

Background Data Report

Does New England Have a Clean Technology Industry Advantage?¹

A Data Overview of Clean Technology Development in the New England States

This paper is designed to provide some descriptive data on clean technology employment, demand, innovation, and business development across the New England states. The term *clean tech* in general describes a group of technologies and industries based on the principles of minimizing climate and environmental impact and using natural resources more efficiently. It includes new physical, process and social technologies in renewable energy (e.g., solar, wind, geothermal) generation and energy, materials and resource conservation. As an industry it is currently a relatively small category mostly contained within the high technology category and broad green employment/jobs category. Nationally it represents less than 1/8th of high tech and 1/4th of the green economy categorization by most definitions.

There is no single or simple definition for clean tech. Here we focus on the clean energy economy definition used by the Pew Trust (2009). This is a definition that is commonly referenced and used.² We also use two other definitions of clean tech in some of the data presentation (see below).

According to the clean tech definition from [The Clean Energy Economy Report](#) (Pew Charitable Trust, 2009), “(a) clean energy economy generates jobs, businesses and investments while expanding clean energy production, increasing energy efficiency, reducing greenhouse gas emissions, waste and pollution, and conserving water and other natural resources.”

The Pew Trust definition has five sub-categories

- Clean energy
- Energy efficiency
- Environmentally friendly production
- Conservation and pollution mitigation
- Training and support

¹ Ross Gittell and Josh Stillwagon, University of New Hampshire. This “data report” is for background for the New England Study Group May 10th 2011 seminar. This report provides data about clean tech development in the six state New England region. Most of the data is not original but collected from previously published sources and focused on New England. The authors would like to thank Bo Zhao and Yolanda Kodrzycki for their suggestions and the Federal Reserve Bank of Boston’s New England Public Policy Center for providing support while Professor Gittell was a visiting scholar.

²See *The Economist* (August 13, 2009), “Greening the Rustbelt”; *New York Times* (June 10, 2009) “Green Sector Jobs ‘Poised for Explosive Growth,’ Study Says, Michael Burnham; *Center for American Progress* website “New Map: The Economics of Clean Energy in 50 States”; *Los Angeles Times* (March 25, 2010) “China Takes Lead in Clean Tech Investment” Jim Tankersley and Don Lee; *Huffington Post* (March 18, 2010) “The Five Best Cities for Green Jobs” Dan Shapley; *The Clean Tech Market Authority*, Oct 2009, Clean Tech Job Trends, Ron Pernick.

Overview of New England Clean Tech Industry Development

Five of the six New England states are among the top 1/3rd of states in employment concentration in clean tech using the Pew Trust definition. Maine leads the region and is second in the nation, behind only Oregon, in clean tech employment concentration with .85% of total employment in clean tech. Massachusetts follows close behind, ranking third among the 50 states with .69% of total employment in clean tech, followed by Vermont with the 5th highest concentration (.59%) in clean tech employment in the nation. NH (12th) and Connecticut (16th) are also among the top 1/3rd states in clean tech employment concentration. Rhode Island is the only state in the region with clean tech employment concentration (.42%) below the U.S. average overall of .49 percent. The regional average at .61% is 20 percent higher than the national average.

Figure 1: Clean Tech Employment as Percentage of Total Employment, (Pew Trust, 2009)

	Clean Tech % of Total Jobs Rank (of 50)	Clean Tech % of Total
CT	16	.47
MA	3	.69
ME	2	.85
NH	12	.55
RI	33	.42
VT	5	.59
Top	OR	1.02
Bottom	MS	.24
US		.49
NE mean		.61

Details on Clean Tech Employment

According to the Pew Trust, there were 51,300 clean energy/tech jobs in the region in 2007 (the last year of fully recorded data). This is about 1/8th the jobs in high technology in the region and one-quarter the job estimates using the U.S. Department of Commerce definition of green economy jobs in the region (Measuring the Green Economy, 2010). In the region clean tech is a relatively small sector currently, but is growing faster than total employment (see data summarized in the table below).

Figure 2: Job Growth Clean Tech Relative to Total Job Growth (Pew Trust, 2009) and High Technology Job Growth (Moody's Analytics, 2010)

	Clean Tech employment Growth Rank (1998-2007)	Clean Tech Job Growth % (1998-2007)	High Tech employment Growth Rank (1998-2007)	High Tech employment Growth % (1998-2007)	Total Job Growth rank (1998-2007)	Overall Job Growth % (1998-2007)	Clean –Total Growth
CT	32	7.0	44	-7.5	44	-2.7	+9.7
MA	36	4.3	38	-3.3	48	-4.4	+8.7
ME	14	22.7	25	4.5	26	3.3	+19.4
NH	38	2.0	48	-15.1	14	6.8	-4.8
RI	39	0.7	11	17.7	38	0.6	.1
VT	22	15.3	28	1.5	12	7.4	+7.9
Top	ID	126.1	NV	51.4	NV	26.5	
Bottom	UT	-12.4	DE	-19.5	DE	-8.9	
NE mean	30.2	8.7	32.3	-.4	30.3	2.1	+6.6
US		9.1		6.6		10.0	-.9

Over the last 10 years for which the Pew Trust clean tech employment data is available (1998-2007) all the New England states except for New Hampshire and Rhode Island had clean tech employment growth significantly above total employment growth. The region overall had slightly lower growth over the time period in clean tech employment than the US average, 8.7 percent compared to 9.1 percent, but the difference between the US average growth and New England average growth was much smaller for clean tech (.4%) than total employment (7.9%).

Clean tech is a growing sector within high technology in the region.³ Significantly, all the states in the region had clean tech employment growth greater than overall high technology

³Clean tech is generally within high technology; however, it is difficult to get at this precisely given the lack of transparency in the Pew Trust definition. We use the Moody's Analytics (2010) definition of high technology industries.

employment growth and had better ranking among the 50 states in job growth in clean tech than in high technology growth with the exception of Rhode Island. In the region high technology declined .4% over the period 1998-2007 while clean tech employment grew by nearly 9 percent. High technology is a very important sector in the regional economy and clean tech being a relatively fast growing component of the region's high technology base makes it an important industry to follow.

In addition to the Pew Trust defined industry, we use two alternative definitions of clean tech in the presentation here and in the empirical modeling presented in the main body of the New England Public Policy Center working paper.

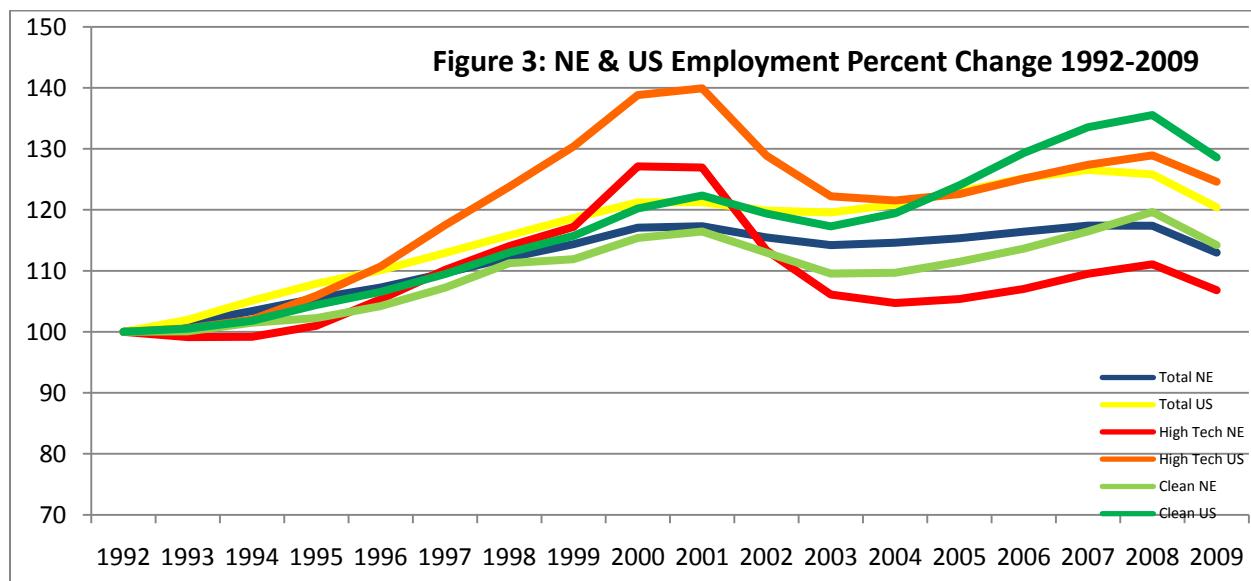
The alternative definitions, unlike the Pew Trust definition, use “simple” standard industry classification (NAICS) definitions and are transparent and therefore can be more easily replicated and this allow for time series data over longer time periods. Below we compare the employment concentrations for the three definitions of clean tech we use here in the six New England States and the US for 2007 (the last year of data available for the Pew Trust definition).

	PEW 2007 concentration	NETS 2007 concentration	NAICS 2007 concentration
CT	0.6	0.24	3.70
MA	0.81	0.12	5.42
ME	0.97	0.18	2.41
NH	0.62	0.24	4.55
RI	0.47	0.13	3.05
VT	0.7	0.35	3.56
US	0.56	0.21	3.85

The first alternative definition – Clean Tech NAICS-based -- is the broadest one we consider, see below. It includes 4-digit NAICS industries that generate energy, transmit energy, and manufacture and service energy and also includes industries that have relative concentration in providing products and services that can readily contribute to energy conservation. It is a significantly (about 7 times) broader industry characterization than the Pew Trust definition.

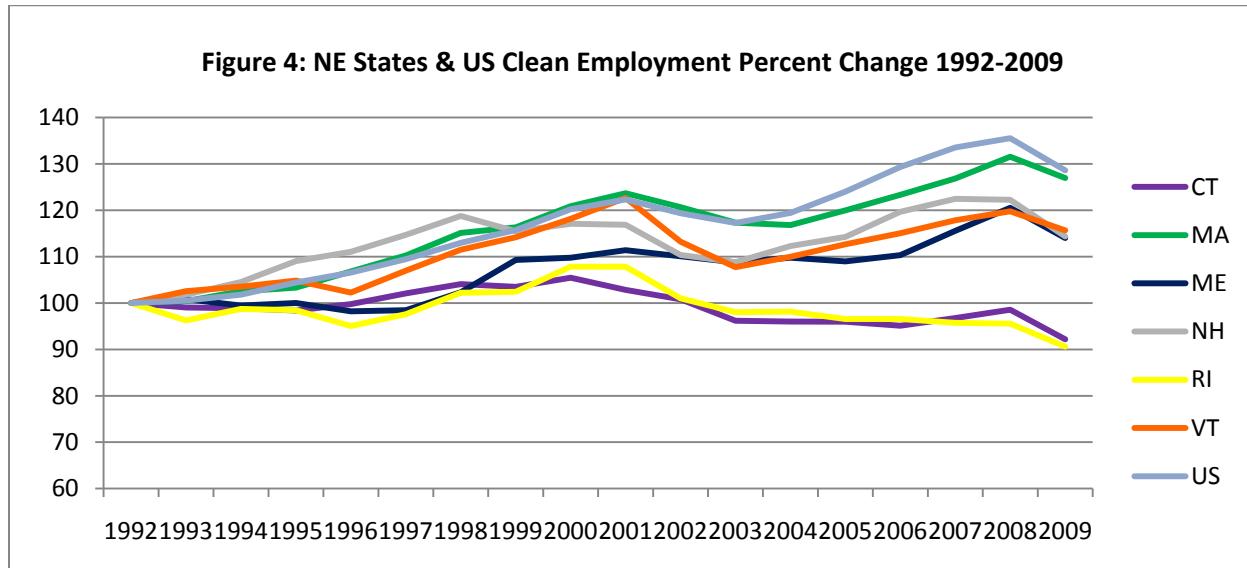
Clean Tech NAICS-based Definition	
NAICS	
2211	Electric Power Generation, Transmission and Distribution
2371	Utility System Construction
3334	Ventilation, Heating, Air-Conditioning, and Commercial Refrigeration Equipment Manufacturing
3336	Engine, Turbine, and Power Transmission Equipment Manufacturing
3345	Navigational, Measuring, Electro-medical, and Control Instruments Manufacturing
3351	Electric Lighting Equipment Manufacturing
3359	Other Electrical Equipment and Component Manufacturing
5413	Architectural, Engineering, and Related Services
5416	Management, Scientific, and Technical Consulting Services
5417	Scientific Research and Development Services
5419	Other Professional, Scientific, and Technical Services

Using the NAICS-based broad definition (4-digit NAICS industries it includes above) we can see in the figure below that the broadly defined clean tech employment has been growing faster than total and high tech employment in New England and US since 1992 and through 2009. This is similar to what we observed in New England with the Pew Trust definition and suggests the broad nature of the region's industry strength.



The figure below shows that US growth has been greater than growth in New England in total employment, high tech (again using the definition of high technology from Moody's Analytics) and the broadly defined clean tech industry. As with the Pew Trust definition, the US growth in clean tech is above the average New England state's growth. Using the broader measure and over a longer period of time, Massachusetts leads the region in clean tech employment growth and concentration and has clean tech employment growth close to the US average. Rhode Island

and Connecticut lag the region's growth in clean tech using what we call the NAICS-based measure.



The 2nd (what we call NETS) alternative definition is by intention a very different clean tech definition than our first alternative and Pew Trust defined industry. It is about 40 percent the size of the Pew Trust defined industry and its difference can be highlighted by the relatively low employment concentration of employment in Massachusetts relative to the other New England states using this definition; while in contrast using the other definitions Massachusetts leads the region or is second.

The “NETS” clean tech definition is the smallest in terms of employment. It focuses specifically on energy research and services. Compared with the baseline Pew Trust measure however, it includes a broader range of industries within the energy sector than those only associated directly with clean energy. For what we call the NETs-based definition we draw on the National Establishment Time-Series (NETS) database that goes up to 2009. Using the NETs-based definition there were 1,129 “clean tech” establishments in the region as identified by Walls & Associates (2010). The largest numbers of establishments are in energy conservation and electrical power generation research and services. Listed below are the energy research and service clean industries in individual states with the most establishments across the six states in the region.

Figure 5: NETS-Based Clean Tech Definition: Energy Research and Services

<u>State</u>	<u>SIC8</u>	<u>Industry</u>	<u>Estabs09</u>
MA	87489904	Energy conservation research and services	250
MA	49119902	Generation, electric power	88
CT	87489904	Energy conservation research and services	80
CT	49119902	Generation, electric power	65
MA	87119906	Energy conservation engineering	52
ME	49119902	Generation, electric power	52
MA	52110301	Energy conservation products	48
NH	87489904	Energy conservation research and services	46
ME	87489904	Energy conservation research and services	35
VT	87489904	Energy conservation consultant	35
NH	49119902	Generation, electric power	34
CT	87119906	Energy conservation engineering	32
MA	87110403	Heating and ventilation engineering	26
RI	87489904	Energy conservation consultant	22
CT	52110301	Energy conservation products	21
VT	49119902	Generation, electric power	20
NH	52110301	Energy conservation products	12
ME	87119906	Energy conservation engineering	10

This clean tech definition may highlight some of the key industries that can provide a foundation for future clean tech innovation.

We now consider-- with the most current data at the state level—some clean technology industry specialized and generalized local factor conditions (that we call “pipeline” factors) that can potentially contribute to clean technology employment.⁴

Local Demand

It appears that the northern states of New England all have strong demand for renewable energy while in the southern New England states there is not as strong a demand for renewable energy. Renewable energy use per capita is the indicator we use for local demand for clean technology. The three northern New England states have the highest use of renewable energy on a kilowatts per capita basis, all ranking among the top quarter of states -- Maine 6th, Vermont 9th and New Hampshire 12th. The southern New England states rank among the 10 lowest users of renewable

⁴ This follows generally from the work of Ricardo, Heckscher and Ohlin, Helpman, Porter and Krugman and others on which industries have competitive advantages in which regions and where and how industry clusters are formed. Porter's (1990) model of competitive advantage includes factor conditions, demand conditions, and related and supporting industries.

energy. The strong northern state ranking most likely reflects the long standing use of wood in the heavily forested northern parts of the region. On another ranking of renewable energy which takes into account overall energy use per capita by the Pew Center and measures renewable energy use as a percentage of total energy use, the southern states in the region fare differently. Connecticut, Massachusetts and Rhode Island rank 12th, 28th and 37th respectively. The northern states still rank higher using this alternative renewable energy use measure, with Vermont (2nd), NH (3rd) and Maine (5th).

Figure 6: Local Demand for Renewable Energy

	Rank	Renewable per capita (DoE 2009)
CT	42	.39
MA	41	.39
ME	6	6.44
NH	12	2.05
RI	48	.15
VT	9	3.30
US		1.38

Use of federal household tax credits for the purchase of energy efficient appliances and other products like doors and insulation is another indicator of local demand for clean tech. Here, again, the northern New England states rank relatively high -- all among the top third of states in energy efficiency tax credits taken per return and in average dollar amounts of energy efficiency investment credits per return (see below). All the southern New England states are in the bottom half of states on this measure of local demand related to clean tech.

Figure 7: IRS Tax Credits for Energy Efficiency Investments

	Tax credits percent of all returns	Rank	Dollar amount of tax credits per total return	Rank
CT	.14	29	1.35	31
ME	.19	12	2.59	4
MA	.11	40	1.01	46
NH	.18	16	1.77	15
RI	.10	45	.82	50
VT	.19	10	2.66	3
Top	1.2	HI	17.58	HI
Bottom	.08	ND	.86	NY (49)

Clean Tech Specialized Local Factor Conditions

Venture Capital

Using data from Pew Trust Report (2009) the region has strengths in clean tech venture capital. Four of the six states in the region, Massachusetts (1st), Vermont (5th) and NH (8th) rank among the top states in clean tech venture capital investments per capita from 2006 to 2008. Rhode Island ranks in the top third (12th), Connecticut at median (25th) and Maine low (45th). This could suggest that the three top ranked states in the region and Rhode Island are relatively well positioned for growth in clean tech businesses.

Figure 8: Clean Tech Venture Capital

	Clean Tech VC\$ per capita rank (2006-2008)	Clean Tech VC\$ per capita (2006-2008)	Clean Tech Patents Rank (1999-2008)
CT	25	8.58	5
MA	1	198.22	6
ME	45	0.00	45
NH	8	50.86	23
RI	12	21.60	27
VT	5	86.51	43
Top	CA (2 nd)	180.00	CA
Bottom	9 States	0.00	AK
NE mean	16.0	61.0	24.8
US		41.72	

Patents

According to Pew Trust (2009) on clean tech patents per capita 1999 to 2008, Connecticut (5th) and MA (6th) ranked highly, NH (23rd) and Rhode Island (27th) rank near the median and Maine (45th) and Vermont (43rd) in the bottom quintile. Based on patent data compiled by 1790 Analytics, from 1990 through the third quarter of 2010 Connecticut and Massachusetts ranked among the top ten states in the number (not per capita) of patents in fuel cell, hybrid renewables, and smart meters technology (1790 Analytics, LLC, 2010). The two states rank particularly high in fuel cells (2nd and 4th). Massachusetts also ranks very high in solar (2nd), batteries (5th) and wind (5th) power patents. New Hampshire for a small state also ranks high in three clean tech focused areas -- clean coal, hybrid and smart meters. There is fuel cell, wind power and battery activity in all the New England states.

Figure 9: Clean Tech Patent, Rankings 1990 to 2010Q3

Patent Data, 1990 to 2010Q3		Ranking among 50 States in numbers								
Category		MA	CT	NH	RI	VT	Maine	TOP	Three	State
										s
Smart Meters		10	8	17	40		32	CA	NY	TX
Batteries		3	17	25	27	39	46	CA	NY	MA
Fuel Cells		4	2	25	18	35	38	NY	CT	CA
Clean Coal		10	8	17			23	CA	OH	PA
Geothermal		19*	15		19*			TX	CA	LA
Hydro		10	14	27				CA	TX	FL
Hybrid		5	8	17				MI	CA	IN
Solar		2	20	16		28	28	CA	MA	NY
Wind		5	11	33	37	21	43	CA	NY	TX
*=only 1										

In terms of number of patents in clean tech specialized areas, the table below lists the categories in which New England states have the most patents from 1990 to 2010q3, or 100 or more. Battery technology patenting is a particularly active area in the New England states over time and continuing in 2010.

Figure 10: Patents by State in Top 2 Clean Tech Categories

	2010q3	1990-2010q3
MA-Batteries	34	500
MA-Fuel Cells	20	238
MA-Solar Energy	16	137
CT-Fuel Cells	34	508
CT-Batteries	14	180
Maine-Smart Meters	0	17
NH-Batteries	10	92
RI-Batteries	2	69
VT-Batteries	2	11

Source: 1790 Analytics, LLC

Non-Specialized Local Factor Conditions

On non-specialized local factor conditions the region ranks strongly. This is true in patents per capita, workforce skills and research and development (R&D) funding. On (all) patents per capita three of the New England states – Connecticut (2nd), Massachusetts (4th) and NH (9th) rank in the top quintile and Vermont and Rhode Island are in the top half. Again, as with clean tech specific patents, Maine is in the bottom quintile.

In workforce skills, on the basis of scientists and engineers as a percent of total workforce, Massachusetts (1st), Rhode Island (5th) and Connecticut (6th) rank highly, Vermont (14th) ranks in top third and NH (25th) and Maine (27th) near the median.

On overall venture capital funding per capita four of the New England states rank in the top quintile with only Vermont (27th) and Maine (38th) above the median.

On industry R&D funding per capita Rhode Island (3rd) leads the region followed by Massachusetts (4th), New Hampshire (8th) and Connecticut (9th), with Vermont (27th) and Maine (38th) lagging. On non-industry R&D funding per capita the rankings are Rhode Island (4th), Massachusetts (3rd), NH (17th) and Connecticut (28th), with Vermont (27th) and Maine (38th) lagging again. The region does not fare as well in business starts per existing business, with all the states except for Maine ranking in bottom third.

Figure 11: Non-Specialized Local Factor Conditions

	Patents Rank	Inventor Patents	Workforce Sci and Eng Rank	Sci and Eng	Venture Capital rank	Venture Capital	Industry R&D rank	Industry R&D	Non-Industry R&D rank	Non-Industry R&D	Business Starts rank	Starts per 100,000
CT	2	0.014	6	0.46%	18	0.20%	9	3.82%	38	0.39%	38	27.82
MA	4	0.012	1	0.77%	2	1.39%	4	5.10%	3	1.34%	46	12.02
ME	43	0.005	27	0.28%	43	0.03%	38	1.26%	35	0.44%	13	74.31
NH	9	0.01	25	0.29%	7	0.37%	8	3.94%	17	0.64%	35	30.42
RI	21	0.007	5	0.49%	32	0.06%	3	5.23%	4	1.24%	44	16.49
VT	13	0.009	14	0.39%	15	0.22%	27	2.01%	23	0.56%	41	26.77
Top	UT	0.015	MD (2nd)	0.77%	CA	1.48%	DE	7.37%	NM	7.33%	ID	212.35
Bottom	AR	0.003	NV	0.16%	AK, NE	0.00%	WY	0.31%	NV	0.21%	AL	
	US	0.008	US	0.34%	US	0.40%	US	3.31%	US	0.70%	US	
NE mean	15.3	0.01	13	0.40%	19.5	0.38%	14.8	3.56%	20	0.77%	36	31.33

Clean Tech Business Development

One indicator of business start-ups in clean tech is the number of initial public offerings (IPOs). This is an indicator of the most highly successful ventures in clean tech by state. The number of IPOs is small nationally over the last few years particularly in such a narrow industry category as clean tech. Yet three states in the New England region have clean tech IPOs over the last four years; with three in Massachusetts with total valuation of \$252 million, one in Connecticut at \$123 million and one in New Hampshire valued at \$500 million. California, leads among states during this time period with 10 IPOs valued at \$1.1 billion. Massachusetts has more IPOs in clean tech than Colorado, Maryland and Minnesota combined, and Connecticut and New Hampshire have more than the latter two which did not have any clean tech IPOs in this time period.

Figure 12: IPOs, New England and Selected States, 2006Q3 to 2010Q2

2006Q3-present	IPO's	Offer Amount \$ millions	Green Tech	Offer Amount \$ millions
CT	6	2,792.6	1	123
MA	25	3,297.4	3	252.7
NH	1	500	1	500
CA	78	28,586.7	10	1,115.5
CO	9	2,954	2	71.5
MD	6	514.9	0	0
MN	6	529.7	0	0

Summary of Clean Tech in New England

All but one (RI) of the New England states ranks among the top third of states in clean tech employment concentration. Massachusetts, Connecticut and New Hampshire are most strongly positioned in the region in the clean tech “pipeline” (i.e., all other elements of clean tech industry documented here), see summary table below. This appears to have benefited the states in terms of high end output in the form of clean tech IPO(s) and clean tech industry concentration. The three states have IPOs in the clean tech categories in which they have significant patent activity--Massachusetts in batteries and fuel cells and Connecticut and New Hampshire in solar.

The northern states have the highest current demand for renewable energy and energy efficiency. Massachusetts and Connecticut are most strongly positioned with regards to specialized and general patent activity—from overall, to clean tech, to specialized in fuel cells and solar. Massachusetts and New Hampshire are best positioned in specialized and general venture

capital, and Maine seems to have strength in business starts relative to the other New England states.

Figure 13: Clean Tech Industry Development Summary

	Emp Conc.	Demand- Renewable	Demand Efficiency	Sci & Tech Workforce	R&D Industry	R&D non- industry	VC- industry.	VC- specialized	Patents- nonspecial	Patents- special	Business Starts	Job Concen.	Ave
CT	16	12	29	6	9	38	25	18	5	2	38	23	17
MA	3	28	40	1	4	3	1	2	6	4	46	4	14
ME	2	5	12	27	38	35	45	43	45	43	13	2	32
NH	12	3	16	25	8	17	8	7	23	9	35	12	18
RI	33	37	45	5	3	4	12	32	27	21	44	36	27
VT	5	<u>2</u>	<u>10</u>	<u>14</u>	<u>27</u>	<u>23</u>	<u>5</u>	<u>15</u>	<u>43</u>	<u>13</u>	<u>41</u>	<u>9</u>	<u>21</u>
NE		14.5	25.3	13.0	14.8	20.0	16.0	19.5	24.8	15.3	36.2	14.3	21

With regards to standing among what we call the pipeline elements of clean tech industry development in the region: the northern New England states have the highest current demand for renewable energy and energy efficiency; Massachusetts and Connecticut are most strongly positioned with regards to specialized and general patent activity—from overall, to clean tech, to specialized in fuel cells and solar; Massachusetts and New Hampshire are best positioned in specialized and general venture capital; and Maine seems to have strength in business starts relative to the other New England states.

Summary

This report documents the New England states competitive positioning in clean tech industry development. The region does have relatively strong positioning in clean tech employment currently and many of what we call the clean tech specialized and general pipeline elements that can contribute to clean tech employment growth in the future. Much of the advantageous position, particularly in clean tech patenting, appears to be derived from the region's general strong position in high technology industries and skilled work force.

Are the seeds in place in the region for clean technology to be at the forefront of a third industrial revolution in New England at some point in the near future? This does not appear to be the case. While clean tech is a relatively fast growing component of the larger and very important high technology sector in the region, its total employment base is still below one percent of total employment in the region and in any of the individual states in the region and current growth rates are below 10 percent per year. From a low base this suggests that clean tech

will not any time soon represent a significant share of regional employment. The region, however, does appear to be relative to other US regions well positioned for future growth in clean tech as the industry expands globally.