

V.E.2 Efficient and Inexpensive Liquefier for Hydrogen

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Subcontractor:

Dr. John Barclay, Prometheus Energy Company

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Objectives

The DOE contractor (New Concepts Research Corporation – “NCRC”) will design, build and test a complete 300° K to 20° K “active magnetic regenerative liquefier” (AMRL) prototype. The aim is to achieve a dual stream hydrogen and oxygen liquefier with a small footprint. The project team hopes to improve liquefaction energy efficiency by 50% resulting in only needing 16% of the energy of the hydrogen for the liquefaction compared to >30% with today’s liquefaction technology. This is intended to assist DOE to achieve performance and cost goals for hydrogen delivery.

Technical Barriers

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

- C. High Cost and Low Energy Efficiency of Hydrogen Liquefaction

Technical Targets

The DOE Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year Research, Development and Demonstration Plan technical targets this project addresses (Table 3.2.2) include the following:

- Small-Scale Cost Contribution of \$1.80/gge of H₂
- Large-Scale Cost Contribution of \$0.75/gge of H₂
- Small-Scale Electrical Energy Efficiency of 25%
- Large-Scale Electrical Energy Efficiency of 40%.

The project's objective is to achieve a liquefaction cost reduction of 50% (based on a current estimated liquefaction cost greater than \$1.00/kg of hydrogen) with an energy efficiency in excess of 80%.

NCRC will:

- Extend the performance calculations of an active magnetic regenerative refrigerator (AMRR) into a more complete performance model and test multiple ways of manufacturing high performance layered magnetic regenerators.
- Design and predict the cost and performance trade-offs of two or three superconducting magnet configurations that are conduction cooled.
- Design, build, and test one AMRR to demonstrate the validity of the core technology.
- Complete an engineering design for an experimental prototype of a complete AMRL.
- Complete the design of a complete hydrogen test facility integrating a source of H₂ with the various components of the AMRL and ancillary equipment.

Approach

The project team will build a performance model of an AMRR and an AMRL. Coupled magnetization-demagnetization refrigerants (CMDRs) will be integrated into a compact regenerator that can heat and cool an external heat transfer fluid as it flows through the regenerator. Once the basic CMDR is modeled, then detailed design (including costing) of the AMRR and the AMRL can proceed.

The next step is to fabricate, test, and analyze performance of a single AMRR stage in the laboratory. Following that, the team will develop the engineering design of all the complete AMRRs. Once these preliminary tasks are done, the project team will complete the fabrication of the entire AMRL.

Accomplishments

This is a new project. The project planning has been completed and the design, phase has begun.

