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Integrated Hydrogen Demonstration Facility Design Study

Contractor
Northern Power Systems

Cosponsors
None

Project Officer
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Background
This project began with the vision of the South Coast Air Quality District (SCAQMD) for a hydrogen system at their facility to serve as a demonstration system, provide real world economic and environmental benefits, and to advance the development of this important technology area.

Project Objective
The objectives of this feasibility study were to compile an equipment review including costing, complete a preliminary system design with several performance options, and perform operational modeling including a cost of energy analysis.

Technology Description
The major components in the Base Case are a 340,000 kWh/year (209 kW) photovoltaic (PV) solar array, a 70 kW electrolyser, 141 kg of pressurized hydrogen (H2) storage, a 120 kW H2 internal combustion engine (ICE), a 60 kW fuel cell (FC), and a H2 fuel dispenser. The system can provide 120 kW of back–up power for a demonstration load for a minimum of 4 hours. The hydrogen-fueled generators (ICE and FC) can provide peak shaving to avoid 100 kW of demand charges per month. The system can support six hydrogen-fueled vehicles driving an average of fifty miles per day for four days per week.

Also presented are three options that may be desirable to include with the Base Case in order to enhance system performance. The options are: Premium Power enhancement, addition of reformer for increased hydrogen production, and H2/CNG blend fueling capabilities.

Status
The conceptual design was completed and presented to the AQMD in May 2003. A major concern was the effect the changing electric rate structure would have on the estimated savings for each scenario. Further analyses would need to be conducted to incorporate the new rates into the model, but the reduced rates would also reduce the net savings from the distributed power.

Another issue was the need for fine control and dispatch of the power generation sources to avoid the demand charge increment (15 minute intervals). The control system would rely on historical demand data as well as real-time monitoring to effectively dispatch the genset.

Results
Below are the budgetary estimates that Northern recommends allocating for equipment, engineering, and installation of the Base Case and the various options:

	Range, $	
Base Case	**$3,287,000**	**$4,823,000**
PV Array* (340,000 kWh, 209 kW)	$625,000	$796,000
Integration	$1,850,000	$3,100,000
Hydrogen System**	$637,000	$637,000
Testing	$175,000	$290,000
Options		
Premium Power Option	**$272,000**	**$452,000**
Reformer Option	**$525,000**	**$875,000**
Hythane Fueling Option	**$45,000**	**$110,000**
Additional H2 Storage, 125 kg	**$108,000**	**$132,000**

* After incentives
** Based on Stuart quote

Key Results from the Study:

- The various roofs at the Diamond Bar Facility can accommodate a maximum of 340,000 kWh/yr (209 kW) of PV. Avoided utility charges will be $45,000 - $60,000 per year.
- The energy required for hydrogen production is completely off set by the energy produced from the PV array
- The FC/ICE combination can be operated in a peak shaving mode to significantly reduce the cost of energy by eliminating 100 kW – 180 kW of peak demand per month throughout the year.
- Coupled with adequate storage, the electrolyser actually has annual production capacity to support the operation of twelve H2 vehicles, supply the peak shaving and back-up power needs for up to 180 kW of stationary power, **and** supply hydrogen for an 8% H2/CNG blend for the entire fleet of CNG vehicles at the Diamond Bar facility.
- The 60kW PEM fuel cell offered by Hydrogenics is currently the only commercially available product in the size range appropriate for this project.
- Primarily because of product life issues, today's PEM products are best suited for intermittent use and not for ba*se* load applications.

Benefits

The benefits from implementing the Base Case are:

- *Produce 4.5 % of SCAQMD energy needs from a* renewable source.
- 120 kW of back–up power for a demonstration load for a minimum of 4 hours
- Save $27,000 per year of demand charges & $45,000 per year of consumption charges
- Produce 1881 kg of renewable H2 @ $6/kg (considering electricity costs only)
- Support 6 H2-fueled vehicles driving an average of 50 miles per day for 4 days per week
- The electrolyser has capacity to produce enough hydrogen so that the entire fleet of compressed natural gas (CNG) vehicles at Diamond Bar could be run on 4% H2/CNG blend. Several studies have shown that a low percentage H2/CNG blend mixture can actually reduce NOx and CO emissions by 40% - 50% compared to running with pure natural gas.

Project Costs

The total project costs were $42,000.

Commercialization and Applications

This projects demonstrates the following technology application:

- Peak shaving using both a fuel cell and H2 ICE in concert with PV
- Hydrogen as an energy carrier for both power generation and transportation
- A control system allowing operation of all equipment in the highest efficiency and economic modes. It will allow hydrogen generation scenarios to maximize hydrogen production, minimize costs, or maximize renewable production
- Backup or peak shaving power generation using fuel cells and ICE engines
- Incorporating hydrogen and compressed natural gas (CNG)for Hythane® use in current CNG vehicle fleet

This project will be conducted using near-term, available technologies. In the case of the electrolyser, ICE, hydrogen storage and fueling dispenser Stuart Energy Systems has the only commercially available unit. The PV array can be composer of a fully mature and proven technology. The component that has less maturity is the PEM fuel cell as proposed by Hydrogenics. The recommended component of 60 kW is made up of a commercially available 20 kW module. The first 60 kW module will be installed this summer. The control system development and integration while using mature technical components represents a challenge in integration, allowing multiple power generation technologies to be used in multiple modes of operation.