DECEMBER 2023

Global Technical Training Services, Inc. Newsletter

The State of the Industry

Sid Crouch, GTTSi Chief Technical Consultant

Nuclear proponents are optimistic after Vogtle 3 achieved commercial operation, with Unit 4 close behind. The lessons learned are expected to be a catalyst for future units; but the industry took a gigantic blow when NuScale and Utah Associated Municipal Power Systems announced termination of the Carbon Free Power Project. The culprit was once again **COST**. In January, NuScale announced an increase in the target price – up 53% from an earlier estimate of $58/MWh (***megawatt hour***) to $89/MWh. But small modular reactors (***SMRs***) and micro-reactors are still valued - from the Nuscale SMR design to the PHYLON micro-reactor design. Tennessee Valley Authority is looking at the GE-Hitachi BWRX-300 SMR, with plans to add 20 SMRs to their nuclear fleet. Duke Energy is planning 15 gigawatts of new nuclear by 2050 and has identified 31 site locations in North and South Carolina. The Belews Creek site is their 1st choice, with no specific design named. Oklo micro-reactors have been slated for Ohio, with plans to build another at the Idaho National Laboratory (***INL***) by 2026 or 2027.The Microreactor Applications Research Validation & Evaluation (***MARVEL***) micro-reactor is another project in full swing at INL, with operation expected by the end of 2024. INL is expecting delivery of Project Pele by the end of 2024. Three other micro-reactor designs were awarded funding at the INL– (***see article on pages 2-3***). **Net Zero Needs Nuclear** but a comeback faces significant challenges.

I welcome your comments or questions - sid.crouch@gttsi.com

Highlights

Minority and Woman-Owned MWBE Business Enterprise

GTTSI
807 Bypass 123 – Suite 31
Seneca, SC 29678
864.882.3111
ginfo@gttsi.com
www.gttsi.com

MICROREACTORS SELECTED FOR FUNDING AND TESTING AT IDAHO NATIONAL LABORATORY

Nuclear is getting smaller, literally, and it's opening opportunities for the industry. Much has been published about SMRs (***Small Modular Reactors***) but have you heard about micro-reactors? Micro-reactors will be small enough to be transported by truck, rail, or air and could help solve energy challenges in many areas, ranging from remote commercial or residential locations to military bases.

Micro-reactor designs vary. They are not defined by the type of fuel they use or their coolant and they produce 1 to 20 megawatts of thermal energy that could be used directly as heat or converted to electric power. They can be used to generate clean and reliable electricity for commercial use or for non-electric applications such as district heating, water desalination, and hydrogen fuel production.

Most designs will require HALEU fuel –High Assay Low Enriched Uranium (***concentration of uranium-235 between 5% and 20%***), although some may benefit from use of high temperature moderating materials that would reduce fuel enrichment requirements while maintaining the small system size.

The U.S. Department of Energy (***DOE***) supports a variety of advanced reactor designs, including gas, liquid metal, molten salt, and heat pipe-cooled concepts.

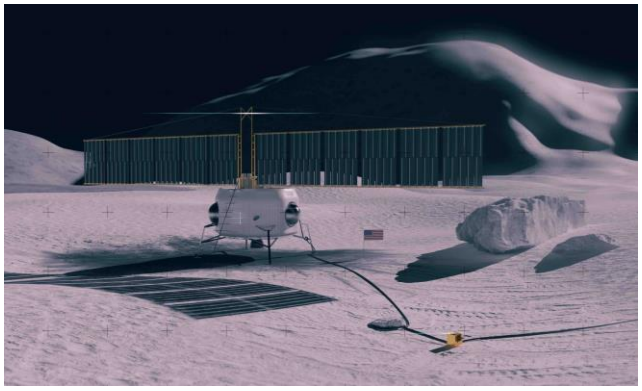
Three microreactor designs were recently awarded DOE funding for test bed experiments at the INL (*Idaho National Laboratory*) – Radiant, Ultra Safe Nuclear Corporation, and Westinghouse.

Radiant's design, called Kaleidos, is a high-temperature gas-cooled (***HGTR***) microreactor. This El Segundo, California-based company was set up in 2020 by former SpaceX engineers Doug Bernauer and Bob Urberger. Kaleidos will be capable of generating up to 1.2MWe (***megawatts electric***) or 1.9 MWt (***megawatts thermal***) for facility heating, water desalination, or as a replacement for diesel generators. The electric power generator, cooling system, reactor, and shielding are all packaged in a single shipping container, facilitating rapid deployment. Radiant is targeting commercial unit production in 2028.

Radiant Nuclear's Kaleidos Portable Nuclear Microreactor
Photo Credit: Radiant Nuclear

Ultra Safe's design, called PYLON, is also a high-temperature gas-cooled (***HGTR***) microreactor. The Seattle, Washington-based company designed this microreactor to be easily transportable for off-grid locations on Earth and in space. The nuclear heat supply system module and the balance-of-plant module are located inside a 20-foot (***6 meter***) container, capable of producing 1.5 - 5 MWe. PYLON is a smaller version of their 3.5 – 15 MWe ***Micro Modular Reactor (***MMR), also called a "fission battery."

Westinghouse's design, called eVinci, is a heat pipe microreactor. *(continued)*

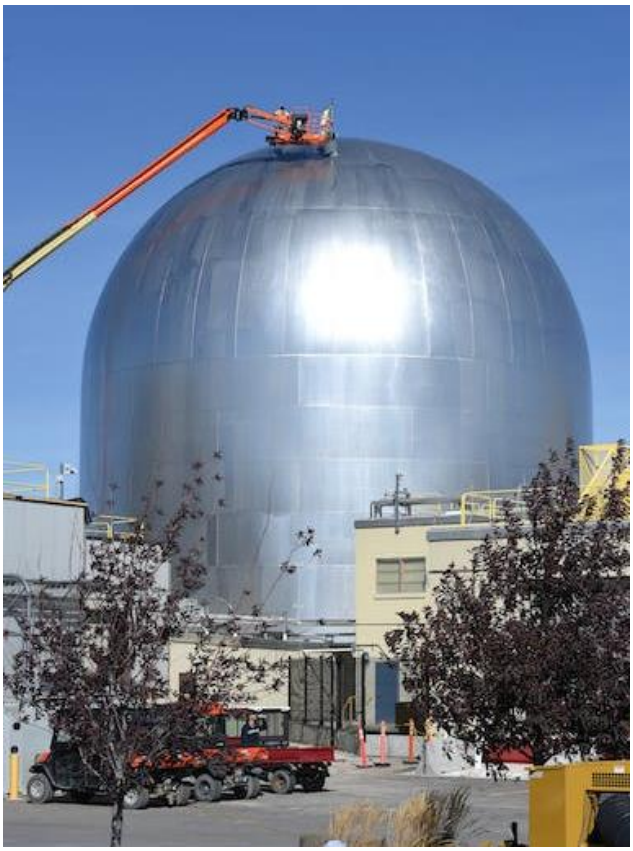


Rendition of Ultra Safe's PYLON SMR Design
Photo Credit: Ultra Safe Nuclear

This Pittsburg, Pennsylvania-based company designed this microreactor to produce up to 5 MWe (***megawatts electric***) or 12 MWt (***megawatts thermal***). It could be used to produce high temperature heat for industrial applications or as a battery, providing power for a variety of applications such as remote communities, universities, mining operations, industrial centers, data centers, universities,, defense facilities, and even on the surface of the Moon. The funding will support planning for the deployment of a one-fifth scale test reactor version of the reactor, which Westinghouse said will enable design finalization, testing and licensing of the technology.

The eVinci microreactor as shown by Westinghouse Nuclear

Testing for these microreactors will be conducted at the Demonstration of Microreactor Experiments (***DOME***), repurposing the Experimental-Breeder Reactor-II (***EBR-II***) containment structure (***pictured below***) at the Idaho National Laboratory. Using this structure, the Department of Energy says, will lessen the environmental footprint and save companies money in the testing process, as well as reduce overall project risk. It is one of two test beds being developed by the DOE. The Laboratory for Operation and Testing in the US test bed will host smaller reactor experiments to support the development of advanced reactors. The DOE said testing at the DOME could begin as early as 2026.



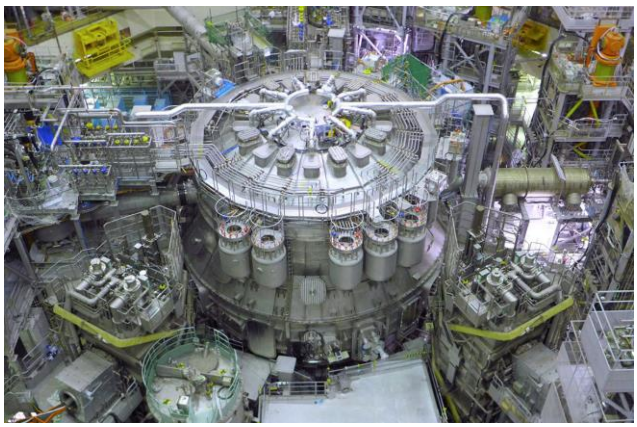
The Experimental Breeder Reactor-II dome receiving internal and external improvements in 2020.
Photo Credit: Idaho National Laboratory

JAPAN'S JT-60SA TOKAMAK ACHIEVES FUSION ENERGY MILESTONE AND PROVIDES LESSONS LEARNED

Japan recently brought the world one step closer to Fusion Energy. Their four-story-high JT-60SA Tokamak Fusion Reactor held a 200 million °C plasma for ~100 seconds, far longer than previous large Tokamaks.

The Tokamak's magnetic fields, created by superconducting coils, are used to contain the blazingly hot cloud of ionized gas, or plasma, within a doughnut-shaped vacuum vessel, with the goal to coax hydrogen nuclei to fuse and release energy.

Many fusion projects have experienced delays in the development and JT-60SA is no exception. It has taken 15 years to reach this milestone. Originally JT-60SA was to come online in 2016, but a redesign, procurement issues, and the March 2011 Tohoku earthquake caused delays. Then during the March 2021 testing, a short circuit occurred in a cable supplying electricity to one of the superconducting magnetic coils. The cause was traced to insufficient insulation in a critical wiring joint. This short circuit caused damage to the electrical connections and caused a helium leak that would have degraded the cooling systems. Fortunately, the short circuit occurred while minimum current was applied.



Japan's JT-60SA Fusion Reactor
Photo Credit: National Institutes for Quantum Science and Technology

ITER Reactor Construction
Photo Credit: ITER.org

The JT-60SA team reworked the insulation for more than one hundred electrical connections, a task that took 2.5 years.

These lessons are being passed along to the ITER Fusion Reactor Project, the mammoth international fusion reactor under construction in France. As an example, one limitation for the JT-60SA is that they will only use hydrogen and its isotope deuterium in their experiments, not tritium, a third form of hydrogen. Tritium is considered the most efficient option for energy production with the Fusion Reactor, so ITER plans to begin using deuterium-tritium fuel in 2035. Although the JT-60SA is 15.5 meters tall, it is approximately half the height of the ITER reactor, and it can only contain 135 cubic meters of plasma. However, its plasma closely resembles those planned for ITER so the lessons learned on plasma stability and how it affects fusion power output at long timescales should provide valuable information to the physicists working with ITER.

Japan hopes to build DEMO, a proposed demonstration power plant that would be a steppingstone from the research of JT-60SA and ITER to commercial fusion power by 2050.

PG&E FILES APPLICATION FOR DIABLO CANYON LICENSE EXTENSION

In 2016, after years of negative public opinion concerning the operation of PG&E's nuclear power plant designated Diablo Canyon, plans were announced to shutter the two units as their operating licenses expired - Unit 1 in 2024 and Unit 2 in 2025.

With the nation's focus directed toward achieving zero-carbon emissions, nuclear energy has gained some support, even in California, where the goal is to achieve 100% clean energy by 2045.

Some of this reversal in the viewpoint on nuclear energy occurred during the summer of 2022, when an intense heat wave prompted a "state of emergency." Californians were looking for ways to keep the lights on, charge their EVs, and operate their air conditioners. So much so, that the state lawmakers passed Senate Bill 846, which approved a $1.4 billion loan for PG&E, allowing Diablo Canyon to continue operations through October 31, 2029, for Unit 1 and October 31, 2030, for Unit 2.

Governor Newsom said passage of this bill was needed to bridge California's transition to clean energy, help the state meet its clean energy targets since Diablo Canyon produces zero carbon emissions, and avoid power outages since Diablo Canyon is a reliable source of power when solar and wind are not available.

Another factor in the governor's decision were his plans to bring offshore wind into California's energy mix, most likely in Humboldt County and offshore from Morro Bay. This plan includes a power distribution center located at the site of a retired natural-gas and oil power plant that shut down in 2014. This center will be used to receive the power generated from offshore wind and distribute it to the grid.

Diablo Canyon Nuclear Plant
Photo Credit: PG&E

The proposed wind project would be the first of its kind in the United States, featuring skyscraper-sized wind turbines roughly 20 miles from shore that float in the open ocean and not visible at Morro Bay or anywhere along the San Luis Obispo County coastline.

Recently, the Nuclear Regulatory Commission granted an exemption that will allow Diablo Canyon to continue operation while it pursues an operating license extension for up to 20 years. This exemption was the first step needed for PG&E to pursue the operating license extension. Now PG&E must provide detailed information on their reactors' condition for NRC's review, which typically takes two years.

In a news release, the NRC said the exemption would "not present undue risk to the public health and safety and is consistent with the common defense and security."

Although Governor Newsom says the plant, which provides 10% of the state's electricity, should stay open until 2030 to help the state meet its clean energy targets and avoid power outages, California lawmakers have not yet indicated any intention of allowing Diablo Canyon to operate beyond the dates previously approved.

CONSTELLATION ADDS SOUTH TEXAS PROJECT TO THEIR ENERGY MIX

Constellation is the operator of the nation's largest fleet of reliable, carbon-free nuclear plants-21 plants to be exact-and has announced its acquisition of a 44% ownership stake of the NRG Energy's South Texas Project Electric Generating Station (STP).

STP is a 2,645-megawatt, dual-unit nuclear plant located about 90 miles southwest of Houston. It is one of the newest and largest nuclear plants in the U.S., with an exceptional track record for safety and reliability, generating enough carbon-free power for two million homes.

Constellation's stake represents ~1,100 megawatts of the plant's output. The ownership transfer was approved on October 30 by the Nuclear Regulatory Commission, which was the final regulatory approval needed before closing the deal.

"Growing our fleet of the nation's best-run nuclear plants is at the heart of our growth strategy," said Joe Dominguez, President and CEO of Constellation. "As the world is waking up to the immense value of nuclear power to address the climate crisis and maintain energy security, Constellation will continue to look for opportunities to expand our ownership of assets like STP. We look forward to working with our new co-owners and the plant's team members to provide reliable, clean, and affordable energy, as well as economic benefits to the people of Texas."

This acquisition only adds to Constellation's presence in Texas. With more than 550 employees, Constellation is a supplier in Texas' competitive retail energy market, supplying electricity, natural gas, energy efficiency and other services to ~200,000 residential and commercial customers statewide. They own and operate three natural gas-fired power plants including Colorado Bend II, Wolf Hollow II and Handley, providing 3,520 megawatts to the Texas grid. They can add an additional 169 megawatts of wind energy to the Texas grid from the Whitetail and Sendero Wind Farms.

Constellation is an industry leader in operating nuclear plants safely, efficiently, and reliably, with a fleetwide capacity factor of more than 94%. With this acquisition, Constellation's owned nuclear assets are capable of powering the equivalent of more than 16 million homes.

The South Texas Project Nuclear Plant
Photo Credit: STP Nuclear Operation Company

DID YOU KNOW?

Delma Island Wind Farm
Photo Credit: Power Magazine/Courtesy: Masdar

The Abu Dhabi Energy Company, better known as Masdar, recently introduced one of four wind farms that make up the United Arab Emirate's first utility-scale wind project. Delma Island wind farm, combined with two others in Abu Dhabi – Sir Bani Yas Island and Al Sila – and a fourth in Al Halah, Fujairah, will offer 104 MW of utility-scale capacity. Discovery of a unique weather phenomenon comprised of higher winds at night in the UAE made this project scalable and economically viable. In addition, this project complements the UAE solar power generation, further diversifying their renewable energy mix.

TotalEnergies, a French-based energy company, has made an agreement with TexGen Power to purchase three of their Texas natural gas-fired power plants for $635 million. The deal includes **Wolf Hollow 1**, a 745 MW combined cycle gas turbine in Granbury, southwest of Dallas; **Colorado Bend 1**, which includes a 530-MW combined cycle gas turbine and a 74-MW open-cycle gas turbine (***OCGT***), located in Wharton, southwest of Houston, and **La Porte**, a 150-MW OCGT, located in La Porte, southeast of Houston. The purchase expands TotalEnergies portfolio in Texas, where they have 2 GW of installed renewables, 2 GW of renewables under construction, and another 3 GW under development.

Photo Credit: TotalEnergies

Photo Credit: orsted.com

Danish global offshore wind developer Orsted announced it will cease development of Ocean Wind 1 & 2. These two wind projects (***1100 MW and 1148 MW, respectively***) were to be located ~15 miles off the coast of Atlantic City, NJ on the Outer Continental Shelf. Significant impacts from macroeconomic factors, including high inflation, rising interest rates, and supply chain constraints, particularly a vessel delay on Ocean Wind 1 that considerably impacted project timing, were cited as the cause for termination.

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GTTSI
807 Bypass 123 - Suite 31
Seneca, SC 29678
Phone: 864.882.3111
Fax: 864.882.1026
ginfo@gttsi.com

Marshalla Schile
President
Phone: 864.882.3111
marshalla.schile@gttsi.com

Clay Schile
Vice-President
Phone: 864.882.3111
clay.schile@gttsi.com

Chrissy Mulay
Technical Staffing Manager
Phone: 864.506.4647
chrissy.mulay@gttsi.com

Lisa Peach
Technical Staffing Specialist
Phone: 864.360.7554
lisa.peach@gttsi.com

Debbie Scott
Administration
Phone: 864.882.3111
debbie.scott@gttsi.com

Sid Crouch
Chief Technical Consultant
Phone: 843.861.0431
sid.crouch@gttsi.com

LD Holland
Senior Human Performance Consultant
Phone: 864.882.3111
ginfo@gttsi.com

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GTTSi

P.O. Box 307
Hartsville, SC 29550-0307

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