V.A.7 Enlarging the Potential Market for Stationary Fuel Cells Through System Design Optimization

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Project End Date: Project continuation and direction determined annually by DOE

Fiscal Year (FY) 2011 Objectives

- Model fuel cells in realistic combined heat and power (CHP) and combined cooling, heat and power (CCHP) applications to quantify the potential benefits of fuel cell-based distributed power for commercial buildings in the United States
- Identify optimal fuel cell sizes and control strategies based on analysis of the tradeoffs between manufacturing fuel cells that are perfectly matched to every application and fuel cells that are economical to manufacture.

Technical Barriers

This project addresses the following technical barriers from the Fuel Cell section of the Fuel Cell Technologies Program's Multi-Year Research, Development and Demonstration Plan (MYRDDP):

(B) Cost

(C) Performance

Even though the specific performance requirements differ from transportation applications, some of the technical challenges for stationary and other fuel cell systems are the same. For example, the overall cost of these fuel cell power systems must also be competitive with conventional technologies or offer enhanced capabilities. However, stationary and other fuel cell systems have an acceptable price point that is considerably higher than transportation systems.

Technical Targets

The Stationary Fuel Cell Modeling project will provide information about how achieving performance and cost targets for fuel cells in stationary applications could affect the competitiveness of fuel cells in stationary CHP and CCHP applications. The modeling effort will support the fuel cell MYRDDP technical and cost targets by evaluating realistic in situ building energy cost and emissions for CHP fuel cells that meet the targets. The values listed in Table 1, which is an excerpt of selected technical and cost targets for proton exchange membrane (PEM) fuel cell systems, are an example of the types of system characteristics that can be analyzed using the model. The modeling effort will also provide insight into the relative impacts of performance and cost targets on the overall lifecycle cost/benefit of CHP and CCHP installations.

Approach

The model must analyze the tradeoffs between manufacturing fuel cells that are perfectly matched to every application and fuel cells that are economical to manufacture. Therefore, two sub-functions must be optimized together: (1) a function to analyze fuel cells' interactions with various building types and occupancy patterns in various climates, and (2) a function to estimate the cost associated with manufacturing fuel cells of various types and sizes at various production rates. Figure 1 schematically illustrates the interactions between the model functions.

The project is divided into four tasks for 2011.

1. Literature review: Gather information about existing fuel cell and CHP/CCHP models with the goal of identifying useful modeling strategies and identifying potential benchmarks for model validation.
2. Collect building load and other input data: Initially, much of this effort will emphasize identifying data gaps and assessing data quality/needs.
3. Develop graphical user interface proof-of-concept design: Initial emphasis will define the output from the model to meet the overall objective.
4. Demonstrate proof-of-concept tool: The goal of this task is to produce a working model that is capable of providing preliminary results that are reasonably accurate by the end of FY 2011.

TABLE 1. Example Technical Targets for Stationary Fuel Cells That Will Be Evaluated in the Stationary Fuel Cell Model

Excerpted from the 2007 Multi-Year Research, Development and Demonstration Plan Table 3.4.4 Technical Targets: Integrated Stationary PEM Fuel Cell Power Systems (5-250kW) Operating on Reformate and 3.4.5 Technical Targets: Stationary PEM Fuel Cell Stack Systems (5-250 kW) Operating on Reformate				
Characteristic	**Units**	**2003 Status**	**2005 Status**	**2011 Targets**
Electrical Energy Efficiency @ Rated Power	%	30	32	40
CHP Energy Efficiency @ Rated Power	%	70	75	80
Fuel Cell Stack System Cost	$/kWe	N/A	1,500	530
Transient Response Time (from 10% to 90% power)	seconds	<3	<3	<3
Durability @ <10% Rated Power Degradation	hours	15,000	20,000	40,000
Emissions (combined NOx, CO, SOx, hydrocarbon, particulates)	g/1,000 kWh	<8	<8	<1.5

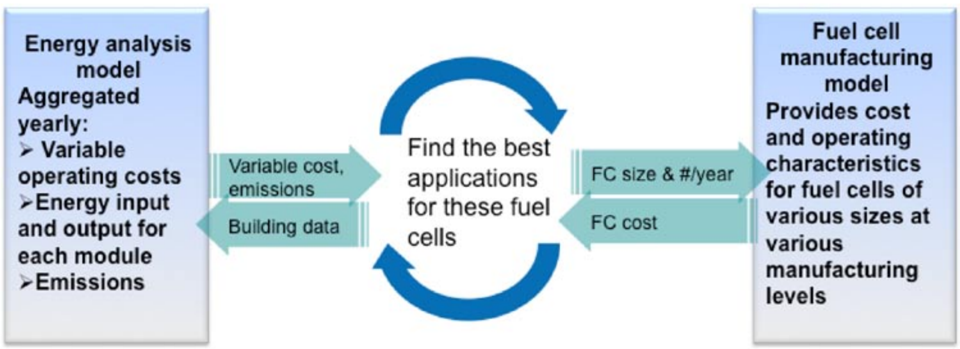

FIGURE 1. Interaction Between Fuel Cell CHP/CCHP Performance Model and Manufacturing Cost Model

FY 2011 Accomplishments

Tasks 1 and 2

- Existing models for benchmarking, partners, and reviewers were identified.
- Attributes for an initial set of buildings, climate, fuel prices, and emissions were collected and entered into an extensible database.
- Attributes of fuel cell manufacturing and performance were collected or estimated for an initial set of fuel cells (proton exchange membrane and solid oxide).

Tasks 3 and 4

- The layout and primary functional screens of the user interface were developed.
- Sub-modules were developed for the initial set of equipment.
- A flexible control strategy was developed.

Future Direction

In FY 2012, NREL will perform the following tasks:

1. Assemble full set of building inventory data and additional fuel cell models.
2. Continue verification and refinement of embedded models and model documentation.
3. Perform initial full-scale optimization analyses.

FY 2012 Planned Milestones

1. Complete draft stationary fuel cell model users guide and model documentation including:
   – Operation of the model including default values and acceptable ranges for input values.
   – Documentation of sources and meta-data for embedded databases and models.
   – Documentation of equations and validation of fuel cell and balance of plant models.
2. Compile detailed plan and prioritized list of proposed additions/enhancements to the model.

Potential Future Model Capabilities

- Interface with building models/or incorporate simple building modeling capability.
- Enhanced environmental analysis capabilities.
- Built-in comparison to other CHP technologies.
- Batteries and/or thermal storage.
- Multi-building/district heating scenarios.
- Hydrogen production for vehicles.