



"Green" Vehicle Technology Expo and Conference

Connecticut Center for Advanced Technology, Inc. (CCAT)

October 23, 2007





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- **Plan for Fuel Cell Economic Development (Hydrogen Roadmap)**
 - Promote improved efficiency and environmental performance:
 - reduced emissions and reduced greenhouse gases,
 - more efficient use of nonrenewable fuels, and
 - increased use of renewable and sustainable fuels
 - Facilitate the installation of hydrogen infrastructure for production, storage, and fueling capability
 - Identify potential mass transit, fleet transit locations, and hydrogen refueling stations
 - Economic development and job creation



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- **Plan for Fuel Cell Economic Development (Hydrogen Roadmap)**

- Improved Efficiency:

More efficient use of nonrenewable fuels

	Average Fuel Efficiency of Conventional Gasoline-Powered Passenger Cars	Average Fuel Efficiency of Conventional Gasoline-Powered Light Trucks	Average Fuel Efficiency of Conventional Diesel Transit Buses	Fuel Efficiency of Hydrogen Fuel Cell Passenger Vehicles	Fuel Efficiency of Hydrogen Fuel Cell Transit Buses
(Btu/mile)	5,417	7,514	30,512	3,009	14,248
Fuel Efficiency	23 mpg	17 mpg	4.5 mpg	41 mpg*	8.7 mpg*
Gallons/50K Miles	2,150	3,000	11,000	1,200*	5,750*

* Gasoline Equivalent



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- **Plan for Fuel Cell Economic Development (Hydrogen Roadmap)**

- Environmental Performance:

Reduced emissions and greenhouse gases

Pollutant	Reduced Emissions from Conventional Gasoline-Powered Passenger Cars (pounds/mile)	Reduced Emissions from Conventional Gasoline-Powered Light Trucks (pounds/mile)	Reduced Emissions from Conventional Diesel Transit Buses (pounds/mile)	Emissions from Hydrogen Fuel Cells (pounds/mile)
NO _x	0.002	0.003	0.028	0
SO ₂	0.00002	0.00002	0.00005	0
CO ₂	0.814	1.127	4.944	0



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- **Plan for Fuel Cell Economic Development (Hydrogen Roadmap)**

- Environmental Performance:

- Reduced emissions and greenhouse gases

Pollutant	Reduced Emissions from Conventional Gasoline-Powered Passenger Cars (pounds per 50,000 miles)	Reduced Emissions from Conventional Gasoline-Powered Light Trucks (pounds per 50,000 miles)	Reduced Emissions from Conventional Diesel Transit Buses (pounds per 50,000 miles)
NO _x	100	150	1,400
SO ₂	1	1	2.5
CO ₂	40,700	56,350	247,200



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- **Plan for Fuel Cell Economic Development (Hydrogen Roadmap)**
 - Societal Lifecycle Costs for Automobiles with Alternative Fuel/Engine Option

Alternative Fuel/Engine Options	Present Value of Air Pollutant (AP) Damage Costs	Present Value of Greenhouse Gas (GHG) Damage Costs	Present Value of Oil Supply Insecurity (OSI) Costs	Present Value of Lifetime Fuel Costs	Retail Cost of Drivetrain (including fuel storage)	Cost of Aluminum Intensive Frame	Total Societal Lifecycle Costs (LCC)
Internal Combustion Engine (ICE)	\$2,640	\$1,429	\$2,654	\$2,828	\$2,837	\$0	\$12,388
Hybrid Electric (HE)	\$1,097	\$683	\$1,235	\$1,316	\$4,179	\$936	\$9,446
Hydrogen (Natural Gas) Fuel Cells	\$257	\$479	\$0	\$2,169	\$5,296	\$936	\$9,137



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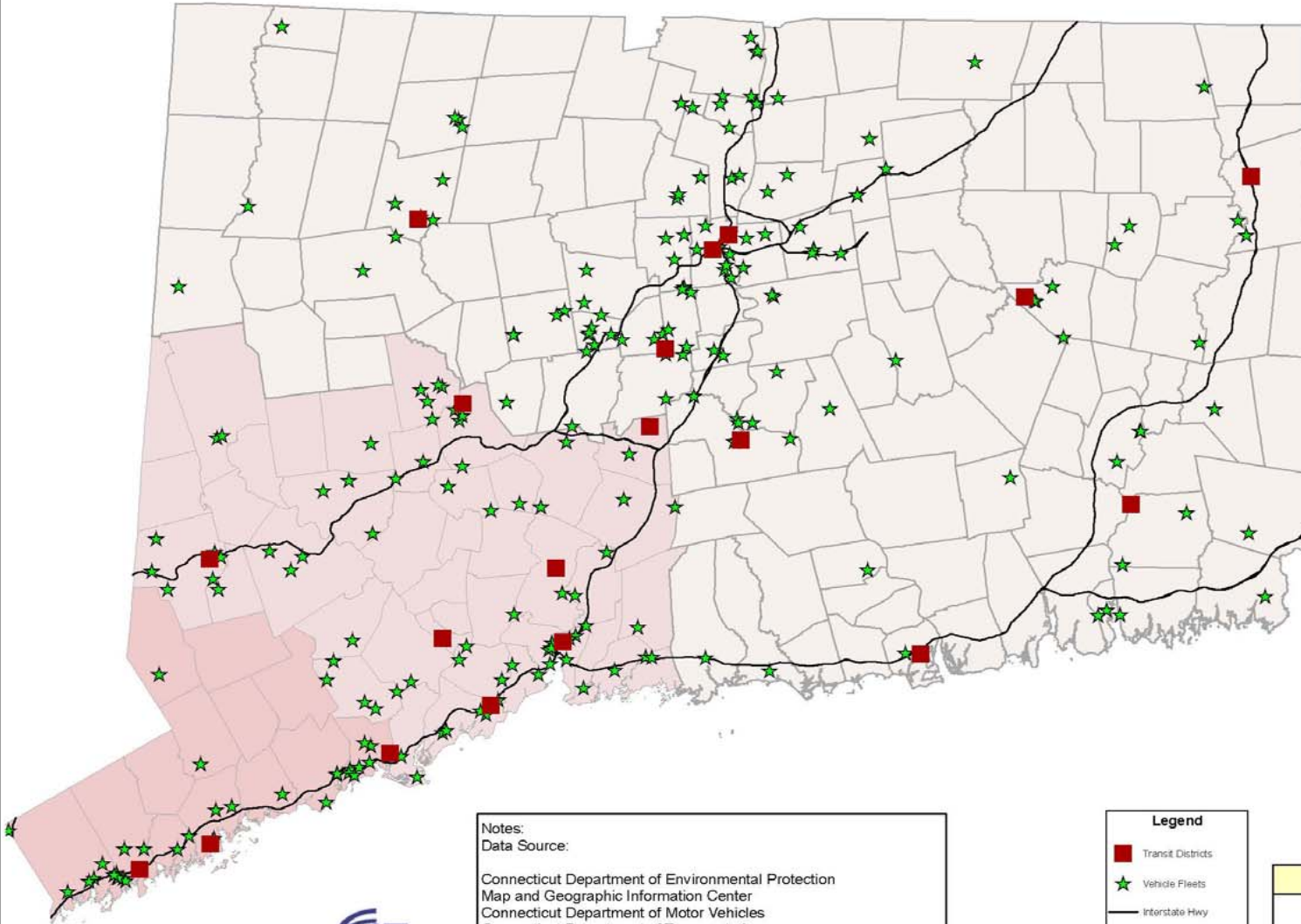
- **Plan for Fuel Cell Economic Development (Hydrogen Roadmap)**
 - Facilitate the installation of hydrogen infrastructure for production, storage, and fueling capability:
 - Lifecycle Costs and Benefits
 - Codes and Standards
 - Partnerships and Cost Sharing
 - Tax Credits, Grants, and Financing



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- **Plan for Fuel Cell Economic Development (Hydrogen Roadmap)**
 - Identify potential mass transit and fleet transit locations for hydrogen operation
 - Identify potential hydrogen refueling stations

Vehicle Fleet Locations



The vehicle fleet locations depicted on this map include companies that have more than 100 vehicles registered in the State. The fleet vehicle locations do not include lease vehicles, but do include rental vehicles. Companies that have more than 100 vehicles in their fleet, and have more than one address in the State are also depicted. Consequently, all the companies depicted have more than 100 vehicles registered to them, but they may not have more than 100 vehicles at each site. Not all companies that may have more than 100 vehicles in their fleets are depicted on this map.

Notes:
 Data Source:
 Connecticut Department of Environmental Protection
 Map and Geographic Information Center
 Connecticut Department of Motor Vehicles
 Connecticut Department of Transportation

Information presented on this map is for planning purposes only. Verification of transit district and fleet vehicle locations have not been undertaken on a site-specific basis. No representation as to the accuracy of the data depicted is implied.

Legend

- Transit Districts
- ★ Vehicle Fleets
- Interstate Hwy

CT Electrical Regions

- CT
- Norwalk-Stamford
- SWCT

Vehicle Fleets

Potential EHS Applications - This map depicts potential opportunities for military and civilian applications that use or could use electricity, thermal energy, and hydrogen in Connecticut.

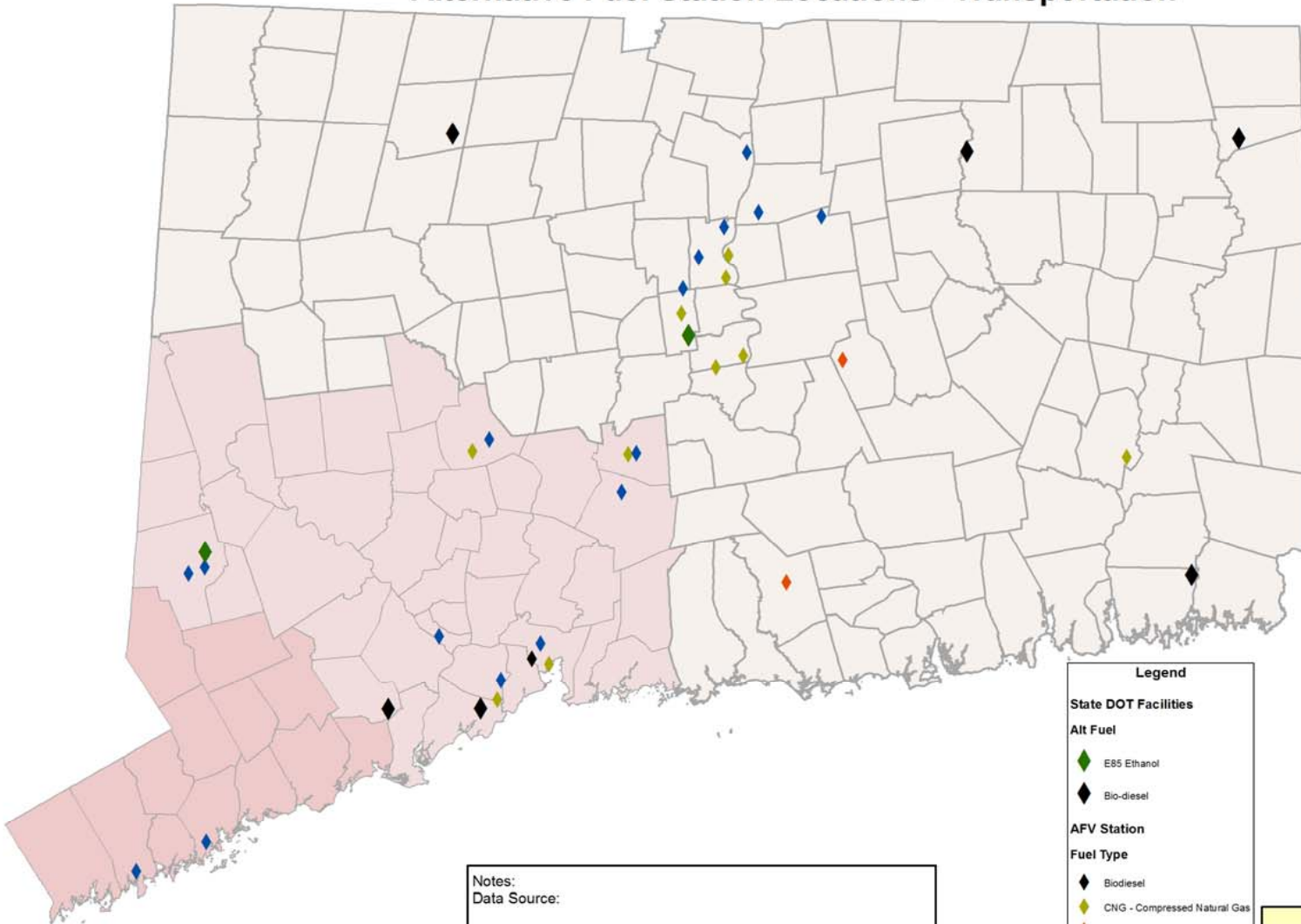
Map: EHS - VF1 Date: June 1, 2007



For Planning Purposes Only

Potential Hydrogen and Fuel Cell Applications

Alternative Fuel Station Locations - Transportation



The public alternative fuels dispensing sites depicted on this map were derived from the US Department of Energy's Alternative Fuels Data Center (AFDC). The AFDC contains data for fueling stations for the following alternative fuels: compressed natural gas (CNG), 85% ethanol (E85), liquefied petroleum gas/propane (LPG), biodiesel (BD), electric, hydrogen, and liquefied natural gas (LNG). Stations are located throughout the United States, and information is gathered from trade associations, industry contacts, retailers, and general literature. The state-owned

Notes:
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 Alternative Fuels Data Center
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Legend

State DOT Facilities

Alt Fuel

- ◆ E85 Ethanol
- ◆ Bio-diesel

AFV Station

Fuel Type

- ◆ Biodiesel
- ◆ CNG - Compressed Natural Gas
- ◆ Electric
- ◆ LPG - Propane

CT Electrical Regions

- CT
- Norwalk-Stamford
- SWCT

Alternative Fuels

Potential Hydrogen and Fuel Cell Applications - This map depicts potential opportunities to improve energy reliability and efficiency, enhance environmental performance, and promote economic development.

Map: AFV Date: November 28, 2006



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- **Plan for Fuel Cell Economic Development (Hydrogen Roadmap)**
 - Economic development and job creation:
 - CT fuel cell jobs: 1000
 - Global fuel cell jobs; 7000
 - Global potential: \$35 billion, 230,000 jobs
 - CT potential: \$4.6 billion, 30,000 jobs



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- **Plan for Fuel Cell Economic Development (Hydrogen Roadmap)**
 - Reduced air emissions and improved health
 - Increased efficiency and reduced use of oil
 - Economic development and job creation



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