V.Q.1 CIRRUS - Subfreezing Start/Stop Protocol for an Advanced Metallic Open-Flowfield Fuel Cell Stack

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- W.L. Gore, Elkton, MD
- SGL Carbon Group, Meitingen, Germany
- University of Delaware, Newark, DE

Project Start Date: TBD
Project End Date: three years after project initiation

Objectives

Demonstrate a proton exchange membrane (PEM) fuel cell stack, based on metallic open flowfield, able to:

- Start from -20°C to 50% of maximum power in 30 seconds.
- Start from temperatures as low as -40°C over multiple exposures (1,000 times) without irreversibly degrading its performances more then 5% of its original life.

Technical Barriers

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

(D) Water Transport within the Stack

(G) Start-up and Shut-down Time and Energy/Transient Operation

Technical Targets

Water transport studies are imperative for achieving DOE targets for fuel cell start-up time in subfreezing conditions. Nonetheless, stack components must be accurately chosen to supply compatibility and reliability to procedures adopted for cold start-up.

The key task to match DOE requirements consists of identifing mechanisms that influence start-up time as a function of temperature, select a suitable gas diffusion layer (GDL) and membrane electrode assembly (MEA), optimize fluid dynamics in the stack and use a reliable shutdown/startup procedure. Nuvera present status is presented in Figure 1.

Approach

The approach Nuvera will pursue during the project is strictly related with Nuvera present architecture. The open flowfield structure is less sensible to ice formation than conventional flowfields because it's more unlikely that ice could block completely the passage of the gases (see Figure 2). From a fuel cell system level the Nuvera stack can run with dry air and hydrogen

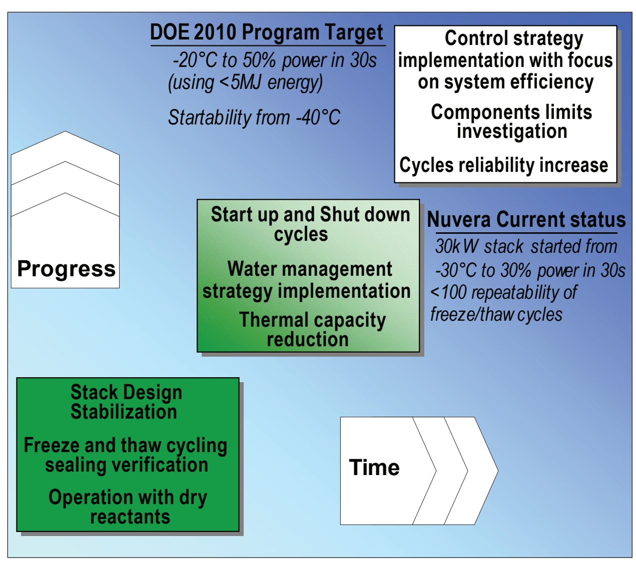

FIGURE 1. Nuvera Status with Respect to DOE Targets

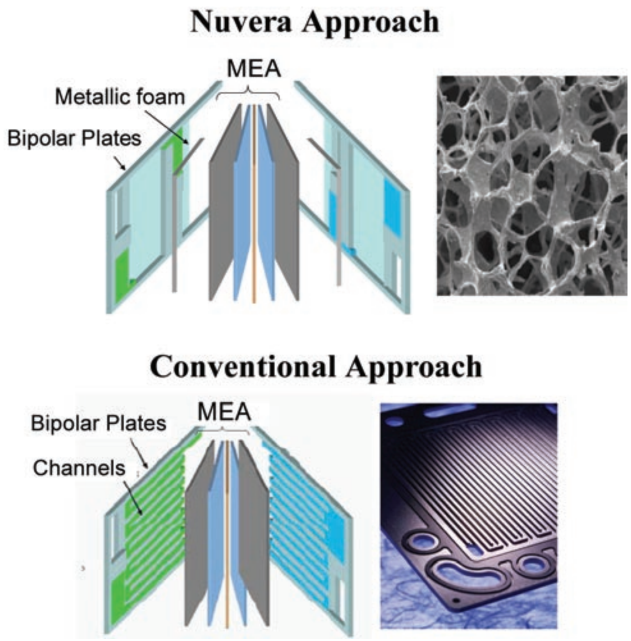

FIGURE 2. Nuvera and Conventional Flowfield Structures

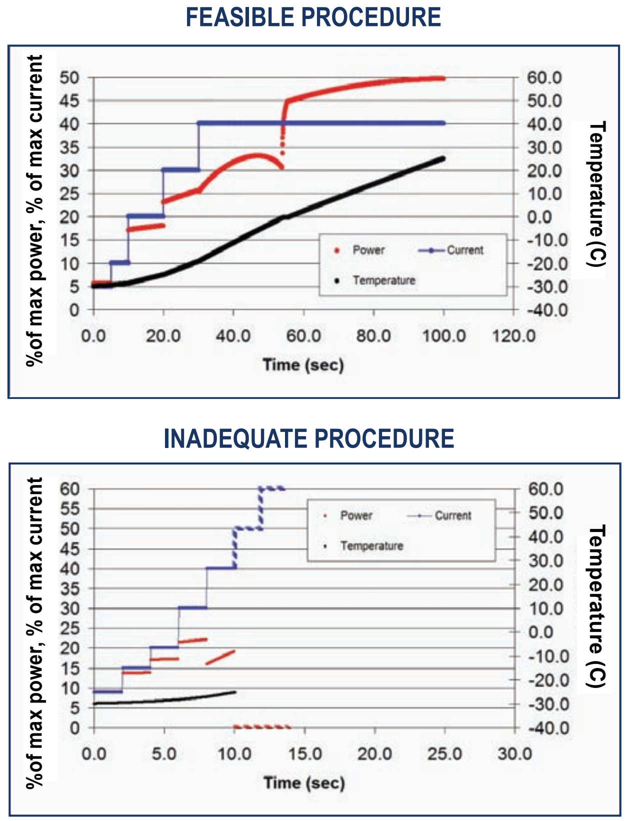

FIGURE 3. Stack Response to Different Ramps of Current Imposed to have a Fast Start-Up

recirculation which involves a simpler system design with no humidification sections. The approach Nuvera will follow to attain the DOE goals will be oriented to keep the system as simple as possible and then it will prioritize purging techniques and internal heating techniques with respect to external heating techniques which implies component additions to the fuel cell system.

Accomplishments

Some preparatory activities have been carried out in order to evaluate, from a theoretical standpoint, the first points which will be investigated once the project is started. In particular, Nuvera has started the development of a model which will be used to simulate different start-up procedures and related phenomena. Figure 3 shows stack response (according to model) to different ramps of current imposed to have a fast start-up. In the first case (feasible) the ramp is adequate then the voltage progressively stabilizes, while in the second case (inadequate) the current ramp is too fast to be sustained by the stack where the presence of ice is still high. As a consequence voltage drops down. Experimental tests carried out in previous campaigns confirm this behavior.

Nuvera has also determined the thermal capacity of cell components and compared to a conventional, graphite based stack components (Figure 4). The findings show the Nuvera stack to be better suited to cold start-up because the lower thermal mass involves a lower need of energy to warm-up the stack components.

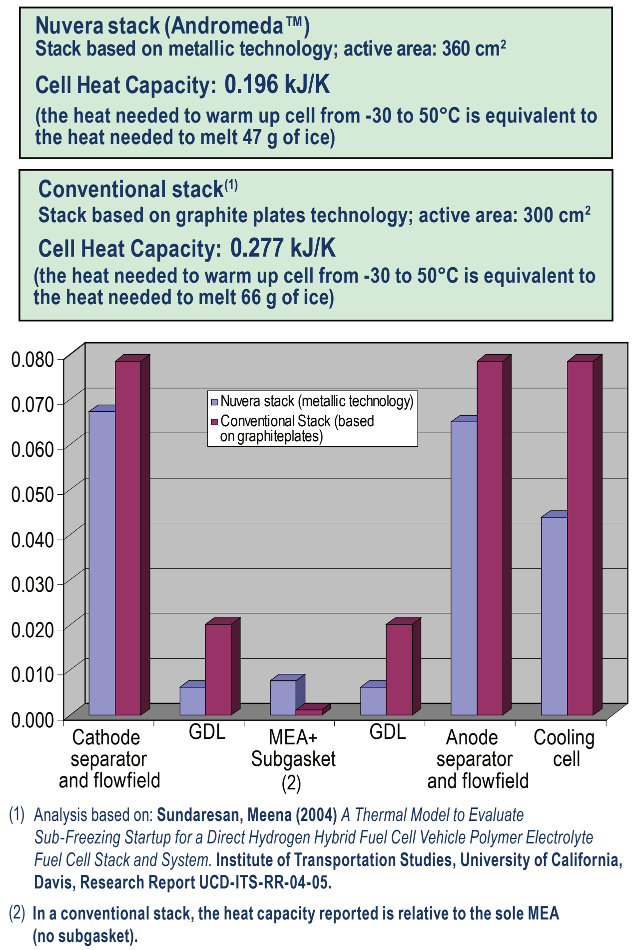

FIGURE 4. Comparison of Cell Component Thermal Capacity