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Explore Together
Adding Small Modular Reactors to Your Portfolio

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Session Objectives

- At the end of this session, attendees will be able to accurately:
  
  1. Discuss the role small modular reactor technology can play in a utility's generation portfolio.
  
  2. Explain the benefits small modular reactors can provide in terms of resilience, reliability and flexibility to meet changing load demands.
  
  3. Understand the role that a third-party operator can serve when licensing and operating a power plant powered with small modular reactors.
Presentation Outline

- Introduction
- Technology Overview
- Diverse Energy Platform
- Current Status
- Economics
- Use of a Third-Party Operator
- Closing & Q&A
Who is NuScale Power?

- Initial concept started with Department of Energy MASLWR program at Oregon State University.
- **NuScale Power** was formed in 2007 for the sole purpose of completing the design of and commercializing a small modular reactor – the NuScale Power Module™ (NPM).
- Fluor, global engineering and construction company, became lead investor in 2011.
- In 2013, NuScale won $226M in matching funds in a competitive U.S. DOE funding opportunity.
  - NuScale was selected for subsequent DOE awards of $16.5M and $40M in 2015 and 2018.
- >350 patents granted or pending in nearly 20 countries.
- ~350 full-time employees in 6 offices in the U.S. and 1 office in London.
- NuScale has made substantial progress with a rigorous design review by the U.S. Nuclear Regulatory Commission (NRC).
Core Technology: NuScale Power Module

- A NuScale Power Module™ (NPM) includes the reactor vessel, steam generators, pressurizer, and containment in an integral package – simple design that eliminates reactor coolant pumps, large bore piping and other systems and components found in large conventional reactors.
- Each 50 MWe module:
  - is small enough to be factory built for easy transport and installation
  - has a dedicated power conversion system for flexible, Independent operation
  - can be incrementally added to match load growth – up to 12 modules for 600 MWe gross (~570 net) total output
A NuScale Power Module is 1/20th the physical size of new nuclear plants currently under construction in the United States.*

*Source: NRC
Coolant Flow Driven By Physics

**Convection** – energy from the nuclear reaction heats the primary reactor coolant causing it to rise by convection and natural buoyancy through the riser, much like a chimney effect.

**Conduction** – heat is transferred through the walls of the tubes in the steam generator, heating the water (secondary coolant) inside them to turn it to steam. Primary water cools.

**Gravity** – colder (denser) primary coolant “falls” to bottom of reactor pressure vessel, cycle continues.
Reactor building houses NuScale power modules, spent fuel pool, and reactor pool.
Advantages of Small Modular Approach

- Factory Fabrication
- Transportable
- Small Footprint
- Flexible Operation
Beyond Baseload: NuScale Diverse Energy Platform

- **MISSION CRITICAL FACILITIES**: Reliable Power for Mission Critical Facilities (NuScale)
- **OIL REFINERIES**: Oil Refineries Study - Reduction of Carbon Emissions (Fluor and NuScale)
- **HYDROGEN PRODUCTION**: Hydrogen Production Study - High Temperature Steam Electrolysis (INL and NuScale)
- **DESLINATION**: Desalination Study - Sized for the Carlsbad Site (Aquatech and NuScale)
- **WIND**: Integration with wind study - Horse Butte Site (UAMPS, ENW and NuScale)
- **NUSCALE PLANT**
Load-Following with Wind

Power (MWe)

Typical Electrical Demand

Horse Butte Output

NuScale Output (target)
Connection to a micro-grid, island mode capability, and the ability for 100% turbine bypass allows a NuScale plant to assure **100 MWe net power at 99.95% reliability over a 60 year lifetime**.

Using highly robust power modules and a multi-module plant design can provide **clean, abundant, and highly reliable power** to customers.

Working with utilities and customers to get “Five 9s”.
A New Level of Plant Resiliency

- **Loss of Offsite Power** – A single module can power the entire plant. A NuScale plant does not require operator or computer actions, or AC/DC power or additional water to keep the reactors safe. Grid connection is not required for safety.

- **First Responder Power** – On loss of offsite grid, all 12 modules can remain at full power or be ramped down while rejecting 100% steam to its condensers.
  - Able to provide power to the grid in 50 MWe increments as soon as the grid is restored.

- **Resilience to Natural Events** – The reactor modules and fuel pools are located below grade in a Seismic Category 1 Building.
  - Capable of withstanding a Fukushima type seismic event
  - Capable of withstanding hurricanes, tornados, and floods

- **Resilience to Air-Craft Impact** – The reactor building is able to withstand aircraft impact as specified by the NRC air-craft impact rule.

- **Cybersecurity** – The NuScale Module and Plant protection systems are non-microprocessor systems (i.e., field programmable gate arrays) that do not use software and are therefore not vulnerable to internet cyber-attacks.
Blazing the Trail to Commercialization

COMMERCIAL OPERATION
OF FIRST NUSCALE PLANT
(2026)

About 1 Billion

First NPM Delivery (2025)

Construction (2022)

COL Received (2022)

Design Certification (2020)

COLA Submittal (2019)

Award First NuFAB Contract (2018)

DCA Completed (2016), Docketed (2017)

Site Selection (2016)

U.S. DOE SMR Grant Awardee (2012)

IP Portfolio > 390 patents

Granted or pending

Engineering + Testing

Topicals

Secured First Customer (2013)

Simulator (2012)

Formation of Advisory Board (2011)

Fluor Acquisition (2011)

Begin NRC Pre-Application (2008)

Formation of NuScale Power, LLC. (2007)

1/3 Scale Integrated Test Facility (2003)

DOE MSLWR Program (2000)

$700 Million

Raising Additional Capital

Securing Additional Customers

Building Supply Chain
• The Design Certification (DC) is prepared by the vendor and is valid for 15 years. Once a design is certified (by rulemaking), its safety cannot be challenged.
• The Construction and Operating License (COL) is prepared by the developer (utility) and is required for construction and operations of each nuclear plant. Once approved, it’s valid for 40 years.
• The Design Certification is incorporated by reference on the COL.
• An Early Site Permit may be obtained in advance of a licensing proceeding and “banked”, or included in the COL application.
First SMR to Undergo Design Certification in the U.S.

- Design Certification Application (DCA) completed at end of 2016
- Docketed and review commenced by U.S. Nuclear Regulatory Commission (NRC) in March 2017
- RAI (requests for additional information) process is in full implementation
- NRC has published its review schedule, to be completed January 2021

DCA stats
- 12,000+ pages
- 14 Topical Reports
- >2 million labor hours
- >800 people
- >50 supplier/partners
- Over $500M
NuScale Baseline DC Review

Today

Completed DCA
12/31/16

P1 – PSER and RAlS
4/16/18
(COMPLETE)

P2 – SER w/Ols
5/16/19

P3 - ACRS review of
SER w/Ols
8/27/19

P4 - Adv SER w/no Ols
12/12/19

P5 - ACRS review
Adv SER w/no Ols
6/23/20

P6 – FSER
9/08/20

NRC Accepted
3/15/17

Rulemaking
Jan 2021

Design Certified
Jan 2021

Total projected duration for NRC review and approval - 46 months
TVA Demonstrates Site Boundary EPZ Possible for SMRs

- TVA analysis adds information on Clinch River early site permit application using NuScale Plant design
- Shows any accident radiological impact would be limited to within site boundary
- Analysis provides basis for exemption from 10-mile EPZ in regulatory breakthrough
The NuScale design has achieved the “triple crown” for nuclear plant safety. I.e., the plant can safely shut down and self-cool indefinitely with
- no operator action
- no AC or DC power
- no external water supply

- In December 2017, NRC approved NuScale’s “Safety Classification of Passive Nuclear Power Plant Electrical Systems” Licensing Topical Report
- Established the bases of how a design can be safe without reliance on any safety-related “class 1E” electrical power.

Why is this important?

“This is a big deal. It means the reactor just won’t melt down or otherwise cause any of the nightmares people think about when imagining the worse for nuclear power. It just shuts down and cools off.”
– Jim Conca, Forbes
Manufacturing & Supply Chain

- Teaming with world class manufacturers
- 100 attendees from 83 companies attended the NuFAB supplier’s day event in November 2016
- Currently undergoing selection of fabrication partner
NuScale has engaged with multiple utilities and other end users to potentially deploy NuScale SMR technology domestically and internationally.

To support engagement with the domestic utility market, NuScale created the NuScale Advisory Board (“NuAB”) in 2008, which initially had 8 members.

• The NuAB now has 29 members and meets at least two times a year to seek member input on design and deployment decisions to ensure we are meeting their operational needs.
**Why Nuclear?**

- Replacement for retiring baseload resources
- Physical hedge against reliance on uncertain future market purchases
- Zero carbon emitting
  - Regulatory benefits
  - Customer sustainability and rate stabilization benefits
- Flexible baseload resource that can interplay with a western market with increasing levels of renewable penetration
CFPP Team

- UAMPS
- NuScale Power/Fluor
- Energy Northwest
- Department of Energy
- Nuclear Regulatory Commission
- U.S. Congress
  - Bi-Partisan Support
- State of Idaho
- Tennessee Valley Authority
Operations

- UAMPS does not have operational nuclear experience
- Energy Northwest has a first option to be the operating agent for the CFPP
  - Energy Northwest currently operates the Columbia Nuclear Generating Station in Washington
  - Energy Northwest has partnered with NuScale to assess operational issues utilizing a NuScale simulator in Richland, Washington
Costs

- Levelized Cost of Energy (LCOE)
  - Average cost of energy for 40 years
  - No higher than $65/MWh (2017$)
  - Projected Price Range $45-65/MWh (2017$)
CFPP Project Location
Idaho National Laboratory Site
NRC Licensing/Why INL Site?

- UAMPS conducted a site selection study consistent with NRC guidelines
  - Looked at sites in Utah and Idaho
- Community
  - Experience and knowledge of nuclear development
    - Experienced workforce
- Site data requirements
  - Numerous studies and data collection for NRC
- Location near UAMPS members
- Existing infrastructure
- Readily available land and resources
- Electrically sound
  - Transmission availability to members
    - Adds system balance and integrity to region
Satellite View of Site

Big Lost
River Rest
Stop

Hwy 20
Hwy 26

Proposed location of CFPP Site
(approximate)

Note: the actual location has not yet been determined within the boundary
View of Site – Closest Highway Approach
(On Hwy 26 approaching junction with Hwy 20, viewing elevation of ~ 100’)

Looking Southwest
SITE USE PERMIT TERM—99 YEARS

• Term:
  • 99 year term that commences upon COD of the first nuclear power module (NPM) at the CFPP and no later than 2026 unless UAMPS has been diligently pursuing its NRC license
    • Term should allow for all 12 nuclear power modules to operate for 80 years (initial 40 year term + 2 license renewals of 20 years each)
  • Term adequately accounts for timeframe to decommission in a cost effective manner
    • Option to extend for 10 years for “sound reasons” (decommissioning)
    • Note: NRC license still in place until decommissioning complete
NRC LICENSING—NEXT STEPS

- Compiling a combined construction and operating license application (COLA) for the preferred site
- Anticipated to be submitted to NRC in the summer of 2020
- UAMPS will conduct pre-engagement submittal with the NRC
PROPOSED WATER SOURCE
EASTERN SNAKE PLAIN AQUIFER (ESPA)

- 200 miles x 60 miles
- 1 billion acre-feet stored in the aquifer
- 8 million acre-feet flows through the aquifer each year

Source: IDWR
Well Yields near CFPP Site

- Typically 1,000 to 4,000 gallons per minute (gpm)
- Locally variable due to variations in the fractured basalt interflow zones
- 5 to 15 wells (approx) may be required to meet CFPP water demand (wet cooling)
  - 18,000 acre-feet per year
PROPOSED TRANSFER OF GROUND WATER RIGHTS TO SUPPLY THE CFPP

- Acquire and transfer irrigation ground water rights to CFPP site
- Must be approved by Idaho Department of Water Resources (IDWR)
- May be protested by others
- Limited to historical consumptive use
- IDWR must consider the local public interest in approving transfer
No fatal flaws have been identified
Continued development work will continue in a phased approach to minimize the cost of developing the CFPP as a resource option
Objective=Increase cost certainty before submitting COLA and further de-risk permitting risk by continued development work
COST CONTAINMENT—MITIGATING RISK TO UAMPS PARTICIPANTS

- Phased development approach with monetary caps that can be spent during a particular phase
- Each Participant has a unilateral right to exit the project at the end of each phase
- Cost estimates will be revised at the end of each phase and budget will be approved before proceeding to the next phase
- Final right to exit the project will be at decision to proceed to construction (2023)
AVOIDING THE PITFALLS OF NUCLEAR POWER PLANT CONSTRUCTION

- Known Issues:
  - Percentage of Engineering Design Complete Before Committing to Construction
    - AP1000 Engineering Design Percentage Complete=Low double digits
    - UAMPS will require > 85% engineering design complete before committing to construction
  - Constructability of Design:
    - NuScale/Fluor working with potential vendors now to daylight potential constructability issues
  - Owner’s Engineering Reviews
    - AP1000 utility owners did not have external experts review AP1000 designs
    - UAMPS will have an external owner’s engineer review NuScale/Fluor designs during the cost estimating process laid out in the EPC Development Agreement
AVOIDING THE PITFALLS OF NUCLEAR POWER PLANT CONSTRUCTION....

• Integrated Project Schedule
  • AP1000 EPC Consortium (Westinghouse & CB & I) did not have an integrated projected schedule to coordinate their respective scopes of work
  • UAMPS will have an experienced nuclear EPC Contractor in Fluor that will have an integrated project schedule with NuScale

• Owner’s Project Management
  • AP1000 utility owners did not have adequate owner’s project management to address schedule/cost overrun issues
  • UAMPS plans to have in house and external owner’s project management if there a decision to proceed to construction
Questions