



Connecticut
Hydrogen-Fuel Cell
Coalition

2021

ANNUAL REPORT

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About the Connecticut Hydrogen - Fuel Cell Coalition



Mission

To enhance economic growth in Connecticut through the development, manufacture, and deployment of fuel cell and hydrogen technologies and associated fueling systems.

Objectives

- To create public awareness with industry, academia, and government regarding the benefits and uses of fuel cell and hydrogen technologies.
- To facilitate identification, communication, and management of key information among users, manufacturers, infrastructure managers, and the supply chain.
- To strengthen Connecticut's fuel cell and hydrogen industry through academic and government involvement.
- To provide a forum for discussing common issues and for developing joint projects.
- To be the state recognized leader for economic development in the hydrogen and fuel cell sector.

Board of Governors

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Doosan Fuel Cell America

David Giordano, Govt Relations and Business Dev

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Anthony Anderson, Director, Marketing and Business Dev.
(Vice Chairman)

Skyre, Inc

Trent Molter, President and CEO

The Connecticut Center for Advanced Technology, Inc. administers the Connecticut Hydrogen Fuel Cell Coalition with support from industry stakeholders

Markets



The hydrogen fuel cell industry in Connecticut has been challenged by the 2020 - 2022 pandemic of COVID; however, the market, consumer interest, and government support for clean, reliable, and dispatchable energy has kept the industry relevant and successful to meet market needs for commercially available energy technology. Further, additional support is projected with the recently passed Infrastructure Investment and Jobs Act, and the U.S. Department of Energy "Hydrogen Earthshot" Initiative. Indeed, there is new interest in research and manufacture of domestically produced technology and resources with optimism that hydrogen and fuel cell technology will be highlighted as a solution for clean stationary power; zero emission transportation for cars, trucks, aircraft, materials management, and space exploration; and as a zero emission energy carrier to integrate and store energy from asynchronous wind and solar resources with hydrogen.

This year has seen progress for solicitation, construction, and operation of stationary fuel cells. Key highlights include the manufacture of over 100 units (50 to 60 MW of capacity) per year from Doosan Fuel Cell in South Windsor and an operational portfolio of approximately 33 MW (as of March 2022); and with approximately 41 MW in various stages of development and construction (as of March 2022) from FuelCell Energy of Danbury and Torrington.

Key Connecticut Statistics

Connecticut Hydrogen and Fuel Cell Industry Data

OEMs **10**

Supply Chain Members: **611+**

Direct Jobs: **983**

Indirect Jobs: **773**

Induced Jobs: **1,078**

Total Jobs: **2,834**

Total Revenue + Investment: **\$601 Million**

Total Labor Income: **\$286 Million**

Economic impact derived from an IMPLAN Economic Financial Model, NEESC, September 2017. This analysis assesses the direct, indirect, and induced values of the Northeast region's hydrogen and fuel cell supply chain using 2016 and 2017 data.

The manufacture of hydrogen production equipment for hydrogen users, including fuel cell electric vehicles, continues to grow with over 3,000 PEM electrolyzers delivered to date from the Nel Wallingford, CT manufacturing facility.

The Connecticut Center for Economic Analysis has analyzed the potential impact of Connecticut's hydrogen and fuel cell industry on jobs and revenues and finds that between 2015 and 2042, the aggregated impacts on employment could yield between approximately 170,000 and 244,000 job-years; the aggregated impacts on real gross domestic products could yield between \$38 B and \$54 B; and that if Connecticut retains its relative market share of fuel cell sales, the fuel cell industry would be a major contributor in restoring Connecticut's economic vitality, particularly in retaining high tech research and advanced manufacturing jobs, generating increased investments, and delivering more tax revenue.

Specialty vehicles such as material handling equipment, airport tugs, and street sweepers, used by a variety of industries, including manufacturing, construction, mining, agriculture, retailers, and wholesalers, can be powered with hydrogen fuel cells. Batteries that currently power some equipment for indoor use are heavy, take up significant storage space, and provide limited hours of run time. Fuel cell powered equipment has zero emissions, a lower annual cost of ownership, and almost twice the estimated product life than battery powered equipment. In addition, hydrogen powered fuel cells are becoming

Fuel cell and hydrogen technology sales to markets reinforces the value of this industry to Connecticut with nearly 1,000 direct jobs, over 2,800 total jobs, over \$600 million in total revenue and investment, and \$286 million in total labor income.



commercialized for drones and other UAV as a lightweight, quiet, long range, and cost-effective transportation alternative. Recently, Connecticut-made hydrogen powered fuel cells and hydrogen generators have been commissioned by NASA for space exploration.

Economic benefits, environmental quality, and energy reliability are driving the development of hydrogen and fuel cell technologies for regional, national, and global markets. Policy for clean reliable stationary energy, energy storage, and clean transportation have been important drivers for deployment of FCEVs, hydrogen infrastructure, and fuel cell stationary power generation.

Connecticut companies have developed hydrogen and fuel cell technology and created significant opportunities for more efficient use of cleaner energy, job creation, and economic development in Connecticut and the region. This technology has also provided Connecticut an opportunity to help utilize its renewable energy industry for transportation, energy storage, and electric generation at consumer sites.

The age distribution of hydrogen and fuel cell companies suggests a substantial expansion in the sector, with several small businesses exhibiting recent growth. Growth of hydrogen and fuel cell patents in the Northeast far exceeds the growth of all types of clean energy patents in the region. The proximity of the original equipment manufacturers and supply chain companies have provided a competitive advantage for research, design, development, manufacturing, and export of commercial products to national and international markets. As hydrogen and fuel cell technology advances, the number of companies and employment for the industry would grow substantially.

These market opportunities represent a short-term investment for long-term productivity. Provisions for support and deployment should recognize the short-term cost to facilitate long-term market productivity with an expectation of a payback on investments.

Research, development, and deployment confirms Connecticut's role as a showcase for regionally manufactured energy storage and renewable energy. Recently, PCI was awarded a NASA project to develop solid oxide fuel cell technology for power generation and hydrogen generation; demonstrate their Army fuel cell system for Platform Electrification and Mobility; was selected by ARPA-E to develop Additively Manufactured Electrochemical-Chip Based Scalable Solid Oxide Fuel Cells, and was awarded a DOE project to develop Thermally and Chemically Stable Metallic Membranes for H₂ Generation with CO₂ Capture.

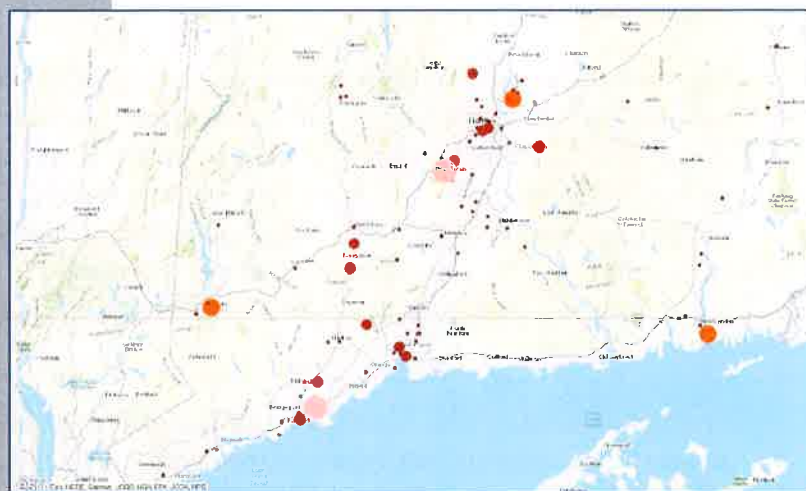


The market continues to grow for advanced technology that delivers zero or low emission power, zero emission transportation, power for unmanned aerial vehicles/aircraft, carbon separation, air filtration, and energy storage. These technologies have been supported by the needs of clean energy markets to deliver products for power, reliability, and energy security.

Connecticut's Hydrogen & Fuel Cell Industry Status

Stationary Fuel Cell Installations in Connecticut

*There are near term market opportunities for:
1) 170 MW of fuel cells, 2) 6-7 hydrogen fueling
stations, and 3) 591 FCEVs in CT.*



Stationary fuel cells provide an opportunity to convert hydrogen or hydrogen rich gas into renewable energy without combustion and emissions associated with conventional power generation technology.

As a transition strategy, fuel cells can use natural gas and “Green” hydrogen produced from asynchronous wind and solar resources that require energy storage to meet the consumer demand for dispatch of reliable energy.

Stationary fuel cells can provide reversible operation to use renewable hydrogen as fuel, and to produce renewable hydrogen for energy storage when needed.

Hydrogen powered fuel cells are providing a solution for zero emission transportation using compressed hydrogen as a long range and fast fill alternative to battery electric vehicles. The manufacture of FCEVs at US Hybrid in South Windsor and hydrogen production and refueling equipment at Nel in Wallingford provides technology as solution for compliance with government clean transportation goals for reduction of carbon emissions.



Automakers are now making plans to comply with a zero emission vehicle program modeled after the California ZEV Action Plan. CT and at least eight (8) states have committed and signed a Memorandum of Understanding requiring large-volume automakers to sell approximately 3.3 M ZEVs between 2018 and 2025.

This initiative will reduce carbon emissions, primary air pollutants, and increase fuel diversity.

Hydrogen refueling stations currently exist in Hartford and Wallingford Connecticut.

The hydrogen from these stations is sourced from solar and hydroelectric resources to minimize carbon and primary air pollutants.



With the availability of commercial technology, government and industry are now investigating the deployment of FCEVs with hydrogen refueling as a replacement of hydrocarbon fuels in the transportation sector, which accounts for approximately 30 percent of Connecticut's total energy consumption.

FCEVs have several advantages over conventional vehicles that can reduce price volatility, decrease dependence on oil, improve environmental performance, and provide greater efficiencies. Targets for FCEV deployment and hydrogen infrastructure development include public/private fleets, bus transit, and specialty vehicles. Zero emission FCEVs could replace existing conventional fleet vehicles in Connecticut, starting with 548 passenger vehicles providing annual CO₂ emission reductions of approximately 2,600 metric tons and 43 zero emission fuel cell electric buses (FCEBs) reducing annual CO₂ emissions by approximately 3,800 metric tons.

Events, Activities, Technologies, and Markets:

THE CONNECTICUT HYDROGEN FUEL CELL INDUSTRY IS WELL POSITIONED FOR WORLD CLASS RESEARCH, DEVELOPMENT, AND DEPLOYMENT. THIS INDUSTRY PROVIDES:

- **GLOBAL LEADERSHIP FOR DEVELOPMENT AND DEPLOYMENT OF CLEAN ENERGY TECHNOLOGY**
- **A REGIONAL SUPPLY CHAIN HUB FOR A CLEAN ENERGY ECONOMY**
- **ENERGY STORAGE TECHNOLOGY TO INTEGRATE RENEWABLE WIND AND SOLAR ENERGY WITH CONSUMER MARKETS**
- **TRANSITION TO A DECARBONIZED ENVIRONMENT**

Coalition Industry Events and News:

- Passage of the *Infrastructure Investment and Jobs Act*, and the U.S. Department of Energy “Hydrogen Earthshot” Initiative with provisions for:
 - *Regional Clean Hydrogen Hubs: \$8 billion to develop at least four large-scale hydrogen hubs for production and utilization across the country.*
 - *Clean Hydrogen Electrolysis Program: \$1 billion for demonstration, commercialization, and deployment of electrolyzer systems.*
 - *Clean Hydrogen Manufacturing and Recycling: \$500,000 to support a clean hydrogen domestic supply chain.*
- Execution of the Hydrogen Fuel Cell Development Plan for the Connecticut Hydrogen Economy – Economic Development, Environmental Performance, Energy Reliability. This “Roadmap” identifies strategic targets for deployment of fuel cells for stationary power, hydrogen refueling, and fuel cell zero-emission vehicles.
- Collaboration with the regional offshore wind industry to examine opportunities for energy storage. This collaboration provides potential opportunities to coordinate hydrogen storage with over 1,100 MW of offshore wind that has been procured by the State of Connecticut to meet renewable energy and carbon reduction goals.
- Collaboration with the public service industry to examine opportunities for hydrogen blending within existing infrastructure. This collaboration provides potential opportunities to reduce curtailment of asynchronous renewable generation with energy storage and incremental decarbonization of energy infrastructure.

- Collaboration with state government and the US DOE to assist in the development of state hydrogen transportation “Roadmaps”. This collaboration provides opportunities for Connecticut hydrogen and fuel cell manufacturers to meet market demands in areas outside of Connecticut.
- Management of the Northeast Regional Technical Exchange Center and expansion of the Hydrogen Fuel Cell Supply Chain Database to support energy storage for offshore wind.
- Coordination with DECD to assist domestic and international companies establish and expand operations in Connecticut.
- Coordination with state, regional, and federal entities, as listed below, to expand opportunities for Connecticut companies:
 - Department of Energy.
 - National Laboratories (NREL),
 - Association of Clean Tech Incubators (ACTION),
 - Clean Cities Coalitions,
 - Connecticut Green Bank, and
 - CT DEEP,
 - CT DECD, and
 - CT DOT.
- Identification and assessment of potential end user sites for hydrogen and fuel cell deployment and technical and economic cash flow analysis for selected public and private clients.
- Assessment of opportunities for Connecticut companies to access regional activities and markets.
- Analysis of fleet clusters, population, and registrations of existing alternative fuel and hybrid vehicles to identify opportunities for fleet FCEV deployment and hydrogen infrastructure development.
- Continued collaboration with regional stakeholders to advance a regional Hydrogen Hub with DOE program goals to:
 - Overcome technical barriers through basic and applied research and development,
 - Integrate, demonstrate, and validate hydrogen and related technologies,
 - Accelerate the transition of innovations and technologies to the private sector,
 - Address institutional issues including safety, workforce development, and deployment, and
 - Identify, implement, and refine appropriate strategies to catalyze a sustainable market with concomitant benefits to the economy, the environment, and energy security.

Industry Milestones

NASA awards Infinity Fuel Cell and Hydrogen to help make power and energy products for lunar rovers, surface equipment, and habitats.

FuelCell Energy selected by DOE in collaboration with the Office of Nuclear Energy to support the design and manufacture of an electrolysis platform.

Nel Receives Purchase Order for multiple H2Station hydrogen fueling station modules in the US.

Nel received a contract for a containerized PEM electrolyzer and light duty hydrogen refueling station package from a leading power and gas and utility in the US.

Precision Combustion wins competition for all-electric aircraft power generation

US Hybrid producing the fuel cell para-transit van with 250 mile-range for SARTA

NASA awards Skyre to develop a system to make propellant from frozen water at the moon's poles.

PCI Wins DOE SBIR Award for Excess Electric Power-Driven Conversion of Carbon Dioxide to Fuels

PCI and UConn Team Win NASA Award to Develop a Fuel Cell System Capable of Using Propellant Grade Reactants.

PCI selected for project for Additively Manufactured Electrochemical-Chip Based Scalable Solid Oxide Fuel Cells

Coalition Members 2021

The **Connecticut Hydrogen Fuel Cell Coalition** is comprised of representatives from the fuel cell and hydrogen industry, government, and other stakeholders. General membership to the Coalition is open to any and all individuals, corporations and organizations whose fuel cell and hydrogen activities are aligned with the Coalition's goals.

- ⦿ **Advent Technologies**
Manufacturer - www.advent-energy.com
- ⦿ **Air Liquide**
Manufacturer/Developer – <https://energies.airliquide.com/>
- ⦿ **Aris Energy Solutions**
Manufacturer/Developer – airswind.com/fuel-cell-mchp/
- ⦿ **Center for Clean Energy Engineering**
Professional Services - www.energy.uconn.edu
- ⦿ **Connecticut Center for Advanced Technology, Inc.**
Non-Profit - www.ccat.us
- ⦿ **Connecticut Clean Cities**
Government Related - www.eere.energy.gov/cleancities
- ⦿ **Connecticut Dept. of Economic & Community Development**
Government - www.decd.org
- ⦿ **Connecticut Department of Transportation**
Government - www.ct.gov/dot
- ⦿ **Connecticut Green Bank**
Government - www.ctcleanenergy.com
- ⦿ **Connecticut Siting Council**
Government - www.ct.gov/csc
- ⦿ **CTTRANSIT**
Public Transit - www.cttransit.com
- ⦿ **Darien High School Fuel Cell Project**
Education - www.dhsfuelcell.org
- ⦿ **Design By Analysis, Inc.**
Technical Services - www.dbaworks.com
- ⦿ **Dexmet Corporation**
Manufacturer - www.dexmet.com
- ⦿ **Doosan Fuel Cell America, Inc.**
Manufacturer - www.doosanfuelcellamerica.com
- ⦿ **Engineered Fibers Technology, LLC**
Manufacturer - www.eftfibers.com
- ⦿ **FuelCell Energy, Inc.**
Manufacturer - www.fuelcellenergy.com
- ⦿ **Fuel Cell Perspectives**
Professional Services
- ⦿ **Infinity Fuel Cell and Hydrogen, Inc.**
Manufacturer - www.infinityfuel.com
- ⦿ **People's United Insurance Agency**
Professional Services - www.peoples.com/peoples
- ⦿ **Precision Combustion, Inc.**
Manufacturer - www.precision-combustion.com
- ⦿ **Nel Hydrogen**
Manufacturer - www.nelhydrogen.com
- ⦿ **Public Utilities Regulatory Authority (PURA) / Department of Energy and Environmental Protection (DEEP)**
Government - www.ct.gov/pura
- ⦿ **Pullman & Comley, LLC**
Professional Services - www.pullcom.com
- ⦿ **Robinson & Cole, LLP**
Professional Services - www.rc.com
- ⦿ **R&D Dynamics Corporation**
Manufacturer - www.rddynamics.com
- ⦿ **Skyre, Inc.**
Manufacturer - www.skyre-inc.com
- ⦿ **US Hybrid Corporation**
Manufacturer – www.ushybrid.com