H2@Scale CRADA: Electrolytic Renewable Fuel Production Optimal Operation Investigation

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H2059

Overview

Timeline and Budget

- Project start date: 9/27/2019
- Project end date: 9/27/2020
- Total project budget: $150k
  - Total recipient share: $100k
  - Total federal share: $50k
  - Total DOE funds spent*: $11.3k

* As of 4/24/2020

Barriers

- Reducing the cost of hydrogen production with electrolyzers
- Multi-sector integration with the natural gas grid
- Improve modeling and analysis for hydrogen-grid integration

Partners

- APEP
  University of California, Irvine

Relevance

Background

- Renewable electrolysis provides a range of potential values such as carbon-free fuel for power, heat, or transportation; storage; and ancillary grid services.
- The potential benefits of renewables electrolysis have often been studied as individual value streams but should be simultaneously co-optimized.
- This project will be valuable to research and planning agencies as well as technology developers on account of the project's focus on four candidate sites that represent key configurations for consideration.

Research Need

- **Hydrogen-electric grid integration study under future grid conditions:** Studies have been conducted looking at the business case of integrating hydrogen systems with the electric grid but most focus on current conditions with limited insight into future grid operation. Conducting this analysis will improve our understanding of the potential cost competitiveness of electrolytic hydrogen across the spectrum of applications.
- **Interactions with the natural gas network:** Hydrogen has the potential to integrate with the natural gas network. This study explores different opportunities for integration of hydrogen with the gas network.

Relevance (cont.)

Opportunity

Electric and gas grid integration of hydrogen can benefit both systems in a variety of ways including:

- **Low electricity prices:** The flexibility of electrolysis systems enables better managing site and grid dynamics which in turn can enable access to low-cost electricity for hydrogen production.
- **Electricity curtailment reduction:** Grid-integrated electrolysis systems have the potential to reduce curtailment by consuming electricity during times of excess generation in current and future power systems
- **Market Participation:** Electrolyzers can participate in different electricity markets, including energy and ancillary services for grid balancing and reliability, as well as capacity for resource adequacy. Demands are growing for hydrogen as product to sell for vehicle fuel, synthetic fuel production, other chemical or industrial processes, metals refining, etc.
- **Emissions reductions:** Integrated renewable-electrolysis systems have the potential to reduce curtailment in current and future power systems and reduce greenhouse gas intensity in the natural gas system.

Objectives

- This project will develop optimized operational strategies for electrolytic renewable fuel (hydrogen and methane) facilities in the California energy market over a time horizon from current through 2045.
- Four specific model projects will be used as the basis for the analysis (three in California and one in Texas or the Midwest).
- All projects include interconnection to the natural gas grid as a method of transport for the product fuel and the hydrogen cases will also consider alternative modes of transport.
- The effort will rely on modeling tools developed by NREL and UCI for grid modeling and California integrated resource planning (e.g., RESOLVE).

Approach

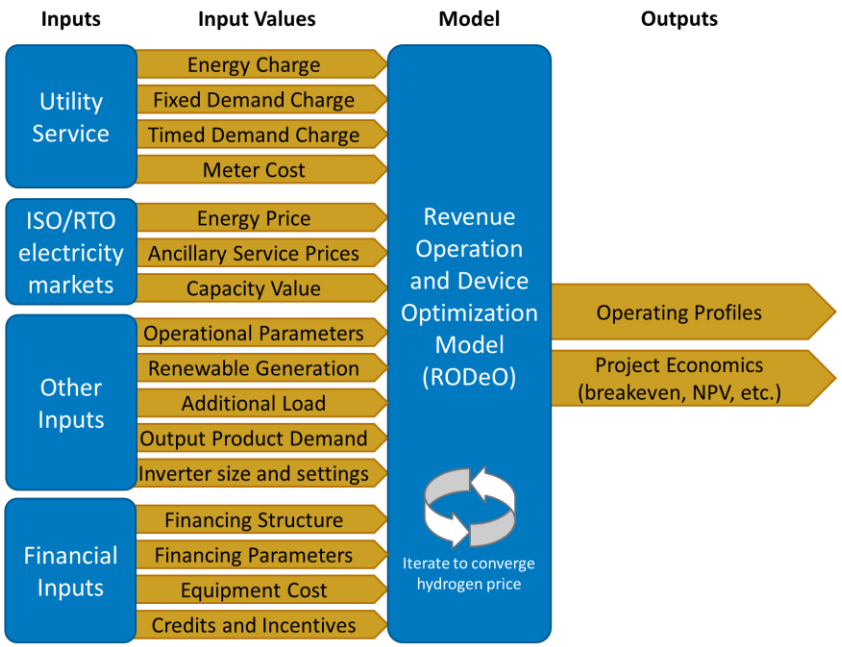
Site selection

- Four locations are selected with unique challenges to showcase the range of hydrogen technologies, strategies and benefits that can be expected. The four proposed model projects will consider:
  - A project located in the Moreno Valley receiving power from local solar and wind resources, producing renewable hydrogen will be assessed. Economic, air emissions, and air quality impacts will be compared for a natural gas blend stock case and an alternative in which hydrogen is liquified and delivered by truck.
  - A project in which CO2 from a diverted food-waste anaerobic digester complex, combined with electrolytic hydrogen to create renewable methane using grid electricity, will be assessed. A specific site near downtown Los Angeles is under consideration for this type of project and is a strong candidate for analysis.
  - A model project to be developed in either Texas or a midwestern location facing challenges with the integration of intermittent resources on the grid will be assessed.
  - Wheeler Ridge will be assessed for dispatching solar PV to produce hydrogen or methane (using CO2 from dairy biogas) production via electrolysis for pipeline injection with product gas piped to southern California.

Approach

Analysis Approach

- Data is gathered for each site described above including surrounding electricity and gas infrastructure (proximity, flowrates, etc.), predictions of future grid mix and resulting electricity prices, etc..
- The Revenue Operation and Device Optimization (RODeO) model is used to determine the optimal operating strategy for the electrolysis equipment. RODeO considers the following:
  - Retail and wholesale market integration
  - Uses the Utility Rate Database with access to over 52,000 rates
  - Includes energy and ancillary service co-optimization
  - System lifetime cost allocation
  - On-site generation (e.g., PV or wind)
  - Additional building or facility loads
  - Can be used as a real-time model predictive controller



Accomplishments and Progress

- While the project is in the early stages, we have already began gathering information about each candidate site (more details on next slide).
- System cost and technical parameters are being gathered from relevant sources.
- Data about future power system portfolios, operation and electricity prices are being gathered (e.g., historical, RESOLVE model output).

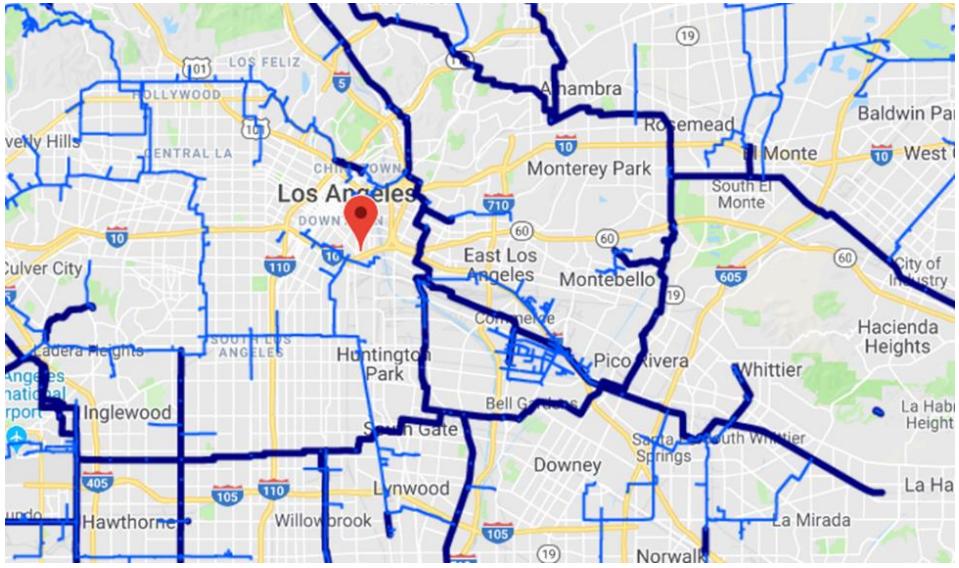
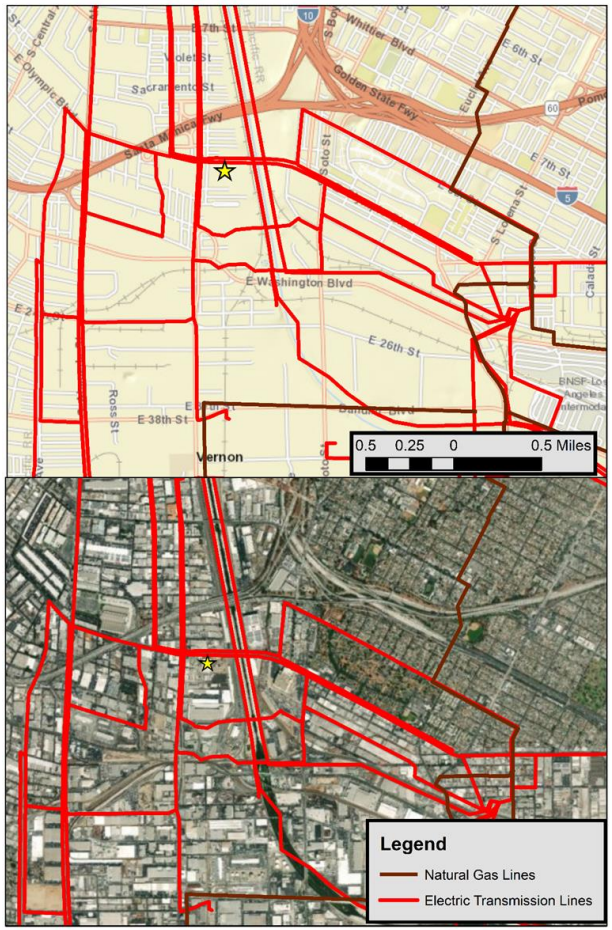


Figure 3. Natural Gas System in the vicinity of potential model project.

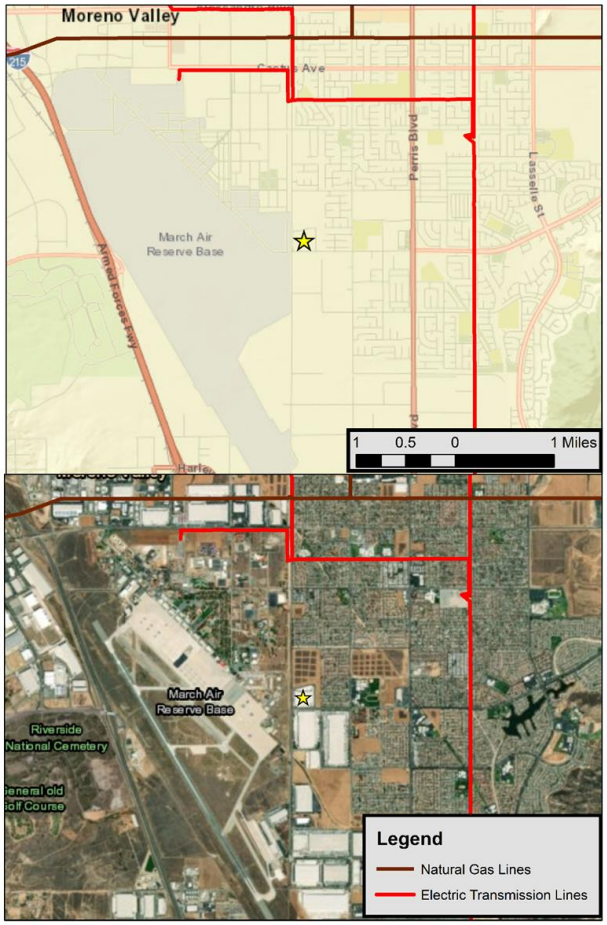
Accomplishments and Progress (cont.)

- Infrastructure in the vicinity of several of the candidate sites has been identified.

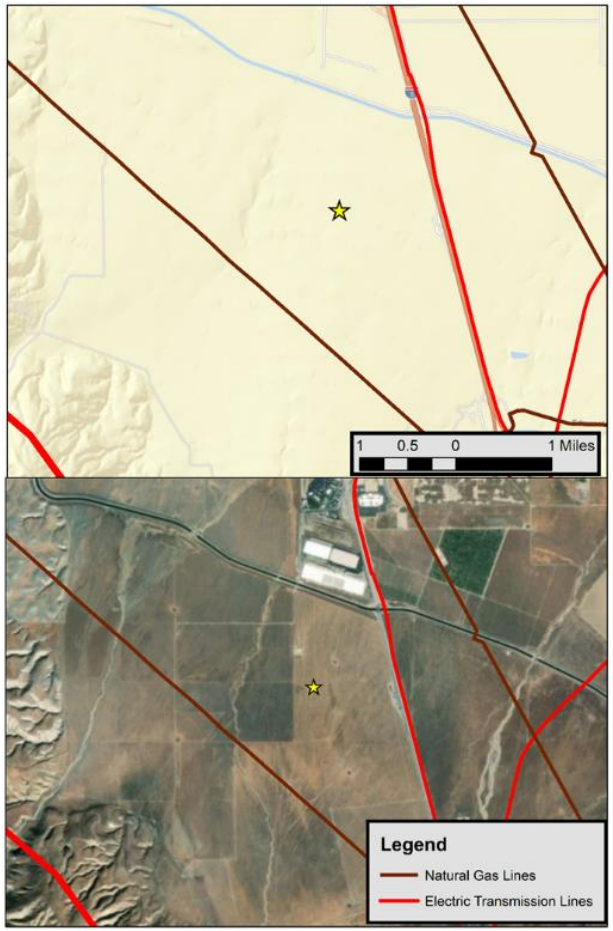
Los Angeles



Moreno Valley



Wheeler Ridge



Accomplishments and Progress: Responses to Previous Year Reviewers' Comments

- This project was not reviewed last year.

Collaboration and Coordination

- University of California, Irvine – Advanced Power and Energy Program.
- UC Irvine is the prime collaborative and funding partner and strongly complements the resources and capabilities of NREL.
- UC Irvine will contribute with their extensive knowledge in the design and operation of the electricity and gas systems along with their expertise in systems analysis and visualization to contribute to the work performed for this project.
- UC Irvine has several related projects from which findings, methods, and data can be leveraged.

Remaining Challenges and Barriers

- As this project is in the early stages, no challenges have yet been identified.

Proposed Future Work

- The team will complete the project in the remainder of this year (FY20) and the coming year (FY21).
- This includes completion of data collection, model development, analysis, and dissemination of results.
- The goal is to use analysis results to determine how best to operate electrolysis equipment in unique and near-term potential locations as well as align the outcomes to support ongoing work related to air quality and system impacts being carried out by UC Irvine.

Technology Transfer Activities

- This work focuses on several specific sites. By performing a deep dive on these sites, we can accelerate the speed at which potential demonstration projects can be implemented at these are similar sites. The project team can engage interested parties.
- There are many configurations for electricity and gas grid integrated electrolysis. We are only able to select a few for this activity; however, there are industrial partners, state-agencies, etc. that can benefit from expanding the scope of this work to their technology or jurisdiction.

Summary

- A Summary slide is mandatory.
  - This project will develop optimized operational strategies for electrolytic renewable fuel facilities in the California energy market over a time horizon from current through 2045.
  - Four specific model projects will be used as the basis for the analysis

Thank You

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