



**NUSCALE**<sup>™</sup>  
Power for all humankind

# The Future of Nuclear: A Designer's Perspective

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# Acknowledgement and Disclaimer

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# 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 was in development and testing since the 2000 U.S. Department of Energy (DOE) MASLWR program
- Fluor Corporation, a global engineering and construction company, became lead investor in 2011
- >560 patents granted or pending in nearly 20 countries
- >400 employees in 5 offices in the U.S. and 1 office in the U.K.
- Rigorous design review by the U.S. Nuclear Regulatory Commission (NRC)—NuScale received Design Approval in August 2020
- Total investment in NuScale to date is greater than US\$1.2B



*NuScale Engineering Offices Corvallis*



*One-third Scale NIST-2 Test Facility*



*NuScale Control Room Simulator*

# Bipartisan Support for NuScale and Advanced Nuclear

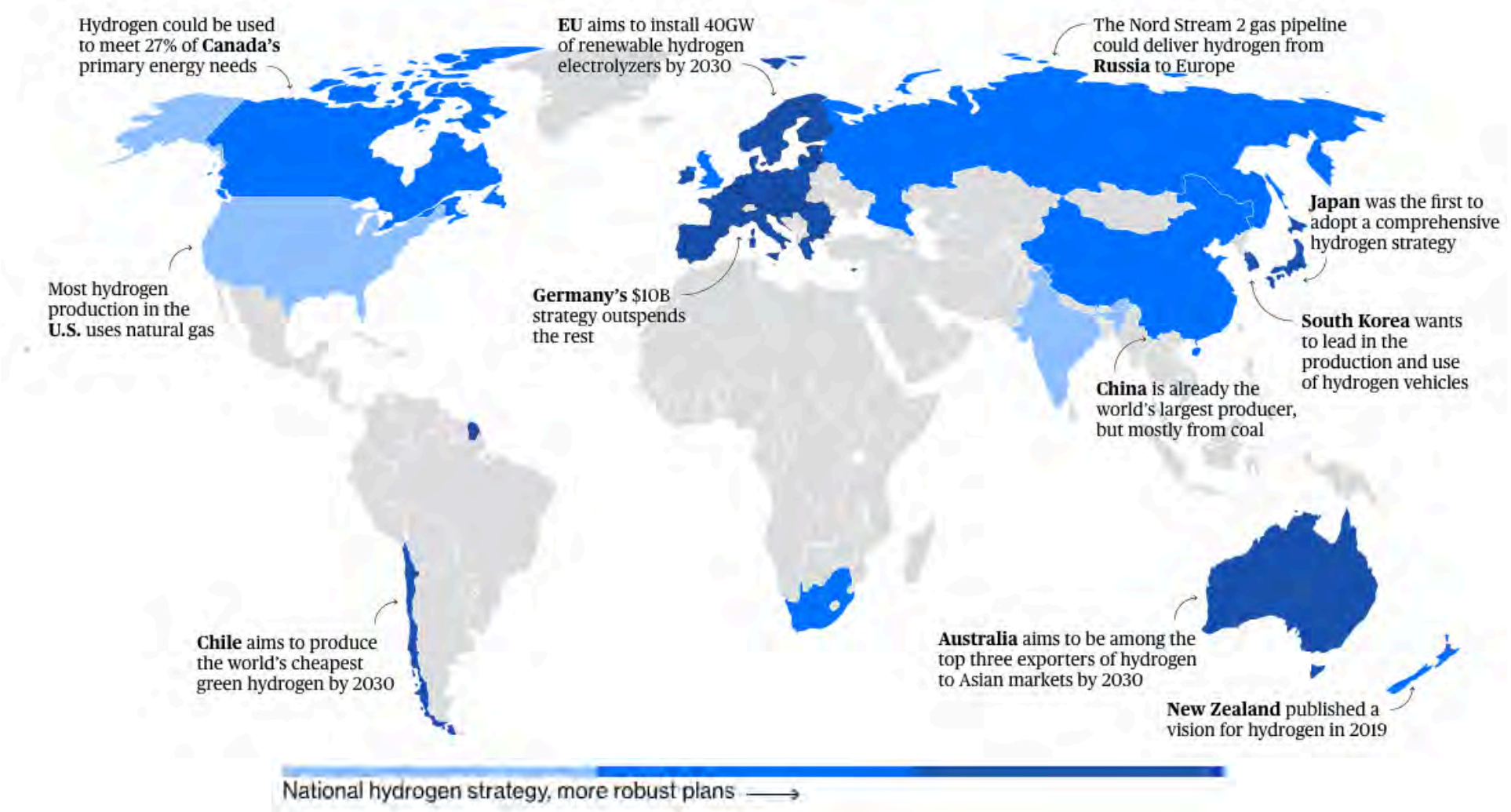
- In 2013, NuScale won a competitive U.S. DOE Funding Opportunity for matching funds, and has been awarded over \$400M in DOE funding since then.
- Advanced Nuclear Production Tax Credit statutes amended in 2018 to secure benefit for municipally-owned nuclear projects, like UAMPS CFPP.
- Nuclear Energy Innovation and Modernization Act ([NEIMA](#)) enacted Dec 2018.
- Nuclear Energy Infrastructure and Capabilities Act ([NEICA](#)) enacted Sep 2018.
- Better Utilization of Investments Leading to Development ([BUILD](#)) Act enacted Oct 2018 .
  - Established U.S. International Development Finance Corporation (DFC).
  - DFC policy changed in 2020 to permit funding of advanced nuclear projects such as the NuScale Power Plant.
- Nuclear Energy Leadership Act ([NELA](#)) provisions incorporated into 2020 National Defense Authorization Acts and passed.
- Clean Energy for America Act
  - Includes “tech neutral” tax credit



# Repurposing Coal Power Plant Sites



# Many Countries Have Established National Hydrogen Strategies

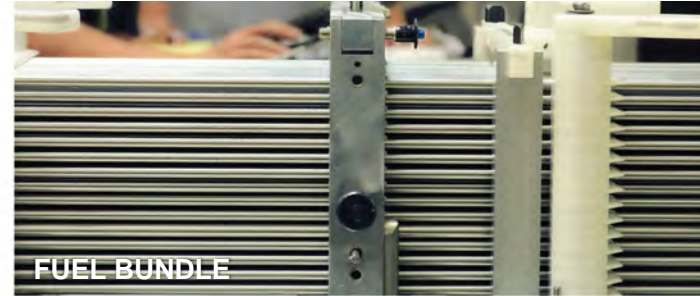
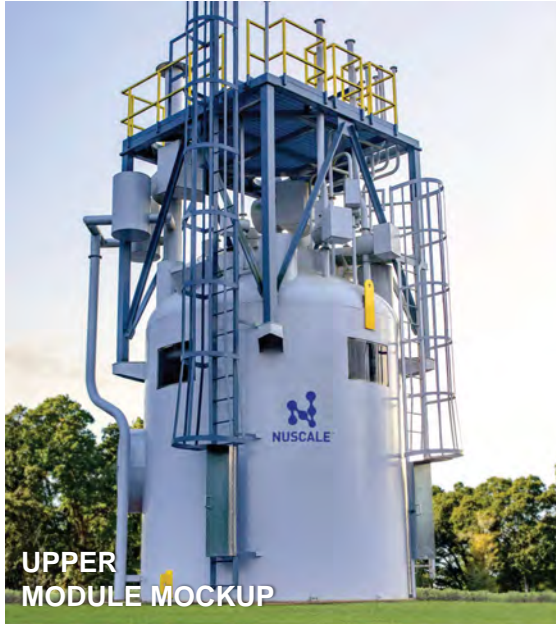




## Demonstrated Technology

- **NuScale Integral System Test (NIST-2)** facility located at Oregon State University in Corvallis, Oregon.
- **Critical Heat Flux** testing at Stern Laboratories in Hamilton, Ontario Canada.
- **Helical Coil Steam Generator** testing at SIET SpA in Piacenza, Italy.
- **Fuels testing** at Framatome (formerly AREVA) Richland Test Facility (RTF) in Richland, Washington.
- **Critical Heat Flux** testing at AREVA's KATHY loop in Karlstein, Germany.
- **Control Rod Assembly (CRA)** drop / shaft alignment testing at AREVA's KOPRA facility in Erlangen, Germany.
- **Steam Generator Flow Induced Vibration (FIV)** testing at AREVA's PETER Loop in Erlangen, Germany.
- **Control Rod Assembly Guide Tube (CRAGT)** FIV at AREVA's MAGALY facility in Le Creusot, France.

# Manufacturing and Testing of Real Components





Vessel cladding testing at Doosan



Automated cladding machine at Doosan

## Supply Chain Development and Manufacturing of NPM

- Design for Manufacturing
  - Manufacturer feedback to optimize design and lower costs
  - Manufacturing plan development
  - Forging procurement drawings
  - Performed by Doosan and BWXT (performing same scope)
  
- Manufacturing Trials (Doosan)
  - Cladding distortion (2 sided) of reactor pressure vessel
  - Steam generator tube bending
  - F6NM material (martensitic stainless steel) use for containment vessel

## Supply Chain and Manufacturing Development

- Instrumentation & Controls
  - Distributed control system supplier selection in final negotiation phase.
    - Scope includes design, testing and manufacturing.
  - Pressure, level and flow sensor technology development.
    - NPM sensors in harsh environment – high temperature and pressure.
    - Development contracts with Sensia and Ultra.
- Refueling and remote handling
  - Reactor building crane detailed design in progress.
    - PaR Systems
    - 3 of 5 design phases complete.
  - 3 additional design scopes to be awarded in 2021.
- Other manufacturing related activities
  - Equipment Qualification Test Chamber deployment.
  - Manufacturing Readiness Level assessments.
  - Product Lifecycle Management implementation for manufacturing module.



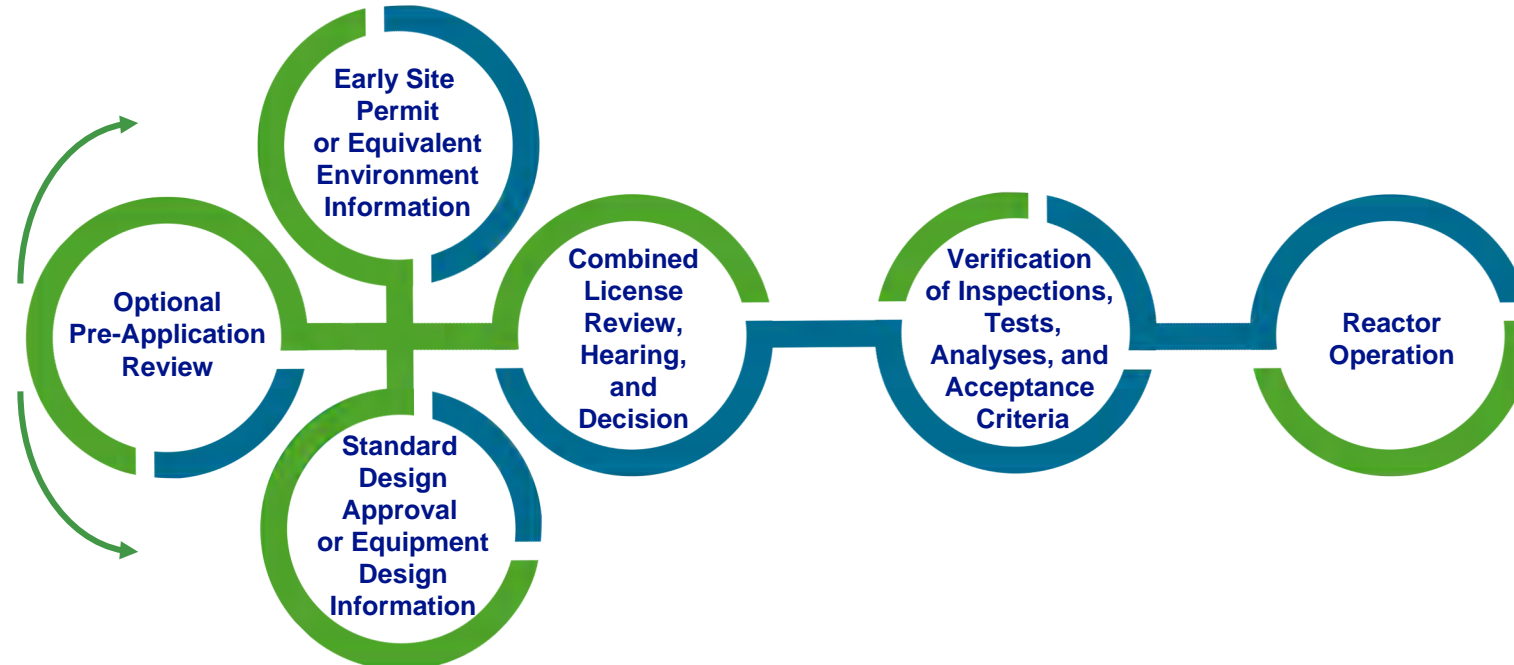
NPM flow sensor testing chamber at Cameron



Crane module lift adapter proof of concept testing

## NRC Licensing Process (10CFR52)

- The standard design approval (SDA) application is prepared by the vendor (e.g., NuScale) and is valid for 15 years.
- The Combined License (COL) is prepared by the customer (e.g., Utah Associated Municipal Power Systems) and is required for construction and operations of each nuclear plant. The SDA is normally incorporated by reference into the COL.
- An Early Site Permit may be obtained in advance of a licensing proceeding (e.g., TVA) and “banked,” or included in the COL application.



# Carbon Free Power Project (CFPP) Timeline



Artistic concept of the NuScale Power Plant

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## International Opportunities

- NuScale made its first submittal to the **Canadian Nuclear Safety Commission (CNSC)** for pre-licensing vendor design review (VDR) and signed MOUs with Ontario Power Generation (OPG) and Bruce Power.
- NuScale has been actively involved in the **United Kingdom's** SMR market activity for several years and signed an MOU with Shearwater Energy Ltd. on developing a wind-SMR and hydrogen production hybrid energy project in North Wales.
- NuScale and Kozloduy NPP-NB Plc signed MOU to consider SMR development for site in **Bulgaria**
- NuScale and Nuclearelectrica SA signed MOU to evaluate SMRs for **Romania's** energy needs.
- NuScale signed an MOU with ČEZ Group to explore SMR opportunities in the **Czech Republic** and broader region.
- NuScale signed MOU with Jordan Atomic Energy Commission (JAEC) to evaluate NuScale's SMR for use in **Jordan**.
- Many international opportunities for deployment in **Europe, the Middle East, Asia Pacific, and Africa.**

## Security by Design

- Physical Security
  - Aircraft impact resistant reactor building.
  - Most safety-related components below grade.
  - Passive safety systems.
  - No reliance on operator actions, electrical power, or additional water to maintain the reactor core or spent fuel safe.
  - Configuration of site structures allows for a simple defensive strategy.
  - Incorporation of multiple layers of intruder delay barriers.
  - Minimization of the number of access points to vital areas.
- Cyber Security
  - The I&C design uses a secure architecture.
  - Module and plant protection systems are non-microprocessor based using field programmable gate arrays that are not vulnerable to internet cyber-attacks.
  - The Cyber Security Assessment Team is embedded in the design lifecycle, analyzing potential vulnerabilities and offering design solutions.



## Safeguards by Design

- NuScale design has been evaluated for safeguardability at a high level.
- Similar to existing light water reactor designs with regards to fuel, processes, and implementation of international safeguards.
- Many of the Security by Design attributes considered the prevention of theft and diversion of nuclear material.
- Safeguards monitoring devices deployed in existing reactors could be utilized within the NuScale design.
- I&C sensors for normal plant operation will be evaluated for dual use to provide Continuity of Knowledge (CoK).
- NuScale supported a project by PNNL on Design Information Verification (DIV) for small modular reactors.
- Additional Safeguards research, planning and implementation is anticipated.

# CHANGING THE POWER THAT CHANGES THE WORLD

