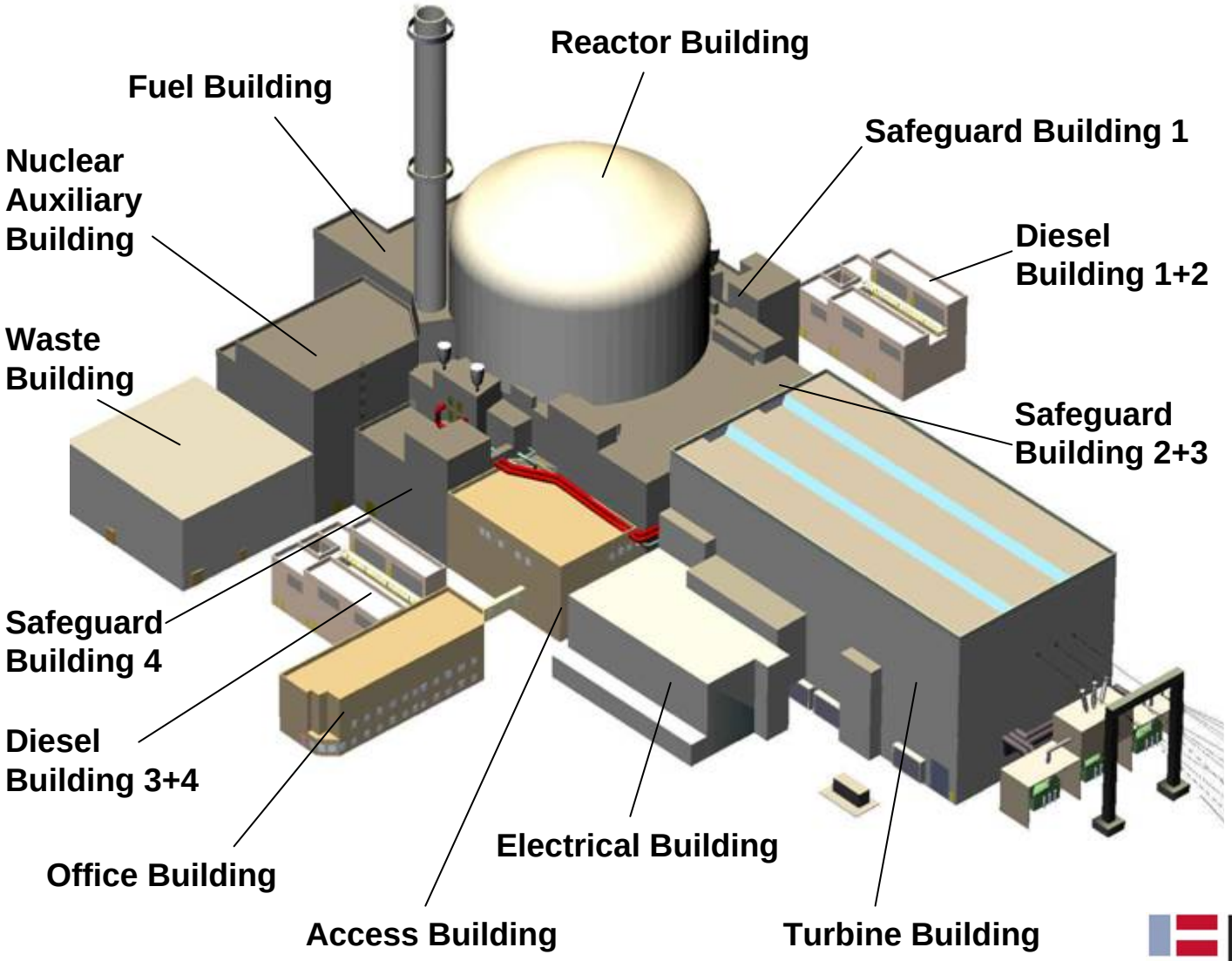
U.S. EPR Fire Protection Systems and Design Features: Other Building Systems

- **Electrical cable and raceway construction**
  - **Cables will meet the flame test criteria of IEEE 383 or 1202**
  - **Cables will be routed in metal raceways and will be separated so that a fire cannot damage redundant systems**
- **HVAC systems will be designed to:**
  - **Limit the consequences of a fire by preventing the spread of the products of combustion to opposite/adjacent division areas**
  - **Provide a means to ventilate, exhaust, or isolate fire areas as required and consideration will be given to the consequences of failure of ventilation systems caused by fire, causing loss of control for ventilating, exhausting, or isolating a given fire area**

U.S. EPR Fire Protection Systems and Design Features: Other Building Systems

- **Emergency lighting will be provided as necessary to support:**
  - **manual fire-fighting**
  - **safe shutdown operations**
  - **emergency egress during a fire event**
- **The communication system design will ensure effective communication capability between plant personnel to support fire-fighting efforts and safe shutdown of the plant**

EPR General Plant Layout



Redundancy of Safety Systems

Four train safety concept

- **1 train is in maintenance**
- **1 train may be affected by a fire**
- **Remaining train(s) required for safe shutdown will be available**

U.S. EPR redundant safety systems exceed regulatory requirements

Safety Systems
Four Separate Buildings

Each safety train is independent and located within a physically separate building

Control Room Considerations

- **Separation of redundant trains in the control room is not practical**
  - **For a fire in the control room, an independent alternative safe shutdown capability is provided that is physically separated and electrically independent of the control room**
- **Remote shutdown station**
  - **Meets RG 1.189 requirements for Alternate Shutdown**

Containment Considerations

- Containment fire area contains redundant train cables
  - Train separation will be demonstrated by a combination of spatial separation and physical barriers
  - Fire protection for redundant divisions will be provided to ensure that at least one shutdown division will be free of fire damage
  - Fire protection design features will be provided for fire hazards in containment
  - Automatic fire detection throughout containment and automatic suppression for the reactor coolant pumps will be provided
- U.S. EPR will meet the requirements of RG 1.189

Summary

- U.S. EPR fire protection approach will be based on standard NRC guidance and requirements
  - Any deviations will be based on risk-informed, performance-based analysis methods (per NFPA 806)
- U.S. EPR is a robust design with increased safety margin with respect to fire safe shutdown capability
- U.S. EPR fire protection design will use insights gained from the design of OL3
- The U.S. EPR fire protection design will incorporate insights gained from operating experience
- AREVA NP Inc. will provide sufficient information in the DCD and supporting documentation to allow the NRC to make the necessary finding with regard to safety

Next Steps

Sandra M. Sloan
Manager, Regulatory Affairs
New Plants Deployment

Next Steps

> **Next meetings**

- **July 25, 2006:** **U.S. EPR Severe Accident Mitigation Testing, Design and Analysis**
- **August, 2006:** **Pre-submittal meeting for U.S. EPR Transient and Accident Analysis Code Applicability Topical Report**

  I&C Safety System & Operational Architecture

Handouts

U.S. EPR Electrical Systems

- AC Power Systems (Onsite)
  - Class 1E Emergency Power Supply System (EPSS)
  - Emergency Diesel Generator Set (EDG)
  - Class 1E UPS System (EUPS)
  - Non-Class 1E Normal Power Supply System (NPSS)
  - Non-Class 1E Diesel Generator Set (NDG)
  - Non-Class 1E UPS System (NUPS)
  - SBO Diesel Generator Set (SBDG)
  - Power Transmission (GEN)
  - Lighting and Small Power System (LGT))
- DC Power Systems (Onsite)
  - Control Rod Drive Power supply System (CRD)
  - Non-Class 1E DC Power System (NDC)
- Offsite Power System
  - Switchyard and Preferred Power System (SWYD)
- Generic Electrical Systems
  - Cables and Cabling Concept Description (CABL)
  - Lightning and Grounding System (GRD)
  - Protection and Coordination Concept (PC)

KKS Electrical Designators

BB	13.8kV and 4160V Non-Class 1E Equipment
BD	13.8kV and 4160V Class 1E Equipment
BF	480V Non-Class 1E Load Centers
BH	480V Non-Class 1E Motor Control Centers
BM	480V Class 1E Load Centers
BN	480V Class 1E Motor Control Centers
BR	UPS Related Equipment
BU	DC Non-Class 1E Equipment
BV, BW	DC Class 1E Equipment
BT	Batteries and Battery Chargers

Electrical Acronyms

AAS:	Alternate AC Sources
CRDM:	Control Rod Drive Mechanism
DCD:	Design Control Document
EDG:	Emergency Diesel Generator
EPSS:	Emergency Power Supply System
ETAP:	Electrical Transients Analysis Program
EUPS:	Emergency Uninterruptible Power Supply
MCC:	Motor Control Center
MSU:	Main Start Up
NI:	Nuclear Island
NPSS:	Normal Power Supply System
PCB:	Power Circuit Breaker
PPS:	Preferred Power Supply
SBO:	Station Blackout
SLD:	Single Line Diagram
SWYD:	Switchyard
TG:	Turbine Generator
TI:	Turbine Island
UPS:	Uninterruptible Power Supply

Fire Protection Acronyms

FHA: Fire Hazard Analysis

FPP: Fire Protection Program

PRA: Probabilistic Risk/Safety Analysis

SSC: Structures, Systems and Components