VII.16 HyDRA: Hydrogen Demand and Resource Analysis Tool

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direction determined annually by DOE

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.

- Support interoperability between HyDRA and similar applications in other domains of energy infrastructure research.

Technical Barriers

This project addresses the following technical barriers from the Systems Analysis section of the Fuel Cell 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/Integration Milestones

This project will contribute to achievement of the following DOE milestones from the System Analysis and System 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 (System Integration): MSM analysis test cases. (4Q, 2006; 3Q, 2009; 4Q, 2010)

Accomplishments

- Completed the Macro System Model (MSM) dynamic integration that can, at the user's request, produce six data layers based on user specified parameters and load them into HyDRA for visualization and querying.

- Initial interoperability between HyDRA and the Scenario Evaluation, Regionalization and Analysis (SERA) model was achieved in Fiscal Year (FY) 2010:

  – External datasets from multiple locations are available within the HyDRA interface.

  – Worked with SERA leadership to finalize the initial data input and delivery needs for SERA which will be supported by HyDRA.

  – The strategy will also support interoperability between HyDRA and other systems, models, and analysis applications including the Bioenergy Knowledge Discovery Framework (BKDF).

- Interaction with the BKDF:

  – Enhancements on the BKDF project resulted in several data services being made available to HyDRA in the fourth quarter of FY 2010.

- Increased the number of spatial data layers related to hydrogen resource, infrastructure, and demand to over 90 layers. These datasets are comprised of background data, model input data, and results spatial analyses and modeling efforts.

- A diverse group of 257 users from 62 countries accessed the HyDRA application over 2,000 times in FY 2010:

–   Universities (University of Chicago, Sonoma State University, University of California, Davis).
–   Industry (Air Products and Chemicals, Inc., Apple, Matheson Tri-gas).
–   Government Agencies (Office of the Secretary of Defense, DOE).

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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 analysis results from multiple domains of research to be explored and compared from within a single interface.

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 maps that can be queried to access the numbers behind the visualization. It is available at http://maps.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 can create their own spatial datasets and provide them to the HyDRA application to create a completely customizable and dynamic analysis tool.

The capability to explore and query spatial data layers is a core capability of the HyDRA application. There are currently more than 90 datasets available in the system including resource cost and availability, hydrogen production potential, hydrogen production cost, resource consumption, hydrogen demand, infrastructure, and results from integration with other hydrogen models. The ability to access externally hosted datasets and also to run the MSM model from within the HyDRA application will provide access to a significant number of additional datasets. Additionally, dynamic data acquisition services will provide up-to-date versions of data that change over time.
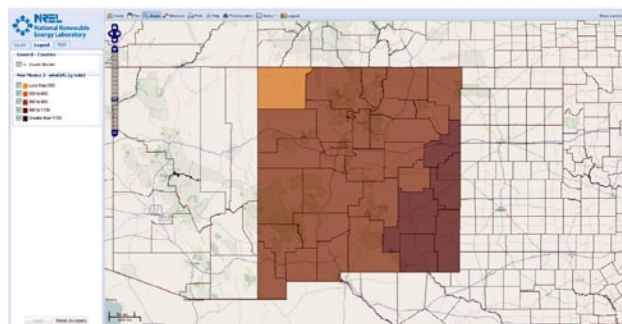
Results

The major HyDRA efforts that we completed this year involve the integration of HyDRA with the MSM, developments to support interoperability between HyDRA and SERA, and preliminary development of spatial analysis and complex querying within HyDRA.

The development of the HyDRA/MSM integration allows for an MSM job to be initiated from an MSM tab in the HyDRA interface. Users can submit a job to the MSM for any state and specify various parameters within their request. Users are limited to running jobs on a state basis due to the time each MSM run requires. MSM jobs take over five minutes per county to run, so larger states that include a sensitivity analysis on electricity cost can take several days. As a result the MSM jobs are submitted in a batch format so that users can send their MSM jobs from HyDRA and then continue using the application while the jobs run in the background. Status information is available in the MSM tab within the HyDRA application.

At this time the forecourt electrolysis MSM scenario can be run from within HyDRA. The interface provides a form for the entry of the required parameters and sends these to the MSM along with the electricity cost and grid mix for every county in the state. The MSM generates a resultant hydrogen cost, greenhouse gas emissions, total energy usage, fossil energy usage and petroleum energy usage for every county in the state. These data are accessible to the user through an interface in the HyDRA application along with the specific parameters entered by the user in the request (Figures 1). Additionally, a preliminary design was completed to support querying of HyDRA data by the MSM.

The NREL HyDRA team built a Web service (a specific uniform resource locator [URL] that allows computers to exchange data) that includes user authentication to allow MSM to access data contained in the HyDRA database such as the electricity and natural gas rates for specific counties (Figure 2). A Web

FIGURE 1. MSM Well-to-Wheels Greenhouse Gas Results for Forecourt Electrolysis in New Mexico
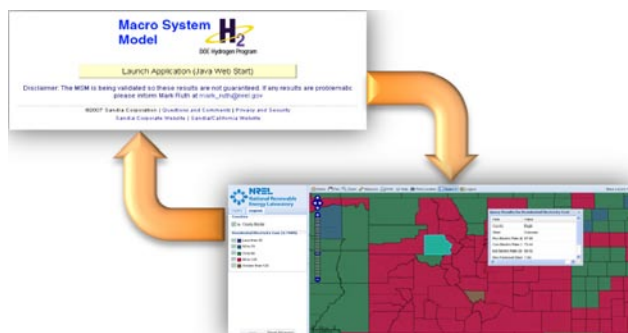
FIGURE 2. MSM Accesses County Attributes such as Electricity and Natural Gas Rates from HyDRA via Web Services

FIGURE 3. HyDRA will both serve data to and access data from a wide range of sources and provide visualization and querying to the research community for all of these data.

service specification was created that will allow the MSM team and the HyDRA team to develop in parallel which. This integration was completed early in the third quarter of FY 2010.
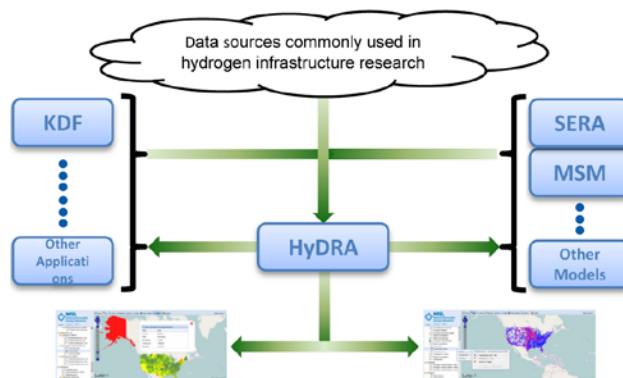
The effort to support interoperability between HyDRA and SERA is being implemented in such a way as to support interoperability between HyDRA and a number of other applications as well (Figure 3). This development effort allows users to specify external datasets that can be dynamically loaded into the HyDRA interface and also to load some HyDRA data directly within other applications. A prototype of this capability is shown in Figure 4 by displaying live weather data, which is an external data source, over the MSM green house gas emissions.

As new datasets are ingested into HyDRA which support analysis and modeling efforts, such as the SERA model, HyDRA will become a venue for results of analysis and modeling applications. Users are able to load these results directly into HyDRA along with the existing HyDRA data layers and external data from applications such as the BKDF.
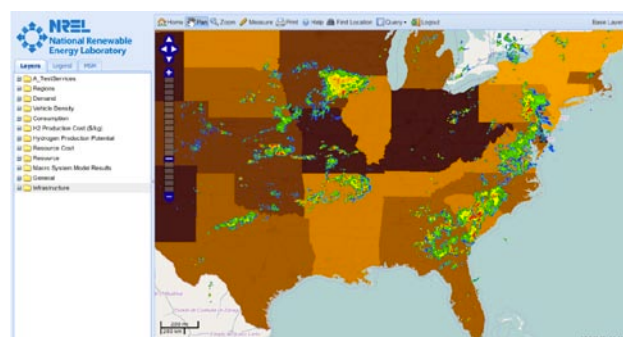

FIGURE 4. Real-time weather data from an external source displayed along with MSM results within the HyDRA interface.

Conclusions and Future Directions

HyDRA provides a single point of reference for spatial data related to hydrogen. Improvements to the user interface and functionality provides an intuitive user experience. Additionally, the enhanced interoperability of HyDRA simplifies the direct use of this data in analysis and modeling and places HyDRA at the center of many other applications and research efforts. In the future HyDRA will:

- Develop a process for automatically updating SERA input data in the HyDRA application on a regular basis.
- Develop an interface to explore, visualize and display complex temporal and multivariate datasets.

- Develop complex querying capability, including enhanced spatial queries, to analyze temporal and multivariate datasets.
- Provide an interface to dynamically create, print, and export images of maps and charts.
- Allow users to customize map classification and dynamically manipulate charting variables.
- Formalize data interoperability relationships and data exchanges between other spatial data analysis and visualization applications in other domains of research.
- Continue to 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.
- Continue to 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 2010 Publications/Presentations

1. Levene, J., Getman, D. "Recent Developments in the Hydrogen Demand and Resource Assessment (HyDRA) Model". Hydrogen Annual Merit Review, 8 June 2010. (Poster Presentation)

2. B. Bush, D. Getman, D. Hettinger, J. Levene, M. Melaina. "Interoperability between SERA and HyDRA". National Renewable Energy Laboratory, 31 March 2010. (Internal management report)