NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Holistic Fuel Cell Electric Vehicle/ Hydrogen Station Optimization Model

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Project ID h2050

Overview

Timeline and Budget

- Project start date: August, 2018
- Project end date: September, 2019*
- Total project budget: $370k
  - Total recipient share: $185k
  - Total federal share: $185k
    - DOE Funds Spent: $63k of $105k**

*Project can be extended with additional industry funds
** Reflects NREL spending as of 3/20/2019

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

Lead

- NREL
- Frontier Energy

Industry

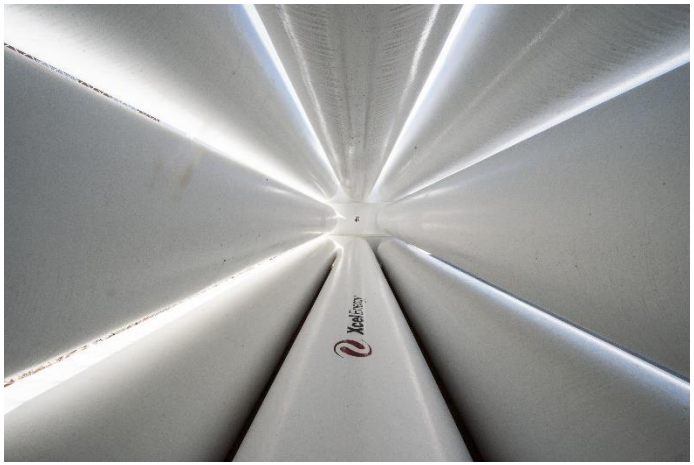
- Ford
- General Motors
- Honda R&D America
- Hyundai
- IVYS
- Shell
- Toyota

Labs

- Sandia National Lab
- Argonne National Lab

Relevance

- No free-to-use validated model which links the station and vehicle 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



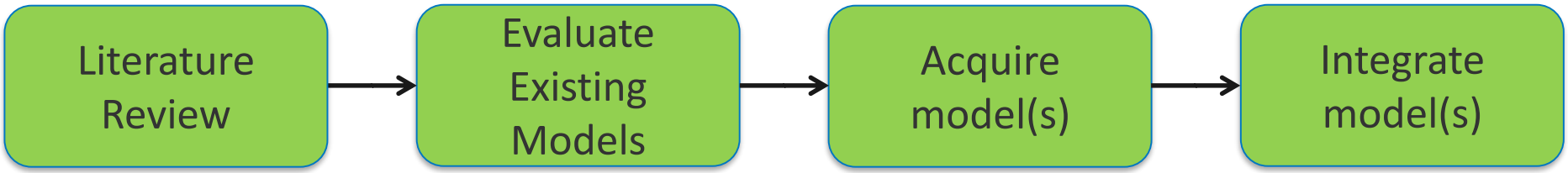
Relevance

- An open-source model which accurately predicts temperature and pressure could be used as a tool to:
  - Bridge the gap between station and vehicle side integration during fueling
  - 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

Model Build

Our goal is not to create a model from scratch with this work, there are plenty of publicly available models that can be built upon – we need to leverage those.



Model Validation

It is essential that users can trust the model is accurate. The team is working hard on collecting and creating as much validation data as necessary to ensure confidence in the model. The team will collect validation data in 3 ways:

- Collect existing data from industry partners
- Compile data from NREL hydrogen fueling station
- Run specific validation tests at NREL's HITRF

Approach

Model Availability

The main goal of this project is to make the model available for use to the public. The model needs to be well documented and vetted before being sent out. Below are the deployment steps involved with the project.

Integrate Graphical User Interface (GUI)

Create Comprehensive User's Manual

Alpha Testing *NREL*

Beta Testing Round 1 *SNL and ANL*

Beta Testing Round 2 Industry Partners

Release Model to Public

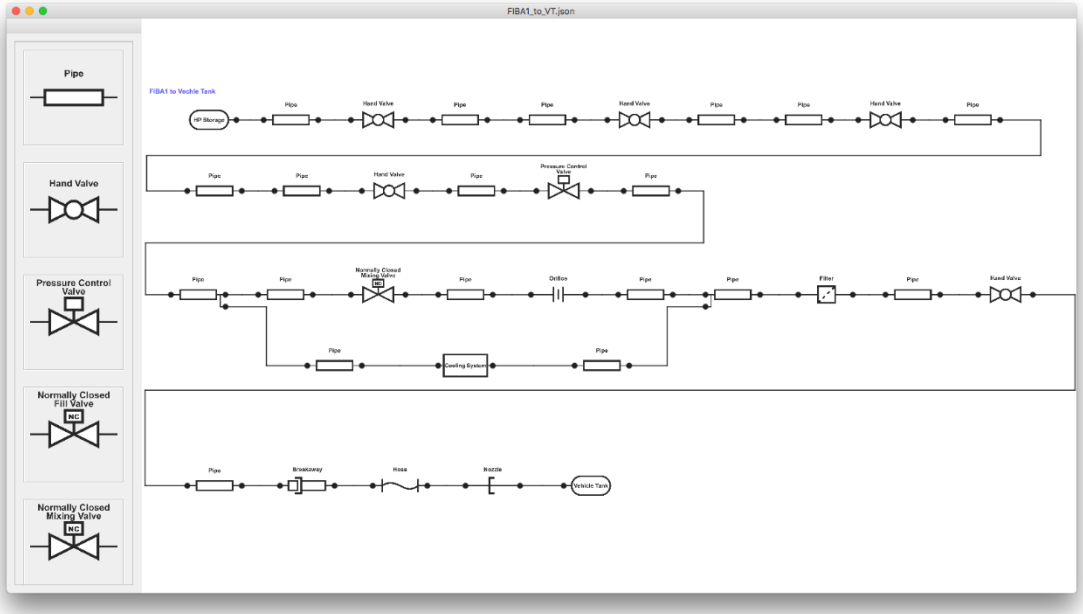
Progress: Timeline Update

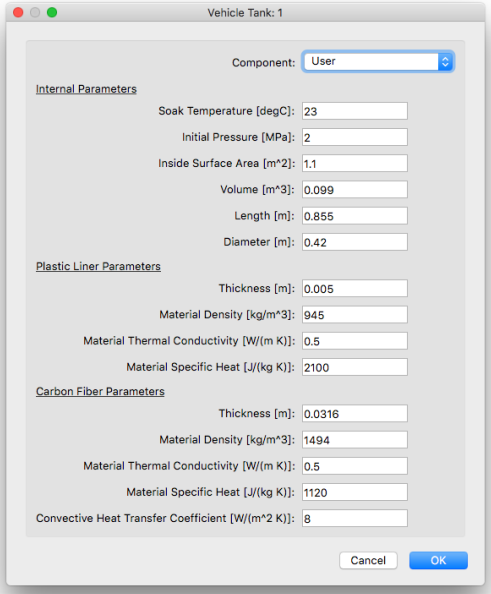
*As of 3/15/2019

- Station Component Modeling
  - 100% complete
  - Validation efforts on track for completion by end of April
- Vehicle Model
  - Obtaining license for validated vehicle model currently under negotiation
  - Model has been validated for FCEV tank size ranges of 0.4 – 7 kilograms
  - After license is obtained, 2 weeks to integrate
- Graphical User Interface (GUI)
  - 80% complete
  - Team working on defining common station designs

Accomplishments: GUI

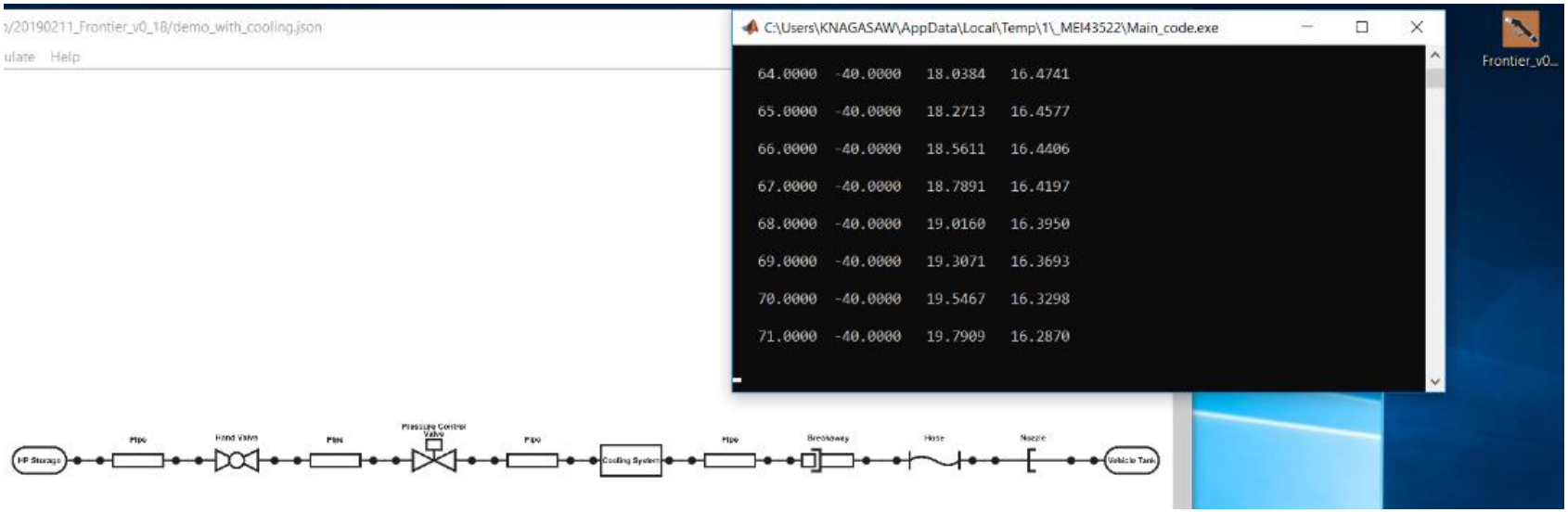
- Developed an easy-to-use graphical user interface (GUI)
  - Allow users to flexibly construct system configurations
  - Can specify user-defined component parameters or select validated component parameters
  - Clearly notify validation ranges





Accomplishments: GUI

- Fully integrated with numerical simulation software
  - Stand-alone application using MATLAB Runtime
  - Analyze network configurations
    - Alert error messages with a link to the user's manual if needed
  - Pass all the input parameters to the simulation software



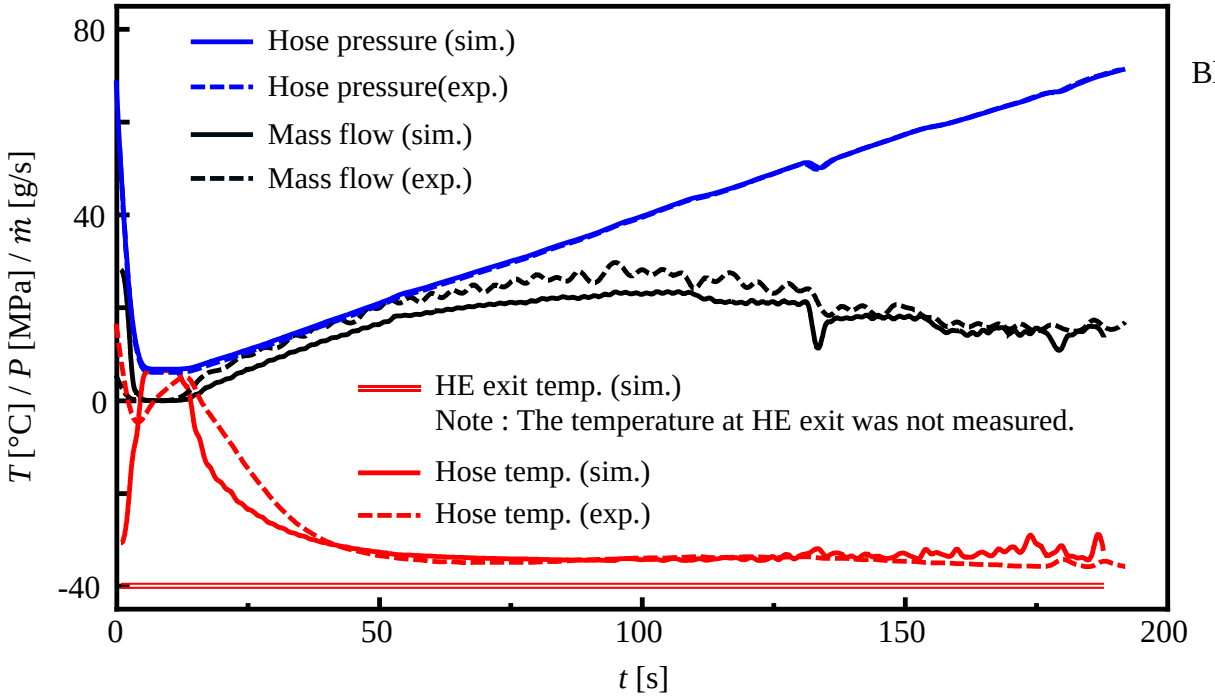
Accomplishment: Model Development

The model can simulate transient change in hydrogen temperature, pressure, and mass flow rate at each downstream position of the high-pressure storage bank during the fueling process.

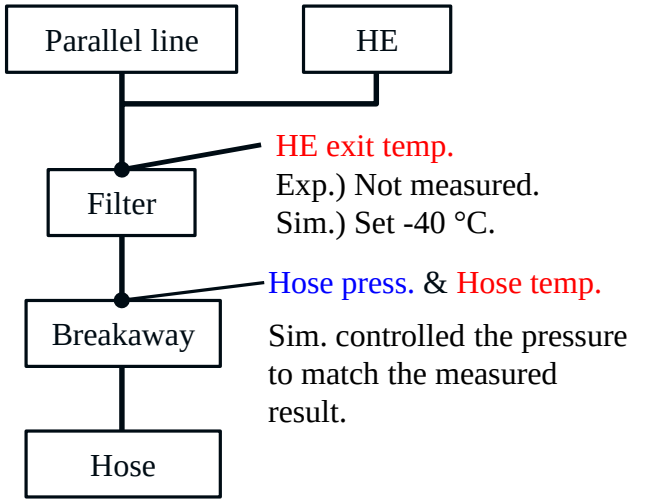
- The temperature and pressure in the high-pressure source are assumed to be constant
- Predict mass flow rate based on the pressure difference between the hose and vehicle tank
- Control the mass flow rate at the pressure control valve so that the hose pressure matches target pressure ramp rate
- Calculate the pressure drop due to the pipe friction and pipe bends
- Calculate the heat transferred through the filling equipment and ambient conditions

Accomplishment: Validation On-going

*Draft validation run, results subject to change



Black line : Fueling line consisting of pipes and joints



- The simulation results roughly agreed with the experimental values.
- The difference between the simulation and experimental results occurs because their conditions such as the HE exit temperature did not exactly match.

Collaboration and Coordination

The project team consists of 8 industry partners and 3 national laboratories. New industry partners can be added if they want to participate.

Lead Lab:

- ✓ NREL

Advisory Role:

- ✓ SNL
- ✓ ANL

Administrative Role:

- ✓ Frontier Energy

Industry Partners:

- ✓ Ford
- ✓ General Motors
- ✓ Honda R&D America
- ✓ Hyundai
- ✓ IVYS
- ✓ Shell
- ✓ Toyota

Remaining Challenges and Barriers

- The team is working on obtaining validation data to ensure confidence in the model
- The project is scheduled to end by September 2019 so the timeline is short to fully validate and deploy the model to the public
  - The team is currently working on risk mitigation of the timeline by working on tasks in parallel

Proposed Future Work

- Finalize agreements between parties
- Execute project plan

Technology Transfer Activities

- The goal is to have this model available to the public by Fall 2019. The model will be 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:
  - Station side modeling is complete, working on validation
  - Working on agreement for vehicle model, already validated
  - GUI is nearly complete
- Challenges:
  - Continued validation effort to ensure confidence in the model

Thank You

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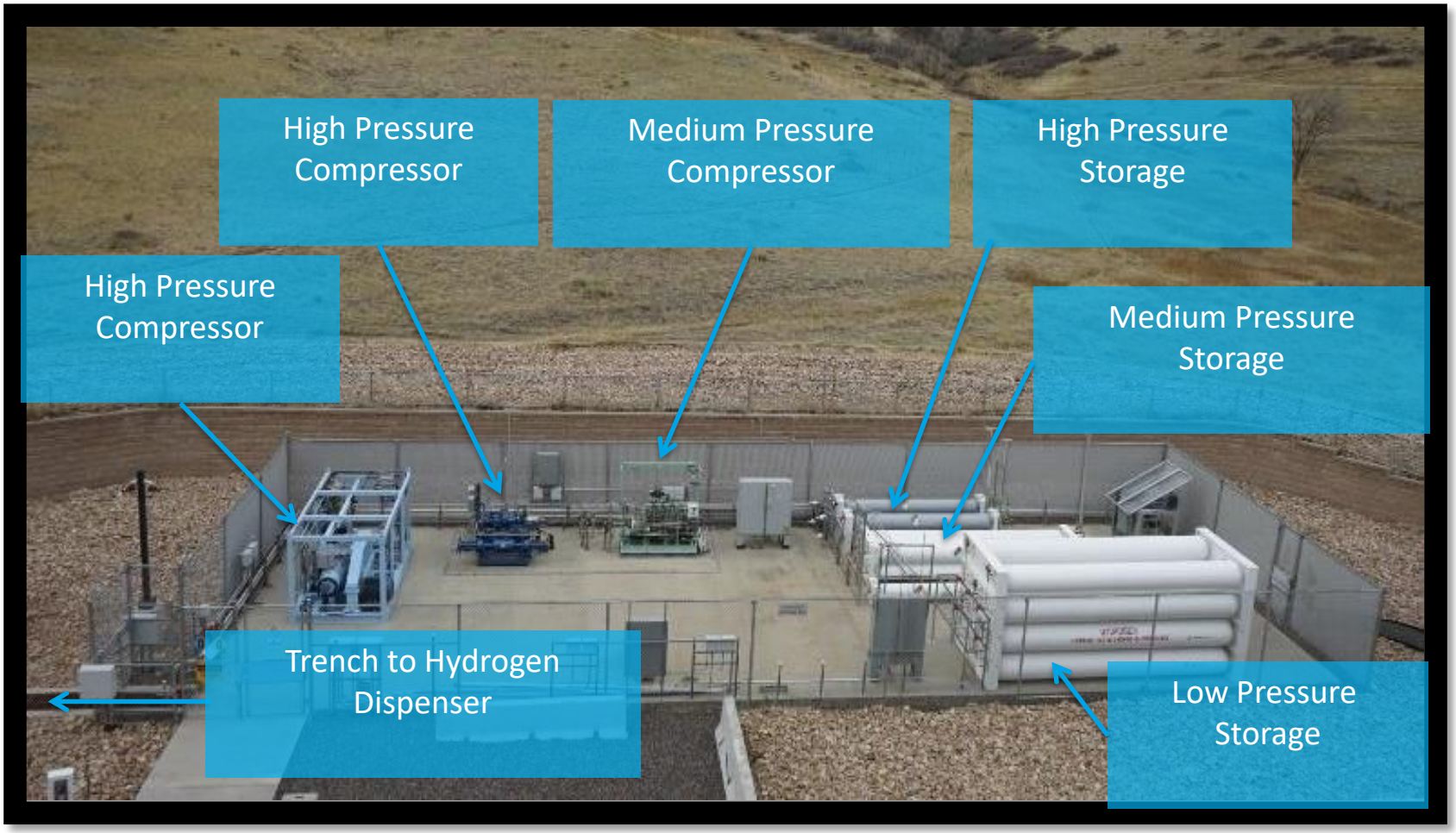
Technical Back-Up Slides

NREL Validation Capabilities



NREL Validation Capabilities