



Regional Hydrogen Infrastructure Panel

Joel M. Rinebold
Connecticut Center for Advanced Technology, Inc.
Washington, DC
June 14, 2018



The Northeast Experience

- Direction
- Markets
- Action
- Policy
- Results



Direction



Goals

- Clean/Low Carbon Emissions
- Efficiency
- Reliability
- Durability
- Lower Costs
- Clean Energy Jobs

Market Drivers

- Emissions Reductions
- Renewable Integration
- Energy Reliability/Resiliency
- Efficiency/Cost
- Economic Incentives

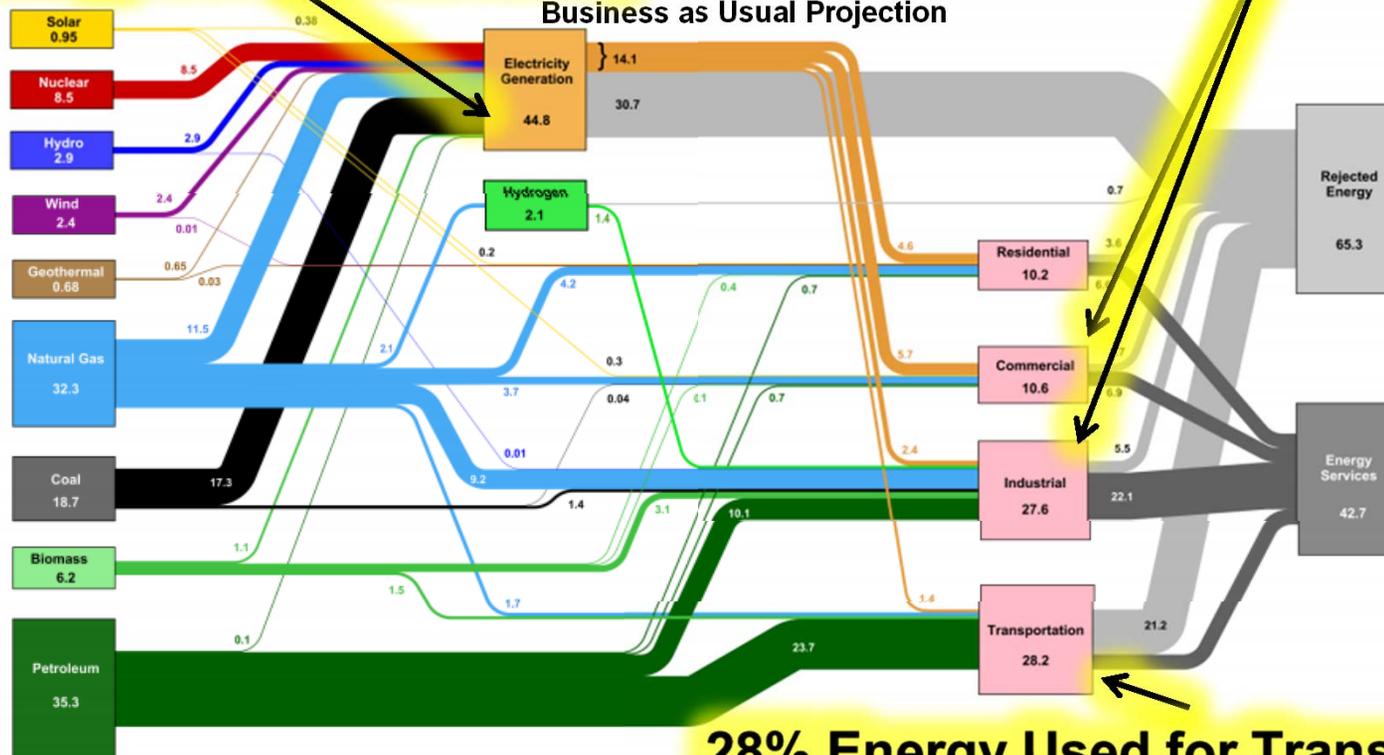
Energy Flow

30% 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

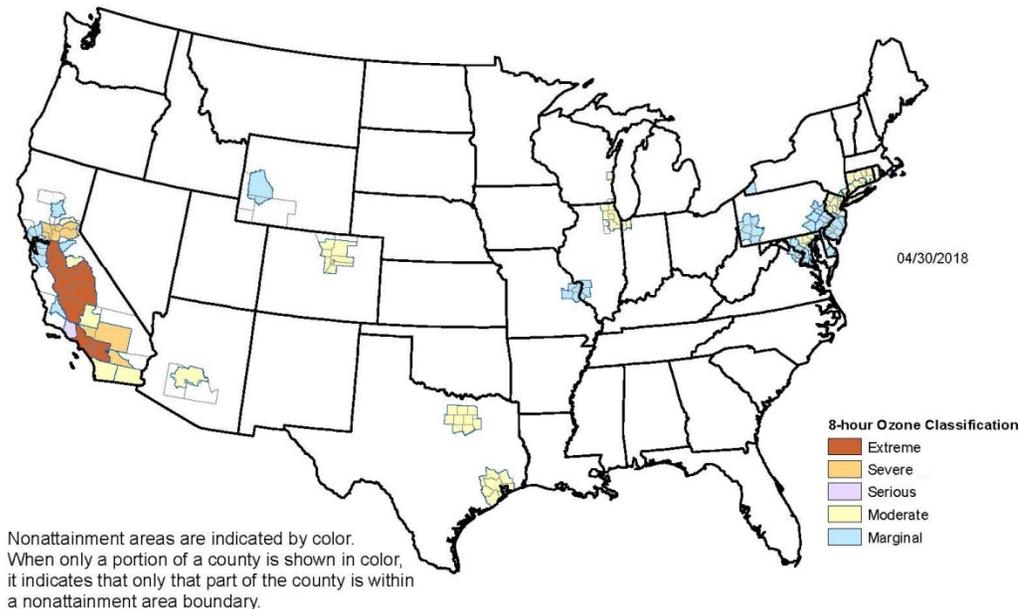
Source: LLNL, March 2016. Data is based on DOE/EIA-0035(2015-03) and Annual Energy Outlook 2016. Distributed electricity represents only retail electricity sales and does not include self-generation. EIA reports consumption of renewable resources (i.e., hydro, wind, geothermal and solar) for electricity in Btu-equivalent values by assuming a typical fossil fuel plant "heat rate". The efficiency of electricity production is calculated as the total retail electricity delivered divided by the primary energy input into electricity generation. End use efficiency is estimated as 65% for the residential sector, 65% for the commercial sector, 80% for the industrial sector, and 21% for the transportation sector. Totals may not equal sum of components due to independent rounding. LLNL-MI-676987

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.

Air Quality (NAAQS) Nonattainment

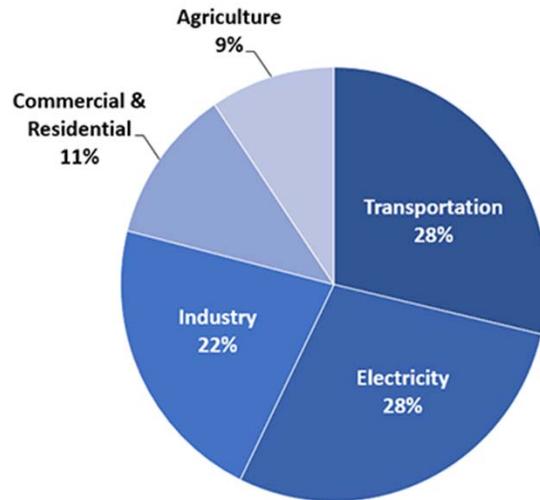
The transportation sector releases significant quantities of hydrocarbons (HC), carbon monoxide (CO), and nitrogen oxides (NOx), (and particulates in the case of diesel vehicles). Vehicles account for over 55 percent of the total NOx emissions in the United States (U.S.)

8-Hour Ozone Nonattainment Areas (2008 Standard)



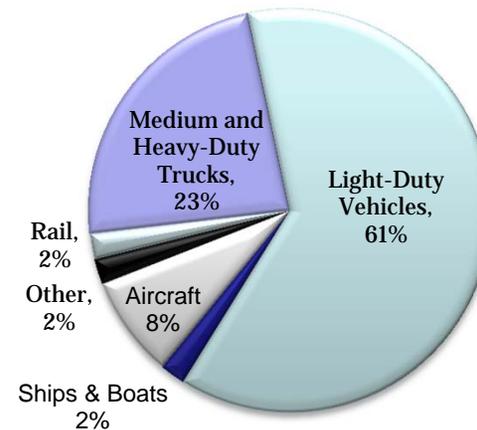
U.S. Transportation Emissions

- 28% of GHG emissions come from the transportation sector
- 61% of transportation emissions come from light-duty vehicles



Total U.S. Greenhouse Gas Emissions by Economic Sector 2016

US EPA; GHG Emissions; <https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions>; 2018



Share of U.S. Transportation Sector Emissions by Source (CO2)

US EPA; "Fast Facts;" <https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100ONBL.pdf>; 2016



Direction

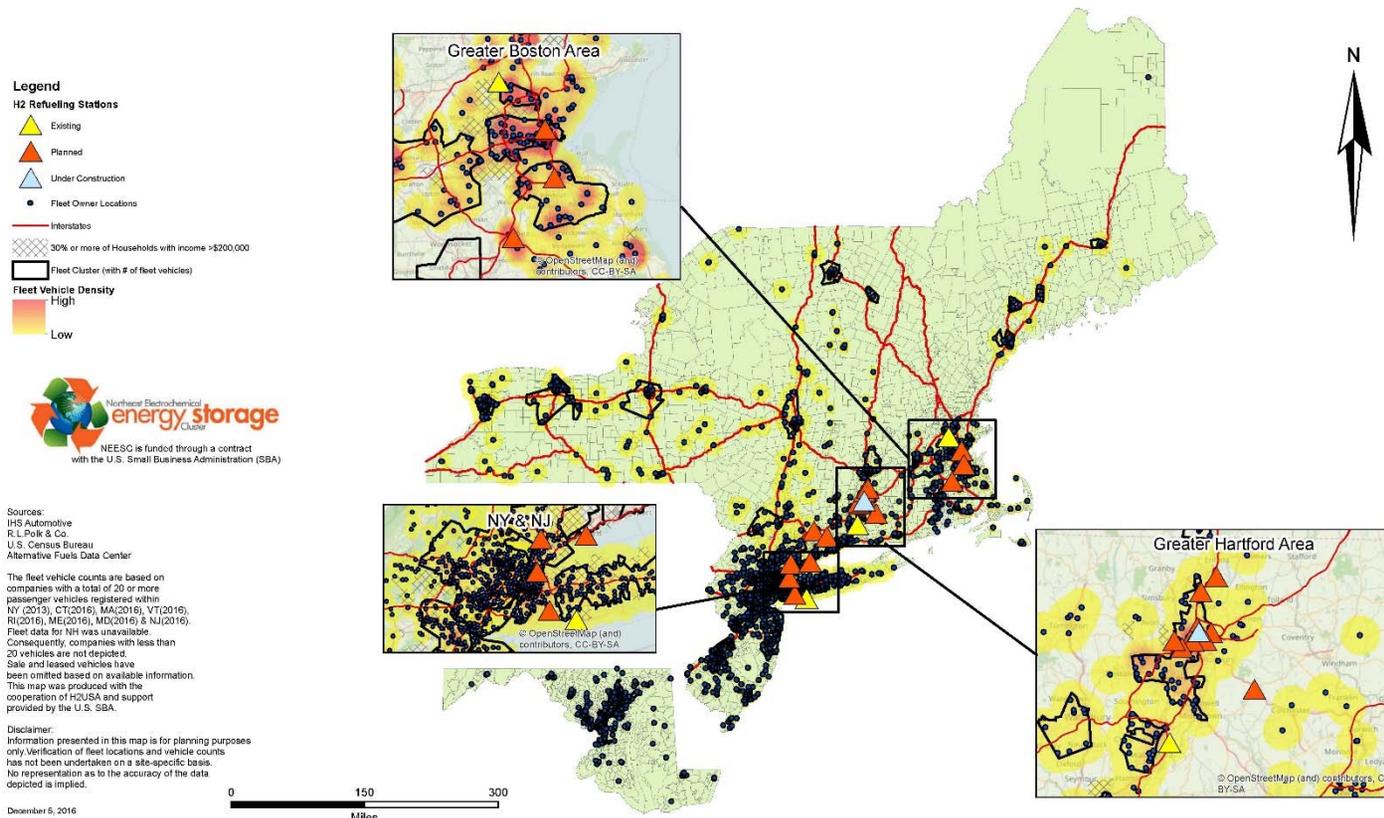


Transportation Market Targets (Fleets)

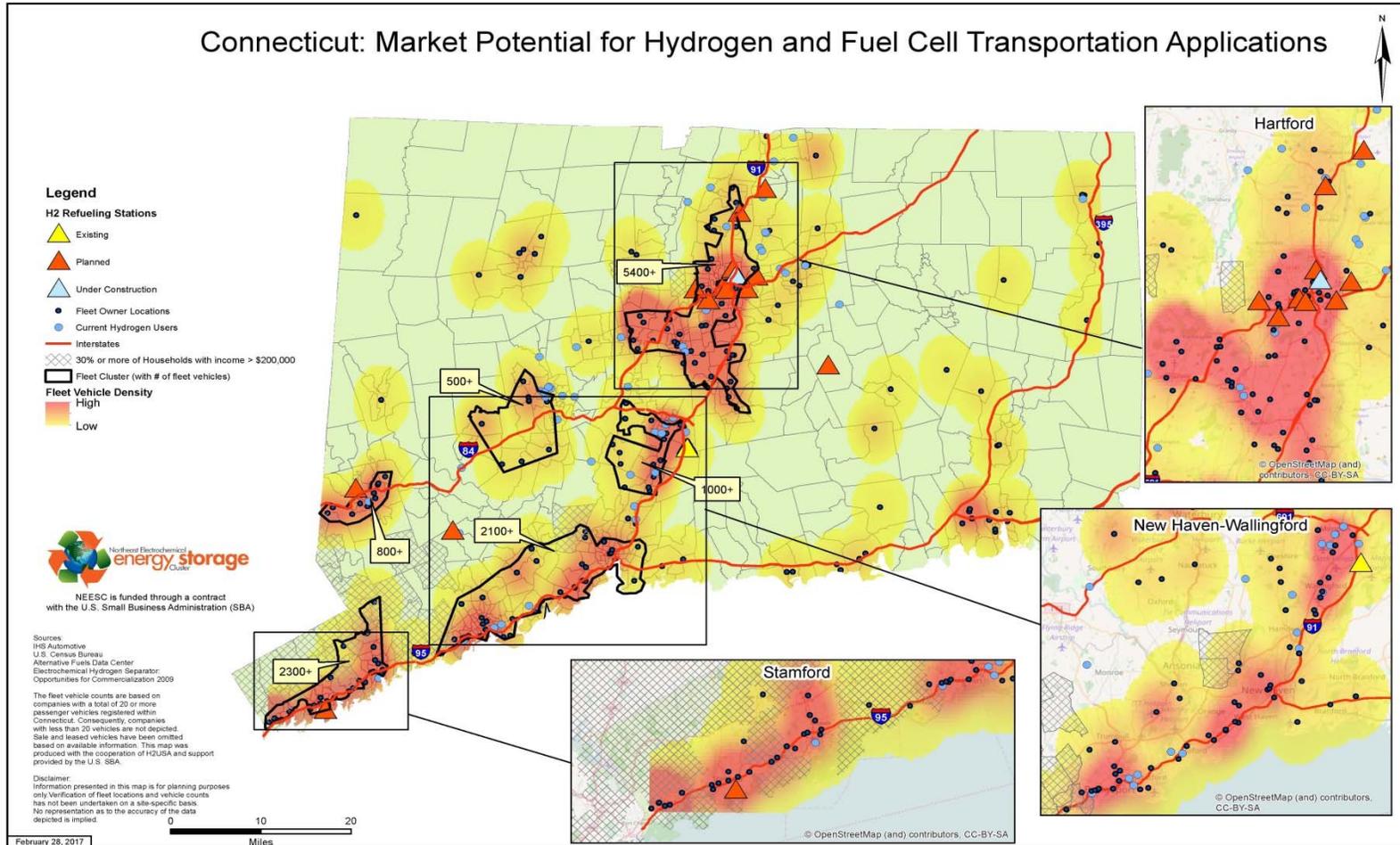
- Fleet Deployment
 - FCEV (Light-Duty)
 - Fuel Cell Electric Buses (FCEB)
 - Specialty Fuel Cell Vehicles
 - Material Handlers
 - Airport Tugs
 - Hydrogen Refueling
 - Hydrogen for Energy Storage

Regional Transportation Targets

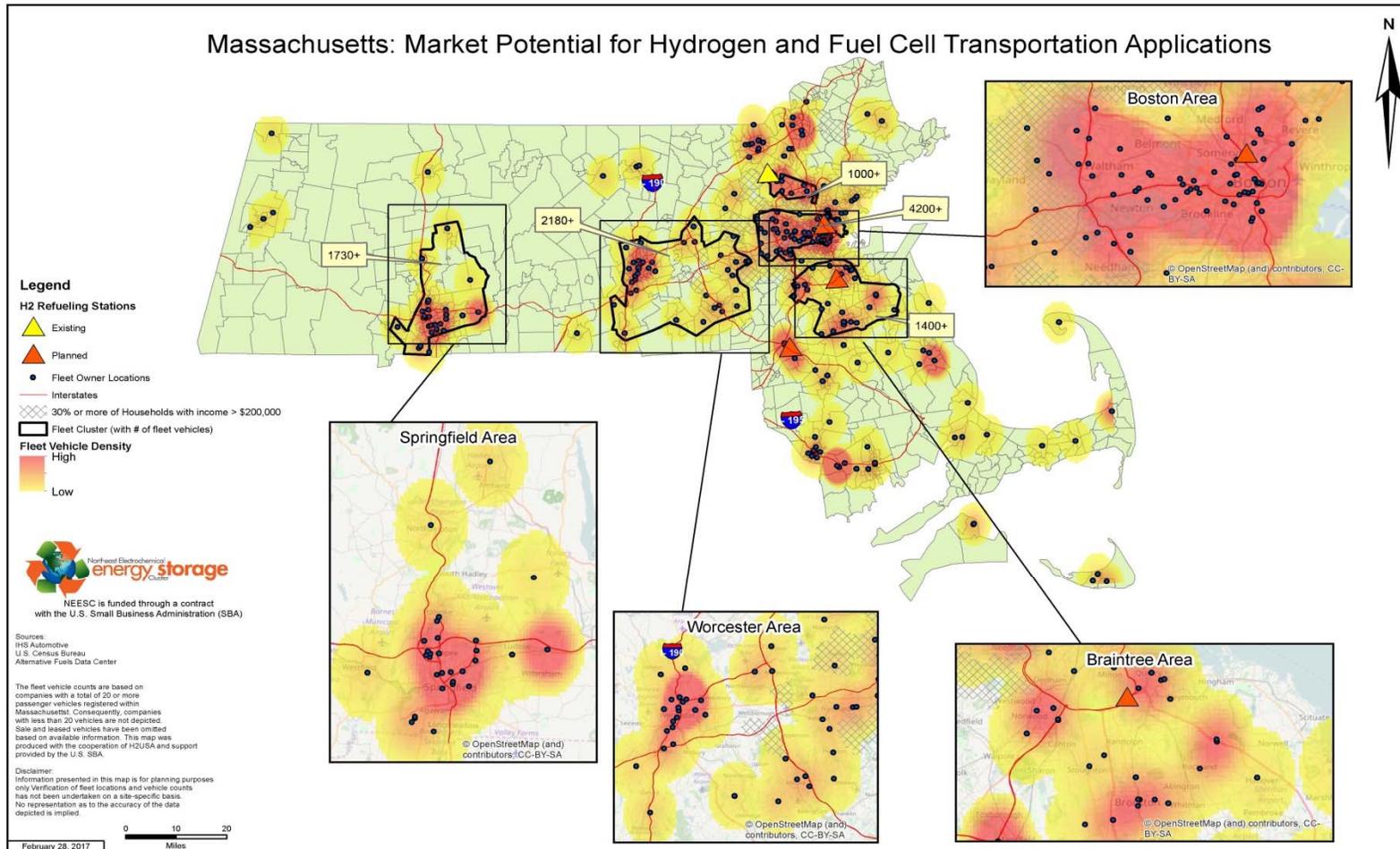
Northeast Region: Market Potential for Hydrogen and Fuel Cell Transportation Applications



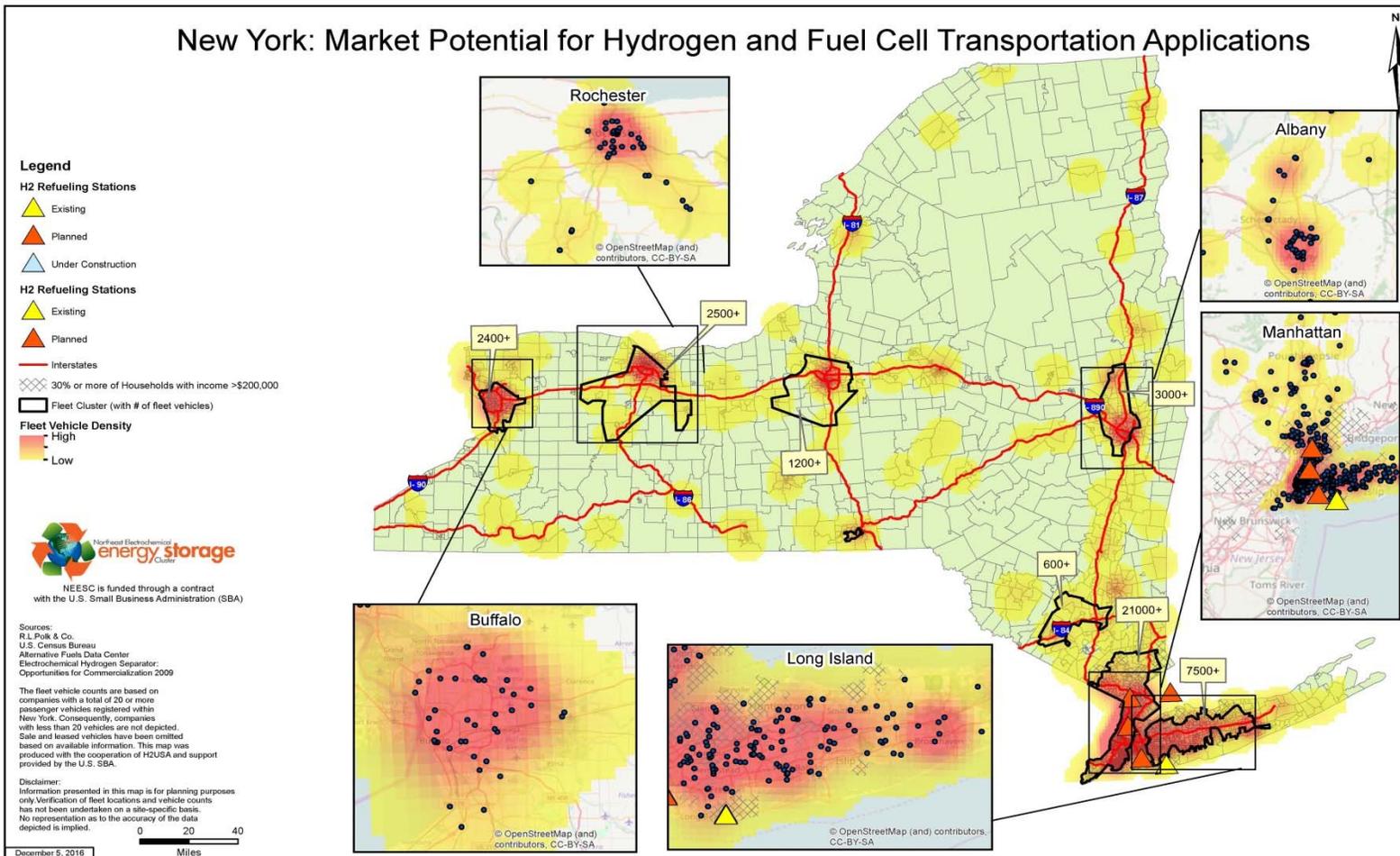
Regional Transportation Targets



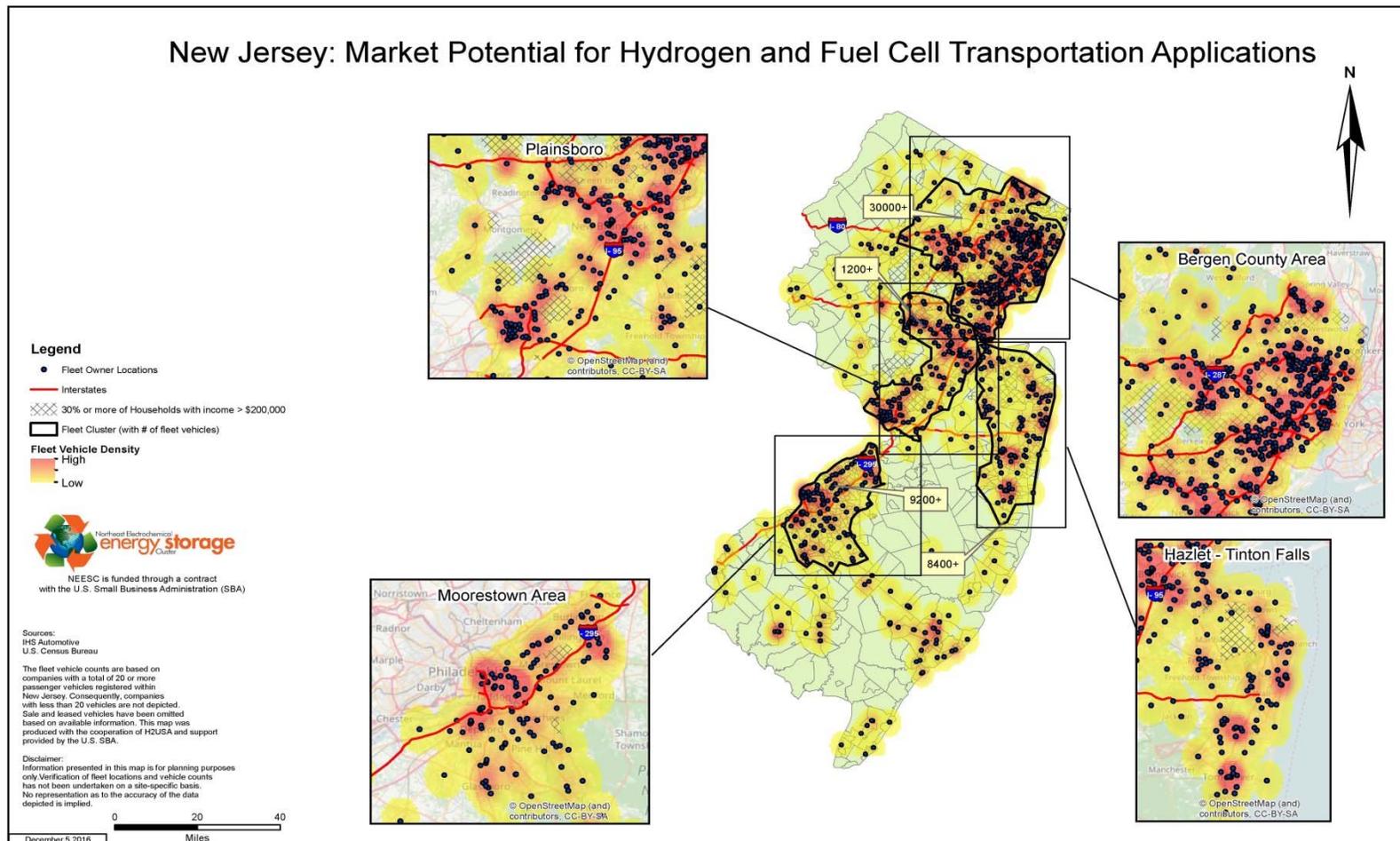
Regional Transportation Targets



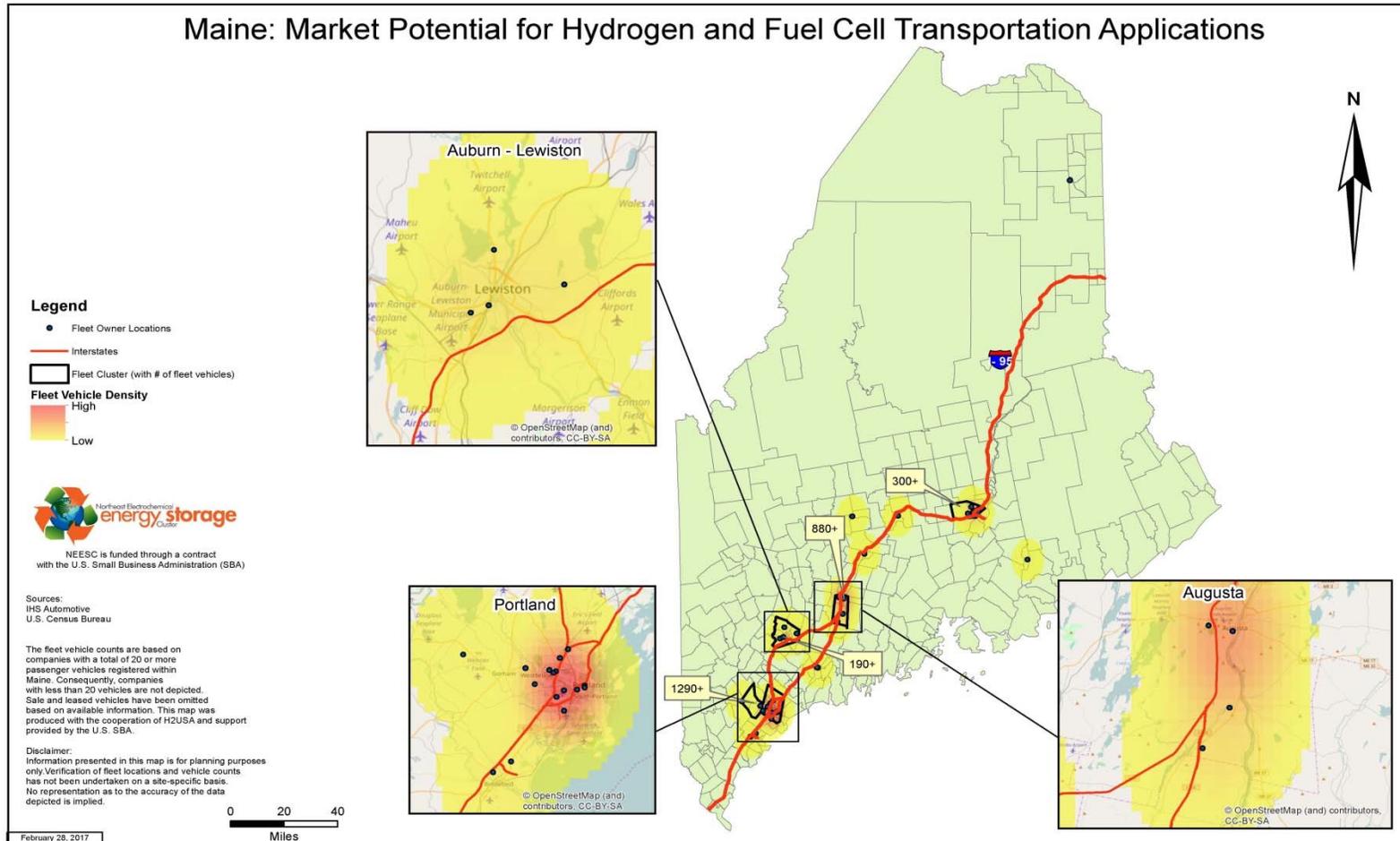
Regional Transportation Targets



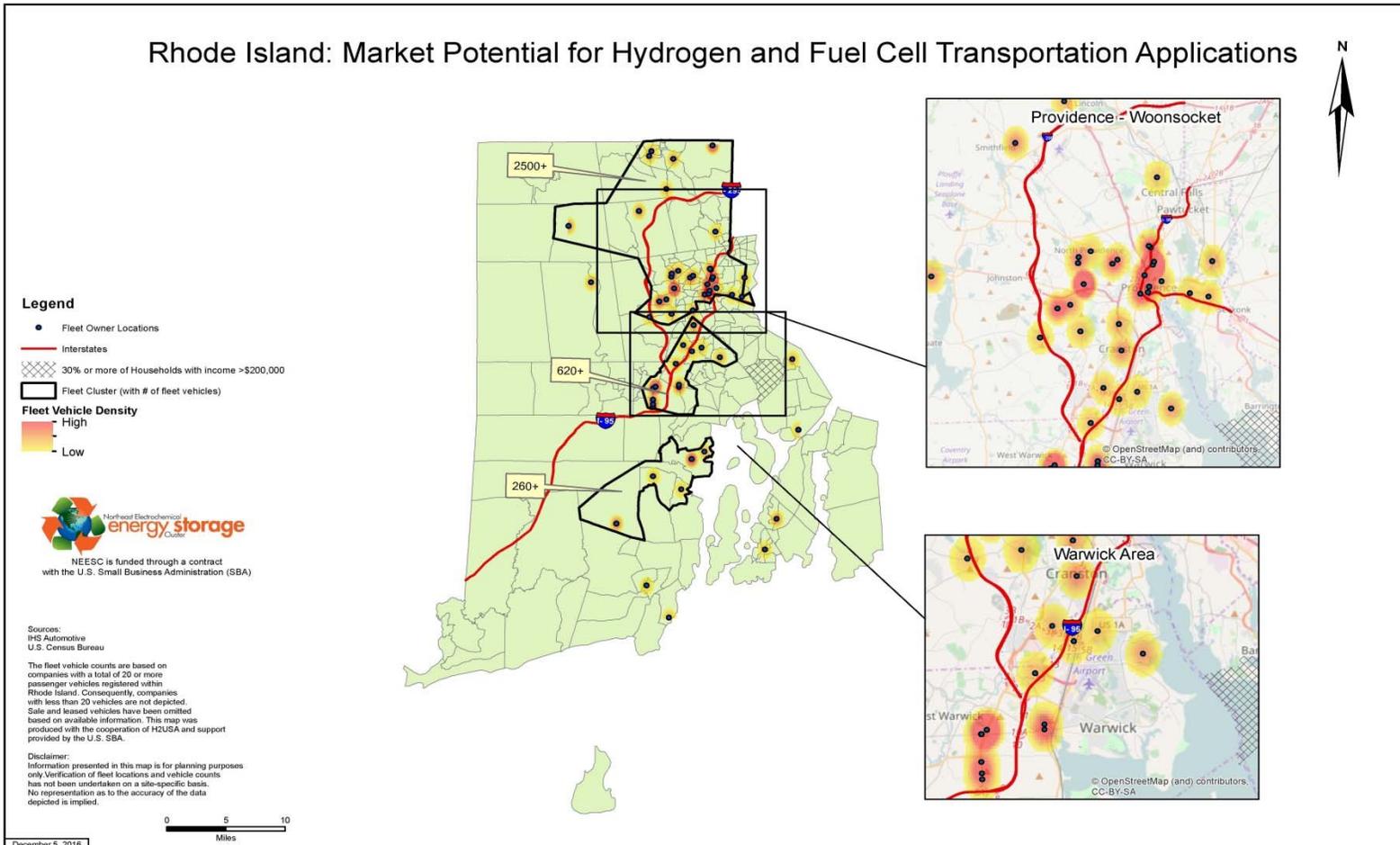
Regional Transportation Targets



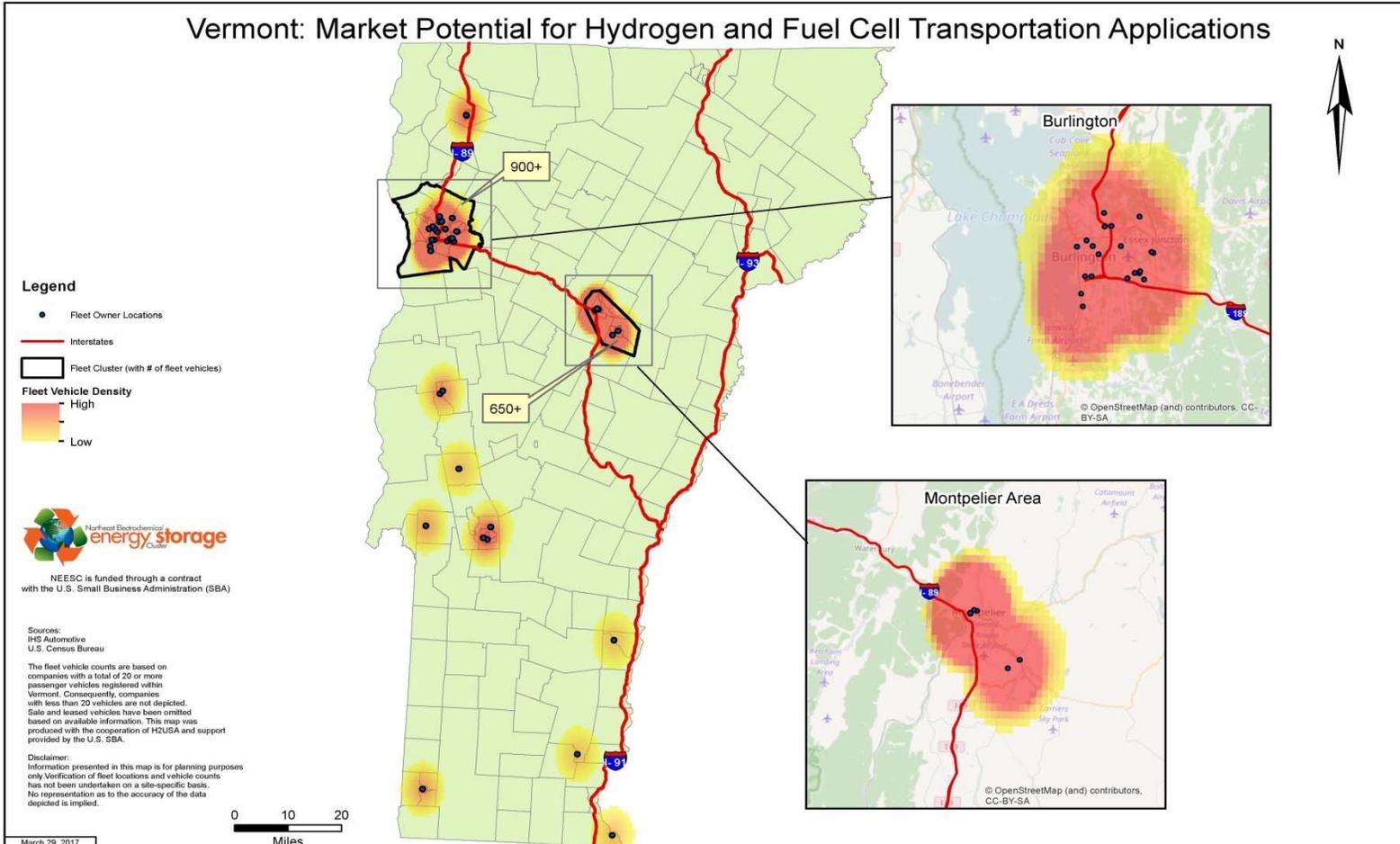
Regional Transportation Targets



Regional Transportation Targets



Regional Transportation Targets



Northeast Fleet Market Opportunities

Regional FCEV and Hydrogen Market Opportunities

State	Total Fleets			Fleet Deployment Goals				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)
 - 7,345 Passenger Vehicles
 - 676 State Passenger Vehicles
 - 728 transit/paratransit buses (FCEB)
- 74 to 89 hydrogen refueling stations



Action



Economy of Scale: Implementation of Roadmap Targets

VW Allocation (2.0L+3.0L)	Allocation for EVSE	CAPEX Application	Cost per Application	Quantity	Cost per state	Subsidy	Cost after Incentives	Cost per State	Cost After Subsidies	Subsidies	
\$55,721,170	15%	Connecticut	• Transit buses (FCEB)	\$1,000,000	43	\$43,000,000	85%	\$6,450,000	\$63,658,400	\$21,850,202	\$41,808,198
		• FCEV LDV State	\$15,800	48	\$758,400		\$758,400				
		• FCEV LDV Private	\$15,800	500	\$7,900,000	\$5,000	\$5,400,000				
		• H ₂ Fueling	\$2,000,000	6	\$12,000,000	23%	\$9,241,802				
\$21,053,064	15%	Maine	• Transit buses (FCEB)	\$1,000,000	7	\$7,000,000	85%	\$1,050,000	\$11,164,600	\$4,547,933	\$6,616,667
		• FCEV LDV State	\$15,800	70	\$1,106,000		\$1,106,000				
		• FCEV LDV Private	\$15,800	67	\$1,058,600		\$1,058,600				
		• H ₂ Fueling	\$2,000,000	1	\$2,000,000	33%	\$1,333,333				
\$75,064,424	15%	Massachusetts	• Transit buses (FCEB)	\$1,000,000	84	\$84,000,000	85%	\$12,600,000	\$111,003,400	\$34,082,711	\$76,920,689
		• FCEV LDV State	\$15,800	101	\$1,595,800		\$1,595,800				
		• FCEV LDV Private	\$15,800	722	\$11,407,600	\$2,500	\$9,602,600				
		• H ₂ Fueling	\$2,000,000	7	\$14,000,000	27%	\$10,284,311				
\$30,914,841	50%	New Hampshire	• Transit buses (FCEB)	\$1,000,000	5	\$5,000,000	85%	\$750,000	\$7,316,000	\$3,066,000	\$4,250,000
		• FCEV LDV State	\$15,800	20	\$316,000		\$316,000				
		• H ₂ Fueling	\$2,000,000	1	\$2,000,000	0%	\$2,000,000				
\$14,368,858	10%	Rhode Island	• Transit buses (FCEB)	\$1,000,000	14	\$14,000,000	85%	\$2,100,000	\$18,701,800	\$5,950,128	\$12,751,672
		• FCEV LDV State	\$15,800	20	\$316,000		\$316,000				
		• FCEV LDV Private	\$15,800	151	\$2,385,800	\$2,500	\$2,008,300				
		• H ₂ Fueling	\$2,000,000	1	\$2,000,000	24%	\$1,525,828				
\$18,692,130	15%	Vermont	• Transit buses (FCEB)	\$1,000,000	4	\$4,000,000	85%	\$600,000	\$7,453,600	\$3,386,934	\$4,066,666
		• FCEV LDV State	\$15,800	20	\$316,000		\$316,000				
		• FCEV LDV Private	\$15,800	72	\$1,137,600		\$1,137,600				
		• H ₂ Fueling	\$2,000,000	1	\$2,000,000	33%	\$1,333,334				
\$127,701,807	15%	New York	• Transit buses (FCEB)	\$1,000,000	349	\$349,000,000	85%	\$52,350,000	\$417,200,400	\$104,974,161	\$312,226,239
		• FCEV LDV State	\$15,800	187	\$2,954,600		\$2,954,600				
		• FCEV LDV Private	\$15,800	1851	\$29,245,800	\$5,000	\$19,990,800				
		• H ₂ Fueling	\$2,000,000	18	\$36,000,000	18%	\$29,678,761				
\$72,215,805	15%	New Jersey	• Transit buses (FCEB)	\$1,000,000	139	\$139,000,000	85%	\$20,850,000	\$252,065,600	\$130,340,918	\$121,724,682
		• FCEV LDV State	\$15,800	130	\$2,054,000		\$2,054,000				
		• FCEV LDV Private	\$15,800	3102	\$49,011,600		\$49,011,600				
		• H ₂ Fueling	\$2,000,000	31	\$62,000,000	6%	\$58,425,318				

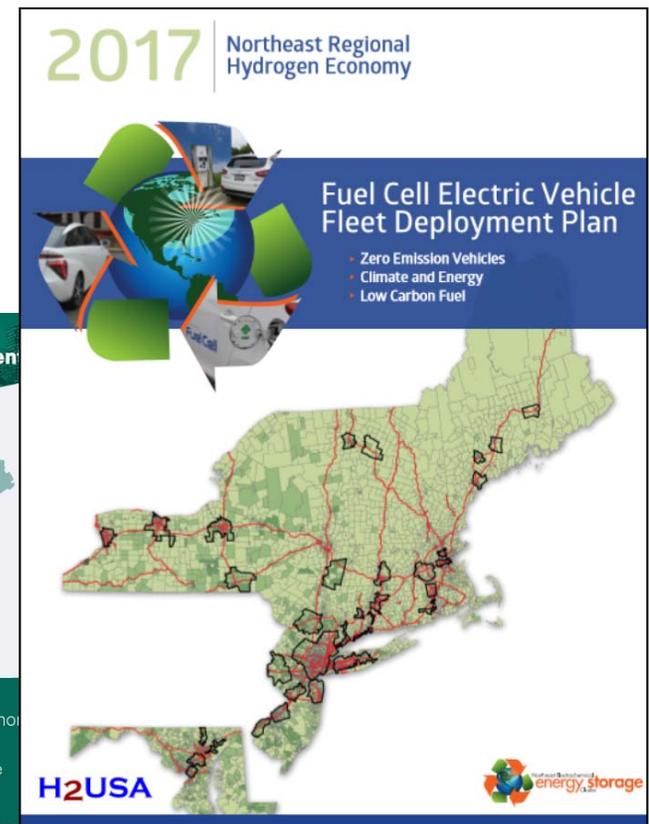
Market Planning: Roadmaps (Updated 2018)

- 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



Regional FCEV Deployment

- Consistent with goals of H2USA, NESCAUM, and the 8 State MOU Action Plan
- Developed for 9 states
 - Northeast states including Maryland
- ZEV Deployment Targets
 - Fleets, early market adopters, 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
- State Roadmaps (8 states)





Action



Implementation of Fleet Deployment Plan

Analysis

- Economic analyses/modeling for 2018 (state/regional engagement)
- Market projections and guidance (OEMs/DOE)
- Business Case Analysis for FCEBs, FCEVs and hydrogen fueling
- DOT alternative fuel corridor designation
- 8-State “ZEV” MOU (FCEV and H2 refueling)

Financing

- H₂ infrastructure (financing and development models)
- VW Settlement, FTA, EPA DERA, States’ resources

Coordination for Deployment (public/private partnership)

- State RFPs (State Roadmaps)
- Safety Reviews / Education and Awareness (Hydrogen Safety Panel)
- Regional Technical Exchange Centers

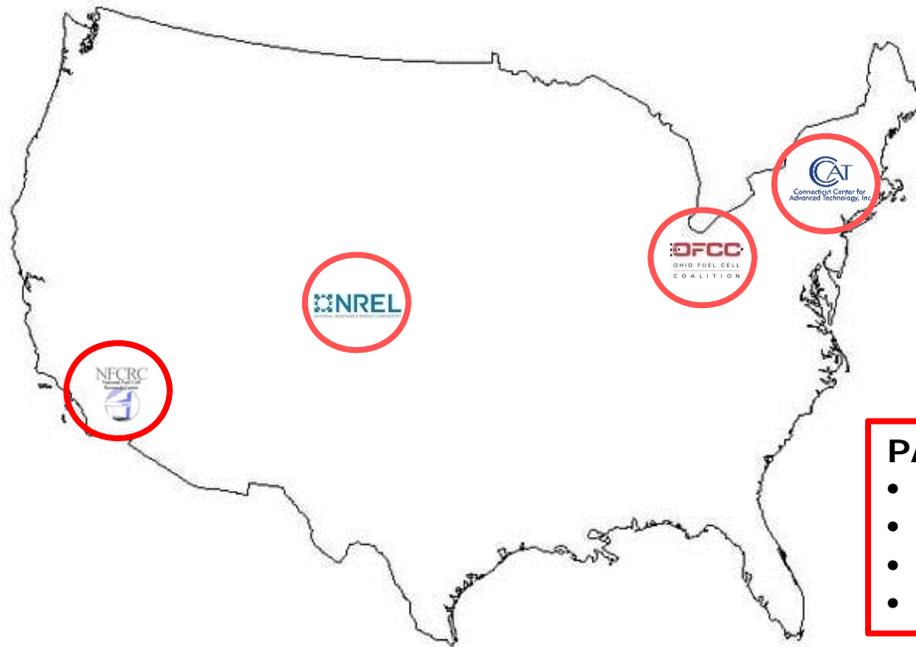
Hydrogen Safety Panel

- Safety reviews
- Safety guidance
- Project design and safety plans
- Safety knowledge and best practices
- Incident investigations



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 (NFRC) at UC Irvine
- Connecticut Center for Advanced Technology (CCAT)



Policy



States Transportation Policy Summary

State Energy Policy/Incentives for ZEV 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									
Time of Day Rates/Variable Peak Pricing									
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 Plan Market Potential									
	ME	NH	VT	MA	RI	CT	NY	NJ	MD
Stationary Fuel Cell (MW, low/high range)	87	74	58	250	52	170	1,131	214	
Transportation FCEV (near-term number of vehicles)	137	20	92	823	171	548	2,038	3,232	960
Transportation Fuel Cell Electric Bus (near-term number of vehicles)	7	5	4	84	14	43	349	139	83
Refueling Stations (low/high range)	1/2	1/2	1/2	7/9	1/2	6/7	18/23	31/34	8/10

Summary

- **Direction/Goals**
 - **Market/Target**
 - **Action/Implementation**
 - **Policy/Incentives**
 - **Results/Public Value**
-
- 16+ stations planned/existing in the Northeast US





Joel M. Rinebold
Connecticut Center for Advanced Technology
jrinebold@ccat.us
(860) 291-8832
www.ccat.us