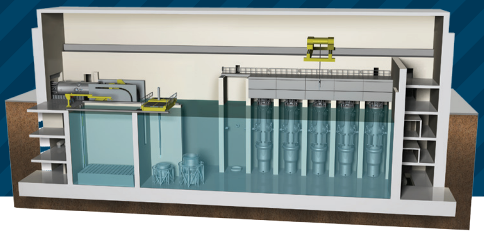
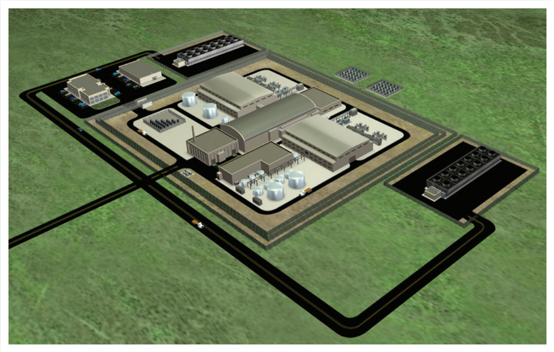
# Small Modular Reactors
## AN OVERVIEW

February 2017



***Small Modular Reactors (SMRs)*** *are one of the most promising new nuclear technologies to emerge in decades. With numerous safety enhancements, the ability to better match new generation capacity with electric demand growth, and the capability to be deployed in diverse applications, the potential for SMRs is strong. Together with large light-water and non-light-water reactors, SMRs are part of the all-of-the-above nuclear energy portfolio needed to meet national goals on energy security and mitigation of climate change.*



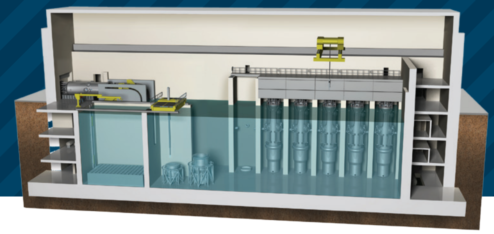
### What are SMRs?

Small Modular Reactors are nuclear power plants that are smaller in size (300 MWe or less) than most current generation baseload plants (1,000 MWe or higher). These smaller, compact designs are factory-fabricated reactors that can be transported by truck or rail to a nuclear power site.

SMRs may be either light water reactor (LWR) or non light water (non LWR) designs. LWR SMR designs come closer to current conventional power reactor designs in that water is used to cool the reactor, allowing well-known, proven technology to be the basis for the reactor's design. Non-LWRs use different coolants such as molten metals or salts, requiring technology that is less mature.

The NRC considers an SMR to be an LWR design, with a 300-MWe generation capacity or less. The Department of Energy extends the definition of an SMR to having the ability to fabricate major components of the nuclear system in a factory environment to be shipped to the location where it will be constructed and operated.

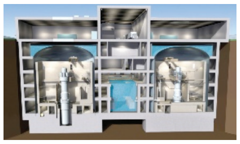
SMR designs incorporate advanced features to enhance safety, capital cost and operating efficiency. Examples include simplified component designs, advanced safety features that use natural phenomenon such as gravity or convection to cool the reactor during off normal events, use of existing commercial fuel designs, and extended periods between refueling and maintenance outages.



Examples of SMRs in various stages of development for the U.S. market are shown below. Each of these SMRs is based on an LWR design.

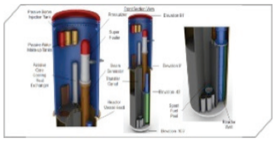
**NuScale Power, LLC Module**

The NuScale Power, LLC (NuScale) Module is a new kind of nuclear power plant, a smaller, scalable version of pressurized water reactor (PWR) technology with natural safety features that enable it to safely shut down and self-cool. Each NuScale power module has a power capacity of 50 MWe and has a fully integrated, factory-built containment and reactor pressure vessel. NuScale SMRs will be mass-produced in a factory and shipped by truck, rail or barge for power stations generating between 50-600 MWe.



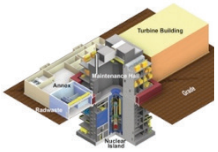
**Babcock & Wilcox Co. (B&W) Generation mPower™ Reactor**

The B&W mPower reactor design is a 180-MWe advanced LWR design with belowground containment that uses gravity, convection and conduction to cool the reactor during an emergency.



**Holtec International SMR 160**

The Holtec SMR-160 is a 160-MW reactor with an underground core. Holtec states that there is no need for a reactor coolant pump or offsite power ability to cool the reactor core.



**Westinghouse SMR**

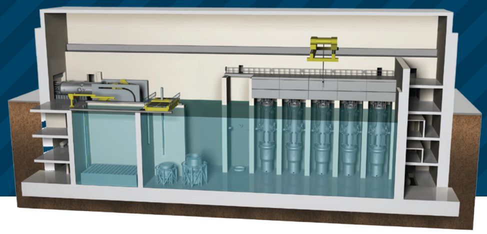
The Westinghouse SMR is a 200-MW integral pressurized water reactor with all primary components located inside the reactor vessel. It is based on the established Westinghouse AP1000 reactor design, which is being built in new nuclear plants around the world.

## *What are the Advantages of SMRs?*

**SMR technologies offer significant benefits, including:**

**Enhanced Safety** – SMRs increase safety using the principles of natural circulation; hence, no pumps are needed to circulate water through the reactor. SMRs rely on the natural laws of physics and passive systems (rather than active systems) to shut the reactor down and remove residual heat in the event of a malfunction – without human intervention.

**Mitigating Climate Change** – SMRs provide baseload energy and capacity to the electrical grid with zero carbon or other types of emissions (e.g. nitrous oxide, sulphur dioxide, mercury, etc.).



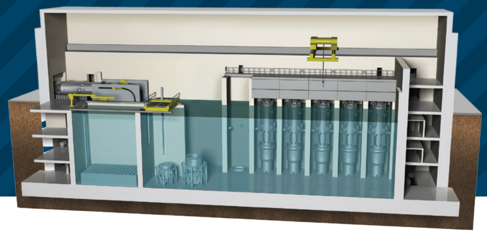
**Improved Operational Flexibility** – SMRs are designed to more quickly adjust their energy output to match demand (load follow). Some SMRs have multiple load following options built into their design providing significant advantages in balancing intermittent renewable resources such as wind and solar.

**Diverse Applications and Siting Flexibility** – SMRs can be deployed in remote areas where the grid is small, and can provide power for industrial process heat, desalination or water purification, and co-generation applications, such as for the petrochemical industry. Safety advances in SMRs are expected to provide public health and safety assurance without the need for large emergency planning zones. These flexibilities allow SMRs to bring the benefits of nuclear energy to more locations and customers.

**Fuel Diversity** – SMRs provide the nuclear energy critical to maintaining fuel diversity in the United States. If the U.S. becomes overly dependent on natural gas-fueled electricity generation, it could expose consumers to punishing volatility and loss of reliability. A diverse portfolio – including nuclear energy as a significant fuel source – is an essential characteristic of a robust and resilient system. Nuclear energy currently produces 63 percent of America's carbon-free electricity, at a 92 percent average capacity factor.

**Matching Demand Growth with Lower Cost** – SMRs allow generating companies to better match construction of new capacity with electricity load growth – particularly important in parts of the country where load growth may have slowed for decades and in areas where the electricity grid is not developed enough to support larger nuclear energy facilities. Capital investments also can be staged as modules are constructed. This could be particularly important for smaller companies – rural electric cooperatives or municipal agencies, for example – that cannot afford the $6 billion to $7 billion up-front costs associated with a 1,000-megawatt reactor. The current Levelized Cost of Energy (LCOE) for SMRs is $78/MWh for a first-of-a-kind plant built with a public power financing model, at an overnight capital cost of $3 billion. These are current estimates for the Carbon Free Power Project with a NuScale design, Fluor construction, and UAMPS ownership.

**Economic Growth and Job Creation** – SMRs will be manufactured in the United States to meet growing domestic and export demand. Factories that manufacture SMR components will employ thousands of engineers, technicians, and craft labor as well as transportation companies to move the modules to site locations. Moreover, construction of SMRs will utilize hundreds of construction workers for a period of four to five years, followed by an operating workforce of about 350 staff for the 40-year life of the facility.



### *Energy Northwest Involvement in Small Modular Reactors*

Energy Northwest has been involved in the development, communication and education of Small Modular Reactors since the early 2000s.

EN's early involvement in a study of SMRs included the coordination of a number of northwest utilities in an SMR Interest Group starting in 2009 and continuing to the present day. With Energy Northwest leadership this group has continued to meet over the years to stay up to date on the technology, government support programs, and implementation strategies for SMRs.

In 2013 Energy Northwest signed a Teaming Agreement with NuScale Power and the Utah Associated Municipal Power System (UAMPS) to develop the Carbon Free Power Project (CFPP). This "first-of-a-kind" NuScale SMR will be located at the Idaho National Laboratory and is scheduled for commercial operation in 2026. Under this agreement Energy Northwest has first right of offer to operate and maintain the project. The first major milestone for the CFPP was reached Dec. 31, 2016, with submittal by NuScale Power of the Design Certification Application to the Nuclear Regulatory Commission.

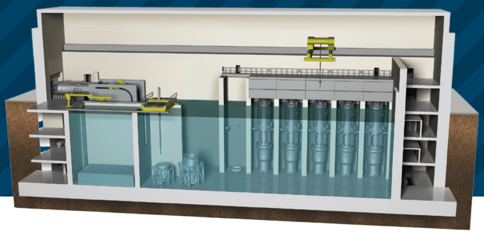
Another SMR effort in 2014 was the development of the Tri-City Industrial Development Council study on siting an SMR in Washington State. This study was funded by the Washington legislature and was completed by URS Corporation – a well-known Architect / Engineering firm. Energy Northwest was intimately involved in this study as the primary locations for the study were Energy Northwest leased sites established for previous nuclear plant development.

In addition, Energy Northwest became a charter member of SMR-Start in 2016. This SMR advocacy group is made up of utilities and vendors nation-wide and is acting as a voice for continued development and government support for commercialization of SMR technology.

### *How can the Federal Government Support SMR Development?*

**Production Tax Credits** – PTCs can offset first-of-a-kind risk for new SMR generating facilities. The Energy Policy Act of 2005 established a nuclear production tax credit (PTC) for new nuclear generating capacity built after 2005; however, it was limited in both availability (new nuclear plants must be placed in service by the end of 2020) and capacity (the first 6,000 megawatts of new nuclear generation). PTCs should be available to stimulate SMR deployment beyond 2020, the current expiration date of the existing program. The PTC should also be revised to allow it to be transferable from public entities to non-public participants.

**Loan Guarantee Program** – The existing loan guarantee program and authority should remain available through the design and construction of SMR facilities and SMR component manufacturing facilities. Loan guarantees that facilitate borrowing of up to 80 percent or more of the total project cost can dramatically improve the scale of SMR



commercialization. Unlike renewable projects, the loan guarantee program office charges the borrower for nuclear projects to cover costs associated with providing the loan guarantee. The existing loan guarantee program should remain available with no additional cost or authorization required.

**Grid Security and Reliability Programs** – Government development and demonstration are needed to enhance the reliability of electricity supply to federal facilities with large electricity requirements and missions that are important to national security. Some SMR design features make them more resilient than other types of facilities to withstand natural phenomena (e.g., earthquakes, floods, tornados) and intentional destructive acts (e.g., aircraft impacts, snipers). Additional capabilities, such as underground transmission, can be coupled with SMRs to improve resiliency of the transmission and distribution system and further improve reliability. Energy and Defense department programs should be funded to develop the requirements and specifications for SMR-Powered Secure and Reliable microgrids. These grids would be capable of operating independent of the main electrical grid, thus improving reliability and resiliency in support of selected federal facilities, and making those facilities less vulnerable to natural phenomena and intentional destructive acts.

**National Laboratory Support** – SMR development can be accelerated with access to and support from U.S. national laboratories (labs). Research and development into SMR technologies can help accelerate the commercialization of SMRs and facilitate regulatory acceptance of new concepts (e.g., passive safety features, fuel designs and testing, digital I&C, nuclear safety codes, dose calculations and modeling & simulation).

Moreover, many states are developing and implementing a “price on carbon” policy that typically results in either a carbon tax (per ton of $CO_2$ emitted) or a carbon cap and trade policy that puts a similar focus on reducing carbon emissions. These types of carbon related policies have a direct impact on the increased competitiveness of SMRs when looking at life cycle economics – including Levelized Cost of Energy (LCOE) comparisons between SMR and Combined Cycle Gas Turbine (CCGT) technology.

## *Conclusion*

Today’s U.S. energy markets are characterized by historically low natural gas prices, heavily encouraged subsidized renewable generation and low growth in electricity demand. SMRs are a new, safer nuclear technology that can bring diversity, flexibility and lower cost to providing baseload energy and capacity to the national electrical grid.