CONTROLS

RESIDENTIAL FUEL CELL PHOTOVOLTAIC SYSTEMS

OVERVIEW

Solar photovoltaic (PV) arrays have been used to meet residential electrical energy needs for many decades now. One of the major challenges for PV systems remains energy storage. With the emergence of regenerative or reversible fuel cells (RFC), we gain access to a new energy storage device that is both analogous to rechargeable batteries and that may also have unique advantages in comparison to them in this application. RFCs use a single anode/cathode electrode pair that is bi-functional, allowing operation in both electrolysis and fuel cell modes. The current project includes designing, analyzing, and testing system components to determine the feasibility of RFC use and the relevant system dynamics for residential power applications.

GOALS

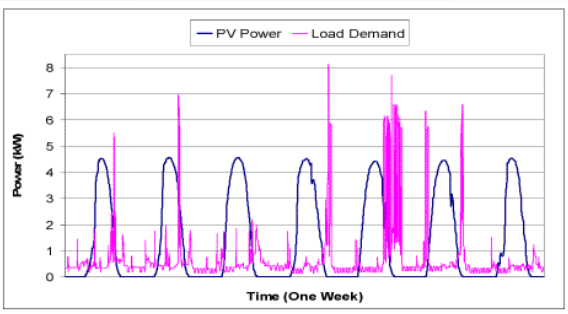
The goals of this NFCRC effort are to:

- Measure dynamic power demand for a typical residence
- Develop dynamic models for each of the components of a residential power system using PV and RFCs
- Design various systems capable of meeting the residential power demands
- Analyze the performance of these systems and compare the effectiveness of RFCs to traditional energy storage technologies

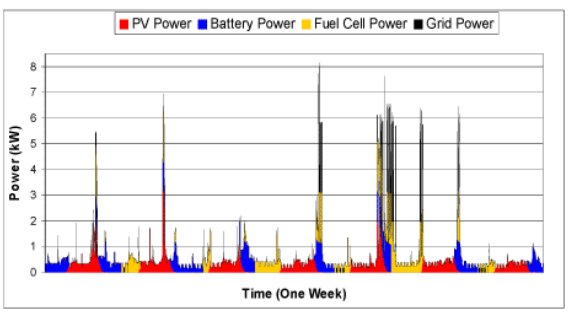
RESULTS

A model of a solar-hydrogen powered residence, in both stand-alone and grid-parallel configurations, was developed using Matlab/Simulink ®. The model assesses the viability of employing a RFC as an energy storage device to be used in conjunction with PV power generation. Other modes of energy storage such as batteries and hybrid storage are also evaluated in an effort to both compare the dynamics of RFC performance and obtain the optimum hybrid system design.

Both PV power output (6 kW nominal amorphous silicon, located at UCI) and residential load demand (6 person family home, Irvine, CA) were measured for the week of 8/2/03 – 8/9/03. PV power supply was found to be poorly matched in time to residential power demand. As a result, energy storage was found to be required to meet 66% of the power needs including peak demand.



Residential Load Demand and PV Power Supply (8/2/03-8/9/03)



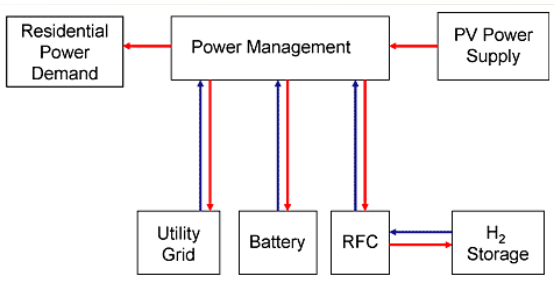
Grid-Parallel Power Balance by Source (1kW Fuel Cell, 1.9kW Electrolyzer, 500A-hr Battery)

PRELIMINARY FINDINGS

A major advantage of RFCs is device independent energy storage capability (hydrogen tank storage vs. internal chemical energy storage in batteries).

Benefits of hybrid storage were found to include, (1) RFC increases PV utilization, (2) RFC allows batteries to operate at higher power density and efficiency, (3) RFC produces hydrogen, a flexible fuel that may be used for electricity, vehicles, heating and cooking, (4) hydrogen storage extends energy density capacity beyond that of using batteries alone, allowing longer term energy storage for the winter.

The type of control strategy employed was found to be a major factor affecting system efficiency and in realizing energy storage size reductions.



Simulink Model Schematic

RECENT PUBLICATIONS

"Understanding the Dynamics of Renewable Reversible Fuel Cell Power for Residential Applications“ J.D. Maclay, J. Brouwer, G.S. Samuelsen, 15th National Hydrogen Association Conference, Paper # 76522, April, 2004.

“Regenerative Fuel Cell Power for Potential use in Renewable Residential Applications” (To be Submitted to: Int’l Journal of Hydrogen Energy)

PERSONNEL

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