NuScale Power SMR: Supporting the Future with Clean Energy

Southern States Energy Board
December 7, 2016

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NuScale Power LLC
Business Development

NuScale Nonproprietary
Acknowledgement & Disclaimer

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NuScale is Born!

- 2005-2007 DOE Commercialization Program
  - Numerous practical modifications to design; 3 Key Patents; Becoming “Investment Ready”
- July 2007 - NuScale is Born!
  - Founders: Lorenzini CEO; Reyes CTO
- February 2008 - Began NRC design certification (DC) pre-application project
- September 2008 – Kiewit Power Constructors and High Bridge Associates – The Economics Work Too!
- December 2009 - NY Times Full Page Article - Increased Media Interest
- March 2011 - Fukushima Event

2008 - NuScale at Bank Building on 2nd Street, Corvallis
NuScale Grows

- October 2011 - Fluor becomes NuScale’s Strategic Partner - Acquires majority interest.
- May 2012 - First 12-reactor Control Room Simulator in the world became operational in for Human Factors Engineering development.
- April 2013 – NuScale Announces its Triple Crown of Nuclear Safety™ - another world’s first.
- July 2013 – Program WIN -Western Initiative for Nuclear.
- December 2013 - DOE announced FOA win and Cooperative Agreement signed May 2014
  - $217M matching funds.

From a concept to a product.
NuScale Today

- More than 600 people currently on project with Offices in:
  - Business Offices: Portland, OR; London, UK; Idaho Falls, ID
  - Engineering Offices: Corvallis, OR; Charlotte, NC; Richland, WA
  - Licensing Office, Rockville, MD
- Fluor/DOE have invested > $500MM life-to-date
- NuScale has teamed with AREVA, ARES, Rock Creek Innovations, Ultra Electronics and Enercon
- Major Testing Facilities in US, Canada, Italy, France and Germany
- 340 Patents Granted or Pending in 20 countries

*to the industry leader in SMR technology*
Site Layout

- Reactor Building
- Warehouse
- Annex Building
- Parking
- Radwaste Building
- Administration Building
- Cooling Towers A
- Turbine Building A
- Control Building
- Switchyard
- Turbine Building B
- ISFSI (Dry Cask Storage)
- Cooling Towers B

34.5 acres (~14 hectares) within the protected area fence
An Integral Small Modular Reactor

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

Size Matters

*Source: NRC
More Barriers Between Fuel & Environment

Conventional Designs
1. Fuel Pellet and Cladding
2. Reactor Vessel
3. Containment

NuScale’s Additional Barriers
4. Water in Reactor Pool
5. Stainless Steel Lined Concrete Reactor Pool
6. Biological Shield Covers Each Reactor
7. Reactor Building

Safety, Safety, Safety
Smaller Emergency Planning Zone (EPZ)

10 mi EPZ

Site Boundary EPZ
(depending on site characteristics)

- Passive Safety
- Additional Fission Product Barriers
- Significant Delay in Release of Radiation
Innovative Advancements to Reactor Safety

Nuclear fuel cooled indefinitely without AC or DC power*

WATER COOLING  BOILING  AIR COOLING

No Pumps • No External Power • No External Water

Decay heat removed by steam generators and DHRS (3 Days)
Decay heat removed by containment (30 Days)
Transition to long-term air cooling (>30 Days)

• 30 days is a minimum based on very conservative estimates.

*Alternate highly reliable power system design eliminates the need for 1E qualified batteries to perform ESFAS protective functions – Patent Pending

**Triple Crown of Safety**
NuScale Fuel—(NuFuel HTP2™)

- Standard 17 X 17 PWR Fuel Assembly
- Half height
- 37 FA’s/core
- Enriched ~3.7%
- ~4% MTU of 1000MW core
- RFO 24-month cycle
- ~1/3 core replaced
- MOX capable
- Areva design and fabrication, Richland, Washington
Fuel Mechanical and Hydraulic Testing

Objectives:
• Measure fuel mechanical and hydraulic performance
• Employ prototypic NuScale fuel assemblies with AREVA HTP/HMP grid technology
CRA and Drive Shaft Drop Alignment Test Hardware

- Fuel Assembly Housing
- Support Beam
- Guide Tube/Card Housing
- Counterweight Guide Assembly
NuScale RPV Head Ingot Being Forged

- 150 inches diameter
- 30 inches high
- 142,000 pounds

Images Provided courtesy of Sheffield Forgemasters International Ltd
Machining of the NuScale RPV Head

Images provided courtesy of Sheffield Forgemasters International Ltd
SG Flow Induced Vibration (FIV) Test Hardware

- Tube Supports
- Vessel Head
- Machining of Tube Sheet
- Tube Bending Rig
- Tube Bending
NRC Design Certification and Commercialization Plan and Status
NRC Licensing Status

- Design Certification Docket Opened in 2009 (NRC starts charging)
  - Significant interactions begin in 2014
- Visits include
  - Tour of NIST Facility
  - Tour of upper module mockup
  - Multi-hour simulator demonstration of plant transient response
  - In-depth meetings with NuScale management and technical staff
- ACRS July 2015
- NRC NRO upper management August 2015
- NRC QA inspection of NIST August 2015
- NRC I&C and Electrical subject matter branch management and key technical staff December 2015
- Human Factors Engineering January 2016
- Office of New Reactors March 2016
- NRC Readiness Assessment review September 2016

Design Certification to be submitted December 2016
Greater than 10,000 pages
First Deployment: UAMPS CFPP

- Utah Associated Municipal Power Systems (UAMPS) Carbon Free Power Project (CFPP) will be first deployment, sited somewhere in Idaho.
- Site selection underway
- DOE INL site use agreement
- NRC COLA commitment
- UAMPS consists of 44 members serving load in 7 western states.
- 37 UAMPS members are subscribers in CFPP

A Groundbreaking Project
UAMPS CFPP Project Schedule

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- **Site Preparation & Mobilization**
- **Site Specific Engineering**
- **Site Selection**
- **Site Use Agreement**
- **Start COLA**
- **Submit COLA**
- **Start Finalized Plant Design**
- **Complete Final Plant Design**
- **EPC Contract Execution**
- **FNTP**
- **LNTPs**
- **NuScale Power**
- **FLUOR**
- **Energy Northwest**
- **UAMPS**
- **SMARTENERGY**
View of Site From Lost River Rest Stop

NuScale Site
(partially occluded, ~ 6 miles from viewer)

Big Southern Butte
(~ 10 miles from viewer)

Southeast  Viewing direction  South

Keeping a low profile
NuDEP
Oil Refineries Study - Reduction of Carbon Emissions
(Fluor and NuScale)

10-Module Plant coupled to a 250,000 barrels/d refinery

Integration with Wind Study - Horse Butte Site
(UAMPS, ENW and NuScale)

1-Module dedicated to UAMPS 57.6 MW wind farm

Reliable Power for Mission Critical Facilities (NuScale)

Hydrogen Production Study – High-Temperature Steam Electrolysis
(INL and NuScale)

6-Module Plant for Emission Free Hydrogen Production

Desalination Study – Sized for the Carlsbad Site
(Aquatech and NuScale)

8-Module Plant can produce 50 Mgal/d (190K m³/d) of clean water plus 350 MWe

12-Module Plant coupled to a 100 MWe Mission Critical Facility
Highly reliable power is required for Mission-Critical Facilities.

- Hospitals, Data Centers, Government Facilities, banking or retail systems
- Security systems, telecommunications, air traffic control
- Safety systems for conventional Nuclear Plants

Process failure can cause significant financial or reputational damage to the organization or may impact national security or safety.

Security of Supply
Financials
### Overall EPC Overnight Plant Costs
($1,000,000)

<table>
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<th>ITEM</th>
<th>2014 Dollars</th>
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<tbody>
<tr>
<td>Power Modules (FOAK Cost plus Fee, Transportation, &amp; Site Assembly)</td>
<td>$ 848</td>
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<tr>
<td>Home Office Engineering and Support</td>
<td>$ 144</td>
</tr>
<tr>
<td>Site Infrastructure</td>
<td>$ 60</td>
</tr>
<tr>
<td>Nuclear Island (RXB, RWB, MCR)</td>
<td>$ 538</td>
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<tr>
<td>Turbine Island (2 buildings with 6 turbines each)</td>
<td>$ 350</td>
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<tr>
<td>Balance of Plant (annex, cooling towers, etc)</td>
<td>$ 225</td>
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<tr>
<td>Distributables (Temp. Bldgs., Field Staff, Const. Equip., etc.)</td>
<td>$ 545</td>
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<tr>
<td>Other Costs</td>
<td>$ 185</td>
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<tr>
<td><strong>Total Overnight Price</strong></td>
<td><strong>$ 2,895</strong></td>
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$ 5,078 per kWe net

Note: Delivered costs shown are in 2014 $’s.
NuScale LCOE results of $96-$106/MWhr (2016 $’s)

Key Assumptions:

– Financing is 55% debt (@5.5%) and 45% equity (@10.0%).

– Modeled as a 40 year project life, but the plant is designed for 60 years

– Excludes owner’s costs such as:
  – HR and management infrastructure, central office
  – COLA, permits, NRC and ITAAC inspections, and legal fees
  – Switchyard
  – Owner's project development costs
  – Owner's engineering services (post-COLA)
  – Owner contingency

– Including an estimate of owners costs would add ~ $6/MWhr
The Challenge - LCOE in North America

Estimated Average US Levelized Cost of New Generation Resources
2022 costs in 2015 $/MWh

Assumptions for EIA and NuScale 12-Pack
WACC of 5.60%; 30 yr cost recovery

Source: U.S. Energy Information Administration, Levelized Cost and Levelized Avoided Cost of New Generation Resources in the Annual Energy Outlook 2016, August 2016, except NuScale (12-Pack); NuScale Model

NuScale 12-Pack FOAK and Nth LCOE include Owner’s Cost of $6.06/MWh. EIA includes transmission investment of $1.10/MWh (Advanced Nuclear). NuScale included $1.10/MWh for transmission investment in FOAK and Nth LCOE values.

Note: EIA projects 2022 Henry Hub spot natural gas prices of approx. $4.35/mmbtu (2015 Dollars) (Annual Energy Outlook 2016)
NuScale LCOE Breakdown

Levelized Cost in 2016 US Dollars per MWh

**FOAK with Regulated Utility Financing (IOU)**
- 55% debt at 5.5%, 45% equity at 10%

  $106 USD/MWh

**FOAK with Municipal Financing**
- 100% debt at 4.12%, no equity

  $80 USD/MWh

Note: Capital costs reflect the Fluor SE estimate completed in 2014.
What Could SMRs mean?

- Strengthens the region’s position as the hub for nuclear innovation
- Creates slipstream for other regional SMR projects
- Project can create ~1000 construction jobs at peak, for duration of 2-3 years
- Full-time plant employment ~360 at average annual salaries $85K
- Establishes the region as a desired location for SMR supply chain members
- Indirect economic benefits and associated job multipliers

Phase I: Economic Impact Summary Results
Nuclear Power Plant Construction

<table>
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<tr>
<th>Impact Type</th>
<th>Employment</th>
<th>Labor Income</th>
<th>Industry Sales</th>
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<tr>
<td>Direct Effect</td>
<td>1,000</td>
<td>$1,143,677,418</td>
<td>$2,800,000,000</td>
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<td>Indirect Effect</td>
<td>3,987</td>
<td>$123,494,919</td>
<td>$353,692,045</td>
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<td>Induced Effect</td>
<td>7,821</td>
<td>$243,927,035</td>
<td>$620,061,282</td>
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<td>Total Effect</td>
<td>12,808</td>
<td>$1,511,099,372</td>
<td>$3,773,753,328</td>
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<td>Multiplier</td>
<td>1.54</td>
<td>1.32</td>
<td>1.35</td>
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Source: Idaho Department of Labor’s analysis of the impact of the UAMPS SMR project on Idaho Falls
What is Needed to Ensure Success?

- Need a committed owner/buyer(s) – will ultimately drive site selection decision for the project
- Project will need to demonstrate sufficient need for/use of generated power
- Suitable plant economics/investment profile (e.g. long-term PPA’s)
- Supportive local and state permitting processes
- Sufficient capable facility workforce and community interest
- Economic development support
  - Economic Development Studies
  - Policy Support
FACT SHEET: Reducing Greenhouse Gas Emissions in the Federal Government and Across the Supply Chain

40% cut in CO2 emissions across Government agencies

30% of energy must come from “alternative technologies” which include SMR’s

Sec. 3. Sustainability Goals for Agencies. In implementing the policy set forth in section 1 of this order and to achieve the goals of section 2 of this order, the head of each agency shall, where life-cycle cost-effective, beginning in fiscal year 2016, unless otherwise specified:

(e) include in the alternative energy portion of the clean energy target established in subsection (b) of this section alternative energy as defined in section 19(c) of this order and associated with the following actions, where feasible:

(i) installing thermal renewable energy on site at Federal facilities and retaining corresponding renewable attributes or obtaining equal value replacement RECs where applicable;

(ii) installing combined heat and power processes on site at Federal facilities;

(iii) installing fuel cell energy systems on site at Federal facilities;

(iv) utilizing energy from new small modular nuclear reactor technologies;

(v), (vi), (vii)

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The Element of Nu