Westinghouse Technology Solutions: Reactors from 5 to >1000 MW_e

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Westinghouse

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“**Energy** is central to nearly every major challenge and opportunity the world faces today.”

—The United Nations

Over the next 20 years, the world population is expected to grow 25% and, by 2030, demand for electricity will **nearly double**.

Finding solutions to our increased energy needs while confronting the realities of a **changing climate might be the most pressing issue of our time.**

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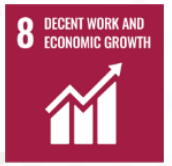
Nuclear alignment to UN SDGs

Nuclear power has several intrinsic technological advantages that align with the United Nations Sustainable Development Goals[1]

		UN SDG
GHG Emissions	Over its lifecycle, nuclear produces an average of 12-16gCO_2e/KWh, **a GHG output lower than solar; similar to wind**	**SDG13** Climate Action **SDG3** Good Health & Well-Being
Resource Intensity	Among low-carbon alternatives, nuclear has the **lowest lifecycle requirements for structural materials** and **lowest land use**	**SDG14** Life Below Water **SDG15** Life On Land
Energy Safety	Globally, nuclear power remains **the safest energy source per unit energy produced** due to low incident rates, safe exposure levels	**SDG8** Decent Work & Economic Growth **SDG9** Industry, Innovation & Infrastructure



1. Sustainable Development Goals (SDGs) are a set of 17 goals used to guide and gauge progress towards the UN's 2030 Agenda for Sustainable Development adopted by 193 member states. Source: US DoE, US EIA, US NRC, IEA, IAEA, World Nuclear Association, secondary research, expert interviews, BCG analysis

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Nuclear alignment to UN SDGs

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		UN SDG
Energy Efficiency	Unlike other sources, there is **no significant age-related decline** in nuclear reactor performance with **the highest capacity factor**	**SDG11** Sustainable Cities & Communities **SDG12** Responsible Consumption & Production
Energy Security	Inherent cost structure of nuclear power generation leaves **end users less exposed to commodity (uranium) prices**, when compared to coal and natural gas	**SDG7** Affordable & Clean Energy **SDG16** Peace, Justice and Strong Institutions

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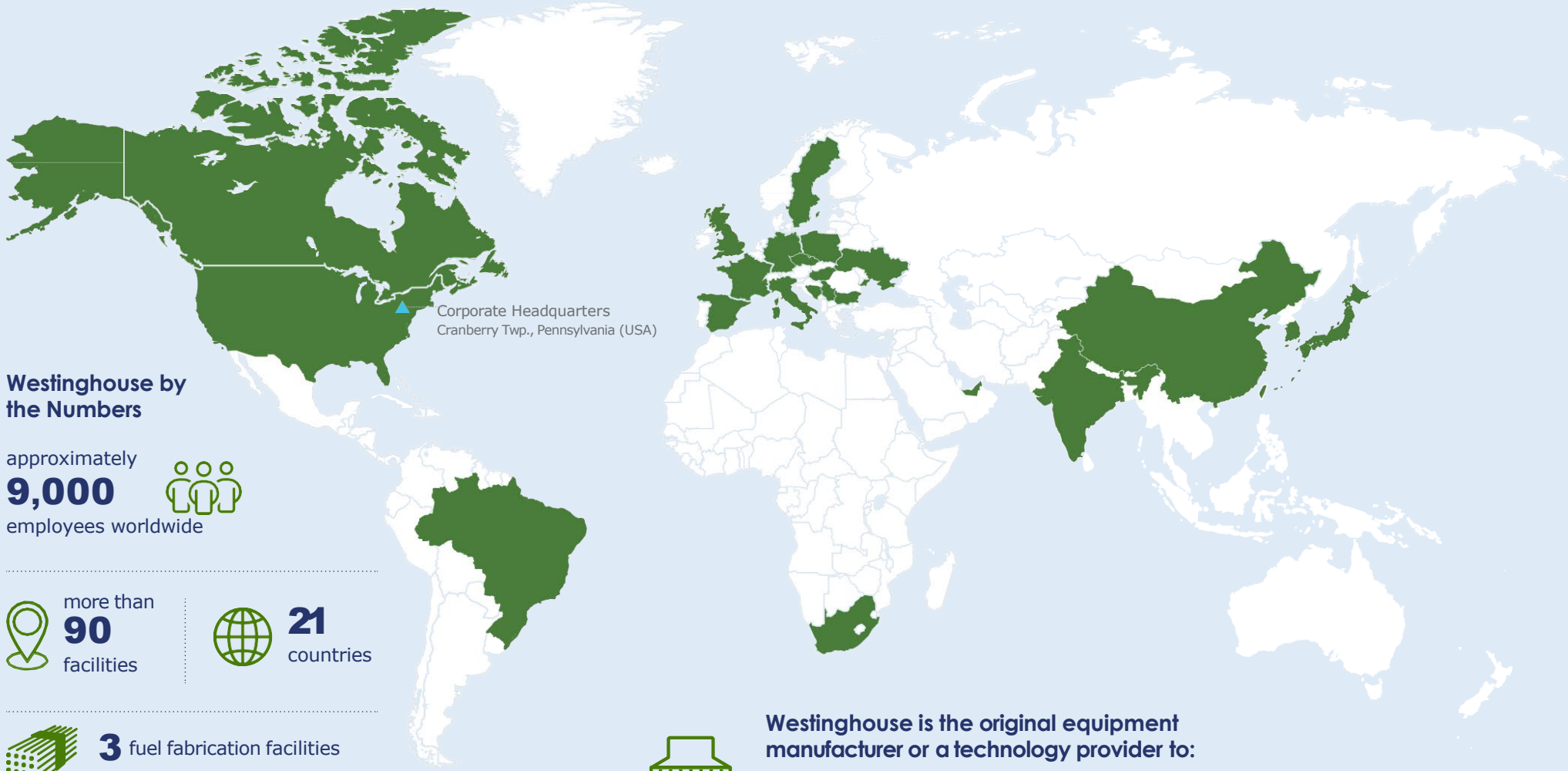
global presence

Legend

- Corporate Headquarters
- Countries with Westinghouse Presence



Westinghouse by the Numbers

approximately
9,000
employees worldwide

more than
90
facilities

21
countries

3 fuel fabrication facilities

Westinghouse is the original equipment manufacturer or a technology provider to:

~50% of the global nuclear reactor fleet, delivering capacity of ~190,000 carbon-free MWe

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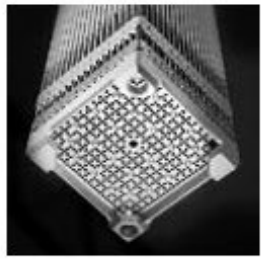
Global Products & Services **Portfolio Snapshot**



Nuclear Fuel

Instrumentation & Control

Staffing Services

Components & Manufacturing

Field Services and Plant Modifications

New Plants

Engineering Services

Decontamination & Decommissioning Solutions

Project and Engineering Services

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Energy Systems

A portfolio of innovative nuclear solutions

AP1000® PWR

1100+ MW_e

Most advanced nuclear technology operating in the world today with record-setting performance

TECHNICAL CAPABILITIES

- Passive Safety Systems
- Simplified Active Systems
- Proven NSSS Components; Canned Motor Pumps
- Compact Footprint
- Modular Construction
- Digital I&C and Advanced Control Room
- Load Follow Capability
- Global Licensing Pedigree

eVinci Microreactor™

5 MW_e

Microreactor designed for safe and reliable electricity and heat generation

TECHNICAL CAPABILITIES

- 5 MWe + ~8MWth @ 200C cogeneration
- Minimum 8 year refueling cycle
- Transportable for ease of installation and elimination of spent fuel storage on site
- Cost-competitive plant lifecycle
- Minimal onsite personnel
- Mature technology, manufacturing, and regulatory readiness
- High speed load following capability

AP300™

300 MW_e

Only SMR based on deployed, operating & advanced reactor technology

TECHNICAL CAPABILITIES

- 300MWe (990MWth) 1-loop PWR with demonstrated reliability
- Based on the fully licensed & operating AP1000 technology
- Utilizes identical passive safety systems used in the AP1000 reactor to maintain safe shutdown condition
- Ultra-compact, simplified design reduces construction timeframes
- Maximizes use of established supply chain
- Less than 0.4 acres needed for safety related buildings

Pumped thermal energy storage

Innovative design coupled with tested technology

TECHNICAL CAPABILITIES

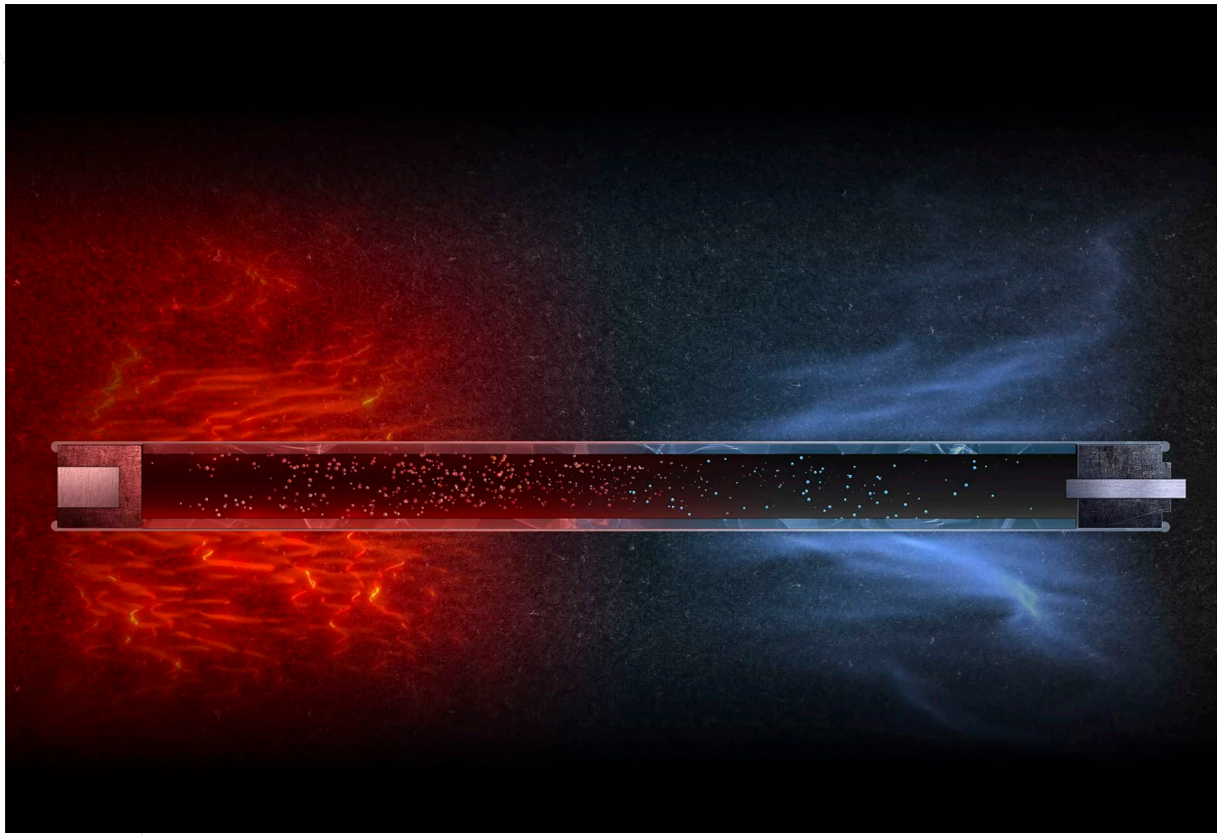
- Advanced Supercritical Carbon Dioxide (sCO2) Technology
- Efficient heat pump and heat engine cycle
- Unique, Patented Thermal Storage Solution
- Engineered concrete thermal batteries
- Low-cost materials; Printed Circuit Heat Exchangers (PCHE)
- Power turbine and low-temperature compressor are derivatives of existing designs
- Heat exchangers, piping, valves, controls are of similar design to existing SCO2 systems

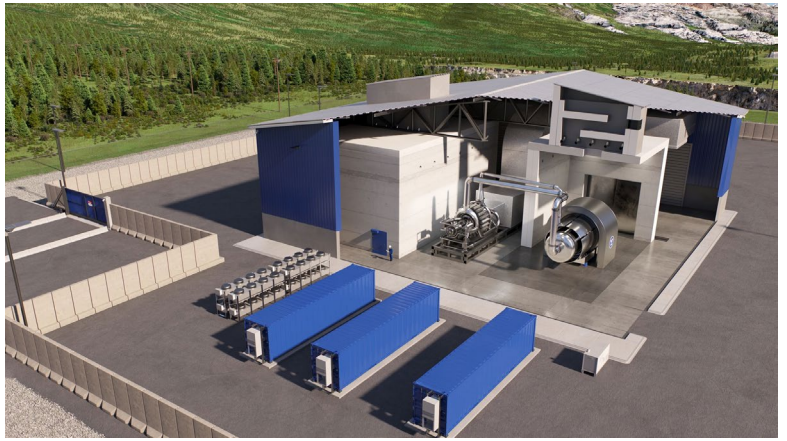
eVinci Microreactor

Clean energy beyond the grid

Nuclear battery designed for safe and reliable clean energy generation

- **5 MWe with ~7MWth @ 170° C usable heat**
- ~13.5MWth @ >700° C heat only
  - Commercial deployment before end of this decade
- **8+ years of operation without refueling**
- Transportable for ease of installation and elimination of spent fuel storage on site
- **Cost-competitive plant lifecycle**
- Minimal site construction and onsite personnel
- High speed load following capability





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eVinci Microreactor

Combined heat and power capability

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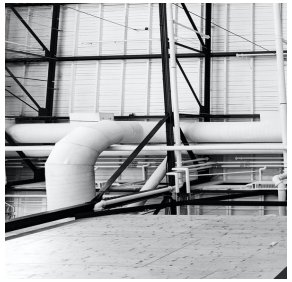
eVinci Microreactor

Distributed energy wherever it's needed

Space Missions

Remote Mining Operations

Industrial Process Heat



District Heating

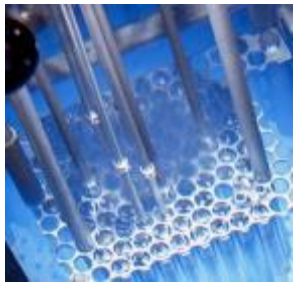
Off-grid Communities

Hydrogen Generation

Universities

Strategic Military Installations

Critical Infrastructure



Research Reactors

Long Duration Energy Storage

Innovative design coupled with tested technology

Advanced Energy Storage Technology

- Nominal system size of 1,000 MWh
  - 100 MWe for 10 hours of energy storage
  - Size of <23,000 m^2

Unique High Temperature Reservoir (HTR)

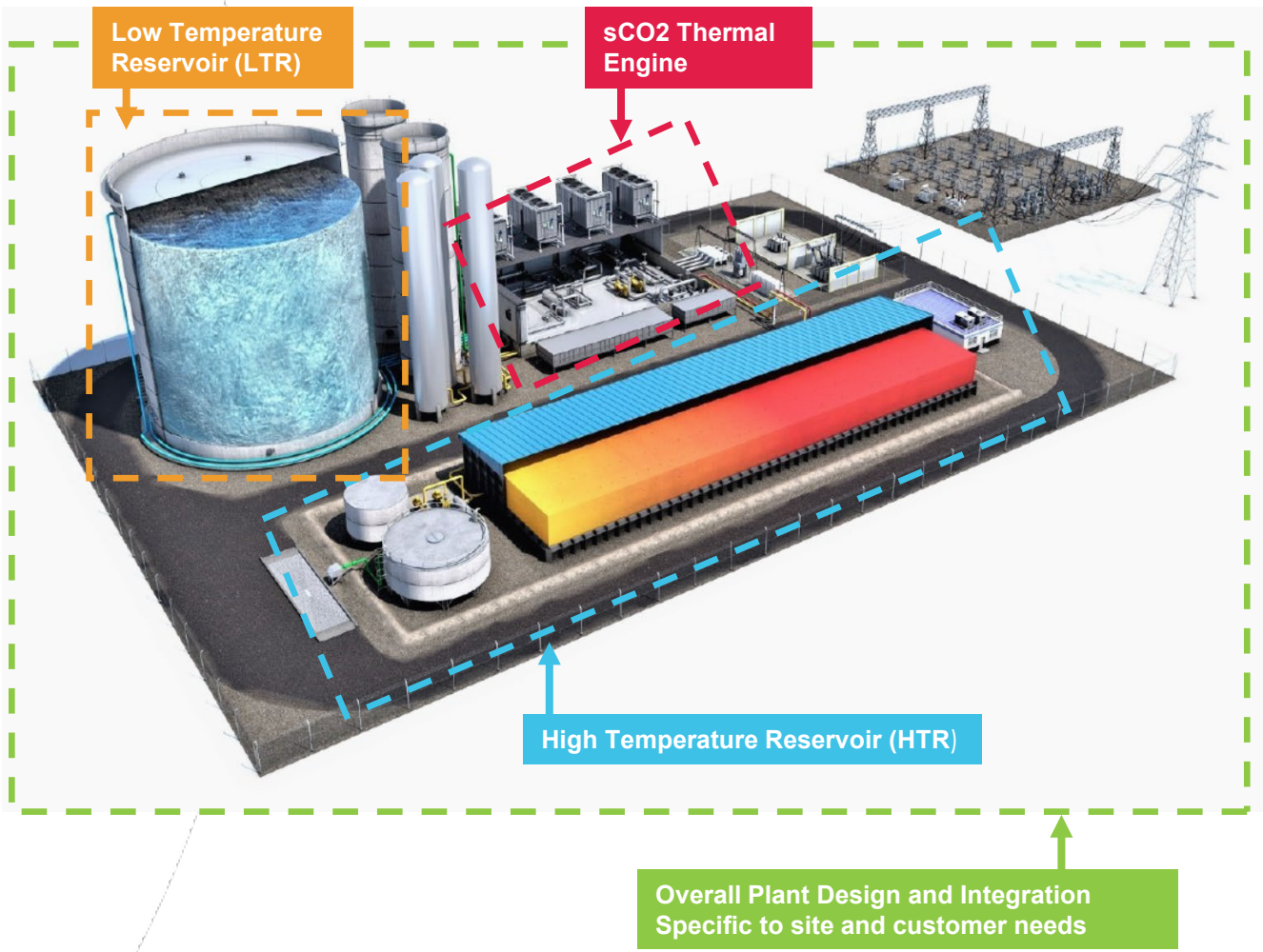
- Engineered thermal batteries
- Low-cost materials (concrete)

Scalable, Affordable Low Temperature Reservoir

- Low-cost bulk material (water)
- Based on proven commercial refrigeration technology

Proven Components

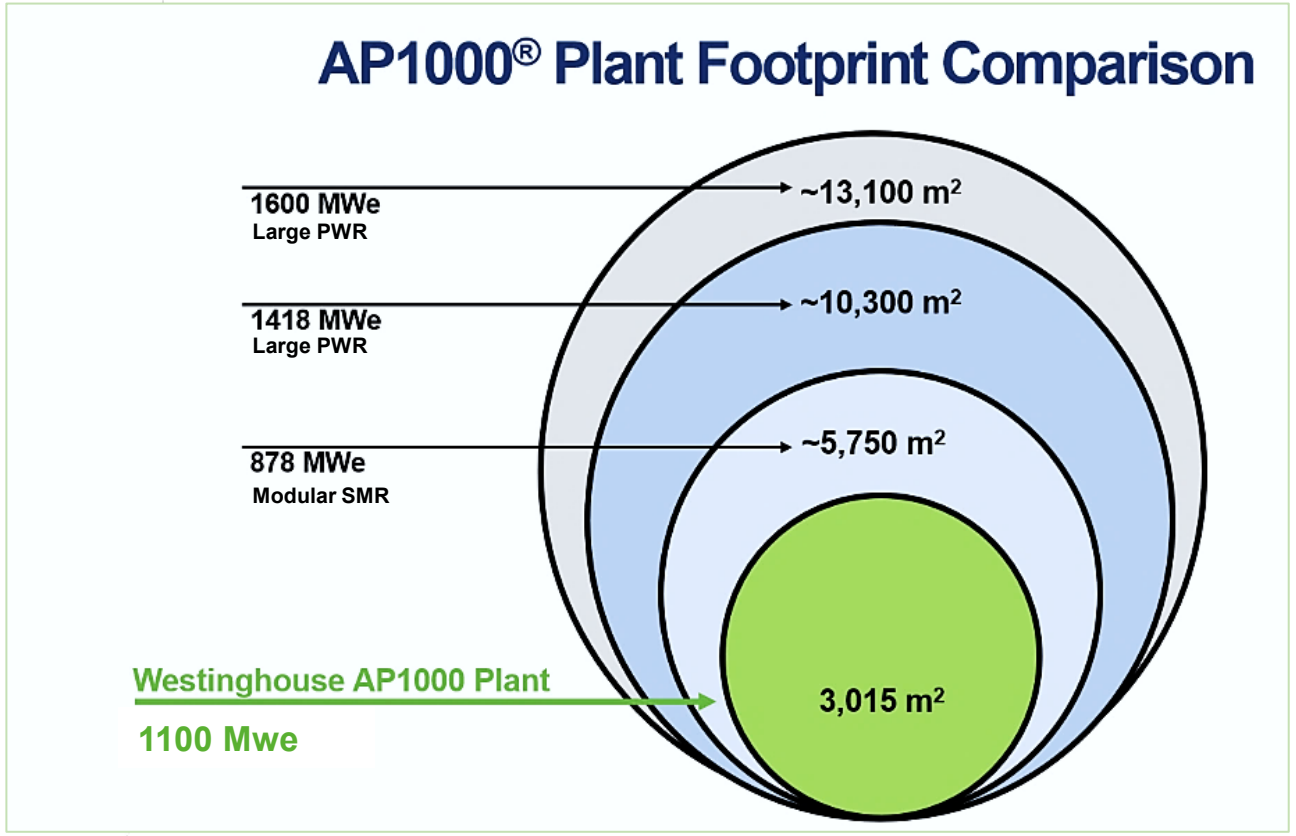
- Power turbine and low-temperature compressor are derivatives of existing designs
- Heat exchangers, piping, valves, controls are of similar design to existing SCO_2 systems
- Printed Circuit Heat Exchangers (PCHE)



AP1000 Technology

Safe, simple, proven

- **Generation III+ plant**; most advanced in operation today
- **Fully passive safety systems** and 72+ hour coping after station blackout
- Optimized design utilizing **advanced modular construction**
- **Licensed by nuclear regulators** in Europe, USA, and China
- **Record-setting** operational performance
- Advanced, **load-following** capabilities
- **Safe, clean, reliable energy**



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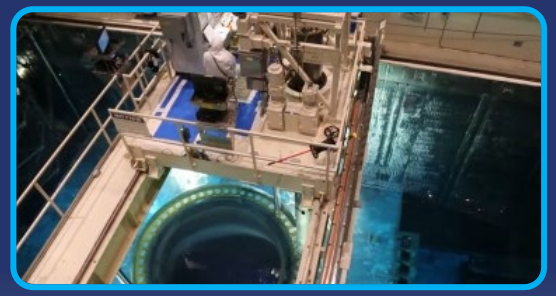
Westinghouse Advantage

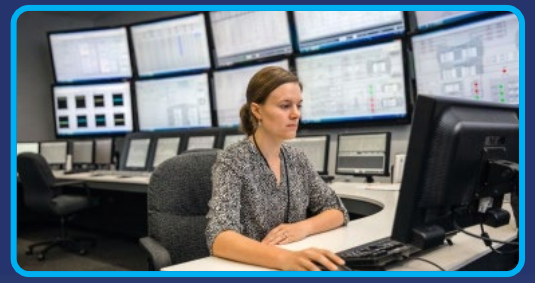
Over **70** years of experience developing & implementing new nuclear technologies that enable reliable, clean, safe and economical sources of energy for generations to come.

3 countries granting regulatory approval to the AP1000 reactor



~50% of the world's nuclear power is generated using our technology

12 AP1000 reactors either completed or undergoing construction



18 More AP1000 reactors under contract or selected by customers globally

Today's Energy Landscape

The world is recognizing the need for nuclear & is seeking proven solutions

CUSTOMER CHALLENGES

- Emission-free Energy
- Energy Security
- Energy Price Stability
- Grid Stability

THE SOLUTION

CUSTOMERS CONTINUE TO SELECT WESTINGHOUSE

- China has 4 AP1000's in operation, 6 in construction, 2 additional units selected
- Poland contracts for 3 AP1000 reactors
- Bulgaria contract for 1 AP1000, expected expansion to 2
- U.S. has 1 operating AP1000 and 1 in final commissioning
- Ukraine contracts for 9 AP1000 reactors
- India selects 6 AP1000 reactors

The SMR Promise

What is the best path to deliver on the promise?

Lower Cost

Easier to License

Efficient Construction

Increased Safety

Quicker Deployment

video

AP300 SMR

Only SMR based on deployed, operating & advanced reactor technology

Proven Technology

20 AP1000 reactor-years of safe operations

Based on the fully licensed & operating AP1000 technology.

Advanced Safety

More than **30** years licensing advanced passive technologies with global regulators

We pioneered passive safety systems. AP300 utilizes identical passive safety systems used in the AP1000 reactor to maintain safe shutdown condition.

Readily Deployable

Less than **0.4** acres needed for safety related buildings

Ultra-compact, simplified design reduces construction timeframes. Maximizes use of established supply chain.

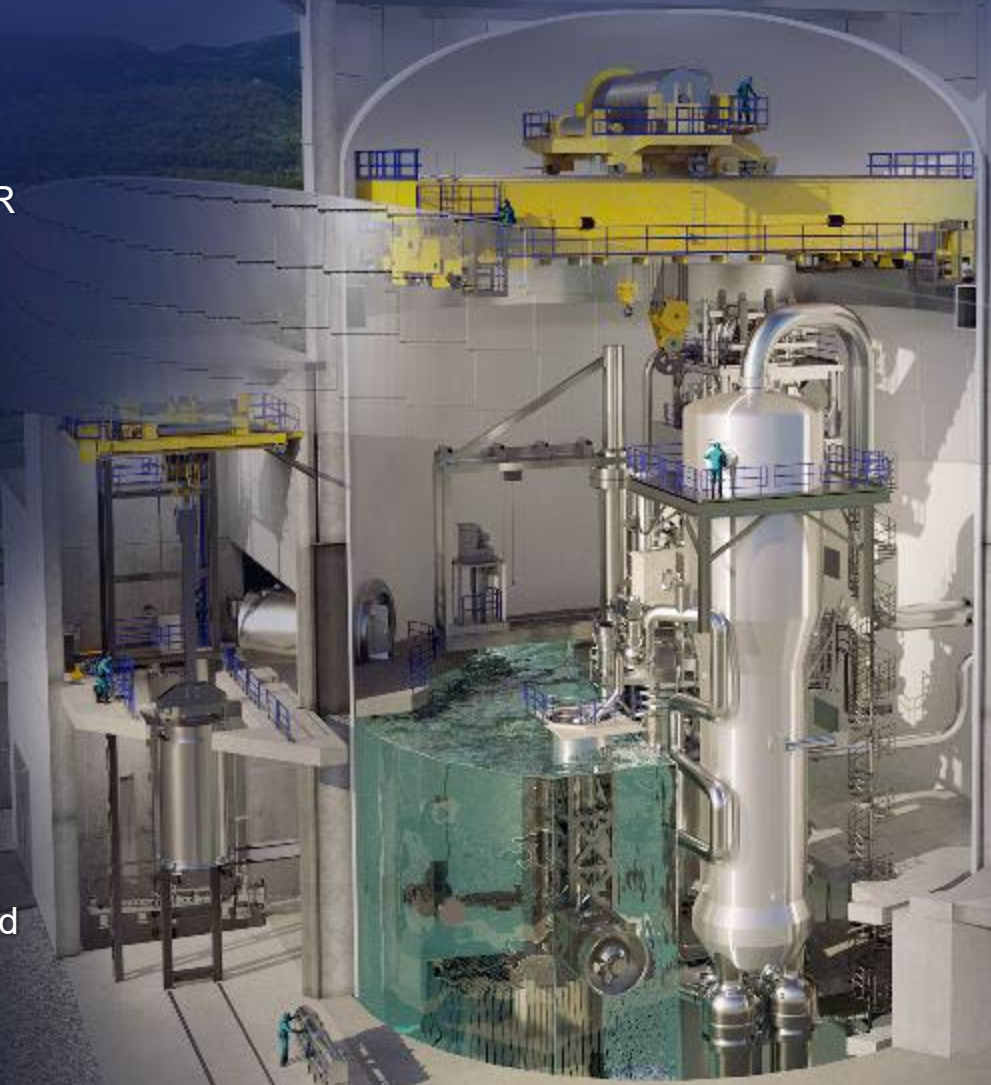
Proven Technology

Leveraging AP1000 technology with demonstrated industry leading reliability

300MWe (990MWth) 1-loop PWR with demonstrated reliability

Westinghouse AP1000 reactor passive safety technology

Reduces overall components creating a simpler plant compared to other SMRs



Identical Technology as AP1000 including:

- **Design & licensing methodologies**
- **Major equipment & components**
- **Passive safety systems**
- **Proven Fuel**
- **I&C systems**
- **Proven Supply Chain**
- **Constructability lessons learned**
- **Steel-Composite structural modules**
- **O&M procedures & practices**
- **Fast load follow capabilities**

Passive Safety Pioneers

AP300 SMR uses the identical proven AP1000 fully passive safety systems

Fail Safe

Automatically achieves safe shutdown without the need for operator action

Self Sufficient

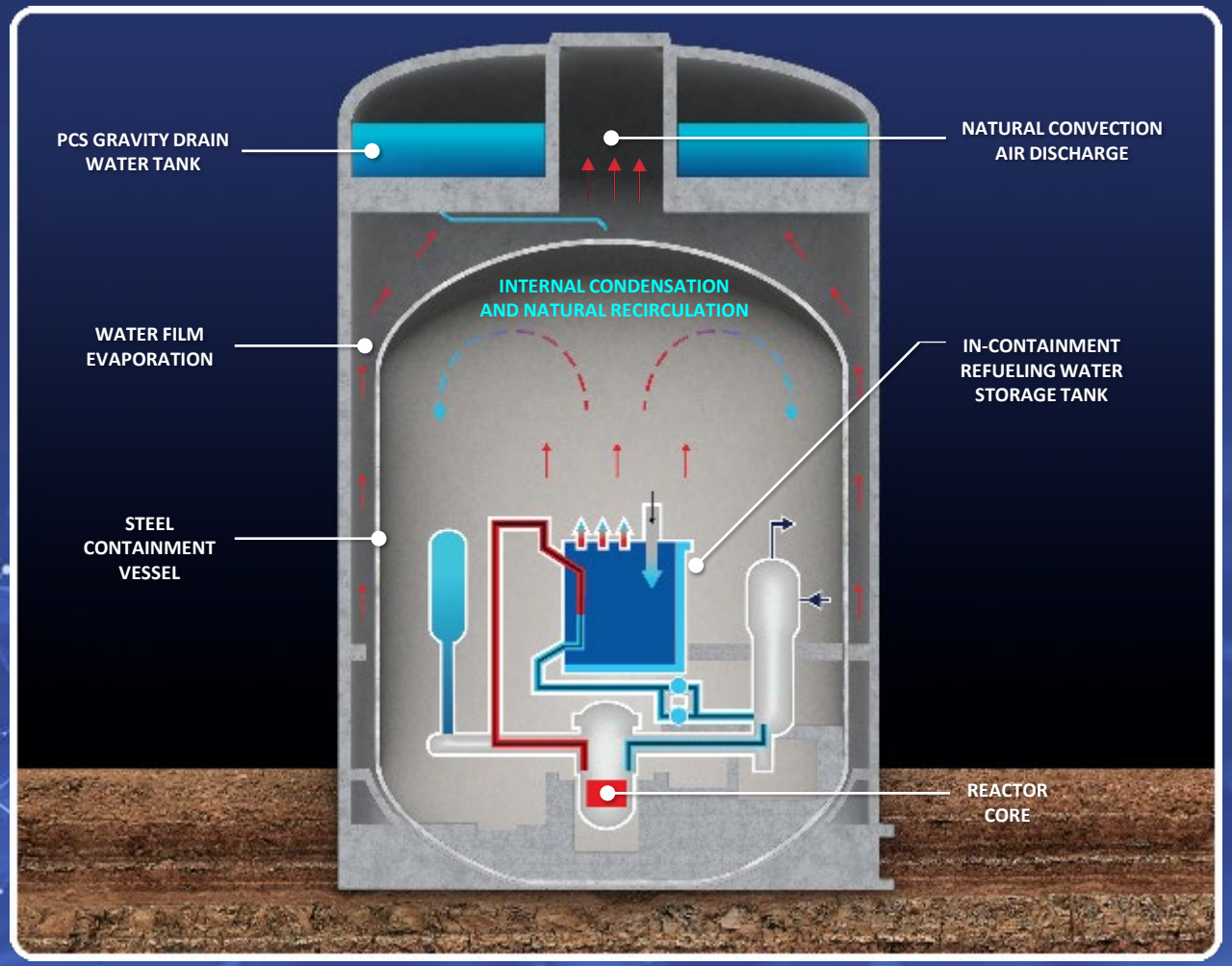
Passive approach to safety eliminates the need for backup power & cooling supply

Hazard Proof

Protected by a robust containment designed to withstand extreme external hazards

Defense in Depth

Multiple layers of defense for accident mitigation



AP300 SMR Advantage

AP300 SMR reduces development risks and increases market potential

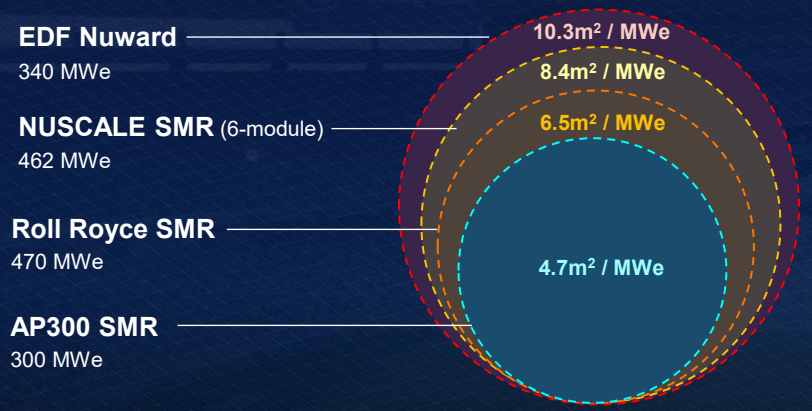
	Key Factors	Competitor #1	Competitor #2	Competitor #3	Competitor #4	Competitor #5	Westinghouse AP300™ SMR
DEVELOPMENT RISKS	**Design & Technology**	Low	Medium	Medium	Medium	Medium	**Low**
	Full Licensing	Low	Medium	Medium	Low	Low	**Low**
	Fuel Cycle	Low	Low	Low	Low	Low	**Low**
	Skills Availability & Supply Chain Maturity	Medium	Medium	Medium	Medium	Medium	**Low**
MARKET POTENTIAL	**Design for manufacturability & construction**	++	++	+	+	+	+++
	Cost Competitiveness & LCOE	+++	++	+	+	+	+++
	Utility Market: O&M synergies	++	+	+	++	+	+++
	Versatility: electricity, steam, H_2, Storage	++	+++	+++	+++	+++	+++

Ultra Compact Footprint

AP300 SMR's smaller safety related footprint reduces construction, operating & maintenance costs

PWR SMR COMPARISON

SAFETY RELATED FOOTPRINTS



Rolls Royce power output and footprint per ONR Project Assessment Report Generic Design Assessment of the Rolls-Royce SMR – Step 1 summary (ONRW-2019369590-1908 Rev 0) | NuScale power output and footprint per NuScale Standard Design Approval Application (www.nrc.gov/docs/ML2300/ML23001A016.pdf) | Nuward power output and footprint per IAEA Advances in Small Modular Reactor Technology Developments (2020 Edition)

AP300 SMR Roadmap

Leverages our AP1000 reactor design and licensing experience to achieve deployment by early 2030's

AP1000 Design & Licensing Completed

1999 - 2012

- Design Certification
- Passive Safety System Testing & Demonstration
- Deployment & operation of AP1000 reactors

AP300 Design & Licensing

2022 - 2027

- NRC design certification
- Standard plant ready for initial deployment

Project Preparation

2027-2030

- Site specific design & licensing
- Long lead time procurement

Ready for Construction

2030

- 36 months for construction

NOAK target overnight cost $3400 per kWe … ~$1B per unit

The AP300 SMR

Our Technology is More Than Possible. It's Proven.

Proven Technology

Advanced Safety

Readily Deployable

Thank You

westinghousenuclear.com

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