UNC CHARLOTTE
The WILLIAM STATES LEE COLLEGE of ENGINEERING
Industrial Solutions Laboratory

Company Information

Company Name	*Orano Federal Services*	**Date Submitted**	*06/18/21*
Project Title	*Digital Twin for Power Distribution from an Advanced Reactor to a Power Grid with Renewables and to Alternative Energy Production Methods* **(ORANO_TWIN)**	**Planned Starting Semester**	*Fall 2021*

Senior Design Project Description

Personnel

Typical teams will have 4-6 students, with engineering disciplines assigned based on the anticipated Scope of the Project.

Please provide your estimate of staffing in the below table. The Senior Design Committee will adjust as appropriate based on scope and discipline skills:

Discipline	**Number**	**Discipline**	**Number**
Mechanical	1	Electrical	1
Computer	1	Systems	1
Other ( )			

Company and Project Overview:

Headquartered in Washington, D.C., Orano USA is a leading technology and services provider for decommissioning shutdown nuclear energy facilities, used fuel management for existing and advanced reactors, federal site cleanup and closure, and the sale of uranium, conversion, and enrichment services to the U.S. commercial and federal markets. With its parent company Orano, Orano USA has more than 30 years' experience in decontaminating and dismantling nuclear facilities, and more than 50 years' experience securely transporting and storing used nuclear fuel (UNF). Prior to a global rebranding in January 2018, Orano USA was AREVA Nuclear Materials or simply AREVA.

The Orano Federal Services business combines the capabilities, technologies and resources from multiple Orano companies to serve the United States Department of Energy (DOE) and its subcontractors in all phases of the nuclear fuel cycle. Orano Federal Services provides key services as an active member in various projects that support DOE's **five strategic services: Environmental Management (EM), Nuclear Energy (NE), Office of Science (SC), Office of Energy Efficiency & Renewable Energy (EERE),** and **National Nuclear Security Administration (NNSA).** Orano Federal Services currently is a contract team member of the following significant projects: the High Burnup (HBU) Demonstration Project; the Atlas railcar designed to ship UNF in transportation casks; the Yucca Mountain repository program (dormant); the Tank Operations Contract (TOC) at Hanford; support to multiple advanced reactors designated by DOE for support under various programs such as the Advanced Reactor Deployment Program;

et al.

In anticipation of the use of advanced reactors in an environment with significant renewable usage, to maintain maximum profitability, the advanced reactors would prefer to run at full power while load following on the grid and using excess power to produce alternative energy sources such as hydrogen, battery, pump storage, etc. These alternative energies could be used at other periods of time on the grid such as when the demand for power exceeds the power that can be produced by the advanced reactor or through alternative methods such as by transportation systems. The objective of this project is to develop a digital twin for the power distribution system to show how the power from an advanced reactor can be distributed for various uses (e.g., to the grid, to electrolysis for hydrogen production, to charge a battery, etc.), while maximizing usage and profit/income from the operation of the reactor. Orano Federal Services is currently working with X-Energy on the XE-100 advanced reactor and would prefer that it be the reactor examined for this activity.

Project Details & Requirements:

Today's electricity production market in the U.S. is a complex system of complimentary generation options combined with incentives, tariffs, and regulations related to precedent of use (order) of one generating technology supplying power to the grid over another. For example, Duke Energy (Duke) is the largest regulated utility in the U.S. with approximately 7.8 million residential customers in six states: North Carolina, South Carolina, Florida, Indiana, Ohio, and Kentucky. Duke generates 51,000 megawatts of electricity with approximately 11,000 megawatts from nuclear and 3,000 megawatts from wind and solar. Depending on the particular market, renewable energy may get precedent over nuclear and fossil for supplying power to the grid. Therefore, at certain times of the day expensive power production units would not be operating at their optimum capacity, making the business model to invest in new technologies less attractive. Many utilities, including Duke, are committed to meeting carbon reduction goals requiring additional renewable sources and consideration of new nuclear. Duke has committed to 50% reduction in carbon emissions by 2030 and to achieve net-zero carbon emissions by 2050.

This proposed project will examine the feasibility of developing a digital twin for the power distribution from an advanced reactor and determining (to the extent possible) the profitability of combining the advanced reactor power output to a grid with a heavy dependence on renewables while using excess generating capacity to produce alternative energies, such as hydrogen and/or backup battery power, to increase the overall profitability of the system. For example, if we assume a valuable asset such as an advanced nuclear reactor has been built at a cost of several billion dollars and is used in a market where renewables have preference to supply power to the grid, could the reactor be used to produce, for example, hydrogen via electrolysis, while load following the electricity demand on the grid?

The objective of this study will be to design a digital twin that maximizes the efficient use of an advanced reactor while also attempting to maximize its profitability and ideally resulting in an efficient means of energy production for multiple sectors (e.g., electricity for the grid, hydrogen production for transportation, battery backup/surge power for the grid, etc.).

Expected Deliverables/Results:

A report documenting a *Digital Twin* designed to model distribution of power from an advanced reactor that considers the following elements:

- Utilization of a specific advanced reactor with a specific power output (e.g., XE-100)
- Select a state with a heavy renewable portfolio and available load curves (e.g., NC, CA)
- Ensure the advanced reactor runs at nearly full power at all time to ensure maximum profitability for the plant
- Assume the plant provides its full power to the grid when demand is high and renewables are low
- Assume the plant has to shed load to alternative power production activities when demand from the grid is low during times when renewables are available
- Utilize the shed load to produce hydrogen using electrolysis method if enough shed power exists
- Utilize the shed load to produce alternative energy (e.g., battery, pump storage, capacitor-like activity(s)), if the shed load is insufficient to power electrolysis
- Ultimately develop a digital model that maximizes profit for the advanced reactor, while co-locating other energy sources and costing these alternative sources.

Disposition of Deliverables at the End of the Project:

Work product is displayed at the last Expo and then results and any developed materials handed over to Orano following the Expo.

List here any specific skills, requirements, specific courses, knowledge needed or suggested (If none please state none):

- Production of a computer model to represent the *Digital Twin* of a power distribution system from a power plant with an interfaces to: a grid with certain precedents (hierarchies) and multiple alternative energy production methods (e.g., hydrogen, battery)
- Understanding of power distribution, power demand, load following, load shedding, etc.
- Understanding of various power production options (e.g., renewables, nuclear, battery) and their interactions
- Understanding of engineering economics associated with utilization of various power production methods, capital expenditures, operating expenditures, etc.