State and Local Government Partnership

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Connecticut Center for
Advanced Technology, Inc.
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PROJECT ID#: ED012

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

OVERVIEW

Timeline

- Start – Sept. 2008
- Extension – Sept. 2010
- Finish – Dec. 2011*
- 100% Complete

Budget

- Total project funding
  - DOE share - $295,548
- Funding received since contract
  - $295,548
- Co-funding through US SBA for deployment of "Roadmap" materials

Barriers

- **Barriers**

  > A. Lack of Readily Available, Objective, and Technically Accurate Information for Decision Makers for Specific Applications

  > B. Disconnect Between Hydrogen Information and State and Local Planning Initiatives

  > C. Lack of Technical Models to Rapidly Assess Costs and Values for Facility Development

Partners

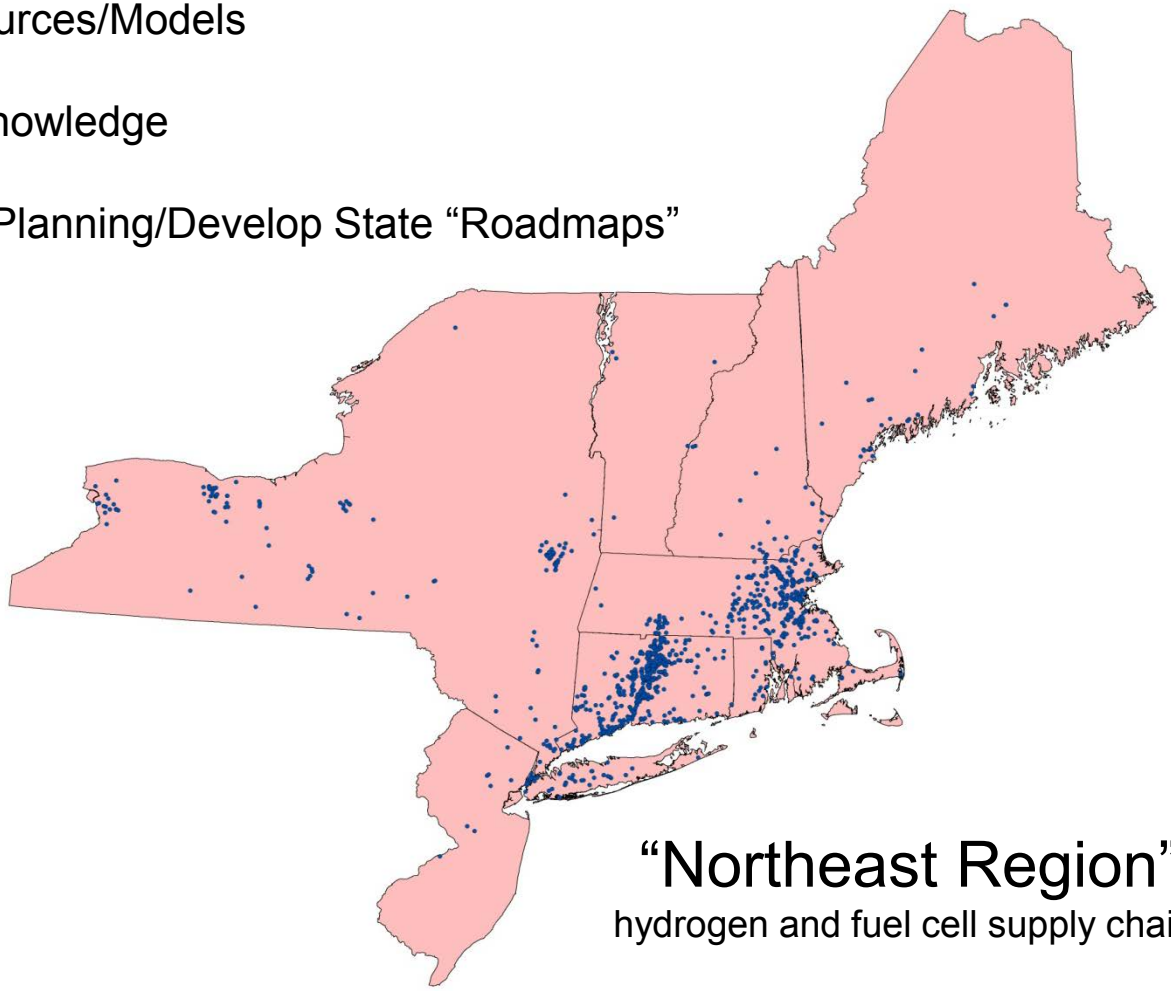
- Hydrogen and Fuel Cell Industry
- Local, State, Federal Stakeholders
- CCAT, CESA, HEC, NENY, MassH2, NECA
- End Users

*** Given a no cost extension from original end date of August 2011**

Objectives

Relevance

- Foster Improved Relationships
- Provide Technical Resources/Models
- Improve Exchange of Knowledge
- Coordinate State/Local Planning/Develop State “Roadmaps”
- Facilitate Deployment



“Northeast Region”

hydrogen and fuel cell supply chain

Project Components

The Partnership Building project has five components:

1: Identify key stakeholders; expand and strengthen partnerships.

2: Develop resources to analyze sites and target locations.

3: Educate state, local decision makers and other key stakeholders, including training on models.

4: Integrate state and local development plans with federal/DOE objectives while identifying financial and investment opportunities.

5: Develop basic “Roadmaps” for each state to provide guidance for technology deployment.

Activities, Milestones, Accomplishments

Relevance

Milestones	Progress Notes	% Complete
Identify Key Stakeholders	Developed a database of local and state decision-makers and key stakeholders.	100% *
Develop Resources for Hydrogen and Fuel Cell Deployment	Developed a brief report detailing criteria for the deployment of hydrogen and fuel cell technologies for transportation, stationary and portable power applications. Developed a database of potential sites for the deployment of hydrogen and fuel cell technology including: commercial and public buildings and transit, public and private fleet vehicle locations.	100%
Develop Online Information, Models and Tools for User Analysis	Developed an inventory of appropriate models and tools to assess environmental value, energy management, renewable energy, cost and economics; and a comparison of competing technologies. Developed a website and Regional Resource Center with appropriate information, models and tools.	100%
Educate State and Local Decision Makers	Organized nine collaborative meetings with regional planning agencies, presented at local associations, conferences, held a workshop and organized an informational forum for policymakers. Assistance provided to municipalities regarding the development of fuel cell projects, grant applications, and transportation initiatives.	100%
Integrate Local Energy Plans with State Plans	Worked with state Department of Transportation to develop hydrogen fueling and vehicle deployment strategies and local municipalities to integrate energy plans with state plans and energy goals.	100%
Identify Financial and Investment Opportunities	Developed a brief report of incentives, funding and investment opportunities for hydrogen and fuel cell technologies.	100%
Organize and Hold Regional Briefing	Developed a database of DOE contacts and key stakeholders in northeast states for regional briefing.	100%
Pre and Post Program Survey	Developed surveys to assess level of knowledge of local and state decision makers and key stakeholders for the beginning of the program.	100%

Activities, Milestones, Accomplishments

Relevance

Milestones	Progress Notes	% Complete
Provide High Level Market Assessment	Undertaking economic modeling and use of an IMPLAN economic model to assess the economic impact of the hydrogen and fuel cell industry (H2/FC) in an 8-state region consisting of NJ, NY, CT, MA, RI, NH, VT, and ME in terms of its direct, indirect, and induced economic effects.	100%
Assist With the Identification and Mapping of Target Locations for Fuel Cell Deployment	Identified and mapped target locations for hydrogen and fuel cell deployment.	100%
Develop a Toolbox for Roadmap Construction	Developed an inventory of appropriate models and tools to assess environmental value, energy management, renewable energy, cost and economics, and a comparison of competing technologies.	100%
Train Individuals on Models	Held regional briefings and workshops including webinars.	100% *
Educate and Assist State and Local Officials and State Organizations	Held state and local briefings to build upon existing partnerships while creating new opportunities.	100% *
Develop a Basic "Roadmap" to provide Guidance for Technology Deployment	A "roadmap" has been developed for each state making up the 8-state region. These development plans include information on the economic value of the region's hydrogen and fuel cell industry identified through a multi-state economic impact (IMPLAN) model, deployment opportunities including mapping of potential end users, and a summary of supporting policies/incentives.	100%
Outreach and Reporting	Provide "roadmaps", white papers, and supporting educational materials to strengthen the level of knowledge of local and state decision makers and key stakeholders.	100%

* **CCAT will continue to educate/train state and local officials, organizations, and decision makers on a limited basis by leveraging resources from other projects.**

Collaborations

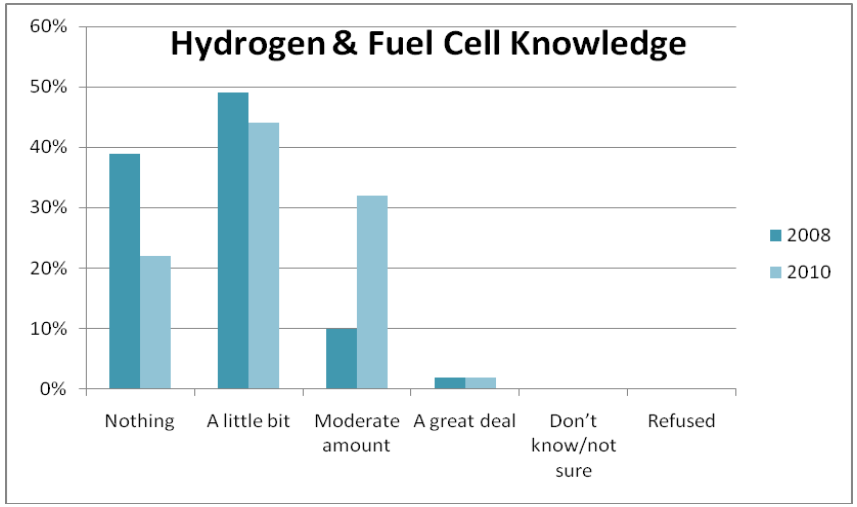
Building upon existing partnerships while creating new opportunities

- Hydrogen and fuel cell industry (FuelCell Energy, UTC Power, Proton Onsite, Nuvera, Plug).
- Federal partners
  - DOE, SBA, DOD, Department of Commerce.
- State partners
  - Legislators, state agencies (DPUC, DEEP, DECD, DOT, CSC, CEFIA, NYSERDA, Mass CEC)
- Regional organizational partners
  - CPES, NECA, CESA, HEC, NENY, MCH, NEESC
- Local partners
  - Mayors, First Selectmen, Public Works Officials, Council of Governments
- Utilities
  - Northeast Utilities, United Illuminating

CCAT Surveyed the Level of Knowledge of State and Local Decision Makers and Key Stakeholders

Which of the following best describes your level of knowledge on hydrogen and fuel cell technologies?

	2008	2010
Nothing	39%	22%
A little bit	49%	44%
A Moderate amount	10%	32%
A great deal	2%	2%
Don't know/not sure	0%	0%
Refused	0%	0%



- Results show a 22% increase in the number of responses that indicate that they know a "moderate amount" and a decrease of 17% in those reporting that they know "Nothing"

Regional Briefing

Westborough, MA – July 22, 2010

Collaboration

U.S. Department of Energy

- *Carole Read, Fuel Cell Technologies Program, Office of Energy Efficiency and Renewable Energy*

State Panel for Regional Perspectives

- Anne Margolis, Clean Energy States Alliance
- Richard Smith, Maine Hydrogen Energy Center, President
- Keith Frame, Connecticut Clean Energy Fund, Director New Technologies
- Charlie Myers, Massachusetts Hydrogen Coalition, President

Industry Representative Panel

- Frank Wolak, FuelCell Energy, Vice President
- Mike Brown, UTC Power, Vice President, Government Affairs
- Thomas Jackson, Avalence, Chief Technology Officer
- Steve Szymanski, Proton Energy Systems, Business Development Manager
- Brad Bradshaw, Hy9, Chief Executive Officer
- Stephen Marlin, General Motors, Driver Relations Manager

Partnership:

NECA
Northeast Energy and Commerce Association

Regional Supply Chain Exchange

Westborough, MA – July 20, 2011

Collaboration

U.S. Department of Energy

- *Greg Kleen, Fuel Cell Technologies Program, Office of Energy Efficiency and Renewable Energy*

State Panel for Regional Perspectives

- Val Stori, Clean Energy States Alliance
- Joel Rinebold, Connecticut Hydrogen Fuel Cell Coalition
- Richard Smith, Gary Higginbottom, and Dave Dvorak, Maine Hydrogen Energy Center
- Charlie Myers, Massachusetts Hydrogen Coalition
- Emily Behnke, New Energy New York

Industry Representative Panel

- Andrew Bosco, General Motors Fuel Cell Research, Chief Engineer
- Christopher Howard, FuelCell Energy, Module Engineer
- Kathy Ciampoli, UTC Power, Strategic Integration Manager
- John Torrance, Proton OnSite, Director of Manufacturing
- Prabhu Rao, Nuvera Fuel Cells, Vice President of Operations

Partnership:

Northeast Electrochemical energy storage Cluster

NECA Northeast Energy and Commerce Association

Regional OEM Summit

Sturbridge, MA – December 14, 2011

Collaboration

Federal Representatives

- *Pete Devlin, Manager of Market Transformation, U.S. Department of Energy*
- *Sean Ricketson, Research Grant Manager, U.S. Department of Transportation*

NEESC Representative

- Anne Margolis, Clean Energy States Alliance
- Joel Rinebold, Connecticut Hydrogen Fuel Cell Coalition
- Richard Smith/Gary Higginbottom, Maine Hydrogen Energy Center
- Charlie Myers, Massachusetts Hydrogen Coalition
- Emily Behnke, New Energy New York

OEM Representatives

Fuel Cell Companies

- Acumentrics Corp. (Tom Ollila)
- Ballard Power Systems (Bill Foulds)
- Electrochem, Inc. (Radha Jalan)
- General Motors (Gary Stottler)
- Giner Electrochemical Systems LLC (Tim Norman)
- Infinity Fuel Cell and Hydrogen, Inc. (Alfred Meyer)
- Nuvera Fuel Cells, Inc. (Gus Block/Prabhu Rao)
- Protonex Technology Corp. (Dr. Paul Osenar)
- Plug Power, Inc. (Gerry Conway)
- SiEnergy Systems LLC (Vincent Chum)
- Trenergi (Charlie Myers)
- UTC Power (Dana Kaplinski/Rich Shaw)

Hydrogen Infrastructure Companies

- Avalence LLC (Deborah Moss)
- Giner Electrochemical Systems LLC (Tim Norman)
- Infinity Fuel Cell and Hydrogen Inc. (Alfred Meyer)
- Nanoptek Corp (John Guerra)
- Nuvera Fuel Cells, Inc. (Gus Block/Prabhu Rao)
- Proton OnSite (Steve Szymanski)

Partnership:

Northeast Electrochemical energy storage Cluster

Regional Finance and Incentive Forum

Storrs, CT – March 13, 2012

Collaboration

Federal Representatives

- *Greg Kleen, Fuel Cell Technologies Program, Office of Energy Efficiency and Renewable Energy*
- *Greg Moreland, US Department of Energy*
- *Alli Aman and Tom Benjamin, Argonne National Lab*

NEESC Representative

- Anne Margolis, Clean Energy States Alliance
- Joel Rinebold, Connecticut Hydrogen Fuel Cell Coalition
- Richard Smith/Gary Higginbottom, Maine Hydrogen Energy Center
- Charlie Myers, Massachusetts Hydrogen Coalition

State Administrators

- Bryan Garcia, President, Connecticut Clean Energy Finance and Investment Authority
- Edward Kear, Senior Project Manager, New York State Energy Research & Development Authority
- Martha Broad, Director of Knowledge Development, Massachusetts Clean Energy Center
- Julian Dash, Director – Renewable Energy Fund, Rhode Island Economic Development Corporation
- Mary Downes, Energy Specialist, New Hampshire Office of Energy and Planning
- Gary Higginbottom, Director, Maine Hydrogen Energy Center
- Anne Margolis, Vermont Project Director, Clean Energy States Alliance
- John Lembo, Vice President of TRC Energy Services, New Jersey Clean Energy Program

OEM Representatives

Fuel Cell Companies

- Ballard Power Systems (Bill Foulds/Melvyn Blake)
- Electrochem, Inc. (Radha Jalan)
- General Motors (Stephen Marlin)
- Watt Fuel Cell (Caine Finnerty)
- Infinity Fuel Cell and Hydrogen, Inc. (William Smith)
- Nuvera Fuel Cells, Inc. (Gus Block)
- FuelCell Energy (Pinakin Patel)
- SolidCell (Arkady Malakhov)
- SiEnergy Systems LLC (Vincent Chum)
- Trenergi (Charlie Myers)
- UTC Power (Lisa Ward/Bob Tierney)

Hydrogen Infrastructure Companies

- Avalence LLC (Nancy Selman)
- Infinity Fuel Cell and Hydrogen Inc. (William Smith)
- Nuvera Fuel Cells, Inc. (Gus Block)
- Proton OnSite (Sheldon Paul)
- Safe Hydrogen LLC (Ken Brown)

Partnership:

Northeast Electrochemical energy storage Cluster

"Roadmap" Value Approach

Approach

- Identify state economic impacts
- Identify and map favorable deployment targets for environmental and energy reliability performance
- Assess state policy and incentives
- Coordinate state policy and incentives to reinforce deployment
- Reinforce deployment to reinforce economic value (with environmental performance and energy reliability)

Economic Impact Summary

	CT	NY	MA	ME	NH	RI	VT	NJ	Regional
Total Employment	2,529	1,728	964	18	45	32	16	111	**5,443**
Total Revenue / Investment ($ million)	$496	$292	$171	$2.9	$8.7	$6.9	$3.3	$26.5	**$1,009**
OEM Revenue / Investment ($ million)	$254	$119	$59.6	0	0	0	0	0	**$433**
Total Supply Chain Companies	599	183	322	28	25	19	5	8	**1189**
Total OEMs	8	9	8	0	0	0	0	0	**25**

"Roadmap" Development Site Selection

Approach

Criteria for Selection

Primary Criteria
- High electric and thermal demand
- Fuel availability
- Energy reliability

Secondary Criteria
- Economic development
- Military applications
- Transportation Opportunities
- Environmental enhancement
- Educational value
- Community support

Target Assessment

Stationary Target Assessment	
- Education	- Federal Operated Buildings
- Food Sales	- Telecommunication Towers
- Food Services	- Wastewater Treatment Plants
- Inpatient Healthcare	- Landfills
- Lodging	- Airports ("Joint-Use")
- Public Order and Safety	- Military
- Energy Intensive Industries	

Transportation Target Assessment	
- Private and Public Fleets	- Distribution Centers
- Transit Buses	- Alternative Fueling Stations
- Material Handlers	- DOT (State) Refueling
- Ground Support Vehicles	- Gasoline Stations

Assessment Summary

Stationary Sites

Description	#
Education	2,190
Food Sales	1,201
Food Services	387
Inpatient Healthcare	422
Lodging	884
Public Order and Safety	313
Energy Intensive Industries	429
Government Operated Buildings	90
Telecommunication Towers	397
Wastewater Treatment Plants	16
Landfills	14
Airports (w/"Joint-Use")	50 (20)
Military	19
Total	**6,426**

Transportation Sites

Description	#
Current Gasoline Stations	15,701
Alternative Fueling Stations	400
DOT Owned Sites	391
Distribution Center/ Warehouses	225
Ports	128
Total	**16,845**

Transportation Vehicles

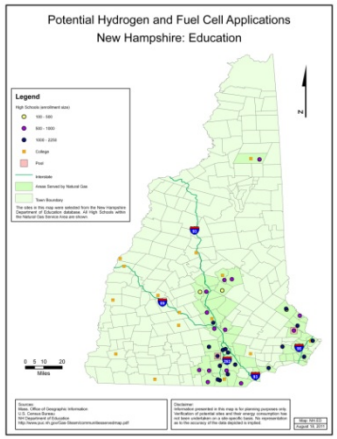
Description	#
State Registered Fleet Vehicles	58,319
Federally Owned Passenger Cars	22,258
Federally Owned Trucks/Vans	27,529
Transit Buses	14,721
Total	**122,827**

***Targets have further been refined in "Roadmap" Documents**

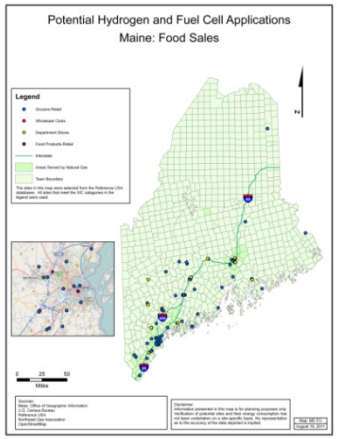
Identification of Mapped Targets

Progress

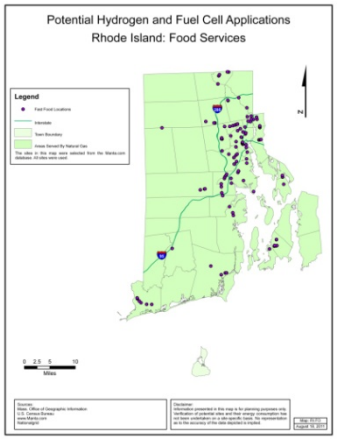
Education



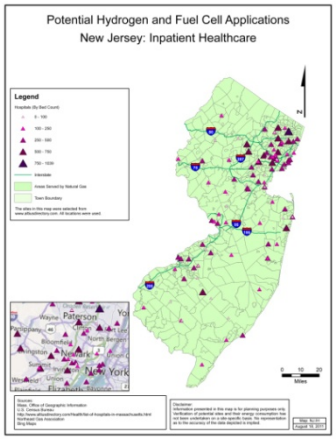
Food Sales



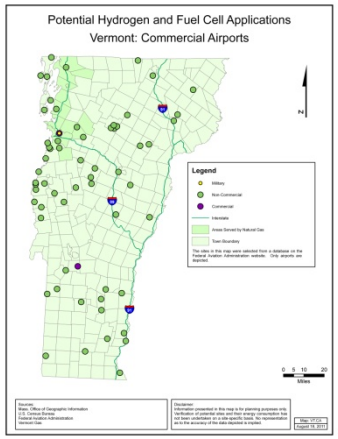
Food Services



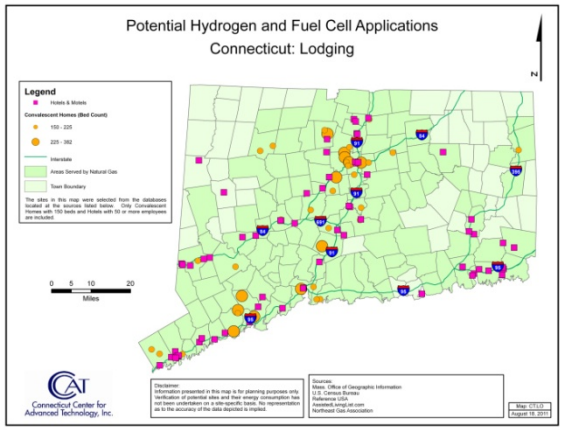
Inpatient Healthcare



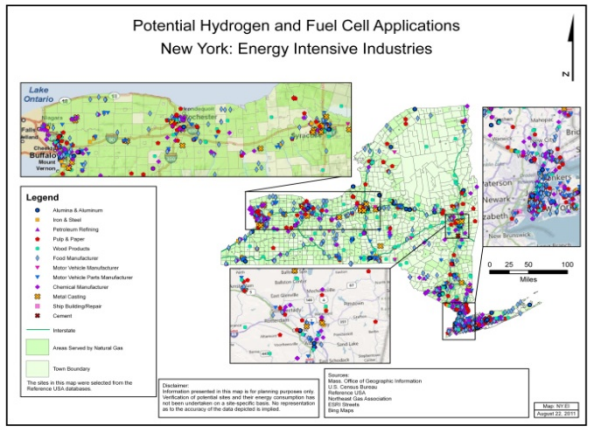
Airports (Military)



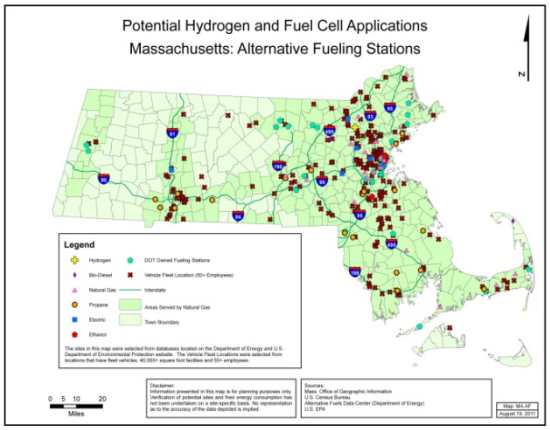
Lodging



Energy Intensive Industry



Alternative Fueling Stations



Target Breakdown (300 kW)

Progress

Category	Total Sites	Potential Sites	MWs	MW-hrs per year	MW at 90% Capacity Factor	Aggregate Annual Thermal Output		CO2 emissions
						MMBTU	MWh	
Education	18,335	2,190	210.9	1,662,735.6	189.81	4,478,301.22	1,312,515.01	434,286.20
Food Sales	51,300	1,201	360.3	2,840,605.2	324.27	7,650,696.67	2,242,290.94	642,698.16
Food Services	64,600	387	116.1	915,332.4	104.49	2,465,295.26	722,536.71	219,715.25
Inpatient Healthcare	3,994	422	126.6	998,114.4	113.94	2,688,254.78	787,882.41	232,631.61
Lodging	8,033	884	265.2	2,090,836.8	238.68	5,631,320.45	1,650,445.62	484,156.44
Public Order & Safety	3,310	313	93.9	740,307.6	84.51	1,993,895.14	584,377.24	179,454.82
Energy Intensive Industries	4,758	429	128.7	1,014,670.8	115.83	2,732,846.69	800,951.55	223,655.68
Government Operated Buildings	1,255	90	27.0	212,868.0	24.30	573,324.48	168,031.79	49,990.87
Wireless Telecommunication Towers*	3,960	397	-	-	-	-	-	-
WWTPs	578	16	4.8	37,843.2	4.32	101,924.35	29,872.32	8,417.75
Landfills	213	14	4.2	33,112.8	3.78	89,183.81	26,138.28	7,327.39
Airports (w/ AASF)	842	50 (20)	16.2	127,720.8	14.58	343,994.69	100,819.08	31,414.59
Military	14	14	4.2	33,112.8	3.78	89,183.81	26,138.28	59,737.86
Ports	120	19	5.7	44,938.8	5.13	121,035.17	35,473.38	10,272.06
Total	**161,312**	**6,426**	**1,363.8**	**10,752,199.2**	**1,227.42**	**28,959,256.51**	**8,487,472.60**	**2,064,422.25**

*** No Base Load**

Policy Summary

Progress

	ME	NH	VT	MA	RI	CT	NY	NJ
Energy Policy								
Mandatory Renewable Portfolio Standard (RPS)								
Fuel Cell Eligibility			*	*	*			*
Interconnection Standards (Includes Fuel Cells)		*	*	*	*			*
Net Metering (Includes Fuel Cells)		*	*	*	*			*
Public Benefits Fund (Includes Fuel Cells)			*	*	*			*
Renewable Greenhouse Gas Initiative (RGGI) Member								
State Incentives for Fuel Cells								
Performance-Based					*			
State Grant Program			*	***	*			
State Loan Program			*		*			
State Rebate Program								*
Property Tax Incentive (Commercial)			*					*
Sales Tax Incentive			*					
Industry Recruitment/ Support				*				*
Property-Assessed Clean Energy (PACE) Financing				**				

All fuel cell types

* Fuel cells using renewable fuels

** Renewable energy eligible technology to be locally determined

*** Fuel cells not specified, but distributed generation technologies eligible through Green Communities program

www.dsireusa.org

Accomplishments

Technical – Modeling

- Economic
- Environmental
- Energy

Economical – "Implan" Modeling

Planning – "Roadmap" Development

- Economic Impact
- Targets
- Policy

Policy

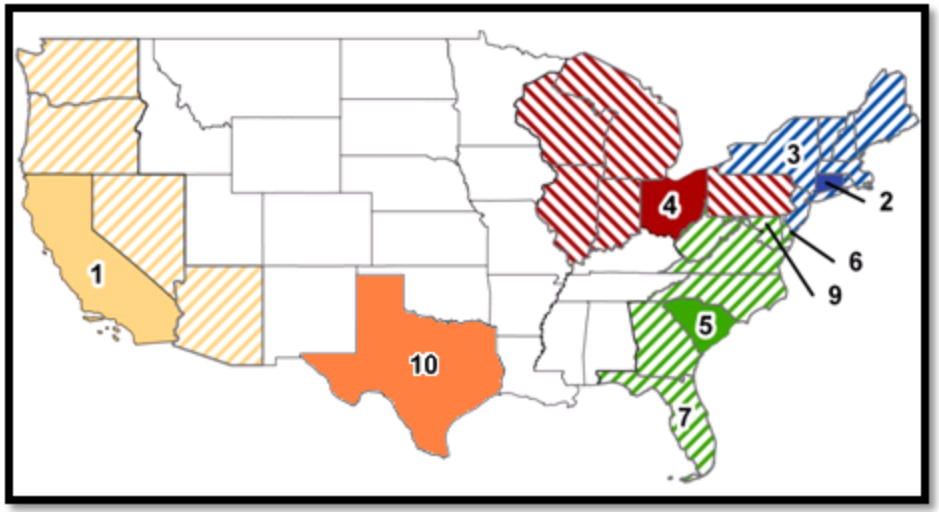
- Regional briefing
- OEM summit
- Summit for state policy coordination

Project Summary

- **Relevance** – Awareness, state/regional and municipal relations, community supported solutions/targets, and state policies.
- **Approach** – Develop partnerships, technical models, and state "Roadmaps" to show economic impact, favorable targets, and to promote supporting policy.
- **Progress**
  - Continue to improve existing relationships and create new opportunities
  - Provide technical resources, including development of economic models
  - Improve Exchange of Knowledge (economic impact, targets, policy) between partners
  - Coordinate State/Local Planning
  - Assist with coordinated state policy development
  - Assist with deployment of stationary, transportation, and portable fuel cells
  - Promote "Roadmaps" for each state in the region
- **Collaborations** – Collaborate with government, industry partners and utilities.

Proposed Future Research

- Educate/train state and local officials, organizations, and decision makers on a limited basis by leveraging resources from other projects.
- Disseminate "Roadmap" documents amongst state and regional agencies.
- Expand "Roadmap" development to additional states and regions
  - It would be of value to focus on regions associated with the U.S. Top Ten Fuel Cell States.[1]
- Coordinate the development of supportive state polices.



Top Ten Fuel Cell States[2]	
1) California	6) Delaware
2) Connecticut	7) Florida
3) New York	8) Hawaii
4) Ohio	9) Maryland
5) South Carolina	10) Texas

[1] Fuel Cells 2000; "State of the States: Fuel Cells in America"; Page 6-7, June, 2011
[2] Top State are based on overall hydrogen and fuel cell related activities

Thank You

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Connecticut Center for Advanced Technology (CCAT)

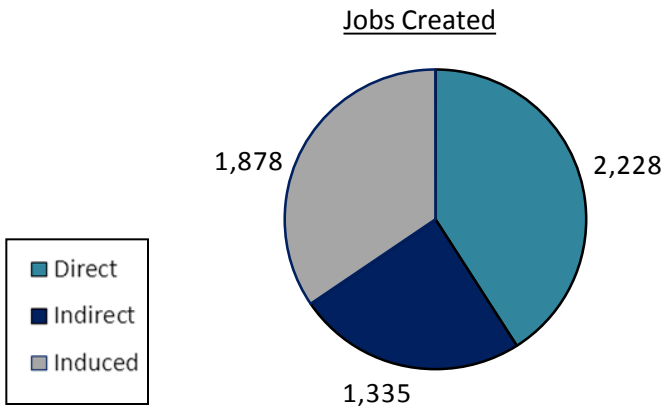
Acknowledgement:

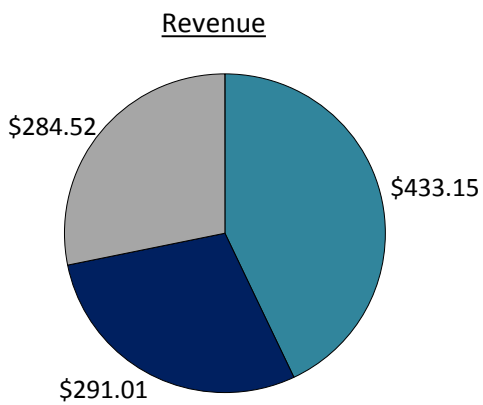
Back-Up Slides

Regional Status and Direction

Jobs and Revenue

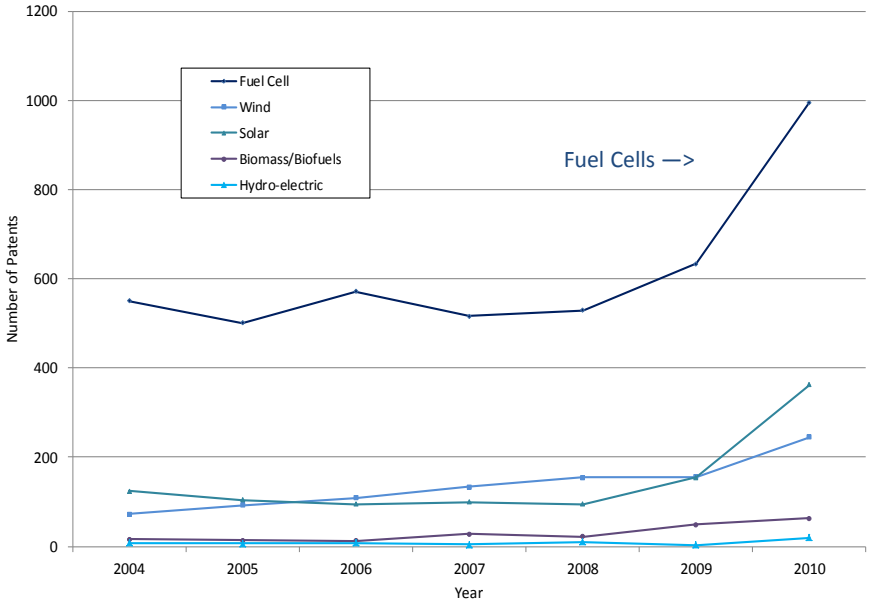
The economic impact of this industry is significant, with a total contribution in 2010 of approximately $500 million in revenue and investments and more than 2,500 related jobs.





Patents

Fuel cells have received significantly more patents than all other clean energy sectors.[1]

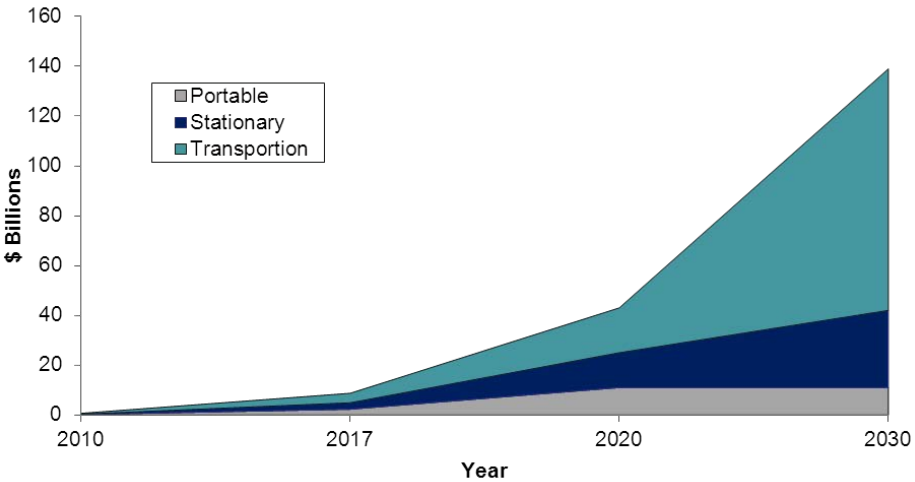


[1] "CEPGI" Heslin Rothenberg Farley & Mesiti P.C,; 2011

Regional Status and Direction

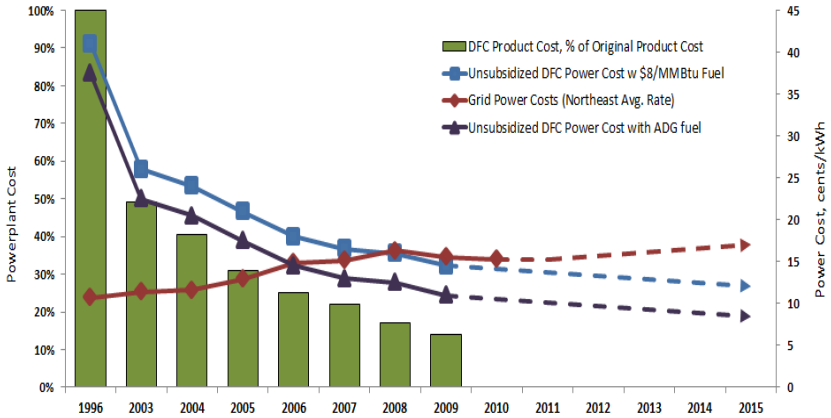
Market

Maturation of the hydrogen and fuel cell global market is forecasted to grow to be between $43 and $139 billion annually by 2030.



Costs

Fuel cell system costs continue to decline.

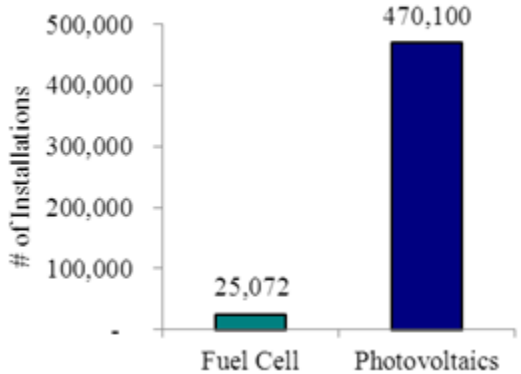


Regional Status and Direction

Market

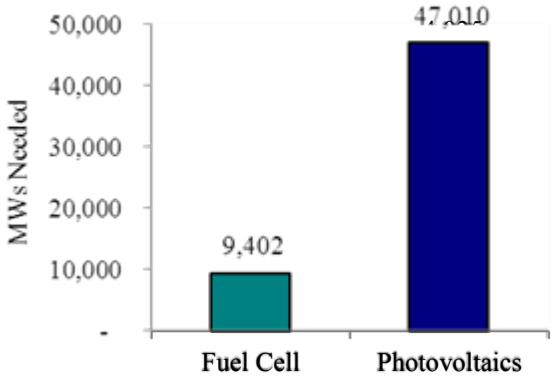
Compared to other commercially available renewable energy technologies, fuel cells have high capacity factors and provide an opportunity for CHP applications.

Installations Needed to Meet 2025 RPS



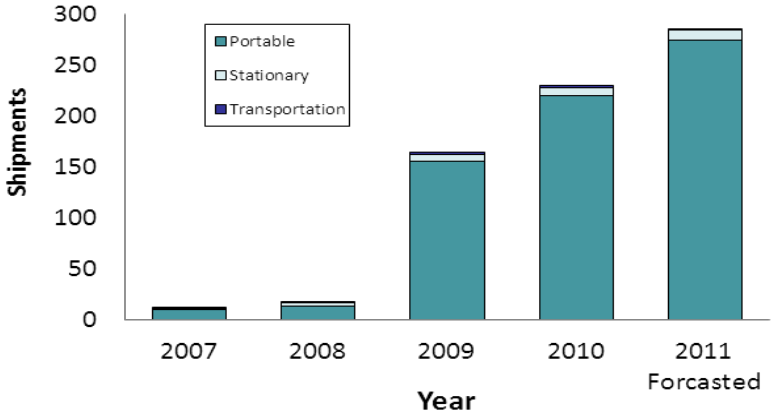
* Fuel Cells: 90% Capacity Factor, 375kW installation
* Photovoltaic: 18% Capacity Factor, 100kW

MWs Needed to Meet 2025 RPS



Exports

Fuel cell shipments have increased significantly since 2007



Educational Video

Education and Informational Video

CCAT developed two videos which (1) encourage student interest in hydrogen and fuel cell technology and (2) educate end users on applications and benefits.

Click here to view the informational video.

To view on the web visit:
http://energy.ccat.us/state_and_local_government_partnership_building

2012 Regional Status and Direction

NORTHEAST HYDROGEN FUEL CELL INDUSTRY
STATUS AND DIRECTION
2012

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Northeast Hydrogen Fuel Cell Industry Status and Direction
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2012 Regional Status and Direction

Introduction

The Northeast region of the United States is home to the current world leaders in hydrogen and fuel cell related technology, research, design, and manufacturing.[1] Fuel cells are highly efficient energy generation devices used to power electronics, vehicles, and buildings. The regional supply chain, which spans all of New England, New York, and New Jersey, includes over 1,180 companies involved in the manufacture, development and deployment of hydrogen and fuel cell products.[2] The northeast supply chain is well positioned to address the growing global market demand and enable a smooth transition from the use of conventional combustion technology operating on imported fuels, to advanced, highly efficient electrochemical fuel cell technology.

Such a market transition will be driven by policy and market demands for clean, renewable, low carbon and highly efficient energy production. Fuel cell technology can meet the needs of end-users seeking distributed energy solutions to improve energy reliability, reduce energy cost volatility, and reduce emissions. These market demands span utility, industrial, commercial, institutional, and residential sectors. As shown in Table 1, the economic impact of this regional supply chain is significant, with a total contribution of approximately $1 billion and more than 5,400 jobs in the New England, New York, and New Jersey region.[3] Research also shows that the hydrogen and fuel cell supply chain has common participants within an established precision manufacturing base in the region. The products and markets of the fuel cell industry are shown in Table 2. The regional hydrogen and fuel businesses are well positioned to compete in the growing global market due to their innovative technologies and the supporting supply chain. Key market drivers include cost, environmental performance and energy reliability (see Table 3).

Table 1 - Regional Cluster Statistics[4,5]

	CT	NY	MA	ME	NH	RI	VT	NJ	Regional
Total Employment	2,529	1,728	964	18	45	32	16	111	**5,443**
Total Revenue / Investment ($ million)	$496	$292	$171	$2.9	$8.7	$6.9	$3.3	$26.5	**$1,009**
OEM Revenue / Investment ($ million)	$254	$119.13	$59.6	0	0	0	0	0	**$433**
Total Supply Chain Companies	599	183	322	28	25	19	5	8	**1189**
Total OEMs	8	9	8	0	0	0	0	0	**25**

Of these companies:

- 96 percent are US owned
- 90 percent are commercial companies
- 80 percent are small businesses that employ 100 people or less and have revenues of less than $25 million
- 55 percent are manufacturing businesses.[6]

[1] Northeast States – CT, MA, ME, NH, NY, NJ, RI, VT
[2] Northeast Electrochemical Energy Storage Cluster Supply Chain Database Search; http://neesc.org/
[3] Northeast electrochemical energy storage cluster; economic impact summary
[4] See Appendix I for complete list of OEMs
[5] Includes direct, indirect and induced
[6] Northeast electrochemical energy storage cluster; economic impact summary

Table 2 - OEM Products and Markets

Stationary power fuel cell systems	○ Utility and large institutional scale fuel cells (1.4-2.8 MW) ○ Commercial, institutional and industrial scale fuel cells (300-400 kW) ○ Small commercial, institutional and residential scale fuel cells (1-10 kW)
Portable and auxiliary	○ Generator replacement fuel cells (300 W-10 kW) ○ Handheld portable electronics power supplies
Transportation fuel cells for vehicles	○ Motive power fuel cells for transit buses ○ Motive power fuel cells for materials handling ○ Motive power fuel cells for cars and light trucks ○ Auxiliary power fuel cells for Class 8 trucks[7]
Energy storage-regenerative fuel cells (1-10 kW)	○ Remote power applications ○ Grid support
Military applications	○ Stationary units for power supply in bases ○ Fuel Cell units in transportation applications ○ Portable units for equipping individual soldiers or groups of soldiers

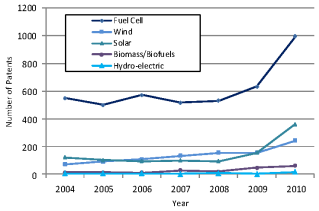
Table 3 - Key Market Drivers and Barriers

Key Market Drivers	○ Increased energy efficiency (oil cost/$bbl) ○ Corporate responsibility – carbon strategy/sustainability ○ Reduced emissions of greenhouse gases and air pollutants ○ Growth of peak electric demand ○ New generation capacity to meet additional demands ○ Renewable energy/RECs ○ Jobs and economic development
Key Barriers	○ Cost ○ Financing ○ Internalization of value ○ Competition with other technologies

Industry Indicators: Patent Growth

According to the United States Department of Energy (U.S. DOE), the fuel cell industry has received significantly more patents than all other clean energy sectors.[8] Figure 1 shows the trend of patents for fuel cells in comparison to solar, wind, hybrid/electric, biofuels, and geothermal from 2004 to 2010.[9] During this period of time the number of fuel cell patents has increased by 57 percent to approximately 1,000 patents issued worldwide. This is equal to roughly three times more than the next largest patent holder, solar, which has approximately 360 patents.

Figure 1 – Clean Energy Patents

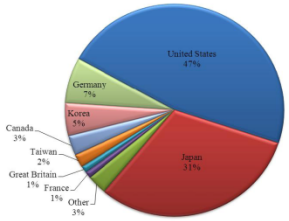


[7] Class 8 refers to the vehicles gross vehicle weight rating of approximately 33,001 lbs http://changingears.com/rv-sec-tow-vehicles-classes.shtml
[8] United States Department of Energy presentation to CCAT's Northeast original equipment manufacturers (OEM) summit in December, 2011.
[9] "CEPGI" Heslin Rothenberg Farley & Mesiti P.C.; 2011

2012 Regional Status and Direction

In addition, as shown in Figure 2, the United States has a competitive advantage in fuel cell research and development. When compared to other countries such as; Japan, Germany, Korea, Canada, Taiwan, Great Britain, and France, the United States has been responsible for nearly 50 percent of the fuel cell patents distributed from 2002 to 2010. This is equivalent to roughly 1.5 times the next most productive country, Japan, which produced approximately 30 percent of the patents distributed during this time period.

Figure 2 – Fuel Cell Patents Geographic Distribution 2002 - 2010

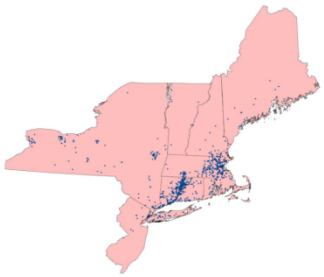


Industry Indicators: Employment

The northeast hydrogen and fuel cell industry employs more than 5,400 people in the region, including direct, indirect, and induced jobs. Direct OEM employment in the region consists of approximately 2,230 jobs and is concentrated in Connecticut, New York, and Massachusetts. Regional employment is anticipated to grow as manufacturing increases to meet global demand.[10] Figure 3 identifies the distribution of the regional supply chain that now exceeds 1,180 companies and organizations.

It is anticipated that the regional economy will increase with a significant rise in employment as this industry grows to meet a maturing market demand for hydrogen and fuel cell vehicles as well as hydrogen generation and power distribution infrastructure.

Figure 3 –Northeast Fuel Cell Supply Chain Company Locations



[10] This information is based on an analysis of direct employment within the fuel cell and hydrogen industry in Connecticut, which has grown three percent a year from 927 direct jobs in 2006 to 1,074 direct jobs in 2011.

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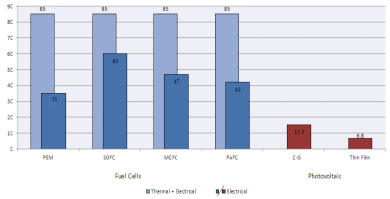
Industry Indicators: System Efficiency

Fuel cell systems generate electrical and thermal energy electrochemically using hydrogen. This generation technology can achieve energy efficiencies of 85 percent in combined heat and power applications utilizing all of the heat and electricity generated. Systems optimized to produce electricity typically achieve efficiencies between 35 percent and 60 percent (see Figure 4).[11] Photovoltaic power systems convert incident solar radiation into usable electrical power at efficiencies between 6 and 15 percent.

Figure 4 –Onsite Generator Efficiency

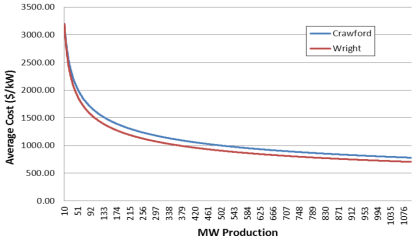


In addition to high system efficiency, the benefits of fuel cell deployment include energy cost containment, energy security and reliability in the form of uninterruptable power and grid security. These benefits are uniquely suited to meet the needs of end users such as hospitals, food sale establishments (supermarkets, wholesale clubs, and distribution centers), telecommunications, educational buildings (high schools and colleges), public safety (fire and police stations), and other mission critical facilities.

Industry Indicators: System Cost

The most significant barrier to increased market penetration is system cost. However, increased production rates and improved design and technology are expected to reduce costs. As MW production increases the average cost per kW decreases. Figure 5 assumes an average fuel cell cost less an installation cost of $1,500 per kW and a federal investment tax credit of 30 percent.[12]

Figure 5 – 80% Learning Curve for Fuel Cell Production



[11] For information on fuel cell electrical and system efficiency please see:
http://www-cta.ornl.gov/cta/Publications/Reports/ORNL_TM2011_101_FINAL.pdf and/or
http://www-cta.ornl.gov/cta/Publications/Reports/ORNL_TM2011_101_FINAL.pdf
For more information on the efficiency of various photovoltaic technologies, please see:
http://www.rensmart.com/Products/SolarPV

[12] Naval Postgraduate School Research, "Chapter 17 Learning Curves", Powerpoint

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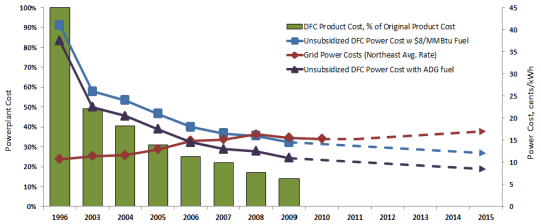
Fuel cell manufacturers in the region expect system costs to continue to decline as technologies and processes improve and economies of scale are reached. Stationary power fuel cell systems such as the FuelCell Energy DFC 300 shown in Figure 6 are already competitive with grid power in some regions of the world. If these systems are operated using biogas fuels, such as those from wastewater treatment plants or landfills which contain large portions of methane gas, operating costs are further reduced and the environmental value is increased.

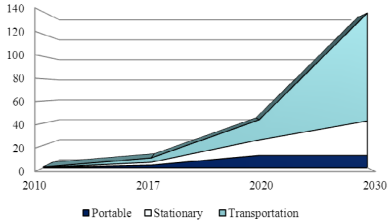
Figure 6 – FuelCell Energy Cost Reduction



Industry Indicators: Growth for Global Market and Deployment

The growing global market for fuel cells and hydrogen equipment is based on the demand for reliable, clean, and efficient energy production for electricity and transportation. Upper bounds of market potential could exceed $139 billion annually by 2030, as depicted in Figure 7. [13,14,15]

Figure 7 – Market Potential

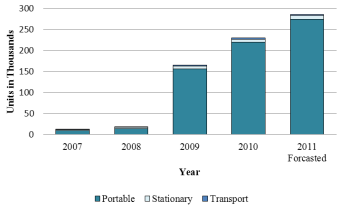


[13] Fuelcellsworks.com, "Fuel Cell Markets in Asia Pacific to Reach $6.7 Billion by 2017, Forecast Pike Research", Sept. 21, 2011
[14] salisonline.org , "Stationary Fuel cell Market Shares, Strategies, and Forecasts, Worldwide, 2011 to 2017", March 21, 2011
[15] TMCnet Contributor, "Portable Fuel Cell Market to Hit a Whopping $2.3 Billion by 2016", Lewis, Hans, January 21, 2010

The growing demand is demonstrated by the increase of fuel cell shipments worldwide, which can be seen in Figure 8. In 2010, 229,600 fuel cell units were shipped. This increase in shipments is significant when compared to the 11,800 fuel cell units shipped in 2007.[16]

In terms of total megawatts (MW) shipped, stationary applications have remained relatively consistent, with between 30 MW and 35 MW shipped per year. Transportation and portable fuel cell annual shipments have increased from 6.1 MW to 55 MW and 0.3 MW to 2.3 MW between 2007 and 2010, respectively. In 2007 the stationary sector accounted for 83 percent of total MW shipped; this has since decreased to approximately 40 percent due to growth in the transportation sector. The increase of unit shipments and capacity output demonstrates the growth of market demand. [17]

Figure 8 – Fuel Cell Shipments



Comparative Analysis

Compared to other commercially available renewable energy technologies, fuel cells have high capacity factors and provide an opportunity for large scale combined heat and power applications.

The value of renewable energy is supported by individual state Renewable Portfolio Standards (RPS) (Appendix VI). The total 2020 Class 1 RPS goal for the northeast is approximately 81,174 MWhs.

A comparison of fuel cell and PV systems shows that the RPS goals could be met with fewer fuel cell installations. As shown in Figure 9, 27,453 fuel cell installations at 375 kW each totaling 10,295 MW of capacity, with a capacity factor of 90 percent, could be used to meet regional RPS Class 1 requirement. Typical installations of 100 kW photovoltaic solar units with a 15 percent capacity factor would require over 617,750 installations totaling 61,775 MW of capacity.[18]

This is not to suggest that fuel cells should be used exclusively to meet the northeast RPS requirements, but rather to demonstrate the capacity advantage that fuel cell systems can provide. All power generation technology and siting decisions must take into account a range of considerations such as locational conditions and needs, available energy sources, demand variances, site conditions, capital equipment and operating costs.

[16] U.S. DOE; "2008 Fuel Cell Technologies Market Report"; http://www1.eere.energy.gov/hydrogenandfuelcells/pdfs/48219.pdf
[17] Fuel Cell Today Consulting; http://www.fuelcelltoday.com/media/1351623/industry_review_2011.pdf
[18] Electrical consumption from EIA: "Electricity Sales by State and Sector"; ISO-NE , ISO-NY, and ISO-NJ for growth projections

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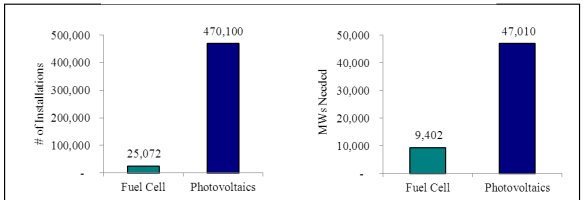
Figure 9 - 2020 RPS Requirements by Technology



Relatively few fuel cells are required to meet 2020 RPS goal vs. solar PV

Conclusion

Commercially available fuel cell products provide highly reliable, efficient, and clean energy to meet market demand. These applications reduce fossil fuel consumption, which results in reduced GHG emissions, and improved environmental performance. By investing in the hydrogen and fuel cell industry the government has an opportunity to create permanent, high quality manufacturing jobs and facilitate economic development.

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APPENDIX I - Fuel Cell Types and Characteristics

Fuel Cell Type	Common Electrolyte	Operating Temperature	Typical Stack Size	Efficiency	Applications	Advantages	Disadvantages
Polymer Electrolyte Membrane (PEM)	Perfluoro sulfonic acid	50-100°C 122-212°F typically 80°C	< 1 kW – 100 kW	kW 60% transportation 35% stationary	• Backup power • Portable power • Distributed generation • Transportation • Specialty vehicle	• Solid electrolyte reduces corrosion & electrolyte management problems • Low temperature • Quick start-up	• Expensive catalysts • Sensitive to fuel impurities • Low temperature waste heat
Alkaline (AFC)	Aqueous solution of potassium hydroxide soaked in a matrix	90-100°C 194-212°F	10 – 100 kW	60%	• Military • Space	• Cathode reaction faster in alkaline electrolyte, leads to high performance • Low cost components	• Sensitive to CO2 in fuel and air • Electrolyte management
Phosphoric Acid (PAFC)	Phosphoric acid soaked in a matrix	150-200°C 302-392°F	400 kW 100 kW Module	40%	• Distributed generation	• Higher temperature enables CHP • Increased tolerance to fuel impurities	• Pt catalyst • Long start up time • Low current and power
Molten Carbonate (MCFC)	Solution of lithium, sodium and/or potassium carbonates, soaked in a matrix	600-700°C 1112-1292°F	300 kW - 3 MW	45 – 50%	• Electric utility • Distributed generation	• High efficiency • Fuel flexibility • Can use a variety of catalysts • Suitable for CHP	• High temperature corrosion and breakdown of cell components • Long start up time • Low power density
Solid Oxide (SOFC)	Yttria stabilized zirconia	700-1000°C 1202-1832°F	1 kW – 2 MW	60%	• Auxiliary power • Electric utility • Distributed generation	• High efficiency • Fuel flexibility • Can use a variety of catalysts • Solid electrolyte • Suitable for CHP & CHHP • Hybrid/GT cycle	• High temperature corrosion and breakdown of cell components • High temperature operation requires long start up time and limits

Polymer Electrolyte is no longer a single category row. Data shown does not take into account High Temperature PEM which operates in the range of 160°C to 180°C. It solves virtually all of the disadvantages listed under PEM. It is not sensitive to impurities. It has usable heat. Stack efficiencies of 52% on the high side are realized. HTPEM is not a PAFC fuel cell and should not be confused with one.

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APPENDIX II - Northeast OEMs

Organization name	Product or Service Category	State
Fuel Cell Energy Inc.	Fuel Cell Stack or System OEM	CT
Infinity Fuel Cell and Hydrogen Inc.	Fuel Cell Stack or System OEM	CT
UTC Power	Fuel Cell Stack or System OEM	CT
Avalence LLC	Hydrogen System OEM	CT
H2 Sonics LLC	Hydrogen System OEM	CT
Proton OnSite	Hydrogen System OEM	CT
Sustainable Innovations	Hydrogen System OEM	CT
Treadwell Corporation	Hydrogen System OEM	CT
H2 Pump LLC	Hydrogen System OEM	NY
General Motors	Fuel Cell Stack or System OEM	NY
Delphi Automotive LLP	Fuel Cell Stack or System OEM	NY
MTI Micro Inc.	Fuel Cell Stack or System OEM	NY
Plug Power Inc.	Fuel Cell Stack or System OEM	NY
Watt Fuel Cell	Fuel Cell Stack or System OEM	NY
Protonex Technology Corp	Fuel Cell Stack or System OEM	MA
Nuvera Fuel Cells Inc.	Fuel Cell Stack or System OEM	MA
Lilliputian Systems, Inc.	Fuel Cell Stack or System OEM	MA
Giner Electrochemical Systems, LLC	Fuel Cell Stack or System OEM	MA
ZTEK Corp	Fuel Cell Stack or System OEM	MA
Acumentrics Corporation	Fuel Cell Stack or System OEM	MA
Hy9 Corp	Hydrogen System OEM	MA
ElectroChem	Fuel Cell Stack or System OEM	MA
Trenergi	Fuel Cell Stack or System OEM	MA

For more information on these companies visit www.NEESC.org

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APPENDIX III - Northeast Stationary Fuel Cell Locations (Through 2011)

Manufacturer	Manufacturer Location	End User Customer	Site Location		Year Installed
Plug Power	NY	T-Mobile cell tower	Storrs	CT	2008
Plug Power	NY	NYSERDA Headquarters	Albany	NY	2006
Plug Power	NY	Albany International Airport	Albany	NY	2004
Plug Power	NY	Town Hall	Babylon	NY	2002
Plug Power	NY	SUNY Farmingdale	Farmingdale	NY	2003
Plug Power	NY	Local 25 International Brotherhood of Electrical Workers Headquarters	Hauppauge	NY	2005
Plug Power	NY	Suffolk County William Rogers Legislative Building	Hauppauge	NY	2003
Plug Power	NY	Hofstra University	Hempstead	NY	2002
Plug Power	NY	Wantagh Animal Shelter	Hempstead	NY	2003
Plug Power	NY	U.S. Merchant Marine Academy	Kings Point	NY	2006
Plug Power	NY	Plug Power	Latham	NY	2004
Plug Power	NY	Union College, Beuth House	Schenectady	NY	2009
Plug Power	NY	Southampton College	Southampton	NY	2003
FuelCell Energy	CT	U.S. Coast Guard Air Station	Bourne	MA	2003
FuelCell Energy	CT	Pepperidge Farms Plant	Bloomfield	CT	2005
FuelCell Energy	CT	Peabody Museum	New Haven	CT	2003
FuelCell Energy	CT	Hartford Insurance	Windsor	CT	2009
FuelCell Energy	CT	Sheraton New York Hotel & Towers	Manhattan	NY	2004
FuelCell Energy	CT	SUNY College of Environmental Science and Forestry	Syracuse	NY	2006
UTC Power	CT	Cabela's Sporting Goods	East Hartford	CT	2008
UTC Power	CT	Coca-Cola Bottling	East Hartford	CT	2011
UTC Power	CT	Whole Foods Market	Glastonbury	CT	2008
UTC Power	CT	Connecticut Science Center	Hartford	CT	2009
UTC Power	CT	St. Francis Hospital	Hartford	CT	2003
UTC Power	CT	Middletown High School	Middletown	CT	2008
UTC Power	CT	Connecticut Juvenile Training School	Middletown	CT	2001

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UTC Power	CT	Water Pollution Control Authority	New Haven	CT	2003
UTC Power	CT	360 State Street Apartment Building	New Haven	CT	2010
UTC Power	CT	South Windsor High School	South Windsor	CT	2002
UTC Power	CT	Mohegan Sun Casino Hotel	Uncasville	CT	2002
UTC Power	CT	Fairfeild WPCA	Fairfield	CT	2006
UTC Power	CT	CTTransit: Fuel Cell Bus	Hartford	CT	2007
UTC Power	CT	Whole Foods Market	Dedham	MA	2009
UTC Power	CT	Bronx Zoo	Bronx	NY	2008
UTC Power	CT	North Central Bronx Hospital	Bronx	NY	2000
UTC Power	CT	Hunt's Point Water Pollution Control Plant	Bronx	NY	2005
UTC Power	CT	Price Chopper Supermarket	Colonie	NY	2010
UTC Power	CT	Mount Sinai Rehabilitation Center	East Hartford	CT	2012
UTC Power	CT	New Haven City Hall	New Haven	CT	2012
UTC Power	CT	East Rochester High School	East Rochester	NY	2007
UTC Power	CT	Coca-Cola Refreshments Production Facility	Elmsford	NY	2010
UTC Power	CT	Verizon Call Center and Communications Building	Garden City	NY	2005
UTC Power	CT	State Office Building	Hauppauge	NY	2009
UTC Power	CT	Liverpool High School	Liverpool	NY	2000
UTC Power	CT	Grand Central Station	New York City	NY	2005
UTC Power	CT	New York Hilton Hotel	New York City	NY	2007
UTC Power	CT	Corona Rail Car Maintenance Facility	New York City	NY	2006
UTC Power	CT	Central Park Police Station	New York City	NY	1999
UTC Power	CT	Conde Nast Building	New York City	NY	2000
UTC Power	CT	Rochester Institute of Technology	Rochester	NY	1993
UTC Power	CT	NYPA office building	White Plains	NY	2010
UTC Power	CT	Wastewater treatment plant	Brooklyn	NY	
UTC Power	CT	Wastewater treatment plant	Staten Island	NY	
UTC Power	CT	Wastewater treatment plant	Yonkers	NY	1997
UTC Power	CT	The Octagon	Roosevelt Island	NY	2011
UTC Power	CT	Carla's Pasta	South Winsor	CT	2011

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APPENDIX IV:

Data acquired from DSIRE (Database of State Incentives for Renewables and Efficiency)
http://www.dsireusa.org/

State	RPS Goal
Connecticut	Class I: 20% by 2020 Class III: 4% by 2010
Maine	Total: 40% by 2017 Class I (New Resources): 10% by 2017
Massachusetts	Class I (New Resources): 15% by 2020 and an additional 1% each year thereafter with no stated expiration date Class II (Existing Resources): 7.1% starting in 2009 and thereafter (3.6% renewables and 3.5% waste-to-energy)
New Hampshire	New Renewables (General): 16% by 2025 New Solar-Electric: 0.3% by 2014 Existing Biomass: 6.5% by 2011 Existing Small Hydro: 1% by 2009
New York	29% by 2015 Customer-Sited: Target of ~7.0% of the annual incremental requirement (0.4788% of State sales in 2015)
Rhode Island	16% by 2019
Vermont*	Goal: 20% by 2017 Minimum obligation: (1) any increase in retail electric sales between 2005-2012 that is also at least 5% of 2005 sales; OR (2) 10% of retail electric sales in 2005

*Vermont uses a renewable portfolio goal rather than a binding renewable portfolio standard.

Fuel Cells:
Class I Renewable: Connecticut, New York, and Maine.
Class I Renewable using Renewable Fuel: Massachusetts, Rhode Island
Class I Renewable using Hydrogen: New Hampshire

Fuel cells are an eligible renewable in Vermont.

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