Innovative Advanced Hydrogen Mobile Fueler

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Project ID #ta017

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Overview

Timeline

- Project Start Date: 07/01/16
- Project End Date: 12/31/20

Barriers

- H2 Codes and standards
- Hydrogen storage
- Lack of hydrogen refueling infrastructure performance and availability data

Budget

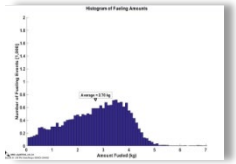
- Total Project Budget: $2,971,537
  - Total Recipient Share: $1,682,754
  - Total Federal Share: $1,288,783
  - Total DOE Funds Spent*: $658,389

    * As of 1/31/19

Partners

- Electricore – Federal Project Manager / PI
- Air Liquide – Design & Demonstration
- HTEC – Design & Fabrication
- QAI – Technical Lead
- Manta Consulting – Economic Analysis

Relevance



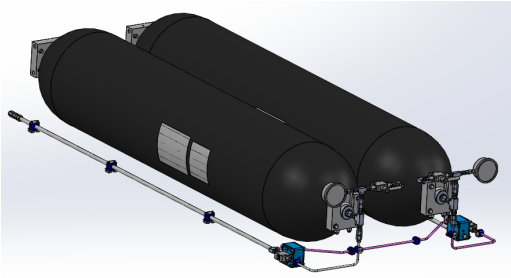
Key Objectives

- Design and build an Advanced Hydrogen Mobile Fueler (AHMF)
- Deploy AHMF to support a network of H_2 stations and vehicles
- Gather and analyze fueling data for NREL Technology Validation Team

FCT Office Barriers	AHMF Impact
Mobile fueler performance and efficiency data	• Real world operations and maintenance data will be provided to NREL technology validation team
Transportable hydrogen storage	• Reduction of cost and setup time by obtaining special permit from DOT to allow transporting of H_2 at 95 MPa
Codes and standards for mobile fueling	• Educating states with no experience in metering of hydrogen • Addressing issues of metering of hydrogen in multiple states

Relevance - Impact

Barrier: Hydrogen storage

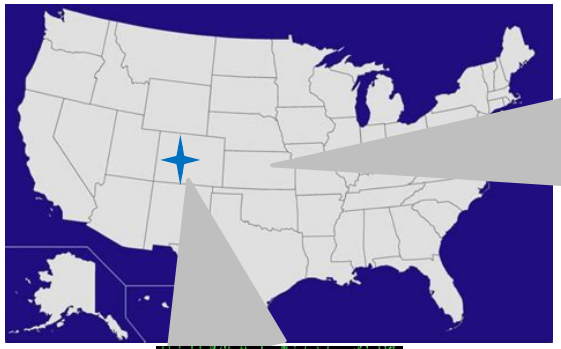


Impact: Received special permit for transport of H2 at 95 MPa

Barrier: Codes and standards

Impact: First H70 mobile system with listing to assist in permitting

Barrier: Lack of hydrogen refueling infrastructure performance and availability data



Impact: AHMF will be deployed to support a network of H2 stations and vehicles

Impact: Will gather and analyze fueling data for NREL Technology Validation Team

Approach - Milestones

Current Activities - *Estimated Completion June 2019*

Task 4	AHMF Build ★	• Complete Procurement • Build and integrate subsystems • Verify Design • Final Assembly
Task 5	Site Selection ★	• Select 3 deployment sites • Targeted areas include Northeast US and California
Task 6	Testing	• Create Test Plan • Sub-system testing • Safety & functional testing

Next Steps - *Estimated Completion December 2020*

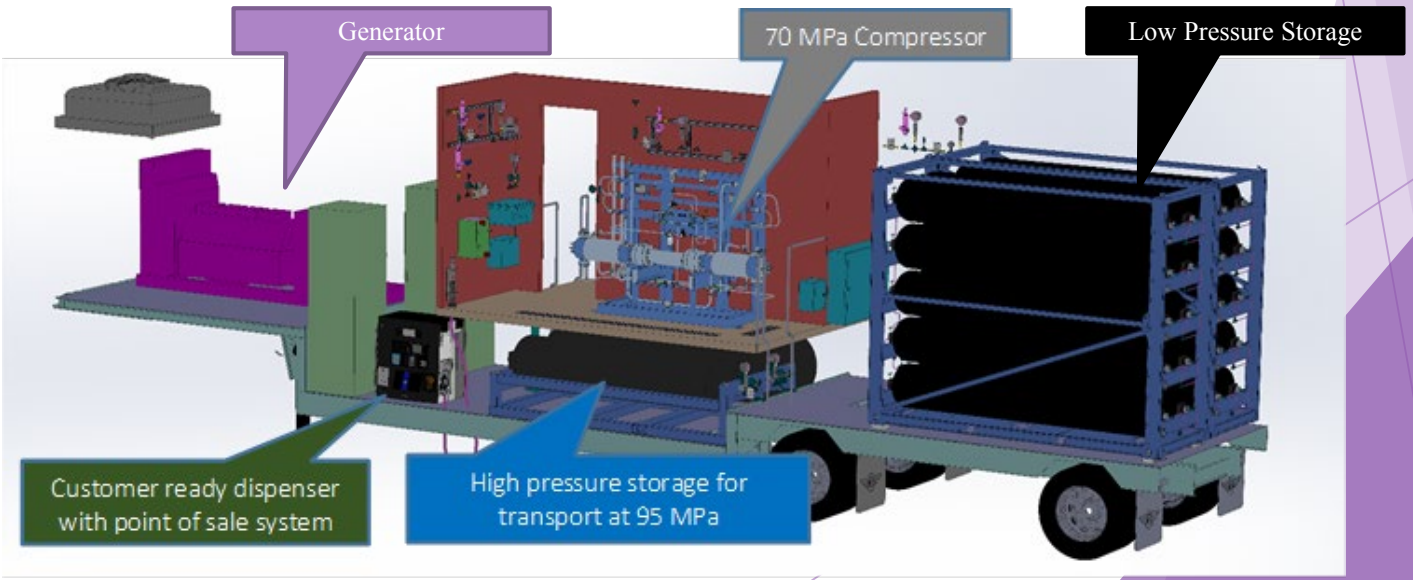
Task 7	Demonstration	• Deployment at 3 sites over 180 days • Provide operational and maintenance support • Collect data for NREL Tech Val Team
Task 8	Economic Analysis	• Conduct economic analysis • Stakeholder meeting • Reporting

★ ***Go/No-Go Decision Points***

Approach - Design

- First mobile fueler capable of filling vehicles to 95-100% in 3-5 minutes (SAE J2601 compliant H70 T40)
- Can fill 3-5 cars in first hour, 20-40 cars daily (175 kg of H2 storage)
- Customer ready dispenser, capable of retail sales
- Fully self contained with option for use of external power and hydrogen supply

Design meets industry need for fully functional mobile station



Approach – Unique Aspects

- AHMF will use unique liquid nitrogen (LIN) cooling system
  - Based upon Air Liquide's "Blueeze" refrigerated transport system
    - Also being implemented on Air Liquide EU mobile fueler
  - Overall >75%% reduction in volume and >50% reduction in weight from convention H2 station cooling system
  - Significant cooling "power" compared to conventional system

Refrigerated truck with Blueeze System

Air Liquide
EU mobile fueler

Approach – Construction

- Build, build, build!
  - Trailer prepared for assembly
  - Medium pressure storage and generator installed

Medium Pressure Storage

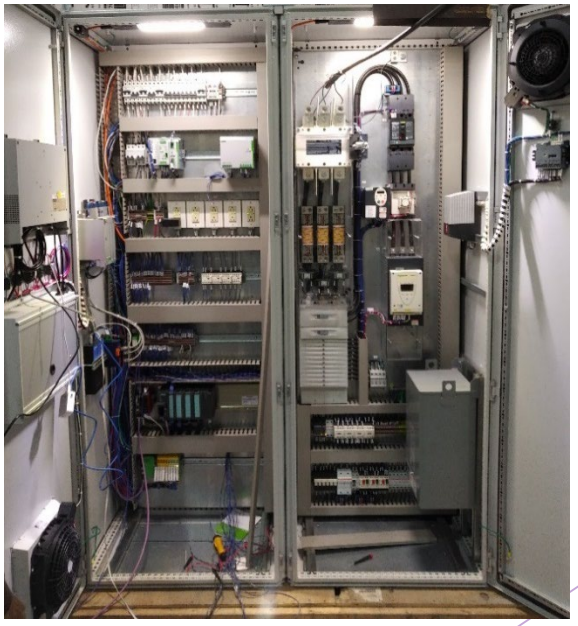
AHMF Trailer

Generator

Approach – Other Components

- Compact consumer-friendly dispenser received
  - Based upon Air Liquide C100 dispenser with point-of-sale system
- Electrical panel built and passed factory acceptance testing
- 50% of systems procured

Dispenser

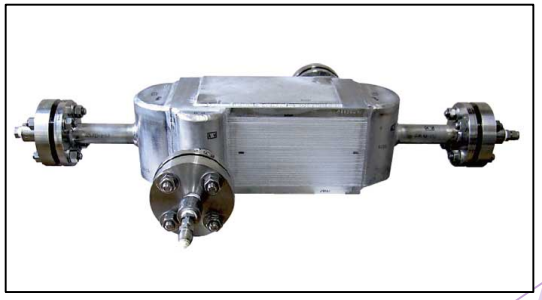


Electrical Cabinet

Accomplishments – LIN Components

- All major components acquired
  - Blueeze LIN storage
  - Diffusion bonded compact heat exchanger (DCHE)
    - 90% reduction in plot area compared to shell and tube
- Preliminary testing proved control scheme
- LIN system allows us to meet cooling specifications in restricted space
  - Conventional system too large, not designed for transport

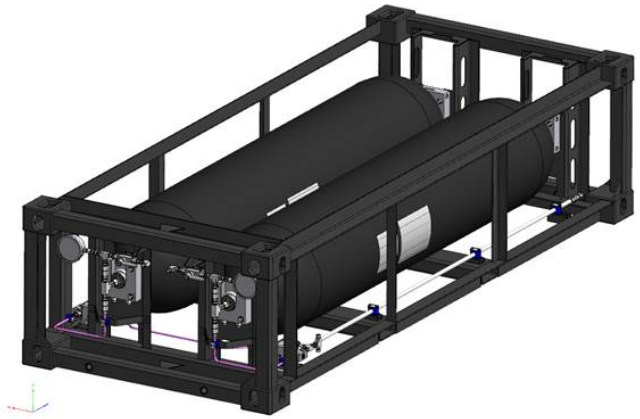
Blueeze LIN Storage



DCHE Heat Exchanger

Accomplishments – H2 Storage

- Special DOT permit acquired
- Allows transport of high pressure hydrogen at 95 MPa
- Without permit, storage would need to be vented and purged
  - Increase costs due to loss of hydrogen and purge gas
- Currently analyzing frame and fire protection design
- Same tanks can use special permit for other applications



High pressure storage and frame

Reviewer Comments

Past Comments	Response
How is hydrogen storage replenished?	The team will use Air Liquide's network of tube trailers to replenish its hydrogen storage using its on-board compressor. The tube trailer can be delivered and returned or can be left on-site depending on usage, location, and cost. The AHMF can also be transported to the plant.
Demonstration period should be longer	Air Liquide has plans to use the AHMF after the demonstration period is complete to support its network of stations.
Can the system be increased to fuel larger vehicles?	Due to the "self-sufficient, mobile" nature of the AHMF, size is very constrained. So significantly increasing storage to handle medium or heavy duty vehicles would be challenging without changing the fundamental design.
How is permitting and siting handled	The AHMF will be listed to NFPA2, NEC and other key codes/standards to assist in AHJ approval. Determination of the AHMF sites is waiting for further detail from the industry on location of future stations and vehicles.

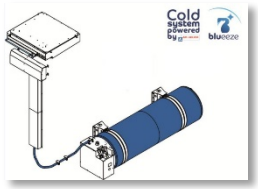
Collaboration & Coordination

Team Members		Role
Air Liquide	Air Liquide	Design/Operations Project Co-Funding
HTEC Hydrogen Technology & Energy Corporation	HTEC Hydrogen Technology & Energy Corporation	Design and Fabrication
	Quong & Associates, Inc.	Technical Lead
MANTA consulting	Manta Consulting	Economic Analysis

Collaboration	Role
National Renewable Energy Lab	Data Collection and Analysis
Multiple automotive companies	Advisor on Site Selection/Usage
US Department of Energy Hydrogen and Safety Panel	Safety Analysis
US Department of Transportation	High pressure special permit
Hexagon Lincoln LLC	Composite tank manufacturer and special permit
Kobelco Steel	Heat exchanger testing for use with LIN

Remaining Challenges & Barriers

Liquid Nitrogen Cooling



- **Challenge**: Build and calibration of LIN cooling system which will be the first to meet SAE J2601 fueling protocol
- **Solution**: Preliminary testing showed feasibility of control system. The team will draw upon experience of Air Liquide's Blueeze™ system and EU mobile fueler

Cost control

- **Challenge**: The project encountered cost overruns due to
1. the use of a custom trailer instead of a container
2. Development costs of LIN system and high pressure storage
3. Additional emissions control on generator
4. Increase in costs of fitting and valves
5. Re-certification of medium low pressure storage
- **Solution**: The cost increase was covered by Air Liquide after a significant detailed re-budgeting and a cost control program was put in place.

Schedule

- **Challenge**: Due to the time to obtain the DOT special permit, the high pressure frame and fire protection is now the critical path which may impact delivery schedule
- **Solution**: The team has developed an assembly plan that allows the insertion of the high pressure storage near the end

Proposed Future Work

Goal	Dates	Tasks
Complete build and testing	Current to Q2 2019	• Complete assembly, piping, wiring • Listing of AHMF • Sub-system and system testing
Site Selection		• Coordinate with auto companies to select 3 sites • Complete operations plan
Deploy AHMF	Q3 2019 to Q4 2020	• Coordinate with Air Liquide for operations and maintenance support
Collect Data		• Transfer data to NREL
Final Reporting		• Includes economic analysis
Beyond Project	Beyond Q4 2020	• Air Liquide plans to use AHMF beyond 2020 to support stations

Any proposed future work is subject to change based on funding levels.

Technology Transfer Activities

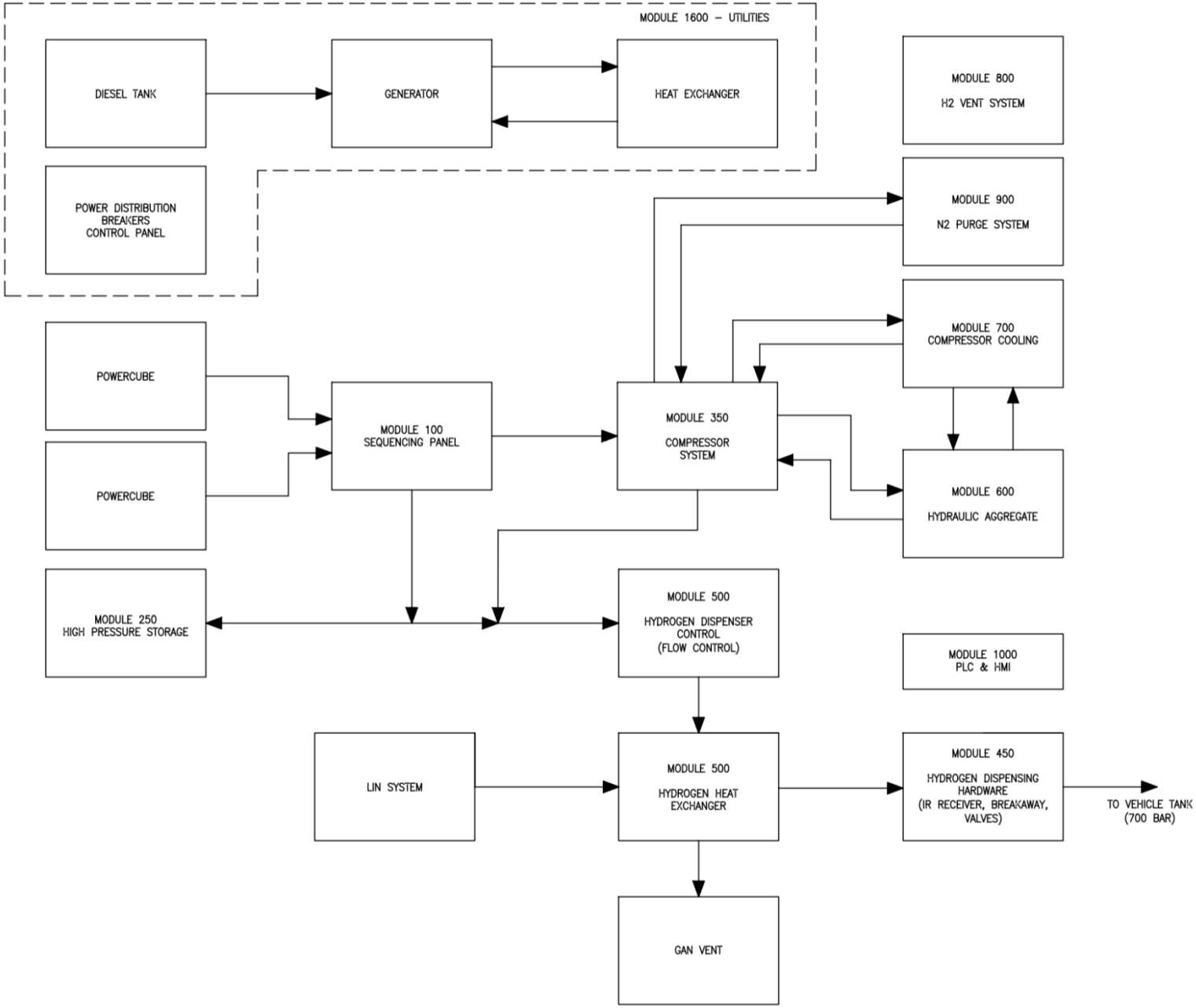
- Special permit for transport of high pressure hydrogen can be used for other applications beyond AHMF
  - Additional mobile systems considering use of same tanks
- Team responding to inquiries for additional systems
  - Public agencies
  - Private companies
- AHMF facilitates establishment of new market areas and expansion of existing markets for hydrogen vehicles

Summary

- Construction of the AHMF has begun
- The first-of-its-kind LIN cooling system successfully completed preliminary controls testing. The system will significantly reduce weight, size, and component costs
- The DOT special permit for transporting high pressure hydrogen in tanks was approved. This has a strong impact on industry because the tanks can be used on other projects
- The project encountered budget and schedule issues, but new controls in place will ensure a successful project

Summary Table

	FY 2018	FY 2019
Construction	Major components ordered/received	Assembly of major components into trailer
Testing	Team preparing test plans	Same
DOT Special Permit	Pending	Approved. Work on frame and fire protection has begun
LIN Cooling system	Design complete	Preliminary testing successful. All major components ordered
Site Selection	Coordinating with automotive companies and nationally recognized testing laboratory for listing	Same

Technical Back-Up Slides

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