VII.1 HyDRA: Hydrogen Demand and Resource Analysis Tool

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Objectives

- Develop a Web-based geographic information system (GIS) tool to allow analysts, decision makers, and general users to view, download, and analyze hydrogen demand, resource, and infrastructure data spatially and dynamically.
- Provide a repository for hydrogen spatial data inputs and model results.
- Display and aggregate the results of spatial analyses.

Technical Barriers

This project addresses the following technical barriers from the Systems Analysis section of the Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year Research, Development and Demonstration Plan:

(B) Stove-Piped/Siloed Analytical Capability
(C) Inconsistent Data, Assumptions, and Guidelines
(D) Suite of Models and Tools

Contribution to Achievement of DOE Systems Analysis/Systems Integration Milestones

This project will contribute to achievement of the following DOE milestones from the System Analysis and Systems Integration sections of the Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year Research, Development and Demonstration Plan:

- **Milestone 5 (System Analysis)**: Complete analysis and studies of resource/feedstock, production/delivery and existing infrastructure for various hydrogen scenarios. (4Q, 2009)
- **Milestone 8 (System Analysis)**: Complete analysis and studies of resource/feedstock, production/delivery and existing infrastructure for technology readiness. (4Q, 2014)
- **Milestone 27 (System Analysis)**: Complete the 2nd version of the Macro-System Model to include the analytical capabilities to evaluate the electrical infrastructure. (2Q, 2011)
- **Milestone 15 (Systems Integration)**: MSM analysis test cases. (4Q, 2006; 3Q, 2009; 4Q, 2010)

Accomplishments

- Completed initial integration with Macro System Model (MSM) to produce six new spatial data layers of cost, energy, and greenhouse gas (GHG) emissions for forecourt electrolysis. Provided a proof-of-concept for MSM integration with spatial models.
- Completed development and deployment of new HyDRA Web 2.0 architecture, which provides improved user experience and a single data store for all layers. The new architecture will also allow for dynamically sending and receiving data to and from other hydrogen models, such as MSM.
- Implemented 69 spatial data layers related to hydrogen resource, infrastructure, and demand. Datasets represent spatial data input layers, and output from spatial analyses.
- Registered 118 users who have accessed the HyDRA application in Fiscal Year 2009.

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Introduction

The HyDRA tool was developed to conduct dynamic geographic analysis of hydrogen processes in Web-based environment. This capability is important as resource, demand, and infrastructure will vary regionally for hydrogen production, delivery, and dispensing. HyDRA provides a repository for storing spatial data used by hydrogen analyses and tools, and allows spatial analysis results to be compared from a common application.

Approach

The HyDRA tool is a state-of-the-art, Web 2.0 application that has the look, feel, and functionality of a traditional client-based GIS application. It provides the capability to view hydrogen data and how they vary across the United States on a regional basis. HyDRA provides analysis results in the form of a map, instead of a number. It is available at http://rpm.nrel.gov. Users can view spatial hydrogen data and interact with the maps to create custom analyses. Data can be downloaded from the application and used in other analyses. To ensure HyDRA's usability, NREL recently redesigned it from its original code base to provide an easier to use, more intuitive interface. Users will be able to create their own spatial datasets and upload them into the HyDRA tool to create a completely customizable and dynamic analysis tool.

Spatial data layers are at the core of the HyDRA application. Currently, 69 datasets have been created. The data layer categories include resource cost and availability, hydrogen production potential, hydrogen production cost, resource consumption, hydrogen demand, infrastructure, and results from integration with other hydrogen models.

Results

The major HyDRA efforts that have been completed this year are the integration of HyDRA with the MSM and the completion of building the model on a new architecture.

The integration with MSM created six new layers displaying the cost, energy usage, and GHG emissions of forecourt electrolysis. This initial proof-of-concept integration was achieved by manually exchanging data between to the models. The input to the MSM was a county level industrial electricity cost layer and a state level based grid mix layer from the Environmental Protection Agency (EPA) eGRID [1]. After processing the provided data in the MSM, six new spatial data layers were provided back to HyDRA: cost (on a state and county basis), well-to-wheel energy use, petroleum energy use, fossil energy use, and well-to-wheel GHG emissions. These new data layers allow users to determine where low-cost, low-energy use, low-emission hydrogen can be produced via forecourt electrolysis. Figure 1 illustrates the integration process.

In anticipation of HyDRA dynamically integrating with the MSM and other models in the future, the application was moved to the new OpenCarto architecture. In addition to providing programmatic integration capability, this architecture provides for a better user experience by providing a more intuitive interface, quick response times, and the ability to use Google maps to view data from street level to the entire world. Figure 2 shows the old version of HyDRA versus the new version of HyDRA.

The HyDRA architecture allows users to interact with maps dynamically to perform custom analyses. Users can zoom, pan, measure, find a location, adjust transparency, and print. Multiple layers can be turned on simultaneously, and then be thresholded so that only certain values presented on the map can be seen. Data can be queried on the map, viewed in a spreadsheet format, and downloaded for additional analysis. Metadata for layers can be viewed and referenced from the layer tree. Figure 3 shows an example of how HyDRA can be used to perform spatial analyses. The screenshot shows the demographic demand and the potential methane available from manure management in the northeastern United States. The application limited the demand classes displayed to just show Good, Very Good, High, and Very High demand. It has also been limited to show methane available from manure management greater than 2,000 tonnes/year/county. The screenshot shows that demand and resource are geographically proximate in southeast Pennsylvania, near Chicago, and in Ohio.

A second example analysis makes use of the new MSM data layers by examining where forecourt hydrogen could be produced inexpensively with low emissions in an area with high potential early demand.

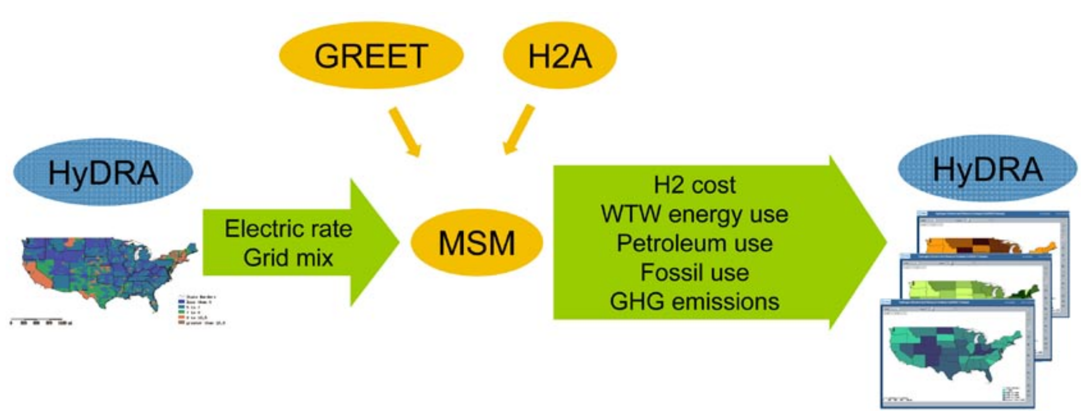

FIGURE 1. Process for the Manual Integration of HyDRA and the MSM

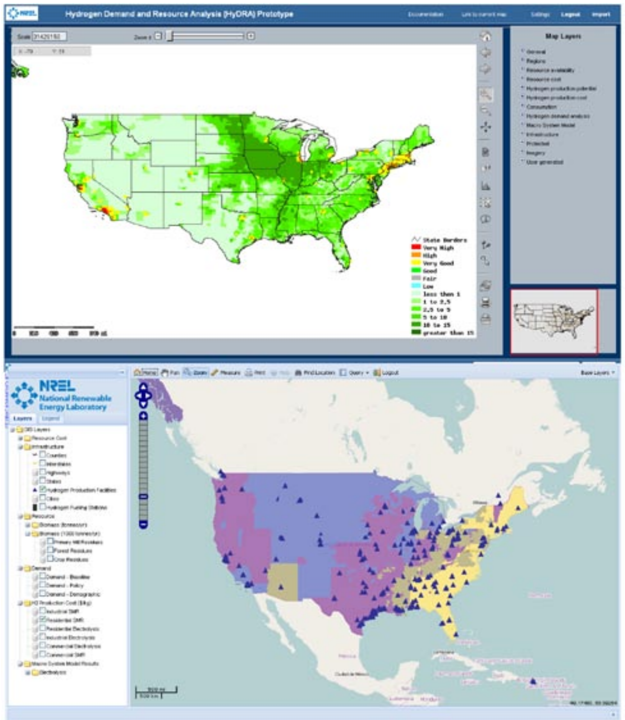

FIGURE 2. HyDRA's Initial Architecture (top) Contrasted with The New Architecture (bottom)

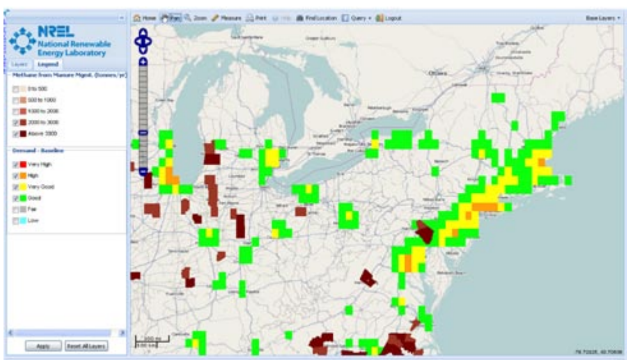

FIGURE 3. Analysis of Demand and Biomethane Potential in the Northeastern United States

Figure 4 shows HyDRA displaying industrial electricity prices less than $50/MWh, early high to very good demand for hydrogen as a transportation fuel, and total GHG energy usage for forecourt electrolysis, by state, less than 8,000 Btu/mile. As highlighted, the Pacific northwest looks to be an area of the United States with good potential for clean forecourt electrolysis.

Data provides the core of HyDRA's capability and the datasets currently available represent spatial source data and hydrogen analysis results. Available data is categorized in the following and the number of datasets in each category is represented in parentheses.

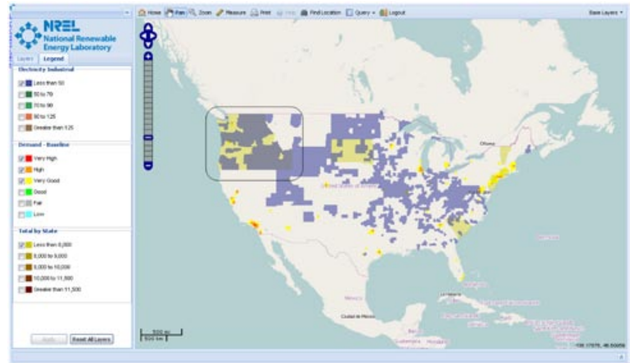

FIGURE 4. Analysis of Low-Cost, Low-Emission, High-Demand Forecourt Electrolysis

Source Data

- Roads, cities, states, counties (6)
- National Energy Modeling System, HyDS regions (2)
- Electric and natural gas rates (6)
- Solar, wind, biomass, geothermal, hydropower resources (5)
- Nuclear, coal (3)
- Biomass potential (5)
- Infrastructure (12)
- Imagery (1)

Hydrogen Analysis Results

- Hydrogen demand (3)
- Forecourt steam methane reformer and electrolysis cost (6)
- Biomass, solar, geothermal, hydropower and wind hydrogen potential (8)
- Nuclear, coal, natural gas hydrogen potential (6)
- MSM cost, energy and GHGs (6)

Conclusions and Future Directions

HyDRA provides a single point of reference for spatial data related to hydrogen. The improved user interface provides for a better look and feel and user experience. In the future, the ability to connect dynamically with other hydrogen models will allow hydrogen analysts to use consistent data inputs, and comparable analytical results. In the future HyDRA will:

- Develop the capability to generate dynamic layers in the HyDRA application from user and model provided data.

- Develop and deploy basic analysis functions such as graphing, changing underlying assumptions, and buffering.
- Integrate with other hydrogen models and analyses to develop new data input layers and display model results using manual and dynamic integration.
- Create case studies to ease user analysis, similar to H2A cases.

FY 2009 Publications/Presentations

1. Sparks, W., Levene, J., Helm, C. (2009) Hydrogen Demand and Resource Assessment. 20 pp.; NHA Conference and Hydrogen Expo.

2. Helm, C., Levene, J., Sparks, W., Hostetler, M. (2008) Facilitating Code Reuse for the Rapid Deployment of Web Mapping Applications at the National Renewable Energy Laboratory (NREL). 1 p.; Poster presentation at American Geophysical Union Fall Meeting.

3. Sparks, W. (2009) OpenAtlas – A Foundation for the Geospatial Web. 22 pp.; Podium presentation at National Laboratories Information Technology Summit.

References

1. eGRID, Clean Energy, US EPA: http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html.