H2CHARGE

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General Motors LLC - U.S. Army Ground Vehicle System Center (GVSC)
Other Transactions Agreement #W56HZV-19-9-0007

DOE Hydrogen Program

2024 Annual Merit Review and Peer Evaluation Meeting

AMR Project ID #
IA009

HYDROTEC GENERAL MOTORS | HYDROGEN FUEL CELL SOLUTIONS
ZERO EMISSIONS • MAXIMUM CAPABILITY

PROJECT GOAL

Design, develop, and demonstrate GM's next generation commercial prototype fuel cell DC Fast Charging solution. The project will additionally study concepts associated with maximizing overall charging capacity in its region of usage, such as a military base, government installation, or a facility with a captured fleet.

System Requirements:

- Provide a peak power capability of 500kW
- Built into a 20ft container
- Conduct charging compliant with
  - SAE J1772
  - ISO 15118
  - CCS (Combined Charging System)
- Vehicle charging will be focused on charging rates > 150kW
- Level 2 charging must be accommodated

OVERVIEW: H2CHARGE

Timeline:

- Project Start Date: 8/31/2023
- Project End Date: 11/30/2025

Budget:

- $2.8M

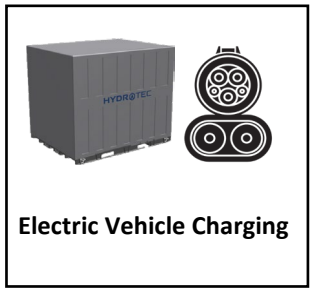
Barriers:

- Hydrogen storage and shipping planning at points of use
- Varying permitting requirements associated with various fuel storage solutions

Supporting Organizations:

- U.S. Army Engineer Research & Development Center, Construction Engineering Lab (CEERD-CERL)
- DOE Hydrogen and Fuel Cell Technologies Office (HFCT)
- U.S. Army DEVCOM Ground Vehicle System Center (GVSC)
- U.S. Air Force Office of Energy Assurance (AF OEA)
- U.S. Marine Corps Expeditionary Energy Office (E2O)

POTENTIAL IMPACT: H2CHARGE



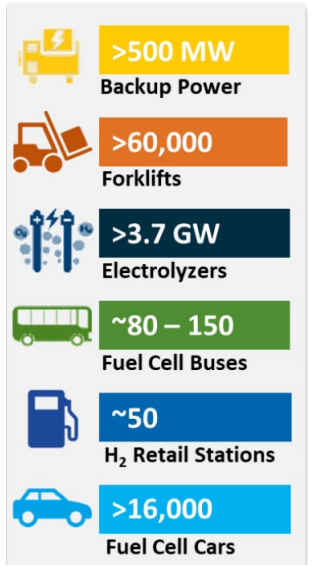


Figure 7. Examples of hydrogen and fuel cell technology deployments in the United States

From U.S National Clean Hydrogen Strategy Roadmap

- Support accelerated decarbonization in the transportation sector with fuel cell power generation directed at supporting electric vehicles
  - Reduce the barrier for electric vehicle adoption in rural areas or areas without significant grid infrastructure for passenger vehicles
  - Accelerate programs implementing electric vehicles by providing grid assistance ahead of infrastructure improvements for electric fleets
  - Enable recreational electric vehicle usage in areas unlikely to produce a grid capable vehicle fast charging
  - Provide capabilities for disaster relief scenarios requiring deployable vehicle chargers in ladened transpiration corridors
- Provide convenience power serving adding additional energy resilience

APPROACH: H2CHARGE

Major Milestones:

- **System Design Study**
  - Evaluated design concepts for 1, 2, and 3 modules dividing the planned 500kW offtake power
  - Compared real world charging performance based on EVs in the marketplace
  - Identified that distributing power offtake in multiped systems benefits users, so long as the charger can provide a meaningful charge in less than 20 minutes and a full charge in less than 30 minutes for most vehicles (20-80% vehicle SOC)
  - Additional benefits can be found if systems can be distributed after shipping is complete to reduce user transit time or to evaluate usage effects when changing charger locations
- **Design Review**
  - Preliminary Design Complete
  - Making progress in Final System Design
- **Demonstration Planning**
  - Evaluating 4 sites as part of a one-year demonstration
  - Demo locations TBD

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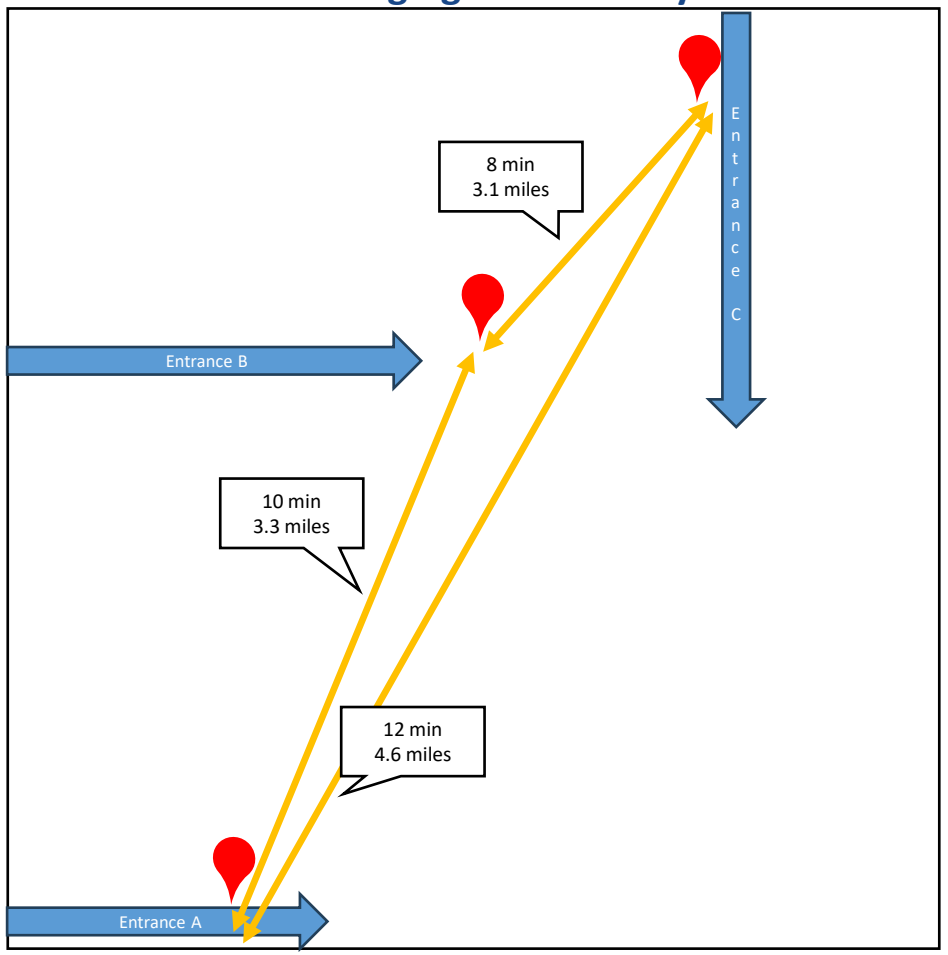
Driving distances impact charging operation time more than charging rate in many scenarios



A Base example with 5 X 5-mile area and 3 entrances. Notice the driving time from one entrance to another entrance is longer than the difference in charging time from the examples on the right. Mobile units enable evaluation of the best location for fixed site chargers ahead of infrastructure.

Charging operation example of two different types of systems, a 500kW charger and 3 150kW chargers.

Three vehicles pull up simultaneously

- 1 X 500 kW DC Fast Charger
  - Each vehicle takes 18.95 minutes totaling **56.84** minutes
  - 38% system utilization when in use
- 3 X 150 kW DC Fast Chargers
  - Each vehicle takes 24 minutes to charge totaling **24** minutes
  - 100% system utilization when in use

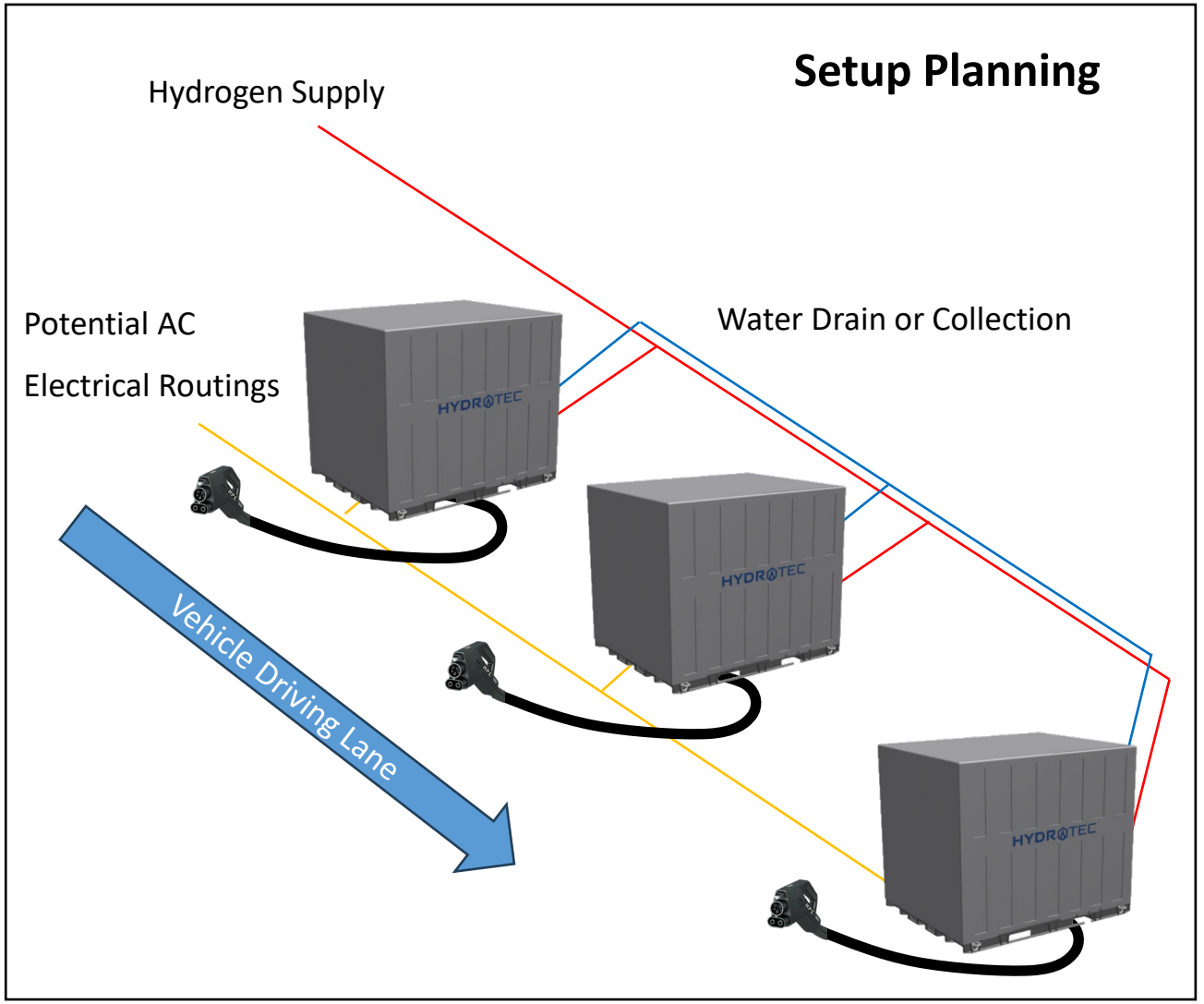
Three vehicles pull up consecutively

- 1 X 500 kW DC Fast Charger
  - Each vehicle takes 18.95 minutes totaling **56.84** minutes
  - 38% system utilization when in use
- 3 X 150 kW DC Fast Chargers
  - Each vehicle takes 24 minutes to charge for a system operating time of **72** minutes
  - 30% system utilization

APPROACH: H2CHARGE

MPGS (Mobile Power Generation System) setup in the field as part of Hydrogen Ecosystem Project

Note: This is a unique application of fuel cell technology leveraging existing infrastructure to Enable EV adoption



Planned Solution For H2 Charge

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SAFETY PLANNING AND CULTURE: H2CHARGE

- Charging systems used in the field complete the same review process as automotive fuel cell systems
- Rigorous acceptance testing is completed on every unit prior to leaving a GM site
- Standard GM processes leveraged for hazard risk identification, risk analysis, communication of issues, and containment
- Systems are designed and validated with diagnostic algorithms and implemented safety sensors to ensure issues are identified prior to field usage, continuously monitored while operating, and designed to shut down to avoid personnel risk if hardware fails in the field
- The user interface will be designed for ease of use to enable a trained operator to function quickly and efficiently
- The system will be delivered with a user manual providing safety critical procedures
- GM leverages similar projects such as the MPGS for reduced risk and increased operational success

ACCOMPLISHMENTS AND PROGRESS: H2CHARGE

- On track with project milestones
- Preliminary design complete meeting all project design requirements
- Commenced part procurement
- Commenced demonstration planning

Previous Accomplishments

- >30,000 total kWh charged
- >100,000 miles of range added to BEVs
- >50,000 system road miles
- >2,000 hours of system runtime
- >30 temporary DCFC stations deployed
- No fuel cell failures
- Average setup time <30 minutes

COLLABORATION AND COORDINATION: H2CHARGE

Funding Organizations:

- U.S. Army Engineer Research & Development Center, Construction Engineering Lab (CEERD-CERL)
- DOE Hydrogen and Fuel Cell Technologies Office (HFCTO)
- U.S. Army DEVCOM Ground Vehicle System Center (GVSC)
- U.S. Air Force Office of Energy Assurance (AF OEA)
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Project shareholders create opportunities to collect key feedback from demonstrations using hydrogen-based mobile power equipment on U.S. military installations across the country and in austere locations. It is additionally important to continue to increase familiarity of the technology for potential users that may not often encounter hydrogen fuel cell equipment or electric vehicles in daily activities.

REMAINING CHALLENGES AND BARRIERS

- This project is just starting to source parts; the availability of prototype materials increases risk
- Demonstration planning is in the works. The team is evaluating appropriate sites to demonstrate the equipment that will be representative and meaningful to the shareholders
- Fuel cell hydrogen logistics will be constant point of interest in this project because it will be setup at multiple sites and for extended periods. Overall usage is uncertain, and hurdles may exist when sourcing fuel trailers or permitting them, depending on local and state requirements
- UL certification process in commercial fuel cell energy products

PROPOSED FUTURE WORK: H2CHARGE

- These energy systems are flexible in many environments requiring mobile power. The system as designed is capable of being scaled to the needs of each site by adding or subtracting charging units and using standardized containerization for ease of transportation
- Additional demonstrations or evaluations of this or similar equipment in disaster relief scenarios would provide valuable feedback on required adaptations to the system design and present opportunities to evaluate the hardware in less predictable environments
- Usage of these systems in U.S. ports could further enable electrified watercraft or emerging zero emission port ecosystems

SUMMARY: H2CHARGE

- Fuel Cell Mobile DC Fast Chargers enable zero emissions targets by providing mobile charging capability ahead of permanent infrastructure, thus accelerating the adoption of battery electric vehicles
- Existing commercial fuel supply networks make the proposition of fuel cell-based charging systems possible even in environments where traditional automotive hydrogen fueling networks do not exist yet
- The planned use cases for the H2Charge systems are where the electrical grid is needed but unavailable. Therefore, the correct comparison for energy costs would be with other zero emission off-grid energy sources
- Widespread adoption and profitability of this technology will greatly benefit from increased hydrogen availability and cost reductions of clean hydrogen
- The development of this hardware is mature thanks to years of GM's development and validation of automotive fuel cells and past GVSC/DOE projects and support

Q&A: H2 CHARGE

THANK YOU!