

# *The Connecticut Hydrogen Economy*



***P.I. - Joel M. Rinebold***

***Connecticut Center for Advanced Technology, Inc.***

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Stationary  
Heat &  
Power



Hydrogen  
Economy



Portable  
Power



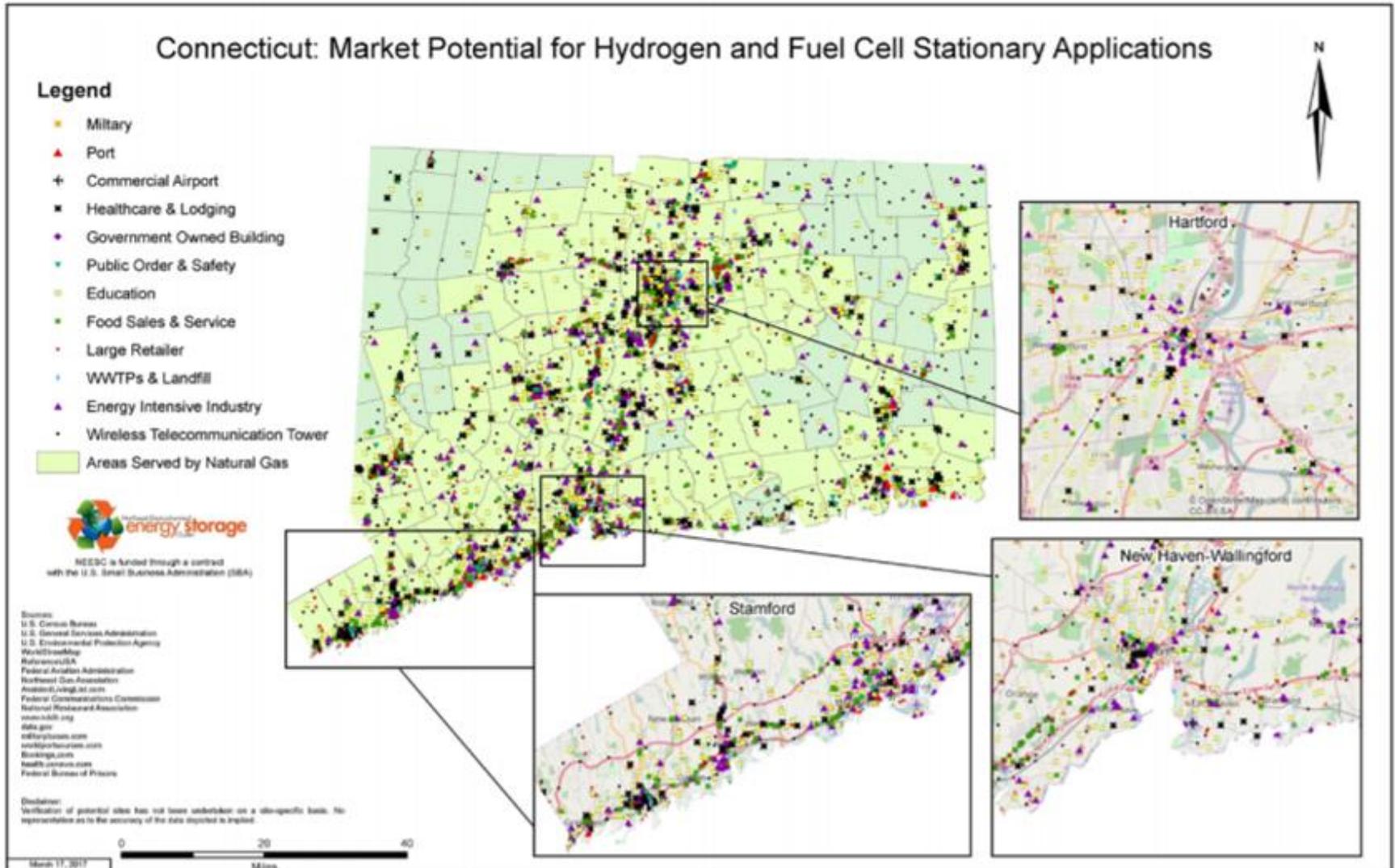
Motive  
Power



## Hydrogen Economy Objectives and Purpose

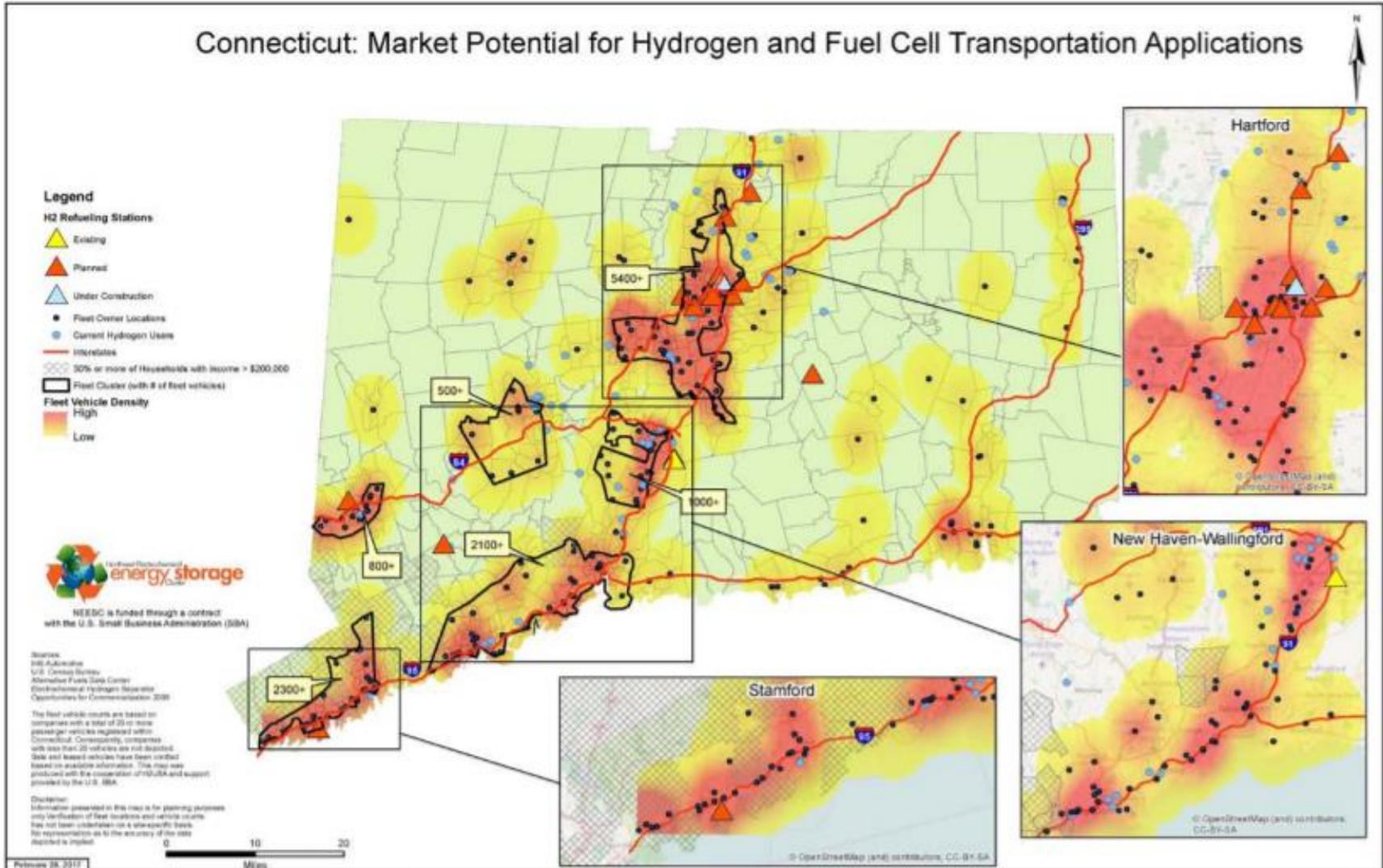
- Low/Zero Emission
  - Life Support, air, water, climate
- Reliable Energy
  - Resiliency, sustainability, adaptively
- Economic Development (Jobs)
  - C&I macroeconomics

# CONNECTICUT



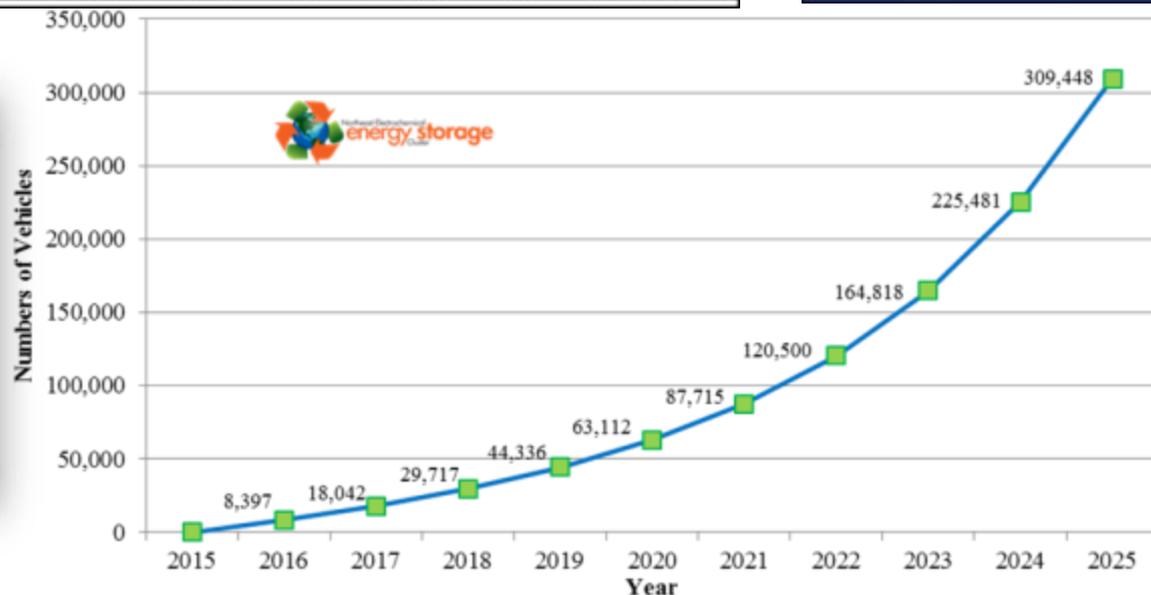
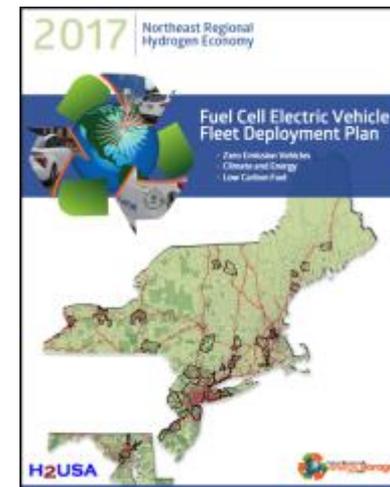
**CONNECTICUT**

Connecticut: Market Potential for Hydrogen and Fuel Cell Transportation Applications



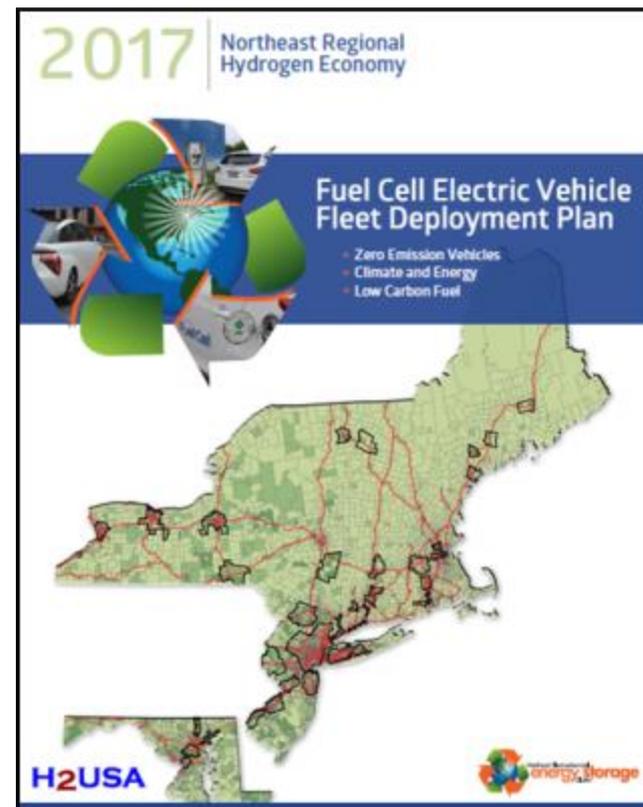
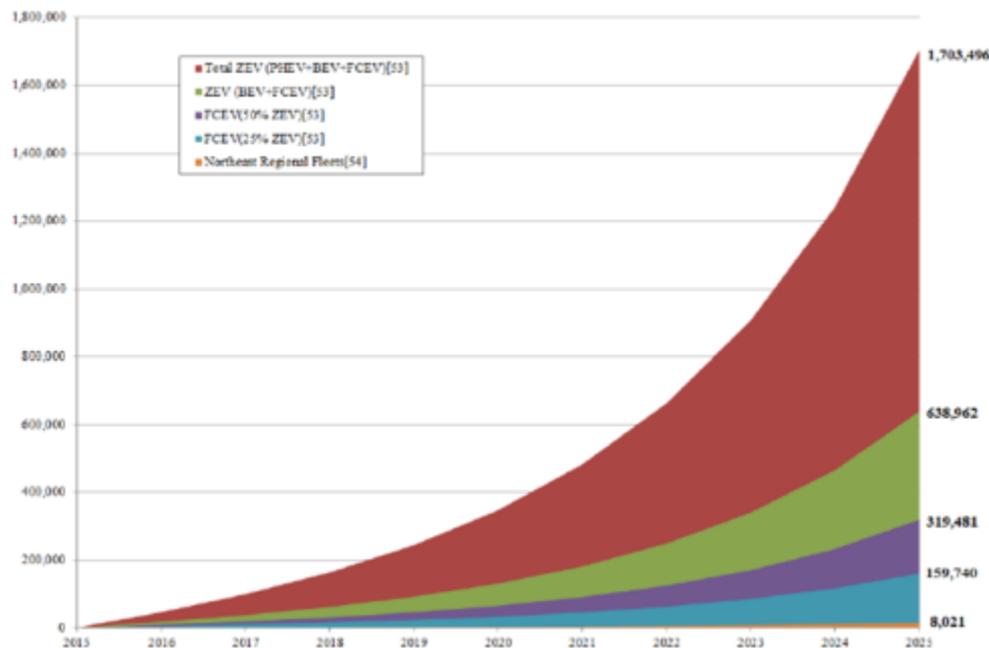
## Initial FCEV Deployment

	Eight (8) State MOU			Projections for FCEVs per each MOU State <sup>63</sup>							
	Total ZEV Sale Requirements	Total FCEV/BEV Sales Requirements	FCEV <sup>64</sup>	CA	CT	MA	NY	RI	VT	OR	MD
2015	0	0	0	0	0	0	0	0	0	0	0
2016	89,543	33,587	8,397	3,595	545	1,008	1,860	167	91	467	662
2017	192,402	72,168	18,042	7,725	1,172	2,167	3,998	360	195	1,003	1,423
2018	316,902	118,866	29,717	12,724	1,930	3,569	6,584	592	321	1,652	2,344
2019	472,806	177,344	44,336	18,984	2,879	5,325	9,824	883	479	2,465	3,497
2020	673,031	252,446	63,112	27,023	4,099	7,580	13,984	1,258	682	3,509	4,977
2021	935,407	350,860	87,715	37,558	5,696	10,535	19,435	1,748	948	4,878	6,918
2022	1,285,032	482,001	120,500	51,596	7,826	14,472	26,699	2,401	1,302	6,701	9,503
2023	1,757,645	659,272	164,818	70,572	10,704	19,795	36,519	3,284	1,781	9,165	12,998
2024	2,404,566	901,925	225,481	96,547	14,643	27,081	49,960	4,493	2,436	12,538	17,782
2025	<b>3,300,000<sup>65</sup></b>	<b>1,237,792<sup>66, 67</sup></b>	<b>309,448</b>	<b>132,500</b>	<b>20,096</b>	<b>37,165</b>	<b>68,565</b>	<b>6,166</b>	<b>3,344</b>	<b>17,208</b>	<b>24,404</b>



## VT, RI, CT, NY, NJ, MA, MD

Year	Total ZEV (PHEV+BEV+FCEV)	ZEV (BEV+FCEV)	FCEV (50% ZEV)	FCEV (25% ZEV)	Northeast Regional Fleets
2017	99,320	37,254	18,627	9,313	468
2018	163,588	61,360	30,680	15,340	770
2019	244,068	91,547	45,773	22,887	1,149
2020	347,426	130,315	65,158	32,579	1,636
2021	482,867	181,118	90,559	45,279	2,274
2022	663,346	248,814	124,407	62,203	3,123
2023	907,315	340,323	170,162	85,081	4,272
2024	1,241,263	465,584	232,792	116,396	5,845
2025	1,703,496	638,962	319,481	159,740	8,021



## CONNECTICUT

			Potential Sites			
Category	Total Sites	Potential Sites	FCs < 400 kW (#)	FCs >400 kW (#)	FCs >1,000 kW (#)	
<b>Stationary Targets</b>						
CBECS Data	Education	1,255	54	14	29	11
	Food Sales/Services	9,470	857	823	28	6
	Healthcare & Lodging	622	51	10	20	21
	Retail	4,123	23	12	10	1
	Public Order & Safety	1,038	62	24	14	24
	Energy Intensive Industries	1,170	34	15	15	4
	GSA Operated Buildings	85	7	7	0	0
	Wireless Telecommunication Towers	301	31	31	0	0
	WWTPs & Landfills	59	5	2	2	1
	Commercial Airports, Military, and Ports	155	15	8	5	2
	<b>Total Stationary</b>	<b>18,278</b>	<b>1,139</b>	<b>946</b>	<b>123</b>	<b>70</b>

Category	Total Units	Potential Target	Emissions (Metric Tons/Year)	
			CO2	NOx
<b>Transportation Targets</b>				
FCEVs	11,725	548	1,501.52	3.45
Transit Buses	921	43	3,543.63	1.76
Retail Refueling Station	2,305	6 - 7	NA	NA

**Stationary Goals:** 170 MW at 1,139 potential locations

**Transportation Goals:** 591 FCEVs (548 vehicles, 43 buses)

**Refueling Goals:** 6 – 7 Stations

## CONNECTICUT

	CT Economic Indicators
OEMs	10
Supply Chain Members	611
Direct Jobs	983
Total Rev & Investment (\$M)	\$601
Total Jobs	2,834
Total Labor Income (\$M)	\$287

- Industry projected to grow
- Major contributor in state economic vitality
- Hub of the Northeast region
- Has an estimated impact of \$601 million in revenue and investment and \$287 million in labor income in 2016
- Ranked third for US fuel cell patents for the period from 2002 to 2015
- Occupies approximately 30 percent of the nation's stationary fuel cell jobs

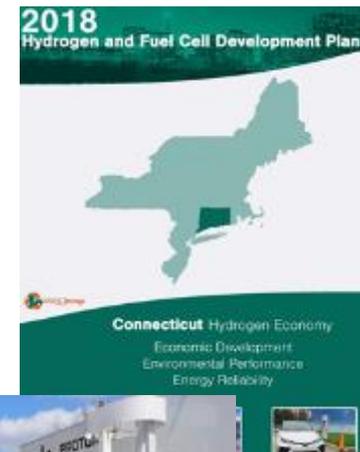
## CONNECTICUT

	Status
H2 and Fuel Cell Plans updated for all NE states	X
Bridges and Tunnels Issues Resolved in CT	X
Coordination with CT DEEP for H2 Station Development with EV Plan	X
State Procurement of 52+ MW of FC (100+ MW Installed/approved in CT)	X
H2 + FC Technologies included in CT's VW Mitigation Plan	X
Hydrogen Safety Workshops/Meetings Held to Facilitate Deployment (CT, NY, RI, NJ, MA)	X
H2@Scale Engagement (Economy of Scale)	X
DOT Corridor Designation	X



## CONNECTICUT

	Status
Hydrogen and Fuel Cell Development Plans	May 24
Hydrogen Fueling Stations: A Business Case for Clean Transportation in Connecticut	May 7
Fuel Cell Distributed Generation: Cost, Value, and Market Potential	May 1
Fuel Cell Electric Vehicles: A Business Case for Clean Transportation in Connecticut	Jan 30
Fuel Cell Electric Buses: A Business Case for Clean Transportation in Connecticut	Jan 23
Commercialization of Fuel Cell Electric Material Handling Equipment	Jan 4



# CONNECTICUT

Connect Synergistic Users with GIS Planning Tool

Procurement of Lead By Example Fleets in CT

Coordination of Transit and Light Duty H2 Stations

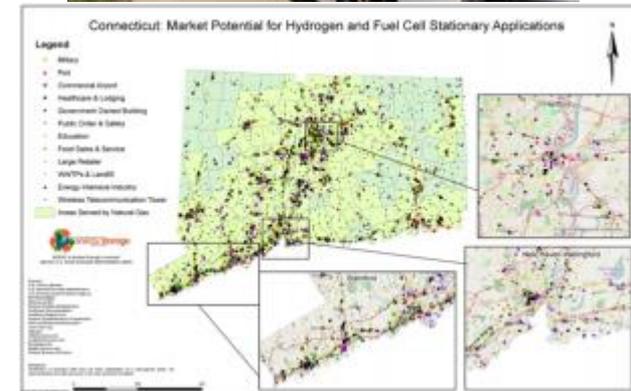
Increase Engagement from CT DOT / Transit Agencies

Leverage VW Funds

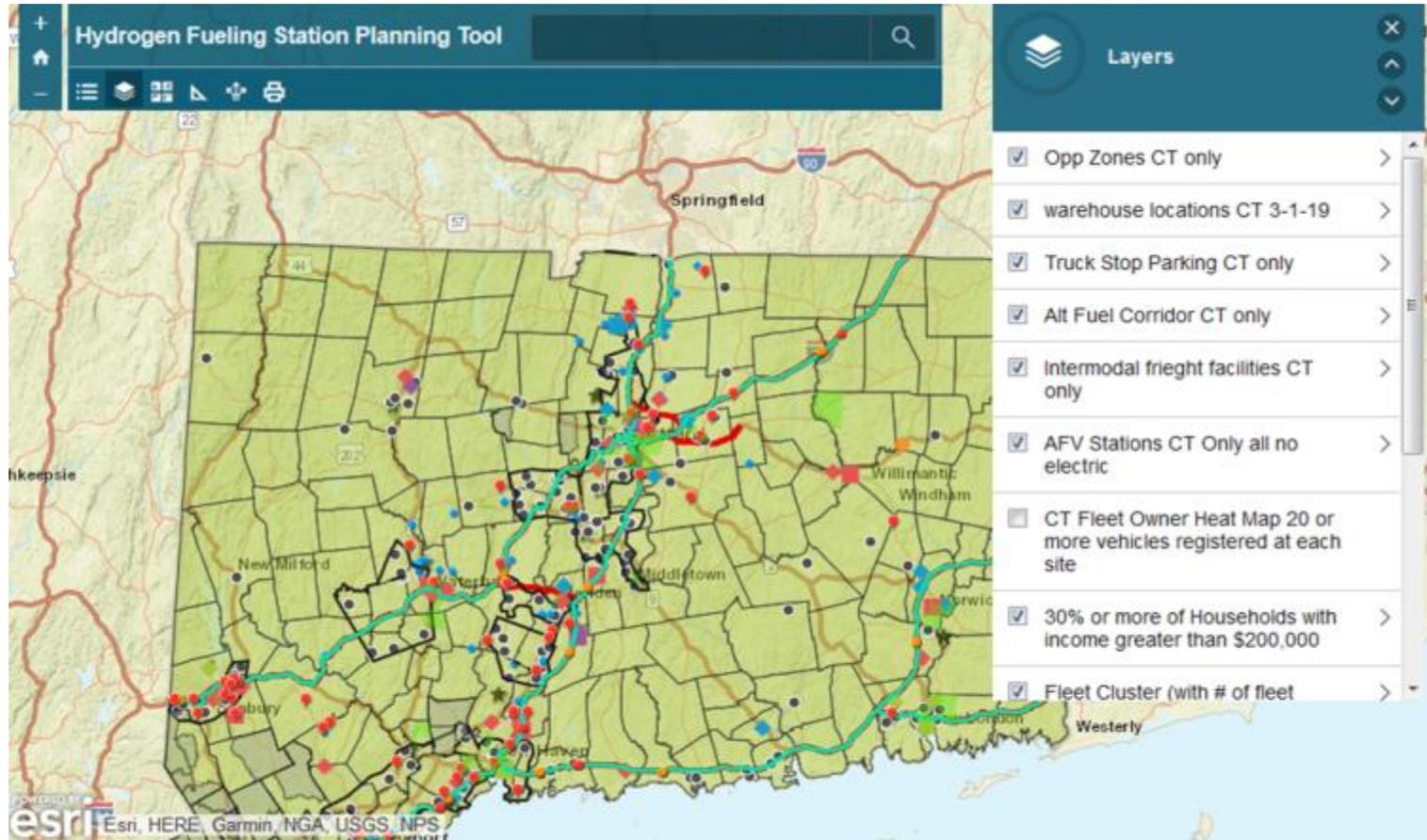
Engage Utilities for Grid management and Resiliency

Expand Electrochemical Technologies for Energy Storage

Use RPS, LREC, and Tariffs for Fuel Cell Deployment



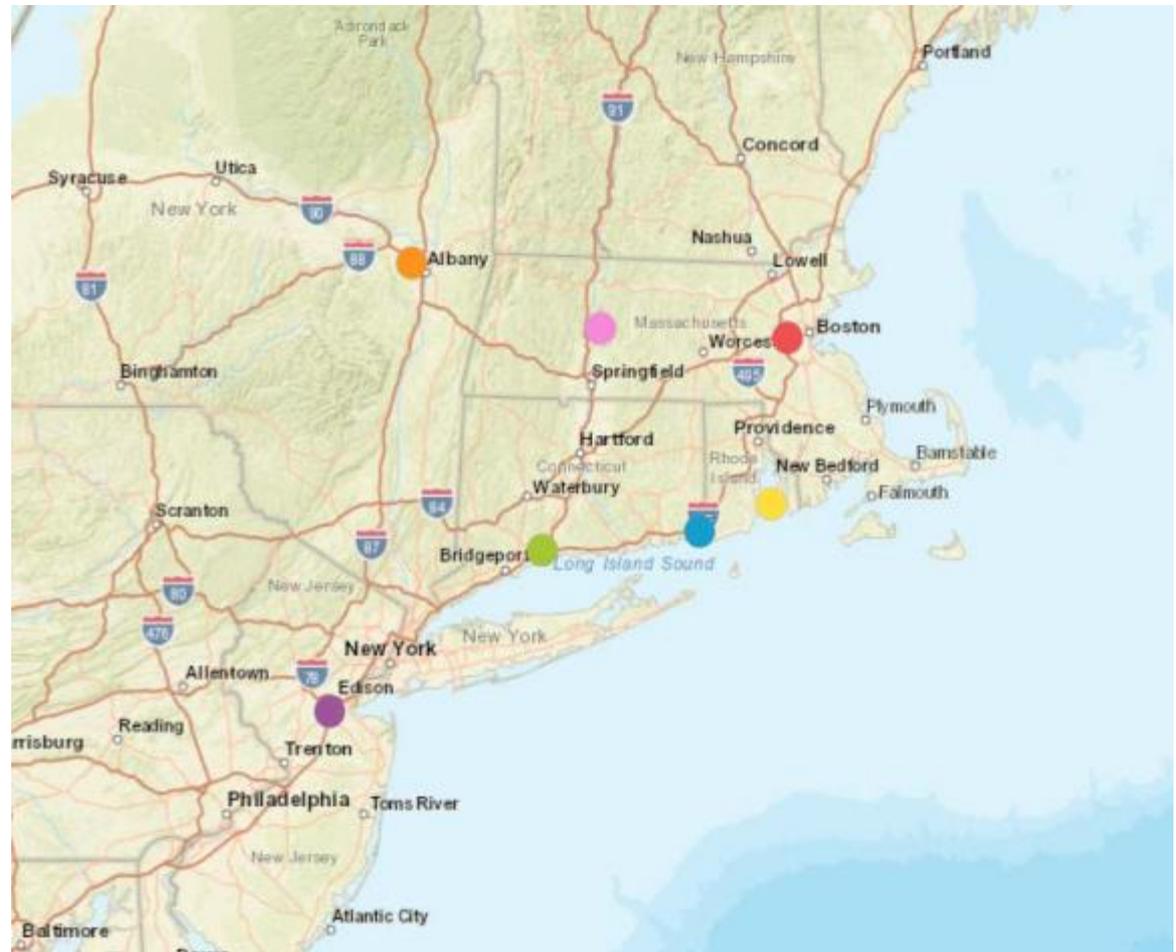
## Hydrogen Fueling Station Planning



For planning purposes only. Confirmation of site specific characteristics for projects has not been completed.

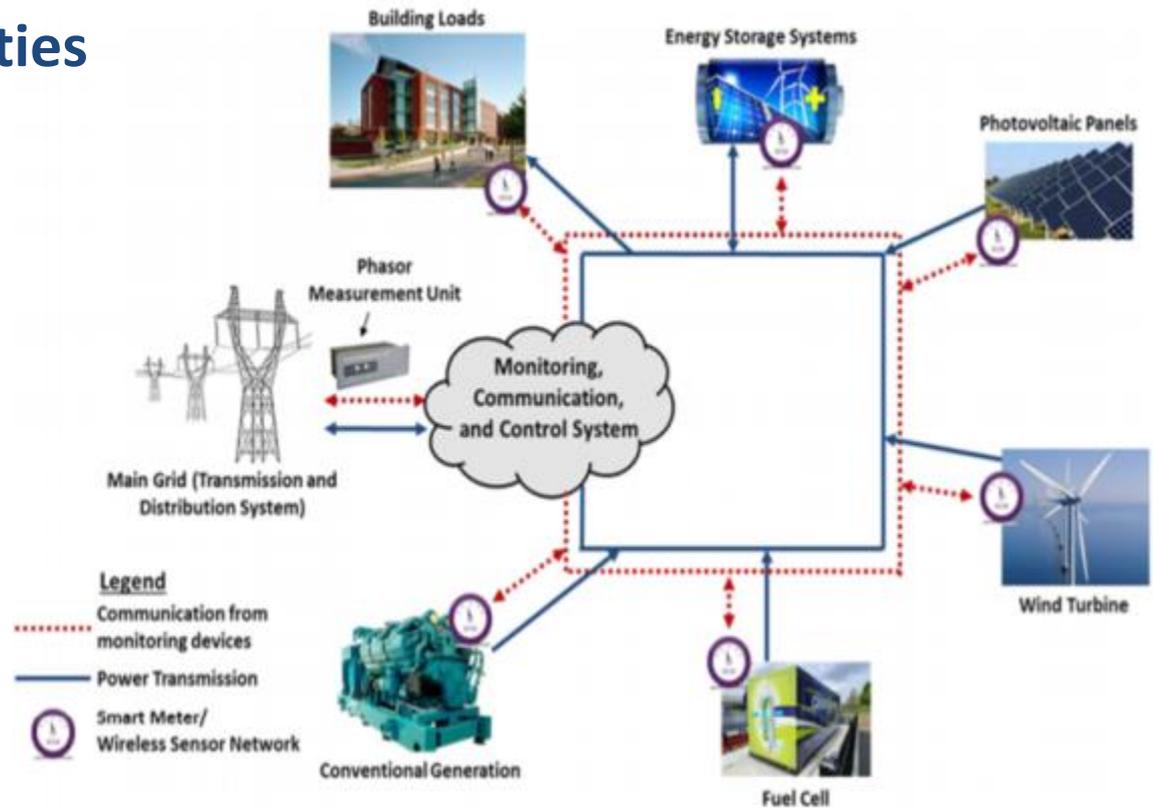
# H<sub>2</sub> Safety Panel Meetings

- MA Stakeholders
- NE Fire Marshals
- NH Fire Training Academy
- NJFCC
- NY Stakeholders
- RI DOD Training
- UMass



## Smart / Connected Cities

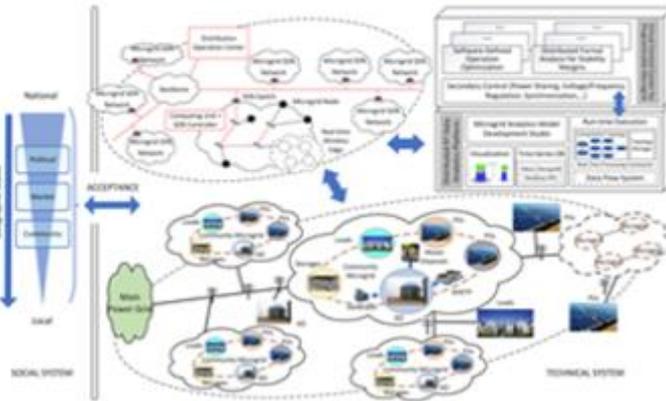
- Microgrids
- Energy Parks
- H2 Refueling
- Smart Cities
- Grid Integration
- Transit Integration



# SMART AND CONNECTED COMMUNITIES

SCC: Empowering Smart and Connected Communities through Programmable Community Microgrids  
NSF Award 1831811, Peng Zhang, Peter Luh, Joel Rinebold, Baikun Li, Amir Herzberg, Fei Miao, Mark Wick, Erin Steward

## Project Aims & integrative research approach

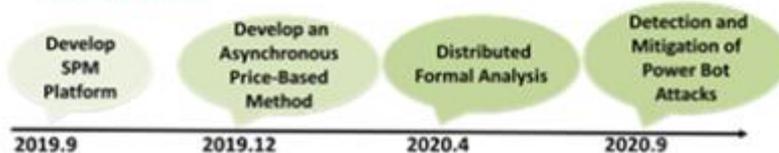


- ❖ Architect a Programmable Microgrid
- ❖ Pioneer a Concept of "Software-Defined Operation Optimization" for Microgrids
- ❖ Devise Software-Defined Distributed Formal Analysis

## Community engagement

- ❖ Community Leadership Engagement and Integration of Leadership Management for Information, Energy, and System Control
- ❖ Leveraging of Government and Private Investments for Development of the Energy Innovation Park

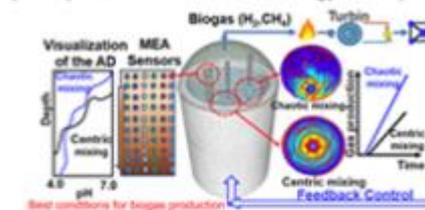
## What's next



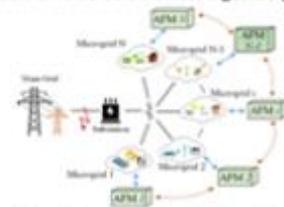
## Status of the Project



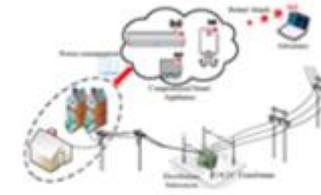
Smart Programmable Microgrid (SPM) Platform  
(Built upon \$1.5 million Eversource Energy Testbed)



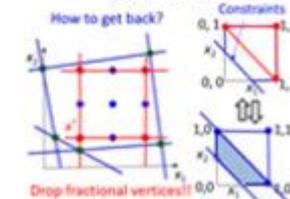
Visualization of Anaerobic Biomass digesters (AD)



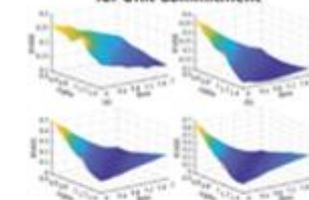
A Real-Time Distributed Active Fault Management (AFM)



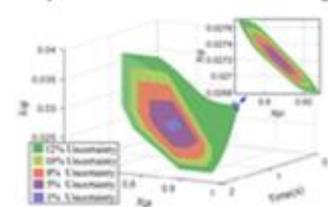
Securing Power Distribution Grid Against Power Botnet Attacks



A Systematic Formulation Approach for Unit Commitment



Cyberattack Resilient Load Forecasting



Distributed Formal Analysis for Networked Microgrids

## Support and Funding provided by:

- State of CT Dept of Economic and Community Development – Hydrogen Economy Program
- State of CT Dept of Energy and Environmental Protection – EV Connecticut Hydrogen Refueling Infrastructure Development (H2Fuels) Program
- CT Hydrogen and Fuel Cell Businesses
- US Small Business Administration
- Pacific Northwest National Lab / DOE CRADA
- UConn / National Science Foundation – Smart and Connected Communities

# Questions?

Joel M. Rinebold

*Connecticut Center for Advanced Technology Inc.*

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

(860) 291-8832

[www.ccat.us](http://www.ccat.us)