Connecticut Hydrogen-Fuel Cell Coalition

Northeast Electrochemical energy storage Cluster

Hydrogen & Fuel Cell Technical Advisory Committee (HTAC)

Connecticut and the Northeast Region

Roadmap Planning • Policy • Business Development

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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

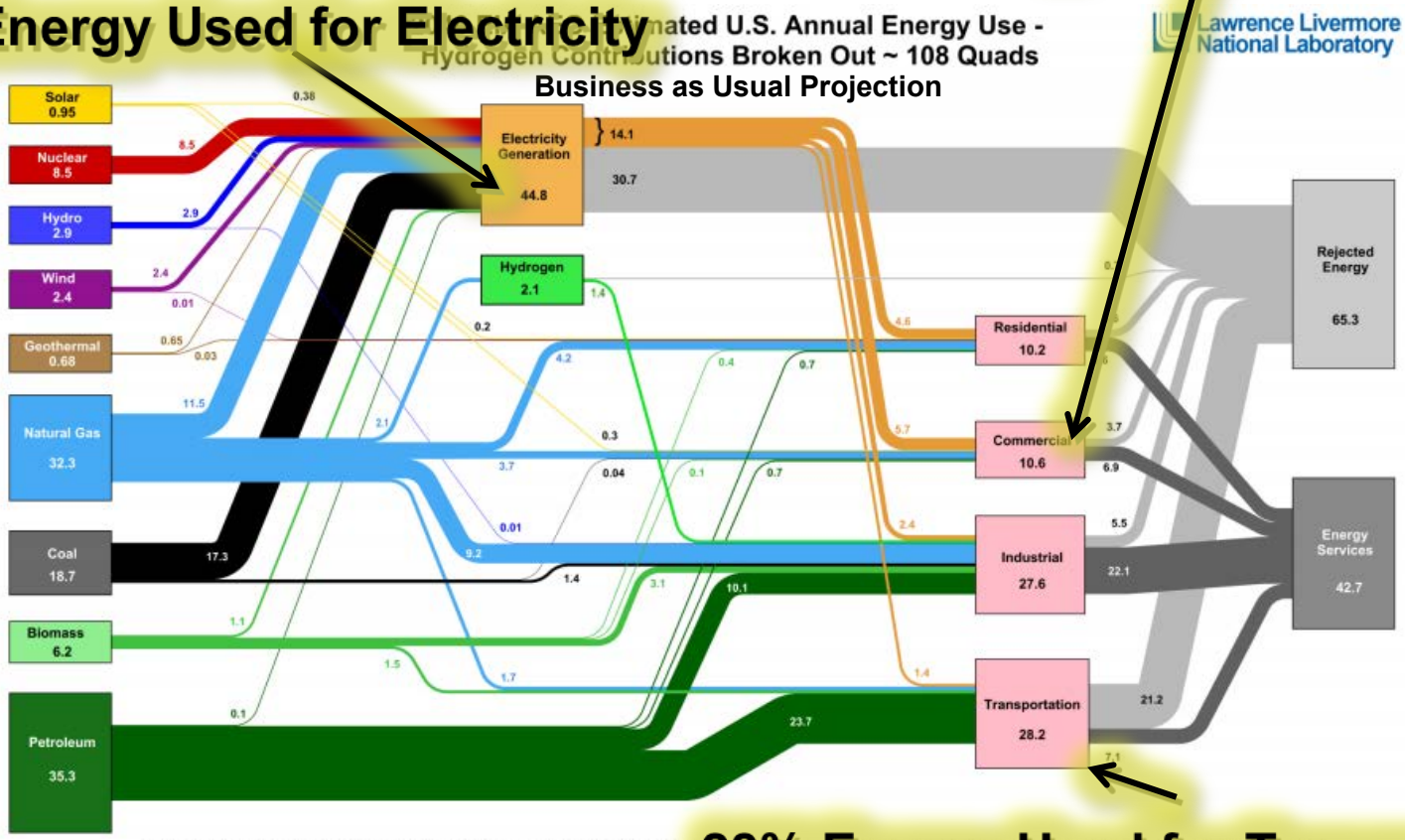
Market Drivers

- 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



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

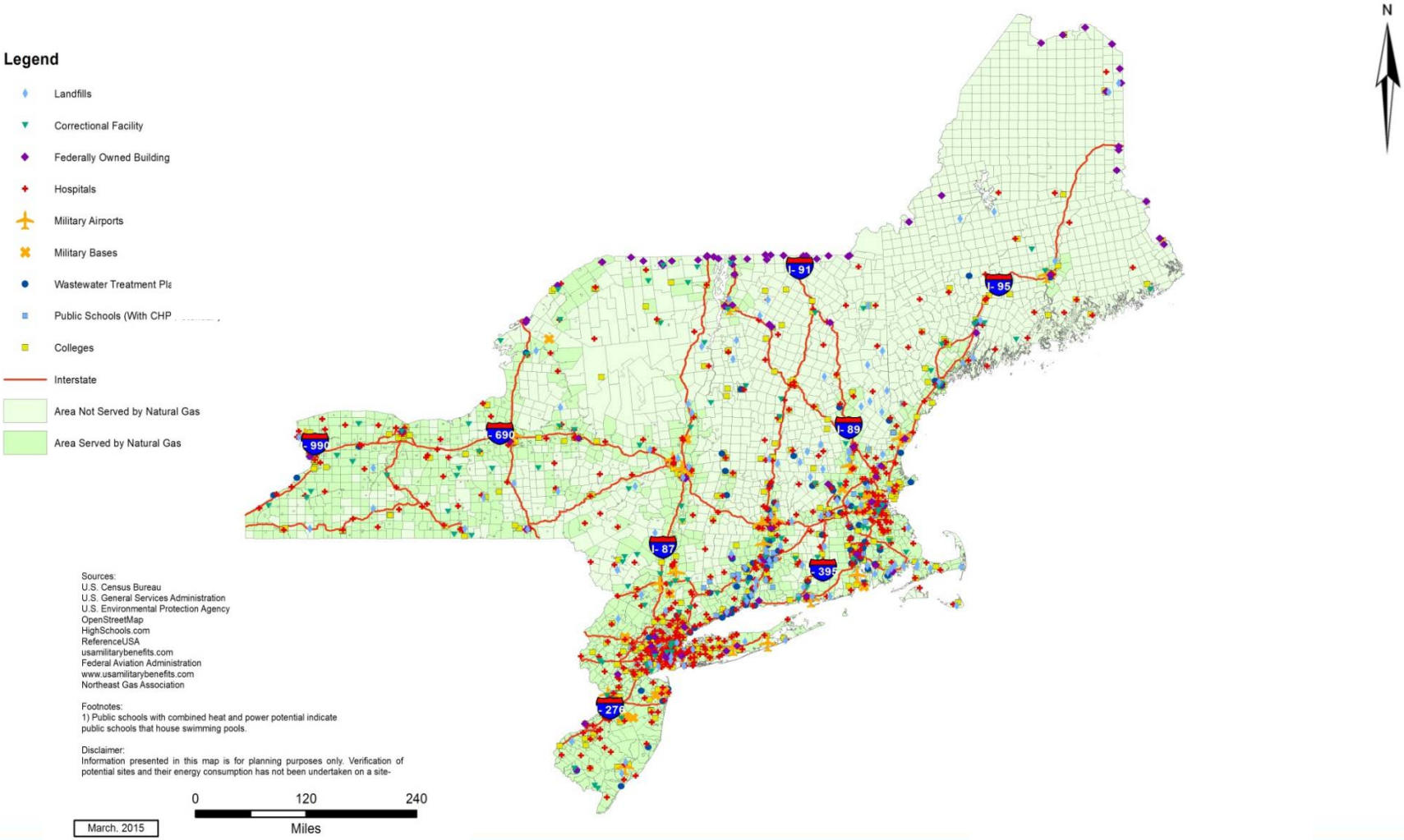
- Economic impacts (jobs, revenue, companies)
- Technology, Applications, and Markets
- Stationary and Transportation Deployment Targets
- Policy and Drivers
  - Job Development
  - Energy Reliability
  - Storm Preparation
  - Environmental
  - Carbon Control
  - Energy Cost

- **Update Planned for 2017**

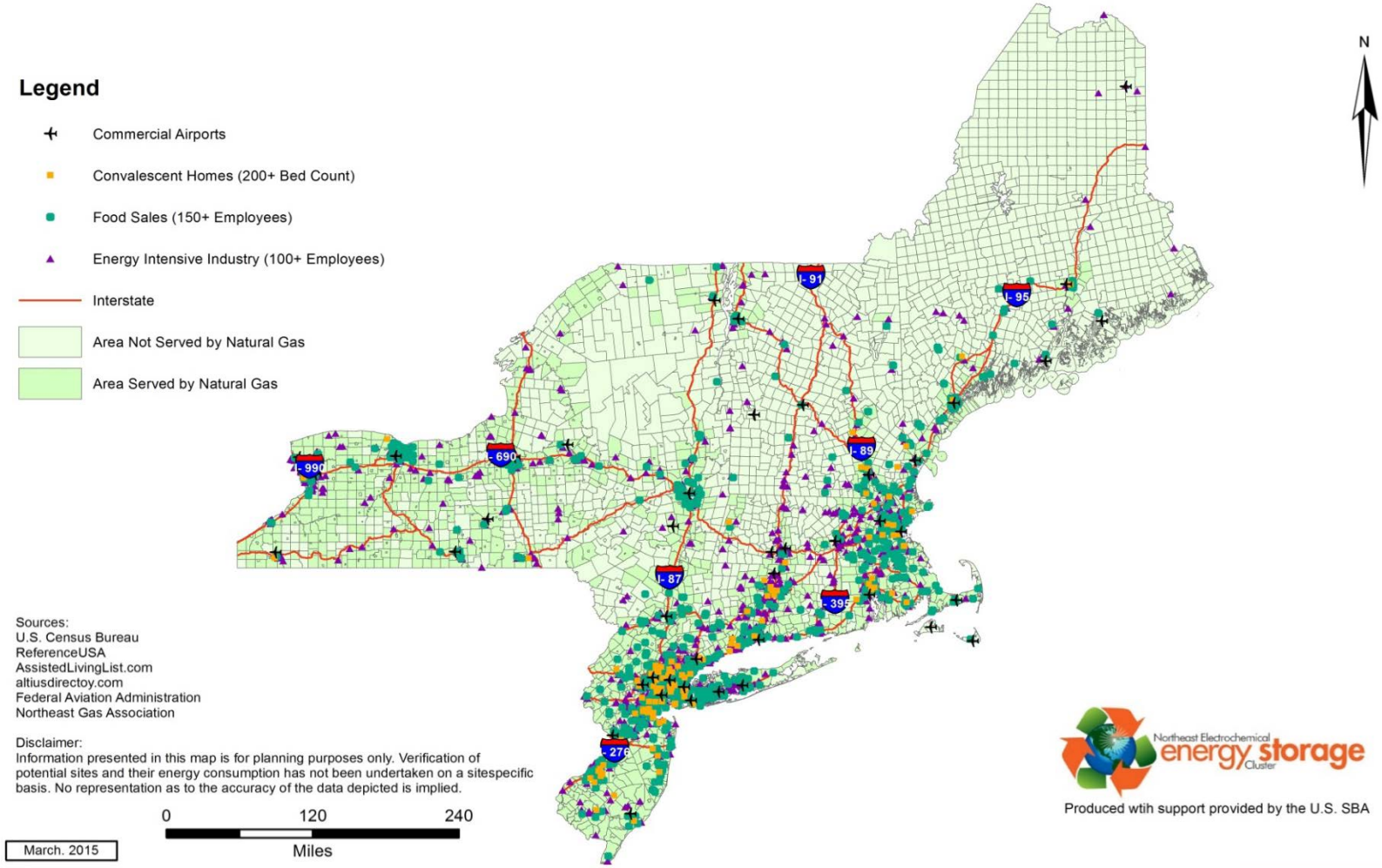
Stationary Market Targets

- 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



Regional Private Stationary Targets



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)									
Net Metering									
Public Benefits Fund									
Performance-Based Power Purchase									
Utility Ownership/Incentives (Rebate Programs)									
State Grant Program									
State Loan Programs									
Microgrid Reliability Program									
Property Tax Incentive (Commercial)									
Sales Tax Incentive									
Property-Assessed Clean Energy (PACE) Financing									
One Stop Regulatory Approval									
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	

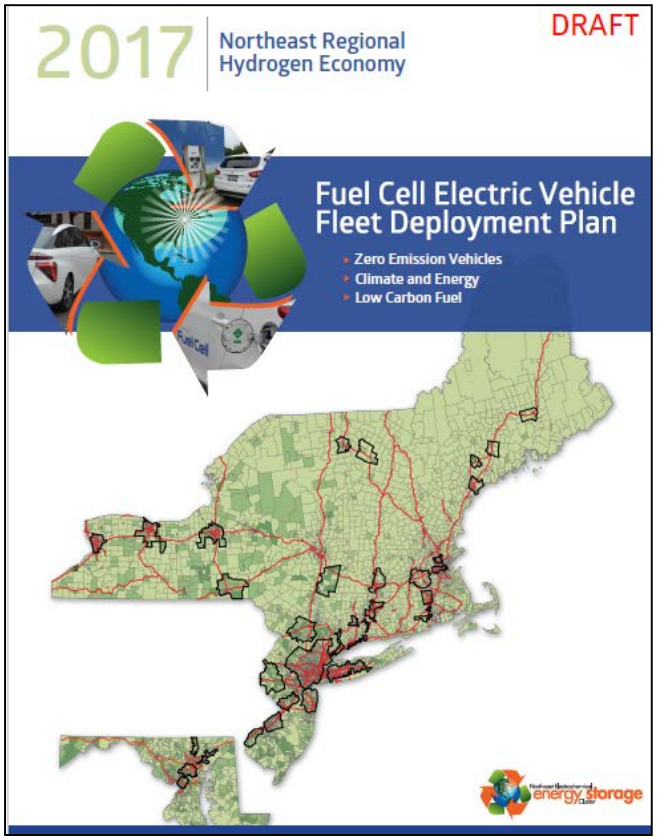
Eligible

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

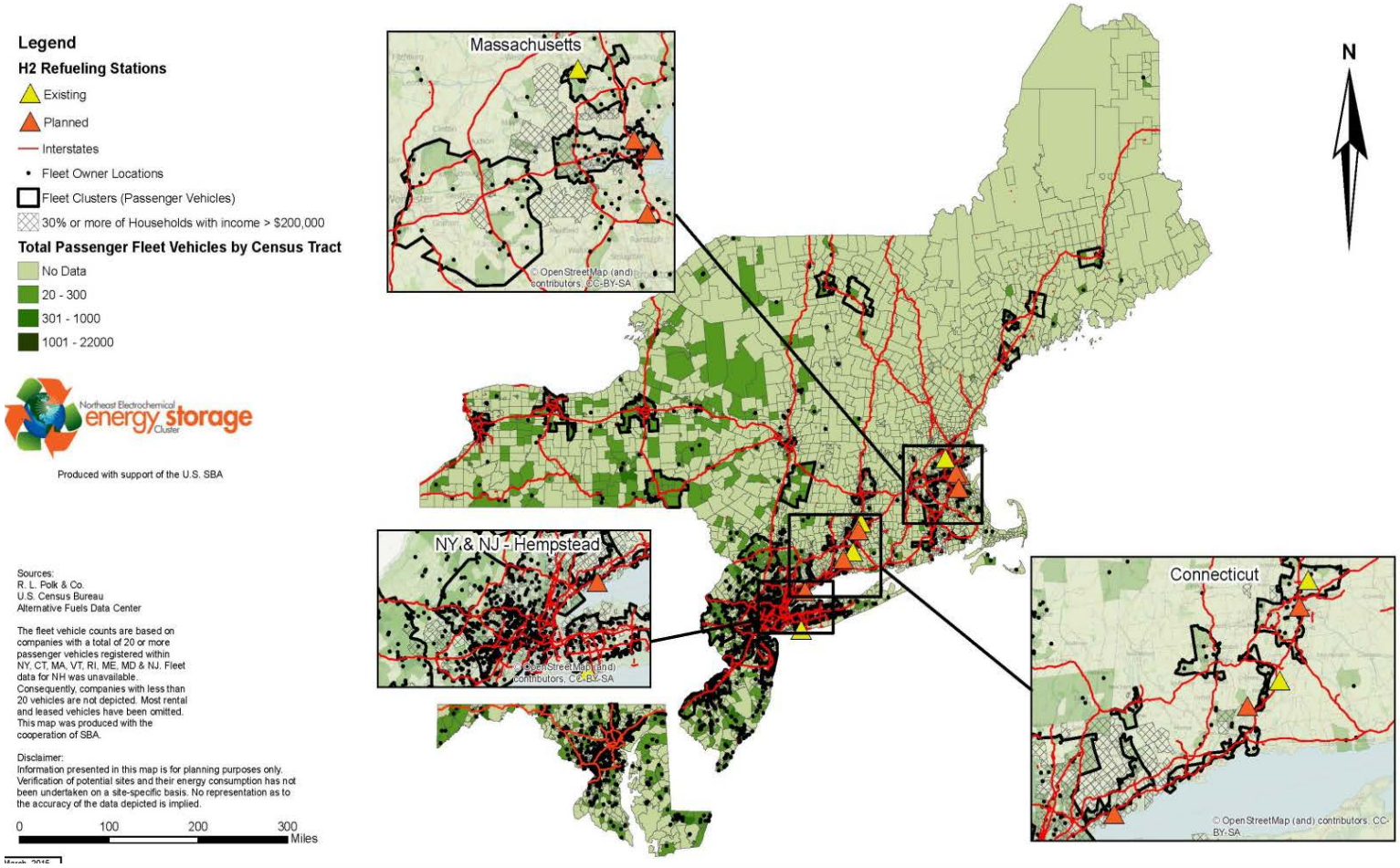
Northeast Fleet Market Opportunities

Regional FCEV and Hydrogen Market Opportunities

State	Total Fleets[28]			Fleet Deployment Goals [29]				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
Region	**171,238**	**67,619**	**15,568**	**7,345**	**676**	**728**	**8,749**	**74 – 89**

- 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



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Policy/Incentives for H_2 Transportation

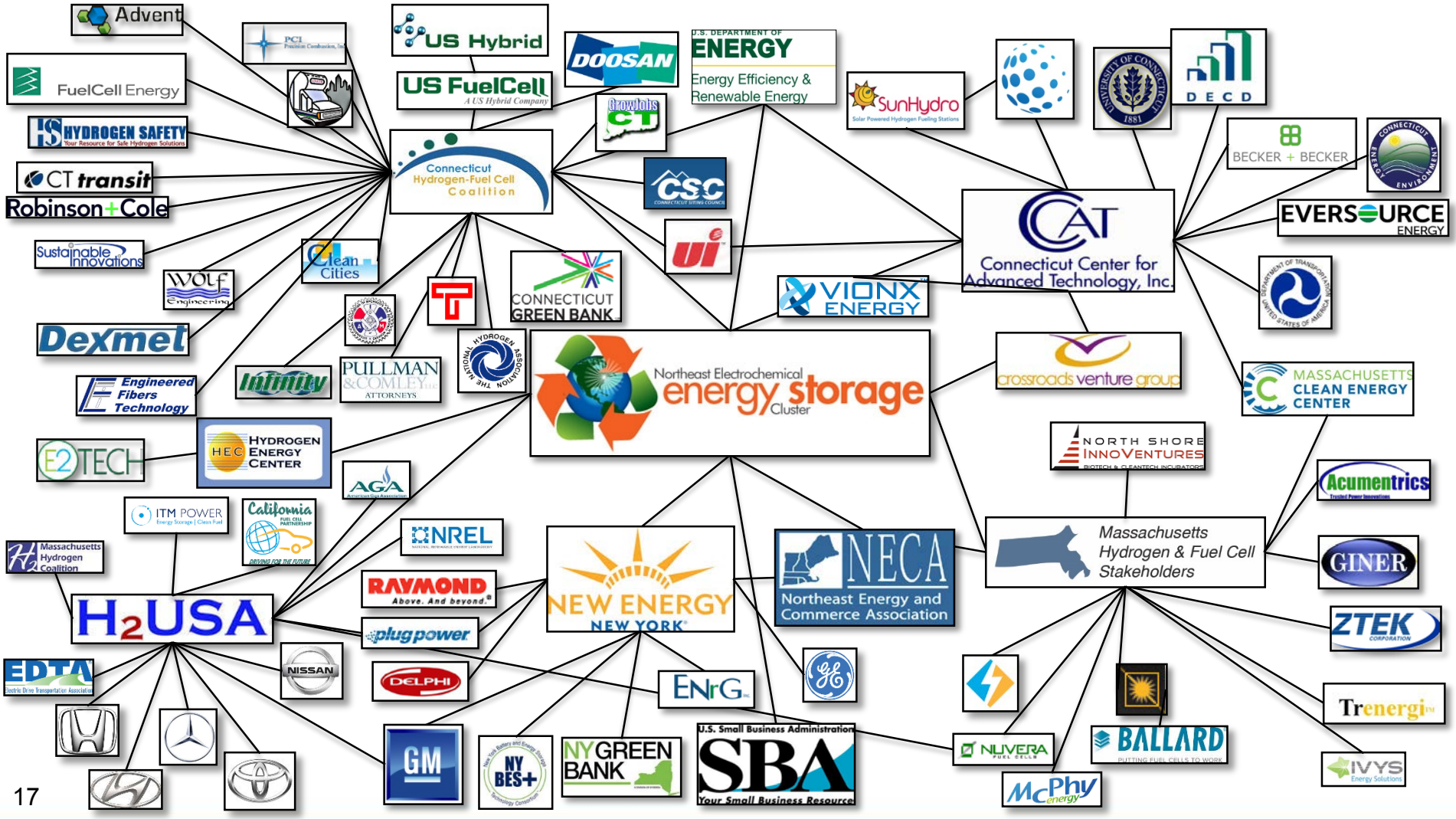
- State/Regional Hydrogen and Fuel Cell Development Plans
- Zero Emission Vehicle (ZEV) Program (FCEV/H_2 Infrastructure)
- ZEV Purchase Target for State Government Fleets
- Purchase Incentives/"Point-of-Purchase" Rebates
- Fuel/Tax Incentives
- Public/Private Infrastructure Partnership
- Fuel Efficiency Standard (Private/State Fleets)
- Refueling Infrastructure Incentives
- REC Available for Renewable H_2
- 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_2 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_2									
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

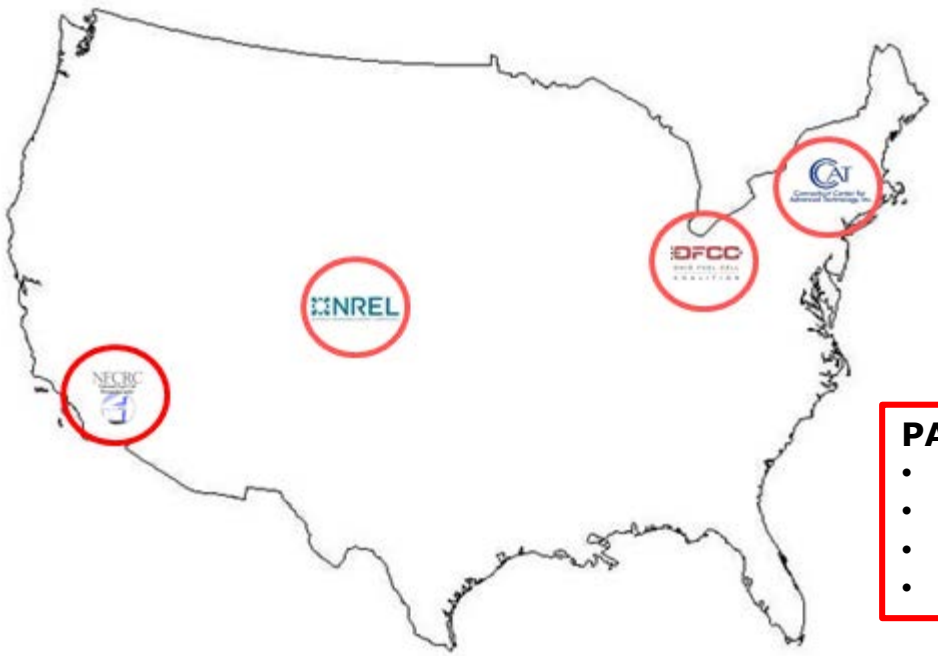
Manufacturing/Business Development



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)

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Manufacturing/Business Development

Integration of Northeast Supply Chain W/ Federal Database

Supply Chain Database Search

Supplier Category: search all
Sub-Category: Search All
Search term
Search | Reset

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

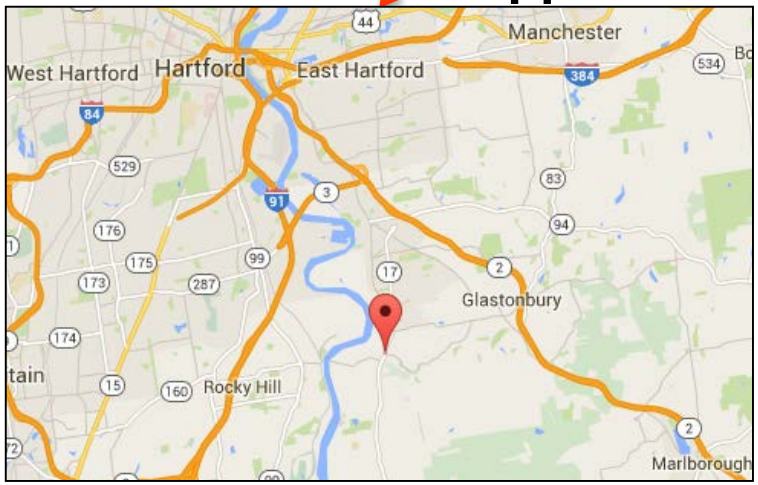
next page >>

14 Supply Products/ over 100 Categories

Supplier Category: search all
Sub-Category
Search term
Search | Reset

- search all
- 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

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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)

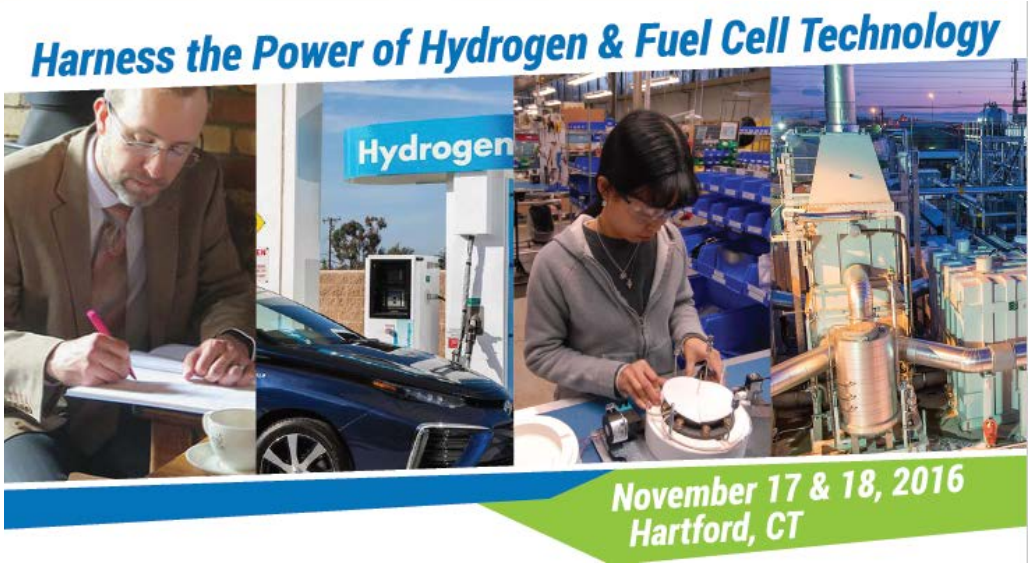
* Regional IMPLAN (ME, MA, VT, RI, CT, NH, NY, NJ) – 2012 vs 2016 Data
- REMI Economic Impact Analysis for Connecticut – 2006
- REMI Economic Impact Analysis for Connecticut – 2007
- Regional IMPLAN Economic Analysis – 2012 (2011 data)
- Regional IMPLAN Economic Analysis – 2016 (2015 data)
- REMI Economic Impact Analysis for Connecticut – 2016

Business Impact

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

Connecticut Hydrogen-Fuel Cell Coalition

Northeast Electrochemical energy storage Cluster



2016 H2FC

Hydrogen & Fuel Cell Forum

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

Northeast Electrochemical energy storage Cluster

CONNECTICUT GREEN BANK

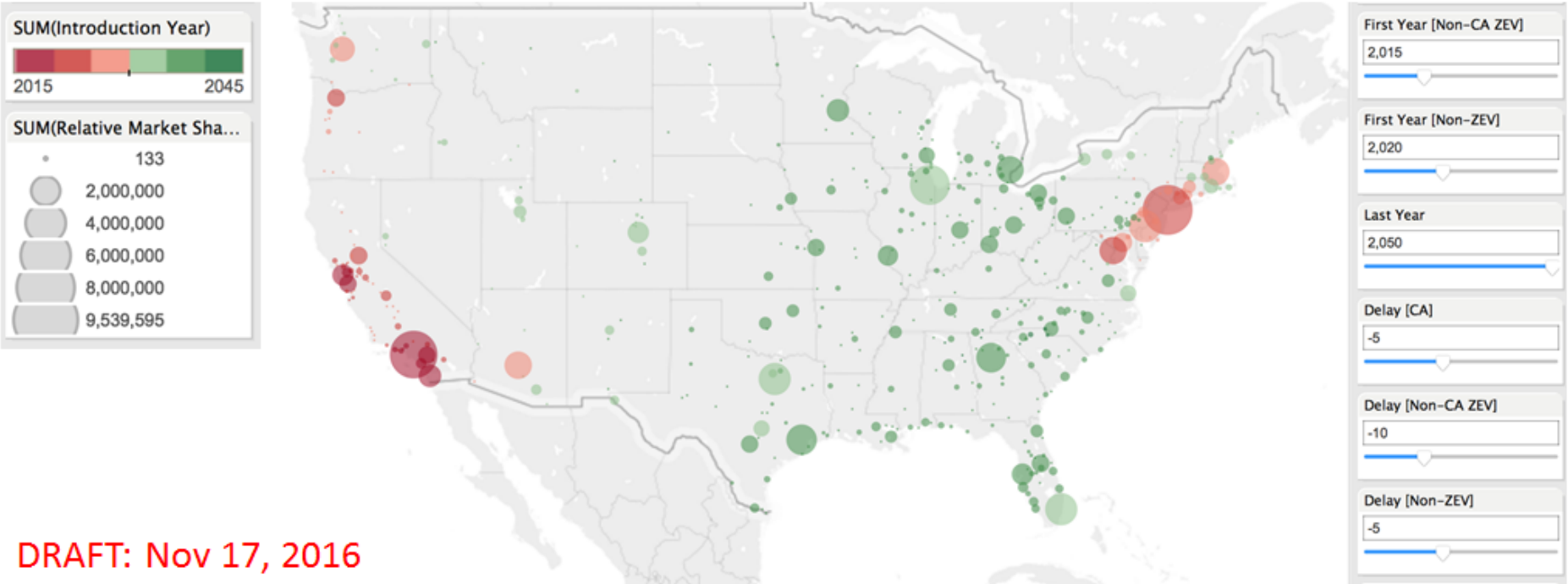
For more info, visit: www.h2fcforum.com

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?



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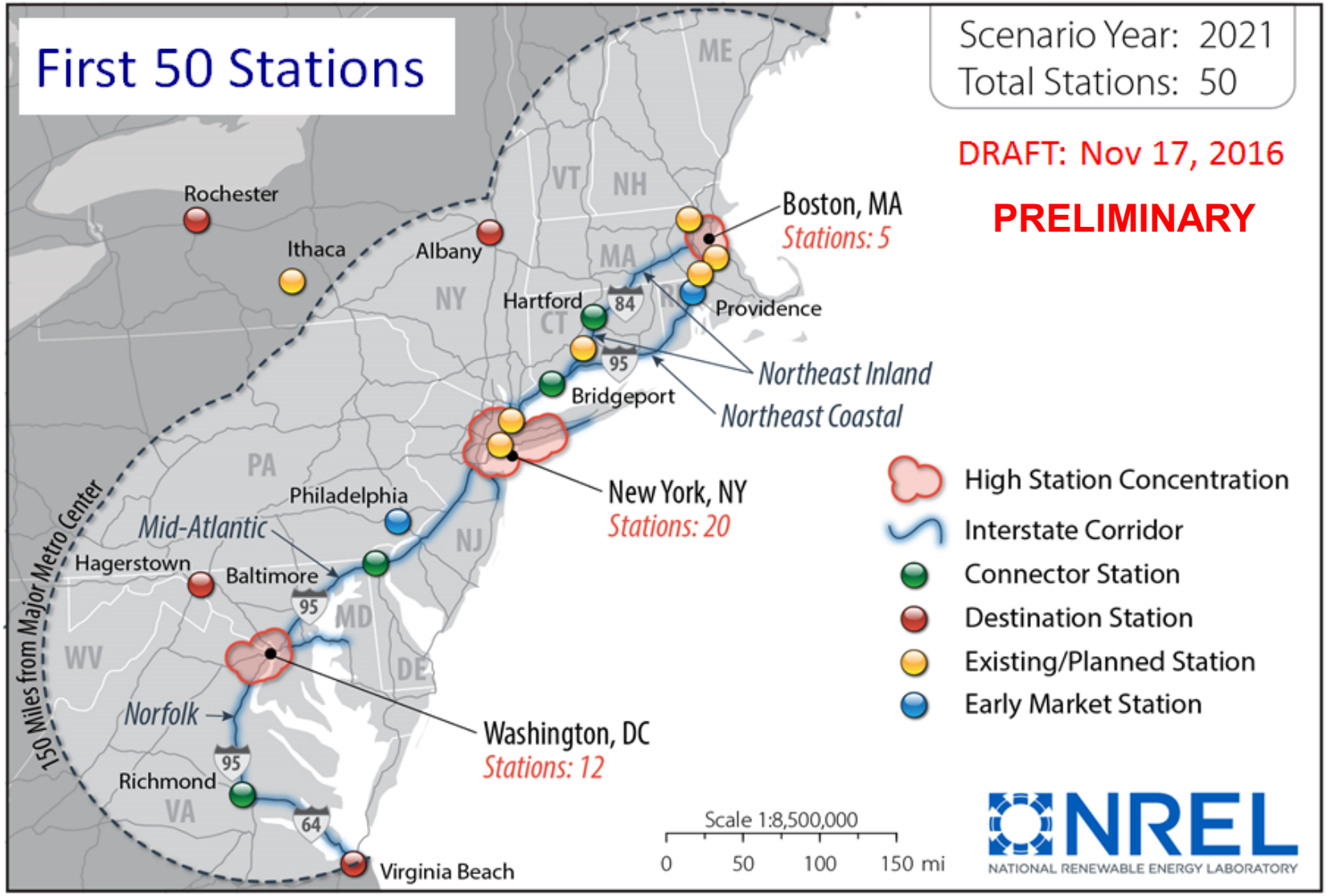
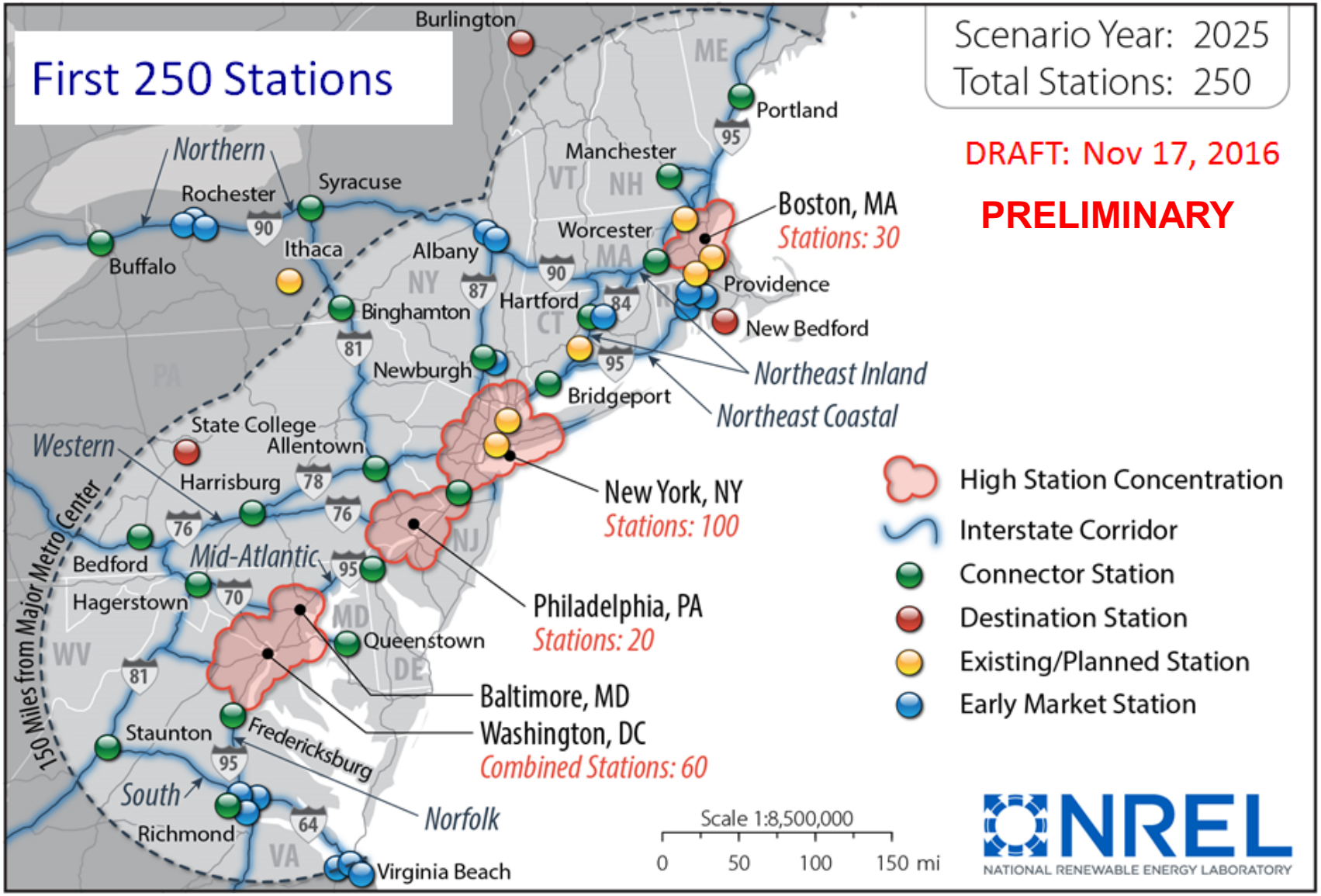


- Most stations are in large cities
- Connector and destination stations are examples of what might be required for an integrated regional network



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

APPENDIX I --- Figure 3

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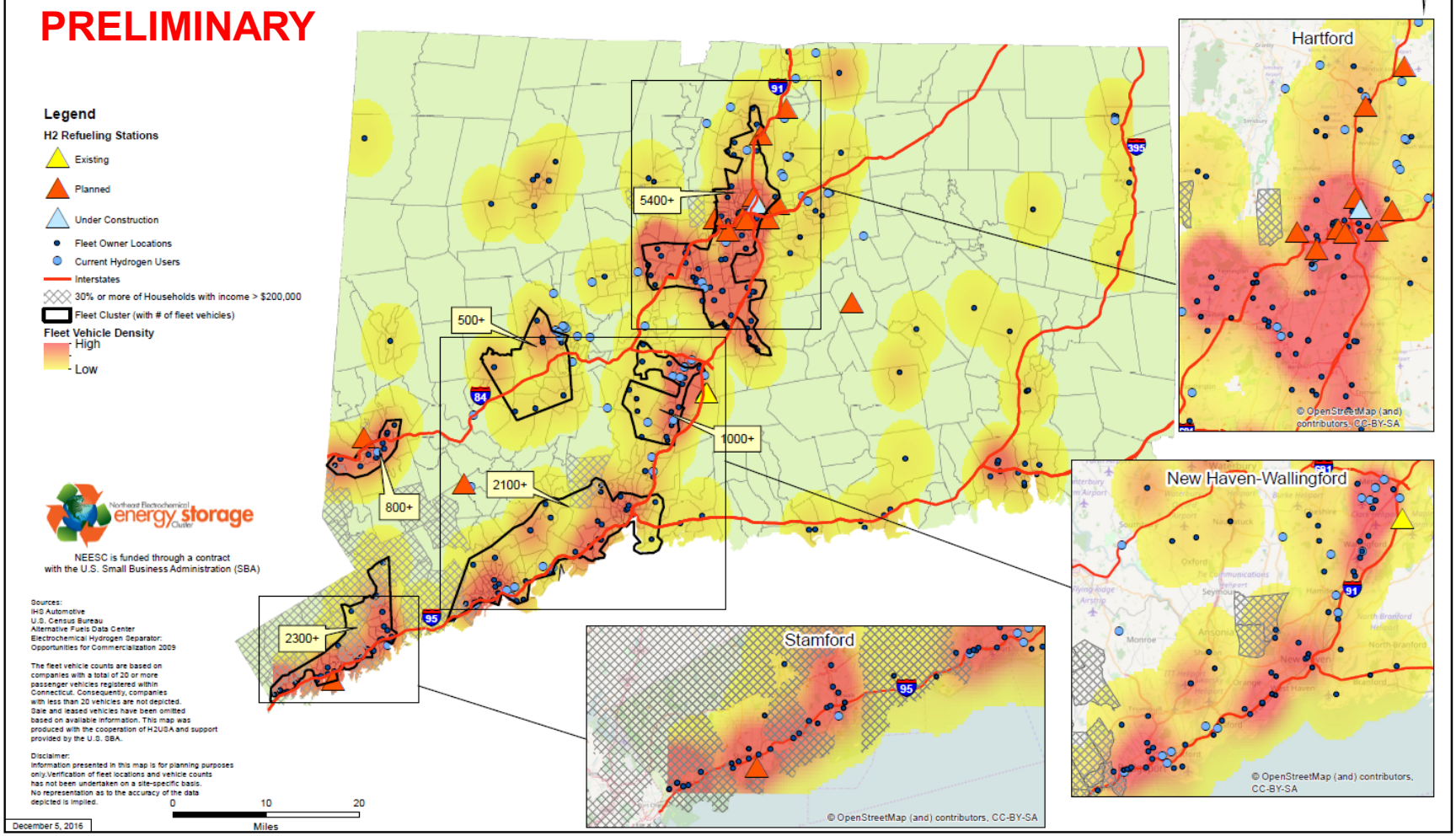
Connecticut: Market Potential for Hydrogen and Fuel Cell Transportation Applications

PRELIMINARY



APPENDIX I --- Figure 4

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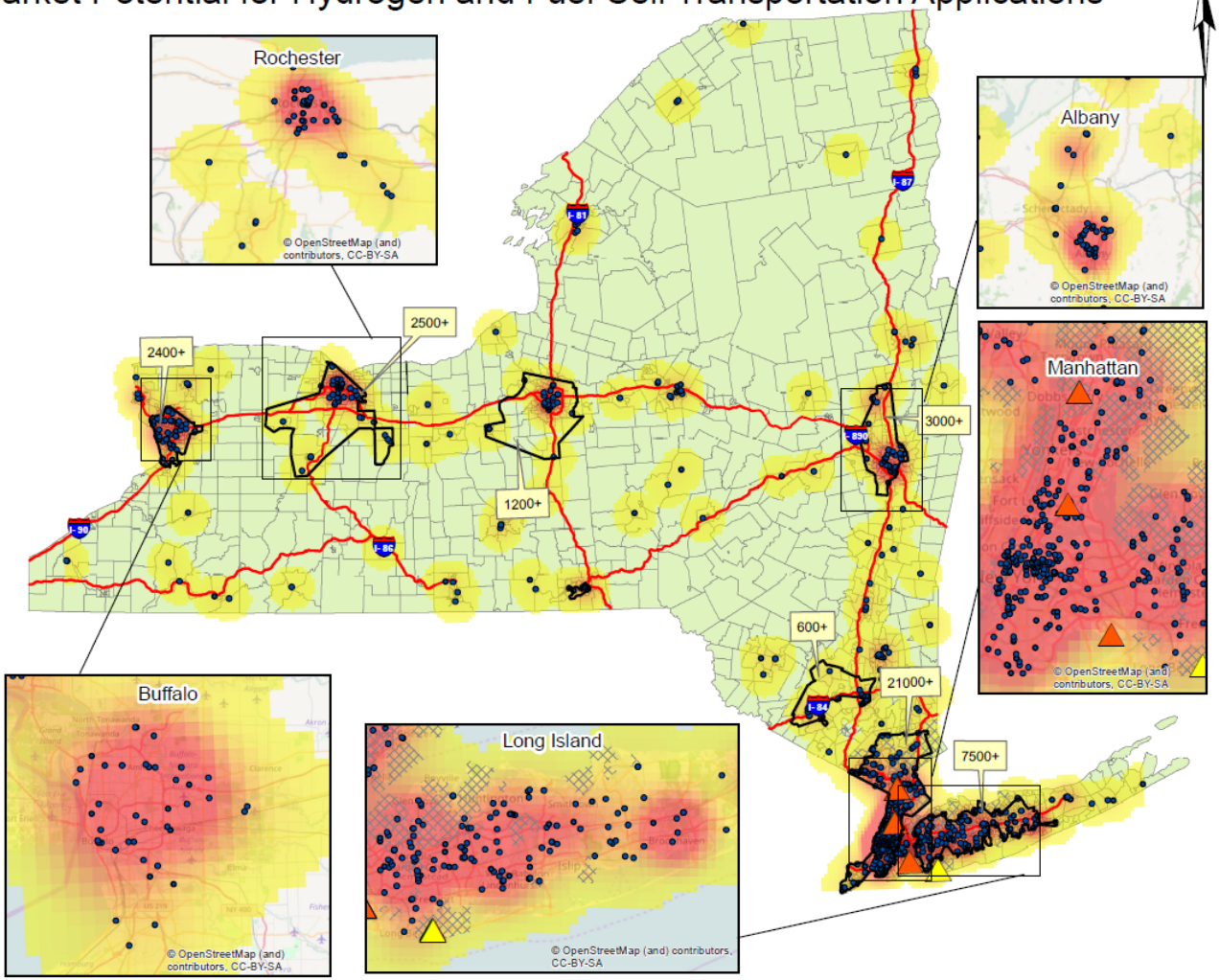
New York: Market Potential for Hydrogen and Fuel Cell Transportation Applications

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

Northeast Electrochemical energy storage Cluster

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 20 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.

0 20 40
Miles

December 5, 2016

APPENDIX I --- Figure 5

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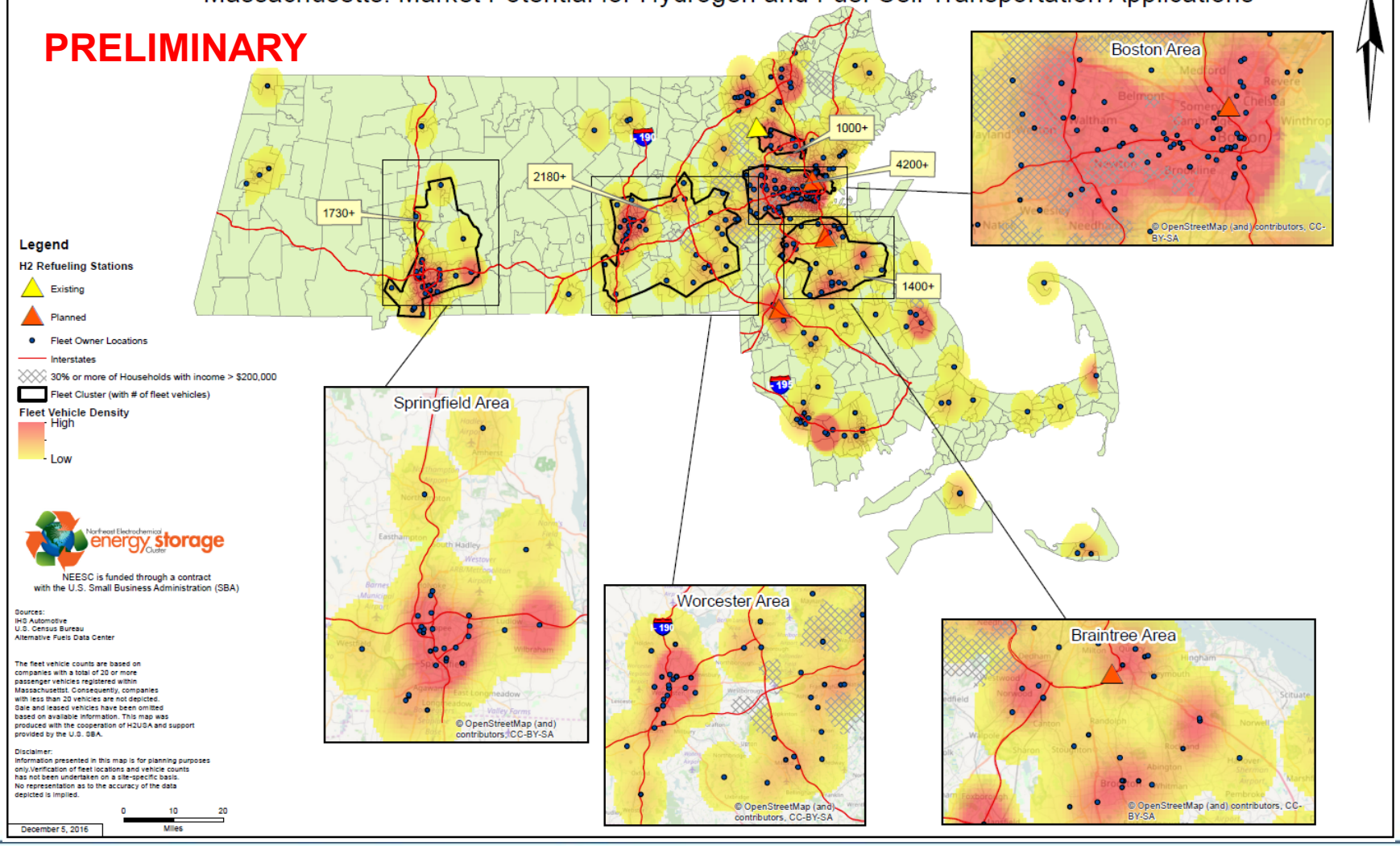
Massachusetts: Market Potential for Hydrogen and Fuel Cell Transportation Applications

PRELIMINARY



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