NuScale Introduction

Generating Resources Advisory Committee

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NuScale Nonproprietary
NuScale Power History

- NuScale first of current US SMRs to begin design of commercial NPP
- NuScale technology in development and design since 2000 (DOE) MASLWR program with INL
- Electrically-heated 1/3-scale integral test facility first operational in 2003, leverages experience from AP600/1000 ¼-scale testing facility (built and operational)
- Began NRC design certification (DC) pre-application project in April 2008
- Acquired by Fluor in October 2011
- DOE $217 million cost-share contract executed May 2014
- ~600 full time equivalent staff currently on project, ~$250MM invested project life-to-date
- 181 patents pending/granted in 19 countries
Design Overview
Size Comparison

Comparison size envelope of new nuclear plants currently under construction in the United States

126 NuScale Power Modules

NuScale’s combined containment vessel and reactor system

Typical Pressurized Water Reactor

*Source: NRC
Reactor Module Overview

Natural convection for cooling

- passively safe, driven by gravity, natural circulation of water over the fuel
- no safety-related pumps, no need for emergency generators

Simple and small

- reactor is $1/20^{th}$ the size of large reactors
- integrated reactor design, no large-break loss-of-coolant accidents

Click HERE for video
Plant Design Overview

NuScale Power Module includes Containment and Reactor Vessel

Shipped by Truck, Rail, or Barge

Skid-Mounted Steam Turbine/Generator

Below-Ground Control Room provides enhanced security and state-of-the-art controls

Each Module is refueled underwater while the remainder of the plant produces power
- Refueled once every 24 months
- Capable of 48-month fuel cycle
- 10 Day Refueling Target

Each Module Installed in its own Isolated Bay
- Natural Circulation (No Reactor Coolant Pumps)
- 37 Standard 17x17 PWR Fuel (Half-Height) Fuel Assemblies
- Standard Magnetic Jack Control Rod Drives
- Internal Helical Coil Steam Generators and Pressurizer
- 50 MWe Gross Power
# Basic Plant Parameters

## Overall Plant
- **Net electrical output**: Up to 570 MWe (nominal)
- **Plant thermal efficiency**: > 30%
- **Number of power generation units**: Up to 12
- **Nominal plant capacity factor**: > 95%
- **Plant protected area**: ~44 acres

## Power Generation Unit
- **Number of reactors**: One
- **Gross electrical output**: 50 MWe
- **Steam generator number**: Two independent tube bundles (50% capacity each)
- **Steam generator type**: Vertical helical coil tube (secondary coolant boils inside tube)
- **Steam cycle**: Superheated
- **Turbine throttle conditions**: 3.3 MPa (475 psia)
- **Steam flow**: 67.5 kg/s (536,200 lb/hr)
- **Feedwater temperature**: 149°C (300°F)

## Reactor Core
- **Thermal power rating**: 160 MWth (gross)
- **Operating pressure**: 12.7 MPa (1850 psia)
- **Fuel design**: UO₂ (< 4.95% U²³⁵ enrichment); 37 half-height 17x17 geometry lattice fuel assemblies; Zircaloy-4 or advanced cladding material; negative reactivity coefficients
- **Refueling interval**: 24 months
Safety
Design Simplicity Enhances Safety

All safety equipment needed to protect the core is shown in this picture

- Natural convection for cooling
  - passively safe, driven by gravity, natural circulation of water over the fuel
  - no pumps, no need for emergency generators
- Seismically robust
  - system submerged in a below-ground pool of water in an earthquake resistant building
  - reactor pool attenuates ground motion and dissipates energy
- Simple and small
  - reactor core is 1/20th the size of large reactor cores
  - integrated reactor design, no large-break loss-of-coolant accidents
- Defense-in-depth
  - multiple additional barriers to protect against the release of radiation to the environment
- Resistant to extended loss of AC power
  - indefinite reactor core cooling without pumps, power, operator action, or external water supply (unlimited coping period)

Steel containment has *10 times pressure rating* of typical PWR

Water volume to thermal power ratio is *four times larger* than typical PWR

Reactor core has only *five percent of the fuel* of a large reactor

160 MWt NuScale Power module
NuScale Major Breakthrough in Safety

- NuScale design has achieved the “Triple Crown” for nuclear plant safety.
- The plant can safely shut down and self-cool indefinitely (unlimited coping period), with:
  - No operator action
  - No AC or DC power
  - No additional water
- Safety valves align in their safest configuration on loss of all plant power.
- Details of the alternate system fail-safe concept were presented to the NRC in December 2012.
Extended Loss of AC Power*

Stable long-term cooling under all conditions
Reactor and nuclear fuel cooled indefinitely without pumps or power

No Pumps • No External Power • No External Water

* Based on conservative calculations assuming all 12 modules in simultaneous upset conditions and reduced pool water inventory
Reducing Plant Risk

**Risk** = (frequency of failure) X (consequences)

Probability of core damage due to NuScale reactor equipment failures is **1 in 100,000,000 years**
Right-Sized Emergency Planning Zone

**NuScale Plant**

- **Passive Safety**
- **Additional Fission Product Barriers**
- **Significant Delay in Release of Fission Products**

**10 mi EPZ**

**Site Boundary EPZ** (depending on site characteristics)
Economics
Cost Competitiveness

- NuScale's power module enables utility companies to "right-size" their power plants for current needs, then add capacity as necessary.
- Design simplification enhances safety, reduces maintenance, and improves plant availability.
- Off-site fabrication and assembly reduces cost, and components are delivered to the site in "ready-to-install" form.
  - As a result, construction occurs in a shorter, more predictable period of time.
- The workforce required to construct NuScale power plants are measured in the hundreds, not the thousands.
- Our short 3-year construction schedule provides greater assurance that the plant will achieve operation before unforeseen external events impact the schedule.
- Projected first plant levelized cost of energy (LCOE) $95/MWhr, and improving.
Simple Design Eliminates Plant SCRAMs*

*SCRAM – an unplanned shutdown of a nuclear reactor

58% of events caused by power conversion systems

86% of power conversion related SCRAMs prevented by NuScale design

27% of events caused by electrical distribution system

82% of electrical related SCRAMs prevented by NuScale design
**NuScale LCOE in North America**

**Levelized Cost of Electricity (LCOE) for Baseload Generation**

2019 costs in 2012 $/MWh

- **First of a Kind (FOAK)**: 95
- **Nth of a Kind (NOAK)**: 81
- **Advanced Nuclear (2 x 1100 MW)**: 96
- **Conventional Coal**: 81
- **Gas Combined Cycle GT**: 64
- **Geothermal**: 48
- **Biomass**: 103

**Sources**
2. NuScale LCOE Model for NuScale (12-pack), FOAK and NOAK

**Notes**
(1) Sources 1 and 2 assume WACC of 6.5%; 30 year cost recovery period
(2) Source 1 assumes Henry Hub spot natural gas prices of approx. $4.70/mmbtu
(3) CO2 tax of $46/ton based on 2019 Annual SCC value from Reference 3, Table A1, 3% Discount Column

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Repetitive Construction of Standardized Plants

Learning Curve – South Korea

Learning Curve Opportunity – Korean Example

Construction Duration (Months)
- 1995: YGN 3, 4
- 1998: UCN 3, 4
- 2002: YGN 5, 6
- 2004: UCN 5, 6
- ~2010: SKN 1, 2
- ~2011: SWN 1, 2

Construction Cost (% of First of a Kind)
- 1995: 100%
- 1998: 94%
- 2002: 82%
- 2004: 80%
- ~2010: 63%
- ~2011: 63%

Goal: 39%
Program WIN
Program WIN

- Program WIN (Western Initiative for Nuclear) is a multi-western state collaboration to deploy a series of NuScale Power projects

- Involved Program WIN participants: NuScale, UAMPS, Energy Northwest

- 5 Other projects: WIN-WA, WIN-UT, WIN-AZ, WIN-NM, WIN-WY
First Deployment: UAMPS CFPP

- Utah Associated Municipal Power Systems (UAMPS) Carbon Free Power Project (CFPP) will be first Program WIN project
- UAMPS consists of 46 members serving load in 8 western states
Challenges Ahead
To Ensure a Successful Project

- Need a committed owner/buyer
- Suitable land, sufficient water, transmission access
- Must demonstrate sufficient need for or use of electricity
- State, tribal, public, and political support
  - Favorable local and state permitting and approval processes
- Suitable plant economics/investment profile
- Timely regulatory review
  - US NRC Design Certification review estimated at 39 months
- Sufficient capable facility workforce
- Active and competitive supply chain engagement
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