V.A.10 Total Cost of Ownership Model for Design and Manufacturing Optimization of Fuel Cells in Stationary and Emerging Market Applications

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Project End Date: September 31, 2016

Fiscal Year (FY) 2012 Objectives

- Literature review including review of fuel cell design and manufacturing patents
- Technical and performance specifications defined for technology/application anchor points
- Detailed design plans and technology bill of materials for low-temperature (LT) polymer electrolyte membrane (PEM) systems
- Ballard and other industry partners engaged

Technical Barriers

- High capital and installation costs
- Potential policy and incentive programs may not value fuel cell total benefits

This project addresses the following technical barriers from the Manufacturing R&D section (Chapter 3.5.5) of the Fuel Cell Technologies Program Multi-Year Research, Development and Demonstration Plan (http://www1.eere.energy.gov/hydrogenandfuelcells/mypp/):

(A) Lack of High-Volume Membrane Electrode Assembly Processes

(B) Lack of High-Speed Bipolar Plate Manufacturing Processes

Technical Targets

This project develops total cost of ownership models for stationary fuel cell applications in emerging markets. The objectives are to include direct manufacturing costs and life cycle costs and to extend existing cost models to include possible ancillary financial benefits such as carbon credits, end of life recycling, and reduced costs for building equipment operations. This work will quantify more fully the benefits of fuel cell systems taking into account life cycle assessment, air pollutant impacts and policy interactions.

A key output of this project will be a publicly available total cost of ownership modeling tool for the design and manufacturing optimization of fuel cell systems for stationary and emerging market applications with the ability to do sensitivity analysis toward meeting 2015 and 2020 DOE cost targets.

TABLE 1. DOE multiyear plan system equipment cost targets for fuel cell combined heat and power (CHP) systems

Characteristic	2015 Target	2020 Target
10 kW CHP System	$1,900/kW	$1,700/kW
100 kW CHP System	$2,300/kW	$1,000/kW

FY 2012 Accomplishments

- Literature review completed for fuel cell system cost studies, market studies, and patent review for LT PEM stack components.
- CHP functional requirements characterized in the LBNL DER-CAM model (Distributed Energy Resource Customer Adoption Model) to model fuel cell system market penetration and operating capacity parameters for power and heat.
- Functional specifications for combined heat and power applications defined for LT PEM fuel cell systems.

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Introduction

The DOE has supported cost analysis studies in the past for fuel cell systems, notably automotive systems [1]. This work extends cost analysis studies to stationary applications and emerging market applications such as combined heat and power and back-up power systems. Detailed cost studies can develop cost sensitivities to stack components, materials, and balance-of-plant components and identify key cost component limiters such as platinum loading. Manufacturing cost sensitivities as a function of system size and annual manufacturing volume are another key output. Such studies can help to validate DOE cost targets or highlight key requirements for DOE targets to be met.

This work extends existing cost models to include possible ancillary financial benefits such as carbon credits, end of life recycling, and reduced costs for building equipment operations. Thus a more comprehensive picture of fuel cell system benefits is provided, consistent with a policy and incentive environment that increasingly values these ancillary benefits. We plan to develop optimized system designs for the lowest manufacturing cost and total cost of ownership as a function of application/functional targets, capacity, and production volume. Three fuel cell technologies will be included (low- and high-temperature [HT] PEM and solid-oxide) and initial stationary applications to be studied are combined heat and power and back-up power.

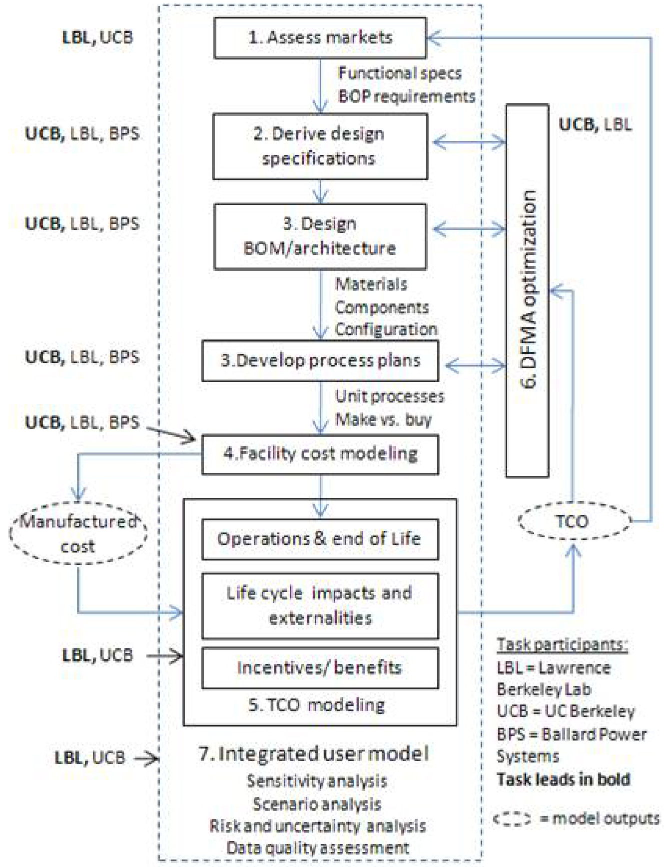

FIGURE 1. Research and Modeling Approach

Approach

The overarching approach is to utilize Design for Manufacturing and Assembly (DFMA®) techniques to optimize system design, materials and manufacturing flow for lowest manufacturing cost and total cost of ownership. System designs will be developed and refined based on the following: (1) existing cost studies where applicable; (2) literature and patent sources; (3) industry and national laboratory advisors. The total cost of ownership model will be implemented in Analytica and include manufacturing costs, operations and end of life disposition, life cycle impacts and policy incentives and benefits. Other software tools employed include commercially available Boothroyd Dewhurst DFMA® software, existing life-cycle analysis database tools, and LBNL exposure and health impact models. The overall research and modeling approach is shown in Figure 1.

Results

In this start-up phase of work, the team has completed literature review of existing fuel cell system cost studies [1,2,3], market studies [4,5], and patent review for LT PEM stack components. Literature review of cost studies were focused on capturing the scope, key learning, and key assumptions of each study. The MEA followed by the bipolar plates dominate stack costs and the studies primarily focus on direct manufacturing with vertical integration. General market studies identify fuel cell cost, durability and utilization as key drivers. Forklift/material handling systems and backup power systems were highlighted as key market opportunities with some opportunity for micro-CHP in colder climates.

CHP functional requirements and an initial characterization of realistic operational parameters were modeled using LBNL's DER-CAM [6]. Operational parameters such as duty cycles will be an input to the total cost of ownership model and will vary as a function of building type and climate zone. DER-CAM is a cost optimization tool for the deployment of distributed energy supply sources such as combustion engines, solar photovoltaic, and fuel cell systems in addition to utility-provided power. Currently DER-CAM utilizes the California Commercial End-Use Survey database of commercial building electrical and thermal demand profiles in California but will be expanded to include building profiles from other regions. DOE cost targets for 2020 were utilized to model fuel cell system penetration and operating capacity parameters for power and heat. Figure 2 shows the DER-CAM output for a large office building in San Diego showing

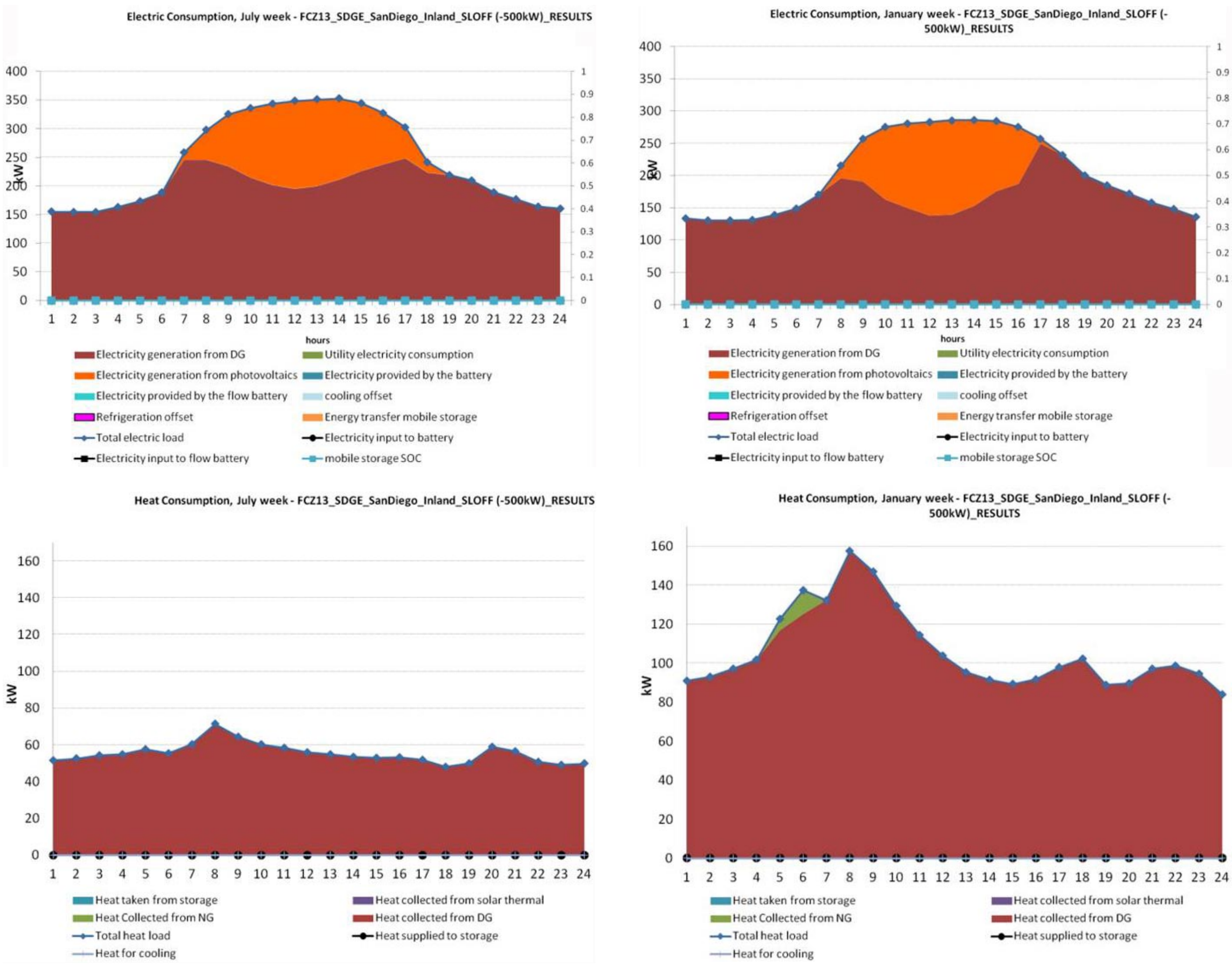

FIGURE 2. Large office building load profiles in San Diego and build-out of distributed energy resources including 250 kW HT PEM fuel cell system for electricity (top) and heating (bottom)

that a HT PEM fuel cell system provides a fairly steady supply of power and virtually all the thermal load for this building.

Based on literature review of company specifications sheets, engineering judgment, and consultation with Ballard Power Systems, initial functional specifications have been defined for combined heat and power applications for LT PEM systems. This includes the cell stack and system sizing, and estimates for parasitic and system efficiencies. This will be the basis for system design and costing activities.

Conclusions and Future Directions

- This project provides more comprehensive cost analysis for fuel cell systems in emerging markets including ancillary financial benefits.
- The approach employs DFMA® analysis cost modeling including mass flow and energy balance for integrated lifecycle cost analysis impacts.
- Future work will focus on system designs, balance-of-plant definition and material/component bill of materials and costing.

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