KNS 2023 Spring Conference
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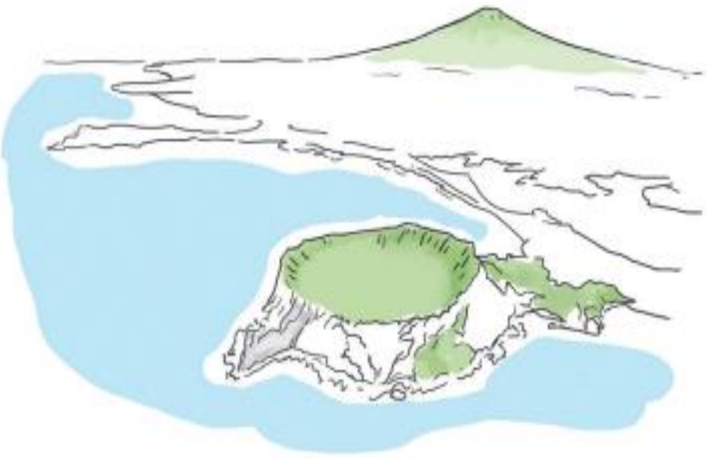

Auxiliary Power System and Protection Scheme for SMR Generating Stations

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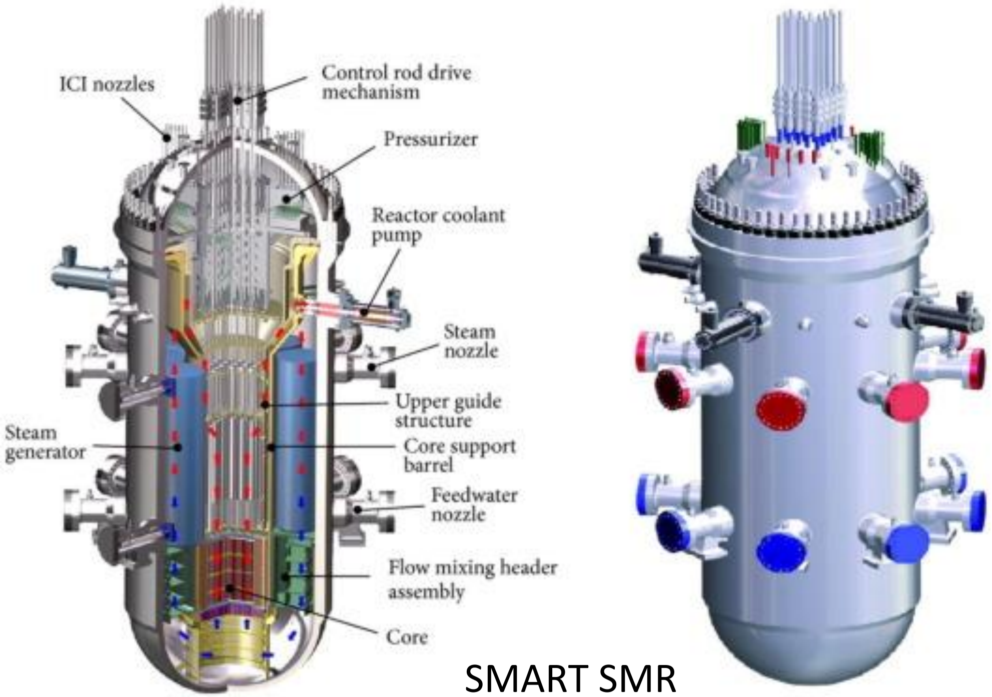
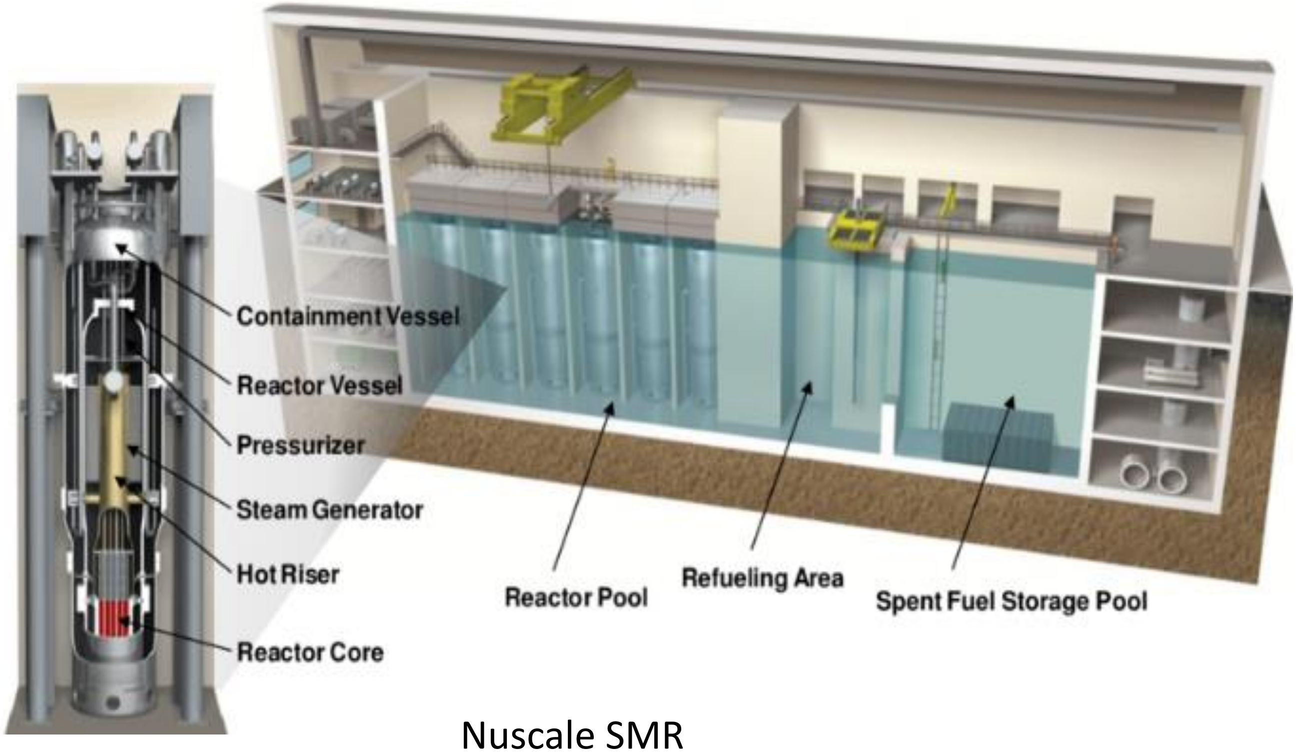
1. Introduction

- Importance of electric systems for safety in nuclear power plants
- Advantages of Small Modular Reactors (SMRs)
- Purpose of this paper: propose a novel electrical configuration and protection scheme for SMR generating stations



SMART SMR



Nuscale SMR

2.1 Requirements Review and Analysis

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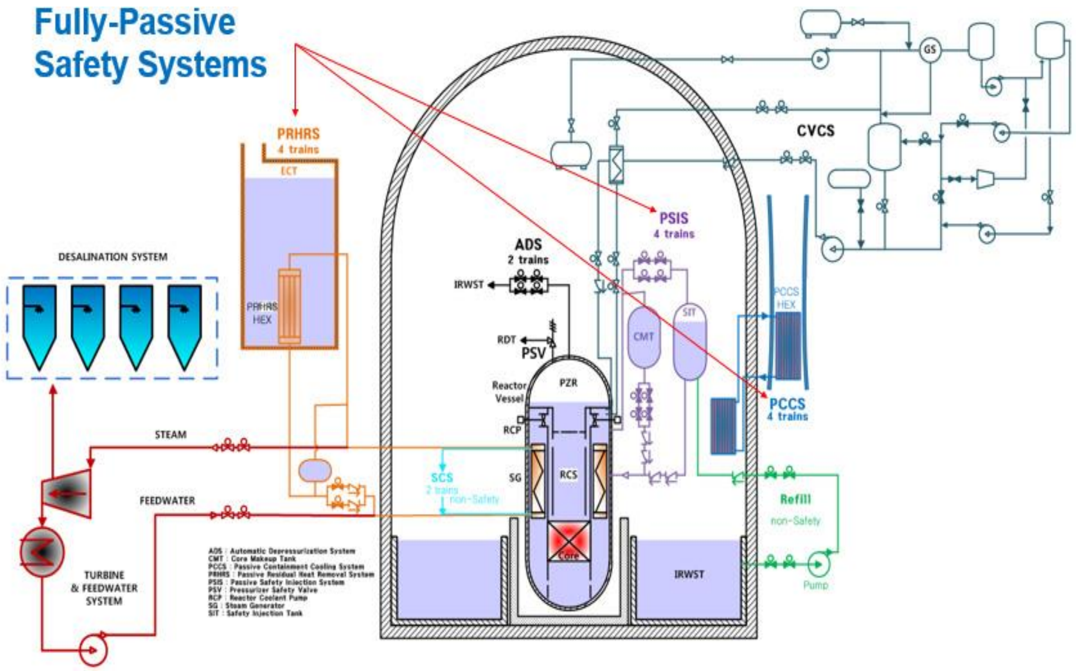
1) **Special Feature of SMRs**
   - Flexibility
   - Scalability
   - Enhanced Safety
   - Reduced environmental impact
   - Compatibility with renewables

2) **Conformity of regulatory requirements**:
   - GDC 2, 4, 5, 17, 18 and 33,
   - IEEE Std. 308-2001



SMART Passive Cooling System

1) Design Philosophies of Electric Power System

- **Redundancy**: multiple backup power supplies
- **Diversity**: variety of different backup power supplies
- **Reliability**: ability to provide consistent and continuous supply of electrical power
- **Robustness**: withstand severe weather event, earthquake, other disasters
- **Safety Systems**: emergency power system

2.2 Functional Analysis and Physical Allocation

2) Major Electrical Components and Systems

- Main Transformer
- Unit Auxiliary Transformers
- Medium Voltage Switchgears
- Low Voltage Switchgears and MCCs
- Emergency Power Systems
- 125V DC Distribution system
- Instrument and Control Power System

Power Transformer

Medium Voltage Switchgear

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1) Defense in Depth (DID) and Implementation of AI and IoT Technologies

- Layers of protection:
- prevention,
- detection,
- mitigation,
- containment,
- and emergency response

Level of defence in depth	Objective	Essential means
Level 1	Prevention of abnormal operation and failures	Conservative design and high quality in construction and operation
Level 2	Control of abnormal operation and detection of failures	Control, limiting and protection systems and other surveillance features
Level 3	Control of accidents within the design basis	Engineered safety features and accident procedures
Level 4	Control of severe plant conditions, including prevention of accident progression and mitigation of the consequences of severe accidents	Complementary measures and accident management
Level 5	Mitigation of radiological consequences of significant releases of radioactive materials	Off-site emergency response

Digital Protective Relays

2) Voltage Level Selection

- 13.8 kV or 4.16 kV (North American),
- 11 kV or 6.6 kV (Europe, Middle East, Africa),
- 400V or 480V (low voltage)

❖ ANSI C84.1

Voltage Class	Nominal System Voltage
Low Voltage	480V
Medium Voltage	4,160V 6,900V 13,800V

\- North American Design -

❖ IEC 60038

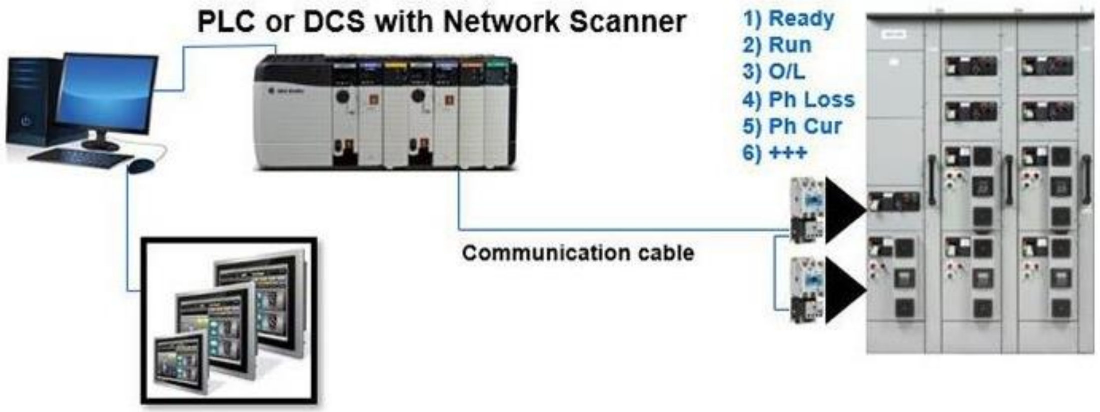
Highest voltage for equipment(kV)	Nominal system voltage (kV)
3.6	3.3 / 3
7.2	6.6 / 6
12	11 / 10

\- European Design -

3) Ratings and Specifications of Major Equipment

- main transformer,
- unit auxiliary transformers,
- medium voltage switchgears,
- low voltage switchgears and MCCs,
- emergency generator
- DC and IP system

Emergency Diesel Generator



Intelligent Motor Control Center

4) **Electrical Protection System** : Benefits of IEC 61850:

- **Standardization**: Explain how the international standard promotes interoperability, leading to increased efficiency and reduced costs
- **Flexibility and Scalability**: Highlight the ability to customize the communication system according to specific needs and accommodate future applications
- **High Performance and Cybersecurity**: Emphasize the real-time monitoring, control, and protection capabilities, along with the security features against cyber-attacks
- **Fault Tolerance and Diagnosis**: Mention the use of redundant communication paths and devices for high availability and detailed diagnostic information for proactive maintenance

3. Conclusion

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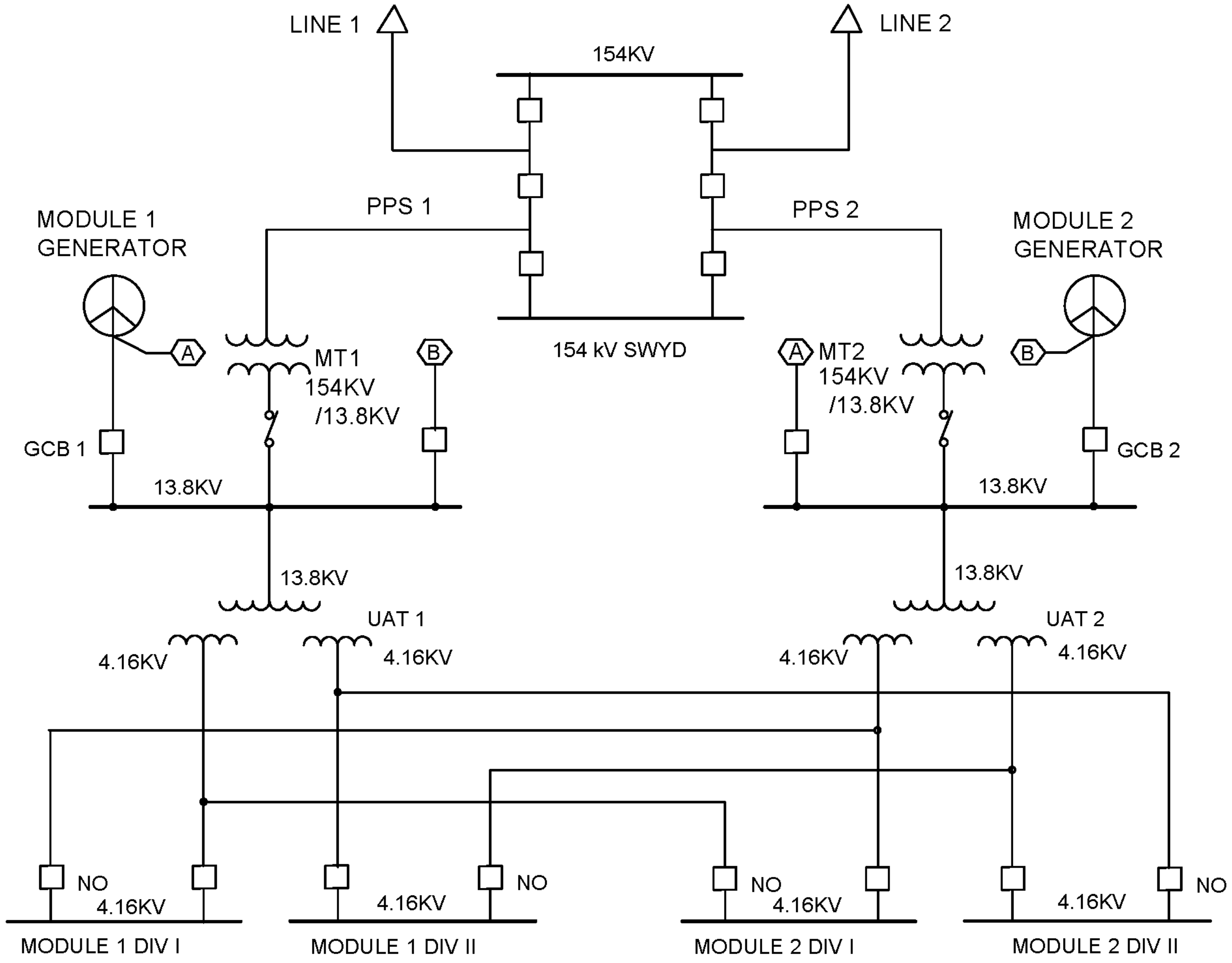
- **Growing concerns on SMRs:**
  - Increasing number of countries incorporating SMRs in their energy mix
  - Influenced by climate change and carbon net zero policies
- **Licensing Challenges:**
  - Lack of separate codes and regulations for SMRs
  - Existing regulations for large nuclear power plants applied as a substitute
- **Urgent Need for Tailored Regulations:**
  - Establishing licensing regulations specific to SMRs is crucial
  - Criteria and guidelines must align with the unique characteristics of SMRs
- **Proposed Solution:**
  - This paper suggests design criteria and guidelines for SMR auxiliary power systems
  - Aim to develop more precise, safe, and efficient regulations in the future

THANK YOU!

Q & A



Simplified Single Line Diagram for SMRs (2 units)