XI.10 HyDRA: Hydrogen Demand and Resource Analysis Tool

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Project End Date: Project continuation and direction determined annually by DOE

Fiscal Year (FY) 2011 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.
- Expand visualization and querying of temporal and multivariate datasets.
- Extend data acquisition and ingestion capabilities.
- Enhance analysis capabilities within HyDRA.

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:

(A) Stove-Piped/Siloed Analytical Capability

(B) Inconsistent Data, Assumptions, and Guidelines

(C) Suite of Models and Tools

Contribution to Achievement of DOE Systems Analysis Milestones

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

- 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 (MSM) 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)

FY 2011 Accomplishments

- Interoperability has been established with other models and applications, including the Scenario Evaluation and Regionalization Analysis (SERA) model.
  - HyDRA data is now available as Web Mapping Service and Web Feature Service which can be used by any external application capable of interacting with these standards-based services.
- Attribute querying capability has been added to HyDRA.
- Basic charting of datasets in HyDRA will be completed within FY 2011.
- Interaction with the BioenergyKDF project.
  - HyDRA and the BioenergyKDF are now interoperable and capable of actively sharing data.
- The OpenEI project will leverage data to be used by HyDRA, with plans to ingest a variety of datasets to be used within HyDRA. These services should be available in FY 2012.
- Increased the number of spatial data layers related to hydrogen resource, infrastructure, and demand to over 100 layers. These datasets are comprised of background data, model input data, and results from spatial analysis and modeling activities.
- A diverse group of 257 users from 62 countries have accessed the HyDRA application in FY 2011, including university (University of Chicago, Sonoma State University, University of California, Davis), industry (Air Products and Chemicals, Inc., Apple, Matheson Tri-gas), and government agency stakeholders (Office of the Secretary of Defense, DOE)

Introduction

The HyDRA tool was developed to conduct dynamic geographic analysis of hydrogen processes in a Web-based environment. This capability is important as resource conversion, demand, and infrastructure components vary regionally for different hydrogen production, delivery, storage and retail dispensing systems. 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 will be able to create their own spatial datasets and upload them into 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 100 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 from within HyDRA, will provide access to a significant number of datasets and analysis results. Additionally, dynamic data acquisition services will provide up to date versions of data that change over time.

Results

The major HyDRA efforts that have been accomplished this year involve interoperability, data querying, and visualization. HyDRA is now capable of full interoperability with other standards-based geospatial data systems and is sharing datasets with the BioenergyKDF. This capability will also allow HyDRA to share data with SERA, MSM, and any other modeling, analysis, or data exploration application that can use standards-based data (Figures 1 and 2).

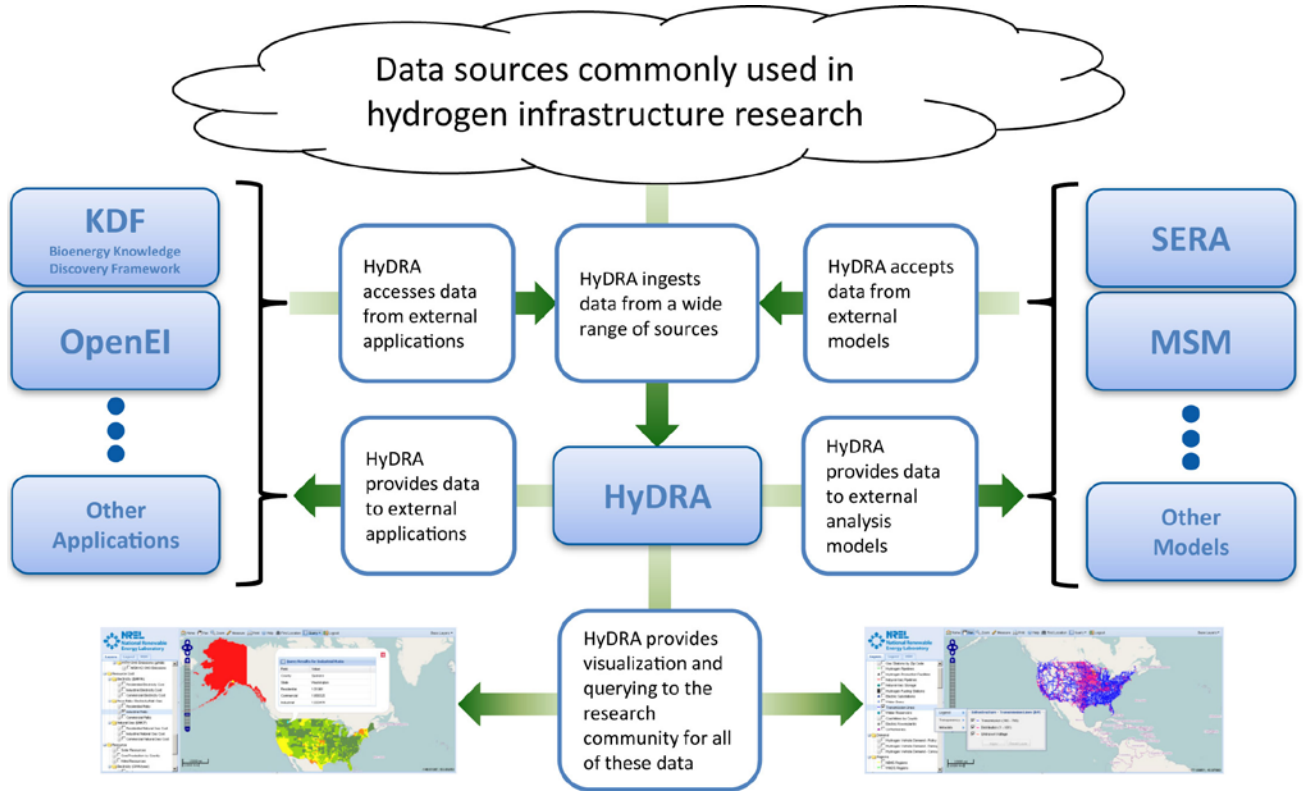

FIGURE 1. Interoperability Between HyDRA and Other DOE-Funded Applications And Modeling Efforts

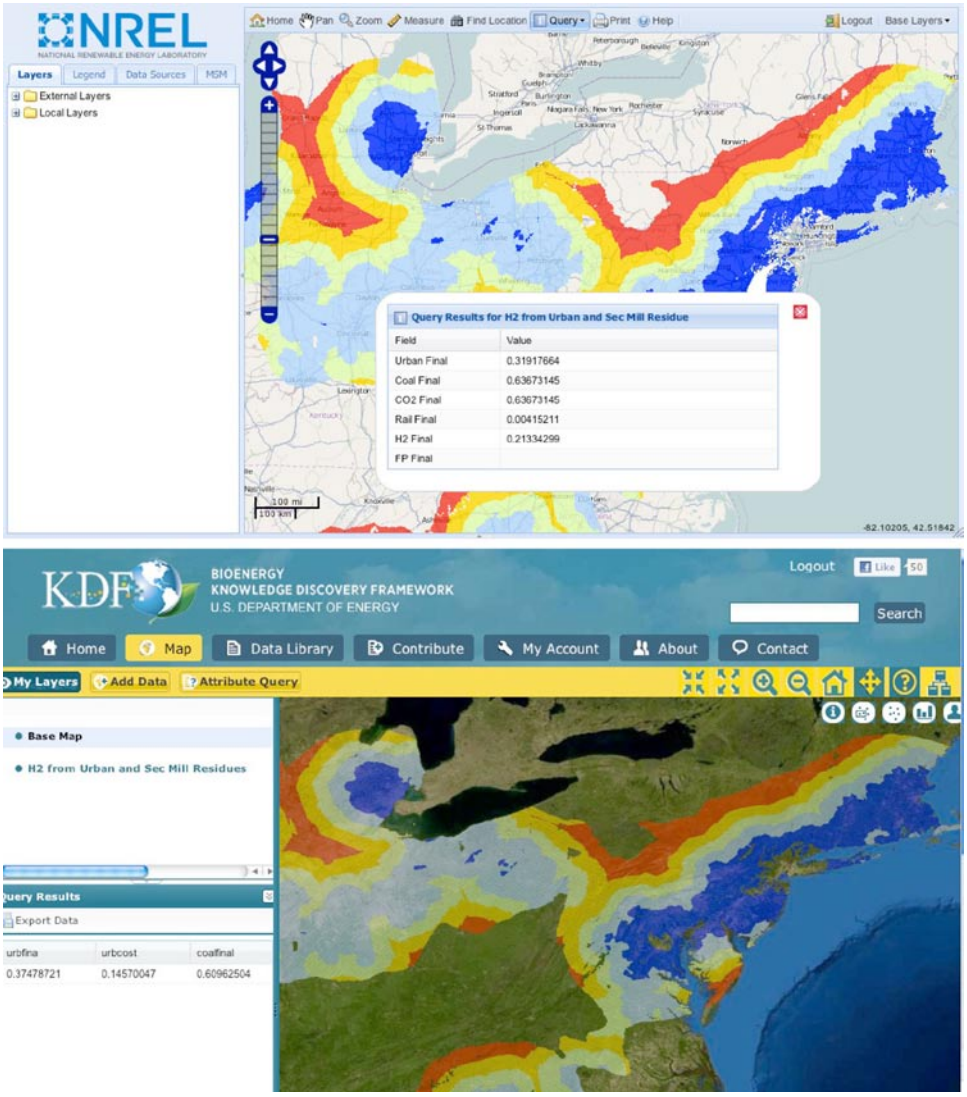

FIGURE 2. Data Stored in HyDRA and Accessed in both HyDRA and the BioenergyKDF

An advanced attribute querying capability has been implemented in HyDRA. For any layer within HyDRA the user can select multiple attributes to build a complex query and then run that query in the interface to select features that meet specific parameters. This capability will allow users to ask complicated questions about data within the HyDRA application and to explore research results in a more sophisticated manner than was previously possible (Figure 3).

In an effort to provide users with another path to visualize research data within HyDRA, a first level charting capability is being implemented in FY 2011. For any layer within the HyDRA application, users can specify up to four attributes to chart from the dataset. In combination with the spatial display and new querying capabilities, this elevates the potential to use HyDRA for analysis and provides information tailored to more specific decision making activities for users (Figure 4).

Additionally, several new datasets have been ingested into HyDRA and are available for use with the new attribute query, for use in external applications, and will be available for charting by the end of FY 2011.

Conclusions and Future Directions

HyDRA provides a single point of access to spatial data related to hydrogen systems. Improvements to the user interface and functionality provide a more intuitive user experience and improved analysis capabilities. Additionally, the enhanced interoperability of HyDRA simplifies the direct use of this data in analysis and modeling activities, and places HyDRA at the center of many other applications and research efforts. In the future HyDRA will focus on the following areas:

- HyDRA as a collaboration tool:

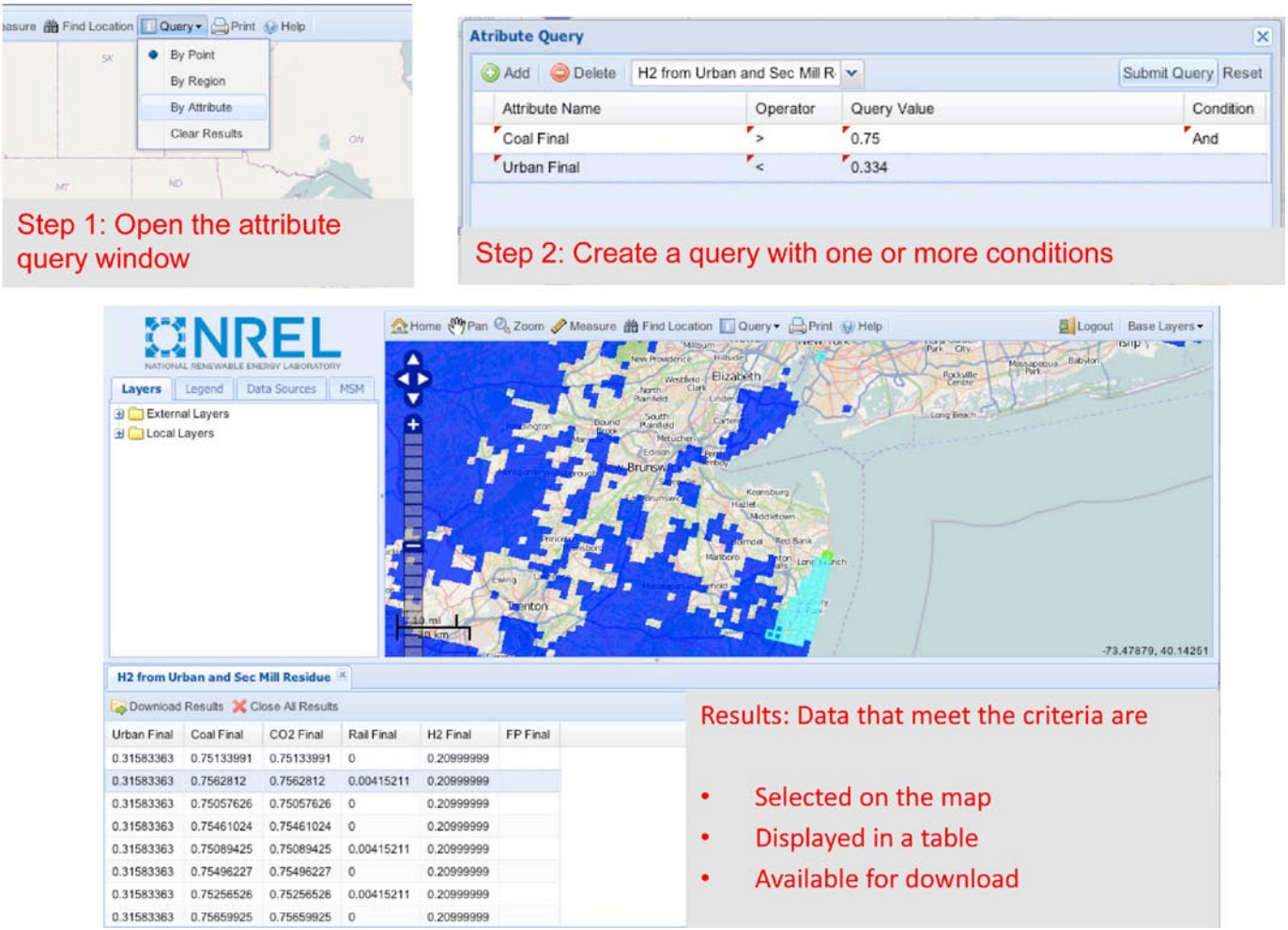

FIGURE 3. Attribute Query Example in HyDRA

- HyDRA will be used as a means of communicating spatial and temporal results from a number of future scenario studies, including wind-to-hydrogen analyses, California and other early market growth case studies, and nationwide hydrogen infrastructure rollout scenarios.
- Coordination with OpenEI will result in the development a process for automatically updating some datasets in the HyDRA application on a regular basis.
- Continue to integrate with other hydrogen models and analyses to develop new data input layers and to display model results using both manual and dynamic data integration.
- Allow for simple hydrogen system cost calculations through the HyDRA interface, relying upon H2A model result and assumptions.
- Formalize data interoperability relationships and data exchanges between other spatial data analysis and visualization applications in other domains of research.

- Completion of the advanced visualization tool:
  - The visualization tool that was cut this FY will be further developed in FY 2012 and focused mainly on exploring the results of NREL hydrogen systems analyses. In its final version, this visualization tool will open within HyDRA and be used to explore data from a wide range of sources, including runs of the MSM and SERA models.
- OpenCarto:
  - Develop complex querying capability, including enhanced spatial queries, to analyze temporal and multivariate datasets.
  - Collaboration with multiple projects that use OpenCarto to improve this framework and to enhance its capabilities in FY 2012 to support new geospatial technologies including advanced visualization and querying.
  - More interaction through the user interface to support communication about data availability and quality.

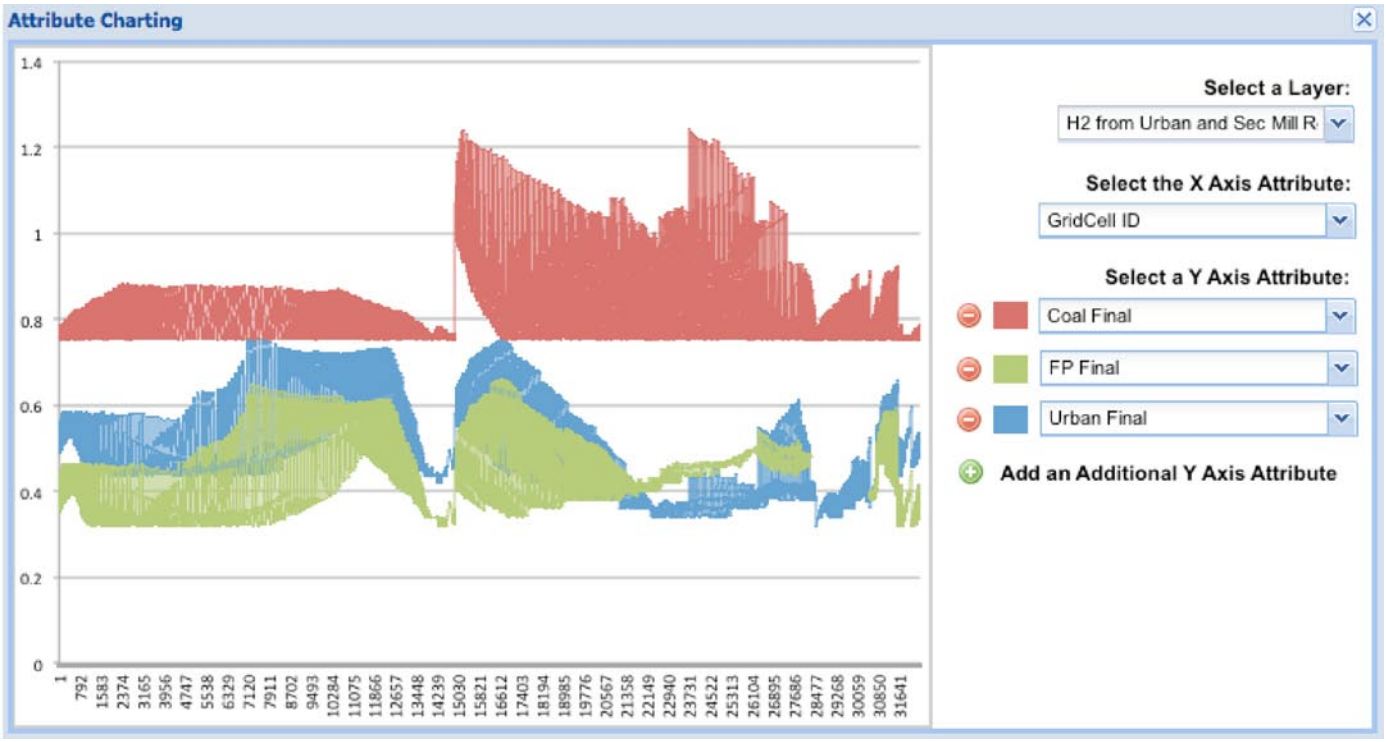

FIGURE 4. A Schematic of Layer Charting in HyDRA

- Long-term project support and data updates.
- Allow users to customize map classification and dynamically manipulate charting variables.
- Provide an interface to dynamically create, print, and export images of maps and charts.
- Continue to develop the capability to generate dynamic layers in the HyDRA application from user and model generated data.
- Develop and deploy basic analysis functions such as graphing, changing underlying assumptions, and buffering.

FY 2011 Publications/Presentations

1. Getman, D., Levene, J. "Developments in the Hydrogen Demand and Resource Assessment (HyDRA) Model: Improvements in Data Interoperability, Availability, and Querying". Hydrogen Annual Merit Review, 10 May 2011. (Poster Presentation)

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

3. 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)