NREL
Transforming ENERGY

Validating an Electrolysis System with High Output Pressure

Joshua Martin (presenter), Sam Sprik (PI)
National Renewable Energy Laboratory
Steve Mathison, Jeff Jetter
Honda R&D Americas, Inc.
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Project ID H2036

Overview

Timeline and Budget

- Project start date: 9/18/2018
  Project end date: 1/18/2020
- Total project budget: $232k
  - Total recipient share: $132k
    - $24k is in-kind
  - Total federal share: $100k
  - Total DOE funds spent*: $17k

* As of 3/01/19

Barriers

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

Partners

- Honda R&D Americas, Inc.
  - Steve Mathison, Jeff Jetter
- NREL
  - Sam Sprik, Joshua Martin, Jacob Thorson, Matt Ruple

Relevance—Compression Required

State of the art electrolysis outlet

30bar

PRESSURE GAP

Light duty fuel cell electric vehicle market

700bar

PRESSURE GAP necessitates additional, costly mechanical compression with reliability issues

Relevance–Objectives

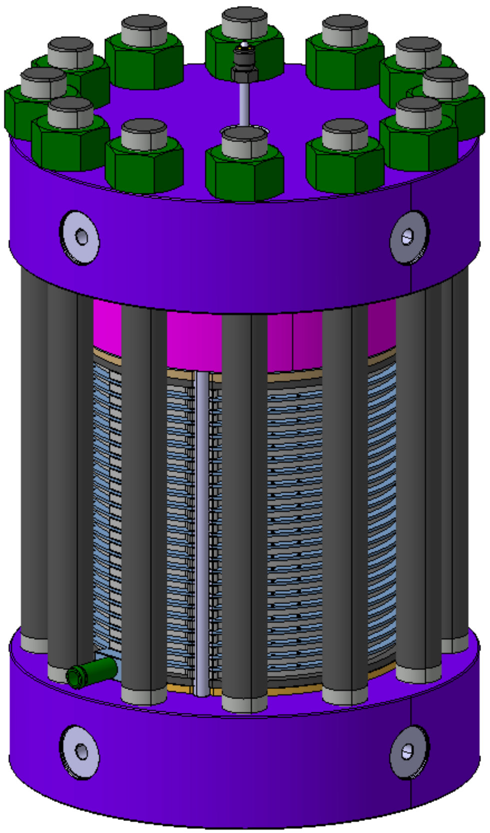
Image courtesy of Honda
Earlier 70MPa stack

- Third party benchmarking and validation of Honda's high differential pressure electrolyzer
  - Low input water pressure
  - High hydrogen output pressure - 70+ MPa (pressure would meet fueling needs of light duty vehicles without mechanical compressor)
- Application of renewable or grid regulation loads using AC/DC power supply
  - Use profiles from regions of interest for potential deployments

Relevance—Combined Electrolysis and Electrochemical Compression

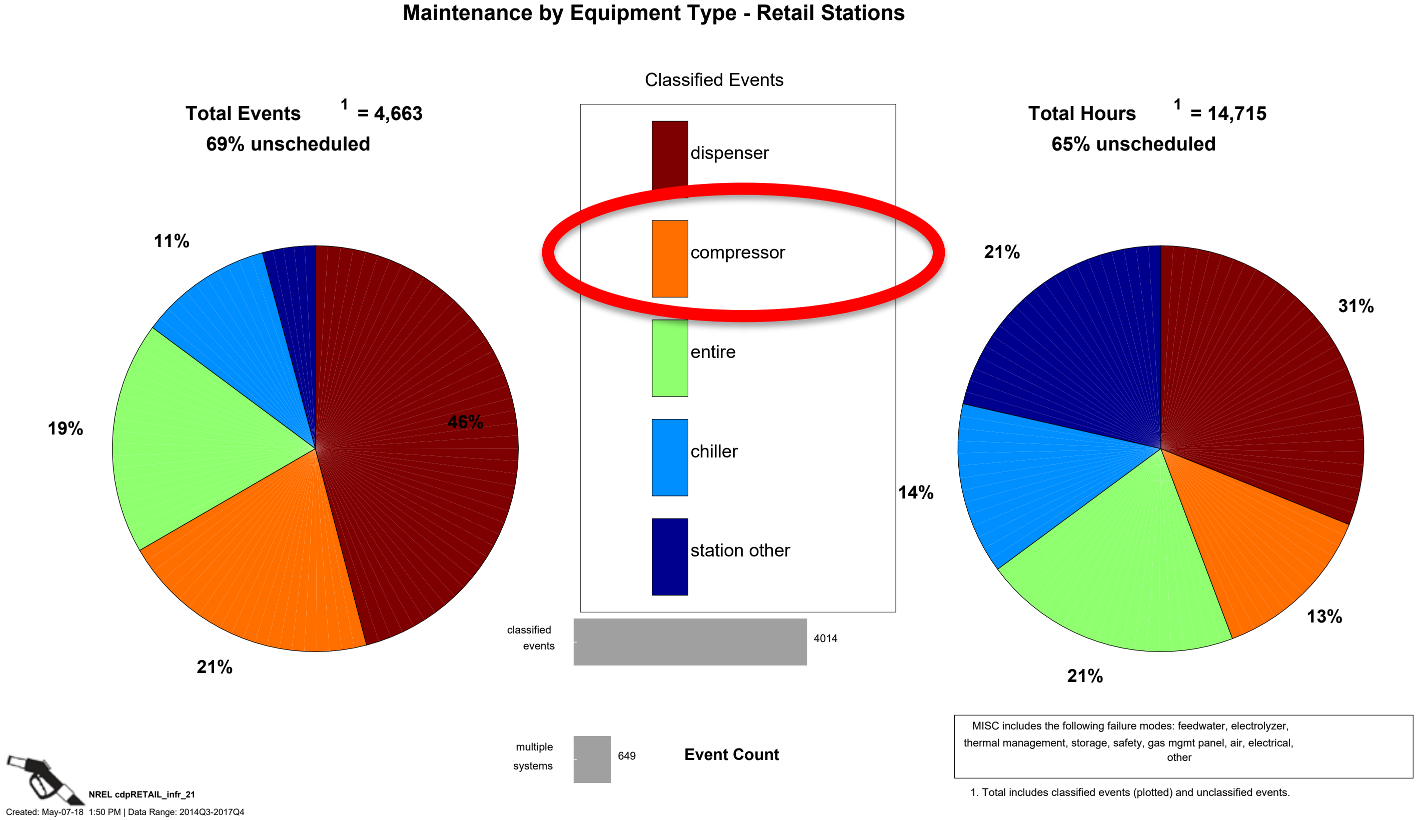
Potential System Benefits

- Small combined footprint for onsite generation and compression
- Increased performance over mechanical compression
  - Increased compression performance (lower kWh/kg)
  - Improved component reliability
  - Avoidance of compression lubricant contamination in output H2
  - Reduced noise levels



Relevance–Compressor Maintenance at Retail Stations

- Retail stations
  - 21% of maintenance events are servicing mechanical compressors
  - 13% of maintenance hours spent on compressors
- This technology does not require mechanical compression and still produces high pressure hydrogen needed for fueling at 70 MPa.



Relevance–Fueling FCEVs

- Honda's system shown here, has fueled FCEVs at 35 MPa
- Increased output pressure means fueling cars to 70 MPa possible

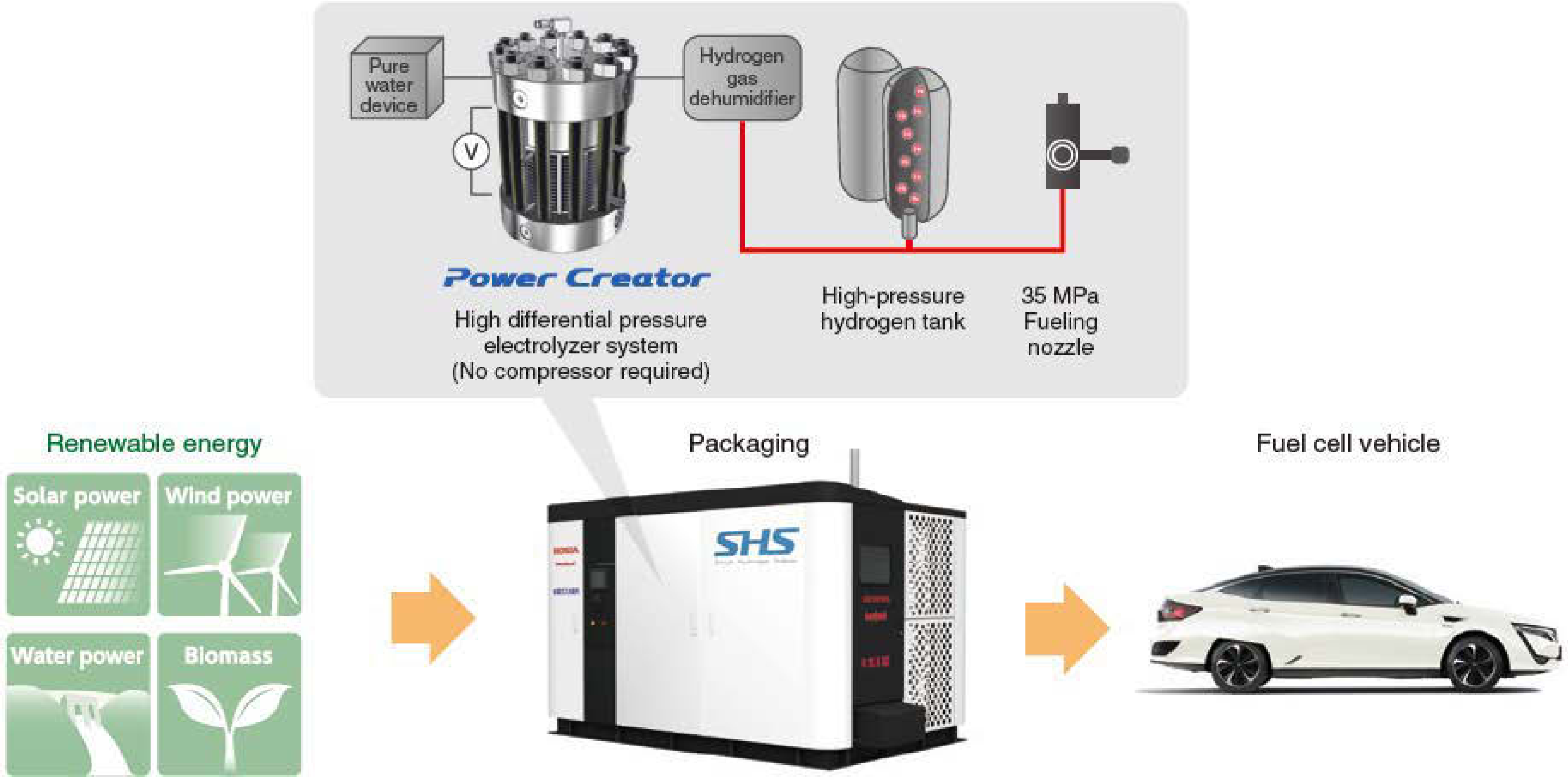


Image courtesy of Honda

Approach—NREL capabilities

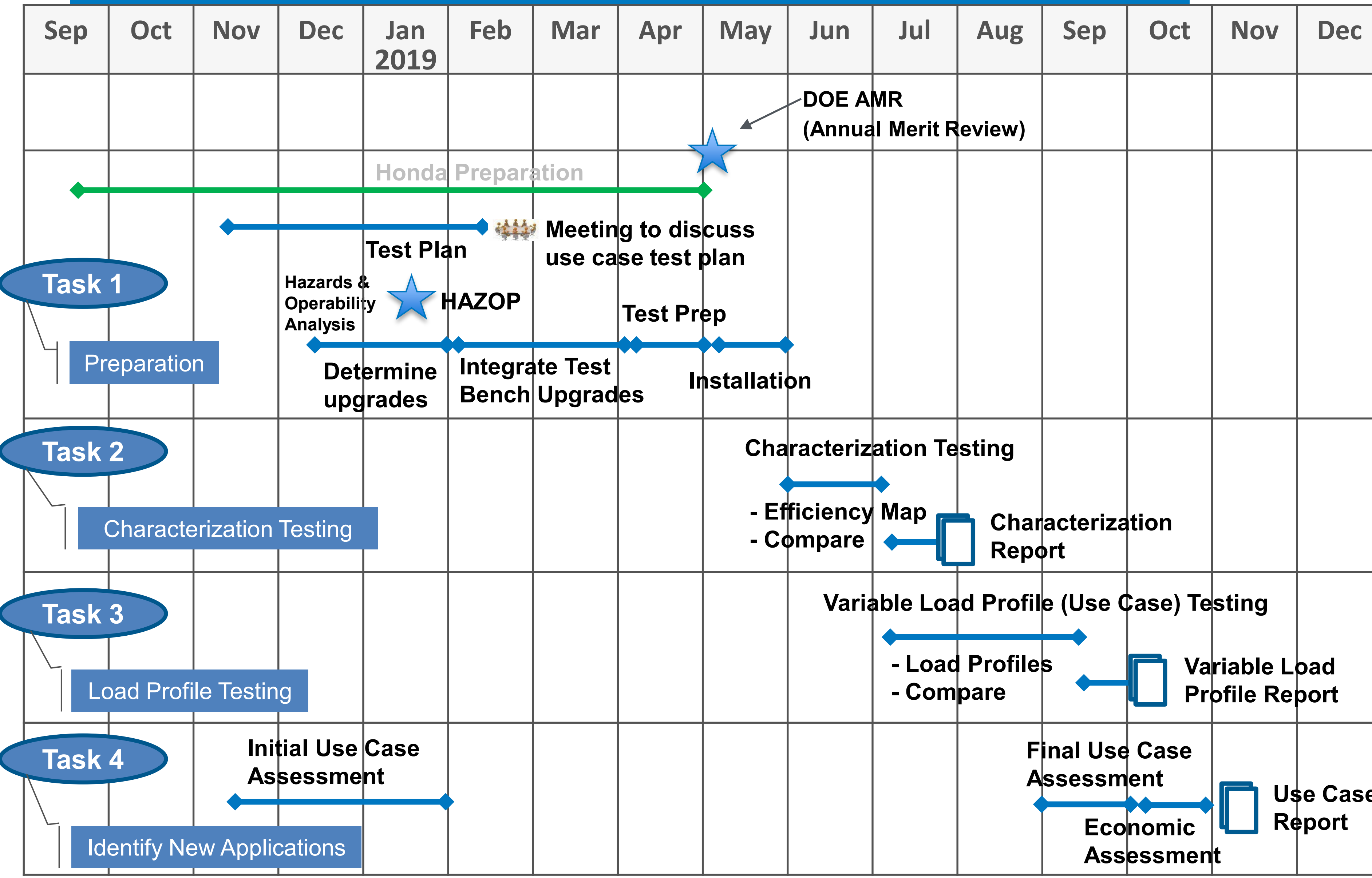
Utilize NREL expertise and facility to integrate and test Honda electrochemical hydrogen compressor in NREL's Hydrogen Infrastructure Testing and Research Facility (HITRF)

Outdoor Test Area, Golden, CO

Stack Test Bed, Golden, CO

HITRF Major System Components			
Low Pressure Storage	200b, 189 kg	5 banks	Type 1 ground storage
Med Pressure Storage	400b, 103 kg	3 banks	Type 1 ground storage
High Pressure Storage	875b, 93 kg	6 banks	Type 2 ground storage
Power supply	4000A DC, 250V DC	4 units	Controlled remotely, high slew
Mechanical compression	400b, 900b	3 units	Up to 1 kg/min

Approach—Schedule



Approach–Task 1
Site Preparation and Test Plan Development

- Honda will provide self-developed PEM stack to NREL
- NREL will perform testing at the Energy Systems Integration Facility (ESIF) in Golden, CO

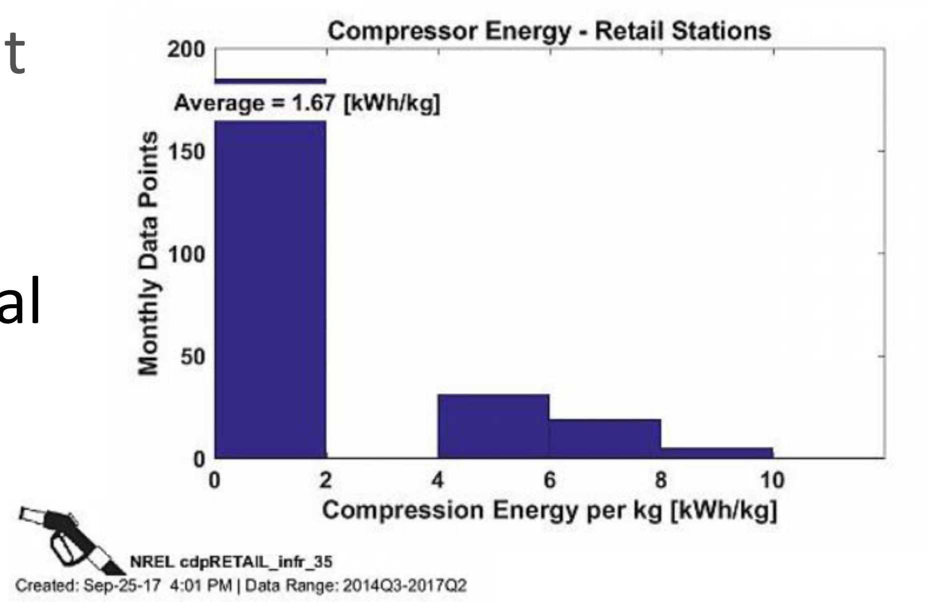
Laboratory space being prepared for 700b stack

- Team will reference widely accepted metrics for benchmarking and design test protocols accordingly

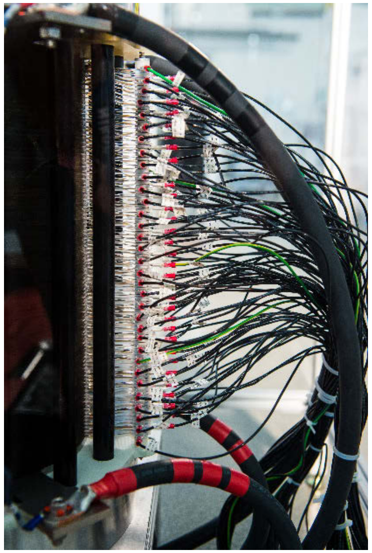
Energy efficiency	Mean time between failure	Product quality
Production rate	Failure modes	Operating temperature
Water flow rate	Output pressure	Response to change

Approach—Task 2
Stack and System Benchmarking

- NREL will operate the stack at various power, pressure and temperature levels for comparison with conventional electrolysis + mechanical compression technologies

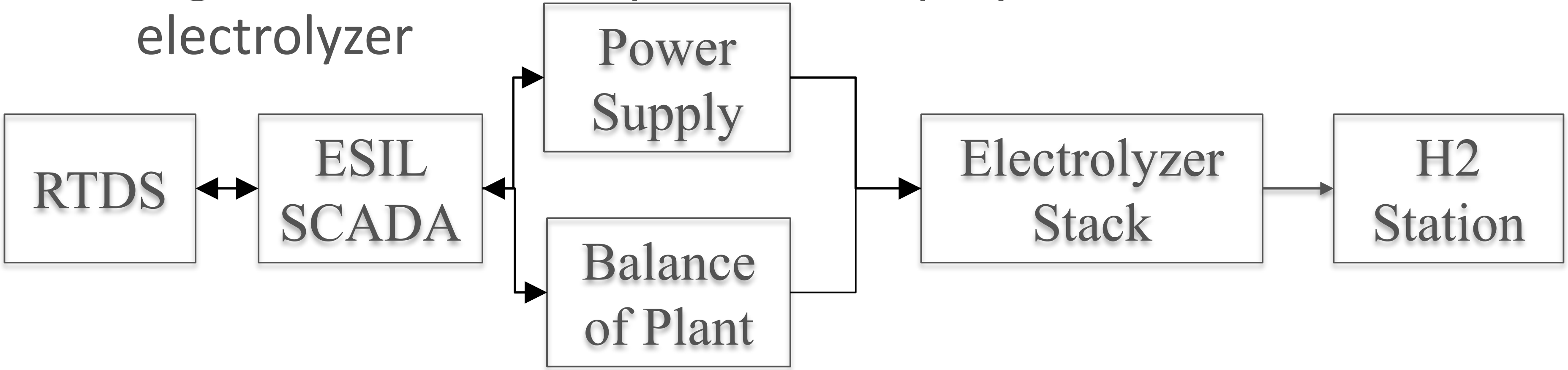


- NREL will leverage in-house developed monitoring capabilities

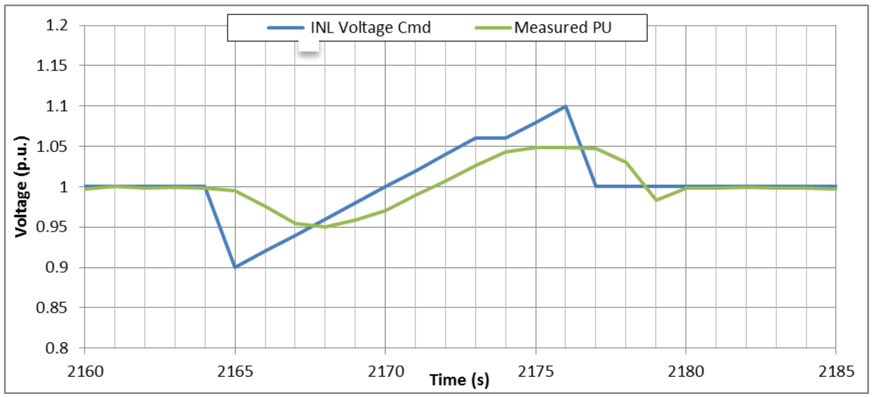


Approach–Task 3
Renewable Source and Grid Integration Testing

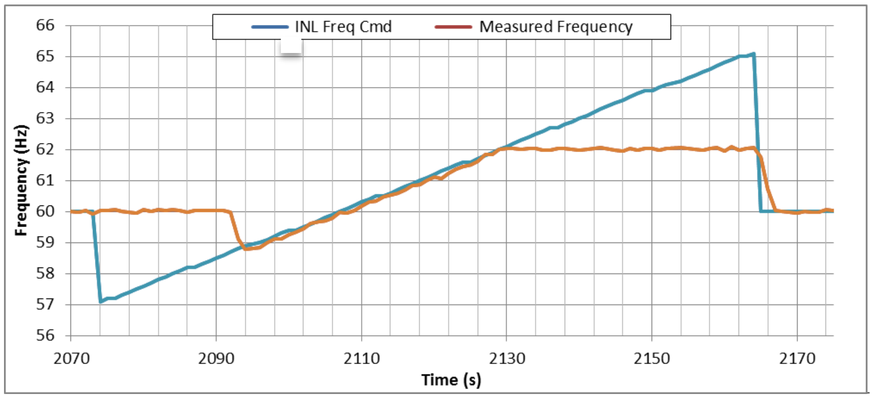
- NREL will use its controllable AC/DC power supplies to simulate different renewable or regulation profiles for regions identified as potential deployment sites for this electrolyzer



Voltage Regulation



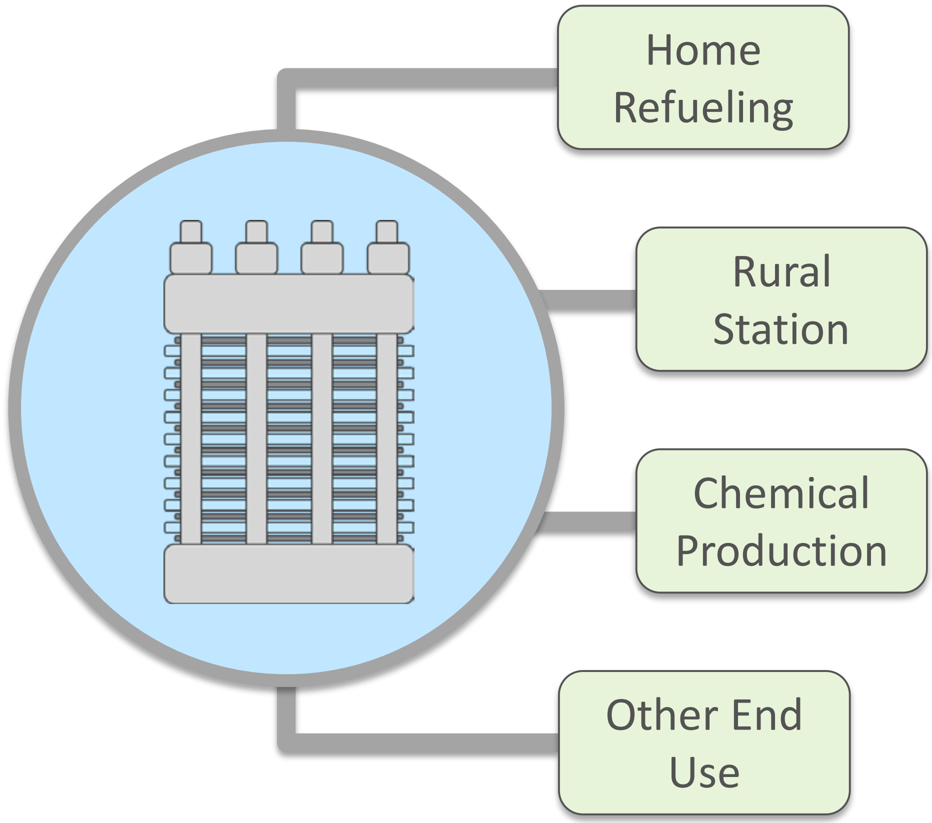
Frequency Regulation



Approach—Task 4
Use Case Assessment

Primary Activities

- Finalize list of use cases for Honda stack
- Perform a basic assessment of the stack for each of the determined use cases
- Generate report



Accomplishments and Progress

- Hazard & Operability Analysis
  - NREL Team at Honda, Japan - January 2019
  - Honda Team at NREL (Process Hazards Analysis – PHA) - February 2019
- Laboratory space reviewed/reserved for project
- Equipment needs identified – Bill of Materials (BOM)
  - Beginning to specify, design and order
    - Water pump
    - Sensors
    - Power supply
    - Vent lines
    - Fresh air supply
    - Nitrogen
- Characterization test profiles agreed upon
- Controls planning in process

Accomplishments and Progress: Responses to Previous Year Reviewers' Comments

- Project was not reviewed last year

Collaboration and Coordination

NREL and Honda R&D Americas, Inc. are coordinating on this project

- Regular teleconferences
- In person meetings at NREL and at Honda
- Honda engineers at NREL during setup and initial testing
- NREL will validate and provide Honda results and comparison to more conventional products
- This may enable improvements in future models and may provide insight into other applications for this technology

Remaining Challenges and Barriers

- NREL to equip lab space to accommodate 700 bar hydrogen from electrolyzer system
- NREL and Honda to determine renewable and regulation validation plans.
- NREL and Honda to assess potential use cases

Proposed Future Work

- Receive Honda system at NREL around AMR timeframe - May 2019
- Finish designing BOP
- Integrate controllers
- Install system at NREL-ESIF
- Characterize system
- Run system with renewable profile or for grid regulation
- Assess potential use cases

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

Summary

Accomplishments

- Initial system design, HAZOPS, lab space prep, BOP parts ordered

Objectives and Future Work

- Characterization of the high pressure electrolyzer system
- Comparison of system with conventional electrolyzer and mechanical compression technology
- Loading of the stack with varying input power, following renewable energy profiles, while measuring performance
- Assessment of potential use cases for system

Thank You

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