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EXECUTIVE SUMMARY

CCEF TECHNOLOGY INVESTMENT STRATEGY STUDY

Prepared for:
Connecticut Clean Energy Fund

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Content of Report

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SECTION 1

Executive Summary

1.0 Executive Summary

The following executive summary provides an overview of the key objectives and results from the investment strategy work completed by Navigant Consulting, Inc. (NCI) for the Connecticut Clean Energy Fund (CCEF's) new technology investment program, Goal 2.

1.1 Context and Goals of the Investment Strategy

In January 2009, Navigant Consulting was commissioned by the CCEF to complete a *Renewable Energy/ Energy Efficiency Economy Study* to help CCEF establish an effective investment strategy for its new technology investments. The first phase of this work included a comprehensive baseline assessment of Connecticut's RE/EE economy with a census of CT companies and institutions, revenue and jobs. The Baseline Study is available at: www.ctcleanenergy.com/Navigant. The goal of the second phase that is discussed in this report was focused on providing guidance and recommendations to CCEF for new technology investments in renewable energy, energy efficiency and the supporting electric infrastructure (RE/EE/EI).

If CCEF does a good job investing, these new technology investments will represent a significant job creation and economic development engine in the next 3 to 5 years and beyond. They can also play an important role in supporting commercialization and adoption of RE/EE/EI technologies that are competitive with today's fossil fuel based technologies.

1.2 CCEF New Technologies and Infrastructure Development Group

Goals & Mandate

The CCEF New Technologies and Infrastructure Development Group is in charge of Goal 2 whose core mission is to accelerate incubation and commercialization of new technologies that become the future engine of Connecticut's (CT's) clean energy industry. These products and services will serve local and global markets. CT also seeks to grow renewable electricity generation and energy efficiency within the State and CCEF seeks to make technology investments that will support this goal.

Eligible Investment Areas

Eligible new technology investment areas for CCEF include renewable electricity generation and the supporting electrical infrastructure and advanced energy efficiency technologies, referred to as RE/EE/EI. The logic behind including advanced energy efficiency is its importance in reducing electricity demand (the need to generate electricity to begin with). These eligible investment areas define the technology scope for this study.

Programs

Goal 2 makes new technology investments through its Operational Demonstration Program, Cleantech fund, and pending Alpha Program:

- The Operation Demonstration Program supports demonstration and testing to validate the commercial viability of new technologies.
- The Cleantech fund provides equity investments to early stage companies and is administered through Connecticut Innovations.
- The Alpha Program, to be launched later in 2010, will support early stage research and product development of high risk, promising RE/EE/EI technologies.

1.3 Approach

The approach used to complete this study included the following key steps.

1) Develop a comprehensive list of technologies (over 300) in RE/EE/EI through joint discussions with industry and academic experts.

2) Develop priorities for four key selection criteria; technology maturity, business attractiveness, Connecticut fit and environmental criteria and associated subcategories (as shown in Table 1) jointly with the CCEF.
3) Develop and run a simple modeling framework that helped down select to a preferred list of technologies (approximately 80) based on the selection criteria and weights.
4) Identify technology/engineering gaps and key policy barriers that might prevent a broader scale adoption and implementation of the preferred technology list.
5) Organize the selected technologies around investment themes based on inherent synergies between the technologies such as capabilities required to execute and/or envisioned end use (e.g. building applications)

Table 1. Technology Selection Criteria

Technology (36%)	Business Attractiveness (36%)
• Technology Readiness Level • Disruptiveness of Technology	• Market Potential • Profitability Potential • Competitive Environment • Strategic Partnering Potential • Intellectual Property Potential • Time to Commercial Viability • Business Sustainability • Breadth of Market Applicability • Investment Required • Disruptive Business Opportunity
Connecticut Fit (21%)	**Environment (7%)**
• Human Resources – CT core competency • Intellectual Resources • Industrial Resources • Location and Infrastructure • Energy Security and Diversity	• Emissions Footprint • Other Emissions (NOx, SOx, Particulates) • Toxic materials in processing

• Natural Resources Availability • Job Creation Potential • Regulatory Risks	

The technologies were down selected to a preferred list of approximately 80, based on the selection criteria and associated scores assigned to each technology for the subcategories. These technologies were then analyzed for engineering/research and development opportunities. The policy gaps that could prevent adoption of these technologies were also analyzed. Technologies that required similar capabilities for development were then combined to create the investment themes and additional recommendations were developed in terms of policy and implementation to help assure successful commercialization of the proposed technologies.

1.4 Investment Strategy Recommendations

The investment strategy required to realize returns on these new technology investments requires concurrent focus on several elements including technology development, policy and implementation. The recommendations for each of these subcategories have been summarized below.

Technology Development Recommendations

Diversify new technology investments

Meeting CCEF Goal 2 objectives requires diversification across RE/EE/EI opportunities. Some of the top-ranked technology opportunities such as fuel cells and solar-PV systems already have support within Connecticut. Consequently, funding should be diversified into other areas such as waste energy recovery and use, high efficiency HVAC systems for buildings, and smart grid technologies where investments have been limited from a technology development perspective.

NCI recommends diversifying across the following five investment themes.

1. High efficiency building systems (and components e.g. HVAC)

High efficiency building systems (as shown in Figure 1) include technologies used in residential and commercial buildings to improve the energy efficiency. Priorities

include HVAC systems, lighting and building envelope improvements such as advanced insulation materials and windows. Additionally, investments in centralized control systems that actively manage system performance based on building occupancy and operational requirements will improve energy efficiency and management goals. Several Connecticut companies including Carrier and Emcor are developing these systems. Existing workforce competencies within the State can be leveraged to capitalize on the opportunities in this space.

Figure 1. Investment Theme 1 – High Efficiency Building Systems

2. Distributed power generation systems (including renewable energy options)

Distributed power generation systems (as shown in Figure 2) include several renewable (e.g. solar, waste heat recovery and use, geothermal, and fuel cells) and non renewable options (e.g. CHP and high efficiency stationary engines/turbines). These systems can be sized to meet the energy requirements of a building or facility. Renewable and non renewable options can be integrated to meet overall demand. For example, PV systems can be used to meet peaking loads while CHP systems are used for the base load of the building. Furthermore, significant quantities of waste heat from industrial and other facilities can be recovered and used. CHP technologies and

applications have broad market potential locally and globally. In this regard several Connecticut companies including Pratt Power, Fuel Cell Energy etc. are well positioned to capitalize on the opportunities within this investment theme.

Figure 2. Investment Theme 2 – Distributed Power Generation Systems

3. Industrial energy efficiency systems

Several of the technologies such as CHP and controls identified in earlier themes can be leveraged to achieve higher energy efficiency in the industries within the state. Investments in automation and controls can also help in this regard (as show in Figure 3). This area represents a near term investment opportunity because significant amounts of waste heat for example are still produced by industrial processes and not utilized due to economic reasons. Additionally, high efficiency variable speed drives, motors etc. can also help enhance the overall efficiency of an industrial process.

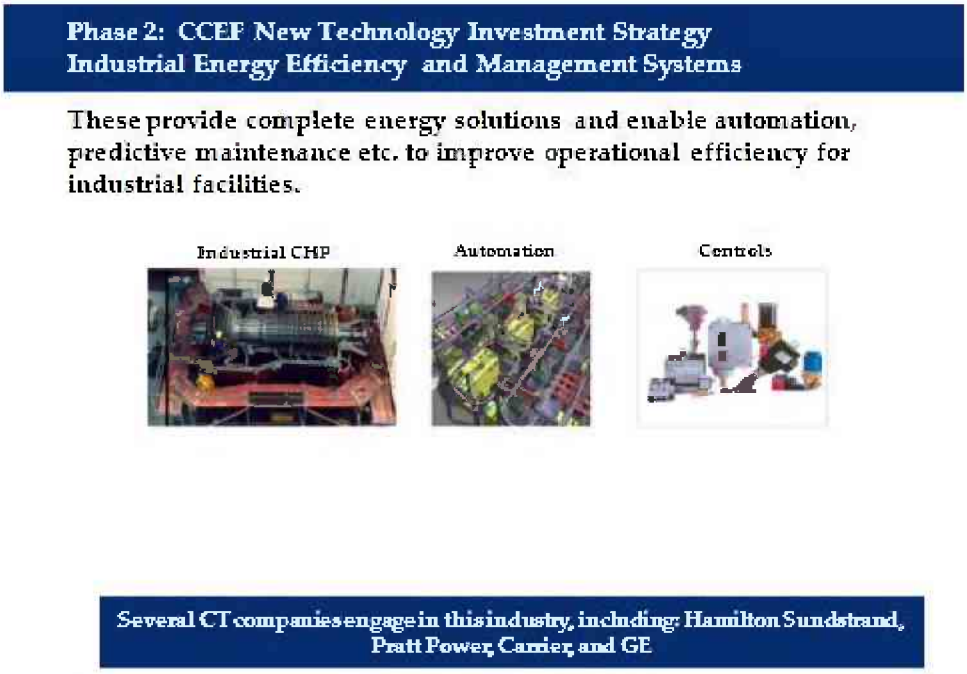

Figure 3. Investment Theme 3 – Industrial Energy Efficiency Systems

4. Utility power generation and power management systems

Utility scale power generation solutions (as shown in Figure 4) such as utility scale wind, solar, and biomass power along with power management features such as smart meters, controls, and energy storage can all be combined with demand side management at facilities to help in the creation of a smart grid. The concept of a smart grid focuses on improving the overall efficiency of the grid through incorporation of features that enable use of electricity only as it is needed and effectively shifting production to parts of the grid that requires power when other parts are powered down. This in turn requires extensive communication between the grid and not only the end users along, but also with other parts of the grid (on the generation, transmission and distribution side). This is an area of extensive growth and significant investment from both a public sector and private sector perspective.

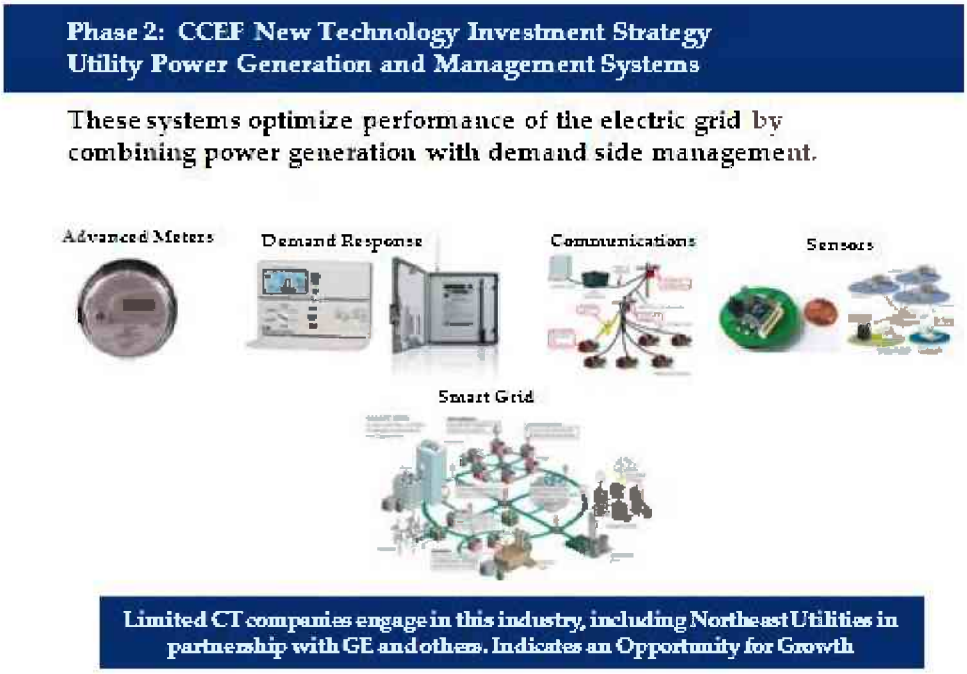

Figure 4. Investment Theme 4 – Utility Power Generation and Management System

5. Renewable fuel production technologies

The energy mix includes both electricity production and fuels production. The area of renewable fuel production technologies (as shown in Figure 5) could potentially address both areas because the fuels that are generated can be used for power generation or transportation applications. Investments could focus on several areas including the production of biodiesels and cellulosic ethanol from biomass sources such as wood waste, agricultural waste, dedicated energy crops, and algae or alternatively focus on the production of renewable hydrogen from electrolysis and photochemical processes. Several oil companies including Exxon, BP, and Shell have all made significant investments in recent years in biofuels and investments in this area could result in a realization of collaborations with some of these entities. Additionally, significant funding from the US Department of Energy's ARPA-E program has been provided to companies proposing various "solar to fuels technologies". Investments in these critical areas are lacking within the state and existing incentives should be expanded to include these in the list of eligible technologies.

Figure 5. Investment Theme 5 – Renewable Fuels Production Systems

Policy Recommendations

Focus incentives on emerging EE and EI technologies going forward.

In general, Connecticut has very strong policies to support development of a vibrant RE/EE/EI industry within the state. There is support for renewable energy technology development and deployment through CCEF. There is also support for deployment of mature energy efficiency technologies through the Connecticut Energy Efficiency Fund (CEEF). There is, however, limited support for technology development in emerging energy efficiency technologies (e.g. building envelope measures such as switchable windows and integrated controls) and electrical infrastructure technologies (e.g. energy storage, smart grid metering and controls). Additionally, support for renewable fuels is limited and these areas require support for the broader investment strategy to be realized.

Implement similar models as those used to build CT's fuel cell industry to create other industries around investment themes identified.

Connecticut's investment in the fuel cell industry is an example of how investments in innovation and early stage technology development can accelerate an industry to create high-paid jobs that develop and deliver products and services globally. These

fuel cell industry investments have leveraged CT's strengths in innovation, product development, materials science, precision manufacturing, and a highly educated work force. Similar efforts should be made in other sectors of the RE/EE industry, helping to diversify CT's industrial base. They should follow the model and leadership set by the fuel cell industry. One opportunity in this regard is the area of integrated building energy management systems which incorporate energy information gathering along with controls of the buildings comfort systems and distributed generation devices to deliver near net zero energy buildings. Several of the elements to support such a cluster exist including industry leaders such as Carrier, Emcor, Schuco, and GE. The support for this type of work could be increased through entities such as the Center for Clean Energy Engineering.

Focus on supporting the front-end and back-ends of the value chain, and invest only in manufacturing activities that align with core capabilities in the state.

The highest paid jobs are in front-end activities (e.g. RD&D, product development, and design for manufacturing), management and back-end activities (e.g. sales, marketing, installation, servicing, and financing). Once technologies become mature, manufacturing is usually commoditized, which is not sustainable in Connecticut if labor rates and energy costs are high. Investing in manufacturing capabilities that have multiple industry off-ramps could be one method for moving past this limitation. For example, similar capabilities are required for wind turbine manufacturing as those required for jet engine manufacturing. Sufficiently diversifying the "turbine manufacturing" base across aerospace, wind, hydro, geothermal power and industrial/DG could be one method of hedging against downside risks in specific industries.

Implementation Recommendations

Solicit investments in currently under-supported areas through an RFP process.

CCEF could solicit ideas/concepts in the technologies that are currently not being developed around the investment themes with a specific focus on technologies that have been less covered. This will help focus investment activities on more mature, high impact technologies. A transition can be made to the next, less mature, technology tier once initial investments have yielded returns. Several energy efficiency technologies under the high efficiency buildings or industrial energy efficiency themes would be ideal candidates for an initial RFP. This could include HVAC technologies

that focus on overall system integration of cooling, dehumidification, indoor air quality and controls projects.

Nurture less mature, high potential technologies through R&D collaborations.
Less mature technologies should be nurtured through joint collaborations with State and regionally located research institutions such as the Connecticut Center for Clean Energy Engineering, Yale, CCAT, and UTRC to demonstrate technical viability in a lab or research setting before transitioning into the CCEF portfolio for commercialization support. Two potential technology areas that warrants this type of approach is likely biofuels and solar to fuels.

Support industry partnerships that leverage and build established industrial strengths.
Several technologies such as home/building automation (aligned with HVAC/building energy systems capabilities of Carrier, GE etc.), wind turbine manufacturing (aligned with competencies in the aerospace cluster in the state e.g. Sikorsky, Hamilton Sundstrand) could be developed by or directly transitioned into established Connecticut companies. This approach could be realized through an RFP process designed to align technology development investment with existing industrial strengths and infrastructure. Given financing limitations of large corporations, it may be prudent to structure this as a grant program with cost share requirements (as opposed to loan repayment and royalty provisions).