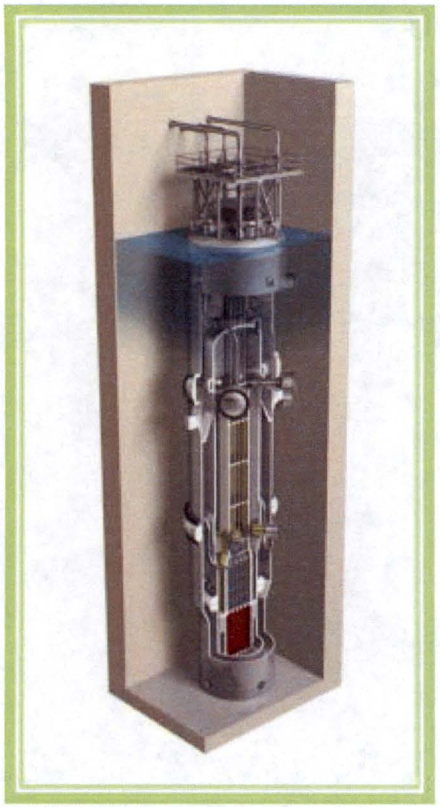
Enclosure 1:

"NuScale Passive Nuclear Power Plant Electrical Systems," PM-0616-49644-NP, Revision 0, nonproprietary version

NuScale Passive Nuclear Power Plant Electrical Systems



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NuScale Power
Template #: 0000-21727-F01 R0

Acknowledgement and Disclaimer

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Agenda/Sequence

- How did NuScale arrive at the highly-reliable, all DC-powered design?
- What led to the Electrical Topical as presented?
- Why NuScale doesn't need AC or DC power?
- What does this mean re: General Design Criterion (GDC) 17?
- Why should NuScale do "island mode"?
- How would island mode work?

Electrical Design Development

- NuScale position and conclusion
  - snippet from the topical
  - "NuScale has performed an assessment to identify what is termed herein as "conditions of applicability," which justify an applicant's determination that the appropriate classification of plant electrical systems is non-Class 1E per the regulatory definitions of "safety-related" and "Class 1E."
  - an assessment of what NuScale has to have to be safe has been conducted, and while electricity can be used, it is *not required to achieve the safety functions*

Overall Electrical System

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Electrical Design Development

- How did NuScale start down the "non-1E" path?
  - original design (2010-2012) had a 1E electrical system, the EDS system
  - compliance with the existing paradigm/regulatory structure
    - IEEE-603, Criteria for Safety Systems, invoked per 10 CFR 50.55 (a)(h)(2)
    - IEEE-308, 1E Power Systems, endorsed by RG 1.32
    - IEEE-946, Design of DC power systems, referred to by 308
    - RG 1.81 and GDC 5 concerning sharing of emergency and S/D systems

Electrical Design Development

- So what does that look like with 12 reactors?
  - direct current (DC) power cannot be shared per RG 1.81

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  - vented lead acid (VLA) is only 1E qualified battery
  - 60 cells per battery

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  - O&M issue
  - seismic category I (SC-I) building issue (footprint)

Electrical Design Development

- First recognition that the electrical plant really could break this design
  - O&M alone would be cost prohibitive even if the capital investment was overlooked
  - AP1000 had approximately 1020 cells for 1000MW
  - NuScale would have nearly four times that for half the MWe
  - What options does NuScale have?
    - Can something different be done?
    - What if, just like mechanical, NuScale could do something passive in the electrical world?
    - Can NuScale solve this by simplifying the design?

Electrical Design Development

- Genesis of 1st concept that NuScale presented in December 2012
  - What is a truly passive electrical design?
  - that's called zero electrical energy to accomplish safety functions

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Electrical Design Development

- **Per IEEE-308 (Endorsed by RG 1.32)**
- **3.7 Class 1E:**
  - The safety classification of the electric equipment and systems that are essential to emergency reactor shutdown, containment isolation, reactor core cooling, and containment and reactor heat removal or that are otherwise essential in preventing significant release of radioactive material to the environment.
  - Users of this standard are advised that Class 1E is a functional term. Equipment and systems are to be classified Class 1E only if they fulfill the functions listed in the definition. Identification of systems or equipment as Class 1E based on anything other than their function is an improper use of the term and should be avoided.

Electrical Design Development

- March 2014 NRC presentation
  - design was a little more flushed out

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Electrical Topical Report

- July 2015 Preapp in Rockville
  - presented assessment that safety could be assured with a highly-reliable DC power system that did not need 1E power to fulfill safety functions
  - provided safety analysis examples to support the concept of zero power to achieve safety functions
  - presented the bones of what would become the Electrical Topical
  - submitted 10-29-15
- Originally planned to be a design topical
  - changed to a "Conditions of Applicability" approach

Electrical Topical Report

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Electrical Topical Report

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Electrical Topical Report

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- If you can say this, and apply the augmented provisions specified in the topical report, then the appropriate classification for these electrical systems is non-Class 1E.

Paradigm Shift

- What do we really need power for?
  - NuScale has demonstrated that it doesn't need electricity for RX trip and ESFAS functions

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- How does GDC 17 factor in?

Paradigm Shift

- Need for electrical power
  - establishing that NuScale does not need power to achieve safety functions reflects all the way back upstream to the transmission grid
  - *NuScale doesn't need power to achieve and maintain safety functions for a minimum of 72 hours from off-site or on-site AC or DC sources*
  - the transmission grid becomes merely the load
  - the terms *"preferred power supply" and "loss of off-site power"* (LOOP) take on a different meaning than that contemplated in the existing regulatory structure
  - GDC 17 off-site connections are not needed

GDC 17

What does that mean for GDC 17?

An on-site electric power system and an off-site electric power system shall be provided to permit functioning of structures, systems, and components important to safety. The safety function for each system (assuming the other system is not functioning) shall be to provide sufficient capacity and capability to assure that: (1) specified acceptable fuel design limits and design conditions of the reactor coolant pressure boundary are not exceeded as a result of anticipated operational occurrences; and, (2) the core is cooled and containment integrity and other vital functions are maintained in the event of postulated accidents…

Electric power from the transmission network to the on-site electric distribution system shall be supplied by two physically independent circuits … Each of these circuits shall be designed to be available in sufficient time following a loss of all on-site alternating current power supplies and the other off-site electric power circuit, to assure that specified acceptable fuel design limits and design conditions of the reactor coolant pressure boundary are not exceeded.

GDC 17

- Background and intent
  - derived from proposed GDC 39:

    "Alternate power systems shall be provided and designed with adequate independency, redundancy, capacity, and testability to permit the functioning required of the engineered safety features. As a minimum, the on-site power system and the off-site power system shall each, independently, provide this capacity assuming a failure of a single active component in each power system."

  - changes in final GDC 17 reflect intended purpose of off-site power
    - revised "to make it clear that the off-site power system need not meet the "single failure criterion." Reference to off-site power has not been deleted because we believe that off-site power is required to provide adequate assurance of safety…"
    - "The requirements in the previously proposed criteria for (engineered safety features) have been incorporated in the revised criteria for the individual systems which are used for this purpose."

GDC 17

- Background and intent
  - AP1000 FSER: "The underlying purpose of the requirement of GDC 17 to provide two off-site power sources to the plant is to ensure sufficient power to accomplish safety functions."

An on-site electric power system and an off-site electric power system shall be provided		Two independent electric systems can power safety functions in order to meet acceptance criteria
Electric power from the transmission network to the on-site electric distribution system shall be supplied by two physically independent circuits		Each electric system is sufficiently reliable to perform those safety functions

Design Comparison

Traditional LLWRs

- AC power necessary for ESFs and other ITS functions
- DC power is complementary on-site system
- Loss of off-site AC means all safety systems depend on EDGs
- Turbine trip may fault grid
- Minimal SBO coping capability

AP1000

- AC power not safety-related (passive ESFs)
- DC power required to monitor and actuate safety-related passive systems
- AC power necessary
  - to power RCPs for 3 seconds following DBEs
  - for RHR during reduced RCS inventory conditions
- Turbine trip may fault grid
- Enhanced SBO coping capability

NuScale

- Neither AC nor DC necessary to perform safety functions
- Reliable nonsafety power systems for defense-in-depth
  - multiple independent on-site power sources
  - highly reliable DC systems
- AC power not required for refueling safety
- Individual turbine trip unlikely to fault grid
- Extensive SBO and ELAP coping capability

GDC 17 Summary

- Fully passive design ensures performance of safety functions without power
- Reliable on-site power system performs important functions and provides defense-in-depth
  - multiple sources of on-site power
- Therefore, off-site power provisions not necessary to achieve underlying purpose of GDC 17

Island Mode (IM)

- A loss of all AC power in the NuScale plant will result in all necessary safety-related functions happening automatically.
- Further, the safety-related functions will be maintained without further reliance on electrical power (whether AC or DC) or operator action for a duration that in most instances far exceeds 72 hours.
- The DCD will specifically state that operation in IM does not adversely impact any safety function and that IM is not required nor prohibited by any regulatory requirements.
- So why would NuScale incorporate an island mode functionality?
- The plant response to a loss of off-site 'load' event, especially when the on-site systems are functioning normally and no protective functions are warranted becomes an important consideration.

Island Mode

- Regulatory considerations
  - grid issues don't warrant challenging safety systems
    - same concept as Maintenance Rule
  - exploit NuScale's capability to achieve greater defense-in-depth
- Commercial considerations
  - support for micro-grid installations or remote installations where grid stability is less than desirable or nonexistent
  - national security aspects of providing a highly reliable base load source that can be independent of the grid
  - prevent unnecessary restart evolution by preventing a RX trip
  - be readily available to support the grid upon resolution of grid issue
- What might this look like?

Island Mode

- The enabling features of the NuScale plant for this function:

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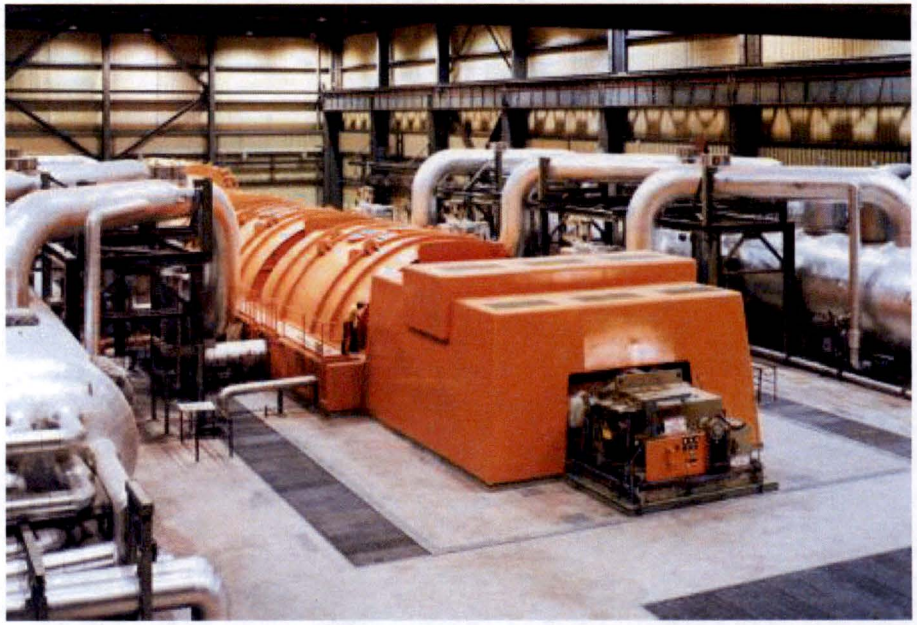

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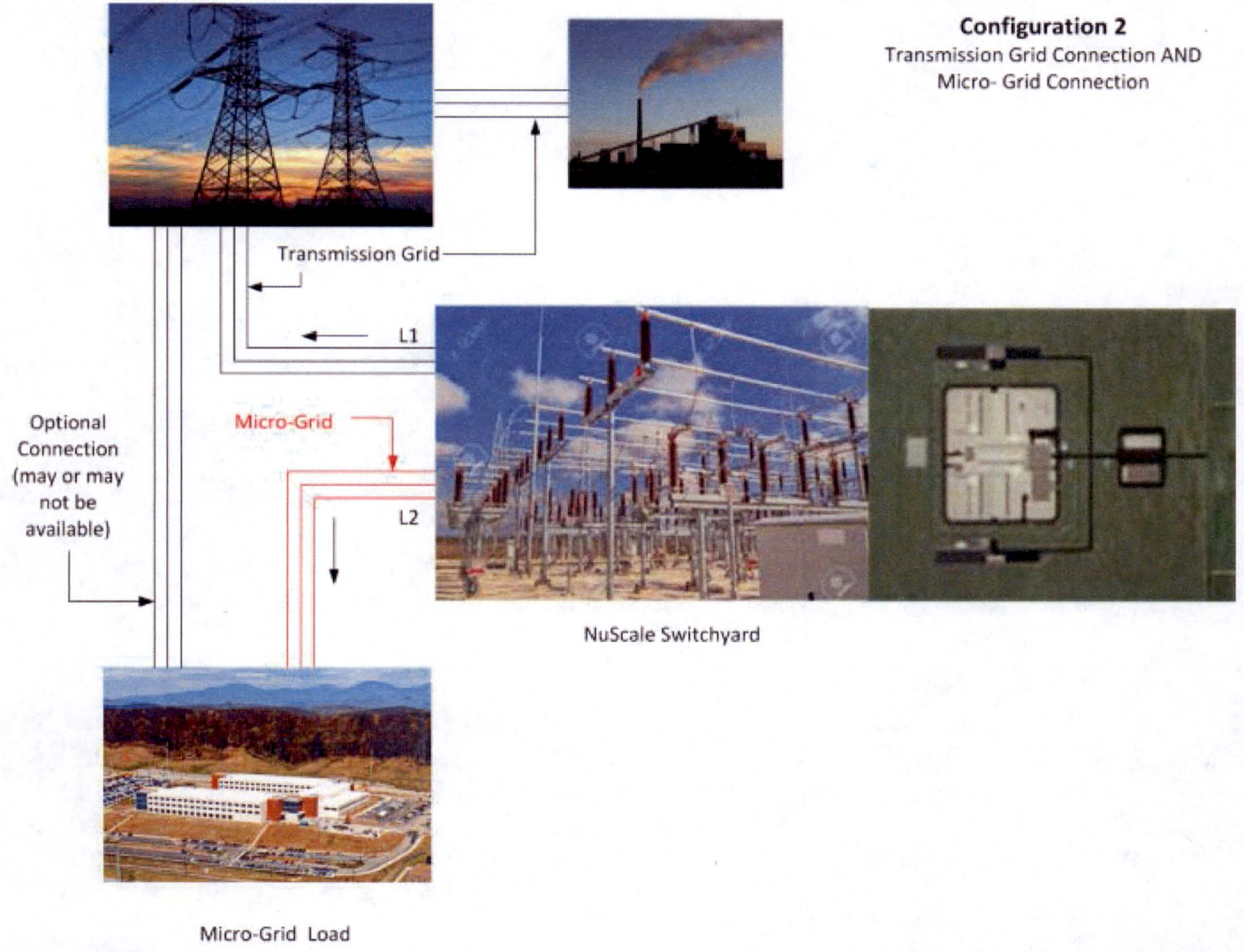
Island Mode



Island Mode

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Island Mode Sequence of Events

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Island Mode Sequence of Events

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