II.F.6 Hydrogen Generation from Electrolysis (New Project)

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Objectives

- Determine pathway to optimum electrolysis-based H_2 fueling through conceptual system design and analysis, and subsystem/component development.
  - Develop the fueling system requirements.
  - Optimize fueling system architecture.
  - Improve subsystem/component performance, cost, and durability.

Technical Barriers

This project addresses the following technical barriers from the Hydrogen Production section of the Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year Research, Development and Demonstration Plan:

- Q. Cost
- R. System Efficiency
- S. Grid Electricity Emissions
- T. Renewable Integration

Approach

- Establish fueling system requirements.
  - Determine daily production/storage requirements for system.
  - Determine applicable codes and standards, present and future.
  - Verify range of vehicle fueling requirements, including pressure.
- Perform conceptual systems design and analyses.
  - Generate system cost vs. performance analysis model.
  - Develop conceptual system design.
  - Perform design trade studies for subsystems and components.
- Perform development test on key subsystems/components.
  - Prototype and test to substantiate analytically predicted performance.
  - Conduct development tests of low-cost materials and assembly techniques.

Accomplishments

- The Hydrogen Generation from Electrolysis project is just now getting underway, and the approach to optimizing the fueling system is defined.
- Development tests of initial concepts for cell stack cost reduction are defined and are in the setup stage.

Future Directions

- Cost analysis model for system that ties to the technical targets for water electrolysis in DOE's RD&D Plan for use throughout the project.
- Conceptual design for systems in the range of 10,000 and 100,000 scf/day, including top-level specifications for subsystems.
- Code compliance and safety analysis for conceptual designs.
- Complete design trade-off to determine optimum electrolyzer output pressure in light of compression requirements.
- Feasibility study of electrochemical compression.
- Evaluation of renewable power converters for cell stack.
- Advanced mechanical and isothermal compressor design study.
- Gas drying system design study and prototyping.
- Complete fluid system design trade-off for cost reduction.
- Electrolyzer cell stack cost reduction, parts reduction, low-cost materials, including sub-scale prototyping and test.
- Wind turbine power coupling trade study, direct or grid.
- Cost study of wind-generated electricity for electrolysis.

Introduction

Large-scale commercial hydrogen production required for vehicle fueling poses significant challenges for water electrolysis considering the state of the technology today. The cost and generation capacity of today's fielded electrolysis systems do not meet the requirements of a commercial vehicle fueling station. The Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year R,D&D Plan outlines the issues to be addressed in the technical barriers and technical targets sections. Starting at the top level and working down to the component level, the electrolysis-based fueling station design can be optimized to overcome the barriers while meeting the technical and cost targets.

Approach

The approach to optimizing the electrolysis-based fueling station has three major elements. The first is the refinement of the requirements so that the direction of the analysis and development can be set with a destination firmly in view. Second, conceptual designs are generated and analyzed against the refined requirements and technical/cost targets. The third element is prototyping and evaluation of subsystem design solutions identified in the conceptual design process.

Requirements Generation

The establishment of a clear baseline set of requirements for the fueling system is an essential first step in the design optimization. Efficiency and cost targets have been outlined in the R,D&D Plan for each subsystem. In addition to these requirements, there are those pertaining to the design, certification, siting, and use of the fueling system. Because the technology is relatively new, complete, released regulations do not necessarily exist. The approach is to extract applicable portions of existing regulations, anticipate the content of future regulations, and define a set of requirements for the system. There will also be a variety of vehicles to be fueled, so establishment of the possibilities and understanding the demands of each is essential.

Conceptual Design and Analyses

The second element in the overall approach to the project is the generation of conceptual designs and analyses of their performance and cost. A block diagram is first generated with the inputs and output characteristics of each subsystem defined. The requirements of the overall system are flowed down to the individual subsystems, and top-level specifications are developed. The entire system implementation is analyzed using a cost model that ties directly to the R,D&D Plan technical targets. Safety analysis is also performed for each conceptual system design. For each subsystem, a variety of implementations are examined against each other in terms of cost, complexity, and impact on adjoining subsystems. Supporting data is used to trade the implementations against one another. This is an iterative process, as changes in one subsystem that can yield significant gains in the overall system may have an impact on adjoining subsystems. As an example, the optimum output pressure of the electrolyzer in terms of cost may place higher than desirable demands on the compression stage. The interaction of the two subsystems needs to be addressed to arrive at a balance that meets the overall performance and cost goals.

Development Testing

The design trade-offs performed for various subsystems require data for completeness and accuracy. New concepts identified are prototyped at a scale that yields relevant information that can be used in the design trade-offs. These prototypes do not have to be of a full-scale nature to be relevant. They are performed at a scale such that the effects on cost and performance with future scale-up to full size in mind are quantifiable. Other development tests that examine new low-cost materials and/or assembly techniques are performed to confirm the possible benefits. Collection of actual test data is essential to the overall project so that the design trades examine what is, rather than what is possible.