

## X.8 HyDRA: Hydrogen Demand and Resource Analysis Tool

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Project End Date: Project continuation and 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

### 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 Milestones

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

- **Milestone 5:** Complete analysis and studies of resource/feedstock, production/delivery, and existing infrastructure for various hydrogen scenarios. (4Q, 2009)

- **Milestone 8:** Complete analysis and studies of resource/feedstock, production/delivery, and existing infrastructure for technology readiness. (4Q, 2014)

### Accomplishments

- Identified, created, and integrated new data layers:
  - Resource cost and availability (fossil and renewable)
  - Hydrogen production cost
  - Resource consumption
  - Hydrogen demand
  - Infrastructure
- Identified several new data layers to be integrated as part of future work:
  - Hydrogen pipelines
  - Oil refineries
  - Power plants
  - Water reservoirs/dams
  - Natural gas pipelines
  - Natural gas storage
  - Liquefied natural gas terminals
  - Electric substations
  - Electric lines
  - Hydrogen producers
- Added the following features to the HyDRA user interface:
  - Select, view, and download the raw data underlying HyDRA maps
  - Upload and plot user-generated point data
  - Graph selected layers
  - Point buffering
  - Dynamic legend and layer control
- Identified and created several new data layers. These will be integrated into the application at a later date



### Introduction

The HyDRA tool was developed to conduct geographic analysis of hydrogen demand and resource and infrastructure spatially in a dynamic Web-based environment. This capability is important as resource, demand, and infrastructure will vary regionally for hydrogen production, delivery, and dispensing. However, existing analyses tend to use national averages.

As a result, a tool is needed to facilitate regional and geographical analyses.

## Approach

HyDRA is based on existing NREL work. Two earlier GIS efforts have been included as data in the model: 1) GIS resource analyses for hydrogen produced from wind, solar, and biomass and 2) hydrogen demand scenario modeling results. The HyDRA model itself is based on the RPM model at NREL, which provides secure, Web-based, open-source architecture. This architecture consists of a database, Web server, and GIS system and is accessed by Web browsers both internal to NREL and external.

The HyDRA application is currently available for general use at <http://rpm.nrel.gov/rpmentry>. The most recent software update was in May of 2008; the next release is scheduled for September 2008.

## Results

The HyDRA project began with the development of the functional requirements. These requirements explain at a high level what capabilities the model needs. The list of functional requirements follows. The first 14 were started in Fiscal Year 2007, while the last three are future requirements.

1. Generic viewing maps
2. Resource maps
3. Infrastructure maps
4. Demand maps
5. Layer control
6. Change underlying assumptions
7. Build hydrogen system
8. Buffer layers
9. Security
10. Import data
11. Export data
12. Graph data
13. Selecting data
14. Print map
15. Emissions
16. Temporal functionality
17. Interaction with other applications

With the basic infrastructure of HyDRA in place, NREL continued to improve and extend application functionality and usefulness. The user now has the ability to re-color and adjust the transparency of layers, which allows the creation of maps tailored to the user's specific needs. The point buffering feature, in conjunction with HyDRA's infrastructure data layers, allows the user to explore scenarios

involving transportation distances and vehicle driving ranges. Graphing functionality provides the ability to easily compare values available in data layers. For example, the user may request a graph of residential vs. commercial vs. industrial electricity costs for any point in the country. Using the solar resources data, it is possible to see how solar radiation varies throughout the year at any given point.

The creation of new data layers including hydrogen production cost (based on the H2A model), resource cost and availability (Figure 1), resource consumption, hydrogen demand, and infrastructure (Figure 2) broadens the array of analyses that a user may perform and gives HyDRA a wider audience. Future data layers as outlined above will provide a complete picture of a potential hydrogen economy.

HyDRA is currently operational and available to end users. It allows users to perform geospatial analyses involving hydrogen demand, resource availability and cost, and infrastructure constraints (Figure 3).

## Conclusions and Future Directions

### Conclusions

HyDRA concept is a Web-based, dynamic, highly interactive demand and resource tool:

- View, download, and report on resource, demand, and infrastructure data

## Resource Data

Renewable  
**Wind**  
**Solar**  
**Biomass**  
 Offshore wind  
 Hydro  
 Geothermal  
*Coal*  
*Natural gas*  
 Uranium  
*Water*  
 Geologic features  
 Sequestration  
 Hydrogen storage  
*Oil/gasoline*



Energy production potential  
 Hydrogen production potential  
 Usage of feedstock by utilities  
 Competition



**FIGURE 1.** Resource data required for HyDRA: Green bold items have been incorporated into the application, green italic items have been started, black items are future items.

## Infrastructure Data

Electricity

Natural gas

Water

Capacity

Location

Availability

Consumption

Rates



Water treatment plants

Transportation sector

Roads

Rail

Ports

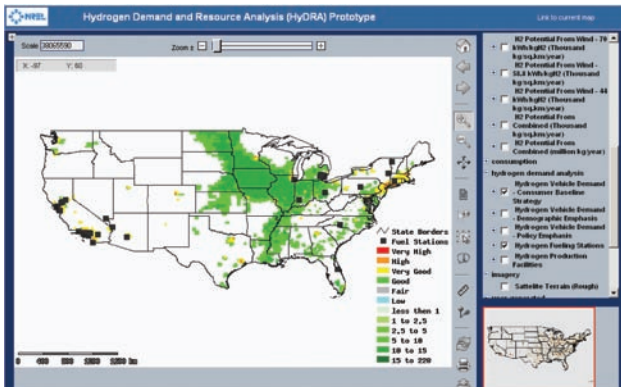
**Hydrogen infrastructure**

Power plants

Renewable installations

Gas stations

**FIGURE 2.** Infrastructure data required for HyDRA: The integration of green bold items into the application has been started; black items are future items.



**FIGURE 3.** Nationwide case study using HyDRA to find a site with good biomass resource, high demand, no nearby hydrogen refueling infrastructure, and a nearby hydrogen-production plant.

- Spatially represent analysis results
- Provides a tool for regional analysis

Current DOE resource and demand analysis is static. Existing DOE models need or could use consistent demand and resource data and regional capabilities:

- HyDS, HyTrans, Macro System Model (MSM), others

Hydra is built on existing work at NREL:

- GIS resource analysis
- Hydrogen demand scenario analysis
- Renewable planning model

## Future Directions

Current and future work will make the HyDRA tool more robust through the addition of new data layers and more user-friendly and responsive by re-designing the user interface. These changes will increase the value of HyDRA for the geospatial analysis of a hydrogen economy.

Integration with the MSM will provide a powerful bridge from the geo-spatial strengths of HyDRA to existing non-spatial analysis tools. For example, using existing regional electrical grid mix and pricing data, an integrated HyDRA/MSM will calculate, on a regional basis:

- Well-to-wheels greenhouse gas emissions
- Petroleum use
- Overall fossil fuel use
- Well-to-wheels energy use
- Hydrogen production cost

These calculations will allow regional planners to determine what method(s) of hydrogen production are best suited to their region.

Specific changes and enhancements planned are as follows:

- June – August 2008: Develop release 3
  - Infrastructure layers. NREL will integrate a number of data layers relating to infrastructure. This will allow users of the tool to perform analyses involving electrical production and distribution, natural gas distribution, hydrogen transportation, and water availability.
  - Improved user interface. The re-architected system will be faster and more intuitive, resulting in an improved user experience (Figure 4).



**FIGURE 4.** Prototype of HyDRA user interface that will be developed as part of the re-architecture task.

- Integration with external tools. By exchanging data with the MSM, HyDRA users will have access to the power of several hydrogen system models.
- September 2008: test and release
- FY 2009 and beyond: temporal functionality, interfaces with other applications (MSM, HyDS, HyTrans), additional resource and infrastructure layers, emissions

### **FY 2008 Publications/Presentations**

1. Presented at FPITT team meeting (March 2008).
2. Presented at the DOE Hydrogen Program 2008 Annual Merit Review (May 2008).

### **References**

1. Melendez, M.; Milbrandt, A. *Geographically Based Hydrogen Consumer Demand and Infrastructure Analysis: Final Report*. NREL/TP-560-40373. Golden, CO: National Renewable Energy Laboratory, 2006.
2. Milbrandt, A.; Mann, M. *Potential for Producing Hydrogen from Key Renewable Resources in the United States*. NREL/TP-640-41134. Golden, CO: National Renewable Energy Laboratory, 2006.