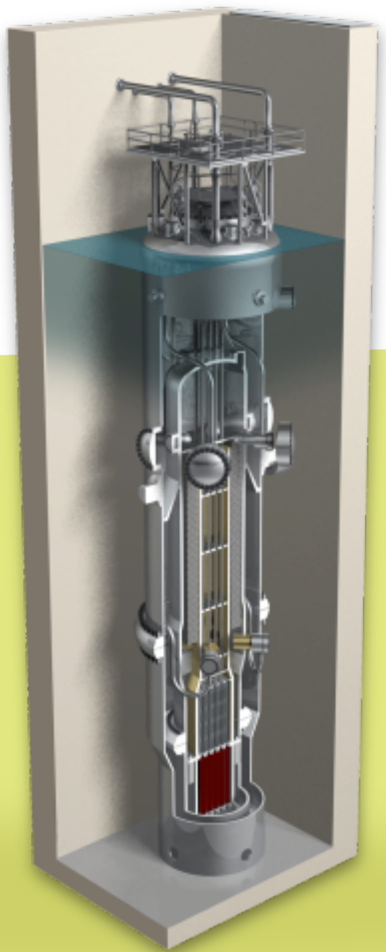

Small Modular Reactor's Role in Future Energy Portfolio's

Camp Atterbury Sustainable Energy *Symposium

March 24, 2015

Jack Bailey

Sr. VP Business Development

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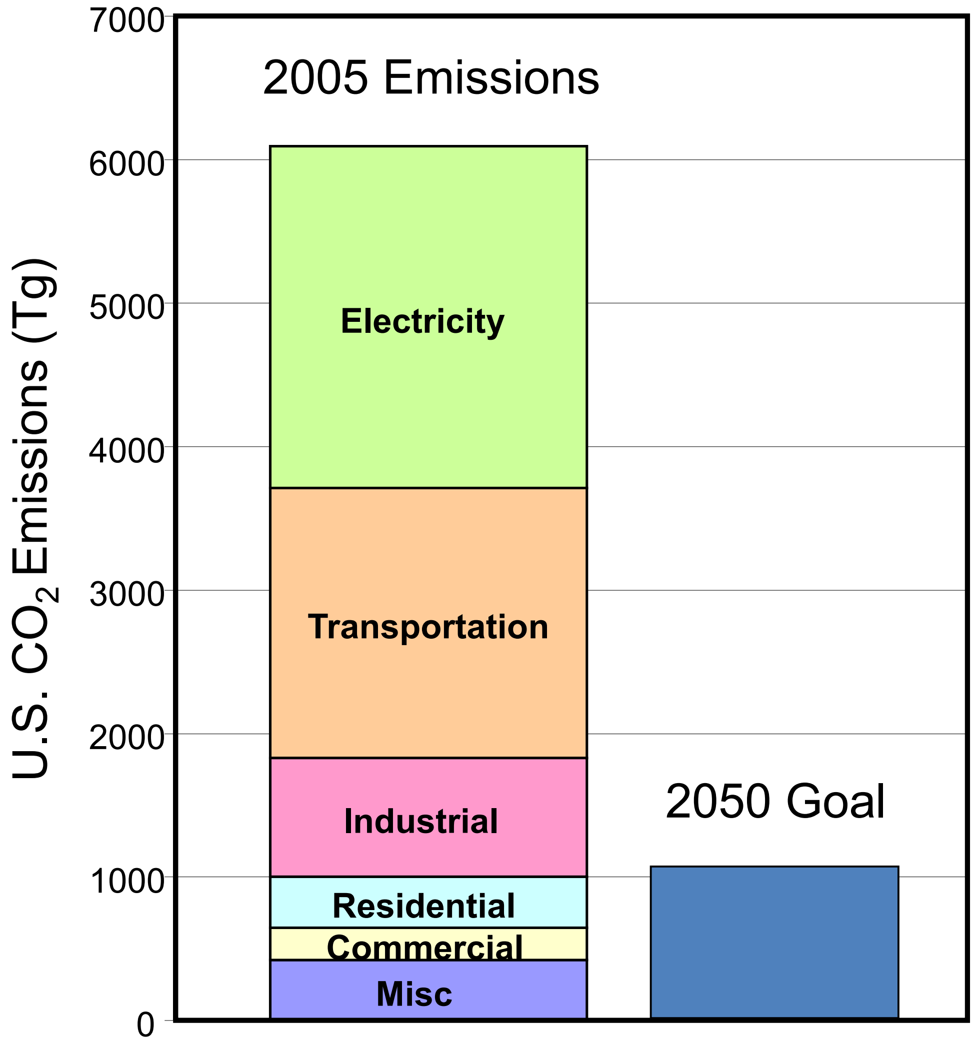
CO2 Emissions Goal



- To achieve dramatic CO2 reductions, emissions from Electricity, Transportation, and Industrial must be substantially reduced.
- The most aggressive current policies do not come close to achieving the goal in any sector.
- Emissions-free nuclear power in combination with renewables, could substantially reduce the Electricity component, and contribute to Transportation and Industrial component reductions.

2005 Emissions from EPA: Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2012, April 15, 2014. 2050 Goal is 80% reduction.

Many SMR Designs and Sizes (But Few Will Become Commercial)

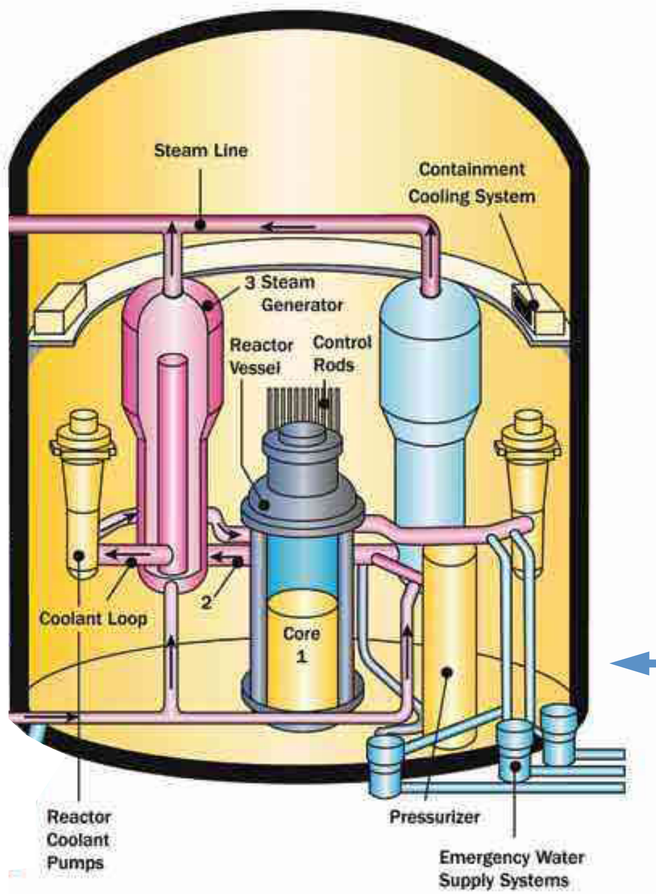
Technology Type	Reactor	Size of Reactor (MWe net)	Developer	Fueling Cycle (years)
Light Water Reactors	NuScale	47.5	NuScale Power	2
	mPower	180	B&W and Bechtel	4
	Westinghouse SMR	225	Westinghouse	2
	SMART	100	Korea	3
Liquid Metal-Cooled and Fast Reactors	4S	10	Toshiba	30
	Hyperion	25	Hyperion Power Generation	7–10
	PRISM	311	GE-Hitachi	1–2
High-Temperature Gas-Cooled Reactors	General Atomics Areva Pebble bed	TBD	US Department of Energy (NGNP) - Suspended	TBD
Other Molten Salt or Fast Reactors	TerraPower TWR Transatomic Power	550 520	TerraPower, LLC (Bill Gates) Transatomic Power Corp	Long term With Shuffling Long Term

NuScale Power

Traditional PWR vs. NuScale Power

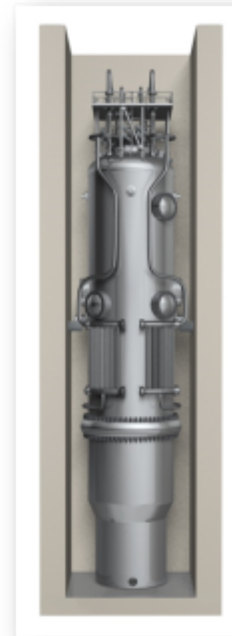
Typical Pressurized Water Reactor

Approx
220 ft.



Grade Level

NuScale Power Module



Approx
80 ft.

Integral Reactor Design

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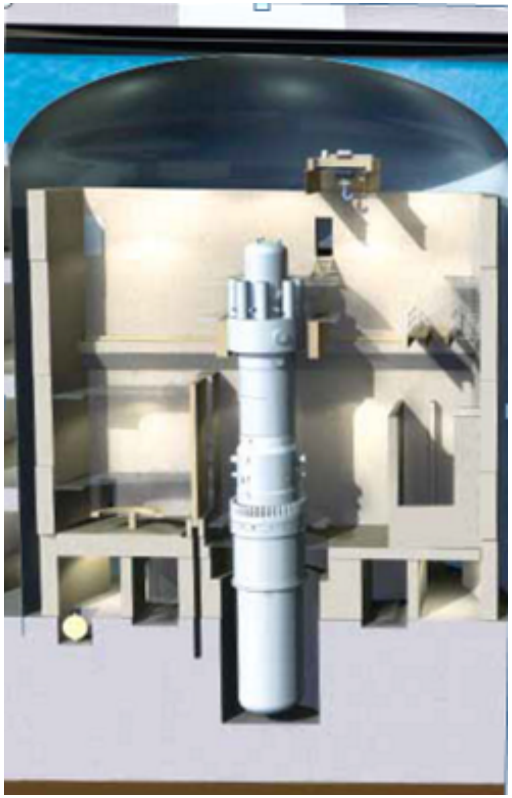
Near Term U.S. Small Modular Reactors (iPWR)

NuScale

50 MWe

mPower



180 MWe

Westinghouse

225 MWe

Holtec

160 MWe

Reactor, Pressurizer, Steam Generators, Pumps (if applicable), and Containment

NUSCALE POWER™

SMR Potential Benefits

- Continue the benefits of nuclear power
  - Emissions-free power production
  - Reliability – 7 x 24 in all weather conditions
  - Economic benefits – good paying jobs
- SMRs add:
  - Additional safety margins
  - Affordable capital investment
  - Greater construction cost and schedule certainty
  - More flexible operation in grids with renewables
  - Additional siting options

Not all SMR designs provide these benefits to the same degree, so need to discern

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, lessons from AP600/1000 ¼-scale testing facility built and operational
- Electrically-heated 1/3-scale Integral test facility first operational in 2003
- Began NRC design certification (DC) pre-application project in April 2008
- Fluor (#109 in the FORTUNE 500 in 2014) acquired majority interest in NuScale in October 2011
- ~600 FTE's currently on project, ~$300MM spent project life-to-date
- 185 patents pending/granted, 17 countries

NuScale Engineering Offices Corvallis, Oregon

One-third scale Test Facility

NuScale Control Room Simulator

NuScale Power™

NuScale and DOE Complete Agreement

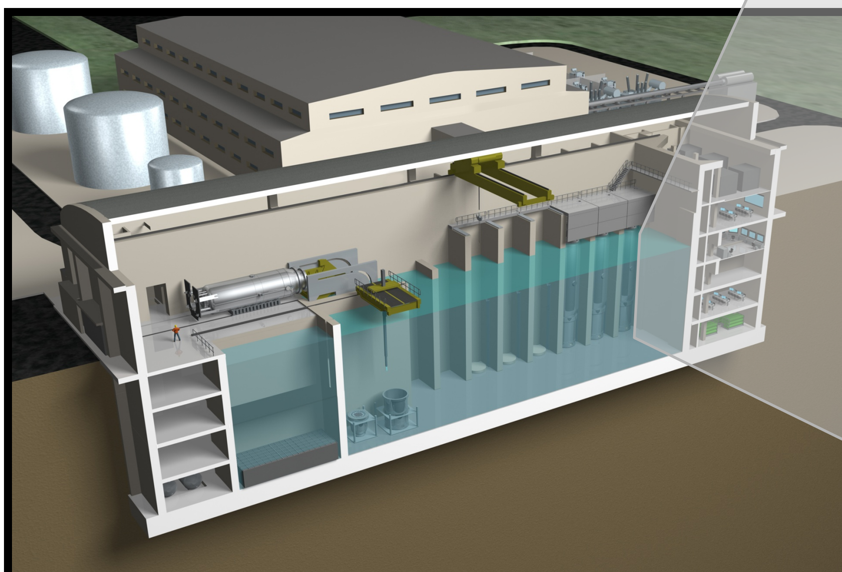
- Contract with DOE completed May 28, 2014 following selection as winner under cost-share program on December 12th, 2013

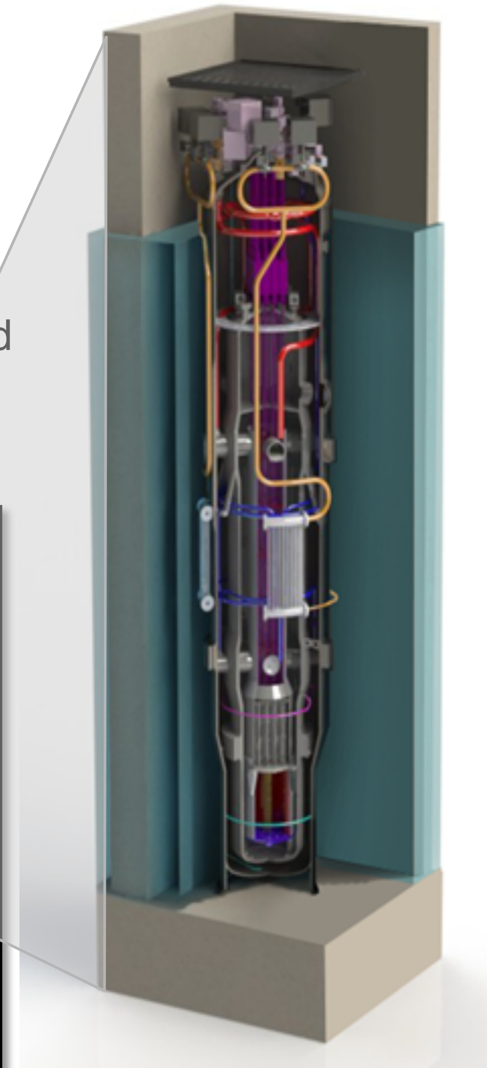
- Initiated up to $217M funding for NuScale SMR Development

- The company will use the funds to perform the engineering and testing needed to proceed through the Nuclear Regulatory Commission Design Certification Process.

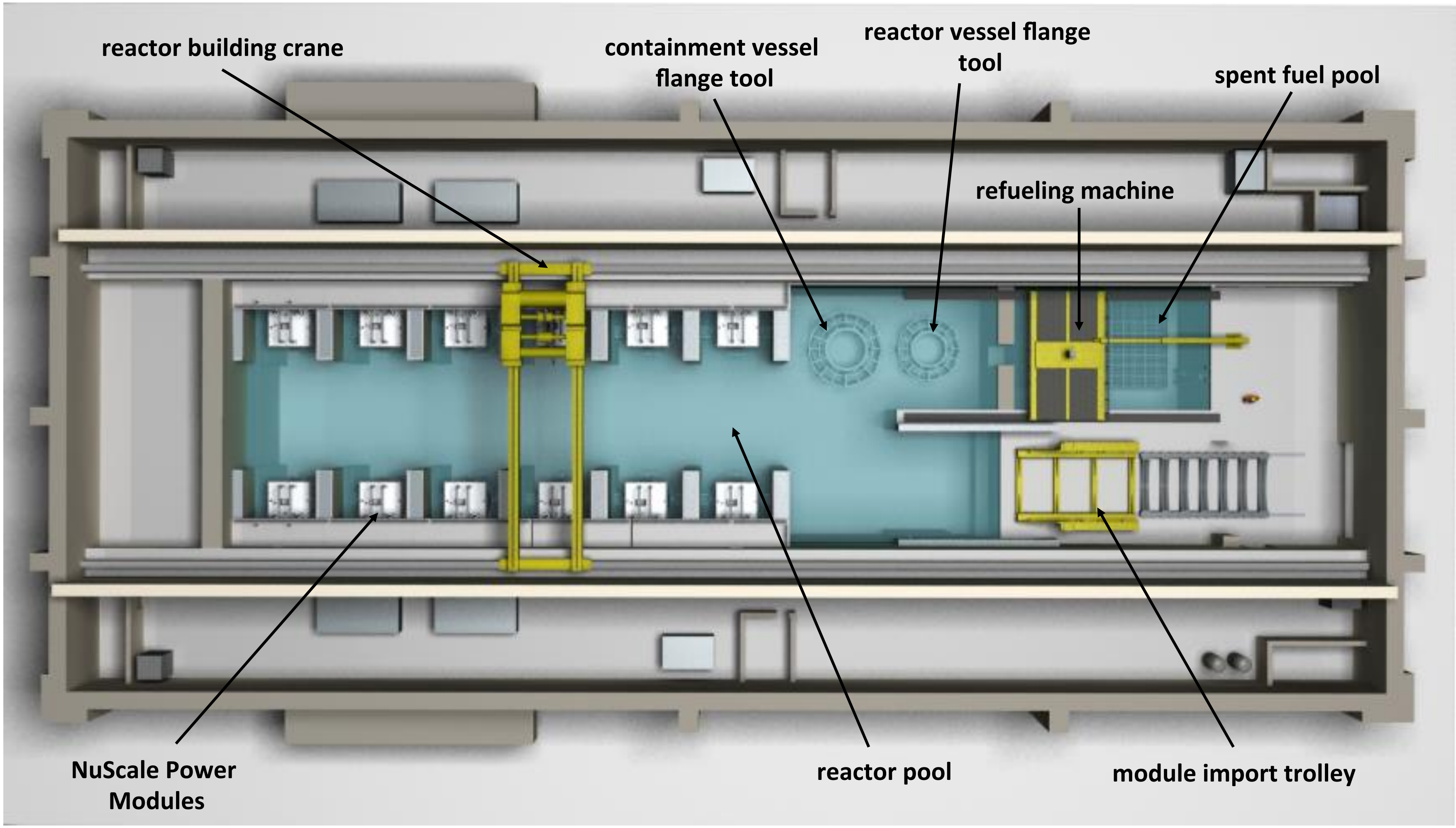
What is a NuScale Power Module?

- A NuScale Power Module (NPM) includes the nuclear reactor, steam generators, pressurizer and ***containment*** in an integral package that eliminates reactor coolant pumps and large bore pipes (no LB-LOCA)
- Each NPM is 50 MWe (gross) and factory built for easy transport and installation
- Each NPM supplies its own skid-mounted steam turbine-generator and condenser
- Each NPM is installed below-grade in a seismically robust, steel-lined, concrete pool
- NPMs can be incrementally added to match load growth - up to 12 NPMs for 570 MWe total net output





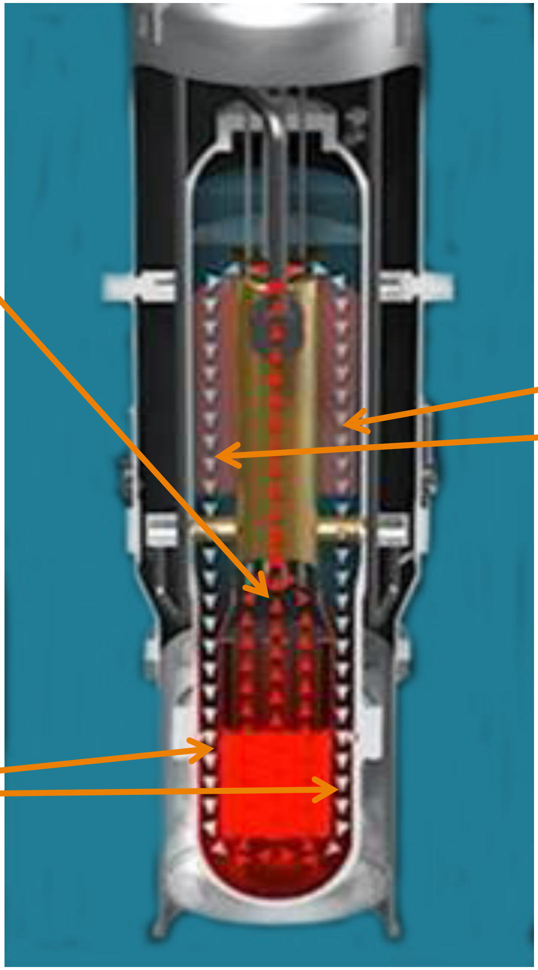
Reactor Building Overhead View



NuScale Power

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**

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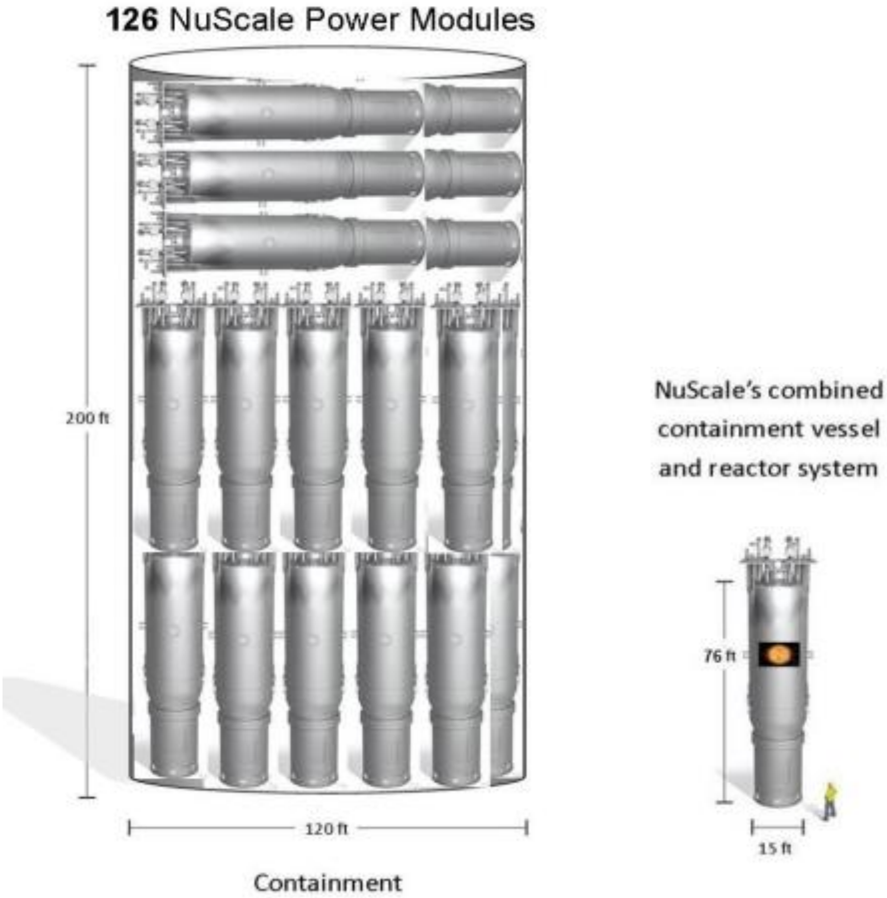
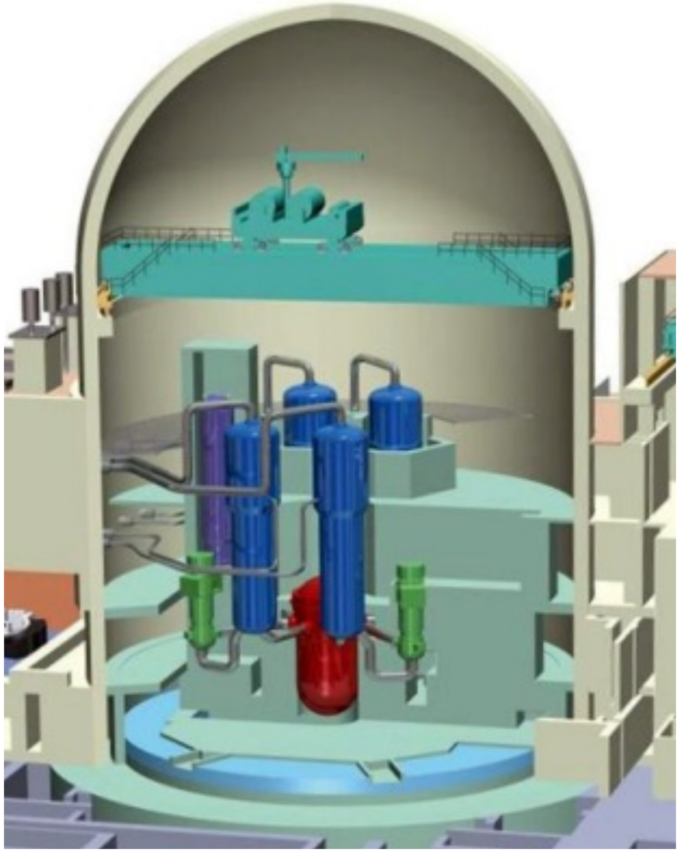
Size Comparison

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

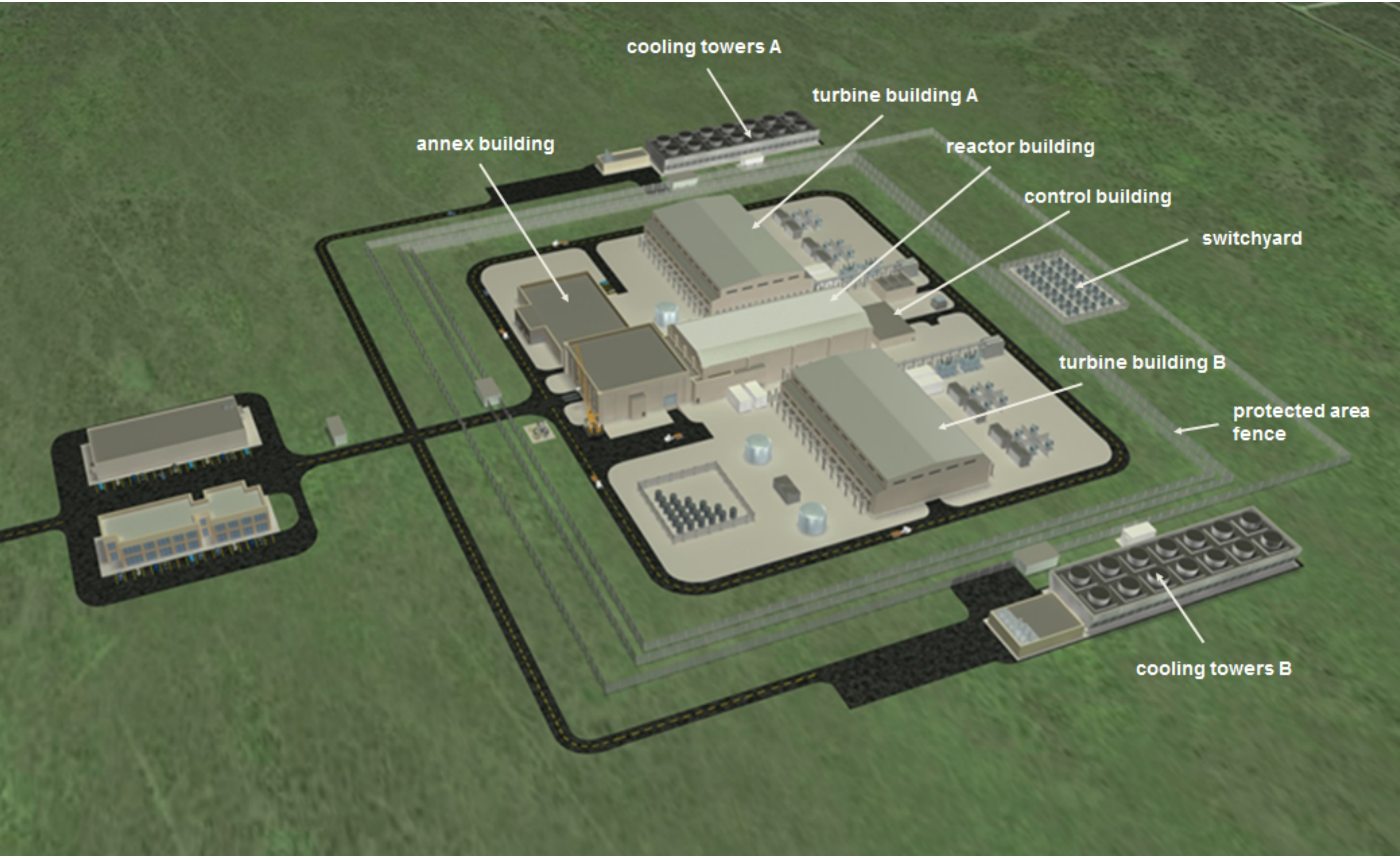


Typical Pressurized Water Reactor



*Source: NRC

Site Layout



NuScale Power™

The Safety Case

NuScale Announces Major Breakthrough in Safety

Wall Street Journal April 16, 2013

- NuScale design has achieved the "Triple Crown" for nuclear plant safety. The plant can safely shut-down and self-cool, indefinitely, 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.

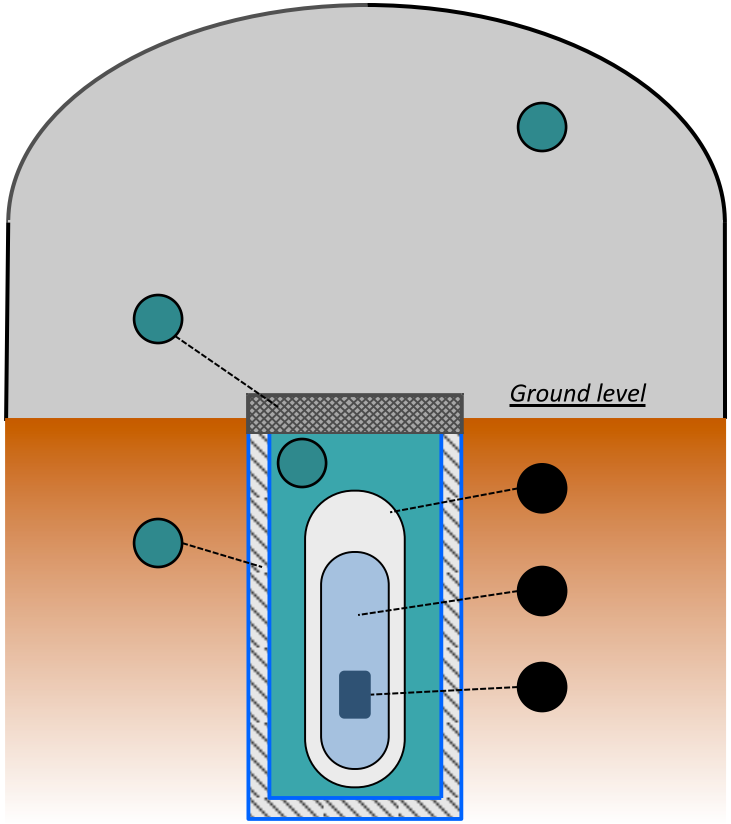
Added Barriers Between Fuel and Environment

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



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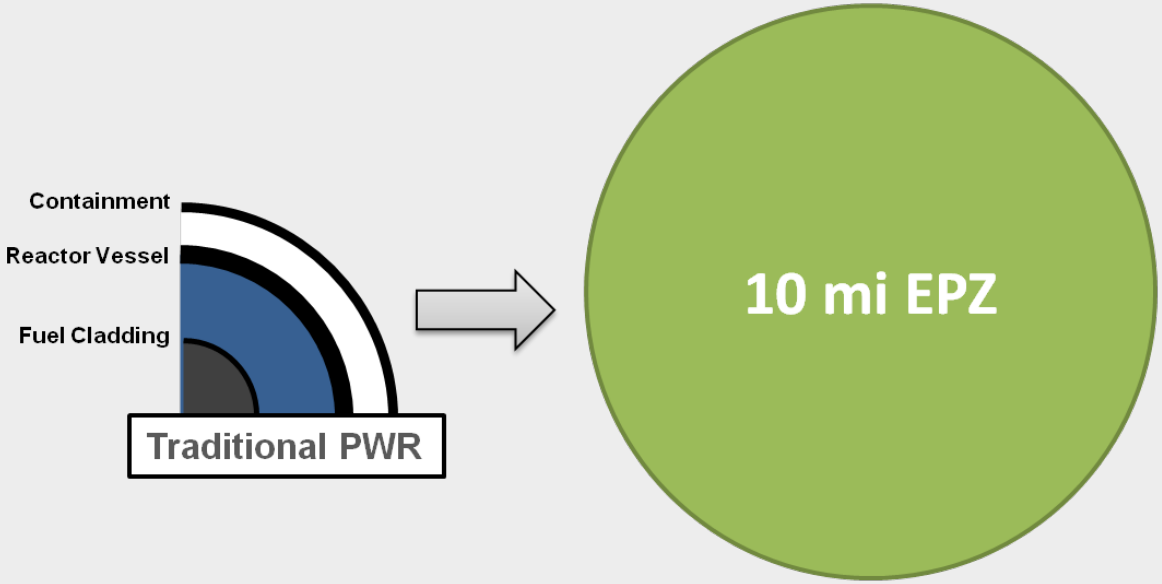
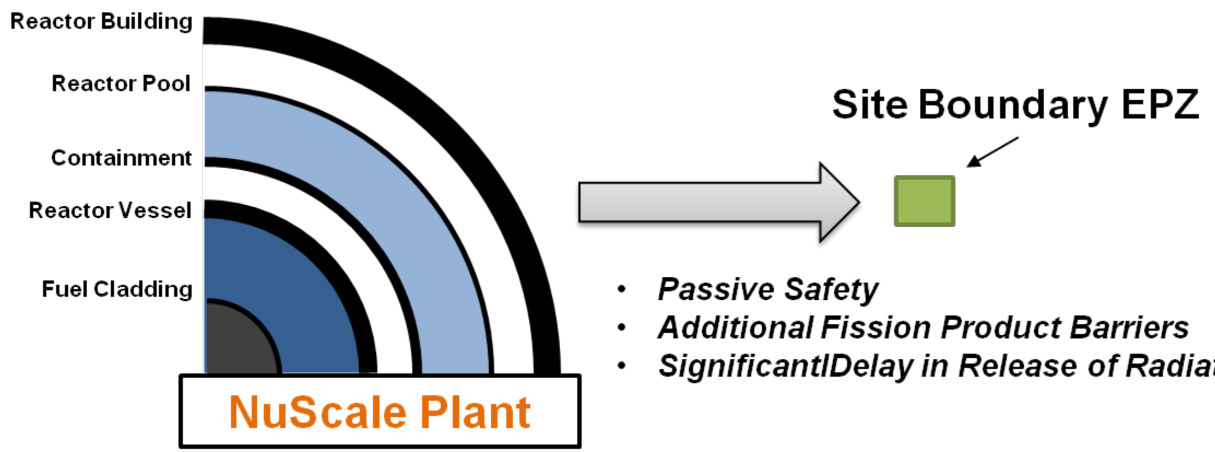
Smaller Emergency Planning Zone Due to Design Attributes





- *Passive Safety*
- *Additional Fission Product Barriers*
- *SignificantlDelay in Release of Radiation*

Typical Nuclear Plant Safety Systems

Systems and Components Needed to Protect the Core:

- Reactor Pressure Vessel
- Containment Vessel
- Reactor Coolant System
- Decay Heat Removal System
- Emergency Core Cooling System
- Control Rod Drive System
- Containment Isolation System
- Ultimate Heat Sink
- Residual Heat Removal System
- Safety Injection System
- Refueling Water Storage Tank
- Condensate Storage Tank
- Auxiliary Feedwater System
- Emergency Service Water System
- Hydrogen Recombiner or Ignition System
- Containment Spray System
- Reactor Coolant Pumps
- Safety Related Electrical Distribution Systems
- Alternative Off-site Power
- Emergency Diesel Generators
- Safety Related 1E Battery System
- Anticipated Transient without Scram (ATWS) System

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What Does This Mean?

Fewer and simpler plant systems

+

Factory manufacturing of NPM and other key modules

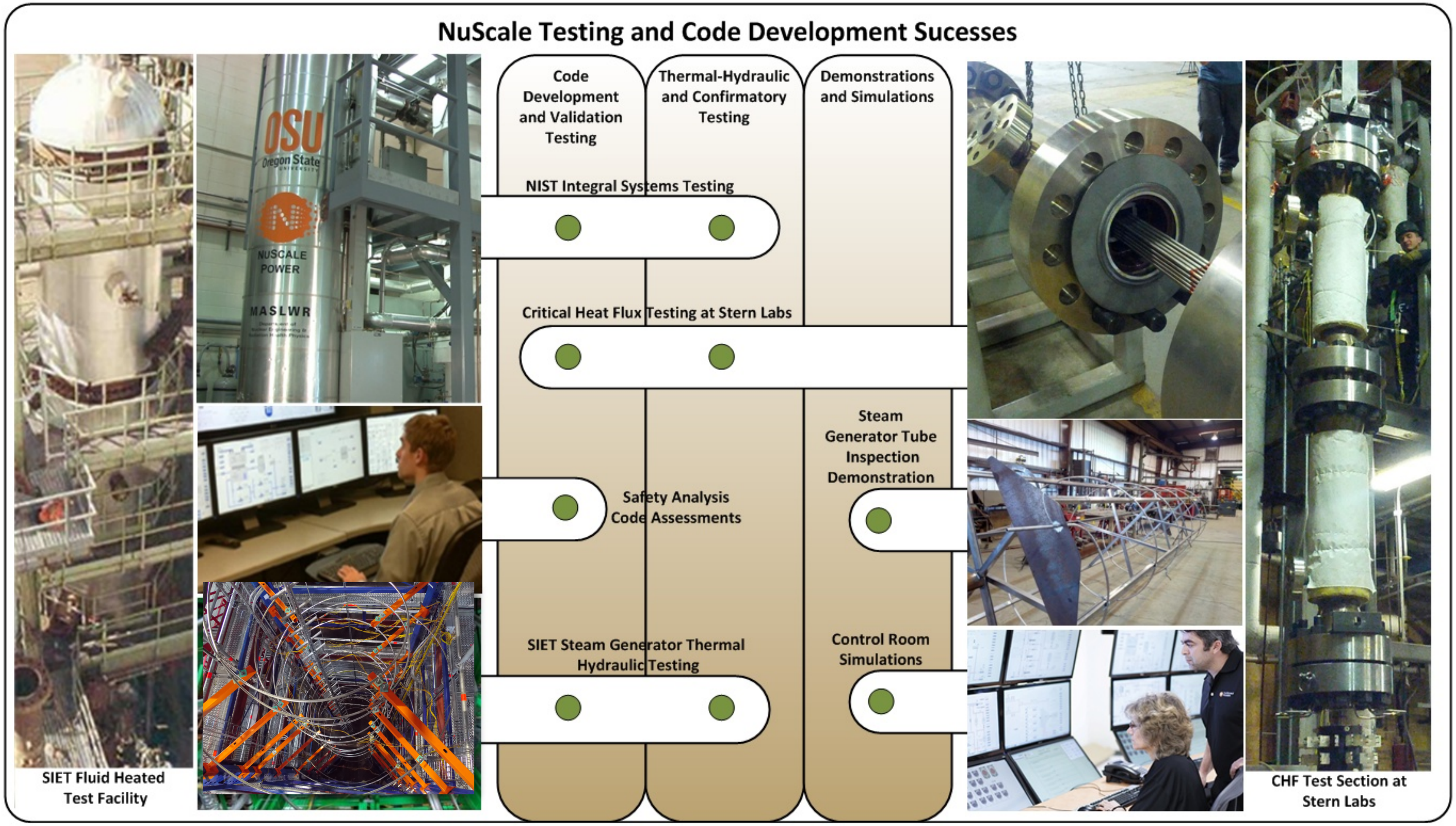
=

Improved safety and quality with lower costs

How do we know it works?

Comprehensive Testing Program

Our testing supports reactor safety code development and validation, reactor design, and technology maturation to reduce FOAK risk.



NuScale Power™

NuScale Integral System Test (NIST) Facility

Containment Vessel and Pool

- 1/3 Scale Test Facility In operation since 2003; upgraded in 2014-15
  - Models RPV, Containment and Pool
  - Prototypic Fluid Conditions
  - NQA-1 Program review and Site Visit by NRC 8/12
- Test Facility Scaling Methodology sent to NRC - 12/10
- IAEA international standard problem test 5/11
- NRC Certification Testing Program in progress.
  - Data Being used for Safety Analysis Code Validation

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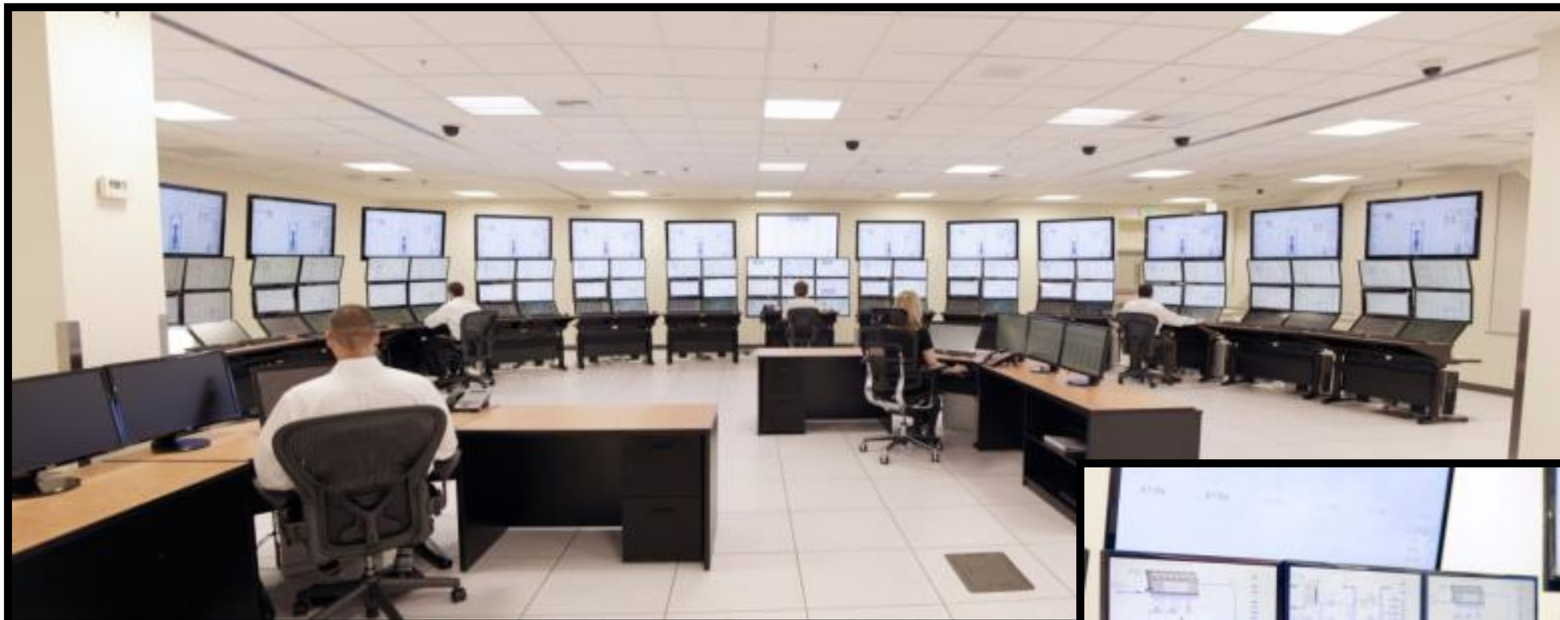
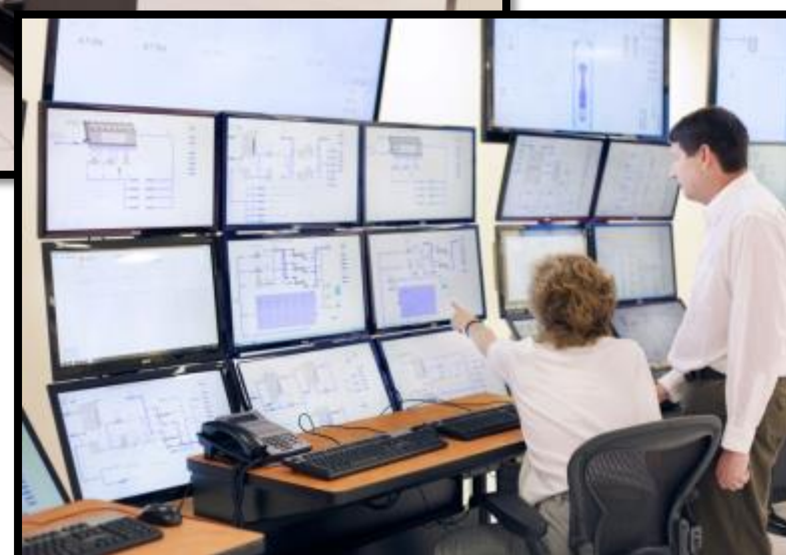
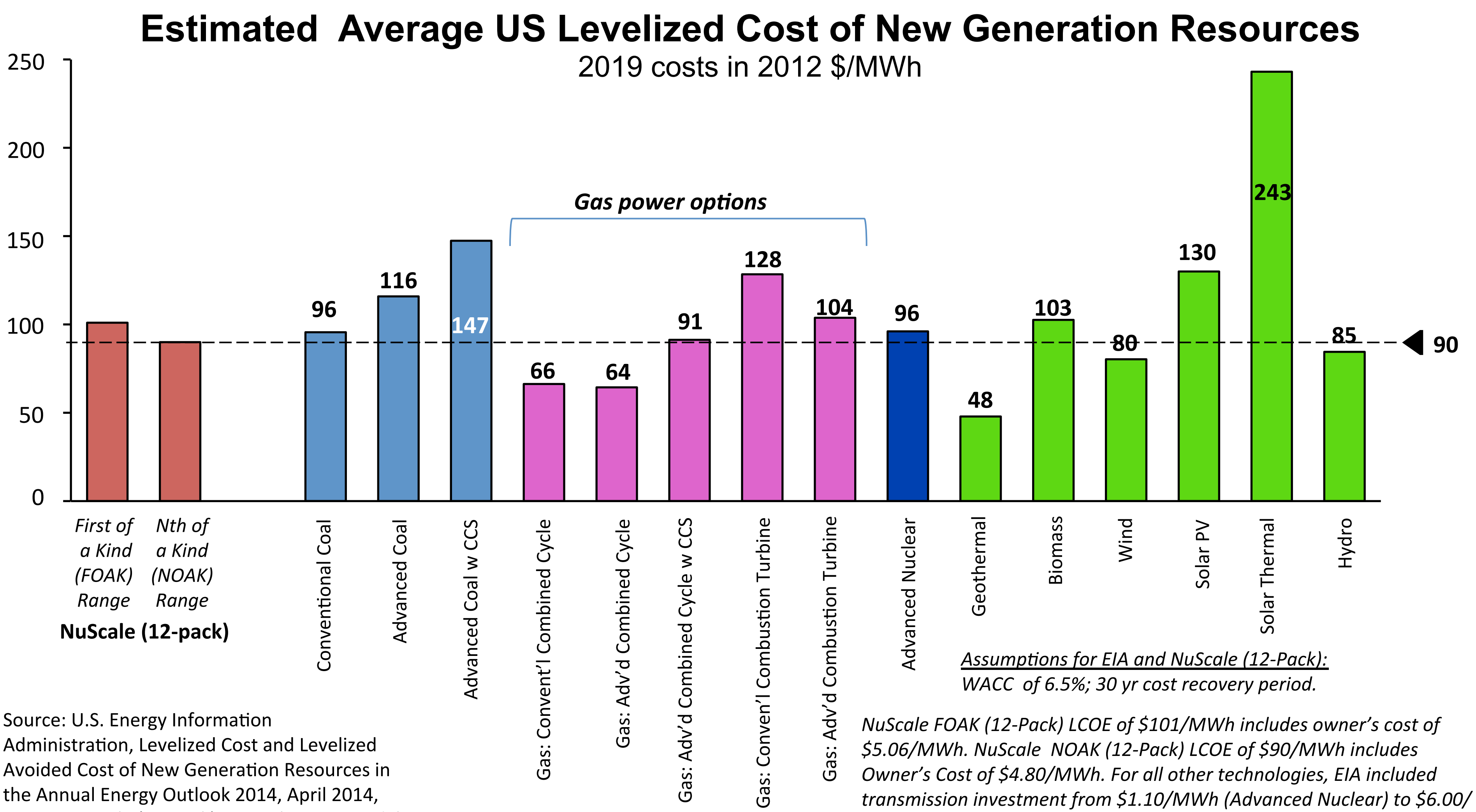
Full-Scale Main Control Room Simulator for Studies

NRC Review of Human Factors Program and Site Visit 1/13





NuScale LCOE in North America Using EIA Methodology



Assumptions for EIA and NuScale (12-Pack):
WACC of 6.5%; 30 yr cost recovery period.

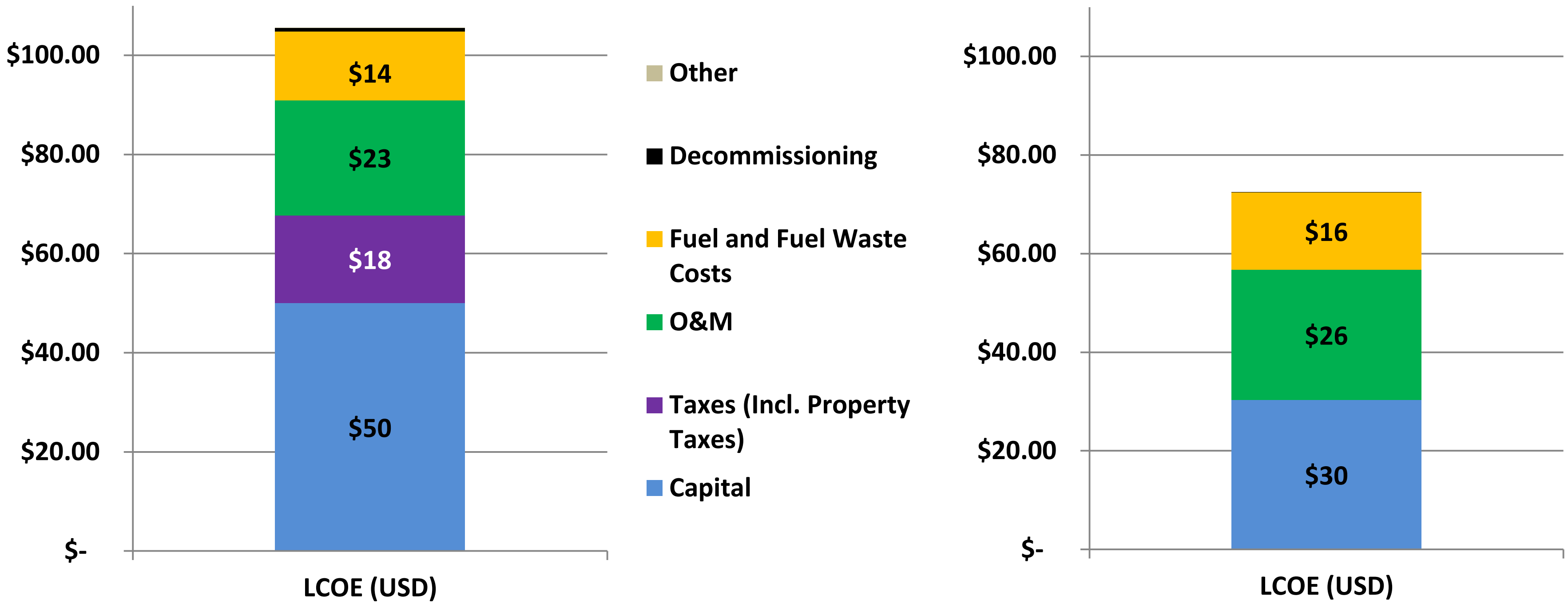
Source: U.S. Energy Information Administration, Levelized Cost and Levelized Avoided Cost of New Generation Resources in the Annual Energy Outlook 2014, April 2014, *except NuScale (12-pack); NuScale LCOE Model*

NuScale FOAK (12-Pack) LCOE of $101/MWh includes owner's cost of $5.06/MWh. NuScale NOAK (12-Pack) LCOE of $90/MWh includes Owner's Cost of $4.80/MWh. For all other technologies, EIA included transmission investment from $1.10/MWh (Advanced Nuclear) to $6.00/MWh (Solar Thermal). NuScale included $1.10/MWh for transmission investment in the FOAK and NOAK LCOE values.

Note: EIA projects 2019 Henry Hub spot natural gas prices of approx.$4.70/mmbtu (2012 Dollars) (Annual Energy Outlook 2014)

LCOE Breakdown (First-of-a-Kind)

Levelized Cost in 2015 US Dollars



FOAK with Regulated Utility Financing (IOU)

- 55% debt at 5.5%, 45% equity at 10%

$106 USD

FOAK with Municipal Financing

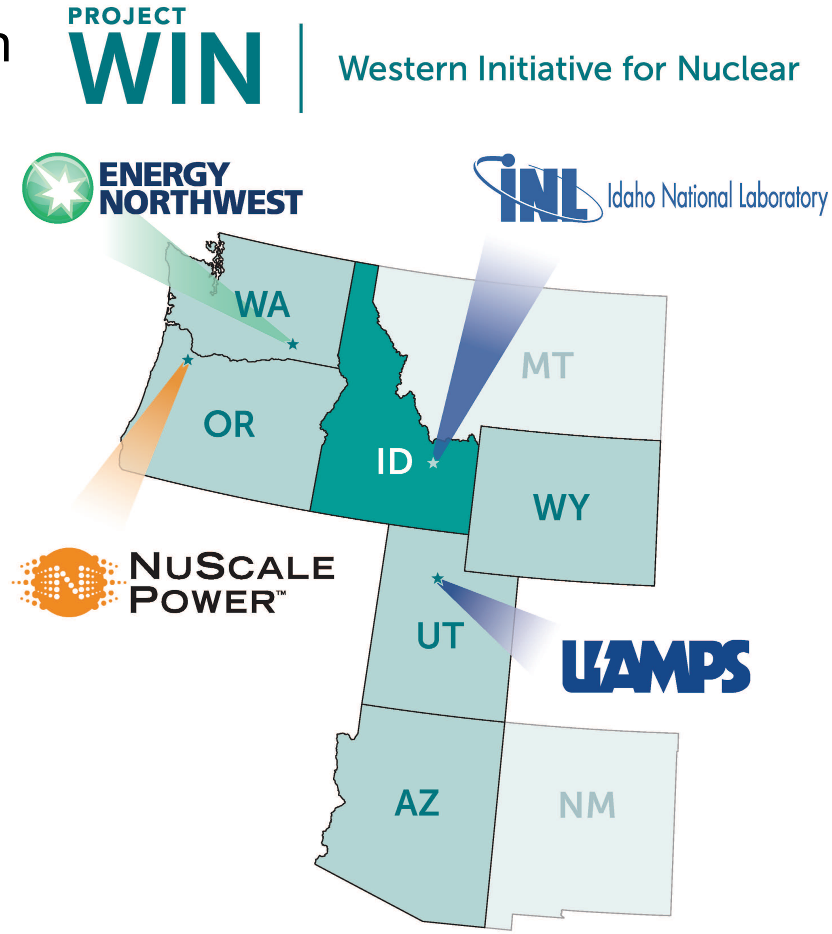
- 100% debt at 3.5%, no equity

$72 USD

Note: Capital costs reflect the Fluor SE estimate completed in 2014.

First Deployment: Program WIN

- Western Initiative for Nuclear (WIN) is a multi-western state collaboration to deploy a NuScale Power Project, sited in ID.
- Involved Program WIN participants: NuScale, UAMPS, Energy Northwest, ID, UT, OR, WA, WY, AZ
- First commercial project: Preferred location within the Idaho National Laboratory (INL) Site.
- Commercial operation 2023-2024
- A 12-module plant (570 MWe)



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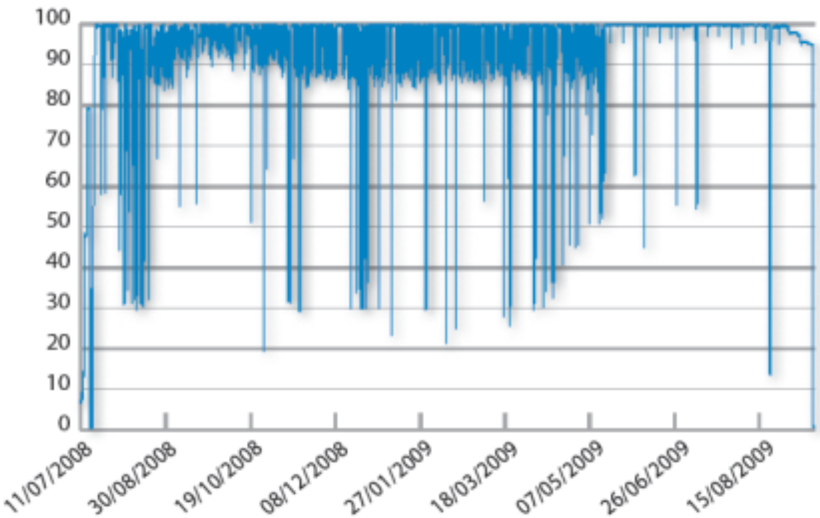
Future Generation Portfolios With Nuclear and Renewables

High Percentage of Nuclear in Portfolio

Figure 1: Typical power history during an EDF reactor cycle (in % of rated power)

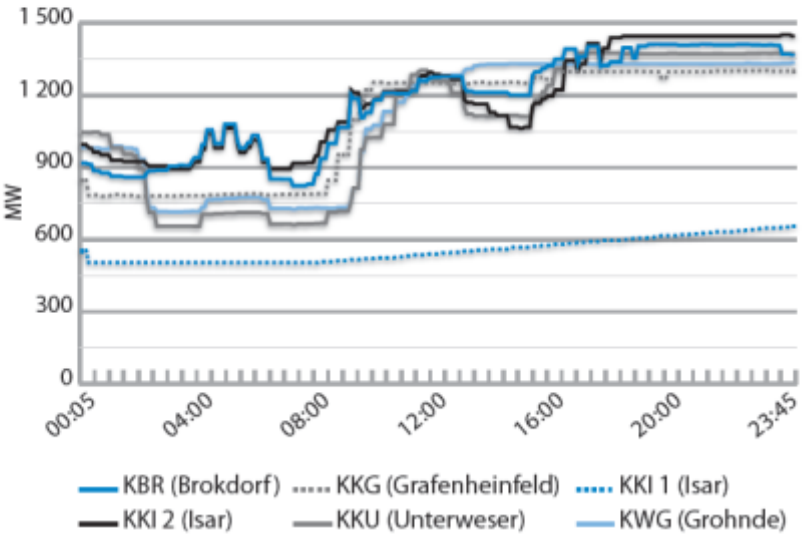


Courtesy of Électricité de France (EDF).

13-month history

High Percentage of Renewables On System

Figure 2: Example of load-following during 24 hours at some German nuclear power plants



Courtesy of E.ON Kernkraft.

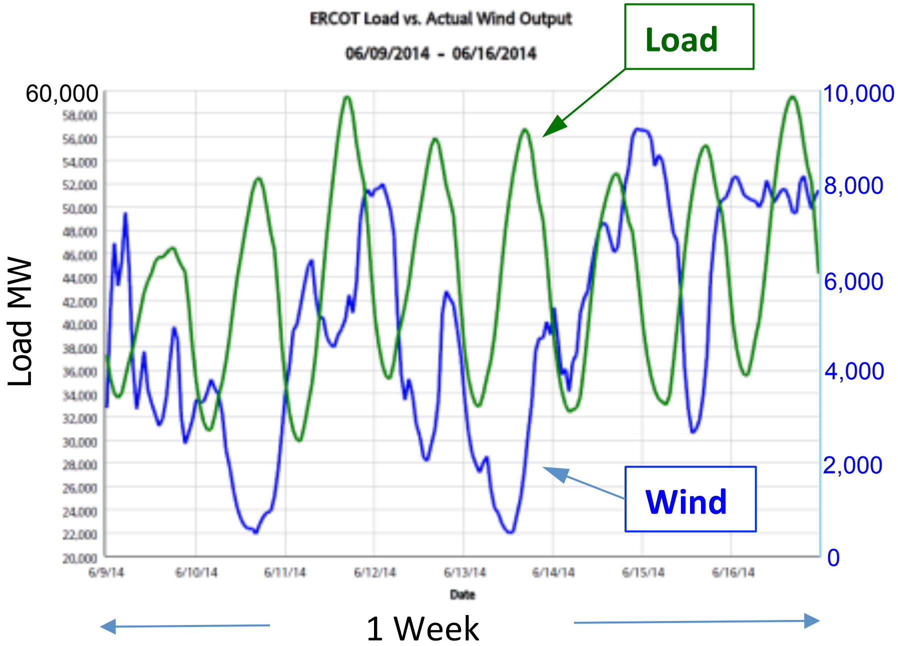
24-hour history

NEA updates, NEA News 2011 – No. 29.2

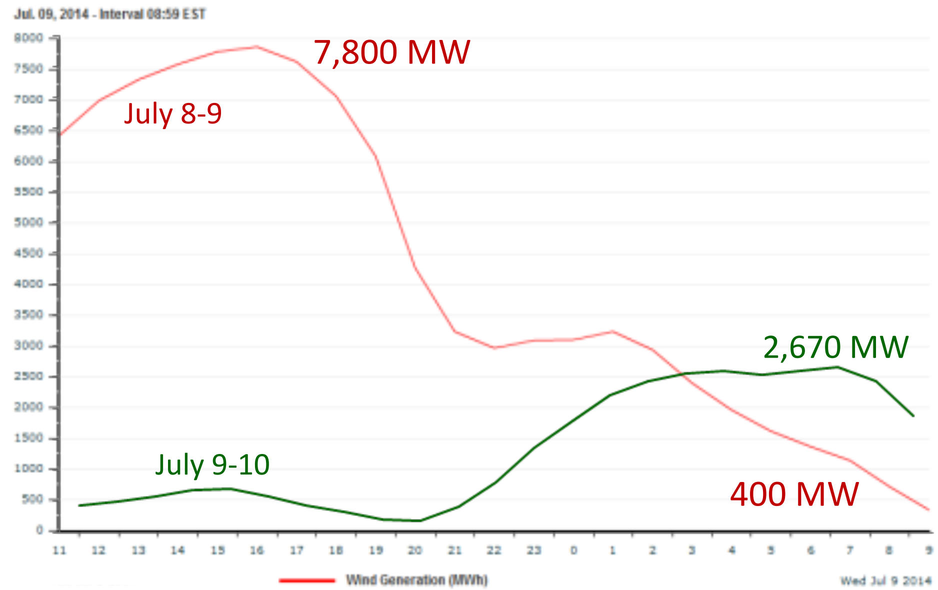
Load Follow Opposite Renewables

Wind Generation in ERCOT and MISO

ERCOT Weekly



MISO Daily – July 8-10, 2014



- NuScale Power Plant designed to load follow, if and when needed
- Three ways, module, ramp-rates, and full bypass capability

NuScale Power

One Approach – Federal Facility
Clean and Secure Power

NuScale Power SMR

Nearby
Federal Facilities

- Longer term power supply agreements with local electricity suppliers and DOE and/or DoD facility to provide cost competitive, carbon-free and reliable electricity supply to large federal facilities (>100MWe)
- DOE selection based on cost and a "credit" for "carbon-free" generation and supply reliability, e.g., continuity of supply during prolonged loss of commercial grid and/or fuel supply
- If needed, government to provide access to federally controlled lands at or adjacent to federal facilities for siting of generation and secure electricity transmission infrastructure

NuScale Power™

So What Is Needed?

- Complete licensing and get first one or two plants built
- National and state policy clarity and consistency regarding clean energy goals and credit for nuclear in helping to meet those goals.
- In areas where competitive energy markets prevail, improvements in how capacity, energy, and reliability are valued and compensated in order to support investments in a balanced generation portfolio and eliminate market bypass mechanisms that distort market capacity and energy prices.

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The Element of Nu

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