

# Hydrogen & Fuel Cell Technical Advisory Committee (HTAC) Connecticut and the Northeast Region

Roadmap Planning • Policy • Business Development



**Joel M. Rinebold**  
**Connecticut Center for**  
**Advanced Technology, Inc.**  
**December 7, 2016**

This presentation does not contain any proprietary, confidential, or otherwise restricted information.

## Goals

- Clean/Low Carbon Emissions
- Reliability
- Durability
- Lower Costs
- Business Development
- Clean Energy Jobs
- Supply Chain Management
- Global Exports

## Market Drivers

- Renewable Integration
- Energy Reliability/Resiliency
- Electricity Market
- Emissions (Carbon) Reductions
- Economic Incentives

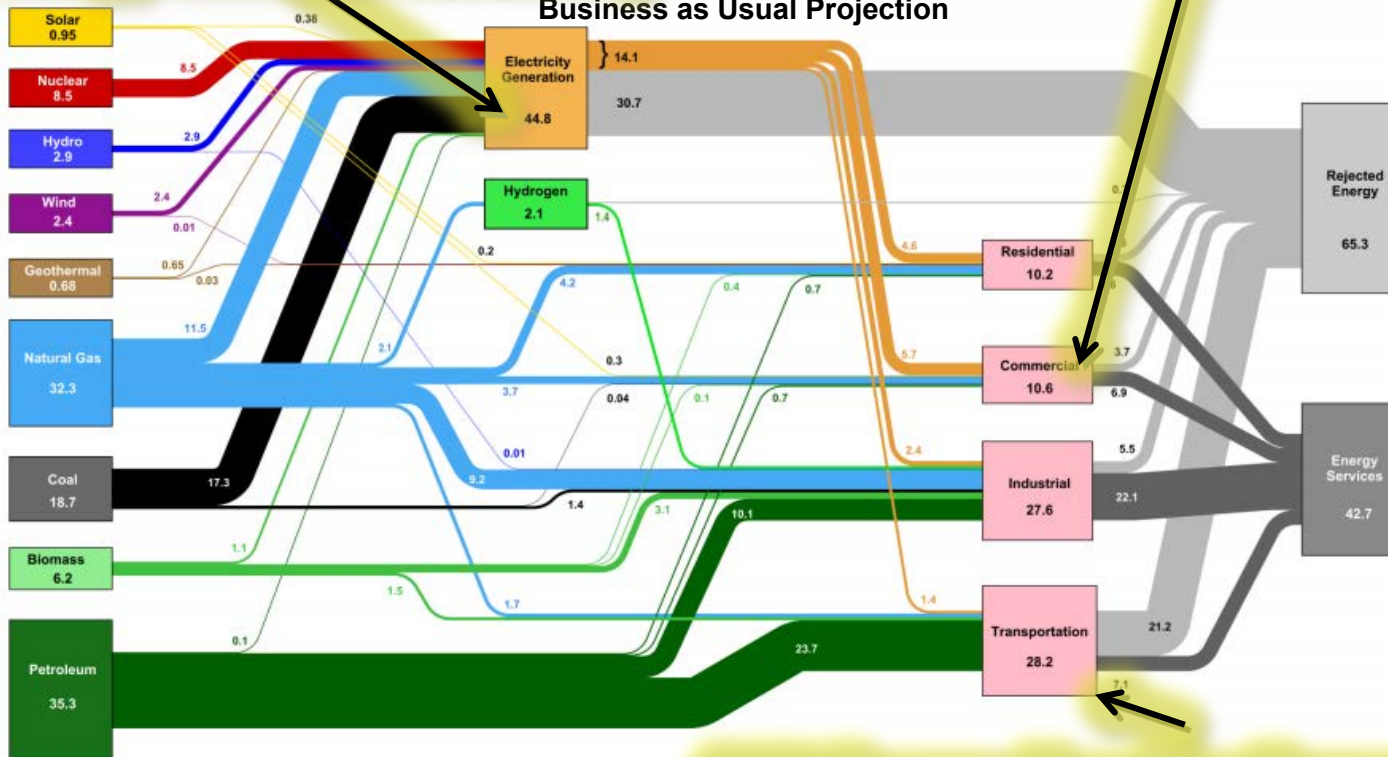
# Energy Flow

**23% Energy Used for C/I Heating**

**45% Energy Used for Electricity**

Estimated U.S. Annual Energy Use -  
Hydrogen Contributions Broken Out ~ 108 Quads  
Business as Usual Projection

Lawrence Livermore  
National Laboratory



**28% Energy Used for Transportation**

Please note, all results presented on this slide are PRELIMINARY and may be subject to corrections and/or changes. A cursory analysis was performed using available information and estimates of impacts due to changes to the modeled energy systems.

## **Activities (Stationary/Transportation)**

- Roadmap Market Planning
- Economic Analysis
- Market Analysis/Target Identification
- Policy Initiatives
- Manufacturing/Business Development
- Supply Chain Management

# State/Regional "Roadmap" Market Planning

- Economic impacts (jobs, revenue, companies)
- Technology, Applications, and Markets
- Stationary and Transportation Deployment Targets
- Policy and Drivers

- Job Development
- Energy Reliability
- Storm Preparation
- Environmental
- Carbon Control
- Energy Cost



- **Update Planned for 2017**

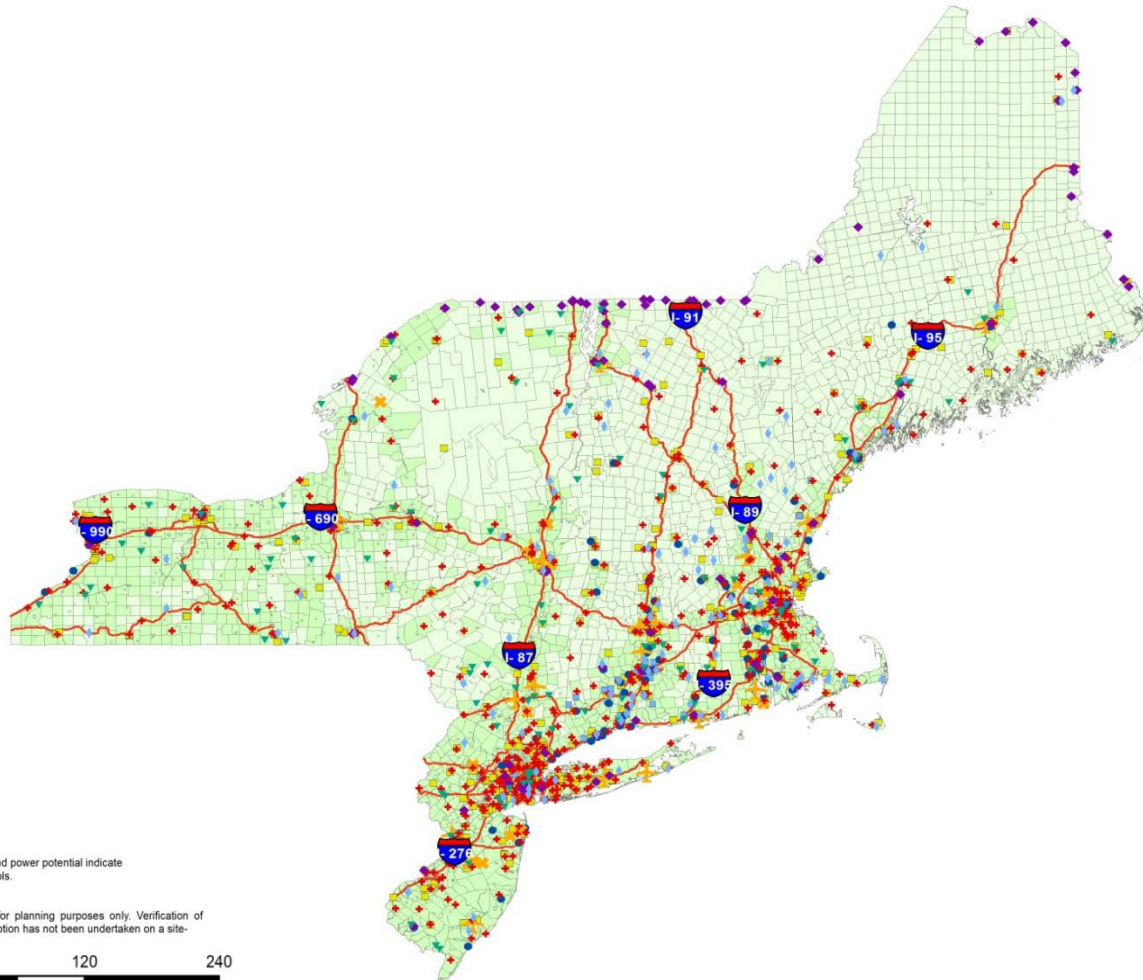
# Stationary Market Targets

- Education
- Food Sales/Services
- Inpatient Healthcare
- Lodging
- Public Order & Safety
- Energy Intensive Industries
- Government Operated Buildings
- Wireless Telecommunication Towers
- Military, Airports, and Ports
- Wastewater Treatment Plants and Landfills
- Grid/Microgrid

# Regional Public Stationary Targets

## Legend

- Landfills
- Correctional Facility
- Federally Owned Building
- Hospitals
- Military Airports
- Military Bases
- Wastewater Treatment Pls
- Public Schools (With CHP)
- Colleges
- Interstate
- Area Not Served by Natural Gas
- Area Served by Natural Gas



Sources:  
 U.S. Census Bureau  
 U.S. General Services Administration  
 U.S. Environmental Protection Agency  
 OpenStreetMap  
 HighSchools.com  
 ReferenceUSA  
 usarmilitarybenefits.com  
 Federal Aviation Administration  
 www.usarmilitarybenefits.com  
 Northeast Gas Association

Footnotes:  
 1) Public schools with combined heat and power potential indicate public schools that house swimming pools.

Disclaimer:  
 Information presented in this map is for planning purposes only. Verification of potential sites and their energy consumption has not been undertaken on a site-

0 120 240



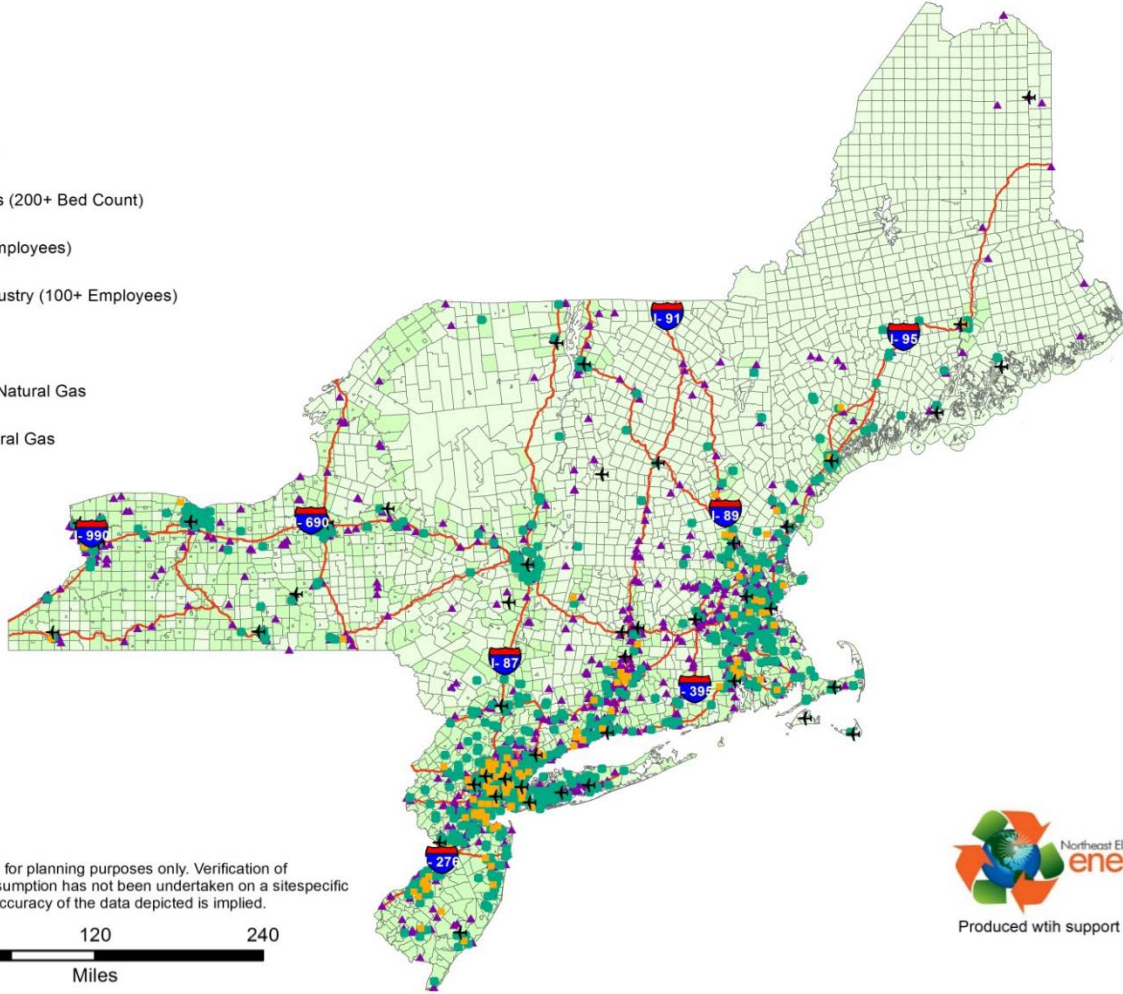
Miles

March, 2015

# Regional Private Stationary Targets

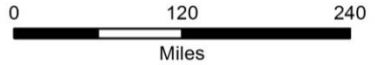
## Legend

- + Commercial Airports
- Convalescent Homes (200+ Bed Count)
- Food Sales (150+ Employees)
- ▲ Energy Intensive Industry (100+ Employees)
- Interstate
- Area Not Served by Natural Gas
- Area Served by Natural Gas



Sources:  
U.S. Census Bureau  
ReferenceUSA  
AssistedLivingList.com  
altiusdirectoy.com  
Federal Aviation Administration  
Northeast Gas Association

Disclaimer:  
Information presented in this map is for planning purposes only. Verification of potential sites and their energy consumption has not been undertaken on a sitespecific basis. No representation as to the accuracy of the data depicted is implied.



March, 2015



# Policy/Incentives for Stationary Fuel Cells

- State/Regional Hydrogen and Fuel Cell Development Plans
- Mandatory Renewable Portfolio Standards (RPS)
- Net Metering
- Public Benefits Fund
- Performance Based Power Purchase
- Utility Ownership/Investment
- State Grant/Loan Program
- Microgrid Reliability Program
- Property/Sales Tax Incentive
- Property-Assessed Clean Energy (PACE) Financing
- One Stop Regulatory Approval
- Identified State “Point” Person

# State Stationary Policy Summary

State Energy Policy/Incentives for Stationary Fuel Cells									
	ME	NH	VT	MA	RI	CT	NY	NJ	MD
Mandatory Renewable Portfolio Standard (RPS)	Eligible	Eligible if Renewable	Eligible if Renewable	Eligible if Renewable	Eligible if Renewable	Eligible	Eligible	Eligible if Renewable	Eligible if Renewable
Net Metering	Eligible	Eligible if Renewable	Eligible if Renewable	Eligible	Eligible if Renewable	Eligible	Eligible	Eligible if Renewable	Eligible
Public Benefits Fund	Eligible		Eligible	Eligible	Eligible if Renewable	Eligible	Eligible	Eligible if Renewable	
Performance-Based Power Purchase	Eligible					Eligible	Eligible		
Utility Ownership/Incentives (Rebate Programs)					Eligible if Renewable	Eligible	Eligible	Eligible if Renewable	Combined Heat & Power
State Grant Program		Eligible if Renewable			Eligible				Combined Heat & Power
State Loan Programs			Eligible if Renewable		Combined Heat & Power	Eligible			
Microgrid Reliability Program				Eligible		Eligible	Eligible	Eligible	
Property Tax Incentive (Commercial)			Eligible if Renewable			Eligible		Eligible	
Sales Tax Incentive			Eligible if Renewable						
Property-Assessed Clean Energy (PACE) Financing					Eligible if Renewable	Eligible	Eligible		
One Stop Regulatory Approval						Eligible			
Identified State "Point" Person									
NEESC Development Plan Market Potential									
	ME	NH	VT	MA	RI	CT	NY	NJ	MD
Stationary Fuel Cell (MW, low/high range)	54 / 73	45 / 61	15 / 20	234 / 312	37 / 49	131 / 175	543 / 724	254 / 339	



Eligible



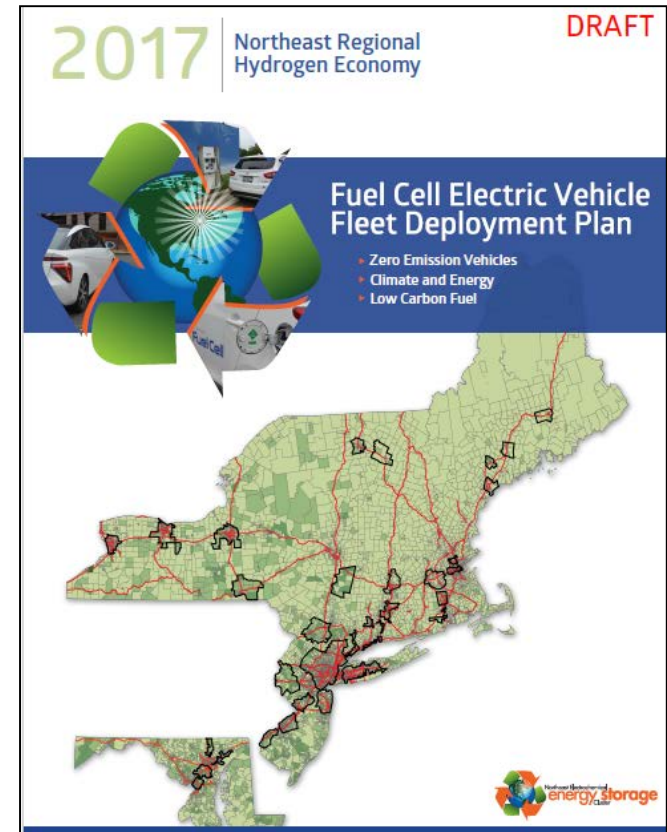
Eligible if Renewable



Combined Heat & Power

# Regional FCEV Deployment Plan

- Consistent with goals of H2USA, NESCAUM, and the 8 State MOU Action Plan
- Developed for 9 states
  - Northeast states including Maryland
- ZEV Deployment Targets
  - Early market adopters, fleets, hydrogen users, hydrogen refueling, proximity to highways, etc
- Hydrogen Infrastructure
- Policy and Drivers
- Plan Expandable to Include:
  - OEM survey data
  - NREL modeling
  - Subset of National Roadmap
  - Additional states



# Transportation Market Targets

- FCEV (Light-Duty)
- Fuel Cell Electric Buses (FCEB)
- Specialty Fuel Cell Vehicles
  - Material Handlers
  - Airport Tugs
- Hydrogen Refueling
- Hydrogen for Energy Storage

# Northeast Fleet Market Opportunities

## Regional FCEV and Hydrogen Market Opportunities

State	Total Fleets <sup>28</sup>			Fleet Deployment Goals <sup>29</sup>				Supporting Infrastructure
	Vehicles	State	Buses	Vehicles	State	Buses	Total	
Maine	2,918	6,960	153	67	70	7	144	1 – 2
Connecticut	11,725	4,000	921	508	40	43	591	6 – 7
New York	43,631	18,708	7,458	1851	187	349	2,387	18 – 23
Massachusetts	17,602	10,072	1,796	722	101	84	907	7 – 9
Rhode Island	3,651	2,026	291	151	20	14	185	1 – 2
New Jersey	69,194	13,000	2,970	3102	130	139	3,371	31 – 34
Vermont	1,966	2,030	86	72	20	4	96	1 – 2
New Hampshire	-	2,023	113	-	20	5	25	1 – 2
Maryland	20,551	8,800	1,780	872	88	83	1,043	8 – 10
<b>Region</b>	<b>171,238</b>	<b>67,619</b>	<b>15,568</b>	<b>7,345</b>	<b>676</b>	<b>728</b>	<b>8,749</b>	<b>74 – 89</b>

- 8,749 Fuel Cell ZEVs (Projected)
  - 8,021 Passenger Vehicles
    - 676 FCEVs for State fleets
  - 728 transit/paratransit buses (FCEB)
- 74 to 89 hydrogen refueling stations

# Regional Transportation Targets

## Legend

### H2 Refueling Stations

▲ Existing

▲ Planned

— Interstates

• Fleet Owner Locations

□ Fleet Clusters (Passenger Vehicles)

▨ 30% or more of Households with income > \$200,000

### Total Passenger Fleet Vehicles by Census Tract

■ No Data

■ 20 - 300

■ 301 - 1000

■ 1001 - 22000



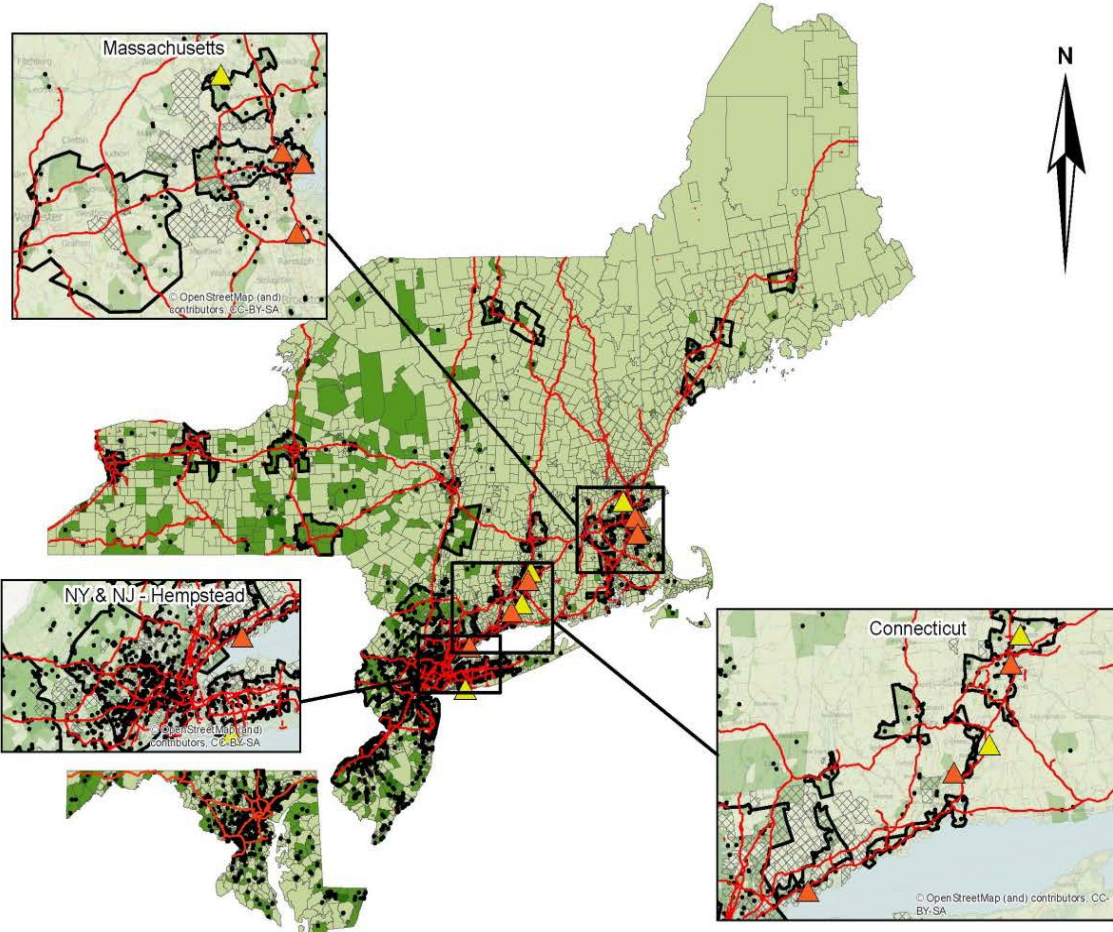
Produced with support of the U.S. SBA

Sources:  
R. L. Folk & Co.  
U.S. Census Bureau  
Alternative Fuels Data Center

The fleet vehicle counts are based on companies with a total of 20 or more passenger vehicles registered within NY, CT, MA, VT, RI, ME, MD & NJ. Fleet data for NH was unavailable. Consequently, companies with less than 20 vehicles are not depicted. Most rental and leased vehicles have been omitted. This map was produced with the cooperation of SBA.

Disclaimer:  
Information presented in this map is for planning purposes only. Verification of potential sites and their energy consumption has not been undertaken on a site-specific basis. No representation as to the accuracy of the data depicted is implied.

0 100 200 300 Miles



# Policy/Incentives for H<sub>2</sub> Transportation

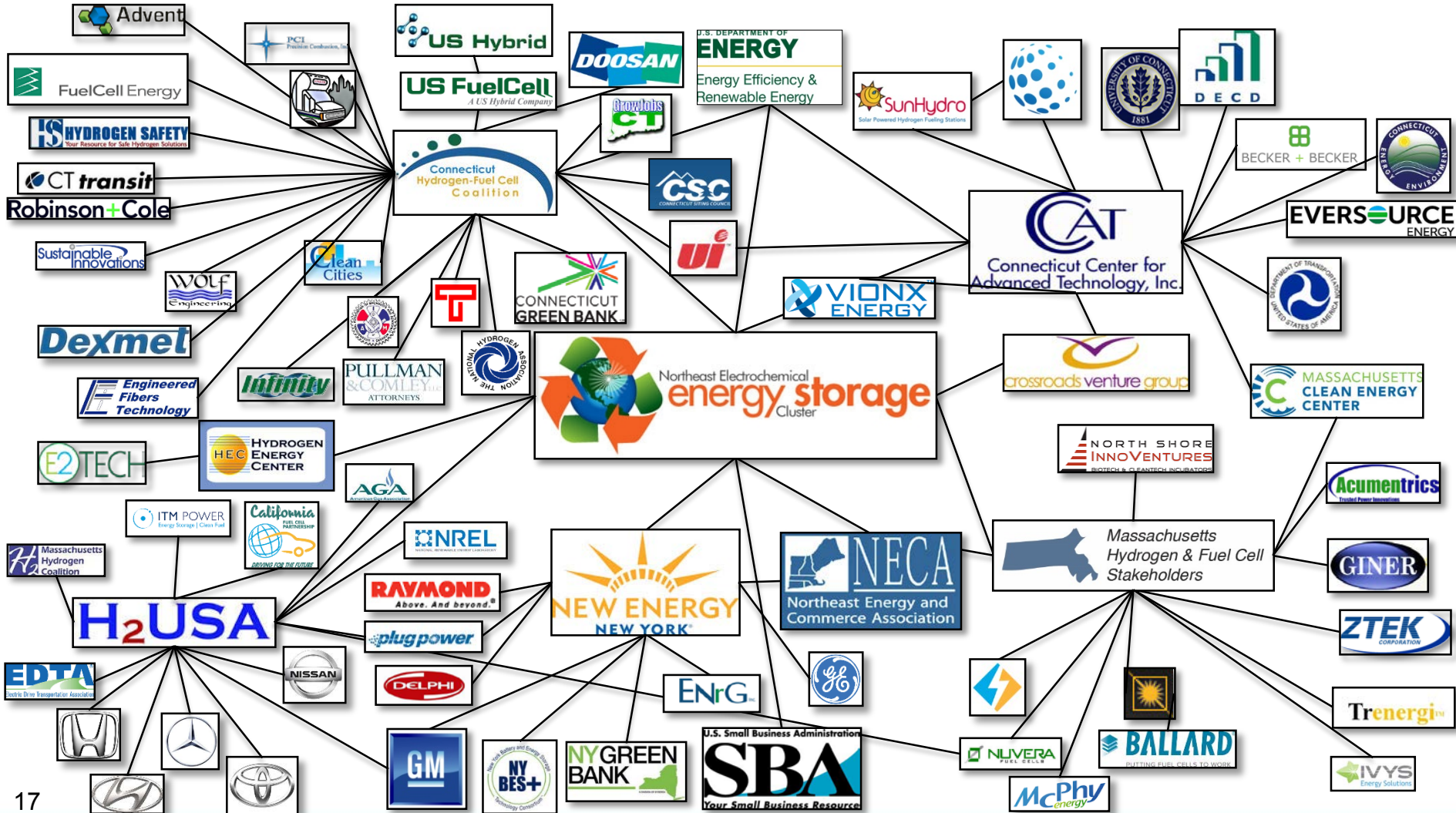
- State/Regional Hydrogen and Fuel Cell Development Plans
- Zero Emission Vehicle (ZEV) Program (FCEV/H<sub>2</sub> Infrastructure)
- ZEV Purchase Target for State Government Fleets
- Purchase Incentives/"Point-of-Purchase" Rebates
- Fuel/Tax Incentives
- Public/Private Infrastructure Partnership
- Fuel Efficiency Standard (Private/State Fleets)
- Refueling Infrastructure Incentives
- REC Available for Renewable H<sub>2</sub>
- HOV Lanes and Parking Incentives
- One Stop Regulatory Approval
- Identified State "Point" Person

# State Transportation Policy Summary

State Energy Policy/Incentives for Hydrogen Transportation									
	ME	NH	VT	MA	RI	CT	NY	NJ	MD
Zero Emission Vehicle (ZEV) Program (FCEV/H <sub>2</sub> Infrastructure)									
ZEV Purchase Target for State Government Fleets (TBD)									
Purchase Incentives/"Point-of-Purchase" Rebates									
Fuel Incentives									
Public/Private Infrastructure Partnership									
Fuel Efficiency Standard (Private/State Fleets)									
Refueling Infrastructure Incentives									
REC Available for Renewable H <sub>2</sub>									
Tax Incentives									
HOV Lanes and Parking Incentives									
One Stop Regulatory Approval									
Identified State "Point" Person									
NEESC Development Market Potential									
	ME	NH	VT	MA	RI	CT	NY	NJ	MD
Transportation FCEV (near-term number of vehicles)	80	21	80	1,818	142	445	2,808	5,585	2,705
Transportation Fuel Cell Electric Bus (near-term number of vehicles)	3	4	2	49	11	32	364	173	53
Refueling Stations (low/high range)	1 2	1 2	1 2	18 19	2 3	4 5	27 32	55 60	26 27



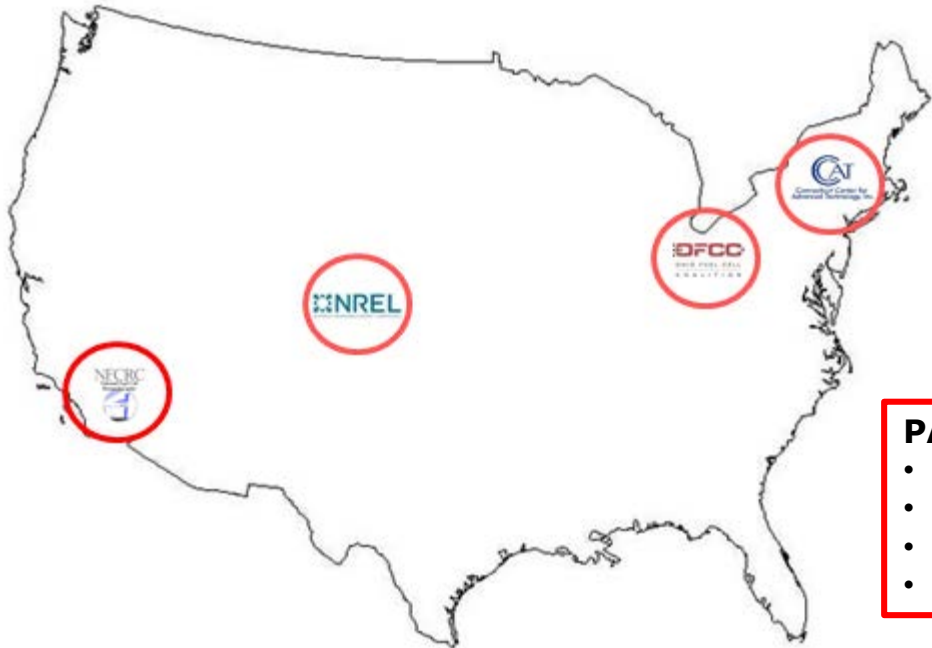
# Manufacturing/Business Development



# Manufacturing/Business Development

## National Technical Exchange Centers

- Supply Chain Database
- Supply Chain Exchange
- Standardization



- PARTNERS/COLLABORATORS**
- Ohio Fuel Cell Coalition (OFCC)
  - National Renewable Energy Lab (NREL)
  - National Fuel Cell Research Center (NFCRC) at UC Irvine
  - Connecticut Center for Advanced Technology (CCAT)

# Manufacturing/Business Development Integration of Northeast Supply Chain W/ Federal Database

**Supply Chain Database Search**

Supplier Category

Sub-Category

Search term

Company Name	Address	City/Town	Zip	State	Website	map
2 Hopewell	2 Hopewell Road	South Glastonbury	06073	CT	2hopewell.com	<a href="#">show on map</a>
901 D LLC	360 Route 59	Tallman	10982	NY	www.901d.com	<a href="#">show on map</a>
A&P Trucking Co Inc.	106 Pent Hwy	Wallingford	06492	CT		<a href="#">show on map</a>
A.E. Electric L L C	89 N Plains Industrial Road #10	Wallingford	06492	CT		<a href="#">show on map</a>
AA Precision Machine Company, Inc.	300 Currant Road	Fall River	02720	Massachusetts	www.aaprecisionmachine.com	<a href="#">show on map</a>
AAA Aircraft	68 Shaker Road	Enfield	06082	CT	www.aaa-aircraft.com	<a href="#">show on map</a>
Aaron / Andersen Advertising LLC	483 Manchester Rd	East Glastonbury	06025	CT	aaronandersenadv.com	<a href="#">show on map</a>

[next page >>](#)

**14 Supply Products/ over 100 Categories**

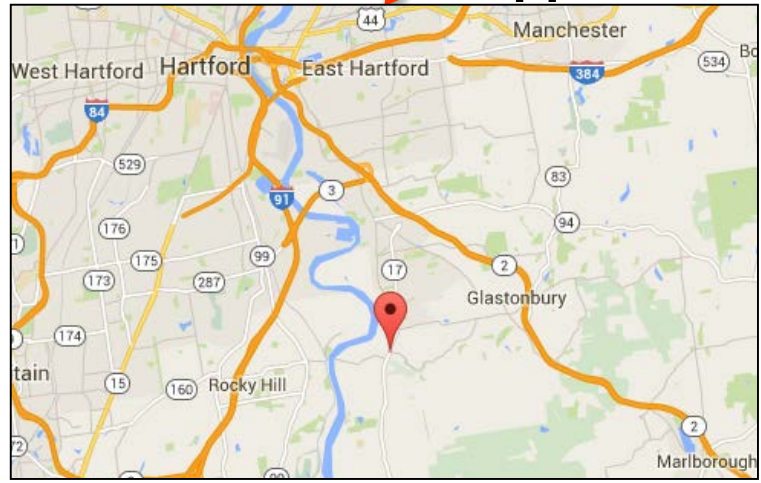
Supplier Category

Sub-Category

Search term

- Components
- Consulting | Legal | Financial Services
- Engineering | Design Services
- Equipment
- FC | H2 System Distr. | Install | Maint Service
- Fuel
- Fuel Cell Stack or System OEM
- Hydrogen System OEM
- Lab or Test Equipment | Services
- Manufacturing Services
- Marketing Products | Services
- Materials
- Other
- Research and Development
- Transportation | Packaging | Shipping Services

**Geocoded/Mapped**



# Manufacturing/Business Development

## Standardization

- Membrane Assembly
- Pumps
- Compressors
- Connections
- Fittings
- Dispensing Equipment
- TBD

## Supply Chain Management

- Durability
- Cost
- Inventory
- Availability
- OEM Coordination

## **Next Steps**

### **Coordination for Deployment (Roadmap Implementation)**

#### Stationary

- Fuel Cell CHP
- Fuel Cell Grid/Microgrid

#### Transportation

- FCEV Delivery
- H2 Infrastructure
- Renewable H2/Storage

### **Policy Support**

- Federal/State (ITC)

### **Business Development**

- OEM Manufacturing
- Supply Chain Standardization and Management

### **Administration of Regional Clusters/Technical Exchange Centers**

# Northeast Economic Results\*

- **Supply Chain:**

- Number of OEMs → 30 OEMs
- Number of Supply Chain Businesses → 1,179 Businesses  
    ↑ 8.1% from 2012 (1,091)

- **Total Annual Revenue and Investment:**

- Total Revenue & Investment → \$1.4 Billion  
    ↑ 18.7% from 2012 (\$1.179 Billion)
- Total Labor Income → \$619.6 Million  
    ↑ 38.1% from 2012 (\$449 Million)







- **Total Jobs:**

- Total Employment → 6,558 Direct, Indirect, and Induced Jobs  
    ↑ 13.7% from 2012 (5,770 Jobs)

\* Regional IMPLAN (ME, MA, VT, RI, CT, NH, NY, NJ) – 2012 vs 2016 Data

- REMI Economic Impact Analysis for Connecticut – 2006
- REMI Economic Impact Analysis for Connecticut – 2007
- Regional IMPLAN Economic Analysis – 2012 (2011 data)
- Regional IMPLAN Economic Analysis – 2016 (2015 data)
- REMI Economic Impact Analysis for Connecticut – 2016

## Business Impact

- Patents 
- Sales 
- Exports 
- Investments 
- Jobs/Manufacturing 
- Costs/Price 

## Harness the Power of Hydrogen & Fuel Cell Technology



November 17 & 18, 2016  
Hartford, CT

# 2016 H<sub>2</sub>FC

Hydrogen & Fuel Cell Forum

- Finance Forum
- Interactive/Live RFI
- Supply Chain Exchange
- Industry Showcase
- **ZEV Workshop**
- FCEV Ride & Drive
- Industry Tour



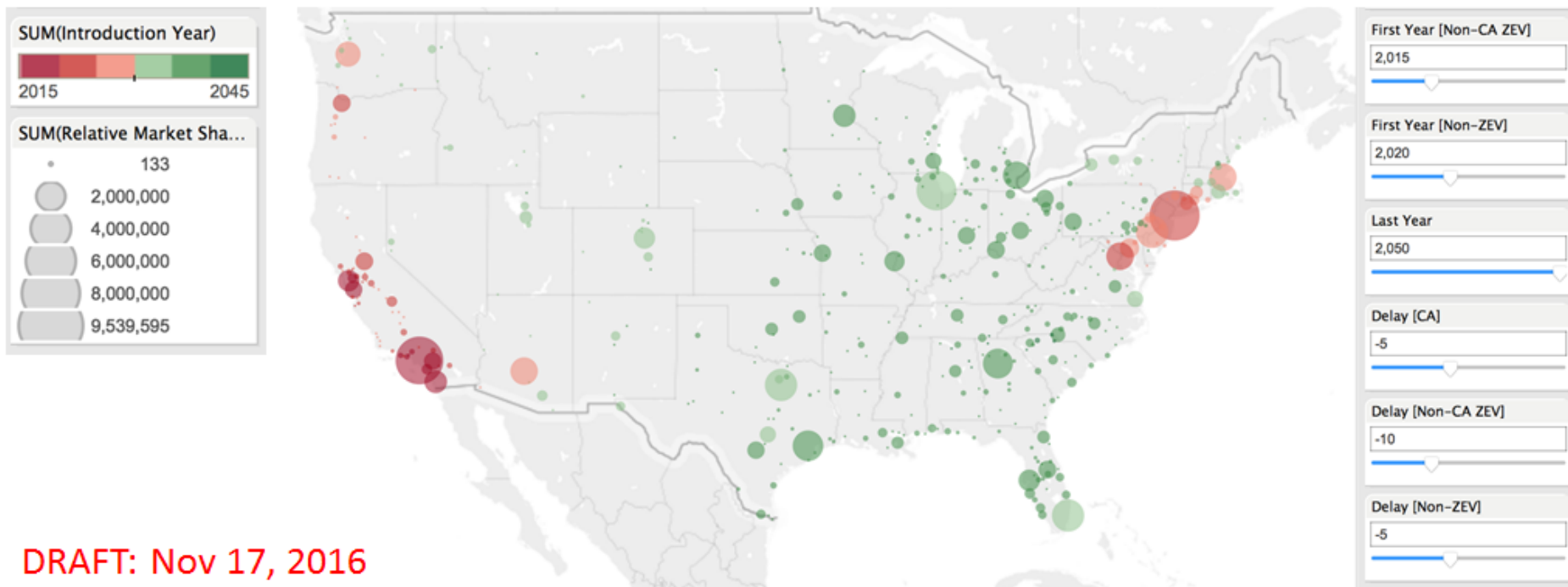


# National Scenarios (LRWG Report)

Planning tools enable H2USA members to explore a wide range of variations in national scenarios

**PRELIMINARY**

- How quickly might FCEVs arrive?
- Which cities or regions require greater or fewer stations?
- What are reasonable timing expectations between FCEV introductions and station network installations?



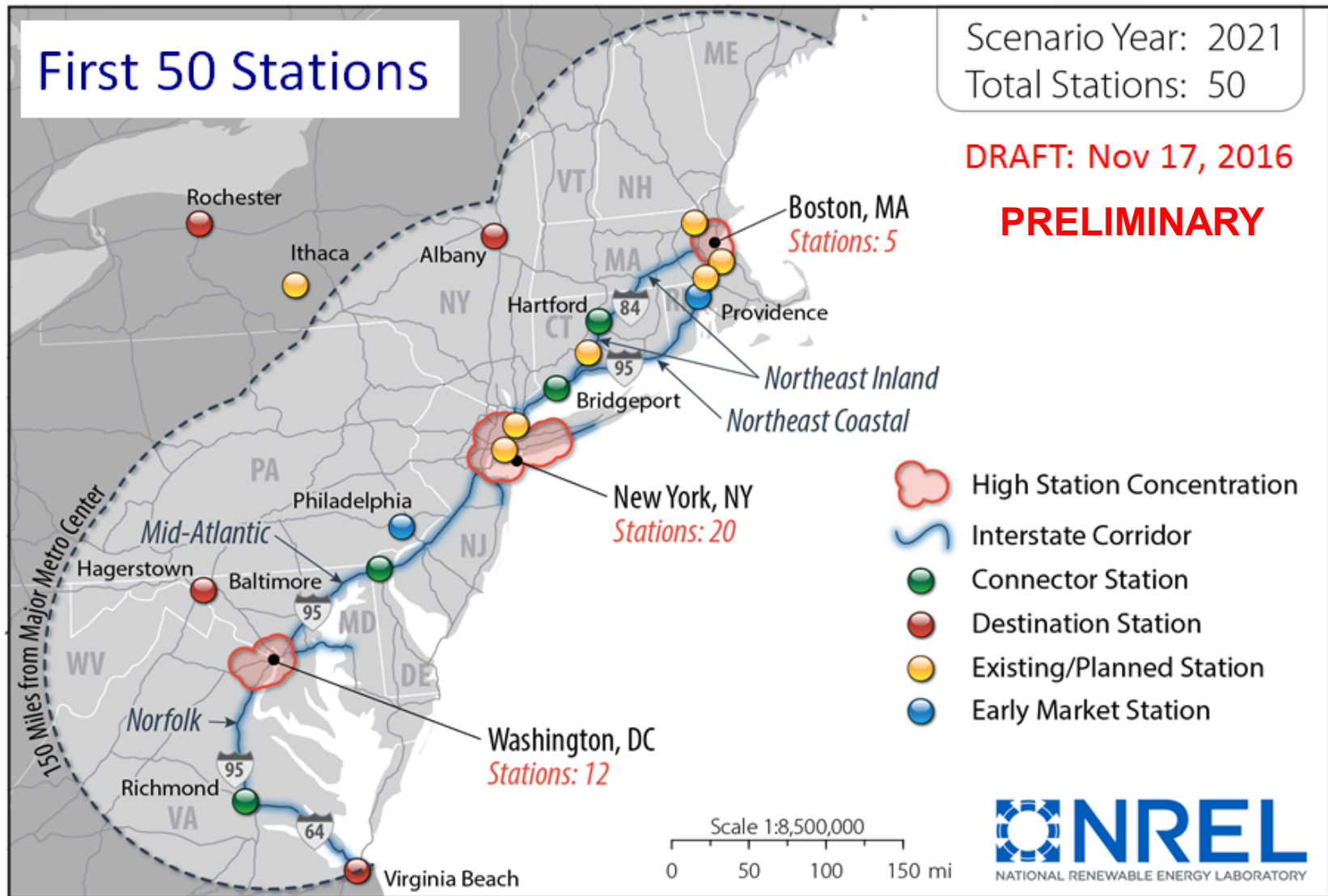
**DRAFT: Nov 17, 2016**

# First 50 Stations

Scenario Year: 2021  
Total Stations: 50

DRAFT: Nov 17, 2016

**PRELIMINARY**



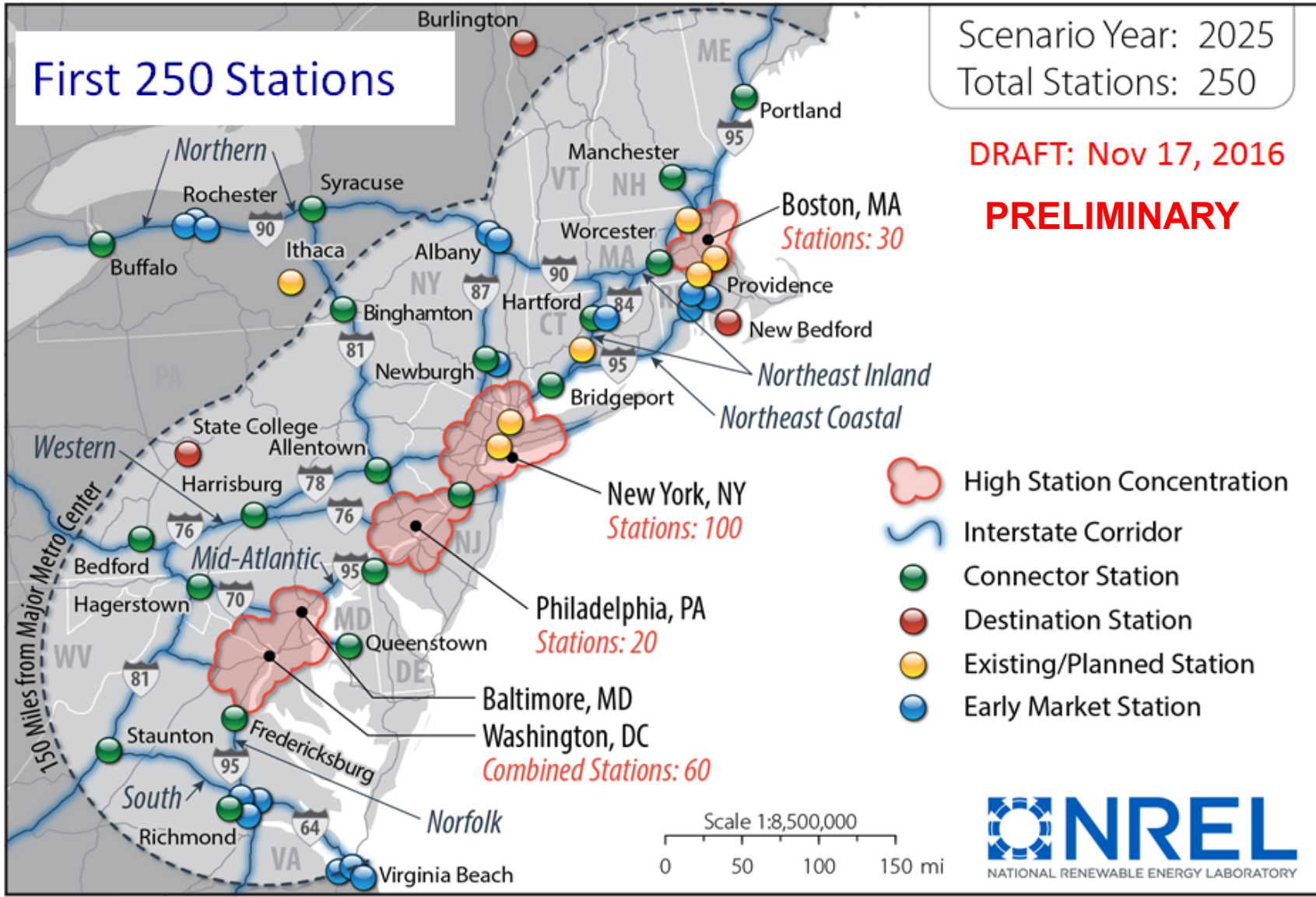
- Most stations are in large cities
- Connector and destination stations are examples of what might be required for an integrated regional network

# First 250 Stations

Scenario Year: 2025  
Total Stations: 250

DRAFT: Nov 17, 2016

**PRELIMINARY**



- Most stations are still located in large cities (210 of 250)
- Regional network includes “early market stations” in promising cities

# Connecticut: Market Potential for Hydrogen and Fuel Cell Transportation Applications

**PRELIMINARY**

**Legend**

**H2 Refueling Stations**

- Existing
- Planned
- Under Construction
- Fleet Owner Locations
- Current Hydrogen Users

- Interstates
- 30% or more of Households with income > \$200,000
- Fleet Cluster (with # of fleet vehicles)

- Fleet Vehicle Density**
- High
  - Low

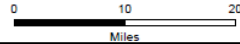
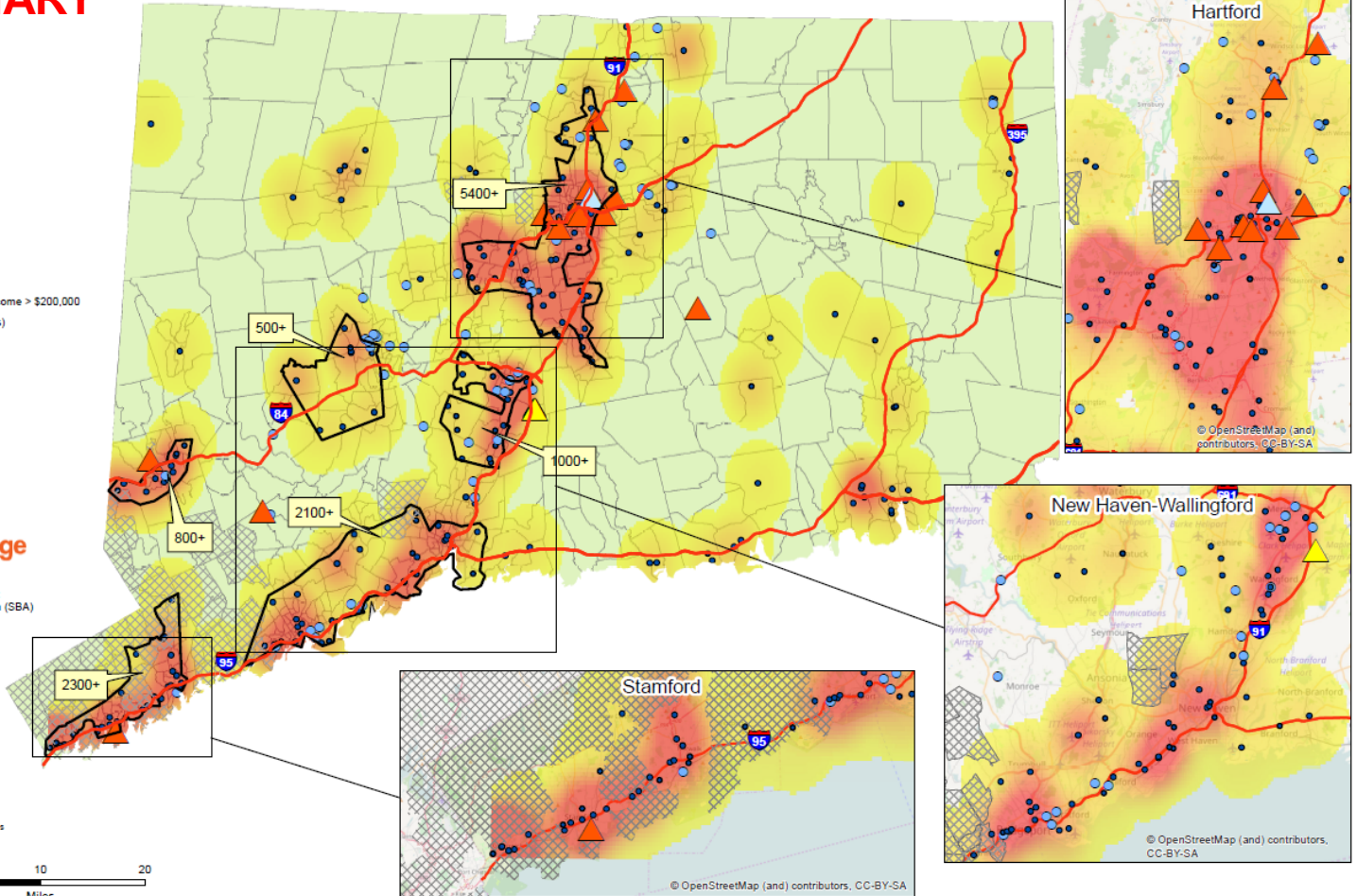


NEESC is funded through a contract with the U.S. Small Business Administration (SBA)

Sources:  
 IHS Automotive  
 U.S. Census Bureau  
 Alternative Fuels Data Center  
 Electrochemical Hydrogen Separator:  
 Opportunities for Commercialization 2009

The fleet vehicle counts are based on companies with a total of 20 or more passenger vehicles registered within Connecticut. Consequently, companies with less than 20 vehicles are not depicted. Sale and leased vehicles have been omitted based on available information. This map was produced with the cooperation of H2USA and support provided by the U.S. SBA.

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



APPENDIX I --- Figure 4

# New York: Market Potential for Hydrogen and Fuel Cell Transportation Applications

DRAFT, DECEMBER 5, 2016 N

**PRELIMINARY**

**Legend**

**H2 Refueling Stations**

▲ Existing

▲ Planned

● Fleet Owner Locations

— Interstates

⊗ 30% or more of Households with income >\$200,000

▭ Fleet Cluster (with # of fleet vehicles)

**Fleet Vehicle Density**

High

Low

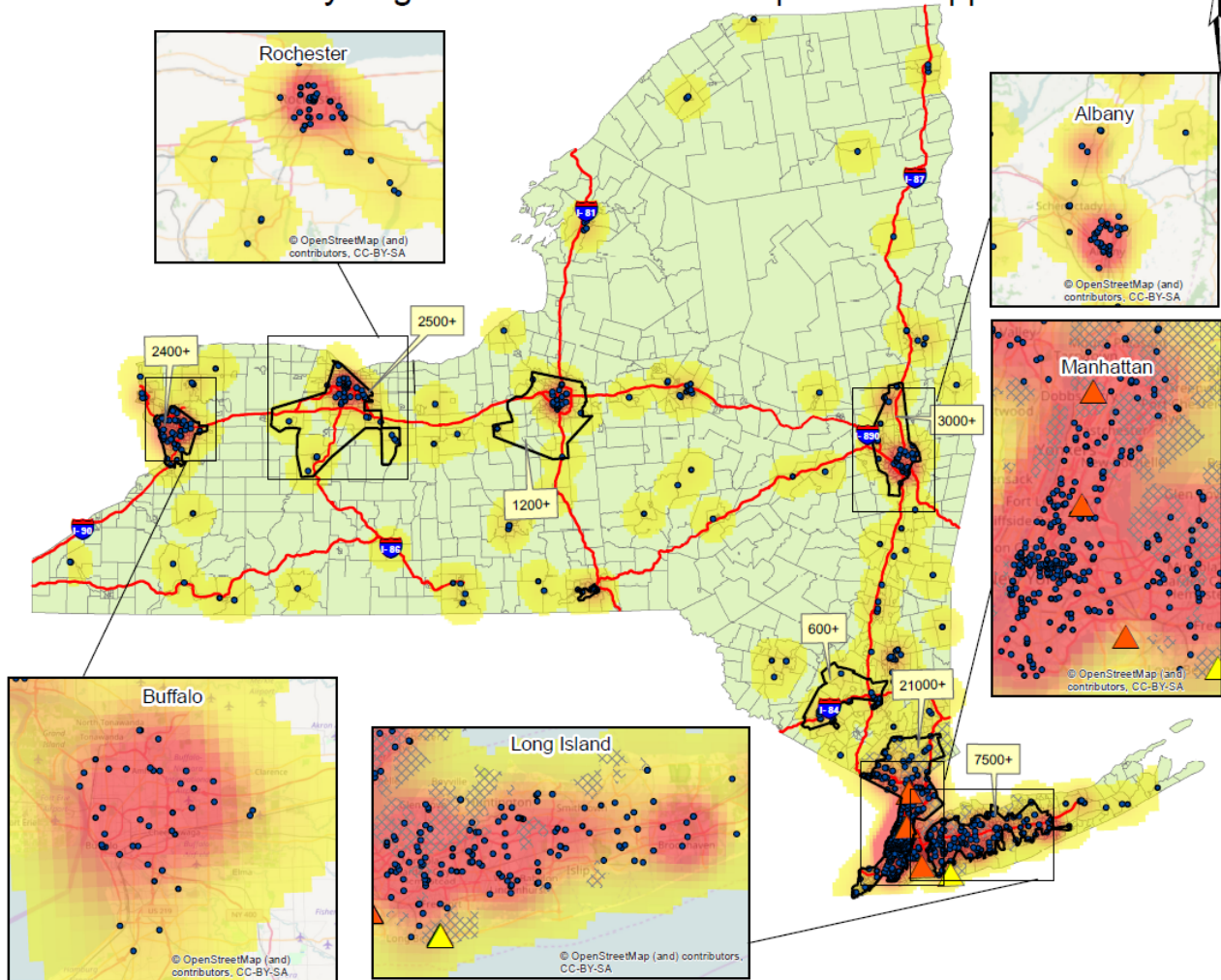
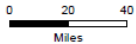


NEESC is funded through a contract with the U.S. Small Business Administration (SBA)

Sources:  
 R.L. Polk & Co.  
 U.S. Census Bureau  
 Alternative Fuels Data Center  
 Electrochemical Hydrogen Separator  
 Opportunities for Commercialization 2009

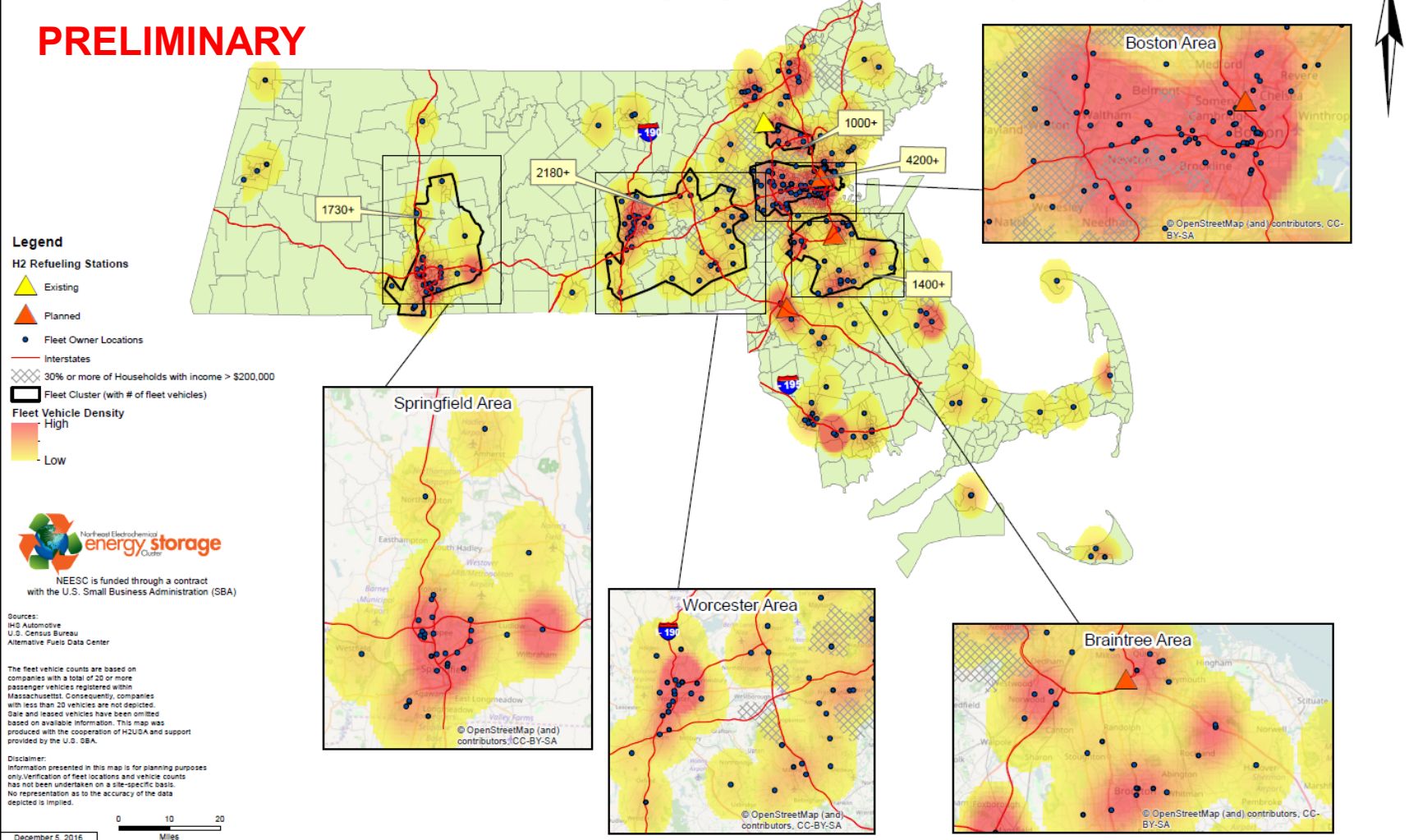
The fleet vehicle counts are based on companies with a total of 25 or more passenger vehicles registered within New York. Consequently, companies with less than 20 vehicles are not depicted. Sale and leased vehicles have been omitted based on available information. This map was produced with the cooperation of H2USA and support provided by the U.S. SBA.

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



# Massachusetts: Market Potential for Hydrogen and Fuel Cell Transportation Applications

**PRELIMINARY**



**Joel Rinebold**

**Director of Energy Initiatives**

*Connecticut Hydrogen and Fuel Cell Coalition*

*Connecticut Center for Advanced Technology*

*Northeast Electrochemical Energy Storage Cluster*

**[jrinebold@ccat.us](mailto:jrinebold@ccat.us)**

**(860) 291-8832**