Hydrogen Experience
Owner's Engineering, Studies, Technical Oversight

Sargent & Lundy

Client	Location	Facility Type	Major Equipment	Schedule
Confidential	**Confidential, U.S.**	**Clean Hydrogen Hub**	**Partial Oxidation Unit with CCS, Electrolyzers, Ammonia Synthesis**	**Q1 2023–Ongoing**
Clean hydrogen hub feasibility studies Providing engineering services to a confidential client developing a clean hydrogen hub in the United States. Hub will include hydrogen generation via both electrolysis and the partial oxidation of natural gas with carbon capture and sequestration. Hydrogen will be fed to ammonia synthesis unit for clean ammonia production. Current work includes development of a design basis for the facilities, feedstock analyses, general arrangements of hydrogen facilities, conceptual process design, conceptual electrical systems design, cost estimating.				
Confidential	**Confidential, U.S.**	**Clean Hydrogen Hub**	**Electrolyzers, Gaseous Storage, Compressor(s), Underground Storage**	**Q1 2023–Ongoing**
Clean Hydrogen hub fatal flaw analysis Providing engineering services to a confidential client developing a clean hydrogen hub in the United States. Hub will include hydrogen generation via electrolysis, compression, pipelines, and underground storage. Current work includes a fatal flaw analysis of the site based on factors such as available land and the suitability for the clean hydrogen production and storage facilities. The project also includes permitting evaluation for the site.				
Confidential	**Confidential, U.S.**	**Clean Hydrogen Hub**	**Electrolyzers, Liquefaction, Liquid Storage, Gaseous Storage, Vehicle Fueling**	**Q1 2023–Ongoing**
Clean hydrogen hub conceptual design and study Providing engineering services to a confidential client developing a clean hydrogen hub in the United States. Hub will include multiple locations with hydrogen generation, storage, and vehicle fueling throughout the region. Current work includes development of a design basis for the facilities, feedstock analyses, general arrangements of hydrogen facilities, conceptual process design, conceptual electrical systems design, and cost estimating.				
Confidential	**Confidential, U.S.**	**35-MW Solar PV and Hydrogen Production Facility**	**Solar PV, Electrolyzers, Liquefaction, Liquid Storage**	**Q1 2023–Ongoing**
Clean hydrogen facility project Providing engineering services to a confidential client developing a 35-MW hydrogen facility with onsite renewable power generation via solar PV. Current work includes pre-FEED and FEED studies evaluating the solar PV system design, feedstock analysis, general arrangement of hydrogen facility, process design, electrical systems design, and cost estimating. Studies also include permitting analysis.				

Client	Location	Facility Type	Major Equipment	Schedule
Confidential	**Multiple Confidential, U.S. Locations**	**Large-Scale Nuclear Hydrogen Production Facility**	**Nuclear Power Plant, Electrolyzers, Storage, Compressor(s)**	**Q1 2023–Ongoing**
Large-scale nuclear hydrogen facility study Providing engineering services to a confidential client developing a large-scale clean hydrogen facility co-located with an existing nuclear power plant. Study includes power sourcing study, feedstock analysis, general arrangement of hydrogen facility, and technoeconomic analysis of offtake possibilities. Evaluating all forms of electrolysis for optimal hydrogen production efficiency.				
Confidential	**Confidential, U.S.**	**Green Hydrogen Production Facility**	**Onshore Wind, Solar PV, Electrolyzers**	**Q1 2023–Ongoing**
Power sourcing study for green hydrogen facility Conducting a power sourcing study for a gigawatt-scale hydrogen production facility. This study includes definition of the power inputs required for a hydrogen production facility and land area requirements. Assessing sourcing power from behind-the-meter greenfield renewable generation, grid supply, and acquisition of existing renewable developments.				
Confidential	**Confidential, U.S.**	**Clean Data Center with Hydrogen**	**Data Center, Hydrogen Fuel Cell, Liquid Hydrogen Storage**	**Q4 2022–Ongoing**
Clean hydrogen data center project Providing detailed engineering services to a confidential client building a clean data center powered by hydrogen. System includes a stationary PEM fuel cell, liquid hydrogen storage, hydrogen vaporizers, and all associated safety systems. Sargent & Lundy is responsible for the detailed design of the hydrogen system, including layouts, piping design, and safety system design. Sargent & Lundy will also be supplying commissioning services for the unit.				
Confidential	**Confidential, U.S.**	**Clean Energy Hub**	**SMR/ATR with CCS, Electrolyzers, Renewables**	**Q4 2022–Ongoing**
Feasibility study for clean energy hub project Providing engineering services to a confidential client developing a clean energy hub around an existing gas treatment facility. This clean energy hub is expected to include renewable power generation, hydrogen production via electrolysis, and hydrogen production via steam methane reforming (SMR) or autothermal reforming (ATR) with carbon capture and storage. Scope includes a design basis, PFDs, layouts, and cost estimating support.				
Confidential	**Multiple Confidential, U.S. Locations**	**Methane Pyrolysis**	**Methane Pyrolysis Unit, Ammonia Synthesis Unit**	**Q4 2022–Ongoing**
Independent engineering services for methane pyrolysis projects Providing independent engineering services to a confidential client working on several methane pyrolysis projects in the U.S. Scope includes an overview of the methane pyrolysis technology, as well as several of the completed projects as benchmarking for the client to predict the performance of a facility expansion. Also performing a high-level design review of the major systems for compliance with industry standards and best practices.				

Client	Location	Facility Type	Major Equipment	Schedule
Confidential	**Confidential, U.S.**	**Solar PV**	**Electrolyzers, Storage, Compressor(s), Offloading**	**Q4 2022–Ongoing**
25-MW green hydrogen production facility feasibility study Performing a feasibility study related to the installation of a 25-MW green hydrogen production facility coupled with solar PV power resources. The study includes design of balance-of-plant (BOP) systems around a 25-MW electrolyzer system, including electrical interconnects, water infrastructure, and more. The study will also investigate scale-up to a 100-MW capacity in the future. Feasibility study also encompasses permitting screening, including determination of permits needed, timelines for approvals, and associated costs, as well as capital cost estimating.				
Confidential	**Confidential, U.S.**	**Green Ammonia**	**Electrolyzers, Storage, Compressor(s), Ammonia Synthesis, ASU**	**Q4 2022–Ongoing**
Fatal flaw analysis of hydrogen production and green ammonia facility Performing a fatal flaw analysis for a ~600-MW renewable-powered hydrogen production facility co-located with a 500-kTPA green ammonia facility for the export of green ammonia. The study involves investigations into feedstock availability, site feasibility, and basic permitting for the system. Also includes Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) greenhouse gas emissions evaluation for the system, as well as capital expenditures (CapEx) and operating expenses (OpEx) estimates.				
Confidential	**Multiple Confidential, U.S. Locations**	**Solar PV, Battery Energy Storage**	**Electrolyzers, Storage, Compressor(s), Offloading**	**Q4 2022–Q1 2023**
Integrated solar PV, battery energy storage system (BESS), and hydrogen facility layouts Providing site-specific layouts for 10-MWac, four-hour BESS, and 10-MWac hydrogen production facilities, both integrated with solar PV. The hydrogen production facility layouts include electrolyzers, control room, water treatment system, hydrogen storage, compression system, hydrogen offloading, and other balance-of-plant (BOP) systems.				
Confidential	**Confidential, U.S.**	**Hydrogen Testing Facility**	**Storage, Offloading**	**Q3 2022–Q3 2022**
Code assessment and fatal flow assessment for retrofit of testing facility for hydrogen Performed a codes and standards analysis and a fatal flaw analysis for adding hydrogen fueling infrastructure to a testing facility. The added hydrogen would enable the testing of internal combustion engines (ICEs) on blended fuels with varying amounts of hydrogen. Investigation included tube trailer siting, piping layout, and HVAC modifications needed to support the addition of hydrogen infrastructure.				
Confidential	**Confidential, U.S.**	**Various**	**Electrolyzers, Storage, Compressor(s), Gas Turbines**	**Q2 2022-Ongoing**
Framework for green hydrogen production, storage, and use for power buffering Assisting a confidential client with developing a framework for green hydrogen production, storage, and use as a fuel for gas turbines in power generation to serve as short-term or seasonal grid buffering. The framework will serve as a starting point for identifying, sizing, and configuring system components based on geographical location and power output. The framework will be presented in the form of an interactive website.				

Client	Location	Facility Type	Major Equipment	Schedule
Confidential	**Confidential, U.S.**	**Nuclear**	**Electrolyzers, Storage, Compressor(s), Offloading**	**Q2 2022–Ongoing**
Design guide for hydrogen at nuclear power plants Assisting a confidential client with developing a guideline for the planning, design, and project execution of a hydrogen plant at existing nuclear power plants. This guide will cover the planning and development of integrating both low-temperature electrolysis (LTE) and high-temperature electrolysis (HTE) into existing pressurized water reactors (PWRs) and boiling water reactors (BWRs).				
Confidential	**Confidential, U.S.**	**Nuclear**	**Solid Oxide (SOEC) Electrolyzers, Storage, Compressor(s)**	**Q2 2022–Q4 2023**
Feasibility study for high-temperature electrolysis at a nuclear power plant Investigated the feasibility and cost of a hot electrolysis facility (SOECs) at an existing nuclear power plant. The study involved approximately 50 MW of electrolysis, hydrogen compression, hydrogen storage, and tube trailer offloading for the facility. The study also included behind-the-meter work at the nuclear plant, as well as integration with the nuclear plant's steam cycle.				
Confidential	**Not Applicable**	**Solar PV**	**Electrolyzers, Storage, Compressor(s), Offloading**	**Q2 2022–Q3 2022**
Green hydrogen modeling Developed a model that blends both economic and technical parameters associated with green hydrogen production. The final model was used to compare and optimize different green hydrogen production plant configurations, operational practices, and other technical considerations for their impact on the levelized cost of hydrogen (LCOH). The modeling focused on different sizes of proton exchange membrane (PEM) electrolyzers tied to solar PV facilities for the creation of green hydrogen.				
Confidential	**Not Applicable**	**Solar PV**	**Electrolyzers, Storage, Compressor(s), Offloading**	**Q2 2022–Q3 2022**
Layouts for battery energy storage system (BESS) and hydrogen production integrated with solar PV Provided standard layouts for a 100-MWac, four-hour BESS, and 50-MWac hydrogen production facility, both intended to be integrated with a reference 150-MWac solar PV project. The hydrogen production facility layout will include electrolyzers, control room and water treatment system, hydrogen storage and compression system, hydrogen rejection system, and hydrogen offloading.				

Client	Location	Facility Type	Major Equipment	Schedule
Idaho National Laboratory (INL)	**--**	**Nuclear**	**Solid Oxide (SOEC) Electrolyzers, Storage, Compressor(s)**	**Q1 2022–Ongoing**
Nuclear plant preconceptual 10 CFR 50.59 evaluation for large-scale hydrogen production facility Providing licensing guidance to INL for the coupling of nuclear power plants with large-scale, high temperature electrolysis hydrogen production facilities. Using the 100-MW preconceptual design from a previous report, an evaluation is performed for a reference plant to observe the applicability of the 10 CFR 50.59 process for a nuclear integrated hydrogen production facility modification. Site-specific considerations and general limitations are provided for plant reference.				
Idaho National Laboratory (INL)	**--**	**Nuclear**	**Solid Oxide (SOEC) Electrolyzers, Storage, Compressor(s)**	**Q1 2022–Ongoing**
Nuclear plant preconceptual design for large-scale hydrogen production facility Providing preconceptual design support for INL relating to coupling nuclear power plants with large-scale, high-temperature electrolysis hydrogen production facilities. This includes evaluation of the required modifications needed to divert thermal and electrical energy to high-temperature electrolysis facilities. Steam extraction and electrical transmission designs are developed for two independent hydrogen facilities, requiring nominal power inputs of 100 MW and 500 MW, respectively. The preconceptual designs are intended to serve as feasibility studies for utilities considering such modifications.				
Confidential	**Confidential, U.S.**	**Combined Cycle**	**Proton Exchange Membrane (PEM) Electrolyzers, Storage, Compressor(s), Gas Turbine**	**Q1 2022–Ongoing**
Owner's engineering for hydrogen production facility Providing owner's engineering services to a utility client for the design of a hydrogen production facility co-located with an existing combined cycle power plant. Our scope includes conceptual design of a 20-MW hydrogen generation facility, encompassing gaseous hydrogen storage, compression, and blending systems. Sargent & Lundy is also assisting with long-lead procurement, cost estimating, facility layouts, and the development of an EPC scope of work.				
Confidential	**Various, U.S.**	**Solar PV**	**TBD**	**Q1 2022–Ongoing**
Owner's engineering for various solar PV facilities Providing owner's engineering services to a solar PV developer with renewable energy facilities across the U.S. Our scope includes conceptual designs of hydrogen generation facilities, energy modeling and forecasting, and siting studies for hydrogen generation capacities from 25 MW to 200 MW, including liquefaction and trucking terminals.				
Confidential	**Confidential**	**N/A**	**N/A**	**Q1 2022–Ongoing**
Hydrogen code assessment Providing a hydrogen code assessment for a confidential client related to the Spanish Islands off the coast of Africa. The work is focused on identifying key hydrogen-related specifications for the islands to prepare for potential projects in the future.				

Client	Location	Facility Type	Major Equipment	Schedule
Confidential	**Confidential, U.S.**	**N/A**	**N/A**	**Q1 2022–Ongoing**

Hydrogen market forecasting tool

Sargent & Lundy was contracted by a large investment firm to support the development of a supply and demand analysis of hydrogen and electricity based on future decarbonization initiatives in home heating and heavy-industry sectors. The client requested Sargent & Lundy's assistance in developing a Microsoft Excel-based model and a data repository of industry data. The model will enable the client to forecast future hydrogen demand for electricity generation based on decarbonization sensitivities. Sargent & Lundy is also preparing a corresponding white paper that will provide supplemental qualitative discussion on various topics in hydrogen markets, home heating, and heavy-industry sectors.

Confidential	**Confidential, Africa**	**Green Ammonia**	**Electrolyzers, Storage, Compressor(s), Ammonia Synthesis, ASU, Tube Trailer Filling**	**Q1 2022–Q3 2022**

Feasibility study for green ammonia facility

Conducted a confidential feasibility study for a green ammonia facility in western Africa. This facility would use excess electricity from a nearby hydroelectric power source to feed alkaline electrolysis on the scale of 240 MW. The hydrogen produced would then feed into 500 tons per day (tpd) ammonia synthesis unit to make green ammonia for distribution. The project also included an air separation unit (ASU) to feed the ammonia synthesis process.

Confidential	**Confidential, U.S.**	**Combined Cycle**	**G-Class Gas Turbines**	**Q1 2022–Q2 2022**

Engineering support for hydrogen cofiring demonstration in large gas turbines

Provided engineering services related to a successful demonstration blending hydrogen with natural gas in large gas turbines up to 20% by volume of hydrogen. Gas turbines included dry low-NO_X (DLN) burners and was the largest demonstration of this type to date. Also provided code reviews, design reviews, and hydrogen supply equipment inspections.

Confidential	**Confidential, U.S.**	**Combined Cycle**	**Advanced-Class Gas Turbines**	**Q1 2021– Q2 2022**

Feasibility study for cofiring of hydrogen in advanced-class gas turbines at new combined cycle facility

Performed a study that included the preliminary engineering, design, and cost considerations of blending hydrogen with natural gas and cofiring in advanced-class gas turbines at concentrations of 30 vol% and 100 vol%.

Confidential	**Confidential, U.S.**	**Wind Farm**	**Proton Exchange Membrane (PEM) Electrolyzers, Storage, Compressor(s), Tube Trailer Filling**	**Q1 2022–Q2 2022**

Owner's engineering for virtual hydrogen pipeline

Provided owner's engineering services for design of a new virtual hydrogen pipeline facility at an existing renewable energy facility of greater than 300 MW. The facility design included 15 MW of PEM electrolyzers with corresponding hydrogen compression and trailer offloading. Sargent & Lundy assisted with activities such as the conceptual design, long-lead equipment procurement, EPC contract development, and overall project execution oversight.

Client	Location	Facility Type	Major Equipment	Schedule
Confidential	**Confidential, U.S.**	**Microgrid / Hydrogen Fueling**	**Proton Exchange Membrane (PEM) Electrolyzers, Storage, Compressor(s), H_2 Fueling, Fuel Cell**	**Q4 2021–Q4 2022**
Resiliency study related to variable renewable energy sources coupled with grid electricity to provide resilient power and hydrogen fueling capabilities Conducted study that focused on both 100-kW and 1-MW electrolyzer systems with differently sized components incorporated within an existing microgrid to produce hydrogen for energy storage and hydrogen fueling stations. These components include electrolyzers, stationary fuel cells, hydrogen storage, hydrogen fueling stations, and all associated balance-of-plant (BOP) supporting systems. Activities included equipment sizing, systems design, and cost estimating for the systems.				
Confidential	**Confidential, U.S.**	**Power-to-Gas**	**PEM Electrolyzers, Storage, Compressor(s)**	**Q4 2021–Q2 2022**
Front-end engineering and design (FEED) study related to a power-to-gas hydrogen demonstration plant for distributed energy storage around renewable assets Conducted study that included engineering, design, and cost estimating for a facility that will produce hydrogen via 5-MW of PEM electrolysis driven by renewable wind power and store the hydrogen on site to be sold to the hydrogen market. The study encompassed hydrogen compression and gaseous hydrogen storage in tube racks along with a filling station for mobile tube trailers. This first-of-a kind power-to-gas demonstration would produce carbon-free hydrogen for sale when the grid does not require all of the power produced at the site.				
Confidential	**Confidential, U.S.**	**Distributed Generation**	**Small Modular Reactor (SMR)-Based Hydrogen Generation**	**Q4 2021–Q1 2022**
Technology due diligence of novel SMR-based distributed hydrogen generation technology Sargent & Lundy was contracted by a potential investor to perform a technology due diligence of a skid-mounted distributed hydrogen generation system capable of generating 1,000 kg/day of hydrogen utilizing a proprietary SMR technology. Sargent & Lundy's review focused on process efficiency, output, and safety features to ensure that the skid was suitable for any site or environment. In addition to reviewing the technical aspects of the skid, Sargent & Lundy was tasked with reviewing the financial model prepared by the manufacturer. The manufacturer prepared a single representative financial model for the skid, which included capital costs, O&M costs, and consumable costs. Sargent & Lundy was tasked with confirming that the financial model parameters were adequate for any site or environment in which the skid may operate. Sargent & Lundy also prepared a technical and financial comparison of the skid against existing commercially available hydrogen technologies, which included SMR, electrolysis, and fuel cell technologies.				
Confidential	**Confidential, U.S.**	**Commercial Trucking Fleet**	**PEM Electrolyzers, Storage, Compressor(s)**	**Q4 2021– Q1 2022**
Development of commercial Class 8 trucking fleet zero-emission/decarbonization transition utilizing multiple technologies, including battery electric and hydrogen fuel cell vehicles Provided energy assessments and conducted modeling for the fleet conversion to evaluate new energy needs to develop the corresponding infrastructure and facilitate power purchase agreements, as well as onsite renewable generation where feasible. The facilities are planned to include 95% of fleet fueling on site at regional distribution centers with onsite hydrogen production and storage.				

Client	Location	Facility Type	Major Equipment	Schedule
Confidential	**Confidential, U.S.**	**Simple Cycle**	**PEM Electrolyzer, Storage, Compressor(s), Gas Turbine**	**Q3 2021–Ongoing**
Engineering for commercial-scale hydrogen production and storage project collocated with existing simple cycle facility for hydrogen cofiring in a gas turbine The project includes 2 MW of renewable solar PV-powered PEM electrolyzers, hydrogen compression, gaseous aboveground storage, and blending of hydrogen with natural gas for use in an existing gas turbine. Hydrogen will be stored on site in stationary tube bundles and be able to be blended into the gas turbine at varying concentrations. The project includes other aspects of the facility, such as integration with the plant's water treatment system, a cooling system, hydrogen detection and monitoring, and fire protection.				
Confidential	**Confidential, U.S.**	**Generation and Storage**	**Advanced-Class Gas Turbine, Alkaline Electrolyzers, Geologic Storage**	**Q3 2021–Ongoing**
Large-scale hydrogen production and storage Providing owner's engineering services for a large integrated hydrogen production and geologic storage project. The project consists of more than 200 MW of grid-connected electrolyzers with corresponding hydrogen compression and geologic storage for seasonal hydrogen energy storage.				
Confidential	**Confidential, U.S.**	**Liquid Hydrogen Terminal**	**Hydrogen Liquefaction, Hydrogen Filling Station/Terminal**	**Q2 2021–Q3 2021**
Pre-FEED study and conceptual design for large-scale hydrogen liquefaction and distribution terminal Conducted study that encompassed the hydrogen liquefaction technology selection, process design, and storage, as well as the truck terminal. The study consisted of conceptual engineering, design, and cost estimating related to the 30-tpd production facility.				
Confidential	**Confidential, International**	**Power-to-Ammonia**	**Solar PV, Electrolyzers, Ammonia Production**	**Q1 2021–Ongoing**
Large-scale power-to-ammonia facility Providing lender's technical advisory (LTA) services for development of a facility that will use renewable solar PV resources to power the production of hydrogen via electrolysis. The hydrogen will then be synthesized into green ammonia using the Haber-Bosch process for distribution. We are also reviewing project documents on behalf of the client to ensure the safe and compliant design of the facility.				

Client	Location	Facility Type	Major Equipment	Schedule
Confidential	**Confidential, U.S.**	**Nuclear Pressurized/Boiler Water Reactor (PWR)**	**High-Temperature Steam Electrolysis (HTSE)**	**Q1 2021–Ongoing**

High-temperature steam electrolysis (HTSE) equipment at nuclear facility

Supporting the client's grant application to the DOE for the installation of an HTSE skid. Sargent & Lundy's work includes conceptual plant interconnection designs and cost estimates for both a BWR and a PWR installation of a demonstration-sized HTSE skid (200-kW to 1-MW). The conceptual interconnect designs encompass both thermal and electrical interfaces, including the unique considerations needed for either a PWR or BWR. Also assisting the client with the development of a purchase specification related to the HTSE skid, now roughly 300 kW in size. Project includes a study of capturing and compressing the hydrogen for offloading or other use on site.

Confidential	**Confidential, U.S.**	**Combined Cycle**	**Advanced-Class Gas Turbines, PEM Electrolyzers**	**Q1 2021-Q1 2022**

Conceptual design for green hydrogen facility powered by renewable solar PV power at advanced-class combined cycle facility

Conducted study that encompassed the compression, storage, and blending of hydrogen with natural gas for use in an advanced-class combined cycle facility. The study tasks consisted of conceptual engineering, design, and cost estimating related to the 25-MW production facility. Hydrogen is stored on site in stationary tube bundles and is blended into the gas turbines at varying concentrations. The project encompassed other aspects of the facility, such as the electrolysis building design, hydrogen detection and monitoring, and fire protection.

EPRI/ NYPA	**Long Island, New York**	**Simple Cycle**	**GE, LM6000**	**Q1 2021 -Ongoing, Q4 2021 (12 months)**

Hydrogen cofiring demonstration plant at simple cycle facility

Provided owner's engineering services for this project being executed in conjunction with owner NYPA, research partner EPRI, and original equipment manufacturer (OEM) General Electric (GE). Our scope included providing technical oversight on behalf of EPRI, to ensure the project design is executed properly, with specific focus on safety. We performed a targeted review of all safety requirements, code requirements, OEM requirements, and utility procedural/safety requirements. Our scope also included providing quality control inspections for all fabricated components.

Sargent & Lundy also provided additional engineer-of-record services directly to NYPA for this project. These services included additional oversight of the project to enable Sargent & Lundy to provide certifying documentation that the project and the work of the engineering and design partners is being performed in accordance with applicable codes, standards, etc. We further provided certifying documentation to the NYPA codes group in support of NYPA's internal certification process for obtaining building permits.

The intent of the project was to perform a short-duration hydrogen cofiring demonstration from 0-30 vol% hydrogen to gather technical data from real-world testing of the existing equipment's cofiring capabilities. The data are expected to be used by the OEM to improve technical knowledge of the impacts of hydrogen cofiring on the equipment. This project is first-of-its-kind for proving hydrogen cofiring capacity in an existing combustion turbine, which was not designed to accommodate hydrogen-blended fuels.

Client	Location	Facility Type	Major Equipment	Schedule
Confidential	**Confidential, U.S.**	**Power-to-Power**	**PEM Electrolyzer, Fuel Cell**	**Q1 2021–Q3 2021**
Pre-FEED study and conceptual design for power-to-power hydrogen demonstration plant for distributed energy storage around renewable assets Conducted study that included engineering, design, and cost estimating for a facility that will produce hydrogen via 2.5 MW of PEM electrolysis driven by renewable wind power and be stored on site for dispatched use in a fuel cell. The study encompassed hydrogen compression and gaseous hydrogen storage in tube trailers. This first-of-a kind power-to-power demonstration would produce carbon-free hydrogen for energy storage to be converted back into power with the fuel cell when required by grid demands.				
Confidential	**Confidential, U.S.**	**Combined Cycle**	**Advanced-Class Gas Turbines**	**Q4 2020–Q2 2022**
Engineering study for mixing and cofiring of pipeline-supplied hydrogen in advanced-class gas turbines at new combined cycle facility Conducted study that included the preliminary engineering, design, and cost estimating of all upstream BOP infrastructure for hydrogen and natural gas conditioning, blending of hydrogen with natural gas, and more, before being sent to the gas turbines. The study also assessed the blending of hydrogen at an initial concentration of 30 vol% and eventual transition to 100 vol% with the focus on the impacts to the fuel delivery system.				
Confidential	**N/A**	**N/A**	**Stationary Thermal Application**	**Q4 2020–Q1 2022**
Independent witnessing for hydrogen thermal application pilot project Provided independent witnessing for a business founded several years ago to produce hydrogen for stationary thermal applications but with higher calorific value and at lower cost than existing hydrogen production technologies. Scope included witnessing and reporting on pilot project test for investors.				
EPRI	**Confidential, U.S.**	**Simple Cycle**	**GE, LM6000**	**Q4 2020–Q2 2021 (6 months)**
Engineering study for multiphase hydrogen cofiring project planning initiative Conducted study that consisted of a two-phase execution plan for hydrogen cofiring at an existing simple cycle peaking plant. The study considered initial execution of the project for proof-of-concept testing utilizing truck/trailer-delivered hydrogen, onsite blending, and cofiring of hydrogen up to a specified percentage (as limited by the existing gas turbine technology). The study also considered long-term execution, including onsite generation of hydrogen via 12.5-MW of PEM electrolyzers, onsite storage of hydrogen, and cofiring at two percentages (again, as limited by the existing gas turbine technology). Both phases of the project required evaluation of technical impacts and cost implications. For cost control, demonstration-phase systems and infrastructure were designed for maximum reuse during long-term execution to support onsite generation, storage, blending, cofiring, etc.				
Confidential	**Confidential, U.S.**	**Nuclear PWR**	**PEM Electrolysis**	**2019–Ongoing**
Multiphase engineering study for coupling of nuclear power and carbon-free hydrogen production Conducting study that focuses on conceptual engineering to couple a nuclear power plant with a PEM electrolyzer-driven green hydrogen production pilot as a proof-of-concept for nuclear-powered hydrogen production. Work covers the engineering change packages associated with the electrical interconnect, control room modifications, and the hydrogen island design. Hydrogen island includes 2 MW of PEM electrolysis, compression, and offtake to tube trailers. Project also investigating the scale-up of the system to larger sizes up to 65 MW.				

Client	Location	Facility Type	Major Equipment	Schedule
Confidential	**Confidential, U.S.**	**Combined Cycle and Simple Cycle**	**GE, LM6000**	**Q4 2019–Q1 2020 (4 months)**

Multiphase study to evaluate hydrogen cofiring as compared to traditional carbon capture at two separate facilities (one combined cycle and one simple cycle)

Conducted study to determine the technical and economic feasibility of carbon reduction strategies after evaluating both hydrogen cofiring and traditional carbon capture. The initial study phase for hydrogen cofiring evaluated hydrogen generation technologies and storage methods (study also considered carbon capture). Consideration was given to onsite generation and onsite storage of hydrogen. Preliminary selections for hydrogen generation technology and hydrogen storage methods were set in this phase, based on high-level cost and technical feasibility considerations. The subsequent study phase for hydrogen cofiring developed the technical impacts and cost implications of onsite generation of green hydrogen (via renewable-powered electrolysis), onsite storage of hydrogen, and cofiring of hydrogen up to a specified percentage (limited by the existing gas turbine technology).

Confidential	**Confidential, U.S.**	**Coal-Fired Power Plant**	**Coal-Fired Boiler**	**2019–2020**

Coal-to-gas repowering study for firing hydrogen-rich gas at ~120-MW coal power plant unit

Conducted study that included conceptual engineering, permitting and environmental investigations, and a cost estimate. The hydrogen source in this case was via pipeline from a neighboring facility; therefore, the study included both offsite and onsite transmission pipeline fuel delivery system infrastructure, such as a gas metering and regulation (M&R) stations, gas compression technology, flare technology and more, as well as BOP supporting systems. Several compressor OEMs were engaged related to the supply of large, multistage hydrogen compressors needed to meet the required pressure and flow at the boiler. The study also interfaced with the boiler OEM related to modifications needed to convert from coal to the hydrogen-rich gas as the primary fuel source, with natural gas as a secondary fuel source.