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Holistic Fuel Cell Electric Vehicle/ Hydrogen Station Optimization Model

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Project ID h2050

This presentation does not contain any proprietary, confidential, or otherwise restricted information.

Overview

Timeline and Budget

- Project start date: TBD
- Project end date: 1-year after start date
- Total project budget: $370k
  - Total recipient share: $185k
  - Total federal share: $185k
  - Total DOE funds spent*: $0

* As of 3/31/18

Barriers

Safety Codes and Standards

- Safety Data and Information: Limited Access and Availability (MYRD&D 3.7.5A)
- Insufficient Technical Data to Revise Standards (MYRD&D 3.7.5G)

Technology Validation Barriers

- Lack of Hydrogen Refueling Infrastructure Performance and Availability Data (MYRD&D 3.6.5D)

Overview: Partners

- NREL
- Frontier Energy
- SNL
- ANL
- Honda R&D America (HRA)
- Ford
- Hyundai
- General Motors (GM)
- Shell
- Air Liquide
- IVYS
- Toyota

Relevance

- No free-to-use validated model currently exists
- A complete, validated, and industry accessible hydrogen systems fueling model is of critical important to understanding and improving hydrogen fueling stations to meet technical DOE targets

Relevance

- An open-source model which accurately predicts temperature and pressure could be used as a tool to:
  - Safely design and operate a fueling station
  - Support code refinement by enabling science-based codes and standards for a variety of system designs and sizes
  - Make infrastructure performance data readily available
  - Develop system/operational improvements which reduce the cost of dispensing hydrogen
  - Enables easy access to station performance and vehicle fill characterization

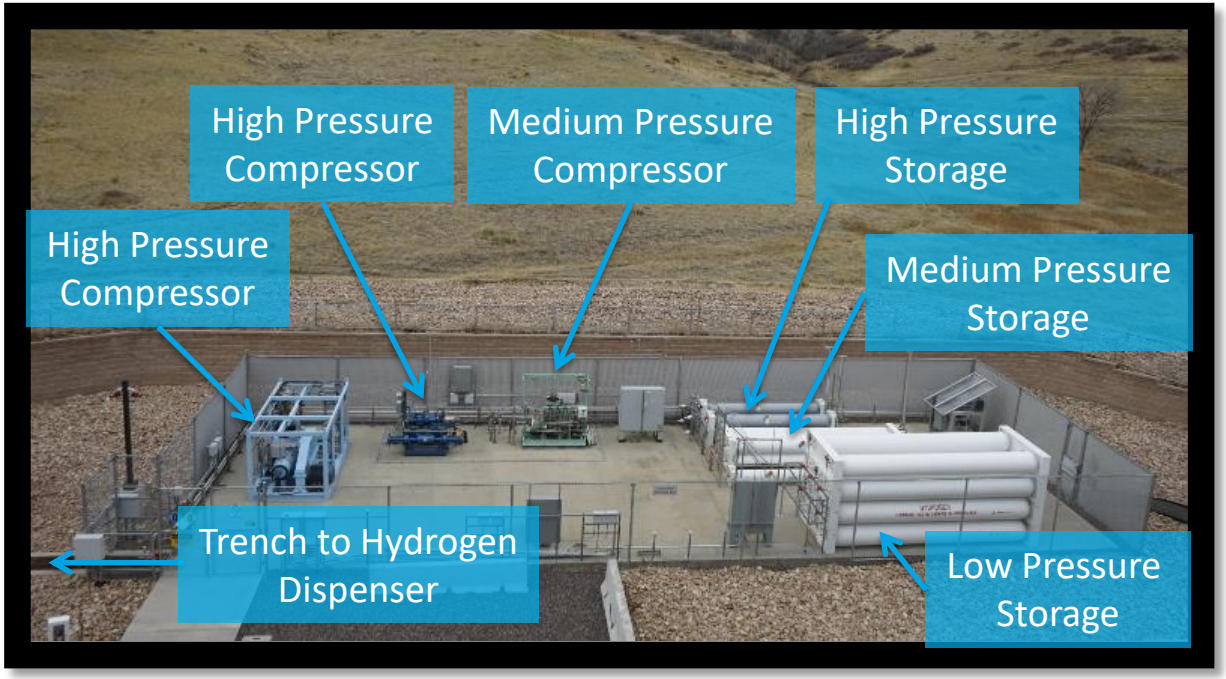
Approach

Thorough Literature Review → Evaluate Existing Models → Acquire Appropriate Model(s) → Join Models → Validate Model → Create Comprehensive User's Manual → Disseminate to the Public

Existing data from industry partners

Existing data from NREL hydrogen fueling station

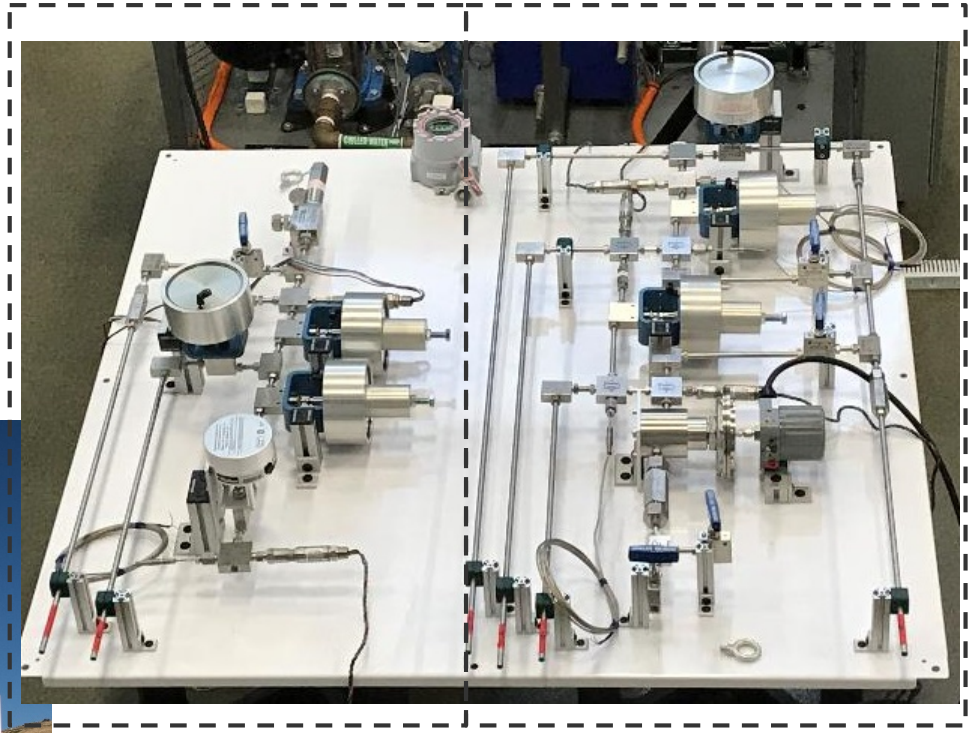
Experimentation at NREL hydrogen fueling station



NREL Validation Capabilities

Recirculation

Research Dispenser



Accomplishments and Progress

- Project has not started yet
- Planning meeting with stakeholders was held on Feb. 9th, 2018
  - Hosted at Honda R&D North America, Torrance, CA
  - Organized by Frontier Energy
- Preliminary literature review was performed as part of the proposal process to evaluate project impact

Preliminary Literature Review

- HyTransfer
  - Experimentally validated CFD, analytical, and parametric models
- Wenger Engineering GmbH
  - Analytical model supported creation of look-up tables in J2601
  - MC Model
    - dynamic control algorithm which calculates internal gas temperature based on real-time inputs
- Monde et. al. Saga University, Japan
  - Analytical model of vehicle tank fill, experimentally validated
- Dicken et al. Clean Energy Research Center, Vancouver, Canada
  - 2D axisymmetric CFD model, validated for a type III, 74L hydrogen cylinder filled to 35 MPa
- Melideo et al. European Commission Joint Research Center, The Netherlands
  - Experimentally validated Ansys CFD model for type III and IV, 77 MPa tanks
  - Parametric study based on CFD results
- Olmos et al. UCLA
  - Analytical model for gas supplied from the pre-cooler including the vehicle tank
  - Validated against limited experimental data
- Kyushu University
  - Simplified analytical model for gas supplied from the pre-cooler to the inlet of the vehicle tank
  - Validated against limited experimental data
- And more… 94 references included in Bourgeois et al. 2017 review

Collaboration and Coordination

Lead Lab:

- ✓ NREL

Advisory Role:

- ✓ SNL
- ✓ ANL

Administrative Role:

- ✓ Frontier Energy

Industry Partners:

- ✓ Honda R&D America (HRA)
- ✓ Ford
- ✓ Hyundai
- ✓ General Motors (GM)
- ✓ Shell
- ✓ Air Liquide
- ✓ IVYS
- ✓ Toyota

Remaining Challenges and Barriers

- Coordinating multiple stakeholders
  - Receive funding
  - Agree on project direction and scope
- Acquiring robust and validated model(s) to kick start the project
- 1-year time frame might be too aggressive
- Legal issues surrounding open-source and/or free-to-use may arise

Proposed Future Work

- Finalize agreements between parties
- Execute project plan

Technology Transfer Activities

- Goal is that the validated model will be used to develop future protocols and hydrogen station designs
  - Accessible and free-to-use by industry and researchers alike

Summary

- Relevance:
  - No free-to-use validated model currently exists, but is important for industry advancement
- Approach:
  - Develop a fueling station model based on existing model(s)
  - Validate and expand scope of the model by utilizing available data and testing at NREL
- Accomplishments:
  - Project has not started
- Challenges:
  - Coordinating large group of stack-holders to arrive at a consensus on project scope and starting model
  - 1-year time frame may be too aggressive

Thank You

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Publication Number

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Technical Back-Up Slides

(Include this “divider” slide if you are including back-up technical slides [maximum of five]. These back-up technical slides will be available for your presentation and will be included in Web PDF files released to the public.)

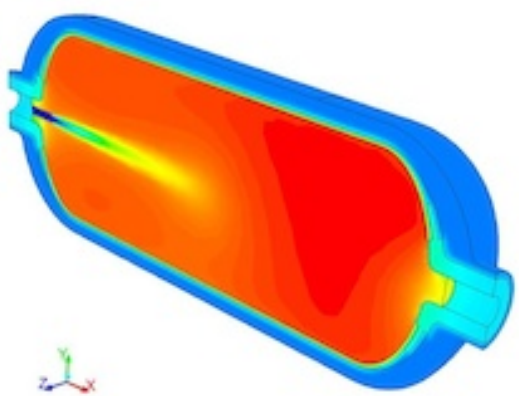
Modeling Options

Analytical Thermodynamic Model

- Set of mathematical equations based on fundamental laws
- Vary in complexity based on assumptions
- Gas pressure and temperature assumed homogeneous
- Solution in seconds or minutes

Computational Fluid Dynamics (CFD) Model

- Complex model requiring specialized software
- Complete temperature field of the gas and materials are resolved
- Solution in hours or days



Parametric Model

- Simple closed-form equation derived from more complex models/experimental results
- Severe limitations based on validation range
- Predicts final average gas temperature
- Solution in seconds