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## X.0 Market Transformation Sub-Program Overview

### INTRODUCTION

The purpose of the Market Transformation sub-program is to verify commercial readiness for domestically produced hydrogen and fuel cell systems. The Market Transformation sub-program conducts activities to evaluate the technical and economic viability of pre-commercial hydrogen and fuel cell systems in real-world operating environments. The results from these evaluations are used to provide feedback to research programs, U.S. industry manufacturers, and potential technology users. By supporting technology operations testing and use in key early market applications, this sub-program helps to identify and overcome technical and non-technical barriers to user adoption. These early market applications will also address other user acceptance factors (such as value propositions beyond incumbent technologies), resulting in further expansion of technology opportunities.

The Market Transformation sub-program aims to support research and development validation to enable more commercial successes such as those realized in material handling equipment (e.g., lift trucks) and emergency backup power applications. For example, Market Transformation has partnered on industry-led projects in applications like fuel cell powered airport ground support baggage tractors, fuel cell electric medium-duty hybrid trucks for cargo delivery applications, and a light-duty utility vehicle range extender. These projects are highly leveraged, with an average of more than half of the projects' funds provided by DOE's industry partners. Partners who provide resources and financial investment to these projects demonstrate their high level of interest to explore these applications and markets. This level of industry interest is very promising for the potential growth of the domestic fuel cell industry and related jobs. Market Transformation also partners with other federal agencies such as the U.S. Department of Transportation Maritime Administration on projects such as auxiliary power for ships in port and onboard ocean-going vessels.

### GOAL

The sub-program's goal is to enable and accelerate expansion of hydrogen and fuel cell system use by lowering the life cycle costs of hydrogen and fuel cell power and by identifying and reducing the barriers impeding full technology commercialization.

### OBJECTIVES

Specific objectives of the Market Transformation sub-program in Fiscal Year (FY) 2017 are:

- Test emerging approaches to grid management using renewable hydrogen.
- Advance the knowledge and expertise of distributed hydrogen fuel generation and dockside and shipboard fuel cell systems in partnership with the U.S. Army, the U.S. Navy, and civilian agencies such as the U.S. Department of Transportation's Maritime Administration.
- Continue industry-led demonstration projects on truck auxiliary power units, fuel cell cargo delivery vans, and aviation ground support applications through targeted testing and evaluation efforts.
- Identify lessons learned from demonstration projects, and complete technical-economic analyses to help identify the best early market applications for industry to commercialize.

### FY 2017 TECHNOLOGY STATUS AND ACCOMPLISHMENTS

In FY 2017, the sub-program continued the collection and analysis of early-market project data. These data are being made available on an ongoing basis so that industry technology developers can:

- Assess the performance of integrated hydrogen and fuel cell systems;
- Determine the technical and economic viability of these applications; and
- Advance applications into production products.

Collaboration with other federal agencies continued. A workshop was held with U.S. Army organizations to determine the best technologies for producing hydrogen fuel at forward operating bases for tactical military

operations. Interagency collaborations also focused on pre-commercial applications such as maritime power through an interagency collaboration with the U.S. Department of Transportation's Maritime Administration and unmanned aerial vehicle testing with the U.S. Navy.

Fuel cells continue to enjoy growing success in material handling equipment and backup power applications. The sub-program's early market deployment efforts have successfully catalyzed a significant level of market activity in these areas. Material handling and backup power industrial orders are up 42%<sup>1</sup> and 9%,<sup>2</sup> respectively, from the cumulative total orders through 2016.

FY 2017 activities include the following.

- **Hydrogen Energy Storage Project:** This project supports the demonstration of a hydrogen energy storage system as a grid management tool. While hydrogen produced from the system could be used in a variety of value-added applications, the initial phase of the project will use the hydrogen for fuel cell buses operated by the County of Hawaii Mass Transportation Agency and the National Park Service. This year construction began, and initial operation is expected to begin in late 2017. (Naval Research Laboratory and the State of Hawaii)
- **Airport Ground Support Vehicles:** This project has a high potential to meet sub-program goals and enable expansion of fuel cells into additional airport applications such as shuttle buses. The initial design has been completed, and 15 units were assembled with the cargo tractors and tested in field operations. Failures in the stacks occurred, and root-cause analysis revealed that the stacks were not robust enough for the air cargo duty cycle. The stacks were redesigned, and new stacks replaced the original stacks. Units in the new fleet operations are showing positive results. (Plug Power)
- **Maritime Fuel Cell Generator Project:** Testing of a first-of-its-kind hydrogen fuel cell power generator for maritime applications was completed and results published. The system was designed to replace pier-side or onboard diesel generators for refrigerated containers used for ocean vessel operations. Initial operations testing at a pier-side site was completed with results confirming substantial energy efficiency improvements compared to diesel engines. Balance of plant components have been redesigned and replaced. A Phase 2 project is now being initiated. (Sandia National Laboratories)
- **Fuel Cell Hybrid Electric Medium-Duty Truck Project:** In this project, a design is being developed for a battery electric powertrain system hybridized with fuel cell power to improve drive performance and range on a medium-duty cargo truck. The project team completed a prototype design, and vehicle testing is being initiated. (FedEx Express)
- **Fuel Cell Auxiliary Power Unit Project:** This project will demonstrate a single-temperature fuel cell auxiliary power system for truck refrigeration units. Subsystems have been assembled, and an integrated system test was successful. The next step is to demonstrate the truck refrigeration unit for a continuous eight-hour operation. (Pacific Northwest National Laboratory)
- **Light-Duty Utility Vehicle Range Extender:** This project is developing a fuel cell range-extended, plug-in hybrid, light-duty utility vehicle. By adding a fuel cell and a few kilograms of hydrogen to a battery electric powertrain, the zero-emission driving range of the vehicle will be extended from ~100 mi up to as much as 250 mi before the batteries need to be recharged, which will greatly increase the commercial potential of these all-electric vehicles. Upon the successful validation of one initial prototype vehicle, US Hybrid will deploy a fleet of 19 additional vehicles for use by National Grid, a leading utility fleet owner and operator in the northeastern United States. The project scope also includes collection and validation of performance data and a complete economic assessment of the value proposition. (US Hybrid)
- **Commercial Acceleration Outreach and Analysis:** Efforts this past year focused on enabling the commercialization process for various industries and organizations, including forums for investors and infrastructure developers, training of state and municipal staff on safe and successful technology operations, and developing novel hydrogen and fuel cell technical-economic analyses. In collaboration with industry, investor outreach events were conducted in key early market regions of the country, bringing together private hydrogen refueling developers, fuel cell automotive manufacturers, and potential investors. To help the launch of fuel

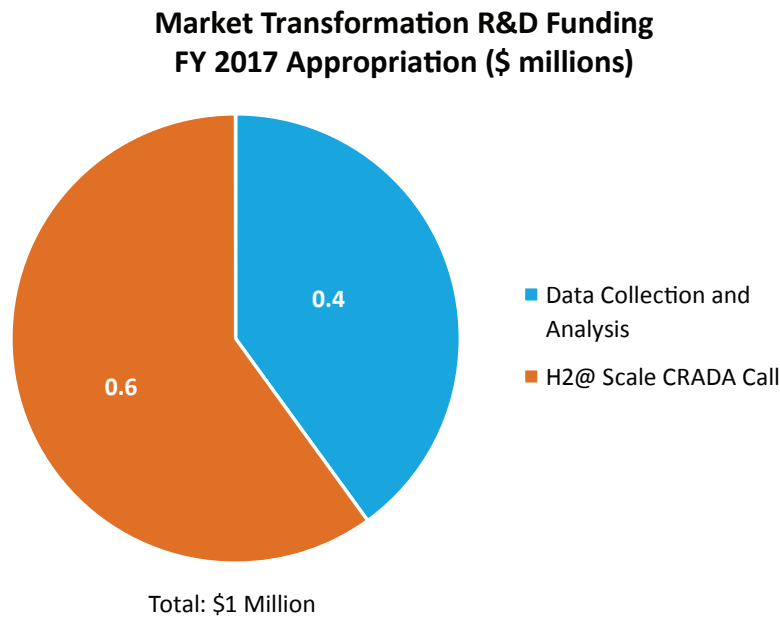
<sup>1</sup> *Industry Deployed Fuel Cell Powered Lift Trucks*, Program Record (Hydrogen and Fuel Cells Program) 17003, U.S. Department of Energy, 2017. [https://www.hydrogen.energy.gov/pdfs/17003\\_industry\\_deployed\\_fc\\_powered\\_lift\\_trucks.pdf](https://www.hydrogen.energy.gov/pdfs/17003_industry_deployed_fc_powered_lift_trucks.pdf)

<sup>2</sup> *Industry Deployed Fuel Cell Backup Power (BuP)*, Program Record (Hydrogen and Fuel Cells Program) 17004, U.S. Department of Energy, 2017. [https://www.hydrogen.energy.gov/pdfs/17004\\_industry\\_deployed\\_fc\\_bup.pdf](https://www.hydrogen.energy.gov/pdfs/17004_industry_deployed_fc_bup.pdf)

cell electric vehicles and hydrogen fueling infrastructure in the Northeast, meetings were conducted to educate state and city officials and municipal authorities in New Jersey, Rhode Island, Connecticut, and Massachusetts on station network locations and technical performance targets. To help accelerate the commercialization of various fuel cell technologies and overcome technology cost barriers, the sub-program supported various focused technical-economic analyses on topics such as ground support equipment, medium-duty vehicles, and auxiliary power systems for port power and refrigerated trucks.

### BUDGET

The FY 2017 Market Transformation sub-program funding allocation totaled \$1 million. These funds were used primarily to support data collection and analysis for continuing demonstration projects and to support projects selected from the H2@Scale cooperative research and development agreement (CRADA) call.



**FIGURE 1.** FY 2017 Appropriations

### UPCOMING ACTIVITIES AND PLANS

In FY 2018, projects with funding remaining from previous fiscal year appropriations will continue. A major priority is alignment with the H2@Scale concept.

Future activities are subject to appropriations.

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