CONNECTICUT HYDROGEN FUEL CELL: STATUS & DIRECTION

"Connecticut has once again been recognized as a fuel cell leader"

U.S. Department of Energy

CT STATISTICS

Total Revenue and Investment: **$604.34 Million**

Gross State Product: **$211.65 Million**

Contributed State and Local Tax Revenue: **$22 Million**

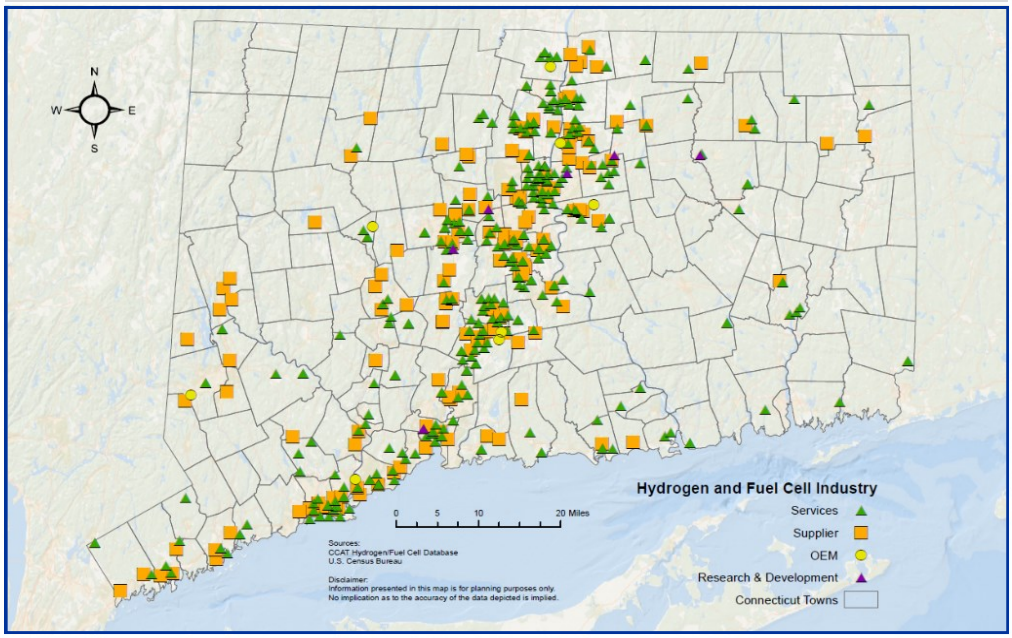
Total Supply Chain Companies: **600 Companies**

Total Labor Income: **$211.23 Million**

Direct Labor Income: **$100.77 Million**

Total Jobs: **2,693 Jobs**

CONNECTICUT HYDROGEN AND FUEL CELL INDUSTRY



NORTHEAST STATISTICS

Total Revenue and Investment: **$1 Billion**

Direct Revenue: **$508.45 Million**

Total Supply Chain Companies: **1,179**

Total Labor Income: **$448.74 Million**

Direct Labor Income: **$207.45 Million**

Total Jobs: **5,770**

CONNECTICUT

"The fact that we consistently rank among the top fuel cell states demonstrates that our work to deliver cheaper, cleaner and more reliable energy sources for Connecticut residents and businesses is paying off" Governor Dannel P. Malloy.

BACKGROUND

Since the 1950s, Connecticut has been a fuel cell leader. Connecticut's relative proximity to major load centers, the high cost of electricity, concerns over regional air quality, available federal tax incentives, and legislative policy have resulted in renewed interest in the development of efficient and cost effective renewable energy. Hydrogen and fuel cell technology provides significant opportunities for more efficient use of cleaner energy, job creation, and economic development.

TRANSPORTATION

⇒ Eight states including Connecticut, have committed and signed a Memorandum of Understanding (MOU) requiring large–volume automakers to sell approximately 3.3 million zero emission vehicles (ZEVS) by 2025. The expected result of this deployment will be high efficiency vehicles that require less fuel and produce very low or zero tailpipe emissions.

⇒ Targets for fuel cell electric vehicles (FCEV) deployment and hydrogen infrastructure development include public/private fleets, bus transit, and specialty vehicles. Hydrogen refueling infrastructure is being motivated by recent FCEV activity.

FCEV Advantages:

- Quiet Operations
- Energy Security
- Domestic Fuel Supply
- Price Volatility Reduction
- Zero/ Near Zero Emissions
- Fast Refueling/300 Mile Range

MICROGRID

- Fuel cells are now being considered as ultra clean generators for microgrids. Fuel cells in microgrids, provide heat and electricity to serve essential needs during extended power outages. Fuel cell capacity is highly reliable, efficient, and can be dispatched when needed.
- Microgrids with a fuel cell component, is an advancing market in Connecticut. Microgrid fuel cell deployments are planned for Connecticut under the state's Microgrid Grant and Loan Pilot Program, administered by the Department of Energy and Environmental Protection. The Microgrid Program has accumulated more than $45 million in state funding.

STATIONARY FUEL CELL

400 kW fuel cell, University of Connecticut; Storrs, Connecticut; Courtesy of Doosan Fuel Cell America, Inc.

Electric energy consumption in Connecticut is expected to grow at a compound annual growth rate of 1.02 percent from 34,145 GWh in 2013 to 37,400 GWh by 2022*.

The state relies on both in-state resources and imports of power to meet electric demand. The need for new electric capacity is expected to grow over the next decade due in part to increased demand and the replacement of older less efficient base-load generation facilities.

*Docket No. F-2012/2013 -CT Siting Council Review of the Ten-Year Forecast of CT Electric Loads and Resources

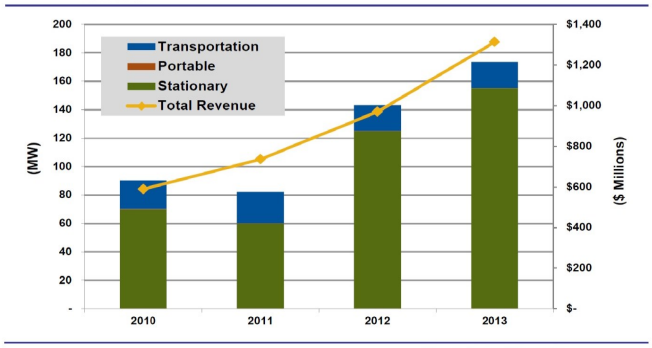
14.9 MW fuel cell installation, Bridgeport, Connecticut; Courtesy of FuelCell Energy

HYDROGEN FUEL CELL INFORMATION

Hydrogen and fuel cell technologies have made significant strides in demonstrating reliability and durability, reducing system costs, and serving emerging markets. Fuel cells are NOT dependent on the sun or wind to produce power. Hydrogen can be produced from renewable energy and domestic fuel sources, stored, and when needed, used to power fuel cells to create electricity for homes, businesses, and automobiles.

EXPORTS & REVENUE

Fuel Cell System Capacity Shipped by Market Sector and Total Revenue, World Markets: 2010-2013



(Source: Navigant Research)

In 2013, fuel cell industry sales exceeded $1 Billion, with revenues of approximately $1.3 Billion. Fuel cell system revenues increased by approximately 35 percent over 2012, with significant growth seen both in North America and Asia. As depicted in the chart, over 150 megawatts of stationary fuel cell capacity shipped in 2013. Approximately 125 megawatts of fuel cell capacity shipped in 2013 were stationary fuel cells used for prime power. Two large stationary fuel cell manufacturers are located in Connecticut: FuelCell Energy and Doosan Fuel Cell America.

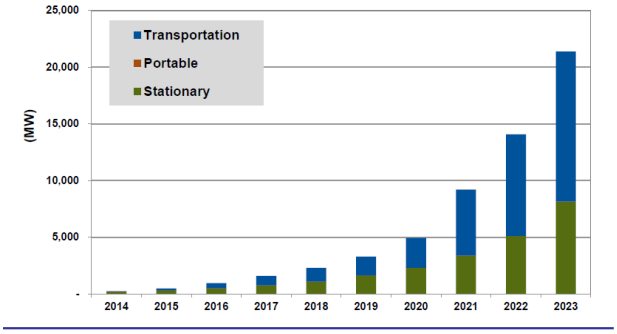
Source: 2013 Fuel Cell Technologies Market Report, Fuel Cell Technologies Office, November 2014; Fuel Cells Annual Report 2014 , Navigant Research

CAPACITY SHIPMENTS BY SECTOR

Between 2012 and 2013, fuel cell system shipments increased globally by 26 percent and the number of megawatts shipped grew by 19 percent. In the U.S., there was a decrease in the number of U.S. fuel cell shipments between 2012 to 2013, but at the same time megawatts shipped from the U.S. grew by 2 percent meaning that fewer, but larger, fuel cells were shipped by U.S. fuel cell manufacturers. As depicted in the chart, the forecast suggests that fuel cell shipments are expected to increase in the near-term with significant growth expected in the transportation sector. This growth offers significant market opportunities for Connecticut's hydrogen producers and technology integrators.

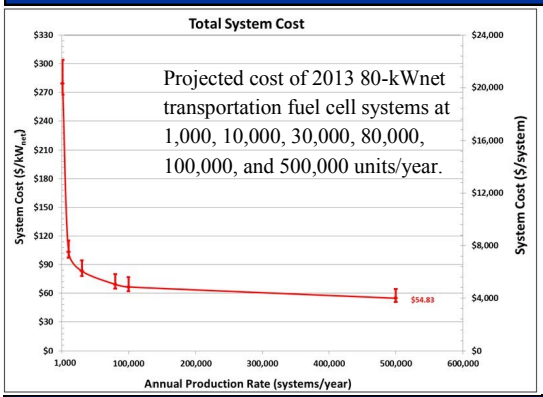
Source: 2013 Fuel Cell Technologies Market Report, Fuel Cell Technologies Office, November 2014; Fuel Cells Annual Report 2014 , Navigant Research

Fuel Cell System Capacity Shipped by Market Sector, World Markets: 2014-2023



(Source: Navigant Research)

SYSTEM COST: TRANSPORTATION



Funded research from the U.S. DOE has enabled:

- PEM fuel cell cost reduction of more than 50% since 2006, and more than 35% since 2008. A greater than 80% reduction in electrolyzer stack cost has occurred over the past 10 years.
- Reduction in the amount of platinum used on fuel cells by a factor of five since 2005.

These cost reductions in small and large stationary fuel cell systems can be attributed, in part, to reductions in size and weight, components, and the use of noble metals. As production increases, the average cost per kW is expected to decrease. Hydrogen and fuel cell manufacturers in Connecticut expect system costs to continue to decline as technologies advance, processes improve, and greater economies of scale are reached.

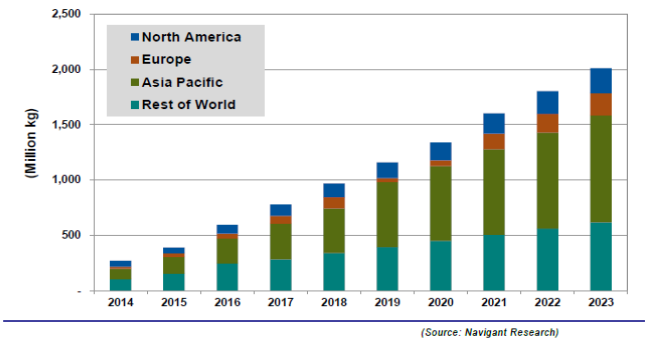
Source: 2013 Fuel Cell Technologies Market Report, Fuel Cell Technologies Office, November 2014
Chart Source: DOE Fuel Cell Technologies Office; June 2014

HYDROGEN PRODUCTION

Hydrogen is used for many commercial and industrial processes and as a means for fuel cells for stationary power; vehicles, such as forklifts, automobiles, trucks, buses; and portable applications. There is significant interest in power-to-gas projects, where excess electrical energy is used to produce hydrogen, which can then be stored and used as needed, in a fuel cell or as a transportation fuel. Europe has a strong interest in the power-to-gas concept given Europe's significant wind energy development and uncertainties regarding the supply and price for natural gas. Research suggests that hydrogen electrolyzer capacity (megawatts) installed to serve the power-to-gas market, is likely to grow to as much as 665 MW in 2018, or an $850 million market. As depicted in the chart, global hydrogen production is expected to increase at a compound annual growth rate of approximately 25 percent between 2014 - 2023.

Source: Fuel Cells Annual Report 2014 , Navigant Research

Hydrogen Consumption by Region of Production, World Markets: 2014-2023



(Source: Navigant Research)

HYDROGEN FUEL CELL MARKETS

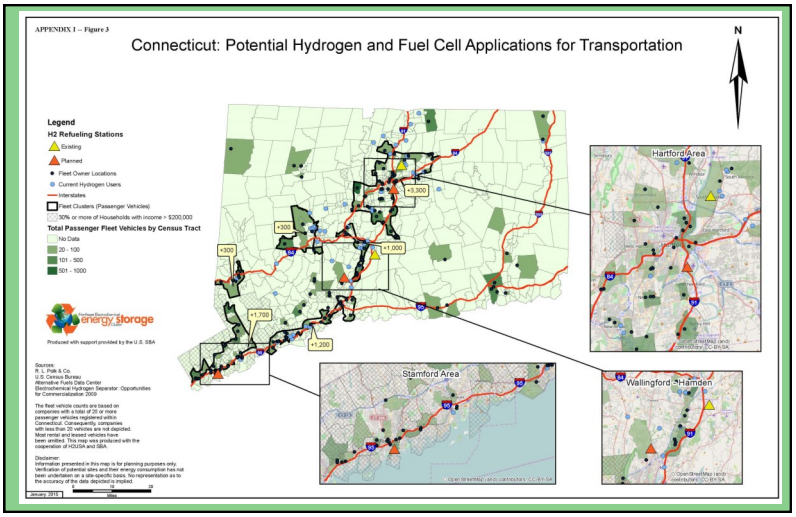
Hydrogen and fuel cell technology provides an opportunity for Connecticut to fully utilize its renewable energy industry using hydrogen and fuel cells for transportation, energy storage, and prime or backup power at customer sites.

TRANSPORTATION

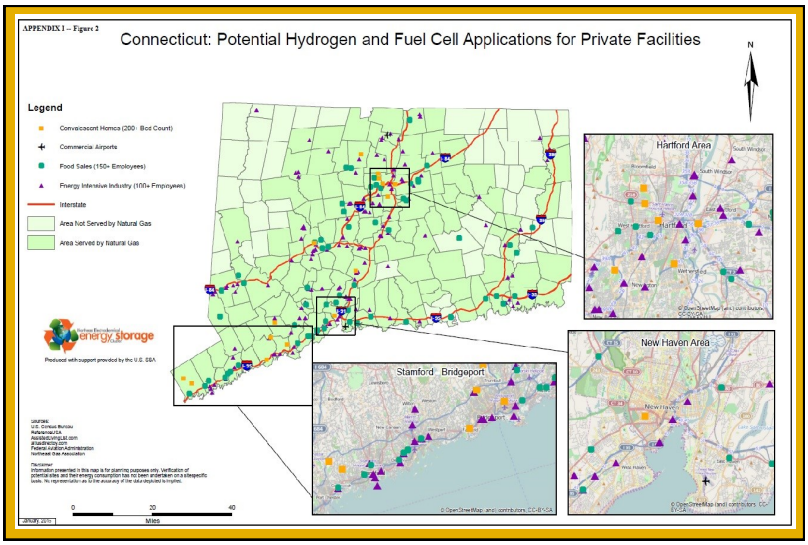
Fuel Cell Targets:

- Ports
- Bus Transit
- Material Handling
- Public/ Private Fleets
- Auxiliary Power Units

Transportation is responsible for one-fourth of the total global GHG emissions and consumes 75 percent of the world's oil production. Roughly 32 percent of Connecticut's energy consumption is due to demands of the transportation sector, including gasoline and on-highway diesel petroleum for automobiles, cars, trucks, and buses. FCEVs can reduce price volatility, dependence on oil, improve environmental performance, and provide greater efficiencies than conventional transportation technologies.



STATIONARY POWER



- Favorable locations for the development of renewable energy generation through fuel cell technology include energy intensive industries, wastewater treatment plants, landfills, wireless telecommunications sites, federal/state-owned buildings, larger airport facilities and energy intensive commercial buildings (education, food sales, food services, inpatient healthcare, lodging, and public order and safety).
- Existing businesses and institutions in Connecticut have the potential to install up to 131 to 175 MW of electric generation and combined heat and power (CHP) using fuel cell technology.

EMERGING TECHNOLOGIES AND RESEARCH & DEVELOPMENT

CT Renewable Energy Policy / Incentives:

- Net Metering
- State Grant Programs
- State Loan Programs
- Sales Tax Incentives
- Public Benefits Funds
- Interconnection Standards
- Performance– Based Power Purchase
- Renewable Greenhouse Gas Initiative
- Mandatory Renewable Portfolio Standards (RPS)
- Property– Assessed Clean Energy (PACE)

- The U.S. Department of Energy (DOE) Office of Energy Efficiency and Renewable Energy has spent over $1.5 billion over the last 10 years on fuel cell and hydrogen research, development, and demonstration. The DOE's investment has led to more than 450 patents and 40 commercial technologies being introduced in the market and about 65 emerging technologies that are anticipated to be in the market within the next three to five years.*
- Research & development by public and private organizations has helped make Connecticut a top fuel state and has helped to drive down costs and increase reliability and durability.
- Public policy has also helped to increase market opportunities for hydrogen and fuel cell technology. Connecticut has approximately 30 MW of fuel cell capacity installed due in large part to CT's policies and incentives.

* Historical Fuel Cell and Hydrogen Budgets , April 2014