

EXECUTIVE SUMMARY

Preliminary Findings

Preamble

In accordance with Section 64 of Public Act 06-187, the Connecticut Center for Advanced Technology, Inc. (CCAT) is pleased to submit to the Connecticut Department of Economic and Community Development (“DECD”), the following Preliminary Plan for fuel cell economic development in Connecticut. This Preliminary Plan has been developed to: (1) identify and assess market conditions for fuel cell and hydrogen technology; (2) analyze Connecticut’s hydrogen and fuel cell industry; and (3) assess the economic potential for Connecticut, including the economic impact of Connecticut’s hydrogen and fuel cell industry.

The following preliminary findings will be validated and refined within the Final Plan, which will be submitted by DECD to the Connecticut General Assembly on or before January 1, 2008:

Market Profile

- 1) The emerging markets for fuel cells and hydrogen technology include: stationary power/distributed generation, portable power for handheld electronics, and transportation.
- 2) Worldwide government spending for fuel cell and hydrogen infrastructure approached \$1.5 billion in 2004.
- 3) In 2005, the global sales of fuel cells generated approximately \$400 million in revenue.
- 4) Preliminary studies suggest that the total global fuel cell/hydrogen market is expected to generate as much as \$18.6 billion annually in revenue over the next decade. This would require an employment base of approximately 120,000. If the

Preliminary Plan

fuel cell/hydrogen industry captures a significant share of the transportation market, projected sales could generate \$35 billion annually in revenue over the next decade. This would require an employment base of approximately 230,000.

Connecticut's Position in the Fuel Cell Industry

- 1) Connecticut has been the leader and innovator of fuel cell technology and electrochemical technologies, since the 1950s, and pioneered its application for spacecraft, submarines, stationary power, and transportation.
- 2) Connecticut manufacturers and researchers have developed expertise in (1) all fuel cell technologies, including alkaline systems, proton exchange membrane (PEM), phosphoric acid, molten carbonate and solid oxides; (2) alkaline and PEM electrolysis technologies; and (3) applying these technologies to applicable markets.
- 3) Two of the major fuel cell developers and manufacturers in the world are located in Connecticut - FuelCell Energy, Inc. in Danbury and Torrington, and UTC Power in South Windsor. These companies dominate the fuel cell market for stationary power/distributed generation for fuel cells greater than 200 kilowatts (kW).
- 4) Several Connecticut suppliers, educational institutions, research facilities (e.g. Connecticut Global Fuel Cell Center), and the Connecticut Hydrogen-Fuel Cell Coalition, including the Connecticut Clean Energy Fund, support Connecticut's fuel cell industry.
- 5) Connecticut's fuel cell and hydrogen industry currently supports 927 direct jobs and 1,221 indirect jobs for a total of 2,148 jobs statewide. The fuel cell and hydrogen industry supports approximately 7,000 globally.
- 6) Connecticut's fuel cell and hydrogen industry generates approximately \$29 million annually in state tax revenue; approximately \$2 million annually in local tax revenue and over \$340 million annually in gross state product.

Preliminary Plan

Major Issues

- 1) Costs – increased production rates, and improved design and technology will be necessary to reduce costs;
- 2) Performance – recognition of reliability and durability;
- 3) Infrastructure – hydrogen refueling stations will be required to support the fuel cell transportation market;
- 4) Perception – utilization of hydrogen as a fuel has not been fully accepted in the market place and may be perceived as high risk;
- 5) Environmental – the positive environmental benefits of fuel cells and hydrogen are not fully considered;
- 6) Market – distribution channels are not fully developed for both fuel cell and hydrogen production systems;
- 7) Support – favorable government structure including education, workforce development, and policy needed to support market development; and
- 8) Threats – other states’ programs and foreign OEMs entering the market are increasing.

As mandated by Public Act 06-187, Sec. 64, the Final Plan will identify strategies to (1) facilitate the commercialization of hydrogen-based technologies and fuel cells; (2) enhance energy reliability and security; (3) promote the improved efficiency and environmental performance of transportation and electric generation with reduced emissions, reduced greenhouse gases, more efficient use of nonrenewable fuels, and increased use of renewable and sustainable fuels; (4) facilitate the installation of infrastructure for hydrogen production, storage, transportation and fueling capability; (5) disseminate information regarding the benefits of hydrogen-based technologies and fuel cells; (6) develop strategies to retain and expand hydrogen and fuel cell industries in Connecticut; (7) identify areas within the state transportation system that would benefit from the integration of potential mass transit and fleet transit locations with hydrogen or natural gas and hydrogen mixture refueling stations; and (8) identify areas in the electric and natural gas distribution system of the state that would benefit from the development

Preliminary Plan

of distributed generation through hydrogen or fuel cell technology as a reliability asset necessary for voltage control, grid security, or system reliability, or for the provision of required uninterruptible service at customer sites.¹ The Final Plan will also evaluate what the economic impact of a developed fuel cell and hydrogen industry will have on Connecticut's economy, and propose recommendations that will enhance Connecticut's position as a world leader in the fuel cell and hydrogen market.

CCAT will consult with the Connecticut Hydrogen-Fuel Cell Coalition, the Renewable Energy Investment Fund, the Connecticut Department of Transportation, Connecticut's electric and gas service providers, and Connecticut's hydrogen and fuel cell industrial base to develop the strategies for the Final Plan.

¹ Public Act 06-187, Sec. 64

Forward

As oil and other non-sustainable hydrocarbon energy resources become scarce, energy prices will increase and reliability for supply will be reduced. With such dependency of the U.S. economy on hydrocarbon energy resources, Americans will be severely affected by shortages of oil and natural gas. Recently Federal Reserve Chairman Ben Bernanke said, “The increase in energy prices is clearly making the economy worse off both in terms of real activity and in terms of inflation. There is no question about it.”²

While the threat of such shortages is real and potentially significant, strategic planning to guide consumers to alternative and more efficient energy resources in a timely manner will extend the time of use for available resources and reduce the impact attributable to shortages of hydrocarbon fuels. Further, the use of alternative energy and more energy efficient generation technologies may be able to improve environmental performance, reduce long-term costs, and create opportunities for economic development. Attractive technologies being considered by the energy industry and supported by a number of states are fuel cell and hydrogen generating systems.

As Connecticut is a world leader in the research, design, and manufacture of hydrogen and fuel cell related technologies, the State is uniquely positioned to develop the fuel cell/hydrogen market and facilitate a smooth transition from hydrocarbon fuels using conventional combustion technology to the use of efficient electrochemical technology. Such a transition will open markets for energy management in the industrial, commercial, institutional, and residential sectors, and thereby, develop opportunities for a substantial creation of high-paying jobs in Connecticut.

² AP Jeannine Aversa 7-21-06

Market Summary

The three primary global markets for fuel cells and hydrogen technology are: (1) stationary fuel cells, (2) portable fuel cells, and (3) fuel cell and hydrogen refueling associated with transportation. These markets are global and Connecticut is well positioned now and well positioned to expand its share for increased employment, increased sales, and increased research and development (R&D). Under existing trends, by the year 2010, Connecticut would be positioned to increase direct employment to over 1,635 jobs (a 12 percent, 716 job gain from 2005); sales would be over \$63 million (a 6.6 percent, \$17 million gain from 2005); and investment in R&D would be \$174 million (an 11 percent, \$71 million gain from 2005).

However, others estimate that hydrogen and fuel cell technology has the potential to be the dominant technology for distributed generation, automotive and transit bus transportation, and portable power as a replacement for batteries. Consequently, some view the hydrogen fuel cell industry as ripe for expansion, and have estimated, to be validated by the final report, that the global fuel cell/hydrogen market, when mature, is expected to generate as much as \$18.6 billion annually over the next decade. This would require an employment base of approximately 120,000. If the fuel cell/hydrogen industry captures a significant share of the transportation market, projected sales could generate \$35 billion annually in revenue over the next decade. This would require an employment base of approximately 230,000.³ The challenge for Connecticut is to develop a strategic plan that will enhance the development of the fuel cell/hydrogen market, counter the market obstacles which are impeding it, and to ensure that Connecticut maintains and increases its position as a world leader in the industry.

This preliminary assessment of the potential for growth in the fuel cell and hydrogen market is encouraging but suggests that the market drivers have not yet been sufficiently addressed for these technologies to fully replace the use of conventional base technologies. The barriers that are inhibiting market penetration include: high costs,

³ Source: Connecticut Department of Economic and Community Development

Preliminary Plan

unappreciated environmental values, cost consuming interconnections, complicated codes and standards, lack of adequate public awareness, investment needed to undertake advanced research and development, lack of continuous (large scale) automated production, and strong competition from rate-base supported grid generation load. The most significant barrier is cost, including life-cycle costs that raise the following critical issues as to the technologies' market acceptability:

Is there a global market sufficient to justify investment by Connecticut?

Yes. With a 13 percent share of a global market that includes \$353 million in annual sales and \$796 million in annual R&D investment, Connecticut now occupies a favorable position to maintain and expand this share for increased employment and gross state product. However, some estimate that the market will grow substantially, and revenues are expected to generate between \$18.6 billion and nearly \$35 billion annually over the next decade as hydrogen and fuel cell technology takes a larger share of the stationary power, portable power, and transportation markets. With a potential market of this size, Connecticut would be in an enviable position for substantial opportunities to increase employment, sales, revenue, and investment in R&D.

Can Connecticut companies capture a larger share of the global market?

While the question of how to increase Connecticut's share of the global sales, R&D and employment market will be the focus of the Final Report, there are no technical barriers that would preclude Connecticut companies from increasing their share of the global market. The fuel cell and hydrogen industry will need to grow within the same business climate that all industries face in Connecticut. Moreover, if Connecticut does not actively and aggressively seek to increase its share, it may face loss of sales, R&D expenditures and employment as other states and countries compete for fuel cell and hydrogen development activities.

Can costs drop to a level that will provide for effective competition and increased market penetration?

Yes. It has been estimated that with increased support for research and development, and if production were to increase, production costs could drop to levels closer to parity with conventional generation.

Will costs decrease if production were to increase?

Yes. It has been estimated that increased production could provide continuous manufacturing of fuel cells that will help to support research, testing, and deployment of hydrogen and fuel cell technology and achieve lower unit costs to effectively compete with traditional generation technologies.

Will supportive measures to be applied to increase market penetration be economically justified to earn a favorable return on public investment?

Yes. With appropriate support, to be determined by the Final Report, production could increase, unit costs will drop, and employment will increase. With favorable multipliers of 2.31 for employment, 1.84 for industrial revenues, and 1.72 for employee compensation, Connecticut is well positioned to invest in the hydrogen fuel cell industry with the potential for substantial indirect and induced effects.

Are there favorable locations for deployment and investment in Connecticut for hydrogen and fuel cell technology?

Yes. Connecticut would benefit substantially through R&D investment and deployment of hydrogen and fuel cell technology. Benefits would include advanced training and education for long-term support of industry needs; improved environmental performance and cleaner air in the state; improved reliability for the electric grid; and reduced costs for

Preliminary Plan

electric consumers. All of these values will help to create new jobs that are directly and indirectly associated with hydrogen and fuel cell technology.

In summary, data in this preliminary report suggests that there are favorable market conditions for the expansion of the hydrogen fuel cell industry in Connecticut, that public investment is appropriate and justified, that certain investment in hydrogen and fuel cell technology could provide a favorable rate of return for investors, and that there are favorable sites for deployment of hydrogen and fuel cell technology in Connecticut with potential to meet energy needs, improve environmental performance, and increase economic development and the creation of jobs.

This preliminary analysis was undertaken by CCAT with assistance from:

- fuel cell and hydrogen equipment manufacturers, including FuelCell Energy, Inc., GenCell Corporation, Infinity Fuel Cell and Hydrogen, Inc., UTC Power, and Distributed Energy Systems Corp.;
- University of Hartford, Quinnipiac University, and the University of Connecticut Global Fuel Cell Center;
- government agencies including the Connecticut Siting Council, Connecticut Clean Energy Fund, and the Connecticut Department of Economic and Community Development; and
- other members of the Connecticut Hydrogen – Fuel Cell Coalition, including Bradley, Foster & Sargent, Inc., GrowJobs CT, International Association of Machinists & Aerospace Workers, Millennium Cell Inc., and Updike, Kelly & Spellacy, P.C.

The detailed assessment and strategies of this plan will be presented in “The State of Connecticut Fuel Cell Economic Development Plan and Hydrogen Roadmap” and will be finalized on January 1, 2008, per Public Act 06-187.