V.H.5 Enlarging the Potential Market for Stationary Fuel Cells Through System Design Optimization

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Project Start Date: January 1, 2011
Project End Date: Project continuation and direction determined annually by DOE

Overall Objectives

Build an open-source tool that helps combined heat and power (CHP) fuel cell developers, end users, and other stakeholders to do the following for their systems:

- Drive economies of scale and cost reduction
- Determine the appropriate sizing to reduce cost at single installations
- Integrate to commercial building control and heating, ventilation and cooling (HVAC) systems to maximize durability and minimize lifecycle cost
- Compare performance relative to incumbent technologies
- Determine optimum system configuration
- Evaluate potential market penetration for new or existing product lines.

Fiscal Year (FY) 2013 Objectives

- Implement updated dispatch for fuel cell system dispatch and control into the model.
- Model verification against actual building/CHP installations.
- Demonstrate the fuel cell model to the Fuel Cell Technologies Office. This demonstration will serve as the basis for a Go/No-Go decision on further work for the project.

Technical Barriers

This project addresses the following technical barriers from the Fuel Cell section of the Fuel Cell Technologies Office Multi-Year Research, Development, and Demonstration Plan:

(A) Durability

(B) Cost

(C) Performance

Technical Targets

This project is providing a tool to fuel cell manufacturers, end users and other stakeholders to help them reduce the cost of fuel cell CHP installations by optimizing their sizing, combining them with hybridizing technologies such as thermal energy storage and batteries, dispatching them in cost-optimal ways, and investigating the fuel cell sizes and features to best address the national market. Relevant DOE targets (2020) are:

- Installed cost, natural gas: $1,500/kW
- Operating lifetime: 40,000-80,000 hours
- CHP energy efficiency: 90%

FY 2013 Accomplishments

- This project successfully implemented four new dispatch strategies which can reduce the lifetime costs of installing and operating fuel cell CHP systems in commercial buildings.
- This project successfully formed a users' group which allows users to test, use and suggest modifications to the software. Compiled versions of the code are under evaluation with eight organizations including Advanced Research Projects Agency–Energy, other national labs, and industrial fuel cell developers.
- The project successfully passed a Go/No-Go stage gate in July 2013.

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INTRODUCTION

This project aims to create an open-source software tool which allows fuel cell developers, their potential customers and other stakeholders to evaluate the ability of fuel cell installations to save money relative to the grid/natural gas paradigm. The model includes 768 model building profiles covering the major American Society of Heating, Refrigerating and Air-Conditioning Engineers climate zones in the United States.

The model can perform design optimizations on single fuel cells and building combinations, campuses of multiple buildings, chillers, energy storage technologies, and onsite renewables such as solar and wind.

APPROACH

The approach taken by the research team is to build a flexible, configurable model which allows users to create modules for the various components which make up a project scenario (fuel cells, energy storage, chillers, buildings and campuses). NREL has teamed with the University of California, Irvine as a sub-contractor to leverage their extensive expertise in this area. In addition, NREL is working cross-center within the lab drawing extensively on the expertise of the Commercial Building group within NREL, to provide model building profiles.

RESULTS

The modeling effort has greatly expanded the number and types of analyses which can be completed. Four new dispatch/control strategies were introduced which can help reduce overall lifecycle costs of stationary fuel cell installations. New modules include vapor compression and absorption chillers (Figure 1), thermal energy storage (Figure 2), on-site renewables, time-of-use pricing in 20+ cities, a sensitivity analysis capability (Figure 3), national impact assessment (Figure 4), and design based on real (as opposed to model) building data.

CONCLUSIONS AND FUTURE DIRECTIONS

Future work will include more outreach and expansion of the users' group to be more inclusive, and add a structured way to receive feedback. Ultimately the desire of the team is to make the software open source to the users' group.

Proposed new work for FY 2014 includes (note, not all of these may be adopted into the final plan):

- Cost optimization instead of area under demand curve (brute force for energy charges only)
- Scale installation to demand with fixed fuel cell sizes based on multiples of baseline system e.g., 4x300 kW
- Advanced controls (e.g., predictive control) with physical distributed generation system models and comparison to ideal dispatch:
  - Single installation level of analysis

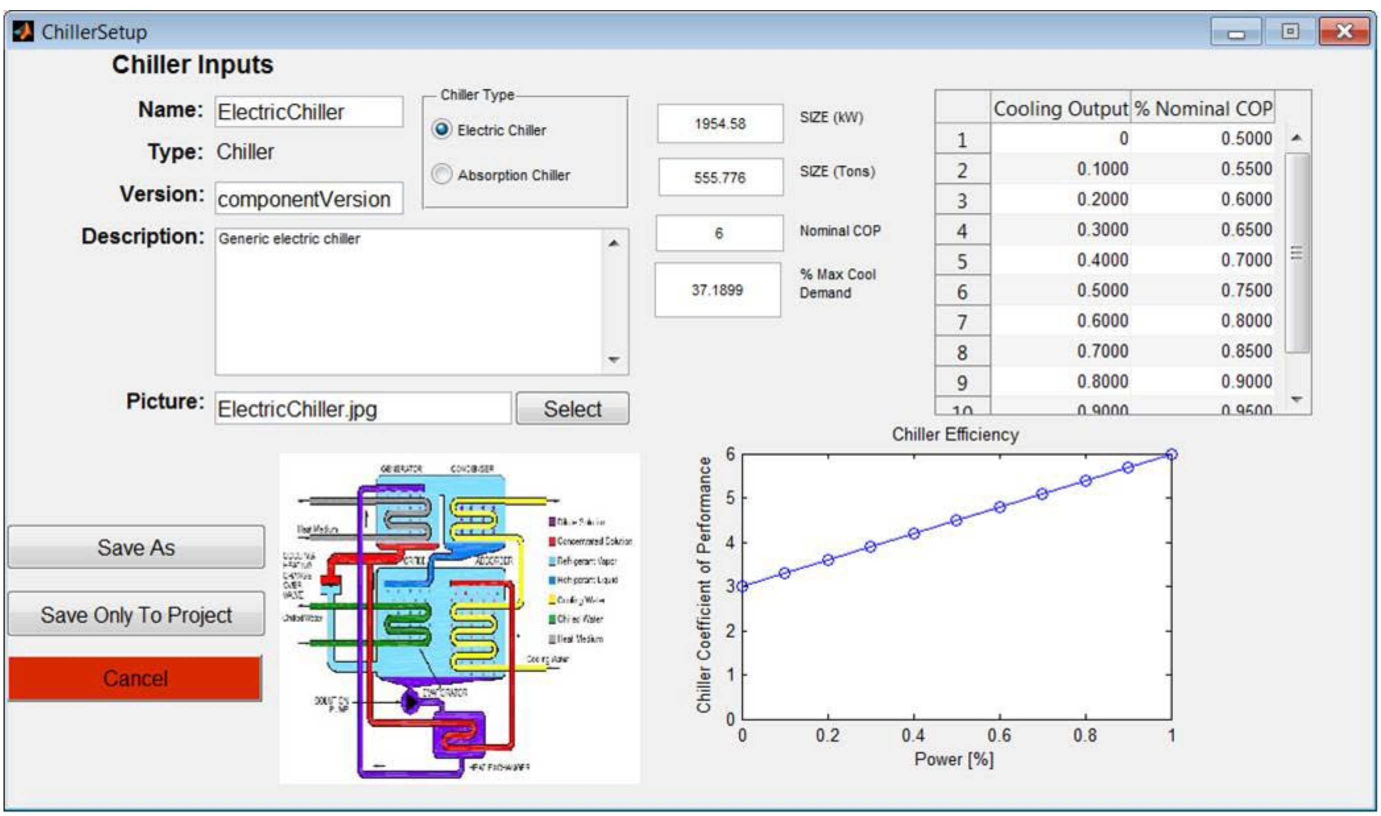

FIGURE 1. Module configuration screen for chillers, allowing users to easily configure both vapor compression and absorption chillers.

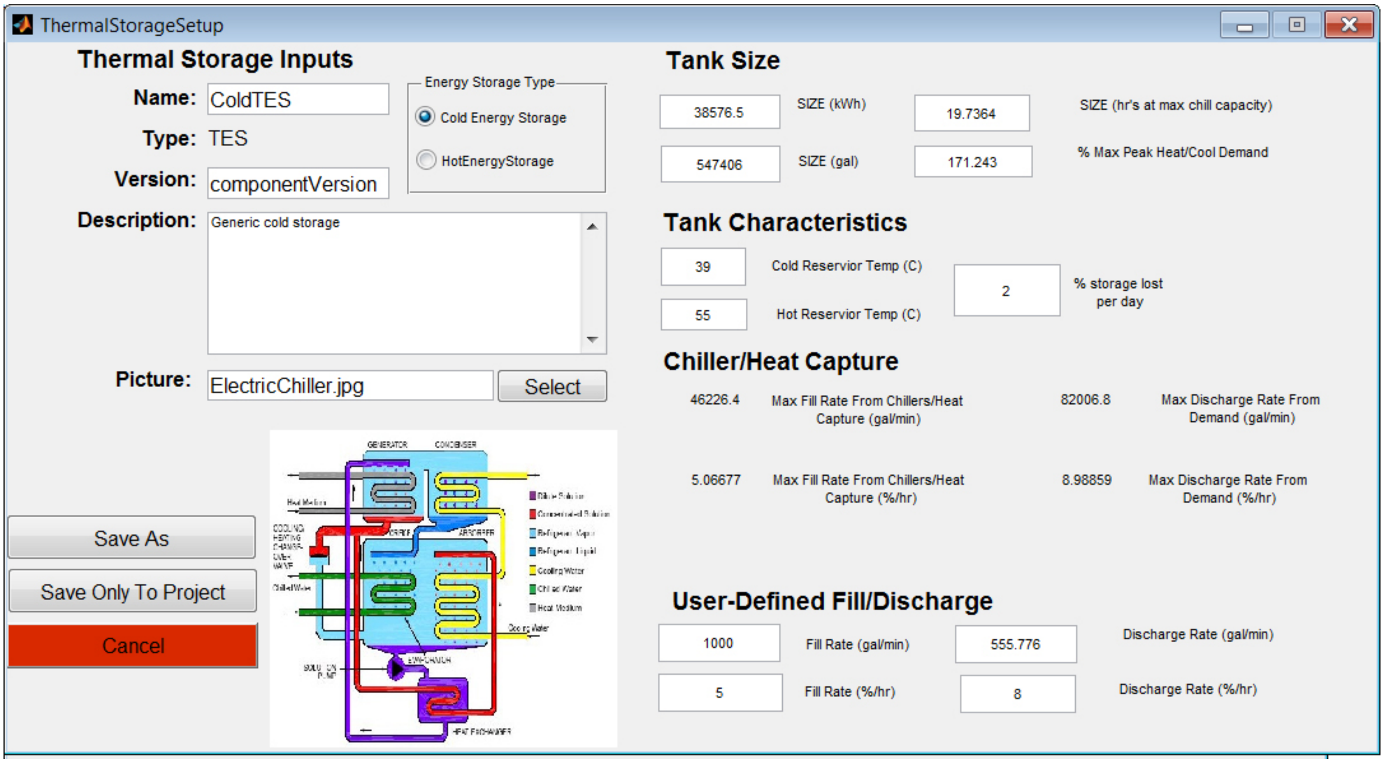

FIGURE 2. Module configuration screen for thermal energy storage, allowing users to easily configure both hot and cold water energy storage.

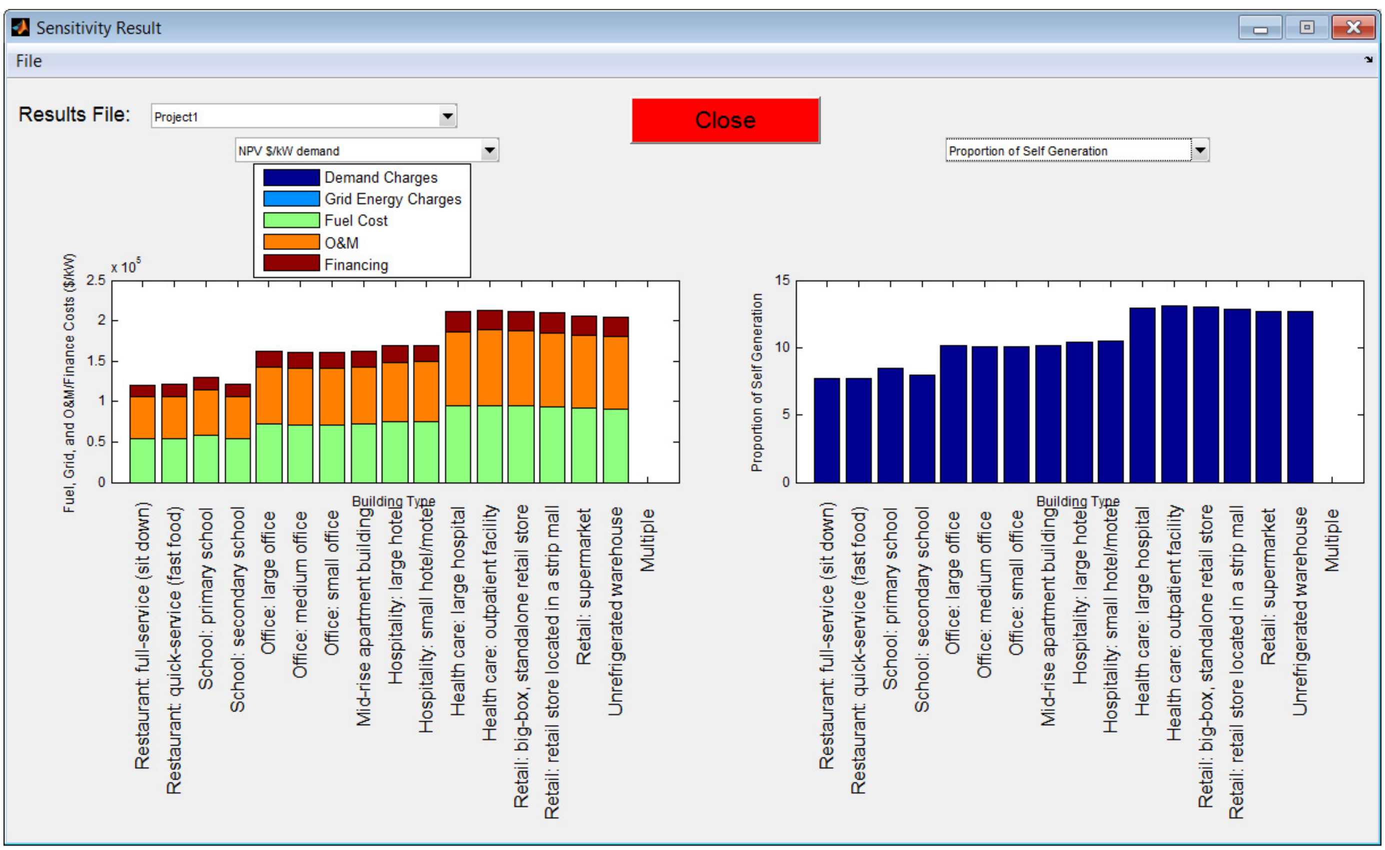

FIGURE 3. A sample sensitivity study showing net present value (NPV, $/kW) for the analysis scenario for various building types (left inset), and the proportion of self-generation (%) (right inset).

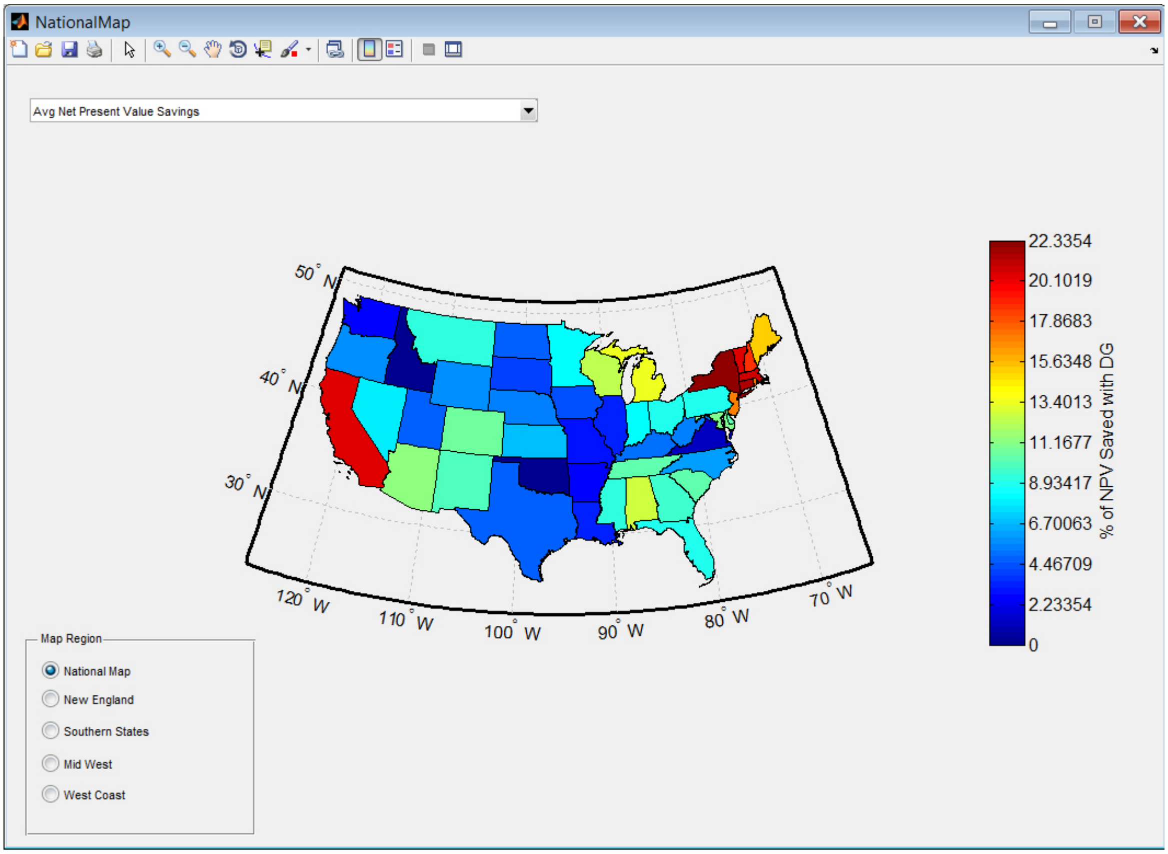

FIGURE 4. A sample map showing the average net present value savings in the continental United States for a sample analysis scenario.

- Building energy demand profiles:
  - Adoption of Pacific Northwest National Laboratory building profiles
  - Addition of American Society of Heating, Refrigerating and Air-Conditioning Engineers 90.1-2007 standard
  - Allow easy user upload of flat data files and conversion to Distributed Generation Building Energy Assessment Tool native format.
- Commercial Building Energy Consumption Survey (CBECS):
  - Update building inventories based on output from CBECS 2012.
- Refinement of economics for scenario analyses:
  - Database of State Incentives for Renewable Energy
  - Projections for changes in utility prices
  - Regional natural gas prices
  - Regional variation in energy vs. demand charges
  - Variation in utility costs and energy vs. demand costs with scale of installation
  - Variation in building sizes of same class (e.g., not all hospitals = 1,200 kW)

FY 2013 PUBLICATIONS/PRESENTATIONS

1. Enlarging Potential National Penetration for Stationary Fuel Cells through System Design Optimization, Fuel Cell Seminar, Uncasville, CT., November 2012.

2. Webinar with fuel cell OEMs, online, March 2013.

3. Enlarging Potential National Penetration for Stationary Fuel Cells through System Design Optimization, Annual Merit Review, Washington, D.C. May 2013.

4. Distributed Generation Build-out Economic Assessment Tool (DG-BEAT), University of California, Irvine, Irvine, CA. June 2013.