California Hydrogen Research Consortium

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National Renewable Energy Laboratory
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DOE Hydrogen and Fuel Cells Program
2020 Annual Merit Review and Peer Evaluation Meeting

Project ID H2041

Overview

Timeline and Budget

- Project start date: 1/15/2019
  Project end date: 1/15/2021
  (continuing into 2021)
- Total project budget: $840k
  - Total recipient share: $300k
  - Total federal share: $540k
  - Total DOE funds spent*: $487k

* As of Feb 2020

Barriers

- Reliability and Costs of Hydrogen Compression (Delivery B)
- Other Fueling Site/Terminal Operations (Delivery I)
- Hydrogen from Renewable Resources (TV G)

Partners

- California Governor's Office for Economic Development, Tyson Eckerle
- California Air Resources Board, Andrew Martinez
- California Energy Commission, Jean Baronas
- South Coast Air Quality Management District, Naveen Berry
- Sam Sprik, NREL, PI

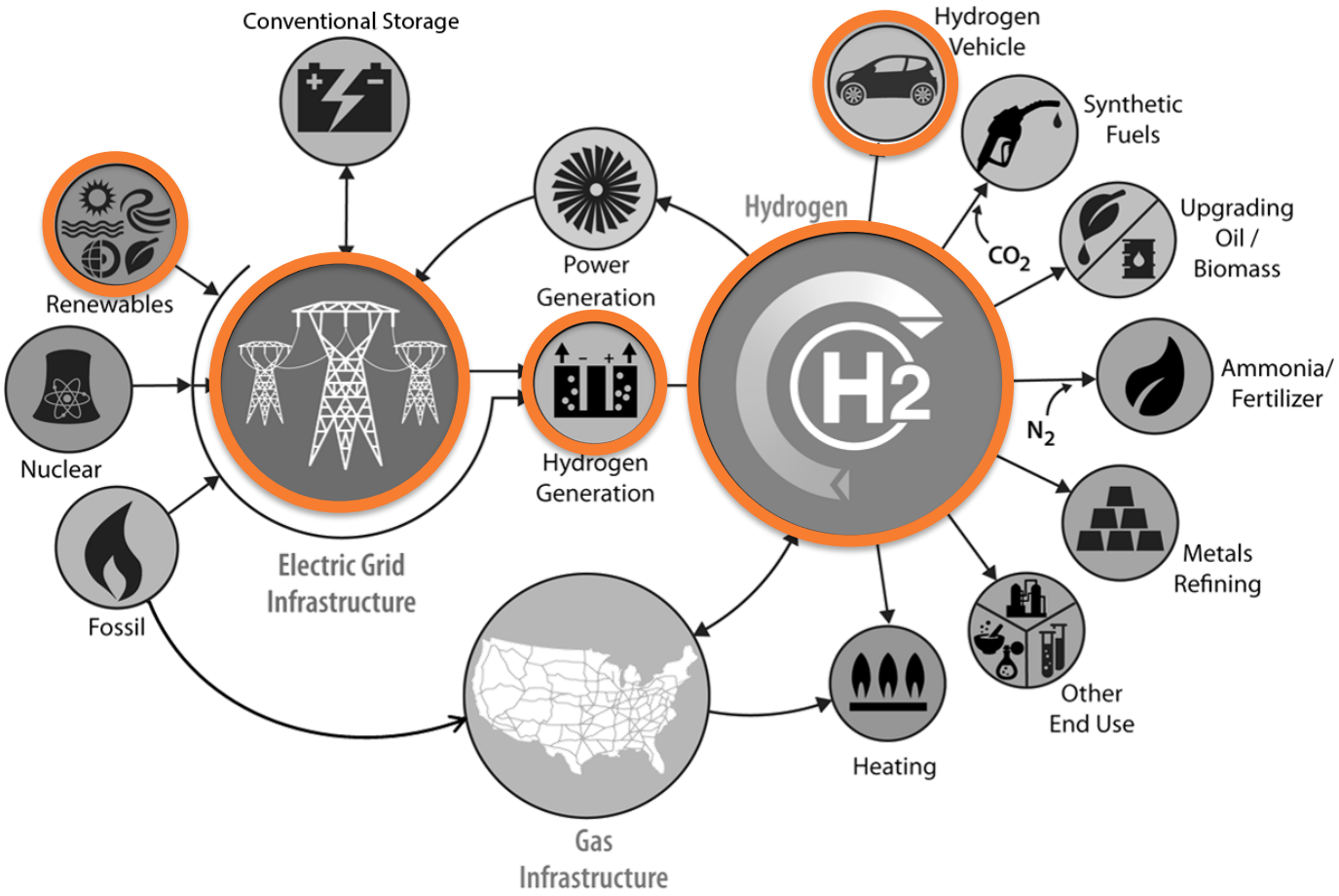
Relevance

Hydrogen and fuel cell stakeholders worldwide are using California's experience as a model case, making success in California paramount to market acceleration and adoption. The technical research capability of the National Renewable Energy Laboratory will be used to assist California in decisions and evaluations, as well as to verify solutions to problems impacting the industry. Because these challenges cannot be addressed by one agency or one laboratory, a hydrogen research consortium has been organized to combine and collaborate. The collaboration aims to:

- Ensure that data are available to evaluate projects and inform decision makers
- Independently verify and validate component solutions
- Provide experimental results for future hydrogen infrastructure
- Increase the availability of technical experts for quick-need issues for California hydrogen infrastructure development, deployment, operation, and technology advances.

4/2019 – 3/2020 Objective: Conduct Research in 6 Separate Tasks

Approach: Cross-cutting R&D objectives with multiple stakeholders



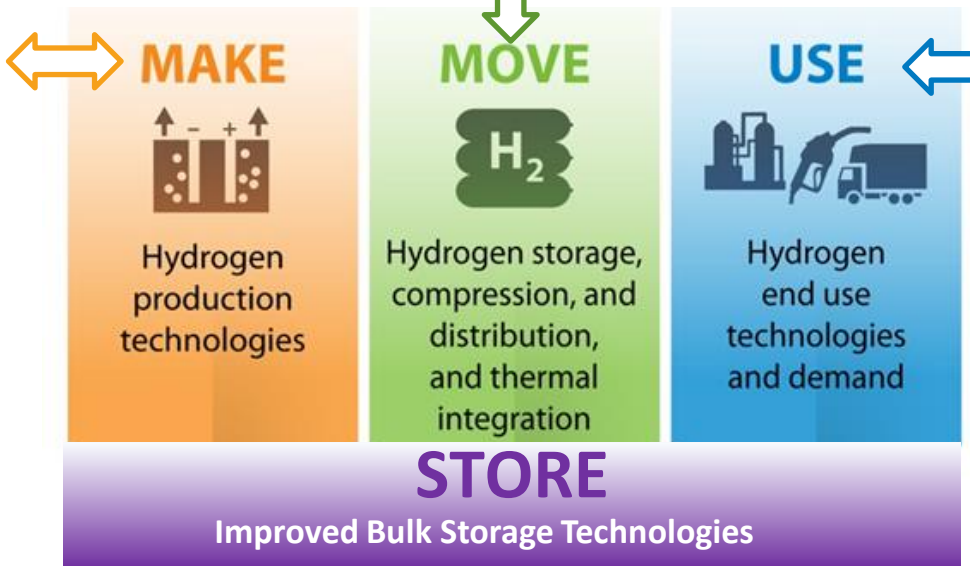
Regular communication and collaboration research partners enables flexible, real-time identification of needs and project progress in order to address top priority hydrogen infrastructure gaps.

Approach: Integrated with H2@Scale Topics

Research Task 3:
H_2 Contaminant Detector

Research Task 4:
Nozzle Freeze-Lock

Research Task 5:
CA H_2 Integration



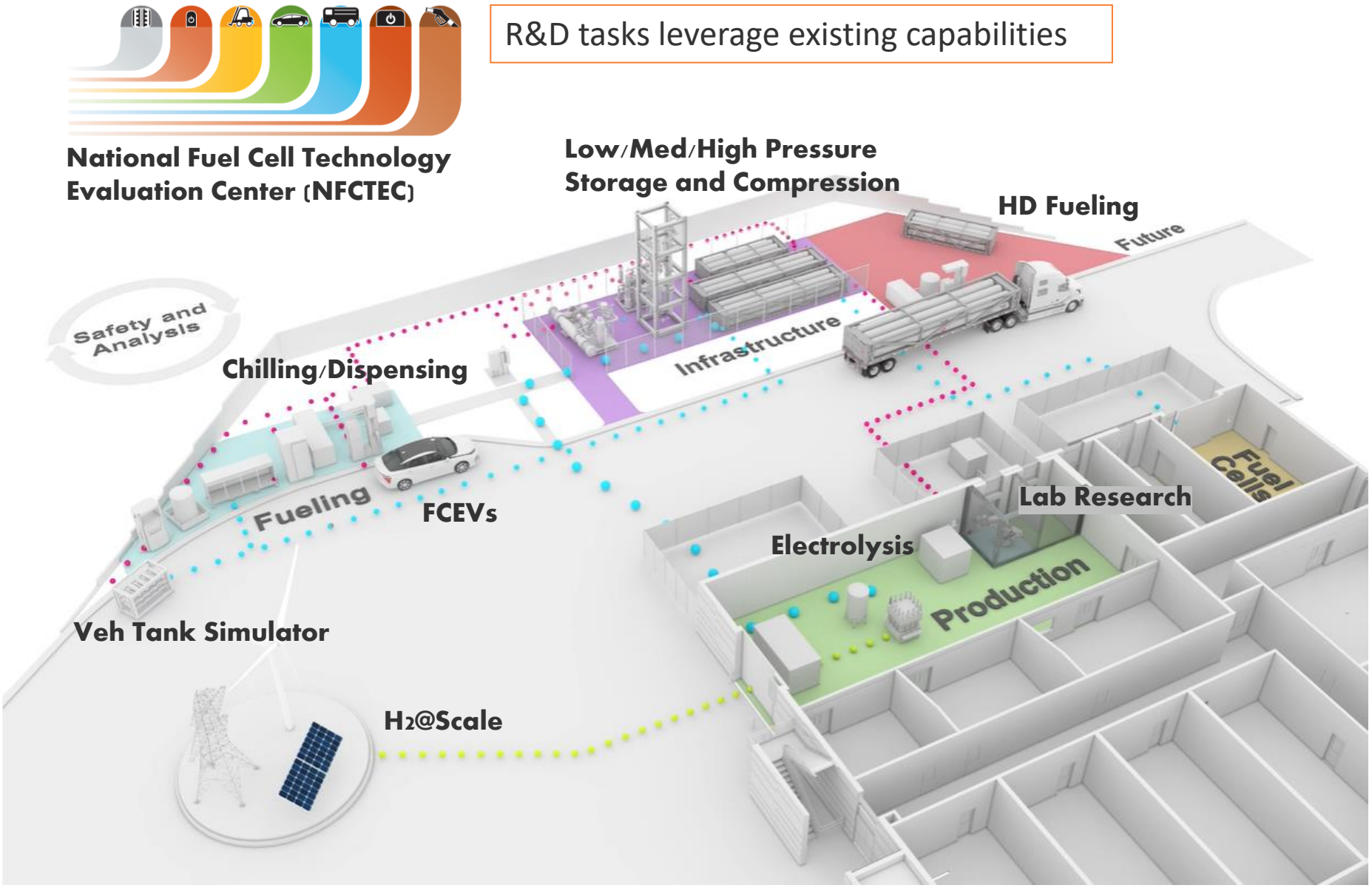
Research Task 1:
Data Collection & Analysis

Research Task 2:
Medium/Heavy-Duty Fueling

Research Task 6:
Technical Assistance

Approach: Utilize NREL Core Capabilities

R&D tasks leverage existing capabilities



Approach: Research Divided into 6 Tasks for 1st Year

Task 1: Station Data Collection & Analysis 12 months, $40k DOE, $40k CA	PI – Genevieve Saur	• Analysis and reporting on current hydrogen station data while setting up data needs for future projects.
Task 2: Medium/Heavy-Duty Fueling 12 months, $150k DOE, $50k CA	PI – Mike Peters	• Analysis of truck fueling needs and operation
Task 3: H_2 Contaminant Detector 24 months, $300k DOE, $100k CA	PI – Bill Buttner	• Down-select and order HCD • Complete verification of HCD operation with pre-mixed gases • Integrate HCD into NREL's HITRF for in-situ operation (1 – 12 months)
Task 4: Nozzle Freeze-Lock Evaluation 6 months, $10k DOE, $60k CA, $75k Industry	PI – Shaun Onorato	• Review, build, and commission experimental ambient control test platform • Complete nozzle experiment to benchmark failure frequency and condition (ambient temperature and humidity) and publish results
Task 5: CA Hydrogen Integration 12 months, $30k DOE, $20k CA	PI – Mariya Koleva	• Collect CA stakeholder needs • Report on existing hydrogen integration data and analyses results that address needs • Identify gaps and possible future analyses
Task 6: Technical Assistance 12 months, $10k DOE, $30k CA	PI –Sam Sprik	• Check in with project partners for brief projects in need of national lab technical expertise • Project chosen: Updating HySCapE

Approach: Reporting

Frequent updates/reporting within the consortium and to the public is key to sharing research learnings and leads to new areas of interest.

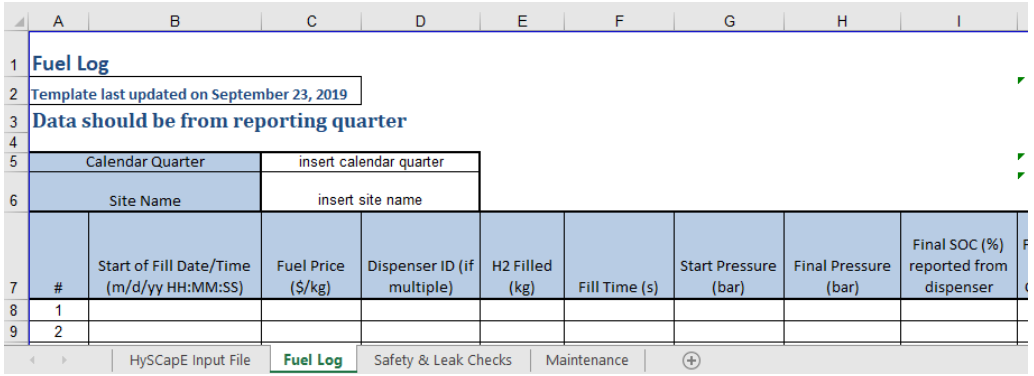
Reporting includes:

- Monthly research status webinars with consortium
- FuelCell Seminar presentations
- H2@Scale working group presentations
- Final reports.

Accomplishments & Progress: Data Analysis

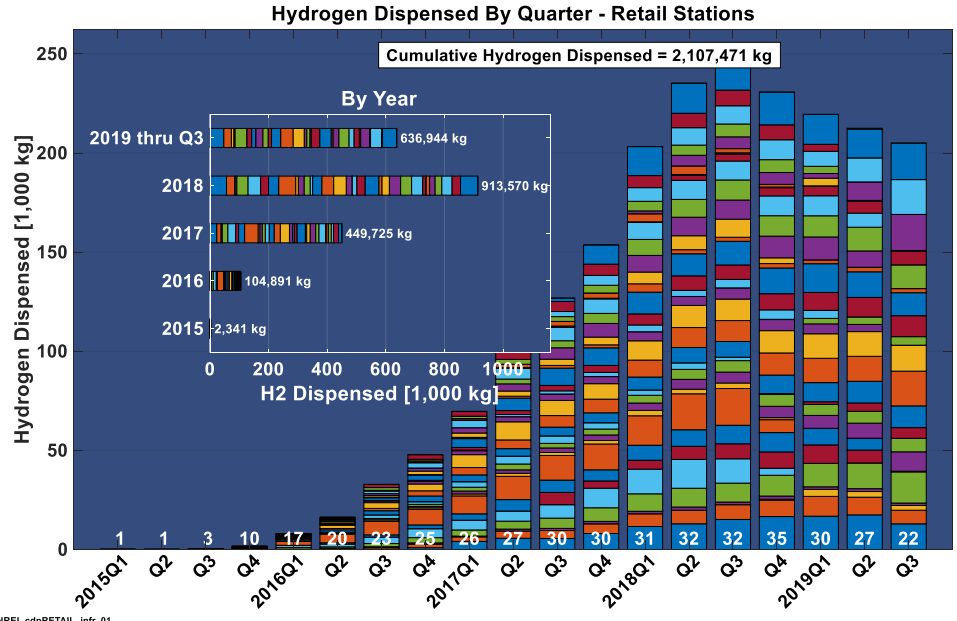
Task 1: Data Collection & Analysis 12 months, $40k DOE, $40k CA	Perform analysis and aggregation of station performance, operation, and maintenance data.

- Data templates updated for future CA stations.
  - Simplified - No longer tracking efficiencies, cost, and power consumption
  - Now focused on station specs, fuel log, safety, and maintenance.



	A	B	C	D	E	F	G	H	I
1	**Fuel Log**								
2	Template last updated on September 23, 2019								
3	**Data should be from reporting quarter**								
4									
5		Calendar Quarter	insert calendar quarter						
6		Site Name	insert site name						
7	#	Start of Fill Date/Time (m/d/yy HH:MM:SS)	Fuel Price ($/kg)	Dispenser ID (if multiple)	H2 Filled (kg)	Fill Time (s)	Start Pressure (bar)	Final Pressure (bar)	Final SOC (%) reported from dispenser
8	1								
9	2								

HySCapE Input File | Fuel Log | Safety & Leak Checks | Maintenance



Note: Colors represent individual stations. Station count is number at bottom of bar.

- Analysis of quarterly reported data completed
- Published CDPs for data through 2019Q3
  - www.nrel.gov/hydrogen/infrastructure-cdps-retail.html

Accomplishments & Progress: M/HD Fueling

Task 2: M/H-Duty Fueling 12 months, $150k DOE, $50k CA	Perform analysis and reporting of retail and experimental fueling data to inform fueling-method decision makers and fueling system design.

In Progress: This task changed focus towards M/HD hardware lessons learned and gap analysis using information gathered from multiple projects at NREL related to HD.

Zero-Emission Bay Area Fuel Cell Bus
Source: NREL

Project Background: HCD Task

- Objective:

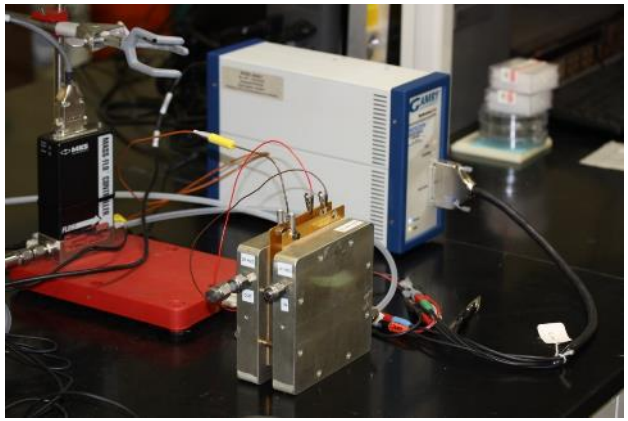
  Implement an in-line hydrogen contaminant detector (HCD) within a hydrogen fueling dispenser that can verify in near real-time the concentration of regulated hydrogen impurities as prescribed by SAE J 2719.

- Approach:

  Identify the best available commercial or near-commercial hydrogen contaminant detector (HCD) technologies and verify their performance through laboratory testing. Then integrate the HCDs into high pressure fueling stations and demonstration instrument capabilities by testing to SAE J2719 standards.

Commercial FTIR
(multi-gas HCD)

LANL EC Sensor
Carbon Monoxide HCD



Approach: HCD Task

Hydrogen Contaminant Detector Integration at Fueling Station: Concept

STEP 1:
A typical FCEV refueling includes a P-check of the hose where H_2 is normally vented but can now be automatically sampled by the HCD-Interface for analysis.

STEP 2:
The NREL HCD-Interface is to be installed within the dispenser and is designed to automatically collect & isolate a portion of the P-Check H_2 into a P-regulated buffer chamber.

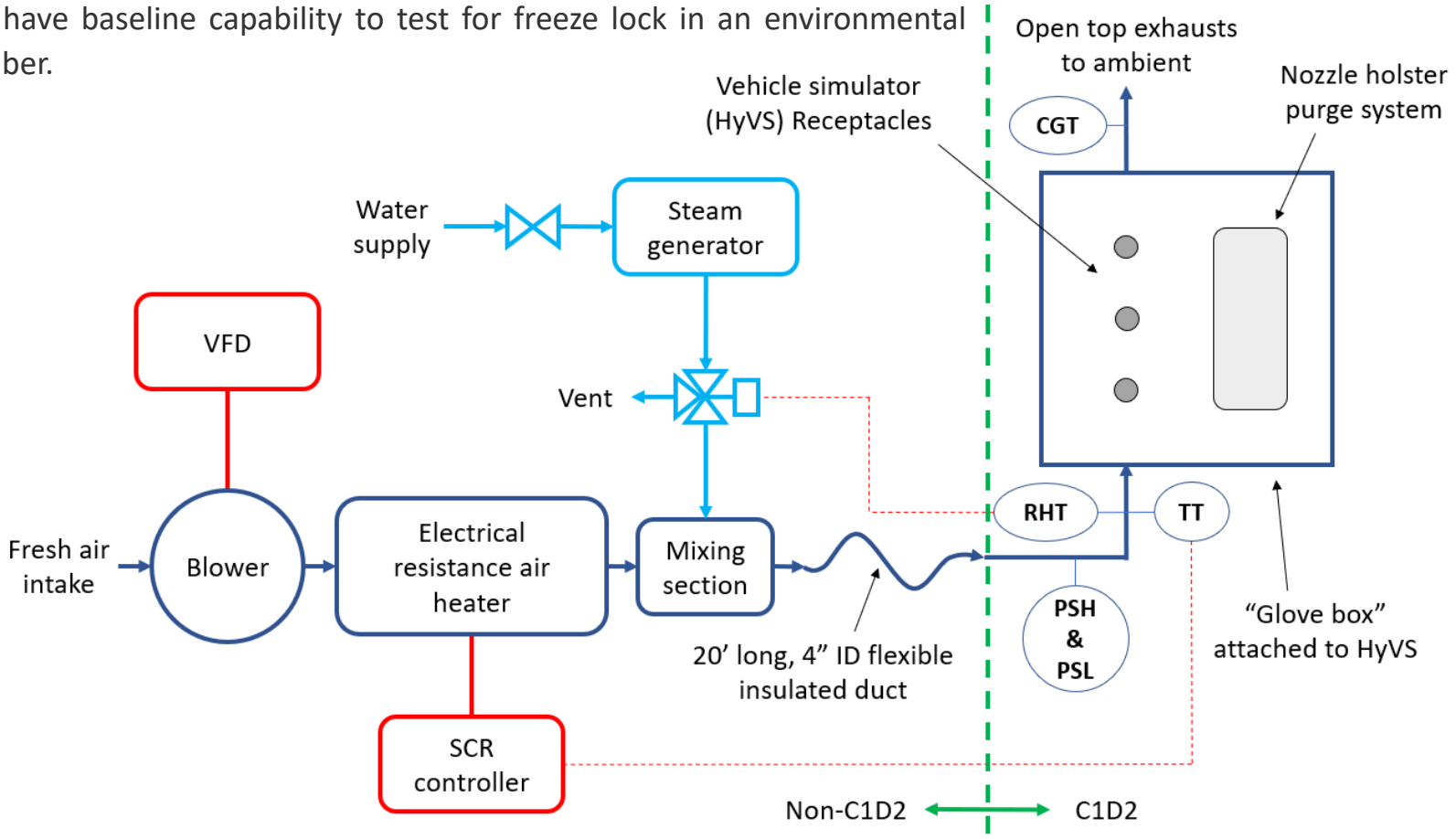
STEP 3:
The HCD-I then transfers collected hydrogen at low-pressure and controlled flow rate to the on-site HCD for analysis.

See Project ID #h2042 “Hydrogen Contaminant Detector” Buttner, Koleva, Post and Hartmann for more details

Accomplishments & Progress: Nozzle

Task 4: Nozzle Freeze-Lock Evaluation 6 months, $10k DOE, $60k CA, $75k Industry	Create an environmentally controlled experiment to identify conditions leading to nozzle freeze-lock and for verifying solutions.

- System test platform designed, built and used to perform freeze-lock tests
- Now have baseline capability to test for freeze lock in an environmental chamber.



Accomplishments & Progress: Nozzle

NREL Systems Leveraged:

1. NREL HITRF Hydrogen Station (hydrogen generation, compression, storage, etc.)
2. APCI Dispenser (H35 & H70)
3. Hydrogen Vehicle Tank Simulator (HyVS)
4. Nozzle Freeze-Lock Test Chamber & Atmosphere Generator

Accomplishments & Progress: Nozzle

Freeze-lock testing statistics:

- Number of freeze events: 47 of 170 fills (28%)
- Temperature with most frequent freeze events: 35°C (11 events)
- Dew Point Temperature with most frequent freeze events: 30°C (14 events)
- Freeze-Lock occurrence during fills: Fills 3 to 6 in back-to-back fills
- Freeze-Lock Average Time: 24.16 secs
- Longest Event: 108 sec at 36°C and 30°C Dew Point

Accomplishments & Progress: H2 Integration

Task 5: CA Hydrogen Integration 12 months, $30k DOE, $20k CA	Identify the top priorities for data share and experimental scenarios to integrate hydrogen into California's energy management strategies.

In Progress

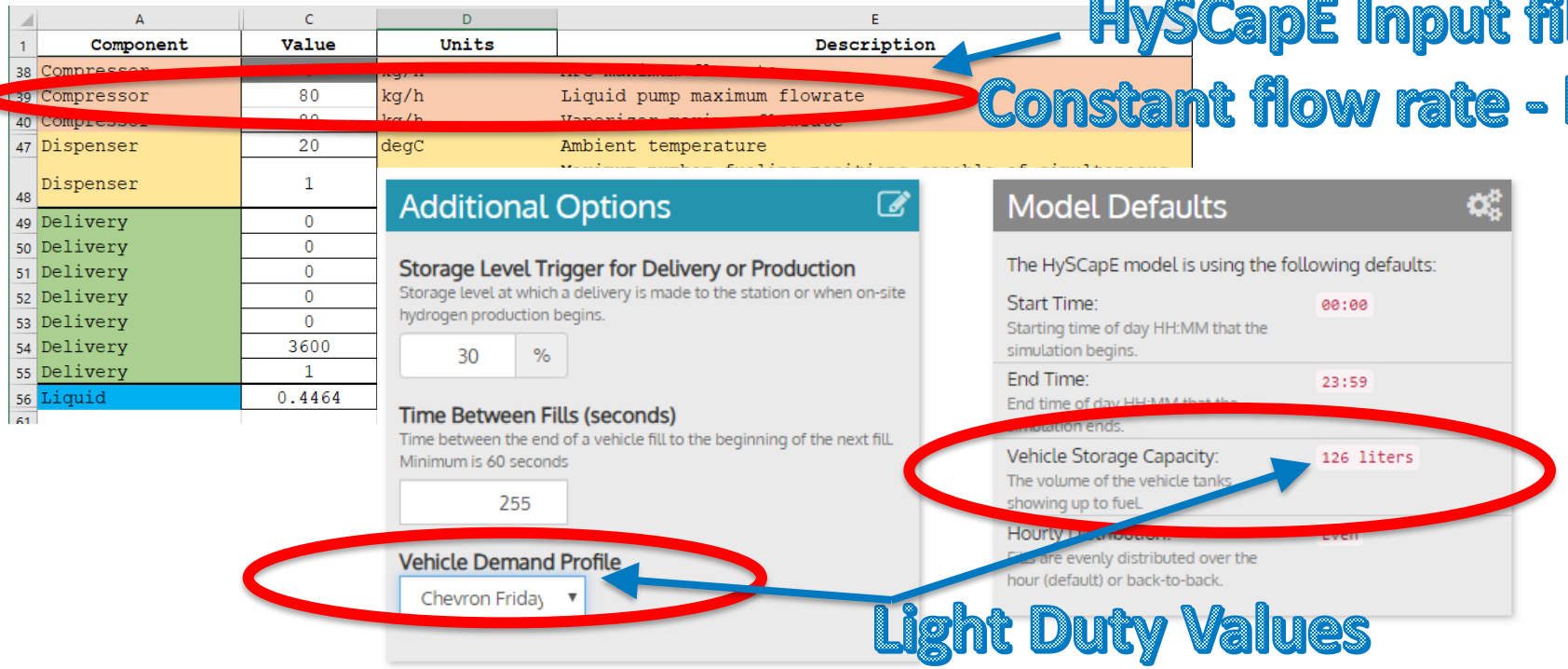
- Draft report under review

Accomplishments & Progress: Tech Assistance

Task 6: Technical Assistance 12 months, $10k DOE, $30k CA	National laboratory technical experts will be available for California infrastructure development, deployment, and operation.

In Progress

- The following tasks identified and initiated
  - Update the Hydrogen Station Capacity Evaluation (HySCapE) tool.
    - Update liquid cryopump flow rates based on variable density of liquid
      - The model currently uses a constant value for liquid pump flow rate.
    - Adjust code for stations that support MD/HD and add demand profile(s) for MD/HD.



Accomplishments and Progress: Responses to Previous Year Reviewers' Comments

- This project was not reviewed in 2019.

Collaboration and Coordination

- California Air Resources Board (CARB)
- California Energy Commission (CEC)
- South Coast Air Quality Management District (SCAQMD)
- California Governor's Office for Economic Development (GO-Biz)

This group of CA agencies identified a need to leverage national laboratory research capabilities to support their hydrogen efforts.

The consortium identifies research tasks based on needs and priorities for the California agency partners. Focus is placed on sharing and translating lessons learned to other jurisdictions, which is a priority in this partnership between state and federal agencies and laboratories.

Remaining Challenges and Barriers

- Hydrogen contaminant detectors are not expected to meet all requirements of SAE J2719
- Review/approval/finalization of reports.
  - Publication and presentation of results is an important metric for the research tasks in order to provide data to stakeholders. Although reports are shared within consortium, publication to general public is not guaranteed to be approved by all parties.

Proposed Future Work

Several research topics are currently being discussed and will depend on interest from both CA agencies and DOE:

Task Name	Potential Topics
Station Data Analysis	• Analysis of hydrogen station data from existing and future stations
HyStEP HD Design	• Establish design requirements for HD hydrogen station test device to analyze fueling performance
HyStEP support	• Software upgrades to analyze data coming from test device • Maintenance support • Design requirements for next version of device
H_2 Contaminant Detector	• Focus on water vapor contaminant sensing at stations in HCD equipment as more electrolysis stations are expected. • Ensure compatibility of HCD pneumatic system with regulated contaminants
HySCapE upgrades	• Add in compression and storage options and refine delivery and production assumptions to correspond to existing and future stations • Documentation, FAQ, Web tool updates
Nozzle Freeze-Lock	• Using the existing test equipment and trends from existing test data, establish freeze-lock bounds for state-of-the-art equipment.

Technology Transfer Activities

- None at this time

Summary

- Expected benefits of this consortium begin with coordinated research efforts that:
  - support the DOE's and CA hydrogen goals and requirements
  - share lessons learned with other states to inform implementation efforts outside of California
  - support shifting the hydrogen infrastructure progress from a government push into a market pull
  - advance the station technology and operation to meet the next waves of vehicle demand
  - leverages existing core capabilities and researchers
  - Published findings from research tasks
- We are heading into year 2 of consortium- Most research tasks from the first year are in final stages. One task (HCD) has a 2-year commitment.
- New tasks are being proposed for next period. Working through which ones are of interest to both CA and DOE.

Thank You

www.nrel.gov

Publication Number

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