"Hydrogen Fuel Cells: Technology and State Policy"

CT Fuel Cell Economic Development Plan

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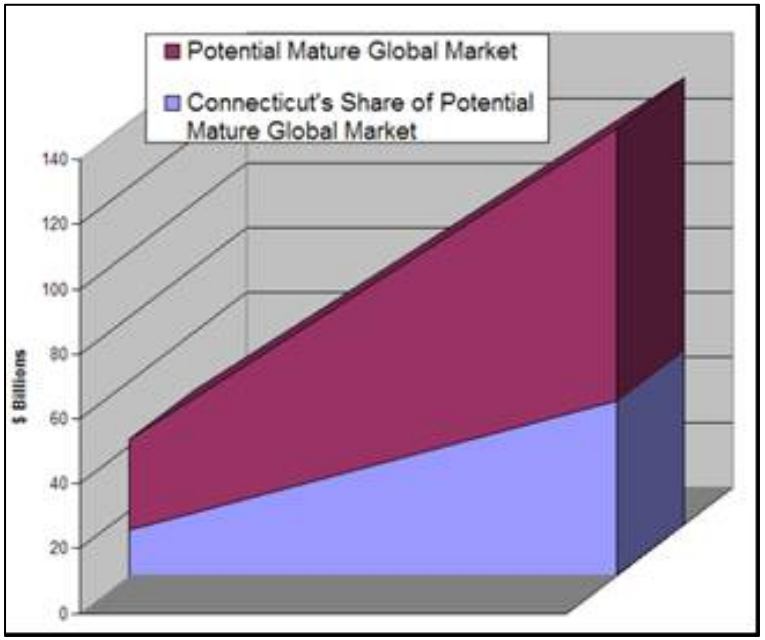
Reasons for Market Growth

- World electric consumption is projected to more than double between 2003 and 2030
- Transportation demands for petroleum currently exceed domestic supply. Alternative fuels will be required for energy security
- Increased energy efficiency for transportation and electric generation will be required by all global consumers as traditional fuel prices increase, i.e. oil prices per barrel increases over $100
- Reduced emissions of GHG and primary air pollutant mandates for mobile and stationary applications
- Summer peak electric demand will require new generation resources in addition to conservation measures
- New generation capacity to meet new demand and to replace retiring units

Potential Mature Global Market



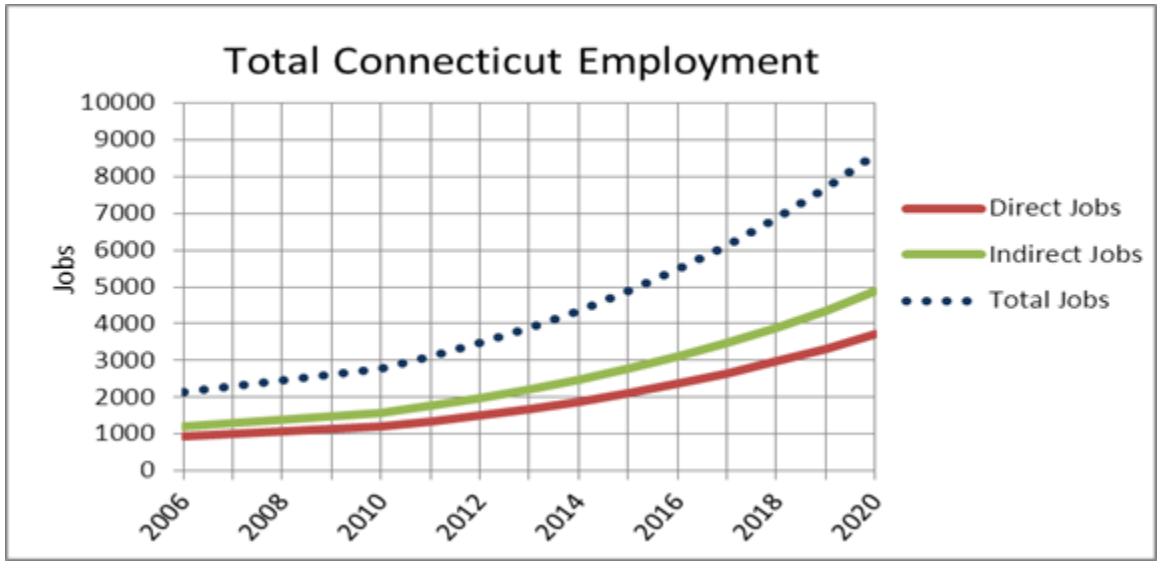
- A mature global market could generate between $43 and $139 billion annually
- If Connecticut captures a significant share of the distributed generation and transportation markets, revenues could be between $14 and $54 billion annually
- A mature market would require an employment base of tens of thousands

Market Growth Barriers

- High costs
- Lack of understanding and recognition of fuel cell reliability and durability
- Unappreciated environmental values
- Lack of investment needed to undertake research and development
- Insufficient infrastructure
- Strong competition from rate-base supported conventional grid generation

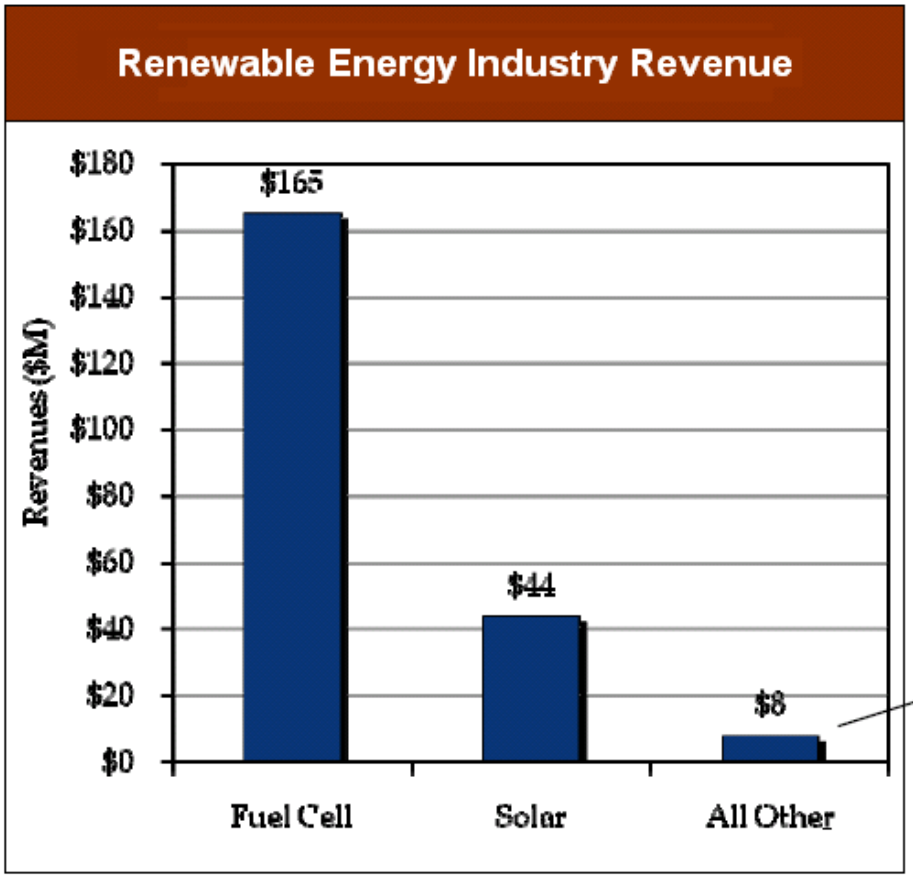
Employment In 2010

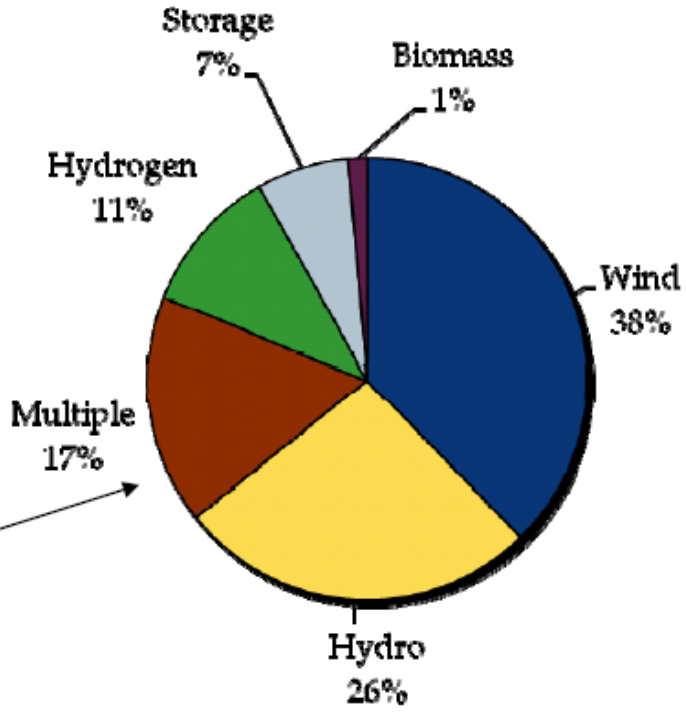
- Approximately 1,300 jobs directly associated with research and development and the manufacture of
- Over 1,600 indirect jobs for a total of over 2,900 jobs statewide
- Total employment of Connecticut's hydrogen and fuel cell industry, including direct, indirect and induced jobs has grown 28 percent from 2006 to 2010, and is projected to grow by an estimated 12 percent each following year



Economic Value

Fuel Cell Industry Revenue





Source: 2009 Study by Navigant Consulting, Inc

Economic Multipliers

Economic Multipliers			
	Employment	**Industry Revenues**	**Employee Compensation**
Multiplier	**2.31**	**1.84**	**1.72**

- For each job the hydrogen and fuel cell industry directly supports, an additional 1.31 jobs are indirectly supported elsewhere in Connecticut
- For every $1.00 of revenue generated by industry, and additional 84 cents of revenue is received by the state of Connecticut
- For every $1.00 paid to industry employees, an additional 72 cents is paid by other employers in the supply chain

State Roadmap Recommendations

- Long-term and predictable tax advantage incentives
- Predictable grant and matching resources for deployment and R&D
- Long-term support for vehicles and H2 refueling
- Increase awareness and knowledge
- Dedicate a percentage of RPS for fuel cell
- State mandates for agency deployment
- Utility Ownership
- Customer choice for state-made technology

Existing State Policy - Renewables

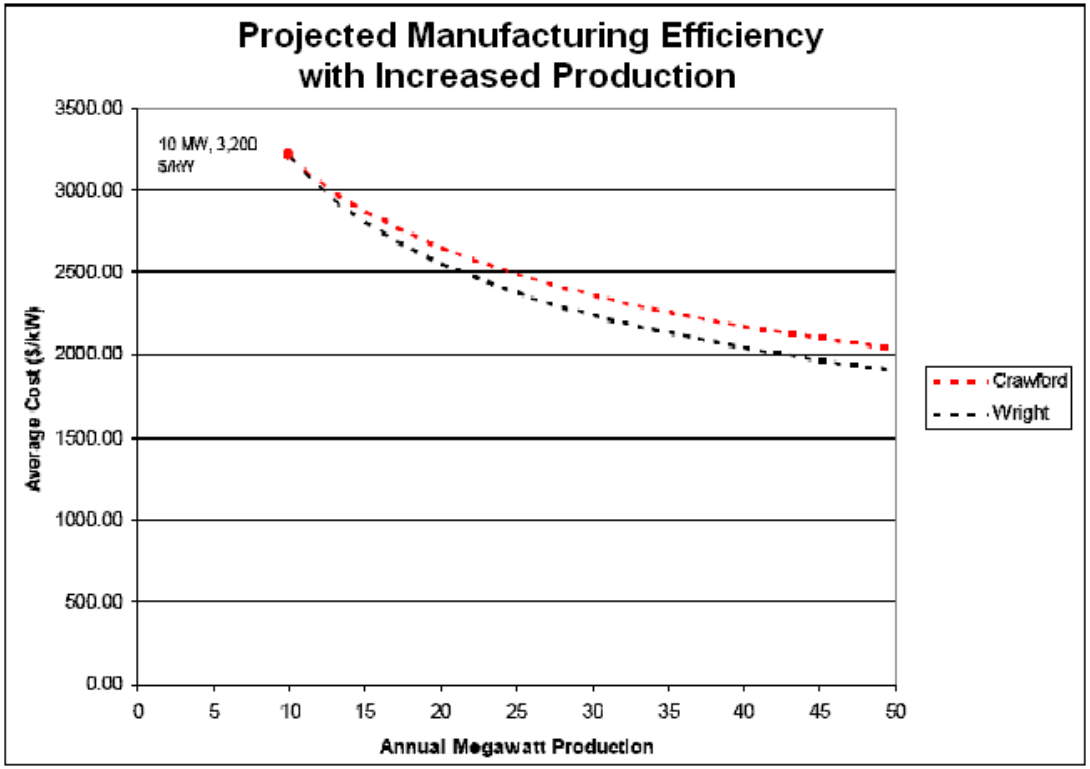
- Fuel cell generation defined as a Class I Renewable Energy
- CHP / heat recovery defined as a Class III Renewable Energy
- Establish Renewable Portfolio Standard (RPS) for Class I and Class III
- RECs awarded for renewable energy projects including fuel cells

Existing State Policy – Regulatory PUC

- Establish a systems benefit charge to fund renewable energy development
- Allow for net metering
- Allow aggregation and net metering of multi-meter buildings
- Establish requirements for renewable energy development
- Waive stand-by rates for fuel cell interconnected buildings
- Waive charges for natural gas delivery
- Low Interest Loans for Customer Side DG

Results - Reducing Unit Costs

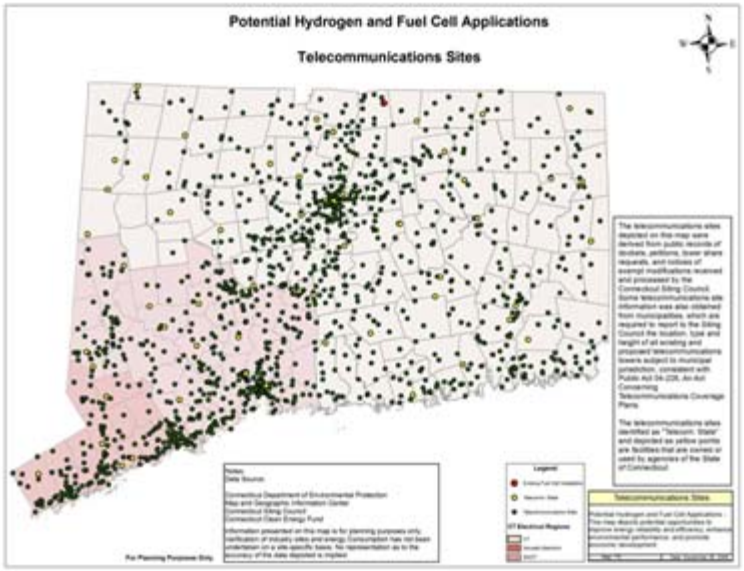
With consistent investment to increase fuel cell production, domestic industries will be able to reduce unit costs and potentially capture a larger share of the global market

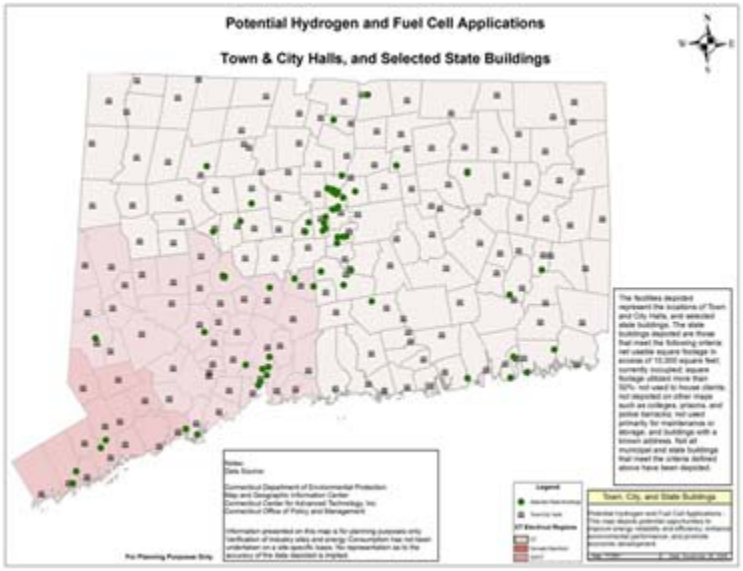


Results – Effective Deployment

Targeted deployment of hydrogen and fuel cell technology could effectively meet electric power, thermal and transportation needs, reduce emissions, increase energy efficiency, and reduce costs

Examples of targets include state public buildings, prisons, universities, hospitals, transit fleets, delivery fleets, major highway fueling stations, etc.





Results - Emissions Reduction and Energy Savings

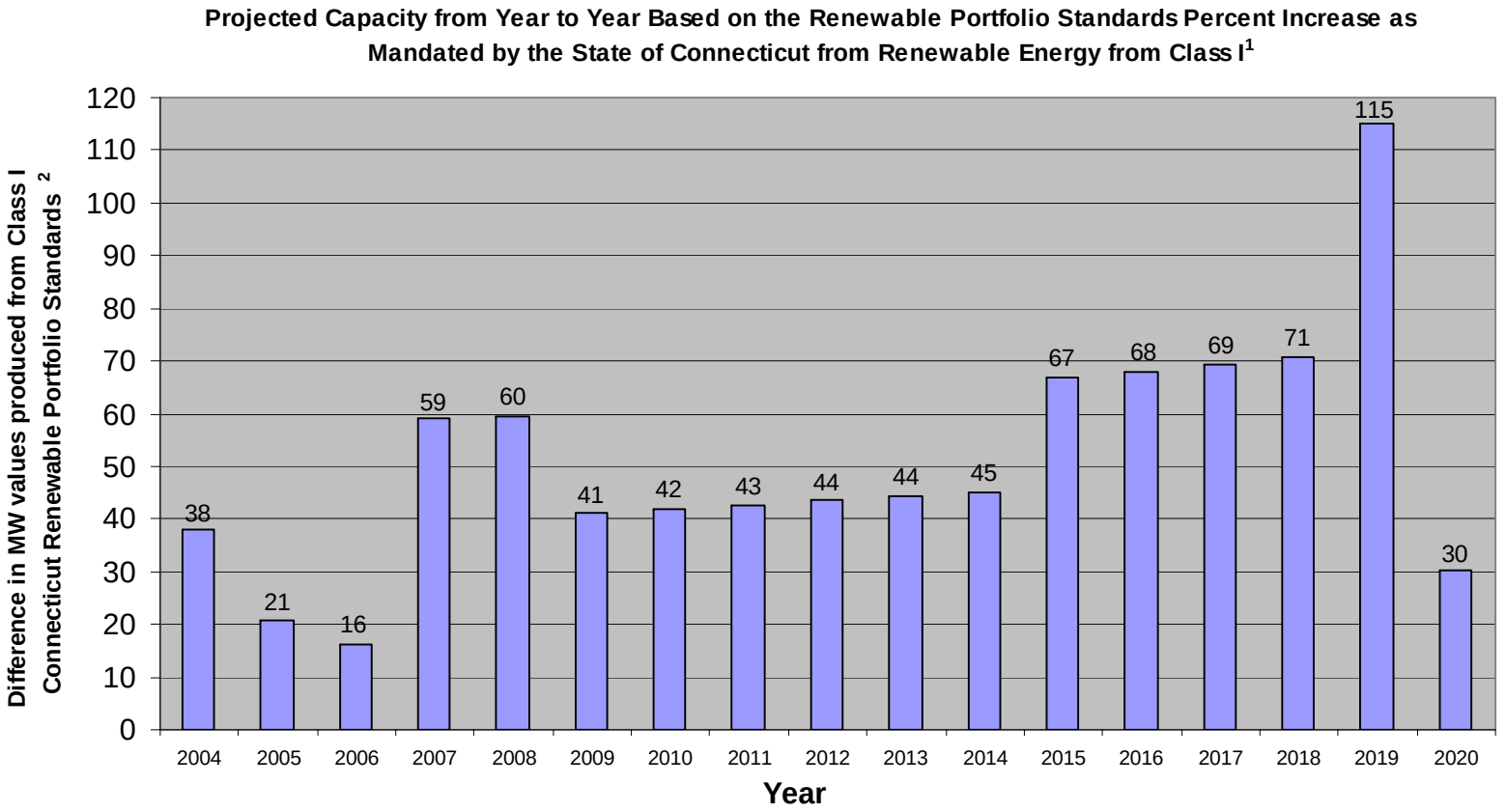
Fuel cell generation facilities can substantially reduce emissions, greenhouse gases, and energy use

Potential Average Annual Emissions Reduction and Energy Savings Associated with the Displacement of 40 MW of Conventional Fossil Fuel Generation			
Air Emissions		Energy Savings	
NO_X	224 tons	Btu	1.4 – 1.6 Trillion
SO_2	187 tons	No. 2 Oil Equivalent	10 - 12 Million Gallons
CO_2	144,365 tons		

Fuel cells would increase transportation efficiency by up to three times

Average Expected Energy Use (mpge)					
Passenger Car		Light Truck		Transit Bus	
Hydrogen Fuel Cell	Gasoline Powered Car	Hydrogen Fuel Cell	Gasoline Powered Light Truck	Hydrogen Fuel Cell	Diesel Powered Transit Bus
81.2	29.3	49.2	21.5	12.4	3.9

Results – RPS Compliance



1. Energy Grow th Estimates are based on the compound Grow th Rate of .98% as provided by The Connecticut Siting Council.
2. Based on 100% load factor

Results – Cost Effectiveness

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Payback in year	4
NPV	$534,274
IRR	15%

UTC FC	Technology
1,033	KWAC Peak Host Demand Capacity
73%	Host approximate Load Factor
5,531,184	kWhs Host Average Energy Demand
0%	Host Expected Retun on Equity
2,854,948	btu/hr Average Host Heat Demand
400	KWAC Fuel Cell Installation
95.00%	Capacity Factor
9,475	Average Heat Rate
31,540	mmbtu Heat Input Per Year Required
3,328,800	Fuel Cell Gen output is 60.2% of Host Requirement
785,000	btu/hr Average generated by UTC FC
16.47	Utility Avoided Energy Cost ¢/kWh
3.0%	Utility & Nat Gas & LFG Esc. Rate
3.0%	O&M Esc. Rate
$12.00	CHP Input Fuel $/mmbtu
$17.63	Fuel Oil Cost $/mmbtu
$0.00	Propane Cost $/mmbtu
$17.23	Boiler 'Natural Gas and Fuel Oil Cost $/mmbtu
$30.00	Recs Market Value De-Esc @2%
2.00	O&M ¢/kWh
80.0%	Natural Gas or Oil Fired Boiler Efficiency
15	- Number of Years in the Analysis
rate 35	Host CL&P Electric Rate
Third Party Rate	0.00

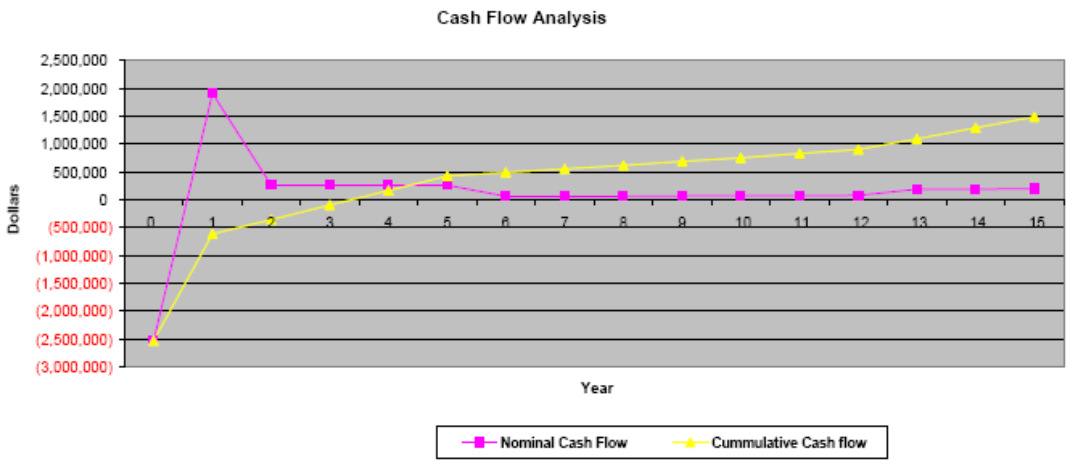
CL&P ☑ U I ☐ Non Profit ☐

Cost of Capital:	Percent	Rate	pre-tax
Debt	100.00%	7.00%	7.00%
Equity	0.00%	12.00%	0.00%
Weighted Capital Cost			7.00%

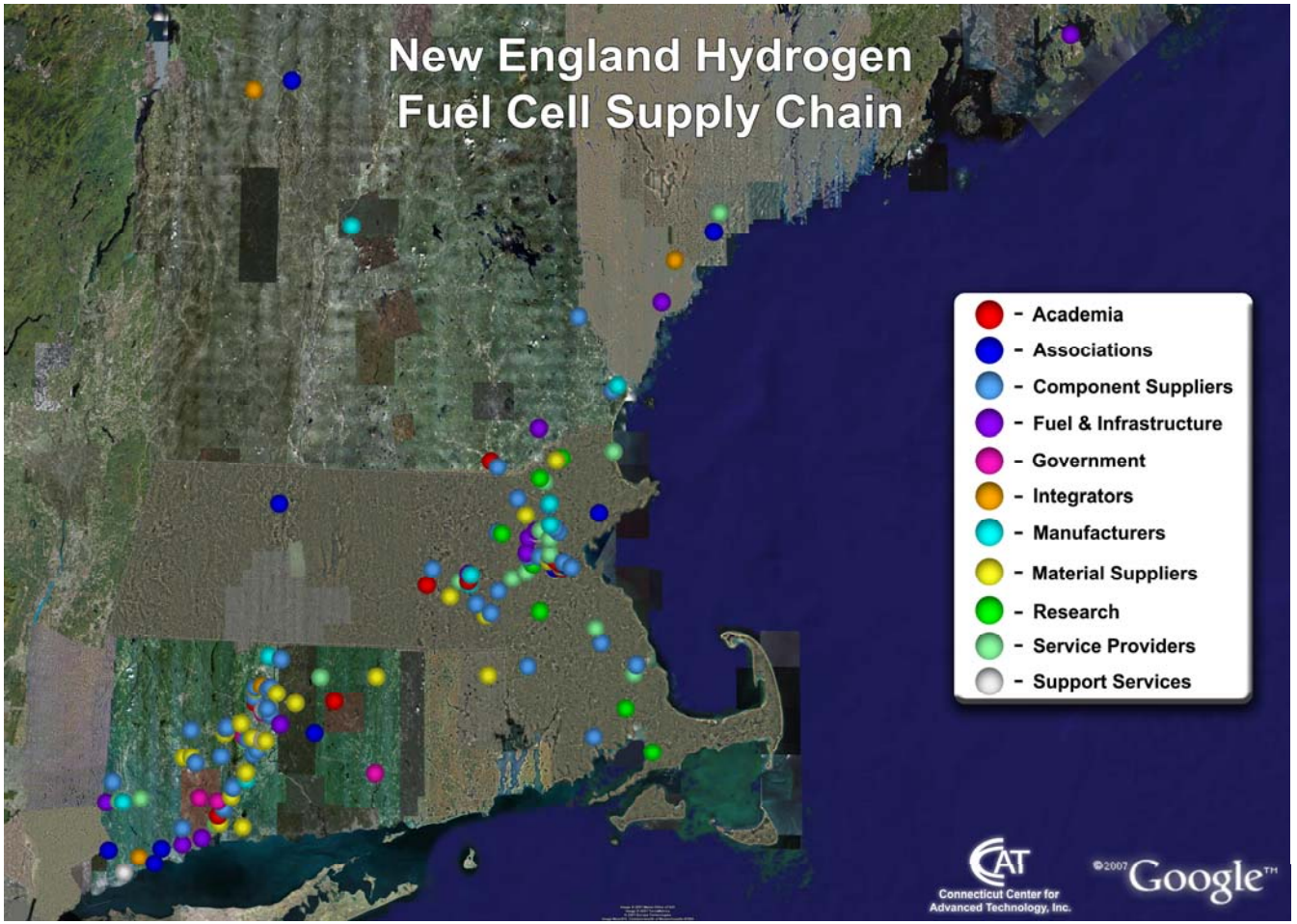
Finance Term - 12 Years

Depreciation - 5 Years

Capital Cost:		
UTC FC	$4,500	perKW
Install Cost	$1,826	perKW
B/E Analysis		perKW
Total Cost	$6,326	perKW
Or	$2,530,400	Dollars
Re-stack	$1,500	per KW
Subsidies&Tax	(1,659,120)	
Host Equity	$0	



Results – Diverse Supply Chain



Summary

- There are favorable market conditions for the expansion of the hydrogen and fuel cell industry in the U.S.
- Public investment is appropriate and justified – up to $4 for every $1 of investment
- Investment in hydrogen and fuel cell technology would provide a favorable return
- There are favorable sites for deployment of hydrogen and fuel cell technology to meet the world's pressing energy needs, improve environmental performance, increase economic development, and create new jobs

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