

# *The Connecticut Hydrogen Economy*



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

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Stationary  
Heat &  
Power



Hydrogen  
Economy



Portable  
Power

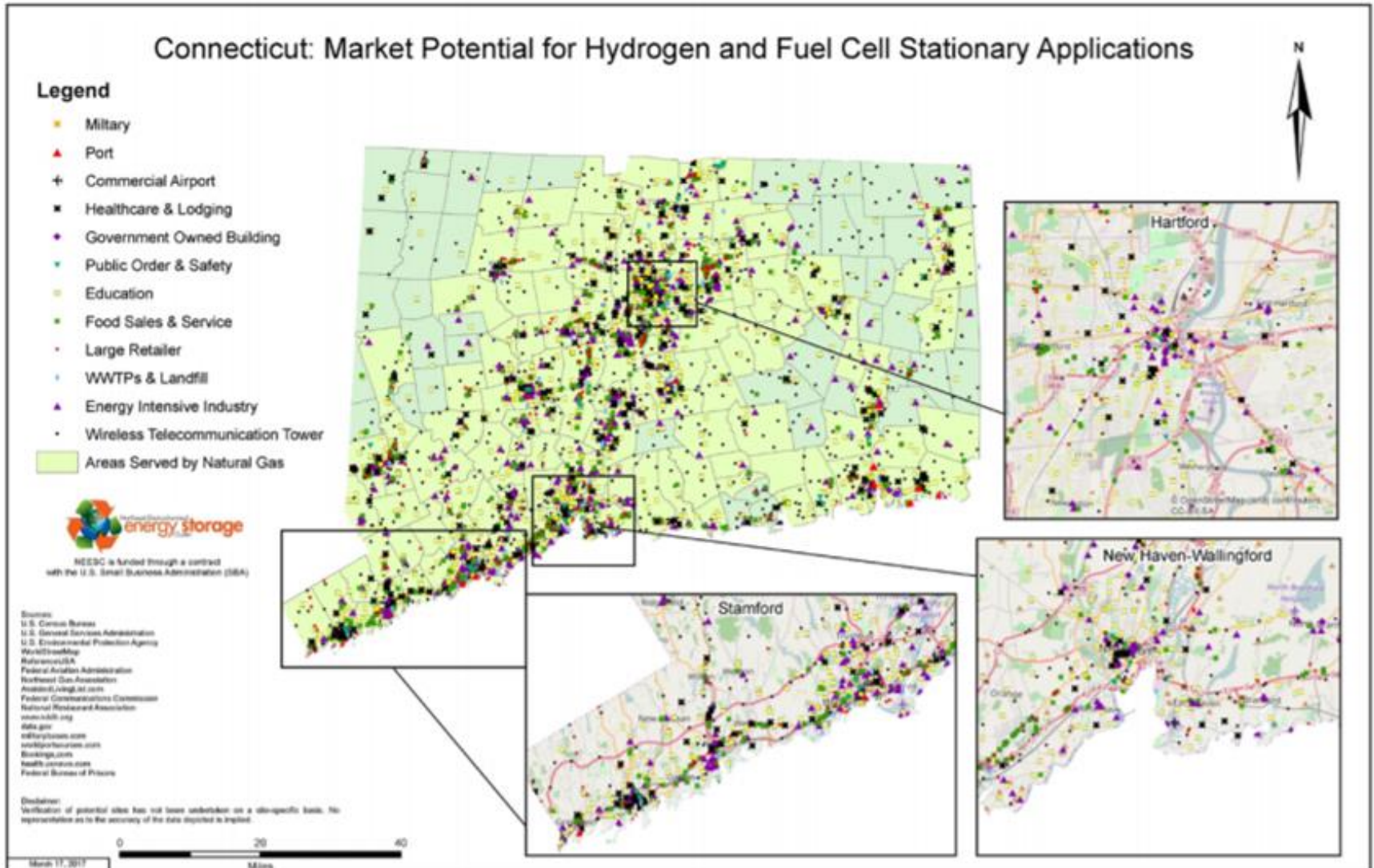
Motive  
Power



## Hydrogen Economy Objectives and Purpose

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

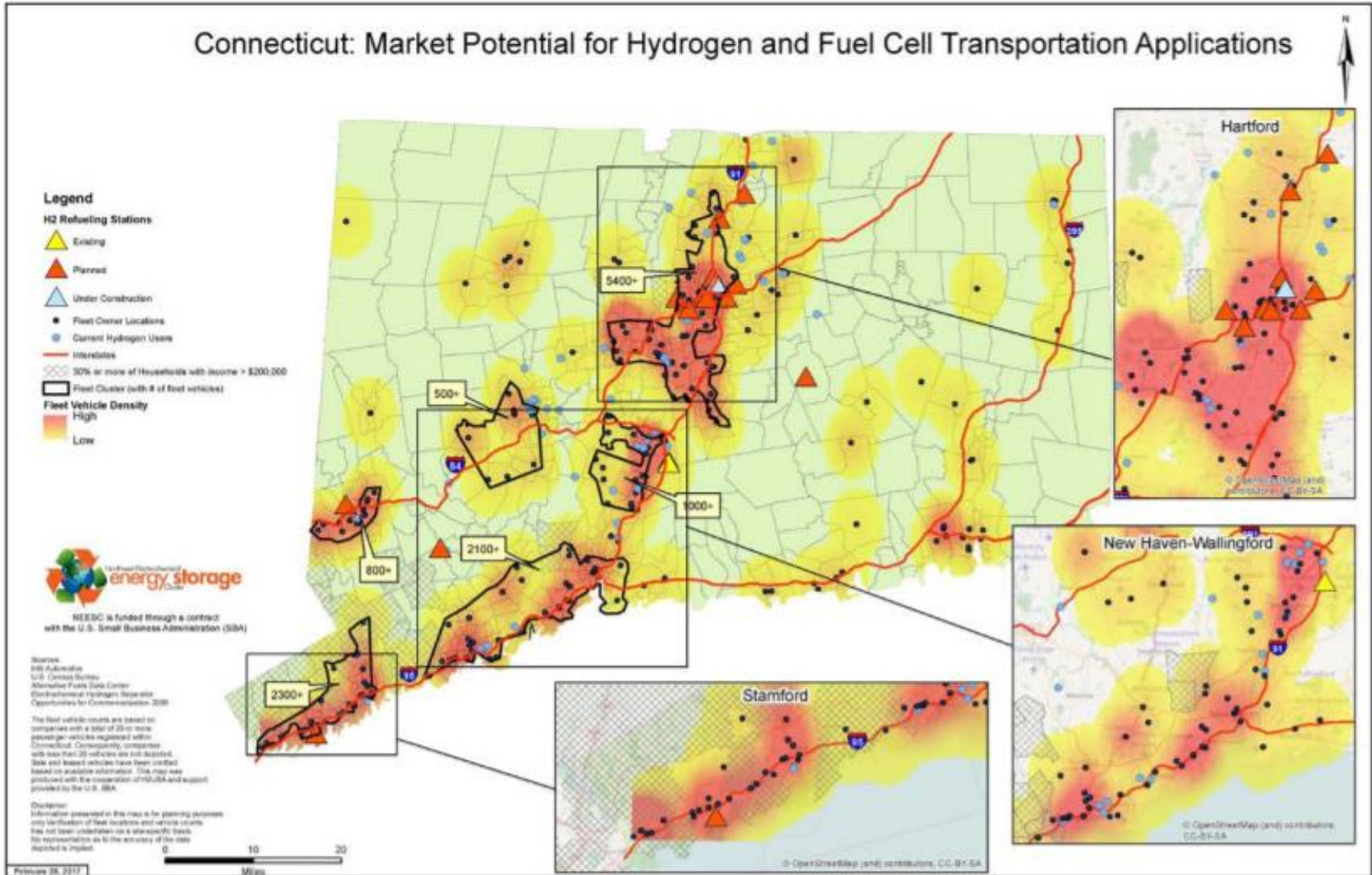
# CONNECTICUT





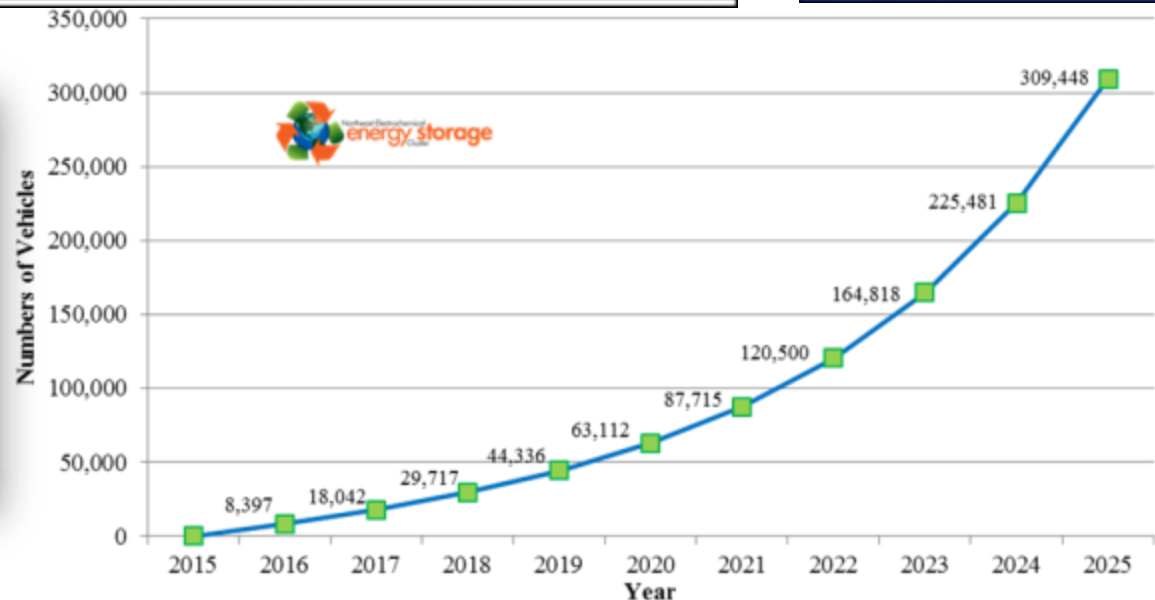
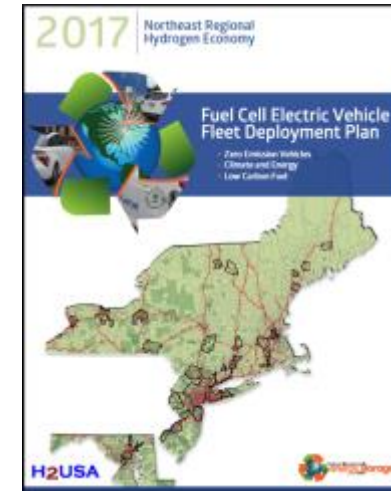
**CONNECTICUT**

Connecticut: Market Potential for Hydrogen and Fuel Cell Transportation Applications



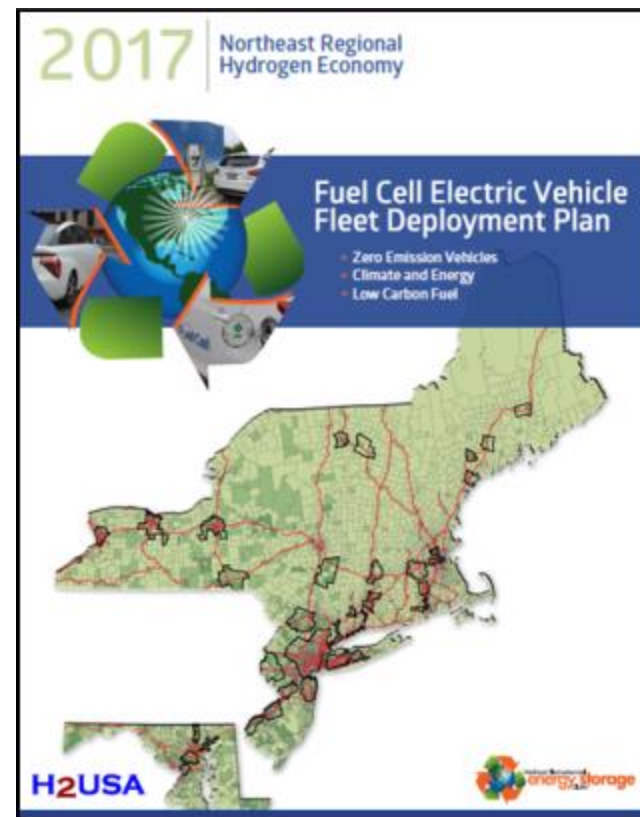
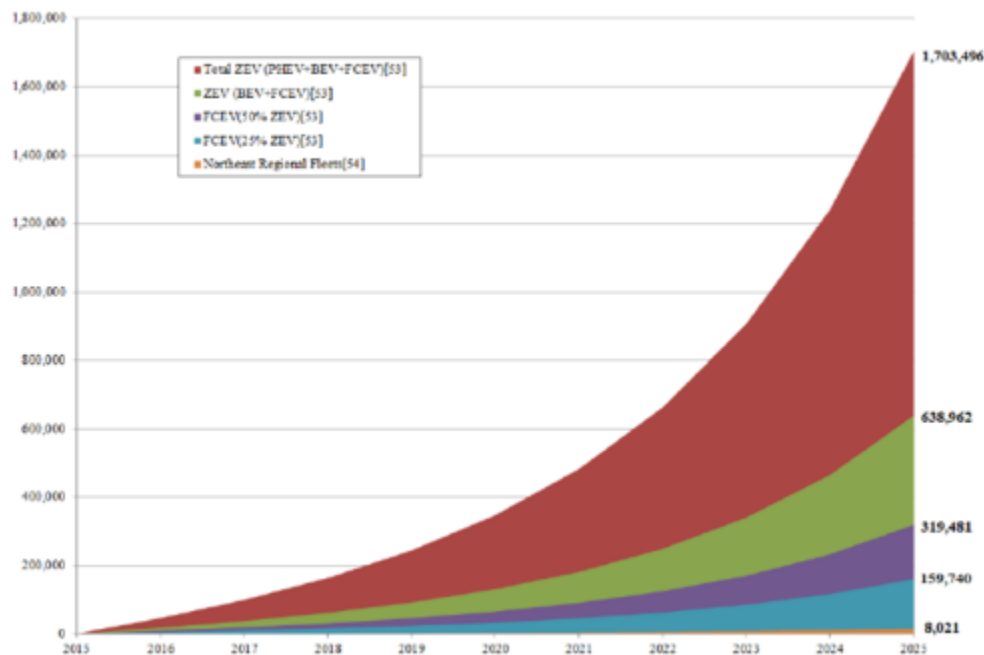
## Initial FCEV Deployment

|      | 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                     |





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|                           |  |                 | 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

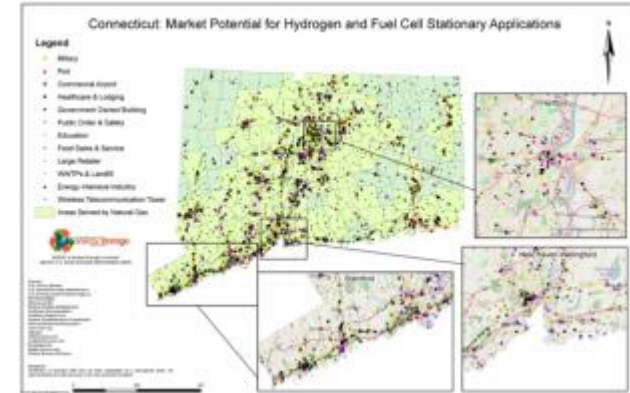
Increase Engagement from CT DOT / Transit Agencies

Leverage VW Funds

Engage Utilities for Grid management and Resiliency

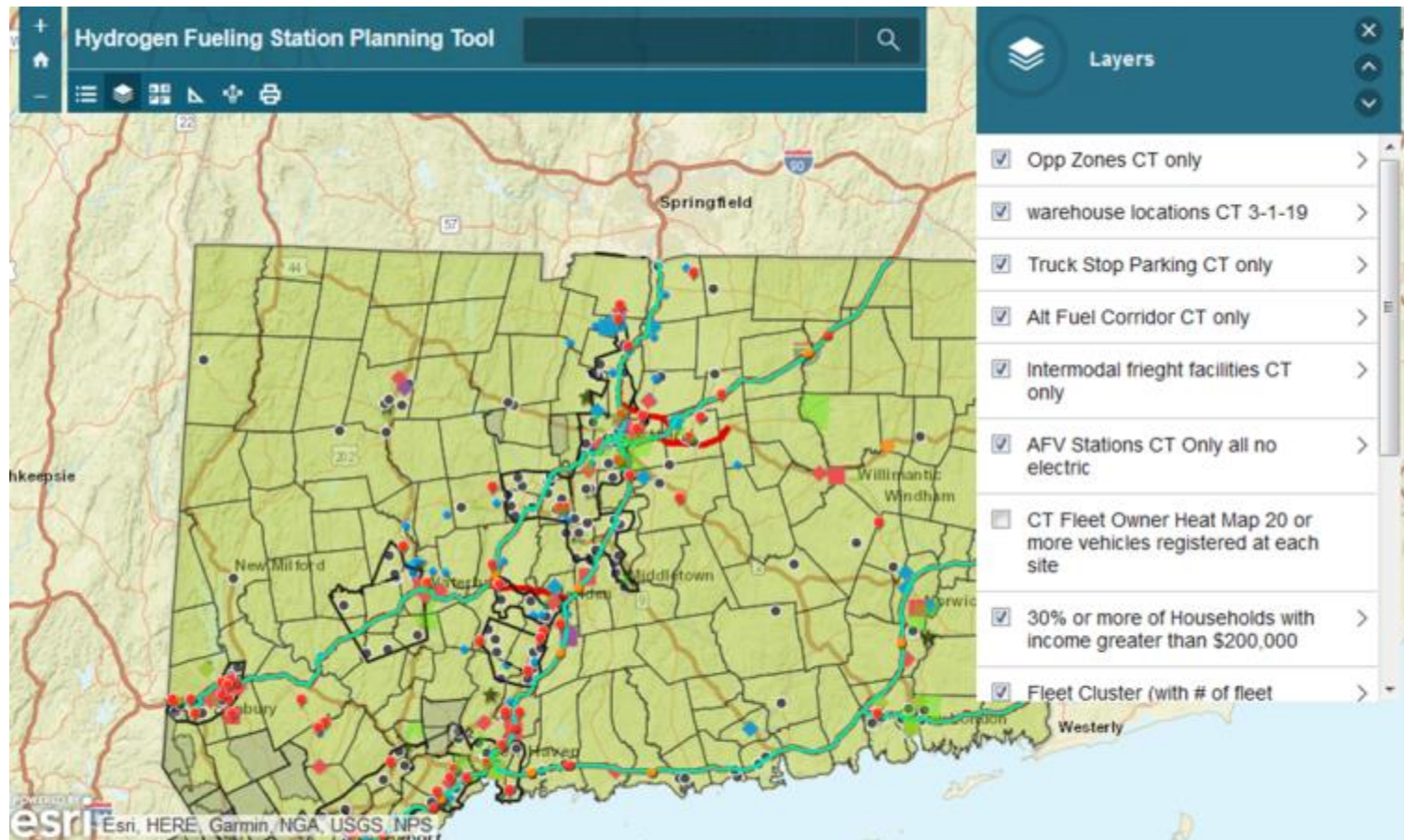
Expand Electrochemical Technologies for Energy Storage

Use RPS, LREC, and Tariffs for Fuel Cell Deployment





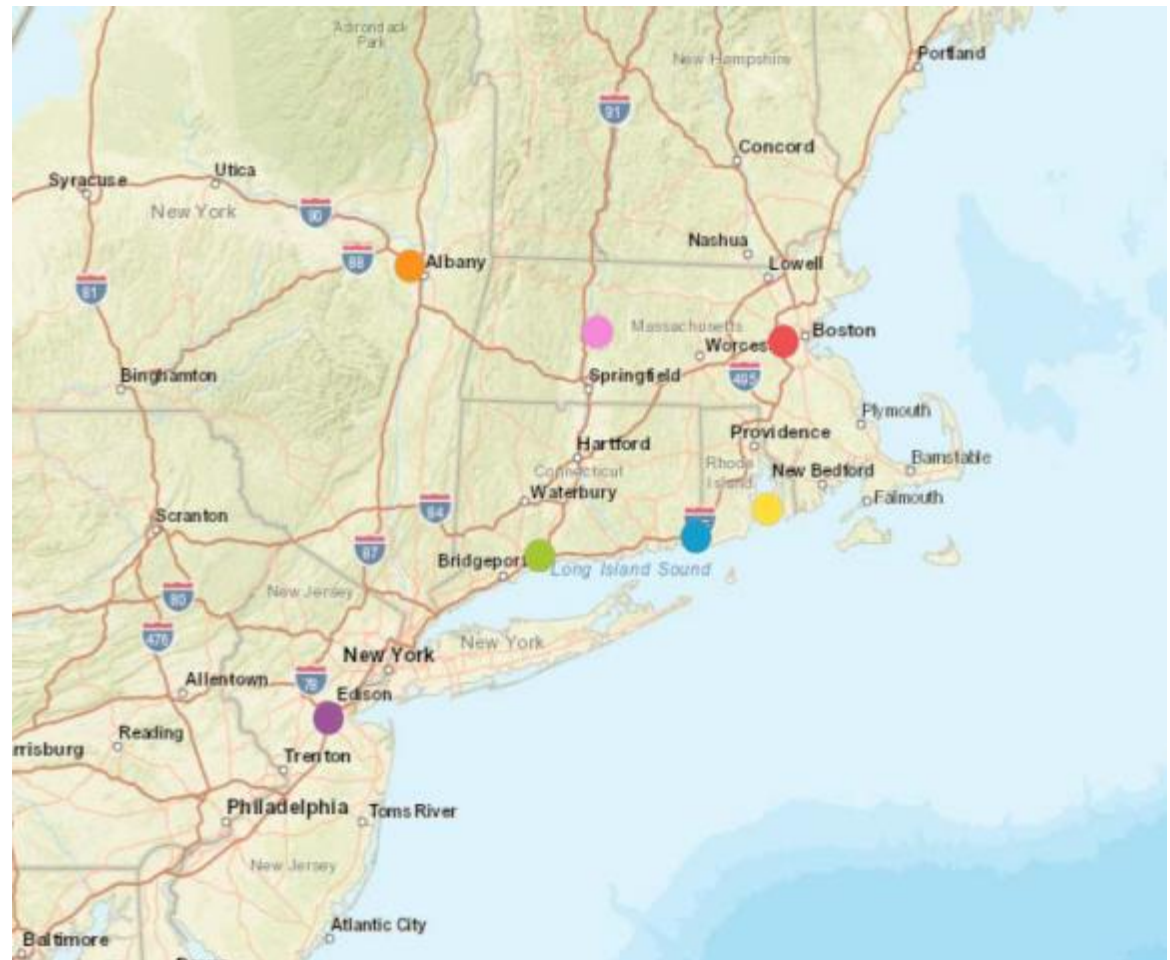
## Hydrogen Fueling Station Planning



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

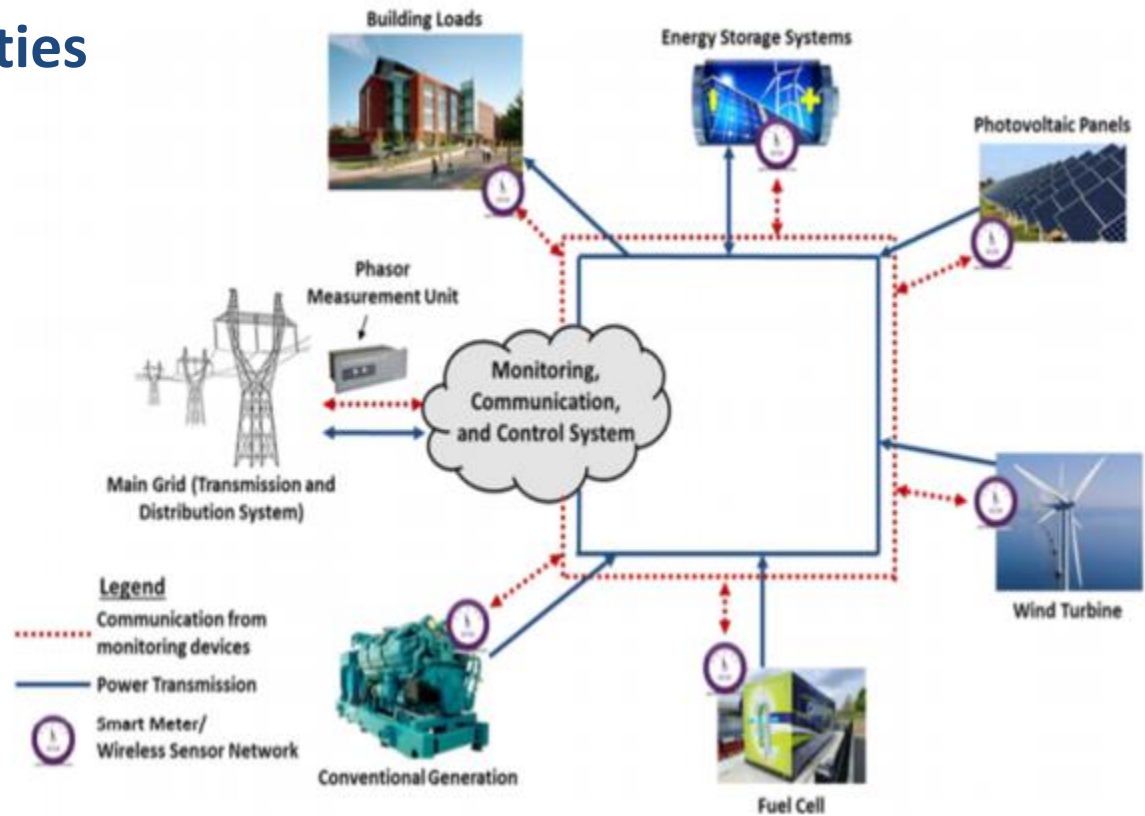
# H<sub>2</sub> Safety Panel Meetings

- 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

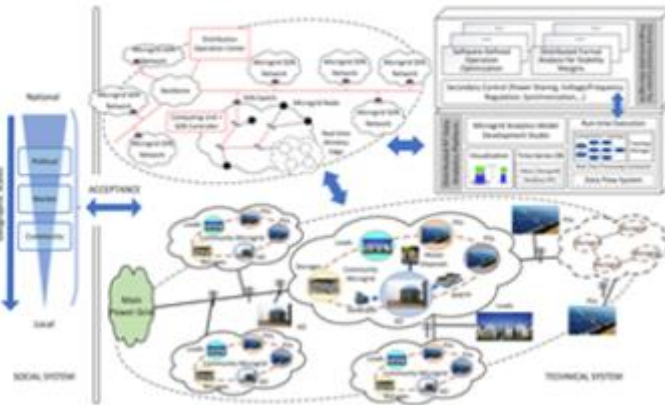




# SMART AND CONNECTED COMMUNITIES

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

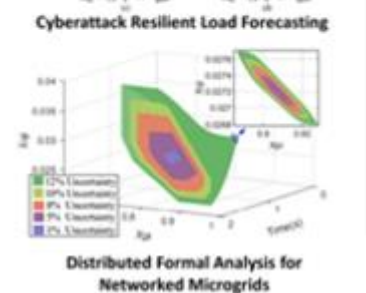
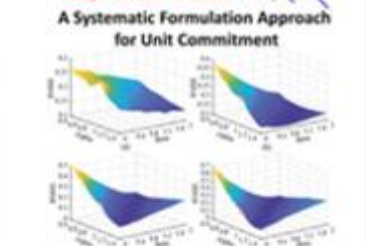
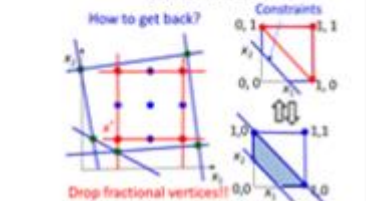
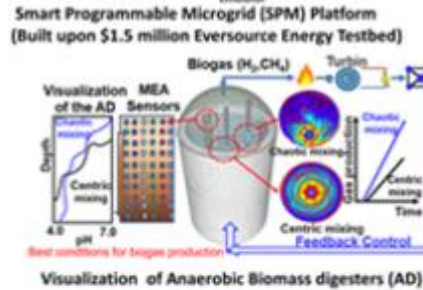
## Community engagement

- ❖ 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





## 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?

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