Fuel Cell Technologies – 2022

Subprogram Overview

Introduction

Fuel cells convert the chemical energy of hydrogen or other fuels into electricity and deliver power for applications across multiple sectors. Fuel cells also provide long-duration energy storage for the grid in reversible systems. The Fuel Cell Technologies (FCT) subprogram applies innovative research, development, and demonstration (RD&D), with the main goal of developing a diverse portfolio of low-cost, durable, and efficient fuel cells that are competitive with incumbent and emerging technologies across applications.

The subprogram's RD&D strategy is target-driven, with technical targets developed for different fuel cell technologies, specifically considering end-use requirements. In this holistic approach, the subprogram develops targets based on the ultimate life cycle cost of using fuel cell systems in diverse applications. Building on previously developed comprehensive technical targets in areas such as light-duty vehicles, the subprogram continues to develop and refine additional targets for emerging and high-impact applications. These include heavy- and medium-duty vehicles, stationary power generation (primary and back-up), and reversible fuel cells for energy storage. The subprogram's RD&D focus is primarily on heavy-duty vehicles, which have more stringent durability requirements than light-duty vehicles. Advances in heavy-duty vehicle fuel cells will also offer transferrable benefits for light-duty, medium-duty, and stationary power fuel cell applications.

The subprogram strategically addresses crosscutting challenges for fuel cell development through focus on materials and components (especially low-platinum-group-metal [low-PGM] and PGM-free catalysts and electrodes); systems integration (stacks, system design, and balance-of-plant [BOP] components); and analysis and modeling.

Goals

The FCT subprogram's goal is to develop fuel cell technologies that are competitive with incumbent and emerging technologies across diverse applications.

Specific objectives of the subprogram include:

- Developing fuel cell systems, including stack and BOP components, with an emphasis on systems that are highly durable, efficient, and low-cost, while meeting the needs and constraints of varied heavy-duty transportation applications for the near to mid-term.
- Developing new materials and components for next-generation fuel cell technologies for transportation, distributed power, and long-duration grid-scale energy storage, emphasizing innovative mid- to long-term approaches.

Key Milestones

By 2030

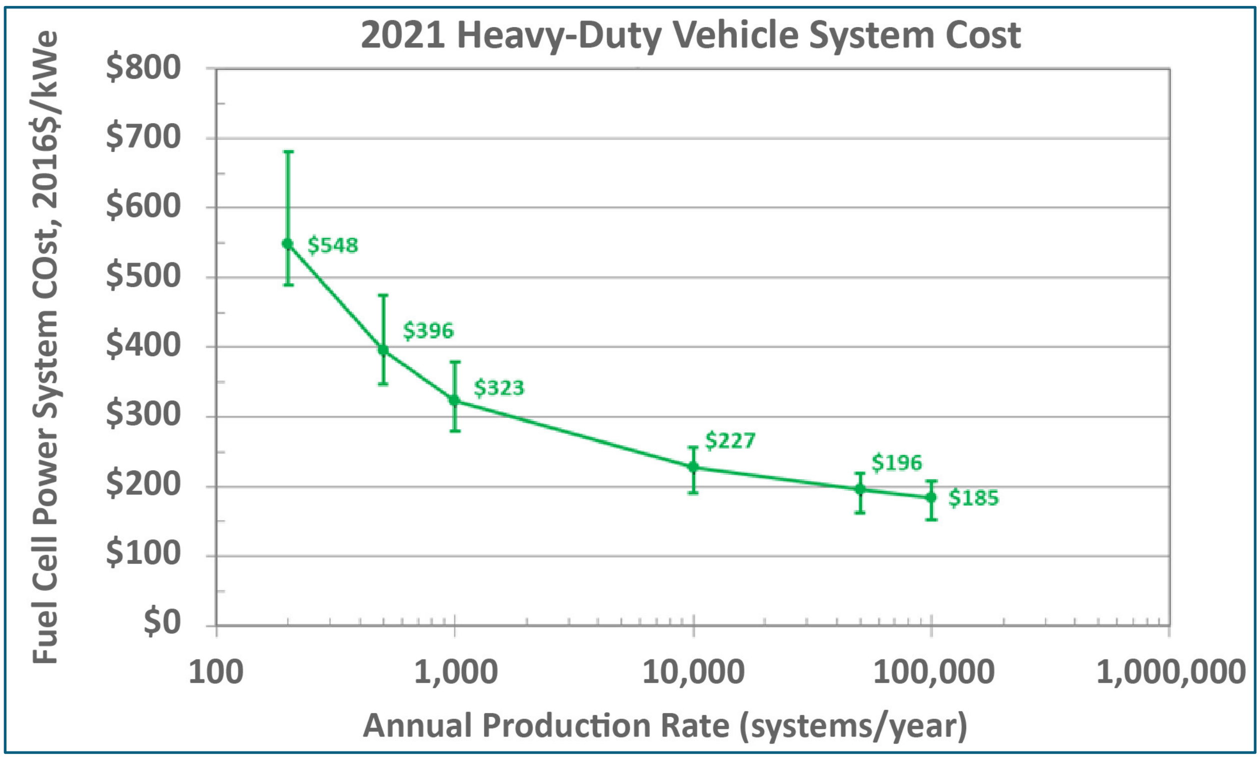
- Develop a 68% (ultimately 72%) peak-efficient direct hydrogen fuel cell power system for heavy-duty trucks that can achieve durability of 25,000 hours (ultimately 30,000 hours) and be mass-produced at a cost of $80/kW (ultimately $60/kW).
- Develop medium-scale distributed generation fuel cell power systems (100 kW–3 MW) operating on renewable fuels, such as renewable natural gas or biogas, that achieve 65% electrical efficiency and 80,000-hour durability at a cost of $1,000/kW.
- Develop reversible fuel cells for energy storage applications that can achieve 40,000-hour durability at a cost of $1,800/kW ($0.20/kWh levelized cost of storage).

Fiscal Year 2022 Technology Status and Accomplishments

One of the most important metrics used to guide the FCT subprogram's RD&D efforts is the projected high-volume manufacturing cost for fuel cells, which is tracked for a range of production volumes. The chart below shows projected costs, based on production volume, of a 275 kW_{net} polymer electrolyte membrane fuel cell (PEMFC) system for a Class 8 long-haul heavy-duty truck based on next-generation laboratory technology[1] and operating on direct hydrogen. Estimates decrease from $323/$kW_{net}$ for a volume of 1,000 units/year to $196/$kW_{net}$ for a volume of 50,000 units/year to $185/$kW_{net}$ for a volume of 100,000 units/year.

These costs include design aspects for enhanced durability anticipated to achieve the one million miles (25,000 hours) of fuel cell system performance needed for long-haul trucks. Durability aspects include stack oversizing (allowing for fuel cell degradation), the use of mono-metallic Pt cathode catalyst at a high loading, 20-micron-thick membranes, and BOP replacement costs.

The subprogram is targeting a cost reduction for heavy-duty vehicle fuel cells to $80/kW by 2030. Long-term competitiveness with alternative powertrains is expected to require further cost reduction to $60/kW, which represents the subprogram's ultimate cost target. To meet these targets, further improvements are needed through RD&D efforts to enhance fuel cell power density and durability, lower PGM loading, and demonstrate manufacturing innovations to enable economies of scale.



Modeled cost of a 275 kW_{net} PEMFC system based on projection to high-volume manufacturing (100,000 units per year) for 2021.

[1] The projected cost status is based on an analysis of state-of-the-art components that have been developed and demonstrated through the U.S. Department of Energy (DOE) Hydrogen Program at the laboratory scale. Additional efforts would be needed for integration of components into a complete commercial vehicle system that meets durability requirements in real-world conditions.

Million Mile Fuel Cell Truck Consortium (M2FCT)

The mission of the M2FCT consortium is to advance PEMFC efficiency and durability and to lower PEMFC cost, thereby enabling PEMFC commercialization for heavy-duty vehicle applications. M2FCT consists of a core lab team, affiliate labs, and industry and university partners selected through competitive solicitations (funding opportunity announcements [FOAs]).[2] A "team-of-teams" approach is being used, featuring collaborative groups in analysis, durability, integration, and materials development. The objective for fuel cell development efforts under this consortium combines efficiency, durability, power density, and (implicitly) cost in a single metric: 2.5 kW/gPGM power (1.07 A/cm^2 current density at 0.7 V) after 25,000 hour-equivalent accelerated stress tests (ASTs).

The consortium has achieved the following:

- M2FCT labs established a baseline catalyst and membrane electrode assembly (MEA) performance, based on commercially available Pt/C, to meet heavy-duty durability requirements.
- Los Alamos National Laboratory (LANL) and Brookhaven National Laboratory (BNL) developed intermetallic PtCo and PtNi catalysts that outperformed the baseline commercial catalyst for heavy-duty fuel cells by >25% at beginning of life and by >45% after a 90,000-cycle AST (A/cm^2 at 0.8 V).
- Carnegie Mellon University and partners demonstrated a novel high-oxygen permeability ionomer. It has twice the oxygen permeability of the conventional ionomer, improves catalyst mass activity by 60%, and lowers local O_2 transport resistance by 50%. Conventional ionomers have restricted O_2 transport that can reduce performance and durability over long heavy-duty vehicle lifetimes.
- General Motors and partners addressed the issue of fuel cell degradation by introducing approaches to tackle cerium migration. Cerium is used in radical scavengers to improve chemical stability, but cerium salt-based additives migrate during operation. The project demonstrated membranes with immobilized radical scavengers (heteropoly acid, dispersed cerium zirconium oxide nanofibers) with enhanced durability compared to membranes with no additives.
- M2FCT developed fuel cell ASTs that are representative of heavy-duty vehicle operation and consider catalyst, catalyst support, and membrane degradation. Temperature and potential cycling were used as primary acceleration factors in a 500-hour H_2/air AST to simulate the high durability requirements (25,000 hours) of heavy-duty vehicle operation.

ElectroCat 2.0

The mission of the Electrocatalysis Consortium (ElectroCat) is to develop durable PGM-free catalysts for PEMFCs and for low-temperature electrolyzers as low-cost alternatives to PGM catalysts, addressing critical mineral supply challenges. The ElectroCat core lab team includes ANL, LANL, NREL, and ORNL. In Fiscal Year (FY) 2022, the performance of PGM-free cathode catalysts in H_2/air was improved by 25% over the FY 2021 baseline using ElectroCat-developed test protocols.

Anion Exchange Membrane (AEM) Fuel Cell Development

AEM fuel cell RD&D continued in FY 2022 with two main projects at LANL and NREL. Efforts resulted in reducing PGM loadings to 0.2 mg PGM/cm^2 for AEM fuel cells while maintaining performance (100 mW/cm^2 at 0.8 V with back pressure under 250 kPa in H_2/air scrubbed to 2 ppm CO_2).

Small Business Innovation Research (SBIR)/Small Business Technology Transfer Research

Two small business projects, one led by pH Matter, LLC, and one by Giner, Inc., attained noteworthy results. The former project developed a new fuel cell catalyst support showing improved durability while maintaining performance and cost. The pH Matter team achieved the end-of-life target (1.07 A/cm^2 at 0.7 V) after heavy-duty

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[2] The core labs are Los Alamos National Laboratory (LANL), Lawrence Berkeley National Laboratory (LBNL), Argonne National Laboratory (ANL), National Renewable Energy Laboratory (NREL), and Oak Ridge National Laboratory (ORNL). The affiliate labs are Brookhaven National Laboratory, Pacific Northwest National Laboratory, and National Institute of Standards and Technology.

ASTs and outperformed commercial catalysts tested under similar conditions. Target power performance of over 1 W/cm^2 was also achieved with this MEA. This multifunctional catalyst support is based on doped carbon with optimized "accessible" pore structure and tuned hydrophobicity.

Giner worked with partner University of Buffalo to demonstrate a fuel cell MEA using Giner's 40 wt % Pt/Mn-N-C catalyst. The MEA was a combination of a highly stable catalyst incorporated with a novel Mn-N-C support and a high O_2 permeability ionomer. The resulting product meets end-of-life performance and durability targets after a 150,000-cycle AST under heavy-duty vehicle conditions (equivalent to 25,000-hour lifetime).

Minority Serving Institutions Partnership Program (MSIPP)

In FY 2022, LANL developed the MSIPP to grow the interest of minority-serving institutions (MSIs) in participating in hydrogen- and fuel-cell-related research and to help produce more qualified candidates from underrepresented colleges and universities for the hydrogen and fuel cell workforce. The MSIPP fosters relationships between MSIs, the national lab, and industry partners. Efforts are ongoing to formalize collaborations with commercial entities such as Pajarito Powder, Plug Power Inc., and Chemours through memorandums of understanding.

In its inaugural year, the program welcomed and supported eight participants who were awarded summer internships and helped perform cutting-edge fuel cell research at LANL. Lab staff planned several additional activities to help grow MSI participation, including fall and spring internships, MSI campus tours, and a hydrogen and fuel cell week at LANL.

New Project Selections

FY 2022 SBIR Phase II

- pH Matter, LLC (Columbus, Ohio): Multi-Functional Catalyst Supports (Phase IIC)
- Giner, Inc. (Newton, Massachusetts): Durable High-Efficiency Membrane and Electrode Assemblies for Heavy-Duty Fuel Cell Vehicles (Phase II)

FY 2022 SBIR Phase I

- Supercool Metals (Branford, Connecticut): Durable Bulk Metallic Glass Catalysts for Medium- and Heavy-Duty PEM [Polymer Electrolyte Membrane] Fuel Cells

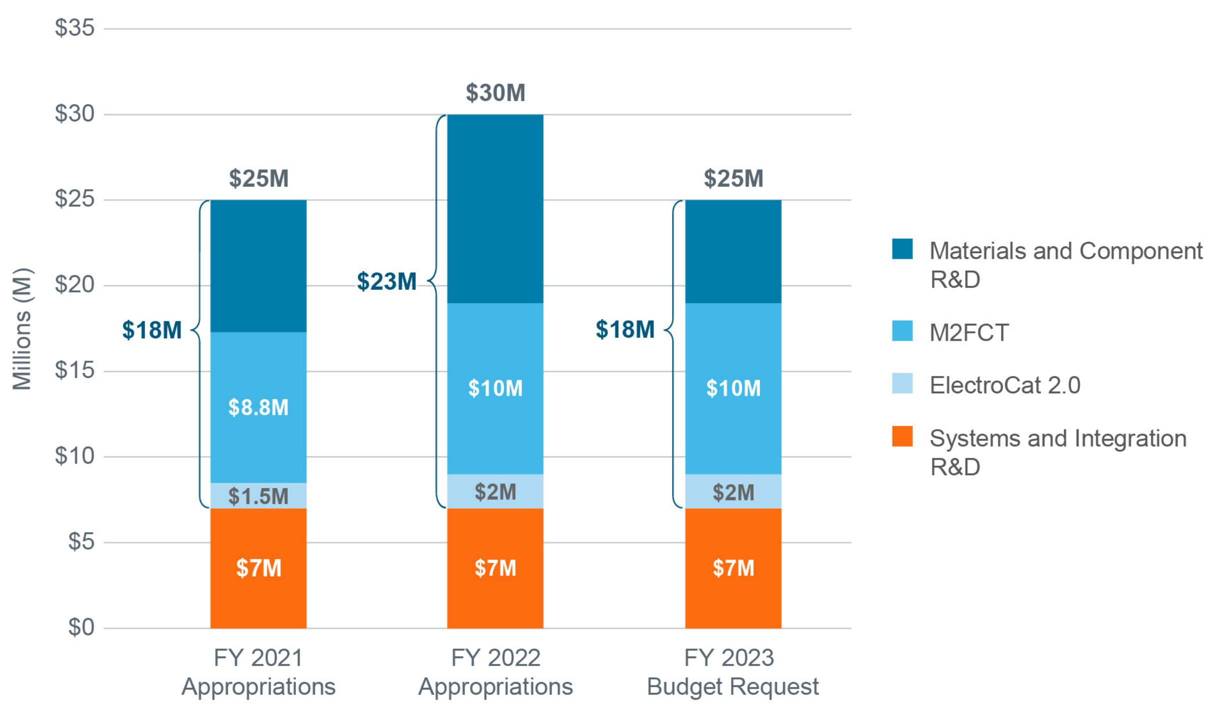
FY 2022 Hydrogen and Fuel Cell Technologies Office FOA

- Planned for release in early FY 2023, this FOA will cover fuel cell components and materials.

Budget

The FY 2021 appropriation was $25 million. The FCT subprogram funded RD&D efforts in two key areas: (1) materials and components and (2) systems integration. Funding was dedicated to the two national laboratory consortia, M2FCT and ElectroCat 2.0, with M2FCT receiving most of the consortia funding (see the chart below). Funding for research into fuel cell materials and components focused on areas such as novel, low-cost manufacturable bipolar plates, MEA components with enhanced durability, and PGM-free catalysts/electrodes. Funding for research into fuel cell systems integration focused on stacks, BOP components (for air management), and systems cost and performance analysis.

The FY 2022 appropriation was $30 million. The FCT subprogram continued its support, at FY 2021 funding levels, of M2FCT and ElectroCat 2.0. Funding for research into fuel cell materials and components focused on additional development of novel, high-performing, durable, low-PGM catalysts incorporated into MEAs for fuel cell trucks. Funding for systems integration primarily supported the newly awarded SuperTruck III projects that included fuel cell technologies as part of these advanced medium-duty truck demonstrations.



The Bipartisan Infrastructure Law adds Section 815 to the Energy Policy Act to support the clean hydrogen supply chain. In response, the FCT subprogram initiated plans in FY 2022 to implement a new clean hydrogen manufacturing and recycling RD&D program, funded (in accordance with Section 815) at $100 million per year over the next five years for a total of $500 million. The planning activities included several workshops and a request for information—both to gather stakeholder input—and coordination with other DOE offices. Additionally, a supply chain analysis was completed, per White House directive, that provided useful information on availability of critical minerals and other materials and components for the clean hydrogen and fuel cell industry in the United States.

Project Summaries

Below are brief FCT project summaries of oral presentations given during the 2022 Annual Merit Review. The full list of projects, including oral and poster presentations, is provided in Appendix D.

Project #FC-160: ElectroCat 2.0 (Electrocatalysis Consortium)

Deborah Myers, Argonne National Laboratory, and Piotr Zelenay, Los Alamos National Laboratory

DOE Contract #	Multiple
Start and End Dates	10/1/2021–9/30/2024
Partners/Collaborators	• National Renewable Energy Laboratory • Oak Ridge National Laboratory

Project Goal and Brief Summary

ElectroCat, which was created as part of the Energy Materials Network, aims to accelerate the development of next-generation catalysts and electrodes that are free of the PGMs currently required for good performance and durability. ElectroCat has focused its efforts on oxygen reduction reaction catalysis for PEMFCs and has established a portfolio of unique synthesis, experimental, characterization, and modeling capabilities. ElectroCat 2.0 has increased focus on improving catalyst durability, investigating electrode engineering, and further advancing high-throughput catalyst synthesis and characterization capabilities coupled with machine learning while still working to improve catalyst performance. The consortium has also expanded its catalyst portfolio to include the development of PGM-free catalysts for low-temperature electrolysis with an emphasis on alkaline exchange membrane oxygen evolution catalysts.

Project #FC-167: Fiscal Year 2020 Small Business Innovation Research Phase IIA: Multi-Functional Catalyst Support

Minette Ocampo, pH Matter, LLC

DOE Contract #	DE-SC0017144
Start and End Dates	05/22/2018–05/20/2022
Partners/Collaborators	• Giner, Inc. • National Renewable Energy Laboratory • Shyam Kocha Consulting

Project Goal and Brief Summary

The research team developed a multi-functional catalyst support for use in PEMFCs to enhance durability. Researchers demonstrated catalyst performance and durability required of MEAs for heavy-duty vehicle applications. The project will continue to optimize the synthesis of the catalyst support to enable higher power and extended durability performance. Heavy-duty ASTs were performed to evaluate the catalyst durability, and the MEA met the DOE 2025 M2FCT end-of-life target of 1.07 A/cm^2 at 0.7 V.

Project #FC-323: Durable Fuel Cell Membrane Electrode Assembly through Immobilization of Catalyst Particle and Membrane Chemical Stabilizer

Nagappan Ramaswamy, General Motors LLC

DOE Contract #	DE-EE0008821
Start and End Dates	10/1/2019–2/28/2023
Partners/Collaborators	• 3M Company • Pajarito Powder, LLC • Colorado School of Mines • Cornell University • Million Mile Fuel Cell Truck Consortium

Project Goal and Brief Summary

This project aims to develop highly stable catalysts and more durable membrane materials for use in direct hydrogen-fed PEMFC MEAs in medium-duty and heavy-duty truck applications. The materials will feature low cost (using less PGM), high fuel efficiency (greater than 65%), and high durability (lifetime of one million miles). If successful, this project will deliver highly durable MEAs for PEMFC applications to enable use in heavy-duty trucks and will elucidate the fundamental degradation mechanisms.

Project #FC-326: Durable Membrane Electrode Assemblies for Heavy-Duty Fuel Cell Electric Trucks

Vivek Murthi, Nikola Motor Company

DOE Contract #	DE-EE0008820
Start and End Dates	Q3 2020–Q3 2023
Partners/Collaborators	• Georgia Institute of Technology • Northeastern University • Carnegie Mellon University • Los Alamos National Laboratory • National Renewable Energy Laboratory • Oak Ridge National Laboratory

Project Goal and Brief Summary

This project will fabricate, characterize, and evaluate an MEA with a novel catalyst layer incorporating a "nanocapsule" electrode structure that separates ionomer and platinum to maximize activity while allowing ionic transport. If successful, this project will allow for better use of highly active and/or highly durable catalysts and the bridging of the activity gap between rotating disk electrodes and MEAs.

Project #FC-327: Durable High-Power-Density Fuel Cell Cathodes for Heavy-Duty Vehicles

Shawn Litster, Carnegie Mellon University

DOE Contract #	DE-EE0008822
Start and End Dates	10/1/2019–1/31/2023
Partners/Collaborators	• The Chemours Company • Ballard Power Systems, Inc. • Million Mile Fuel Cell Truck Consortium

Project Goal and Brief Summary

This project aims to (1) synthesize and implement a custom-designed ionomer that permits enhanced oxygen transport to the platinum surface for improved performance and durability, (2) demonstrate that the ionomer will reduce oxygen transport resistance in an MEA, and (3) optimize the design of the ionomer for commercialization. If successful, the project will facilitate low platinum loadings in an advanced MEA cathode catalyst layer for heavy-duty vehicles.

Project #FC-333: Advanced Membranes for Heavy-Duty Fuel Cell Trucks

Vivek Murthi, Nikola Motor Company

DOE Contract #	DE-EE0009243
Start and End Dates	Q3 2021–Q3 2024
Partners/Collaborators	• The Chemours Company • Million Mile Fuel Cell Truck Consortium

Project Goal and Brief Summary

This project aims to develop membranes with optimized architectures that incorporate thermally stable ionomer chemistries and immobilized radical scavengers. If successful, the project will improve the lifetime efficiencies of MEAs in heavy-duty fuel cell vehicles, reduce the lifetime operational expenses of heavy-duty fuel cell systems, and improve their commercial viability relative to diesel energy sources. Nikola Motor Company is collaborating with The Chemours Company and M2FCT on this project.

Project #FC-334: Extending Perfluorosulfonic Acid Membrane Durability through Enhanced Ionomer Backbone Stability

Michael Yandrasits and Gregg Dahlke, 3M Company

DOE Contract #	DE-EE0009244
Start and End Dates	1/1/2021–12/31/2023
Partners/Collaborators	• National Renewable Energy Laboratory • General Motors

Project Goal and Brief Summary

This project aims to increase membrane lifetimes by improving the inherent chemical stability of perfluorinated membrane ionomers. If successful, the project will increase fuel cell lifetimes and allow fuel cells to meet the DOE 2030 heavy-duty transportation target of 25,000 hours of operation.

Project #FC-335: Additive Functionalized Polymers for Extended Heavy-Duty Polymer Electrolyte Membrane Lifetimes

Tom Corrigan, The Lubrizol Corporation

DOE Contract #	DE-EE0009245
Start and End Dates	Q2 2021–Q3 2023
Partners/Collaborators	• National Renewable Energy Laboratory

Project Goal and Brief Summary

The Lubrizol Corporation will work with NREL to develop membranes with enhanced chemical durability, with the goal of improving the lifetimes of PEMFCs for heavy-duty vehicles. The research team will identify novel additives to mitigate chemical degradation and find strategies to immobilize these additives, thereby addressing radical scavenger shortcomings. The improved membrane durability could enable PEMFC heavy-duty vehicle lifetimes that achieve the DOE target of 25,000 hours (one million miles for long-haul trucks).

Project #FC-336: A Systematic Approach to Developing Durable Conductive Membranes for Operation at 120°C

Tom Zawodzinski, University of Tennessee, Knoxville

DOE Contract #	DE-EE0009246
Start and End Dates	10/1/2020–1/31/2024
Partners/Collaborators	• Oak Ridge National Laboratory • Akron Polymer Systems

Project Goal and Brief Summary

This project aims to develop membranes with sufficient performance and lifetime to meet the requirements of long-term applications of PEMFCs for heavy-duty vehicles. The research team will use background measurements and literature evaluation to inform paths forward for membrane development to meet cell resistance requirements over ranges of temperature and relative humidity that reflect operating conditions in heavy-duty vehicles. Researchers will then identify and prepare new membrane materials with side chain and polymer chemistry tailored to achieve acceptable conductivity and resistance, with low water uptake and swelling.

Project #FC-337: Cummins Polymer Electrolyte Membrane Fuel Cell System for Heavy-Duty Applications

Darren Hickey, Cummins Inc.

DOE Contract #	DE-EE0009247
Start and End Dates	8/1/2021–7/31/2024
Partners/Collaborators	• Cummins Hydrogenics • Argonne National Laboratory • W.L. Gore & Associates, Inc. • Dana Incorporated • Cummins Turbo Technologies

Project Goal and Brief Summary

The objective of this project is to develop and demonstrate a new standardized, modular, and scalable 100 kW PEMFC stack that meets performance, efficiency, durability, and affordability requirements for heavy-duty applications. MEA and bipolar plate development efforts will be undertaken and demonstrated in progressively larger stacks. The stack will be designed to run at higher pressure and tolerate high temperatures (≥100°C) during peak power excursions. A key metric is the system cost of $80/kW at a production volume of 100,000 units per year. To achieve this objective, a study on advanced manufacturing methods to reduce production costs will be undertaken. This project is a collaboration between Cummins Inc.; its Fuel Cells and Hydrogen Technologies division (comprised in part by Cummins' acquisition of Hydrogenics); Cummins Turbo Technologies; ANL; W.L. Gore & Associates, Inc.; and Dana Incorporated.

Project #FC-338: Domestically Manufactured Fuel Cells for Heavy-Duty Applications

John Lawler, Plug Power Inc.

DOE Contract #	DE-EE0009248
Start and End Dates	5/1/2021–5/1/2024
Partners/Collaborators	• Argonne National Laboratory

Project Goal and Brief Summary

Plug Power Inc. is working with ANL to develop a heavy-duty fuel cell stack that is a suitable drop-in replacement for diesel engine applications. If successful, this project will enable high-volume production of bipolar plates and 100 kW modular stack systems to create a reliable and efficient stack with improved durability, cost-effectiveness, and performance.

Project #FC-339: M2FCT: Million Mile Fuel Cell Truck Consortium

Rod Borup, Los Alamos National Laboratory, and Adam Weber, Lawrence Berkeley National Laboratory

DOE Contract #	WBS 1.5.0.402
Start and End Dates	10/1/2020–9/30/2025
Partners/Collaborators	• Los Alamos National Laboratory • Lawrence Berkeley National Laboratory • Argonne National Laboratory • National Renewable Energy Laboratory • Oak Ridge National Laboratory • Pacific Northwest National Laboratory • Brookhaven National Laboratory

Project Goal and Brief Summary

The project team is working to construct fuel cells that provide 2.5 kW of power per gram of PGM after a 25,000-hour-equivalent accelerated durability test. The purpose is to create durable and efficient fuel cell designs suitable for adoption by the heavy-duty vehicle market.

Project #FC-353: Fuel Cell Cost and Performance Analysis

Brian D. James, Strategic Analysis, Inc.

DOE Contract #	DE-EE0009628
Start and End Dates	10/01/2021–09/30/2025
Partners/Collaborators	• National Renewable Energy Laboratory • Argonne National Laboratory

Project Goal and Brief Summary

This project's primary goal is to develop fuel-cell-centric technoeconomic analysis models based on Design for Manufacture and Assembly, an engineering methodology geared toward reducing time-to-market and production costs by simplifying manufacture and assembly in the early design phases of the product lifecycle. This methodology will be employed in an effort to understand the state-of-the-art fuel cell technology for low-, medium-, and high-duty vehicles; project the cost of future fuel cell systems; and measure and track the cost impact of technological improvements in these systems. The project will highlight cost drivers to facilitate Hydrogen and Fuel Cell Technologies Office programmatic decisions. The information gained from these initiatives will be disseminated to the fuel cell industry through comprehensive reports.

Project #FC-354: L'Innovator Program

Emory S. De Castro, Advent Technologies, Inc.

DOE Contract #	Multiple
Start and End Dates	04/1/2021–03/31/2023
Partners/Collaborators	• Los Alamos National Laboratory • Brookhaven National Laboratory • National Renewable Energy Laboratory

Project Goal and Brief Summary

The L'Innovator ("Lab Innovator") was developed to enable a robust domestic fuel cell industry by assembling bundles of unique, state-of-the-art national lab intellectual property and facilitating their development by a commercialization partner. This pilot project for L'Innovator, led by Advent Technologies, focuses on demonstrating a minimum viable product of high-temperature, polymer electrolyte MEAs, using LANL's ion-pair coordinated membrane and MEA technology and BNL's core catalyst technology. With the technology's viability confirmed, the project team will scale up these next-generation MEAs and demonstrate their benefits in stacks or systems. Anticipated outcomes include lower costs, better durability, higher efficiency, and higher power density.

Project #FC-356: Durable High-Efficiency Membrane Electrode Assemblies for Heavy-Duty Fuel Cell Vehicles

Hui Xu, Giner, Inc.

DOE Contract #	DE-SC0021671 (SBIR)
Start and End Dates	06/28/2021–06/27/2022
Partners/Collaborators	• University at Buffalo (State University of New York) • Compact Membrane Systems • Indiana University and Purdue University Indianapolis • University of Connecticut • Oak Ridge National Laboratory of the Million Mile Fuel Cell Truck Consortium

Project Goal and Brief Summary

This project aims to develop robust MEAs for heavy-duty vehicles. Researchers will develop a catalyst using highly active and stable Pt or PtCo nanoparticles, with well-controlled particle size and composition for enhanced performance and durability. The catalyst will be integrated with a high oxygen permeability ionomer to improve fuel cell performance. Researchers will then determine the optimal variables for preparing inks and MEAs using the newly developed catalysts. The developed MEAs will be evaluated using M2FCT ASTs.

Annual Merit Review of the Fuel Cell Technologies Subprogram

Summary of Fuel Cell Technologies Subprogram Reviewer Comments

This section provides a summary of the reviewers' remarks. The content reflects those inputs only and not the views of Program management. The complete set of review comments received is provided as Appendix A.

Fuel Cell Technologies Subprogram Portfolio and Technology Applications

Overall, the FCT subprogram is well-balanced across near-, mid-, and long-term research and development and is consistently strong, appropriately aligning priorities and investments. While significant innovation in fuel cells has traditionally been fostered and important challenges have clearly been identified, more work is needed to prioritize and connect these challenges to the process of meeting the goals.

The decrease in the Program's 2023 FCT budget request, when the overall Program budget is increasing, is a concern. Although outstanding progress has been made in improving fuel cell performance and reducing costs, the shift in focus from light-duty vehicles to medium- and heavy-duty vehicles makes cost goals more challenging to achieve, as durability requirements are also increased. Moreover, despite advancements in light-duty fuel cell vehicles, improvements are still needed, especially in durability and costs. Furthermore, reducing funding for fuel cell research and development is premature, as significant performance and cost challenges remain for heavy-duty vehicle applications. Thus, the budget for fuel cell research should be increased to achieve the more challenging goals.

The heavy-duty vehicle market alone may not generate the demand needed in the transportation sector to reduce the cost of hydrogen to the Hydrogen Shot goal or to enable widespread commercialization. Researchers should also consider cost breakthroughs needed to achieve a cost-effective heavy-duty fuel cell system. The FCT subprogram is focusing on decreasing the fuel cell stack cost by 80% and has identified which components will need to be improved to meet this goal; however, during the Annual Merit Review, there was no clear expression of how much cost reduction would actually be possible with each component. Moreover, light-duty fuel cell vehicles could remain a zero-emission-vehicle option for fleet vehicles and for drivers whose vehicle range and refueling needs are not met by battery electric vehicles. The subprogram should communicate clearly where the advances in one application may or may not be transferrable to the other and to keep stakeholders appropriately informed.

Research Focus

The research focus of the FCT subprogram has been changing in the past couple years, with some previous achievements being put aside to some extent, which could result in losing capabilities that could benefit both fuel cells and electrolyzers.

Some research areas are underrepresented, while others have too much focus:

- Non-PGM catalysts are over-represented. While these catalysts hold great promise for addressing cost in the long term, they also remain far from commercial viability. Also, the effect of decreased performance of non-PGM catalysts compared to PGM-based catalysts might bring forth different design considerations, such as larger fuel cell stacks, more bipolar plates, or more membranes.
- Off-road fuel cell electric vehicles are underrepresented.
- The fuel cell BOP should have greater emphasis.
- The reduced emphasis on solid oxide fuel cell research is concerning. Industry is still interested in commercializing the technology, and these higher-temperature fuel cells have a vital role to play in stationary power generation applications and do not require the use of precious metals. However, there are many important challenges to overcome, requiring supportive funding and more emphasis on the current state of solid oxide fuel cell technology. Furthermore, the split between low-temperature fuel cells (with higher technology readiness levels) and high-temperature fuel cells (with lower technology readiness levels) seems out of balance; future funding and research should be more balanced.

Regarding sub-cell and cell-level fuel cell research, there is a need to reevaluate the tradeoff between near-term high performance and long-term stability, as the techniques that achieve high-performing electrochemical cells often do not persist and may require replacing the expensive electrochemical hardware more frequently.

Recycling of fuel cell components is another matter of interest. While it is a longer-term issue, recycling fuel cell stacks, systems, and vehicles could receive more focus. There should be more emphasis on refurbishing fuel cells rather than recycling them, as most of the value (other than the PGMs) is in the structure of the materials, rather than in the metal. This is particularly true of bipolar plates and of advanced catalysts with no PGMs.

Consortia

The consortium approach is innovative and enables timely progress toward addressing challenging problems. However, the consortia need more visibility. Many of the small businesses that are only tangentially related to the hydrogen and fuel cell industry are unaware of these consortia and the potential benefits of participating. Such businesses may be more likely to change their business models to support the hydrogen economy if they could leverage the consortia to modify their products to address emerging opportunities.

In addition, the focus of the ElectroCat consortium could be shifted toward developing PGM-free catalysts for AEM electrolyzers over the next three to five years.