NU
Power f

NuScale Sma
Reactor (SM

INPRO Dialogue Forum on
Challenges in Small Modula

Ulsan, Republic of Korea

2-5 July 2019

Ken Lang
VP, Operatio

Acknowledgement and Disclaimer

This material is based upon work supported by the Department
Award Number DE-NE0000633.

Artistic concept of the NuScale Power Plant

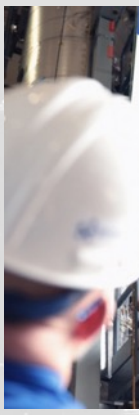
NuScale's Miss

NuScale Power provi
advanced nuclear tec
production of electric
clean water to **impro**
life for people arou

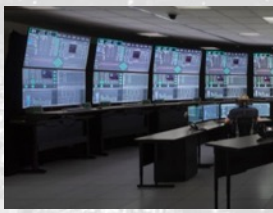
Who is NuScale Power?

- NuScale Power was formed in 2007 for the sole purpose of completing the design and commercializing a small modular reactor (SMR) – the NuScale Power Module™.
- Initial concept had been in development and testing since the 2000 U.S. Department of Energy (DOE) MASLWR program.
- Fluor, global engineering and construction company, became lead investor in 2011.
- In 2013, NuScale won a $226M competitive U.S. DOE Funding Opportunity for matching funds.
- >400 patents granted or pending in nearly 20 countries.
- >350 employees in 6 offices in the U.S. and 1 office in the U.K.
- Making substantial progress with a rigorous design review by the U.S. Nuclear Regulatory Commission (NRC).
  - Phase 4 of NRC Review is on schedule for completion December 2019.
- Total investment in NuScale to date ~US$800M.
- On track for first plant operation in 2026 in the U.S.

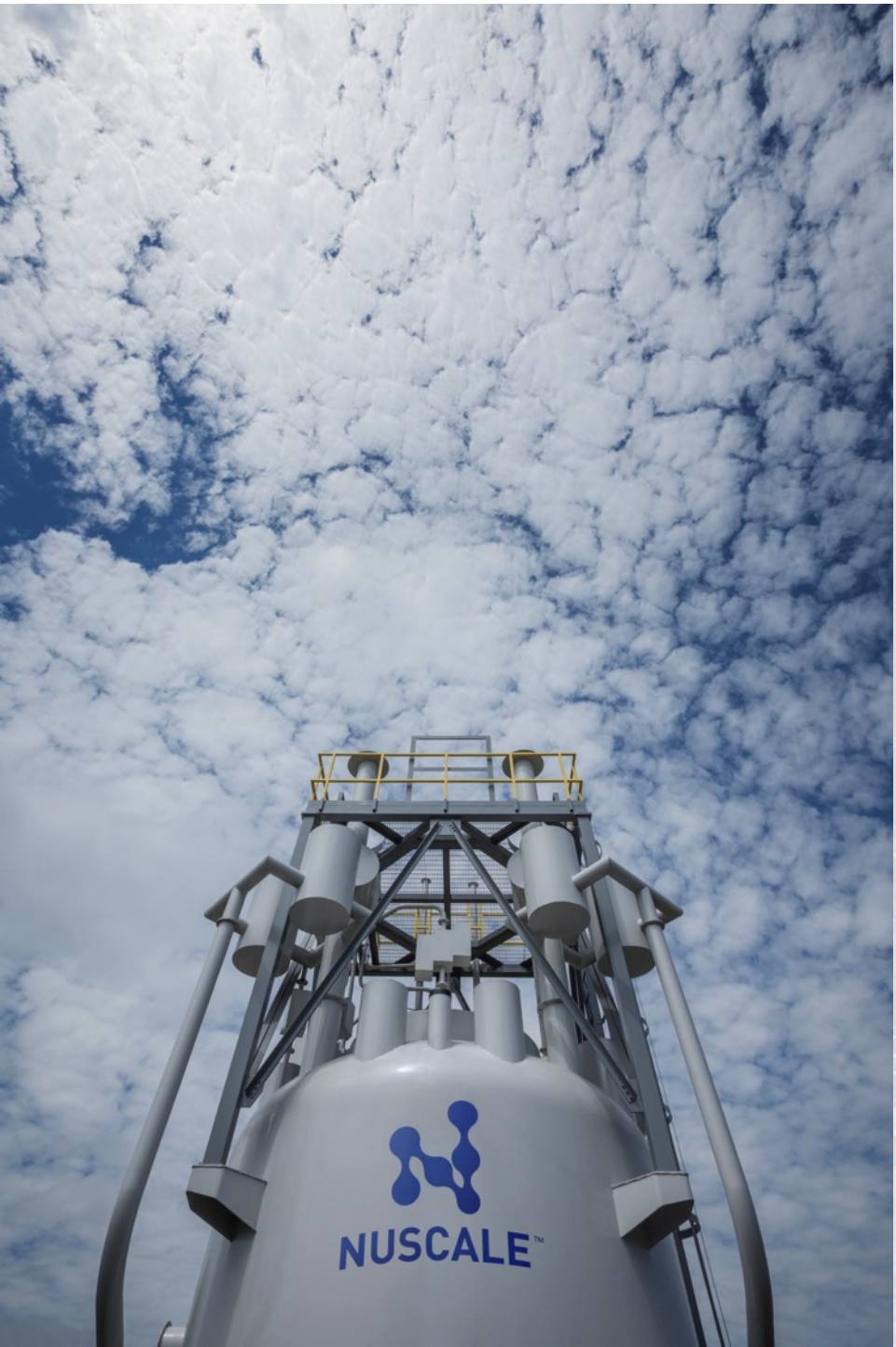
NuScale Eng



One-third s

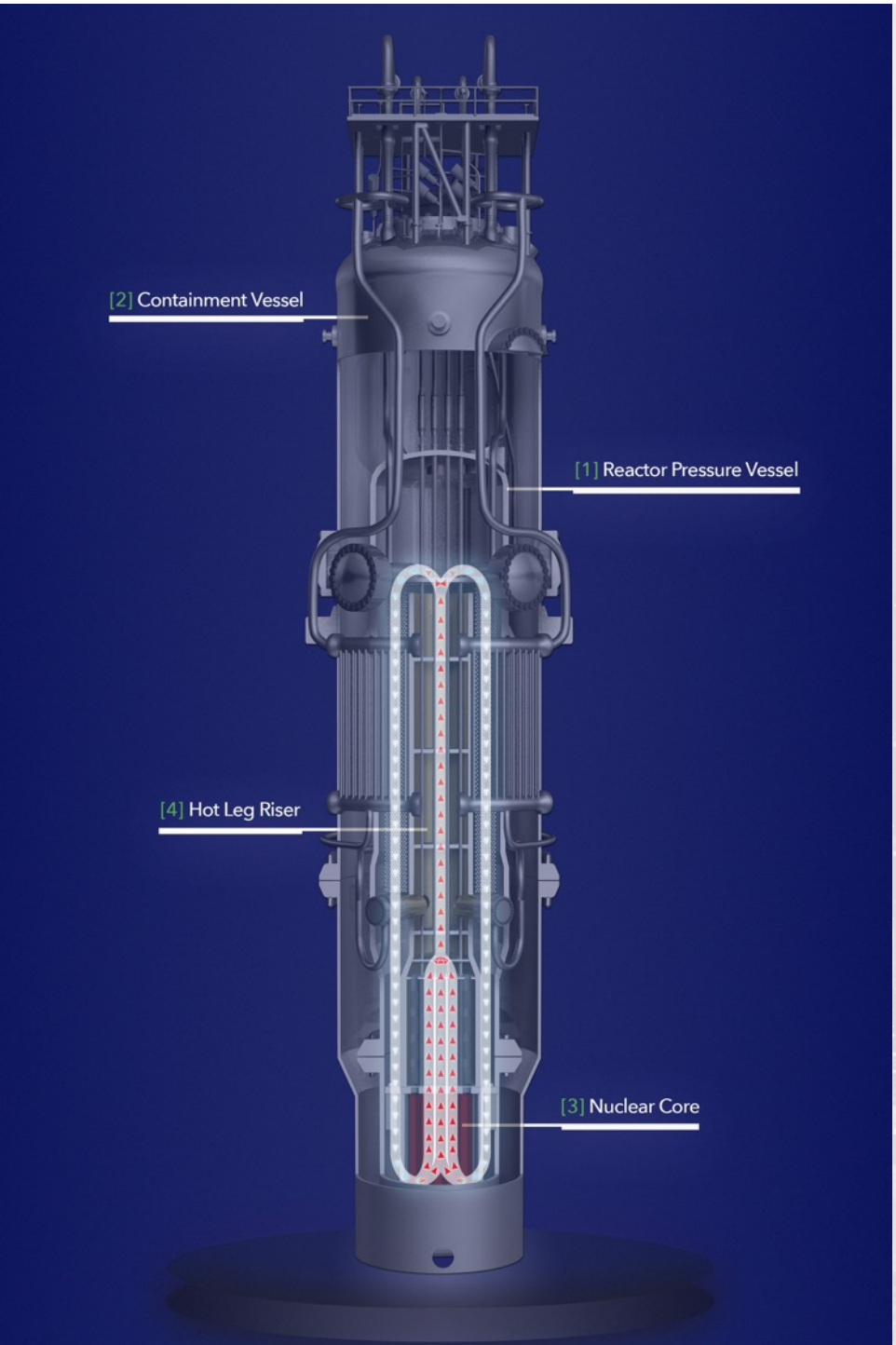


NuScale C



A bold, new en

- **Smarter energy** – flexib multiple applications, int resources, provide highl mission critical facilities, baseload power.
- **Cleaner Energy** – 100% as clean as wind or sola footprint.
- **Safer Energy** – should i NuScale's SMR shuts its cools for an indefinite pe operator action required and no AC or DC power
- **Cost Competitive** – the less complex than other fabrication and assembly Components are deliver to-install form. All of this occurring in a shorter, m of time.

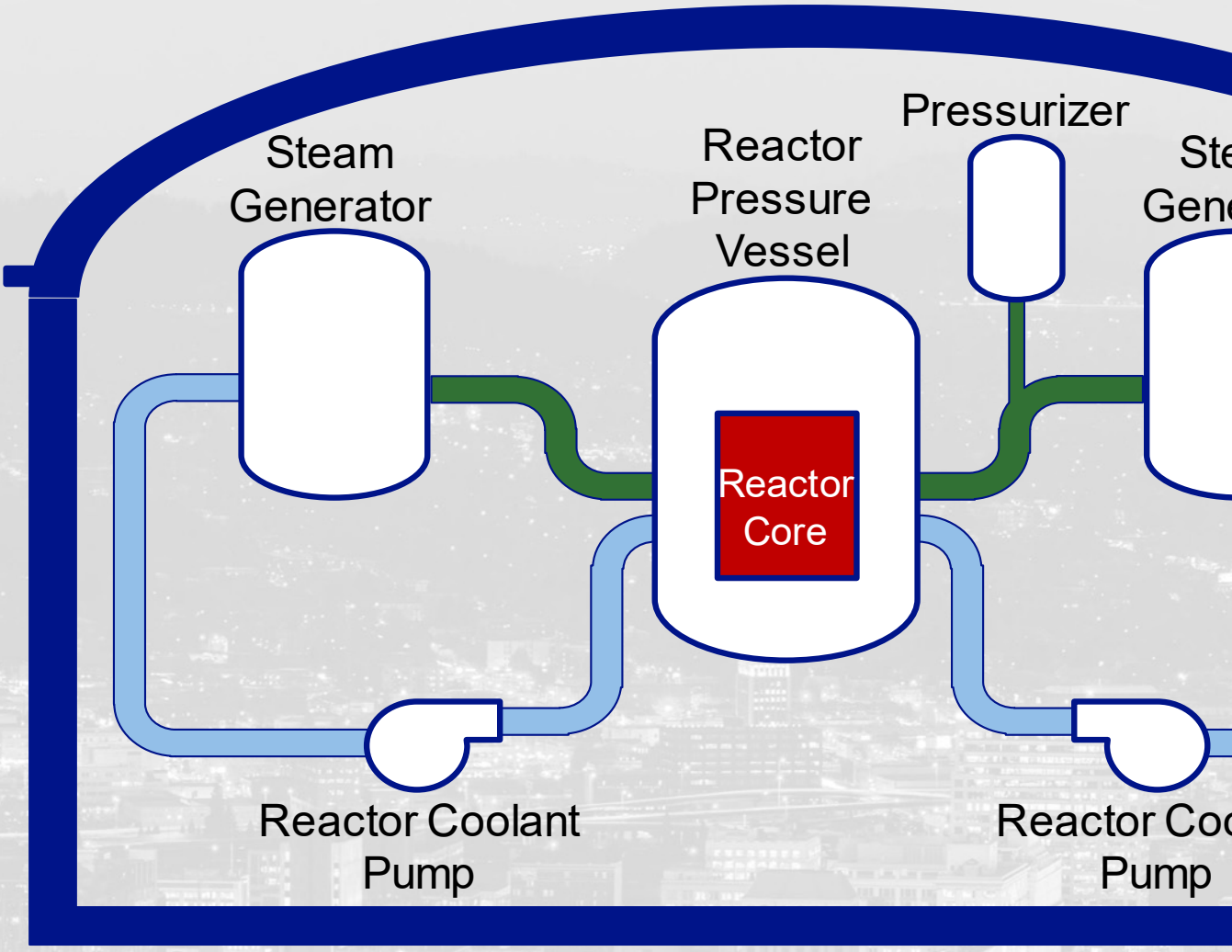


Core Technolog
NuScale Power

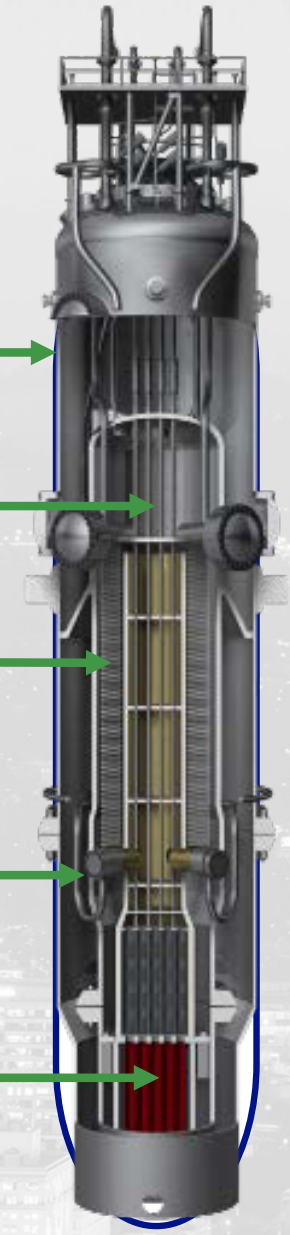
- A **NuScale Power Mod** the reactor vessel, stear pressurizer, and contain **package** – simple desig reactor coolant pumps, l other systems and comp conventional reactors.

- Each module produces
  - small enough to be fa transport and installa
  - dedicated power con flexible, independent
  - incrementally added t – up to **12 modules** (684 MWe net) total c

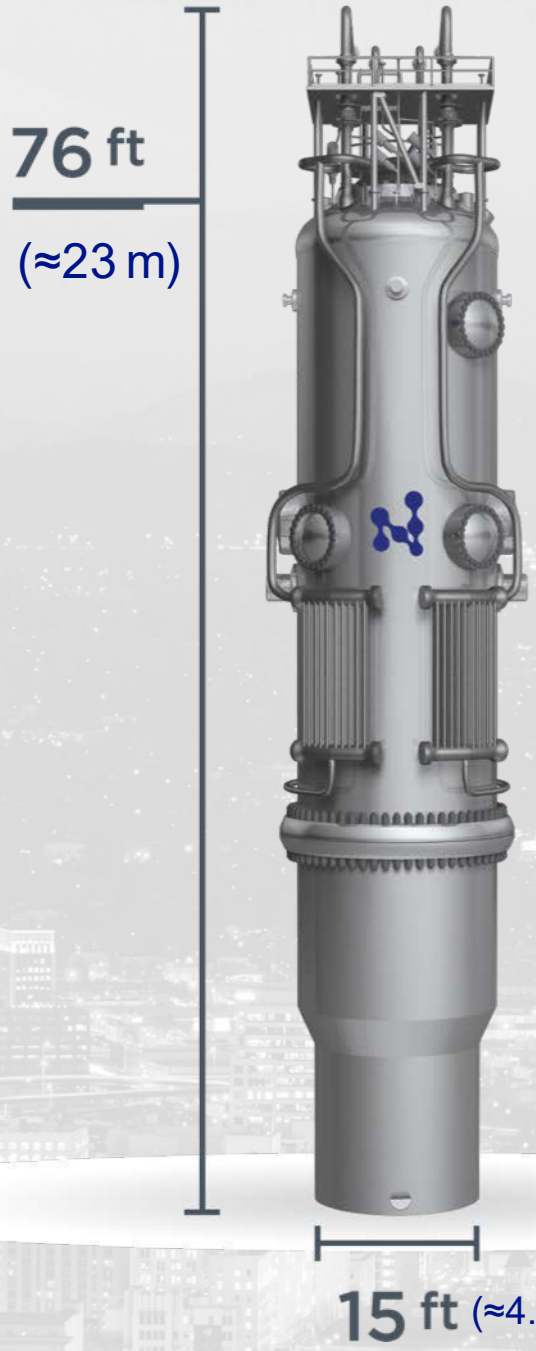
Typical Pressurized Water Reactor



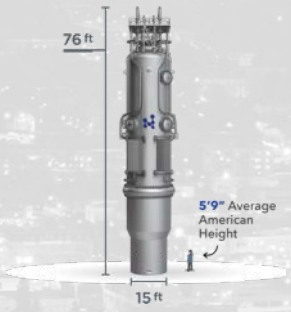
NuScale Small Modular Reactor



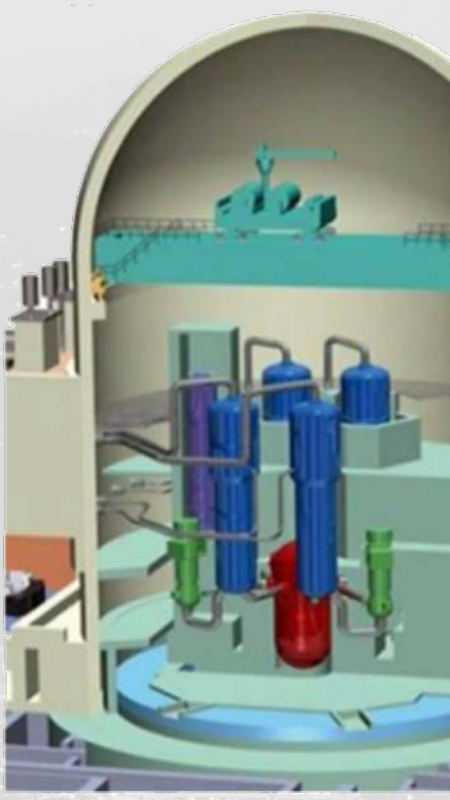
Dimensions



Comparison to a Large Pressurized Water React



NuScale Power Module



Typical Large PW

Image: U.S. Nuclear Regulatory Commission

Simplicity Enhances Safety

Natural Convection for Cooling

- Passively safe - cooling water circulates through the nuclear core by natural convection eliminating the need for pumps

Seismically Robust

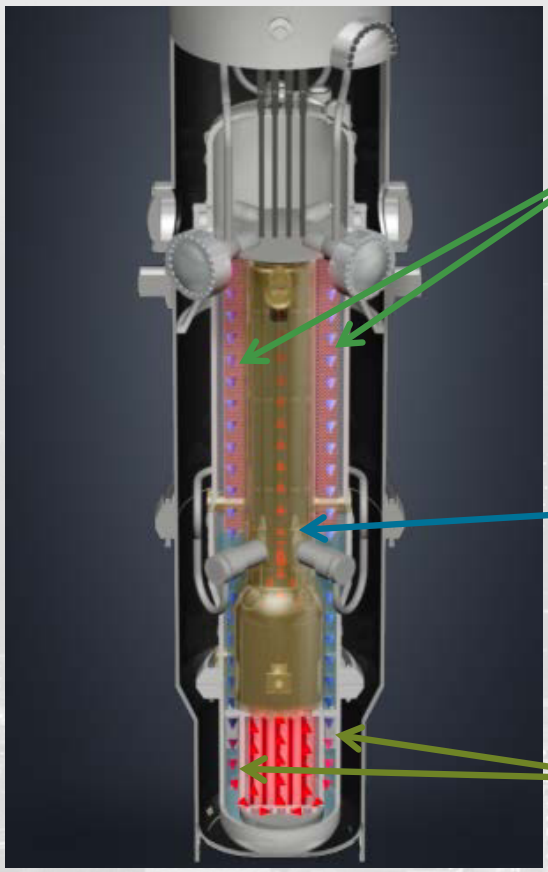
- System submerged in a below-grade pool of water in an earthquake and aircraft impact resistant building

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



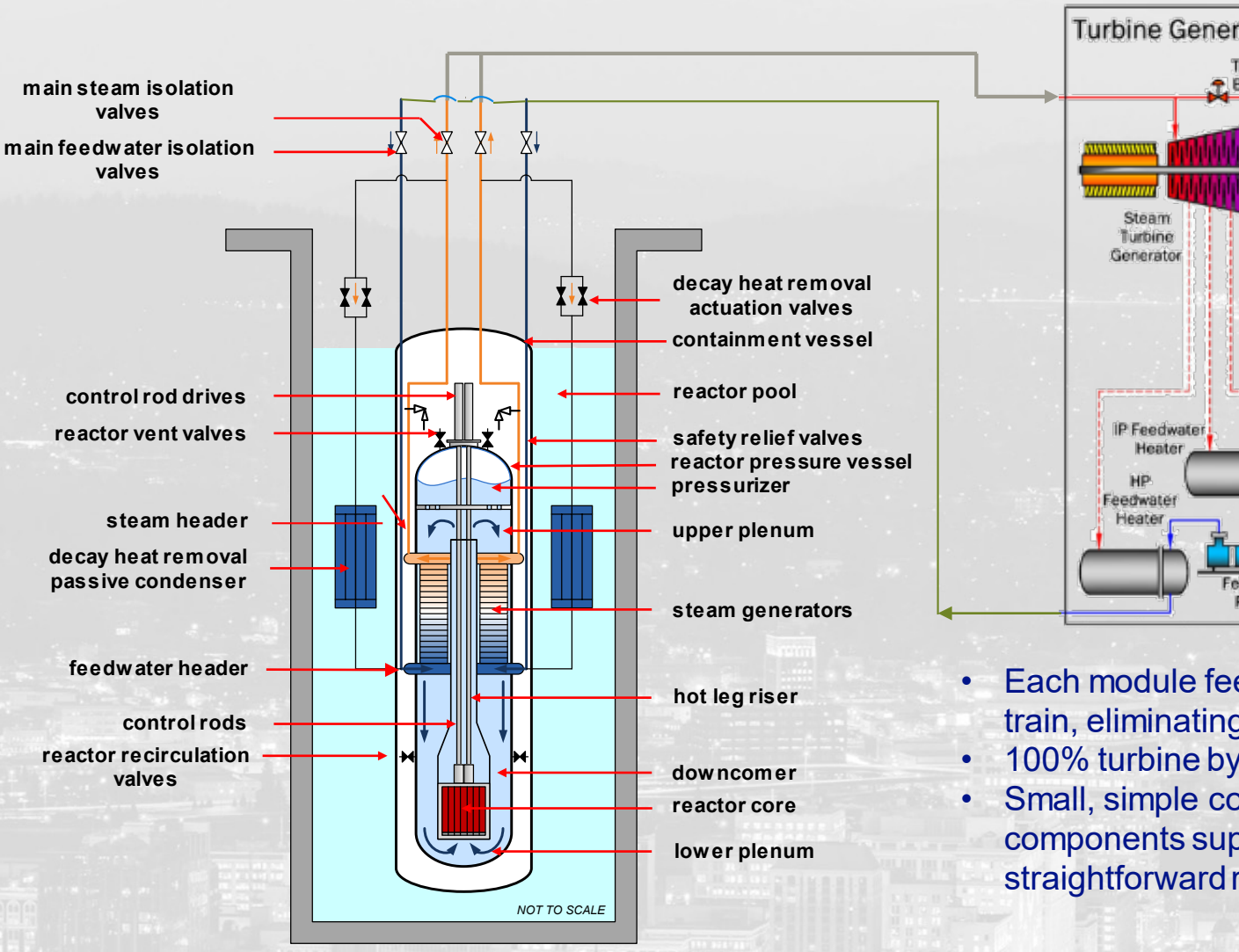
Cond
by th
(prim
heat
tube
heati
tube
turni
trans
wate

Conv
nucle
prima
by co
throu
chim

Grav
(dens
to bo
vess
circu

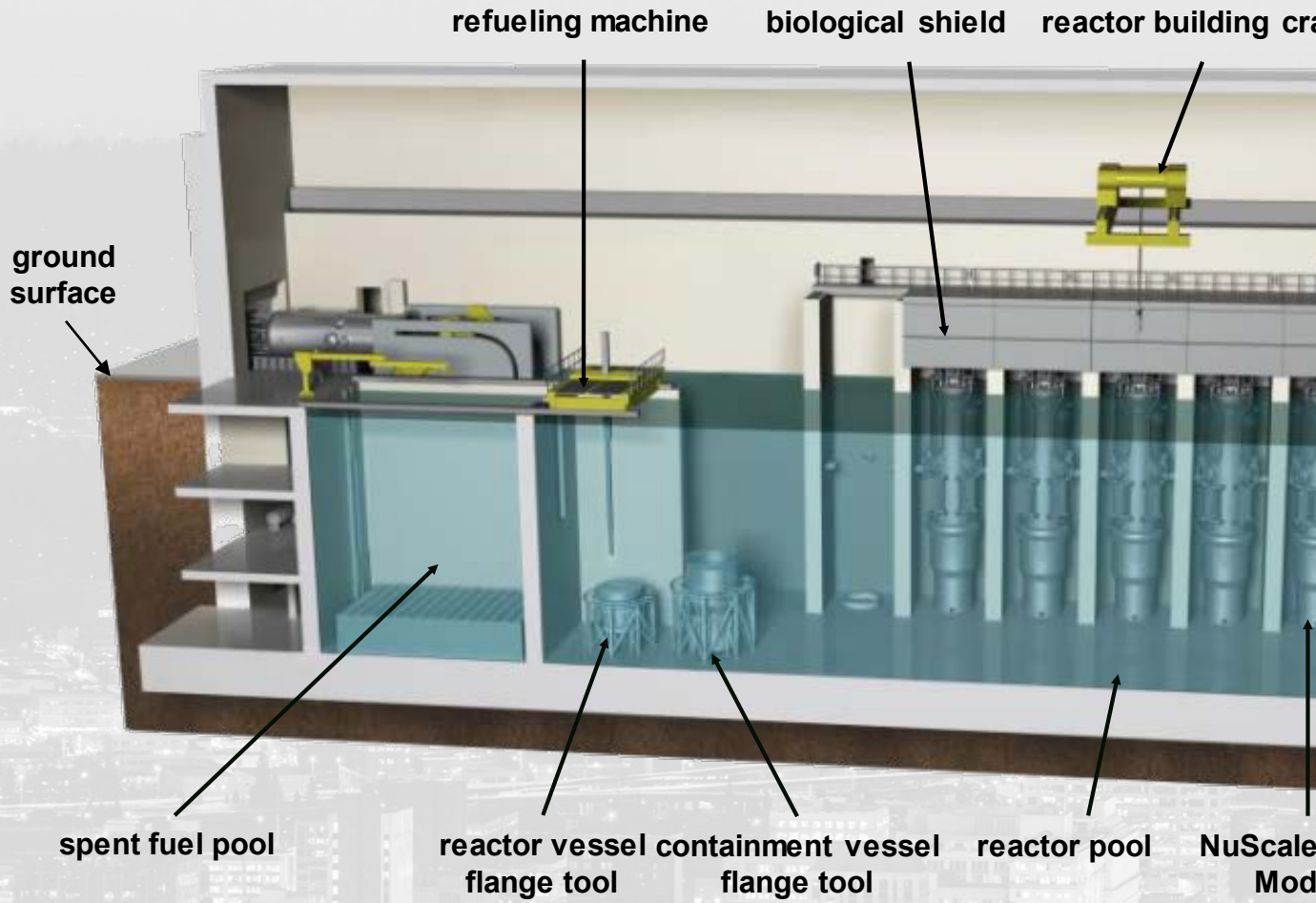
Second-to-none safety case – site boundary Emergency Plannir

NuScale Power Train

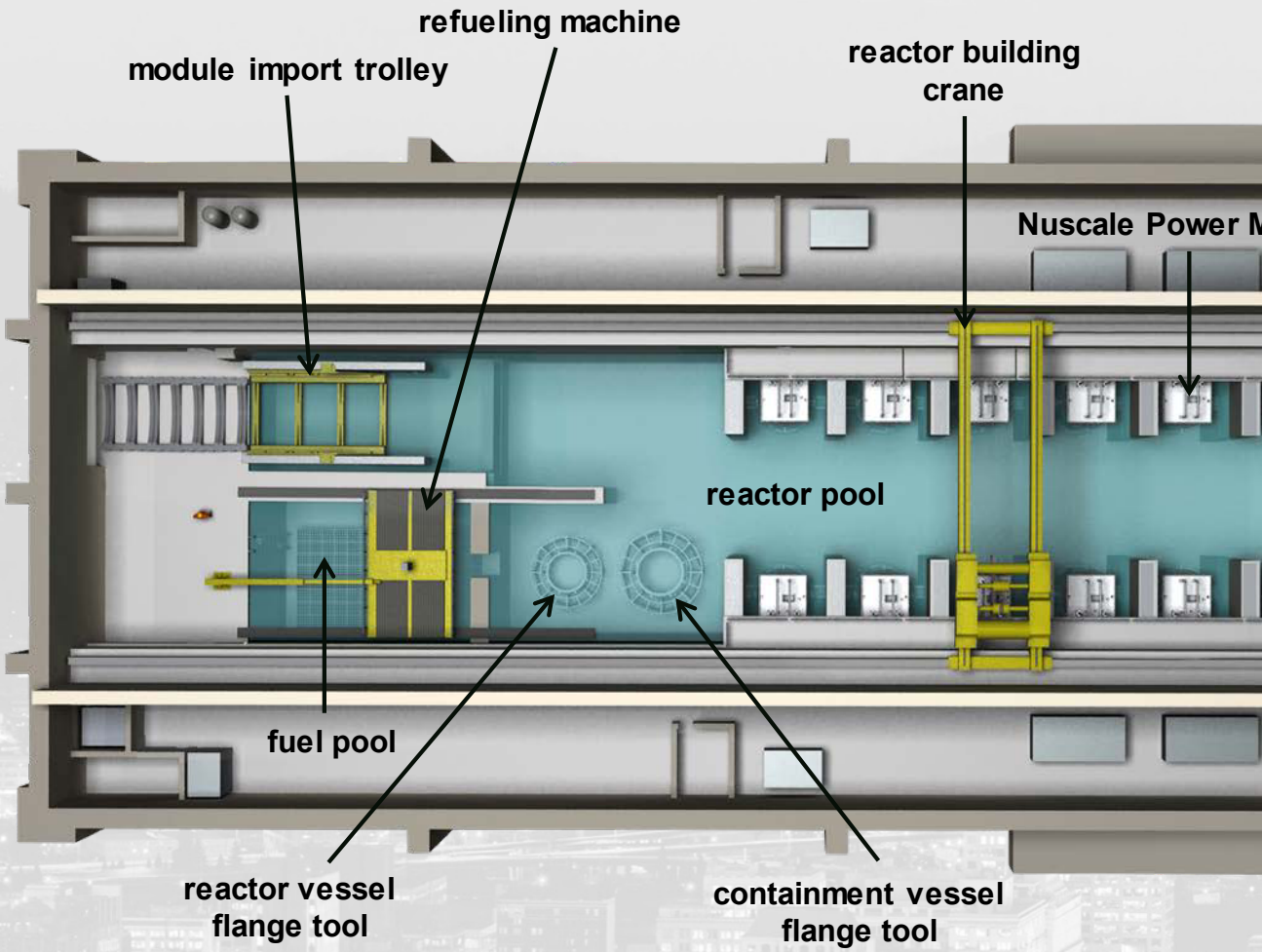


- Each module fe
  train, eliminating
- 100% turbine by
- Small, simple co
  components sup
  straightforward r

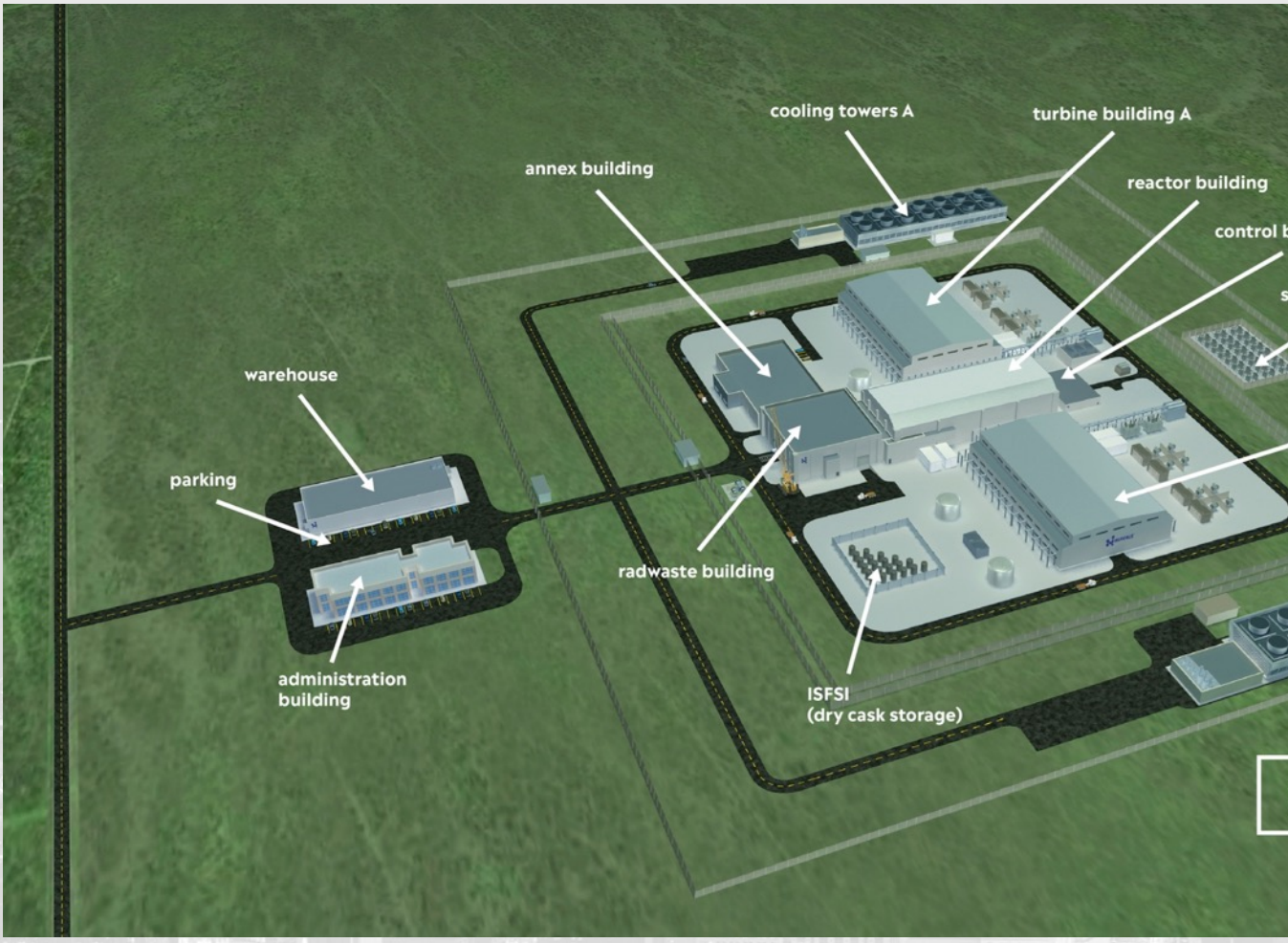
Reactor building houses NuScale Power Module spent fuel pool, and reactor pool



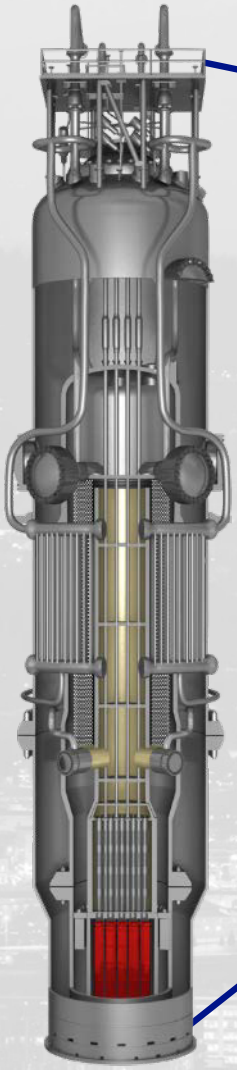
Reactor Building Overhead View

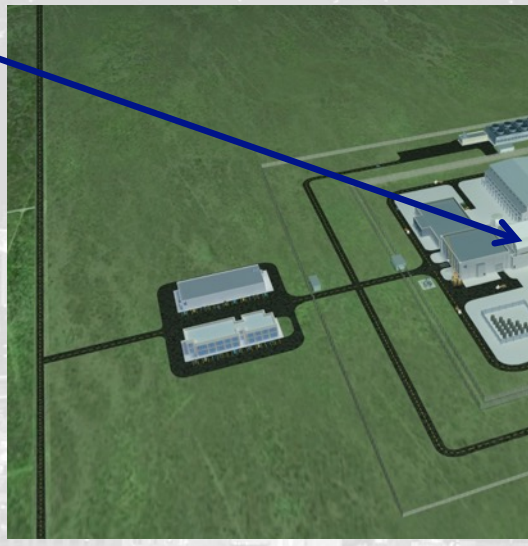


Detailed Plant Site Layout



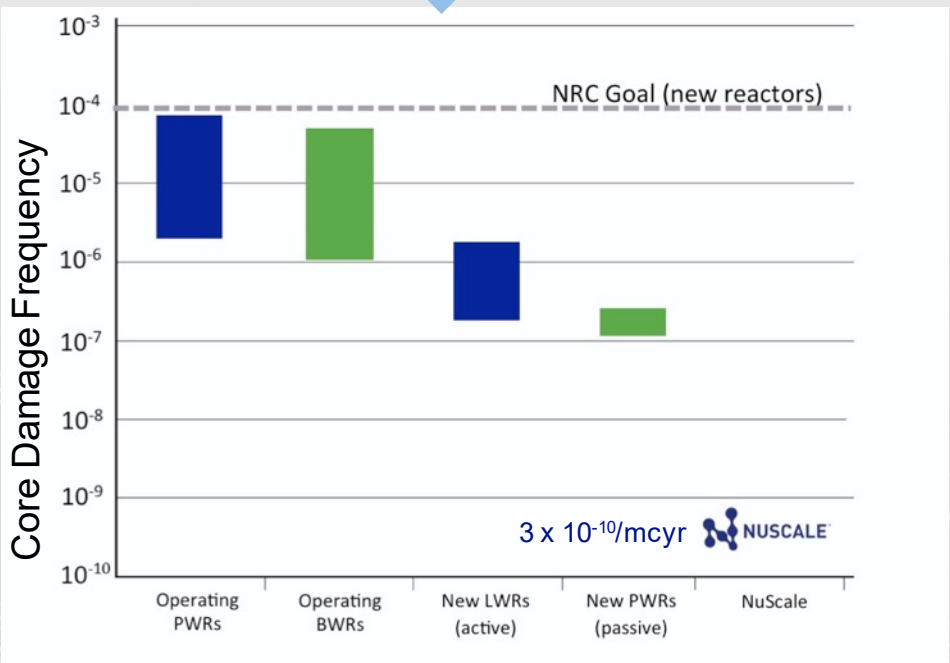
NuScale Plant Site Overview

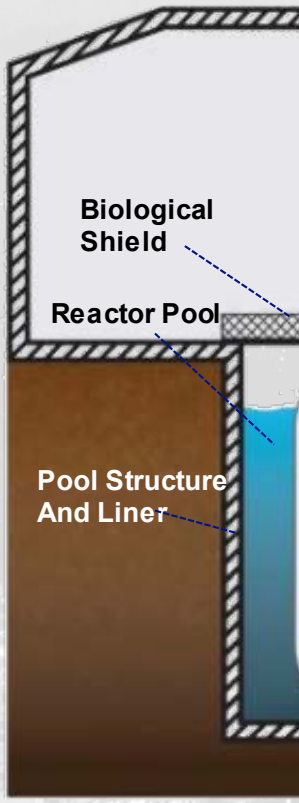




Reducing Plant Risk

Risk = (frequency of failure) X (conse

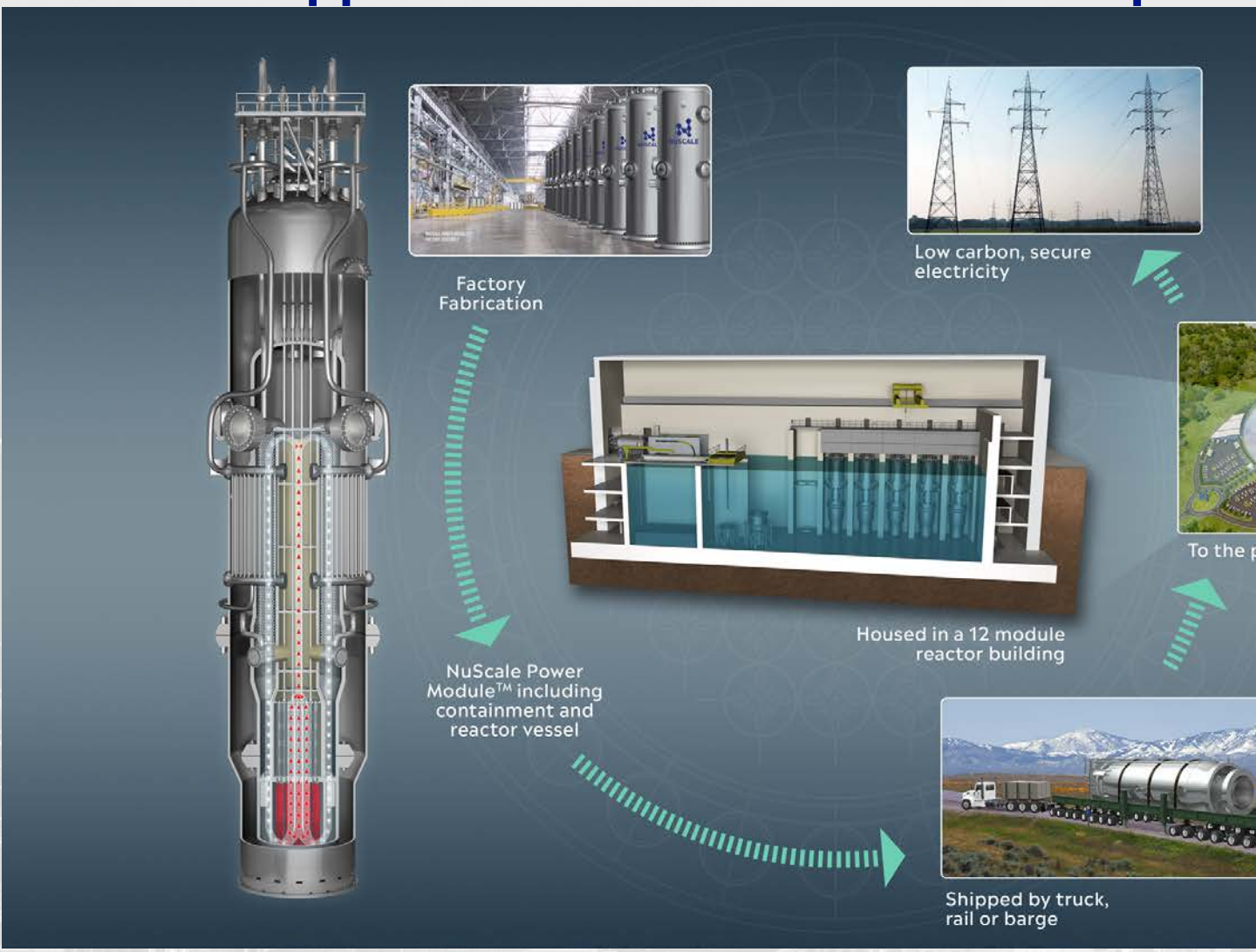




Probability of core damage (Full Power) due to NuScale reactor equipment failures is ***1 event per module every ~3 Billion Years***

Four additional
radioactivity fr

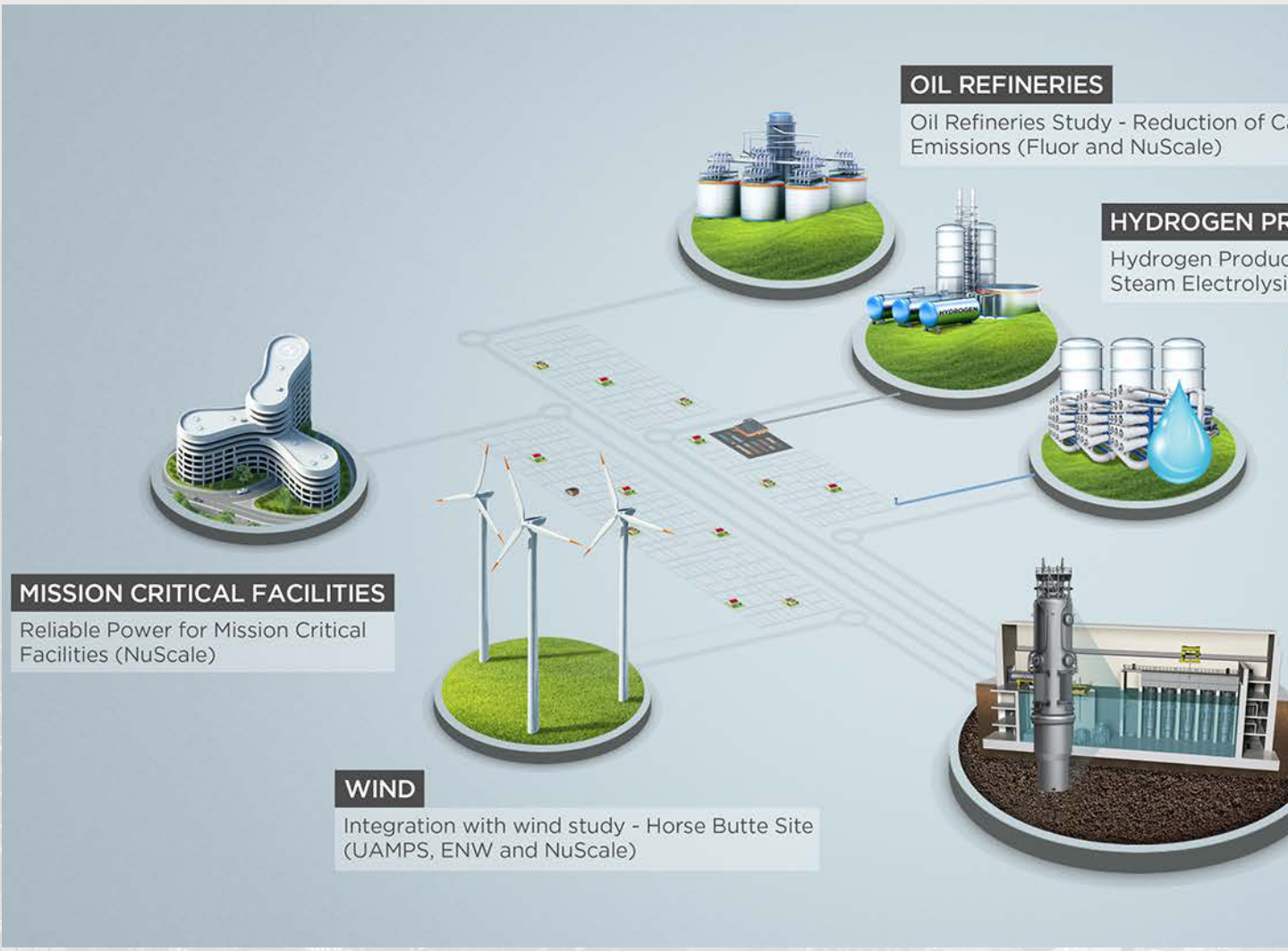
A New Approach to Construction and Operat



Technology Va

- **NuScale Integral Syste** facility located at Oregon Corvallis, Oregon
- **Critical Heat Flux** testin in Hamilton, Ontario Can
- **Helical Coil Steam Gen** SpA in Piacenza, Italy
- **Fuels testing** at AREVA Facility (RTF) in Richlan
- **Critical Heat Flux** testin loop in Karlstein, Germa
- **Control Rod Assembly** alignment testing at ARE Erlangen, Germany
- **Steam Generator** Flow testing at AREVA's PET Erlangen, Germany
- **Control Rod Assembly** FIV at AREVA's MAGAL Le Creusot, France

Beyond Baseload: NuScale Diverse Energy



Reports for associated technical studies are available at: www.nuscalepower.com/technology/technical-publications

A New Level of Plant Resiliency

Island Mode/Loss of Offsite Power

A single module can power the entire plant in case of loss of the grid; no operator or computer actions, AC/DC power or additional water required to keep the reactors safe

First Responder Power

On loss of the offsite grid, through variable (0% to 100%) steam bypass, all 12 modules can remain at power and be available to provide electricity to the grid as soon as the grid is restored

Resi

Reac
locate

– C
F
– C
h

Resilience to Aircraft Impact

Reactor building is able to withstand aircraft impact as specified by the NRC aircraft impact rule

Cybersecurity

Module and plant protection systems are non-microprocessor based using field programmable gate arrays that do not use software and are therefore not vulnerable to internet cyber-attacks

Electron

Re
geoma
and el
events

Reliable Power for Mission Critical Facilities

UTILITY MACROGRID

684 MWe (net)
> 95% Capacity

NuScale 12-Module Plant

DEDICATED MICROGRID
120 MWe (net)
> 99.95% Availability

MISSIO

- Connection to a micro-grid, island m
  the ability for 100% turbine bypass a
  (gross) NuScale plant to assure **120**
  99.95% reliability over a 60 year li
  - 60 MWe at 99.98% availability
- Using highly robust power modules
  plant design can provide **clean, abu**
  reliable power to customers
- Working with utilities and customers

Image courtesy of Third Way Nuclear Reimagined

NuScale Micro-Re

10-50 MWe Micro-NuScal

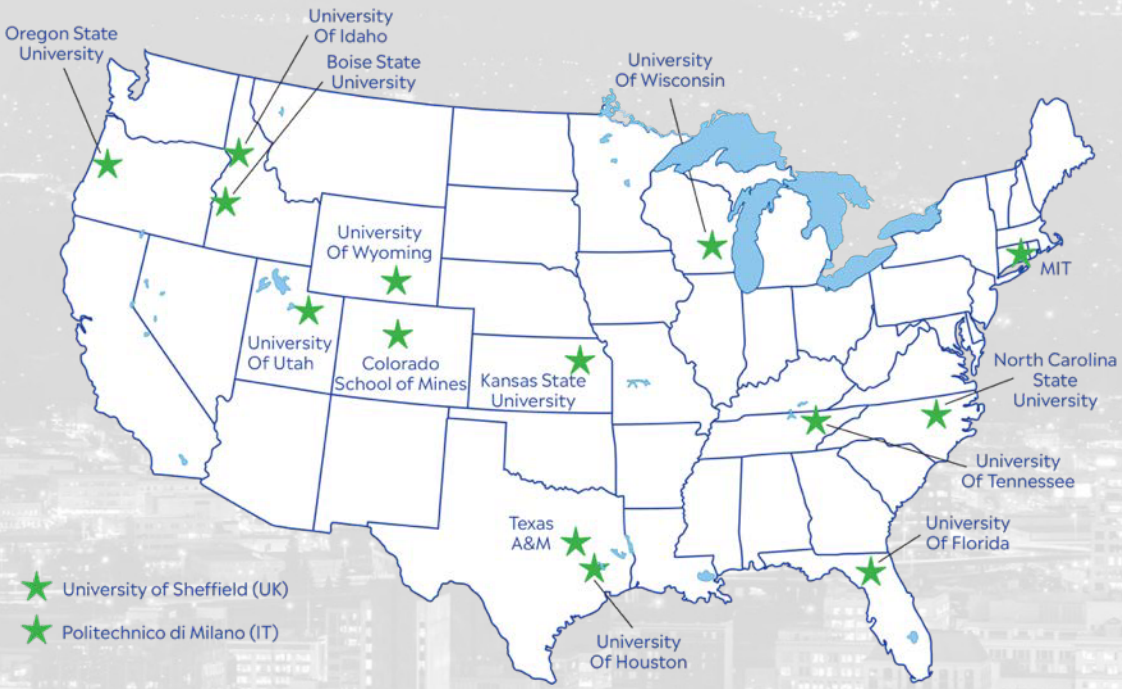
- **Builds on NuScale's existi**
  - Supplying power to comm
  - Remote and off-grid com
  - Off-grid industrial facilities
  - Long duration remote mi
  - Stationary / permanent m
- **Design imperatives includ**
  - Reduced construction tim
  - Simplified operations
  - Increased fuel cycle lengt

1-10 MWe Heat Pipe Reac

- **Simple and inherently safe reactor concept** that require rapidly deployed, and are ful operation
- **Applications include:**
  - Remote small off-grid co transportation delivery lim
  - Remote mining operation
  - Temporary power for disa
  - Power in space

Research Collaborations

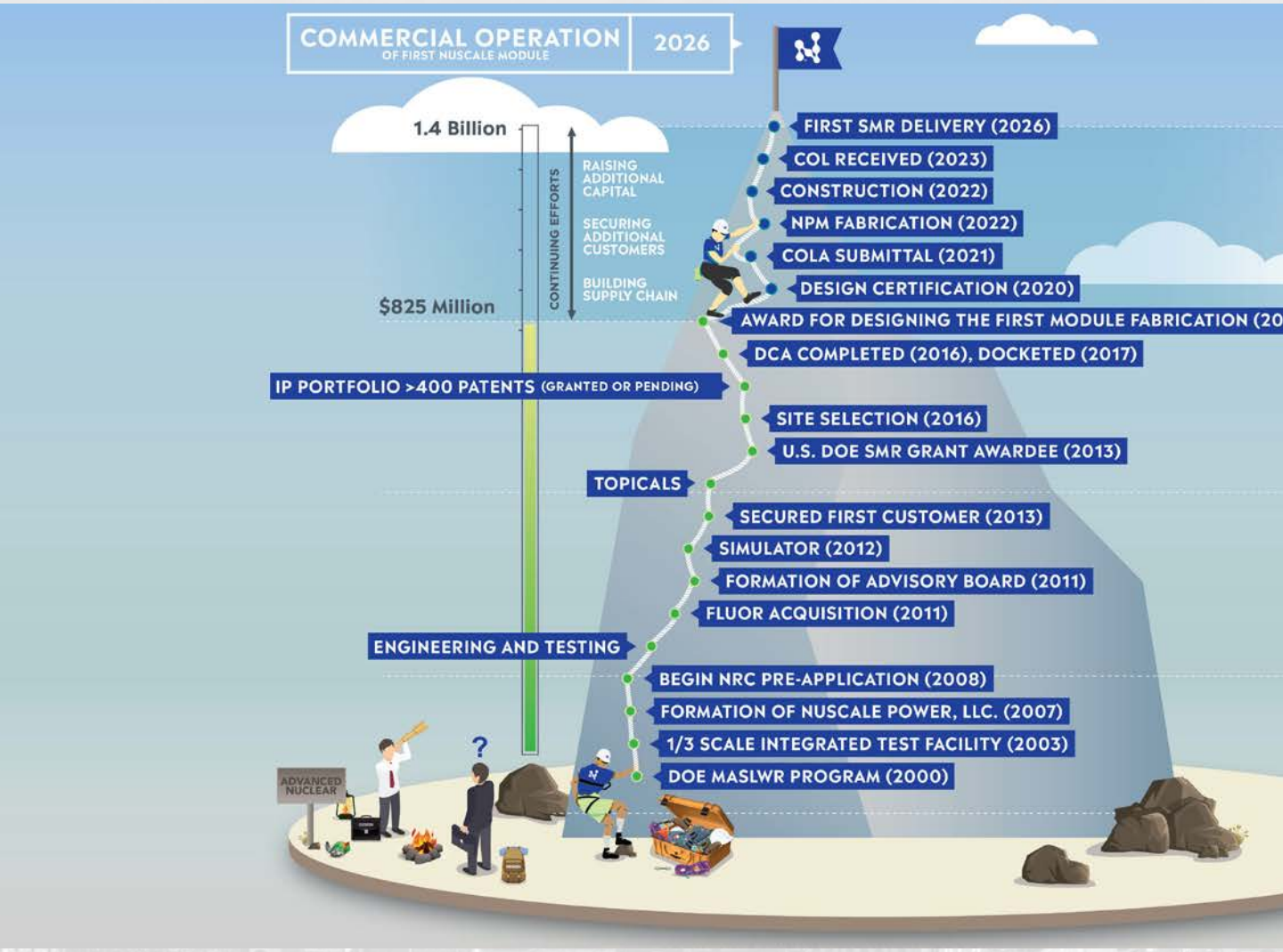
- Since 2012, NuScale Power staff has engaged in over 70 research collab external organizations.
- **NuScale has collaborated on approximately $34 million in external r from DOE-sponsored university and laboratory grants.**



- Collaboratio different com laboratories
- International included res Czech Repu Italy and the
- National labo have include Idaho (INL), (LLNL), Oak Pacific North Sandia (SNL

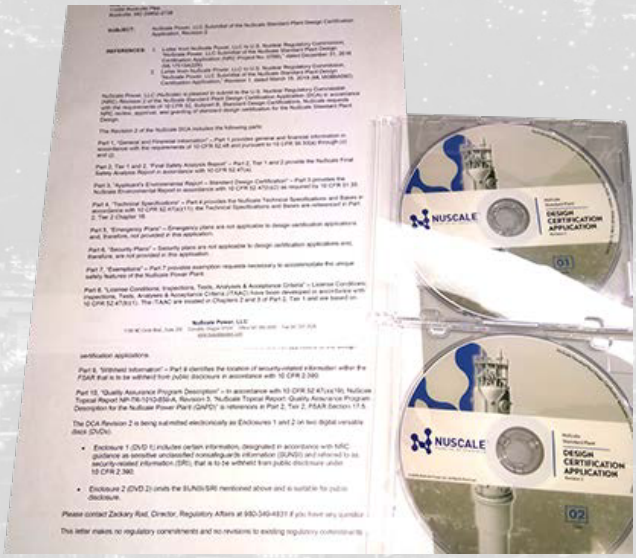
Current Progress in Commercialization: Licensing, Supply Chain, and Customers

Blazing the Trail to Commercialization



First SMR to Undergo Licensing in the U.S.

- Design Certification Application (DCA) completed in December 2016
- Docketed and review commenced by U.S. Nuclear Regulatory Commission (NRC) in March 2017
- Phase 4 of the NRC review on schedule for completion December 2019. Technical review would be completed.
- NRC has published its review and approval schedule; **to be approved in September 2020**



DCA Statistics

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

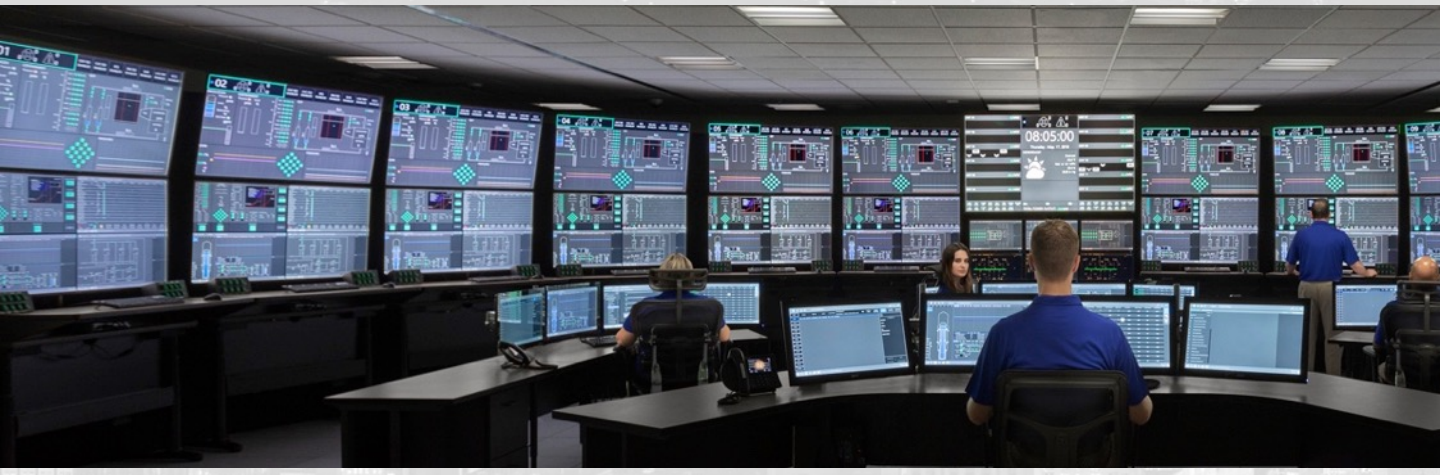
Image courtesy of Third Way Nuclear Reimagined

Right-sizing the
Planning Zone (

- NuScale's small core siz
  safety, defense-in-depth
  reduced EPZ to the site
  - NuScale plants could
    population and indust
    energy is needed mos
- **Tennessee Valley Auth**
  demonstrating that site
  possible for SMRs
  - TVA analysis included
    River early site permi
    NuScale Plant design
  - Shows any accident r
    would be limited to wi
  - Analysis provides bas
    10-mile EPZ
  - NRC preliminary findi
    analysis that reduced
    are feasible

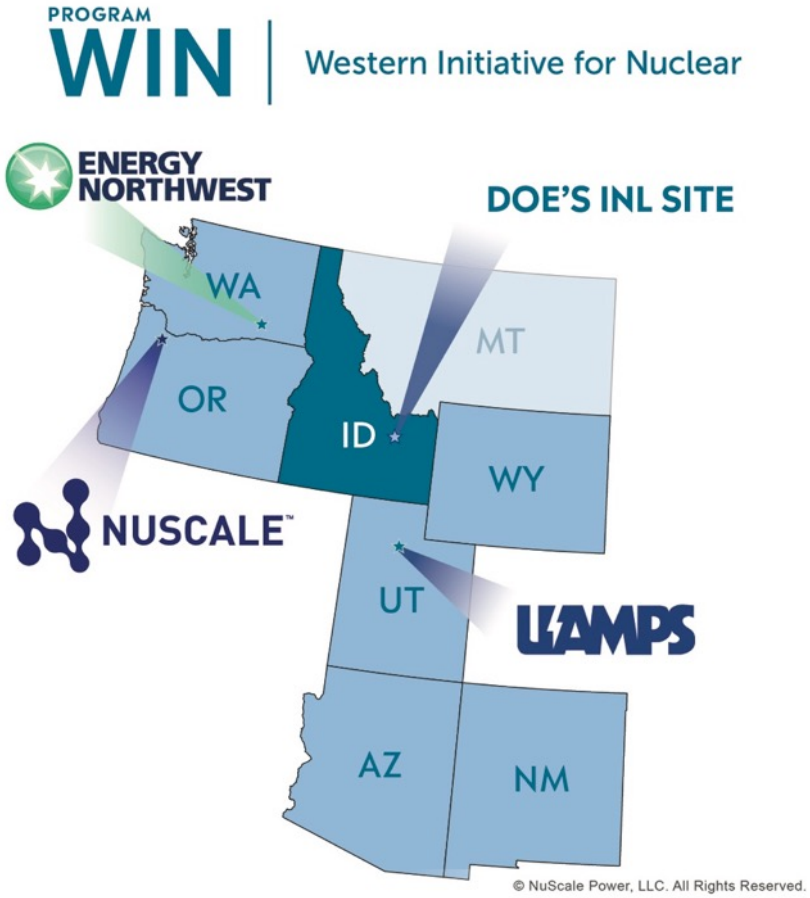
Reduced Operator Staffing

- **Integrated System Validation (ISV) completed using simulator**
  - Verifies the integrated system that supports safe operation (NUREG-0711)
  - Performance based evaluation of hardware, software, and personnel using t licensed operators
    - Operators trained similar to an operating plant license class
    - 12 full-scope, evaluated scenarios over 11 weeks
  - NRC audited ISV activities, no significant open items
  - Demonstrated reduced operator staffing model feasibility
- **Novel regulatory solution to overwrite 50.54(m) with Applicable Requirem certification appendix**



Factory Fabrica

- NuScale Power Modul
  produced in a factory a
  to be installed in the re
- In 2018, **BWX Techno**
  was selected to provid
  leading to fabricating t
  Modules™.
  - The decision follows a
    process, with expresse
    companies based in 10
  - BWXT and NuScale ar
    design optimizing for m
    transportation and redu
    NPMs.
- In 2019, **Doosan Heav**
  Construction Co., Ltd
  signed an MOU for stra
  support deployment of
- Manufacturing trials ar



First Deploymer Carbon Free Pow

- **Utah Associated Mur Systems (UAMPS)** pr to community-owned p throughout the Intermo
- First deployment will b **(720 MWe)** within the I Laboratory (INL) site, s **operation in 2026.**
- DOE awarded $63.3 m to perform site selectio water, and prepare co license application to N site specific design.
- **Joint Use Modular Pl** INL-DOE will lease on 12-module plant, for re additional module may Purchase Agreement (to INL.

Ken Langdo
VP, Operations
klangdon@nus