Reducing Financial Risk for Nuclear Power Generation

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April 27, 2009
Financial Risk of Nuclear?

“The nuclear **industry cannot give any reliable cost estimate** for how much it will take to build a nuclear plant. When a utility is confronted with the absence of any advances for how much the construction cost is going to be, then that’s a problem. Because the **economics of nuclear only work at scale**. You’ve got to have a 1,000 megawatt plant for it to be efficient and competitive.” - Al Gore, March 18th, 2009

<table>
<thead>
<tr>
<th>Gen II Nuclear</th>
<th>New Nuclear</th>
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<tbody>
<tr>
<td>Every plant is different</td>
<td>NRC “Design Certification” standardizes plant designs for 20 years</td>
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<tr>
<td>Separate licenses for Construction and Operation</td>
<td>Combined Construction &amp; Operating License issued before construction begins</td>
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<tr>
<td>Capacity factors less than 70%</td>
<td>Capacity factors routinely exceed 90%</td>
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<tr>
<td>Active safety systems require emergency power to operate</td>
<td>Passive safety systems rely on natural circulation</td>
</tr>
<tr>
<td>Most plants &gt; 1000 MWe requiring large financial commitment</td>
<td>All plants &gt; 1000 MWe requiring large financial commitment</td>
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</table>
NuScale – The Next Major Advance

- Keep it Small and Simple
- Use Well-Established Technology
- “Numbered-up” instead of “Scaled-up”

Result:

- Greater Cost Certainty
- Greater Regulatory Certainty
- Increased Speed to Market
- Competitive Costs at Smaller Power Increments
Business Overview

- NuScale is commercializing a 40 MWe system that can be scaled to meet customer requirements of virtually any size.

- NuScale technology developed and tested by Oregon State University. Company formed in 2007 with tech-transfer agreement from OSU.

- Design innovations simplify construction, strengthen safety, reduce costs and financial risks, and improve reliability.

- Reliance on existing light water technology reduces regulatory risk and increases speed to market.
# Management Team

<table>
<thead>
<tr>
<th>Executive</th>
<th>Position</th>
<th>Experience / Accolades</th>
</tr>
</thead>
</table>
| Paul G. Lorenzini, PhD | Chief Executive Officer         | President, Pacific Power & Light  
CEO, PowerCorp Australia  
VP/General Manager, Rockwell Hanford Operations |
| Jose N. Reyes, PhD  | Chief Technical Officer         | Internationally recognized for leadership in developing scalable test facilities for nuclear plants  
United Nations International Atomic Energy Agency (IAEA) technical expert on passive safety systems  
Department Chair, Nuclear Engineering, Oregon State University |
| Tom Marcille       | Chief Operating Officer         | Chief Engineer, Advanced Reactors, Los Alamos National Laboratory  
Twenty years as a contributing, managing and chief engineer in GE's advanced and terrestrial BWR business units |
| John “Jay” Surina  | Chief Financial Officer         | V.P. Financial Planning and Analysis, Boart Longyear  
Executive positions, Texas Genco, Centrica North America, Sithe Energies  
Co-founder and a managing partner of Cornerstone Energy Advisors  
MBA, Wharton School, University of Pennsylvania |
NuScale Project Organization

Nuclear Vendor
- Design & Engineering (NSSS)
- Licensing (Certification)
- Support services

Owner (typical utility)
- Site selection
- Licensing (ESP/COL)
- Operations

Suppliers
- Fabricate Modules
- Steam Generator
- Forgings
- CRDM’s

A/E Constructor
- Design & Engineering (BOP)
- Project Management
- Site Preparation & Construction
Strategic Partner - Kiewit Construction: NuScale / Kiewit MOU signed April 2008

- Employee-owned company; $6 billion annual revenue with 120 year history and 16,600 Employees
- FORTUNE’s most admired company in the engineering and construction industry in 2007
- Major power plant constructor
- Major commitment to new nuclear projects based on past nuclear construction experience
Key Industry Contractors and Partners

- NuScale Power
  - Product Development
  - Strategic Planning
  - Safety Analysis
  - Core Neutronics
  - NSSS Design
  - Operations & Maintenance
  - Training & Development
  - Project Management

- Studsvik
  - Core Design
  - Refueling
  - Safety Analysis Support

- Oregon State University (OSU)
  - Test Facilities
  - Safety Analysis Support

- Modarres Consulting
  - Probabilistic Risk Analysis

- MPR
  - Core Internals
  - Seismic
  - Licensing
  - Project Management Support

- Creare
  - Safety Analysis Support

- Longnecker Associates
  - Digital I&C
  - Control Room Design

- SAIC
  - Security
  - Emergency Planning
  - Safety Analysis Support

- Kiewit
  - Site Prep
  - Plant Construction
  - Engineering Support
  - Balance of Plant
  - Fabrication
Prefabircated, simple, safe ...

- **Construction Simplicity:**
  - Entire NSSS is 60’ x 15’. *Prefabricated and shipped by rail, truck or barge*

- **Natural Circulation cooling:**
  - *Enhances safety* – eliminates large break LOCA; strengthens passive safety
  - *Improves economics* -- eliminates pumps, pipes, auxiliary equipment

Below grade configuration enhances security
Prototype Confirms Design

- Fully integrated, one-third scale, electrically heated prototype of NuScale plant confirms performance and safety
- Light water technology coupled with test facility reduces technology and licensing risks
NSSS and Containment

- Containment
- Reactor Vessel
- Helical Coil
- Steam Generator
- Nuclear Core
- Containment Trunnion
Engineered Safety Features

- High Pressure Containment Vessel
- Shutdown Accumulator System (SAS)
- Passive Safety Systems
  - Decay Heat Removal System (DHRS)
  - Containment Heat Removal System (CHRS)
- Severe Accident Mitigation and Prevention Design Features
High Pressure Containment
Enhanced Safety

- **Pressure Capability** - Equilibrium pressure between reactor and containment following any LOCA is always below containment design pressure.

- **Insulating Vacuum**
  - Significantly reduces convection heat transfer during normal operation.
  - No insulation on reactor vessel. **ELIMINATES SUMP SCREEN BLOCKAGE ISSUE (GSI-191).**
  - Improves steam condensation rates during a LOCA by eliminating air.
  - Prevents combustible hydrogen mixture in the unlikely event of a severe accident (i.e., no oxygen).
  - Eliminates corrosion and humidity problems inside containment.
Decay Heat Removal System (DHRS)

- Two independent trains of emergency feedwater to the steam generator tube bundles.
- Water is drawn from the containment cooling pool through a sump screen.
- Steam is vented through spargers and condensed in the pool.
- Feedwater Accumulators provide initial feed flow while DHRS transitions to natural circulation flow.
- Pool provides a 3 day cooling supply for decay heat removal.
Containment Heat Removal System (CHRS)

- Provides a means of removing core decay heat and limits containment pressure by:
  - Steam Condensation
  - Convective Heat Transfer
  - Heat Conduction
  - Sump Recirculation
- Reactor Vessel steam is vented through the reactor vent valves (flow limiter).
- Steam condenses on containment.
- Condensate collects in lower containment region (sump).
- Sump valves open to provide recirculation path through the core.
Expert PIRT Panel Reviews

- June 2-3, 2008, a panel of experts convened to develop a Thermal-Hydraulics/Neutronics Phenomena Identification and Ranking Table (PIRT) for the NuScale module:
  - Graham Wallis, Creare (Panel Chairman)
  - Mujid Kazimi, MIT
  - Larry Hochreiter, Penn State
  - Kord Smith, Studsvik Scanpower
  - Brent Boyack, LANL retired
  - Jose Reyes, NuScale Power, OSU

- February 24-26, 2009 Severe Accidents Analysis PIRT Panel convened in Corvallis
  - Mike Corradini (Panel Chairman)
  - Vijay Dhir
  - Joy Rempe
Independent Review Panel Results

- **LOCA Thermal Hydraulic Review**
  - Large-break Loss of Cooling Accident (LOCA) eliminated by design
  - DBA Small break LOCA’s will not uncover the core, thus do not challenge plant safety

- **Severe Accident Review**
  - Indicated that the PRA is overly conservative with regard to events that lead to core damage.

- **Preliminary PRA already indicates that the overall Core Damage Frequency is extremely low**
(internal events at-power for U.S. plants only)

CDF (yr)

1x10^{-8} 1x10^{-7} 1x10^{-6} 1x10^{-5} 1x10^{-4} 1x10^{-3}

operating PWRs operating BWRs new LWRs (active) new LWRs (passive)

NRC Goal (new reactors)
Severe Accident Mitigation and Prevention

- Reduced source term due to modularization and additional fission product barriers
- No need for combustible gas control in containment (no oxygen)
- No molten concrete coolant interactions
- Reliable and redundant reactor depressurization system (no high-pressure melt ejection)
Additional Fission Product Barriers

- Fuel Pellet and Cladding
- Reactor Vessel
- Containment
- Containment Cooling
  Pool Water
- Containment Pool Structure
- Biological Shield
- Reactor Building

_NOT TO SCALE_
Reduced Emergency Planning Zone

“Generally, the plume exposure pathway EPZ for nuclear power plants shall consist of an area about 10 miles in radius ... The size of EPZs may also be determined on a case-by-case basis for ... reactors with an authorized power level less than 250 MWt.”

10 CFR 50.47 (c) (2)
NuScale Design
Multi-Module
Modules can be “Numbered-Up”

Each module has a dedicated Turbine-Generator

Modules can be “numbered up” to achieve large generation capacities
Multiple-Module Complex offers flexible capacity (Ex: 12 modules – 480 MWe)
Refueling Animation
Multi-Module Control Room

Plant Overview Display

Redundant High-Tier Alarming

Reactor Control Cluster A

Reactor Control Cluster B

Reactor Control Cluster C

User-Defined Panel (up to 4 modules)
- Alarm Interface
- Procedure Operation Interface
- Trending and Graphing

Control Room Supervisor

Alarms and User-Defined Panels

Reactor Module Panels

Safety Channel (SC) A

Reactor (Rx) 1 Interface
NuScale Integral System Test Facility
A Scaling Analysis was used to guide the design, construction and operation a 1/3-Scale Integral System Test facility for the MASLWR design.

NuScale will modify the design to incorporate design improvements and will have exclusive access to the test facility.

Facility can be used to:
- Evaluate design improvements
- Conduct integral system tests for NRC certification

OSU has significant testing capability.
- Performed DOE and NRC certification tests for the AP600 and AP1000 designs.
- 10 CFR 50 Appendix B, NQA-1, 10 CFR 21
NuScale Integral System Test Facility

- Stainless Steel Integral System Test Facility operating at full system pressure and temperature
  - Reactor Vessel (<1500 psia) with 398 kW electrically heated rod bundle
  - Core Shroud with Riser
  - Pressurizer
  - RV and Sump Valves
  - Helical Coil Steam Generator (450 psia)
  - Variable Speed FW Pump
  - Containment Vessel
  - Exterior Cooling Pool
  - Instrumentation
Integrated Reactor Test Vessel

- Pressurizer
- PZR Steam Drum
- SG Helical Coils
- Riser
- Core Shroud
- Core Heaters
- Flange
- Pressure Vessel
Containment and Cooling Pool

Exterior Cooling Pool

Trace Heated High Pressure Containment

Containment Heat Transfer Plate
SBLOCA Transient Phases

- **Phase 1: Blowdown Phase**
  - Begins with the opening of the break and ends with the reactor vent valve (RVV) initiation

- **Phase 2: RVV Operation**
  - Begins with the opening of the reactor vent valve and ends when the containment and reactor system pressures are equalized

- **Phase 3 - Long Term Cooling**
  - Begins with the equalization of the containment and reactor system pressures and ends when stable cooling is established via opening of the sump recirculation valves
Reactor Vessel Level (OSU Test - 003B)

Collapsed Liquid Level (m)

LDP 106 Vessel

Top of Core

Sump Recirc Valve Open

Time (s)

Collapsed Liquid Level (m)
## Pre-Application Schedule

<table>
<thead>
<tr>
<th>Meeting</th>
<th>FY2008</th>
<th>FY2009</th>
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<tbody>
<tr>
<td></td>
<td>4Q</td>
<td>1Q</td>
</tr>
<tr>
<td><strong>1st Meeting</strong></td>
<td>● NuScale and Design Introduction</td>
<td>▲</td>
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<tr>
<td><strong>Submit Design Description Report</strong></td>
<td></td>
<td>●</td>
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<tr>
<td><strong>2nd Meeting</strong></td>
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NuScale Advantages Reduce Financial Risk

- Made in the USA; multiple suppliers
  - Eliminates foreign supplier choke points
- Offsite manufacturing of entire NSSS
  - Reduces costs
  - Improves predictability and control
- Modularity of NSSS
  - Sequential addition of generation matches load growth
  - Eliminates “single shaft” risk
NuScale Advantages Reduce Financial Risk

- Smaller size permits construction in “bite-size” chunks
- Enhanced safety
  - Elimination of Loss of Coolant Accident
  - Passive cooling/natural circulation
  - Additional barriers
- Security advantages
  - Nuclear plant, control room, and spent fuel storage all below ground – minimizes terrorist targets
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Corvallis, OR 97330
541-207-3931

For more information contact:

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