



Developments in the Hydrogen Demand and Resource Assessment (HyDRA) Model: Improvements in Data Interoperability, Availability, and Querying



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NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

Overview

Timeline

- Project start date – September 2006
- Project end date – Ongoing
- Percent complete – Ongoing

Budget

- Total Project Funding: \$1,270k
 - 100% DOE-funded
- Funding for FY 2009 – \$266K
- Funding for FY 2010 – \$300K
- Funding for FY 2011 – \$150K

Barriers

- Stovepiped/siloed Analytical capability [4.5.B]
- Inconsistent data, assumptions, and guidelines [4.5.C]
- Suite of models and tools [4.5.D]

Partners

- NREL project with support from Alumni Consulting, for programming expertise

Relevance: Why Spatial Analyses and Datasets?

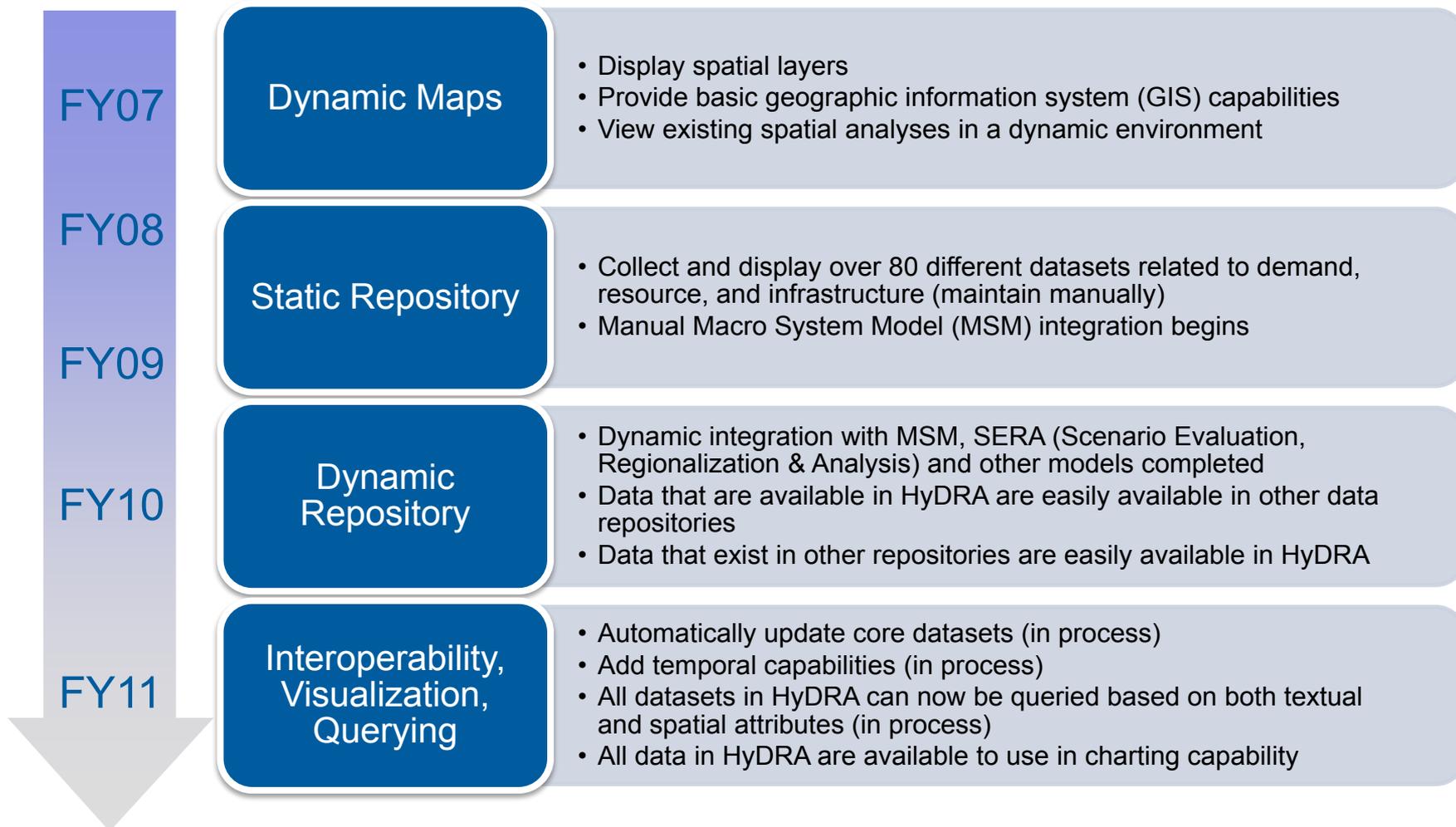
- Estimating hydrogen demand, finding and organizing resources, and designing, building, and managing the hydrogen production and distribution infrastructure all require spatial and temporal modeling and analysis which require and produce spatial and temporal datasets.
- The input and output from these analysis require the development of a common visualization platform so information can be used to communicate to analysts, decision makers and policy makers.



The transition to hydrogen requires an understanding of the spatial relationships and interdependencies of a wide range of changing datasets.

Relevance: The History of HyDRA

HyDRA has evolved from a basic display of spatial data to a repository of over 100 datasets with dynamic data, querying, and interoperability with other models and spatial data repositories and over 350 registered users.



Relevance: Impact on Barriers

| Barrier | Impact |
|---|--|
| <p>Stovepiped/siloed analytical capability [4.5.B]</p> | <ul style="list-style-type: none"> • The OpenCarto framework supports applications across multiple funding sources at DOE. This promotes sharing of resources and data, which results in a significantly higher value for DOE. • HyDRA's Web Feature Service (WFS) and Web Map Service (WMS) standards lead to easy integration with other GIS models. (FY11) • HyDRA provides advanced querying capabilities. (FY11) |
| <p>Inconsistent data, assumptions, and guidelines [4.5.C]</p> | <ul style="list-style-type: none"> • HyDRA provides a common repository for spatial data inputs and results related to hydrogen. • HyDRA is being enhanced in FY11 to automatically update datasets from existing data sources. |
| <p>Suite of models and tools [4.5.D]</p> | <ul style="list-style-type: none"> • HyDRA is interoperable with SERA and MSM and provides spatial data to both models for analyses. (FY10) • Through MSM integration, spatial data can be used to make GREET and H2A results regionally accurate. (FY10) • HyDRA is interoperable with any standards-based GIS, including the BioenergyKDF. (FY11) |

Approach: Milestones

| <i>FY</i> | <i>Milestone</i> | <i>Description</i> | <i>Date</i> | <i>Status</i> |
|------------------|-------------------------|---|--------------------|----------------------|
| 2010 | 2.4.1 | Releases of new HyDRA functionality | Apr-10 | Complete |
| | 2.4.2 | New layers and metadata to support layers | Aug-10 | Complete |
| | 2.4.3 | Complete beta version of enhanced analytic capabilities | Sep-10 | Complete |
| 2011 | 2.4.1 | New layers available as data services from HyDRA | Jun-11 | In Process |
| | 2.4.2 | Release and demonstration of new HyDRA functionality | Sep-11 | In Process |

Approach: Capabilities and Development Goals

In FY 11, HyDRA has been focused on allowing users to answer questions with data and providing visualizations of the results.

The HyDRA team communicated with users, sponsors, and other OpenCarto projects to determine what capabilities would receive focus in FY 11. These focus areas included Visualizing Data, Querying Data, and Data Interoperability.

- Data Interoperability

- HyDRA is actively sharing data with multiple DOE-funded projects
 - This work is now complete and in production

- Querying Data

- Data in HyDRA can now be queried by their attributes and through spatial queries
 - Will be deployed in Q3 FY11

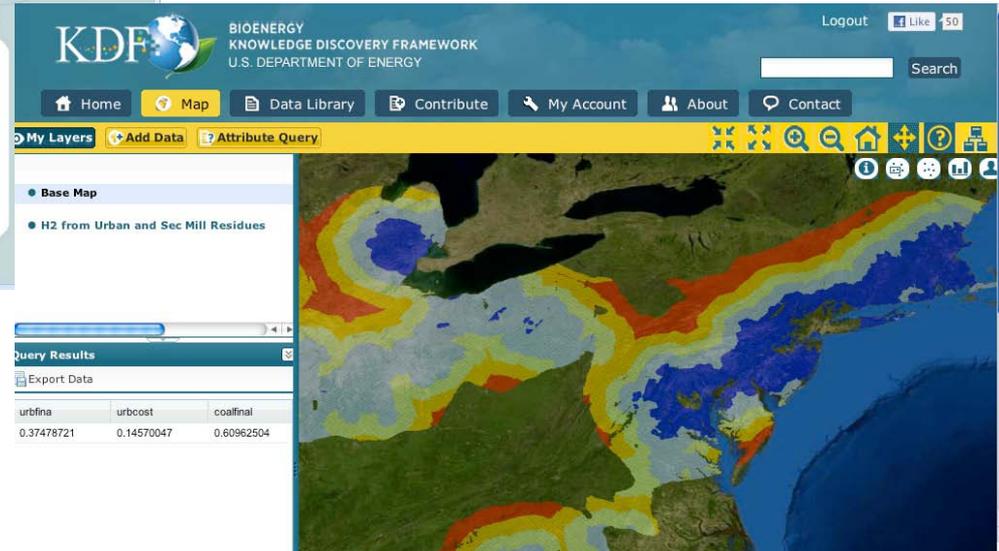
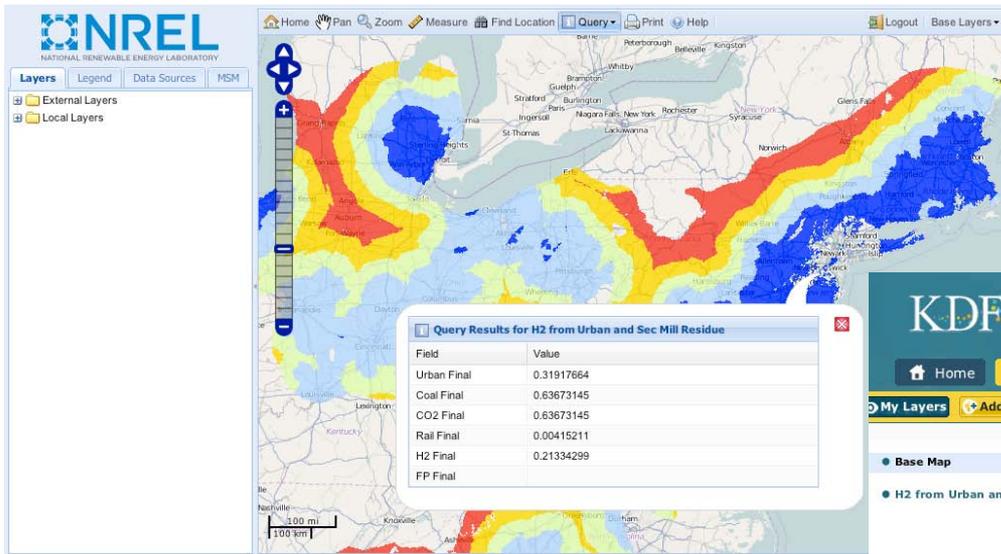
- Visualizing Data

- Data in HyDRA that can be viewed as maps can also be shown as graphs
 - Will be deployed in Q3 FY11
- Complex datasets that would require hundreds of maps can be loaded into a new visualization tool where users can explore, chart, and query those data as well
 - Will be demonstrated in Q4 FY11

Accomplishment: Data Interoperability

Data can be exchanged easily between HyDRA and other data repositories.

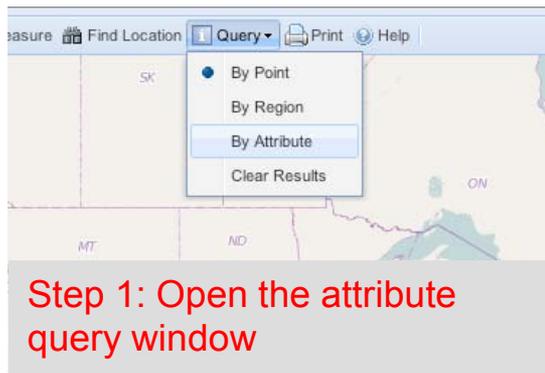
These data are sourced from HyDRA and viewed in both HyDRA and the Bioenergy Knowledge Discovery Framework (KDF).



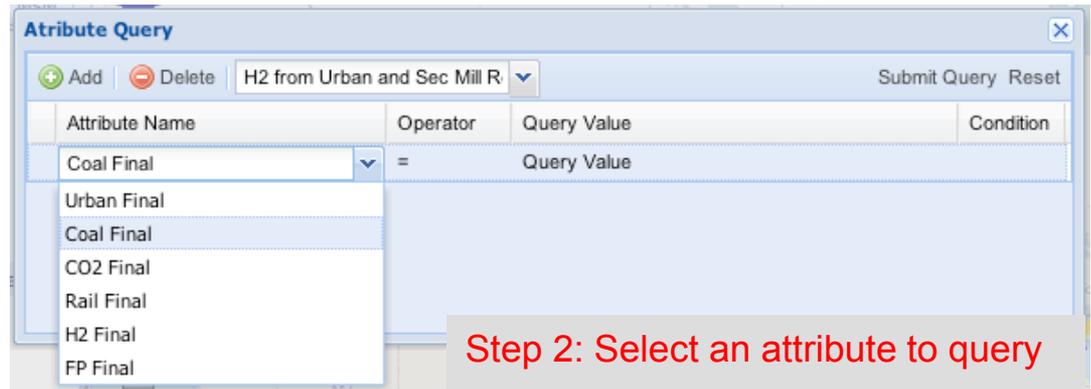
Accomplishment: Attribute Querying for Data Layers

Attribute querying allows users to ask very specific questions and explore spatial relationships between attributes.

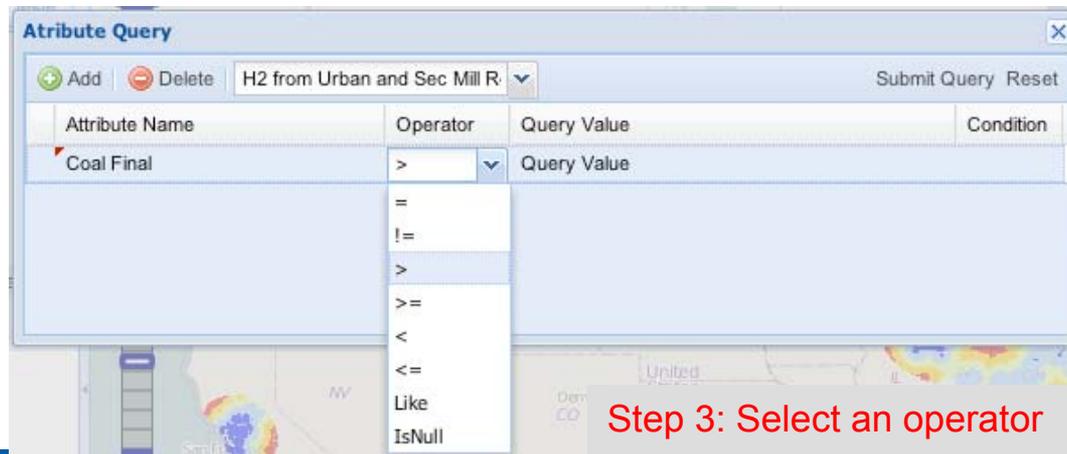
Question: Where can I find areas that have a low cost of producing H₂ from urban biomass and a high cost of producing H₂ from coal?



Step 1: Open the attribute query window



Step 2: Select an attribute to query

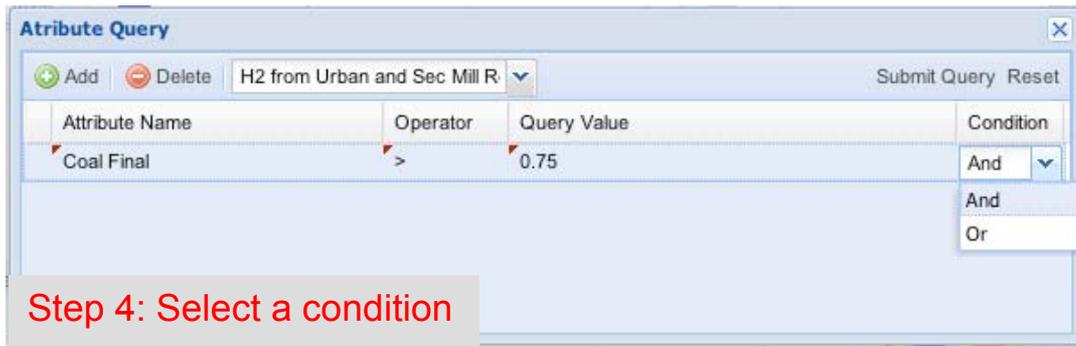


Step 3: Select an operator

Accomplishment: Attribute Querying for Data Layers

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Question: Where can I find areas that have a low cost of producing H₂ from urban biomass and a high cost of producing H₂ from coal?



Attribute Query

Submit Query Reset

| Attribute Name | Operator | Query Value | Condition |
|----------------|----------|-------------|-----------|
| Coal Final | > | 0.75 | And |

Step 4: Select a condition



Attribute Query

Submit Query Reset

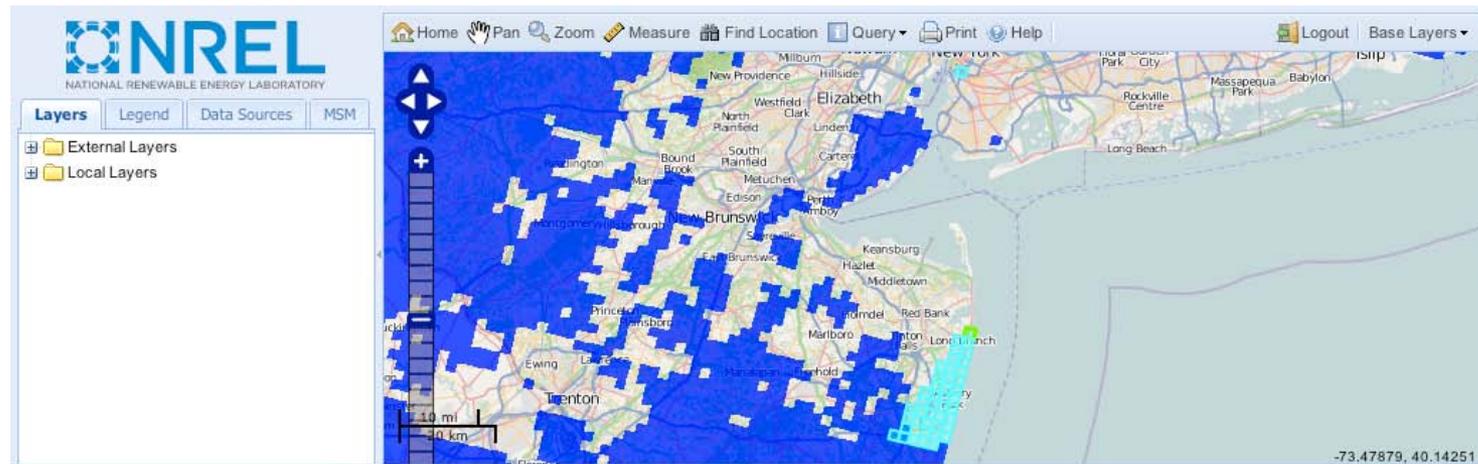
| Attribute Name | Operator | Query Value | Condition |
|----------------|----------|-------------|-----------|
| Coal Final | > | 0.75 | And |
| Urban Final | < | 0.334 | |

Steps 5 and 6: Repeat for multiple variables and submit the query

Accomplishment: Attribute Querying for Data Layers

Attribute querying allows users to ask very specific questions and explore spatial relationships between attributes.

Question: Where can I find areas that have a low cost of producing H₂ from urban biomass and a high cost of producing H₂ from coal?



H2 from Urban and Sec Mill Residue

Download Results Close All Results

| Urban Final | Coal Final | CO2 Final | Rail Final | H2 Final | FP Final |
|-------------|------------|------------|------------|------------|----------|
| 0.31583363 | 0.75133991 | 0.75133991 | 0 | 0.20999999 | |
| 0.31583363 | 0.7562812 | 0.7562812 | 0.00415211 | 0.20999999 | |
| 0.31583363 | 0.75057626 | 0.75057626 | 0 | 0.20999999 | |
| 0.31583363 | 0.75461024 | 0.75461024 | 0 | 0.20999999 | |
| 0.31583363 | 0.75089425 | 0.75089425 | 0.00415211 | 0.20999999 | |
| 0.31583363 | 0.75496227 | 0.75496227 | 0 | 0.20999999 | |
| 0.31583363 | 0.75256526 | 0.75256526 | 0.00415211 | 0.20999999 | |
| 0.31583363 | 0.75659925 | 0.75659925 | 0 | 0.20999999 | |

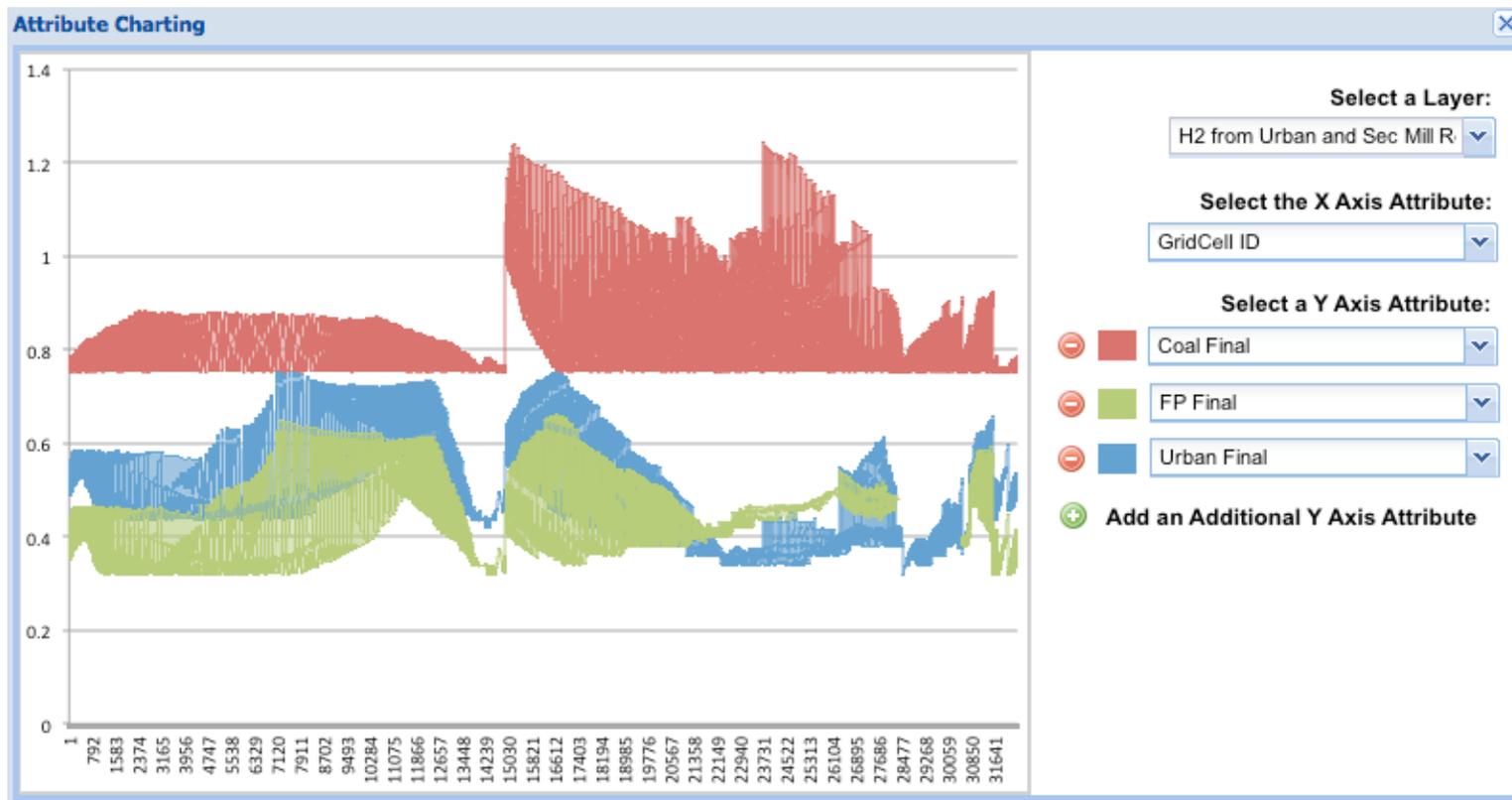
Results: Data that meet the criteria are

- Selected on the map
- Displayed in a table
- Available for download

Accomplishment: Attribute Charting for Data Layers

The ability to chart or graph data is an additional end user capability being developed in FY11.

Chart: Display a chart depicting the cost at the same geographic point of producing H₂ via forest and primary mill biomass residues, urban and secondary mill biomass residues, and coal where H₂ from coal is > 0.75 \$/kg to produce.



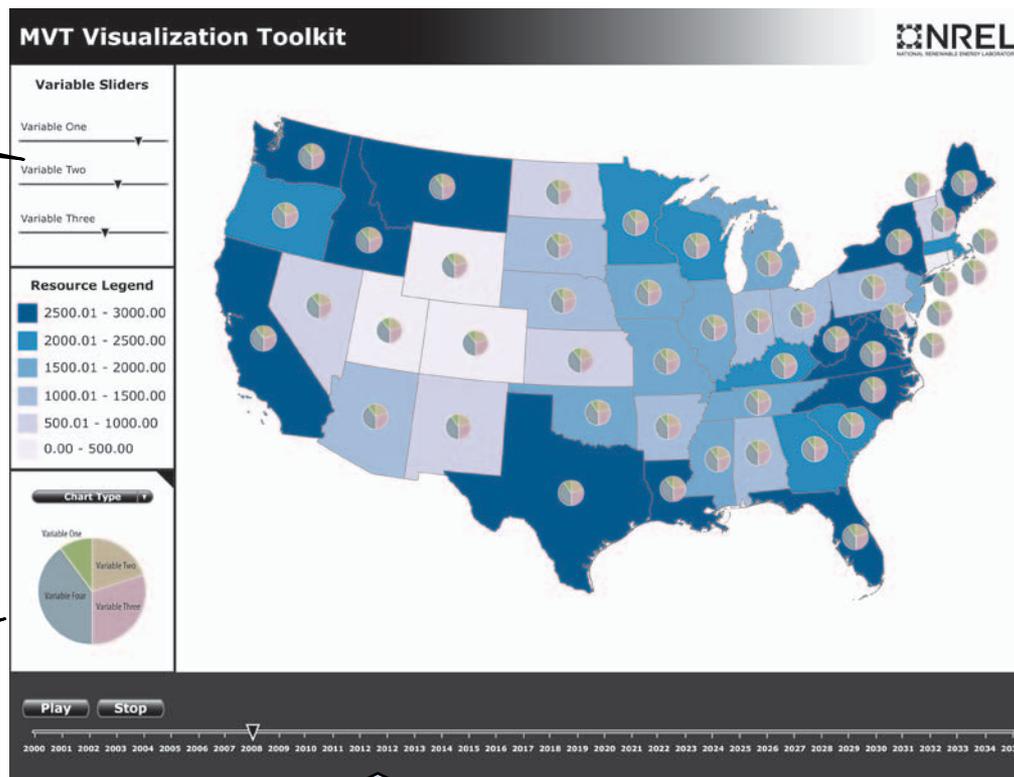
Accomplishment: Data Visualization

Interface example of the advanced scenario visualization tool that will be developed in summer 2011

Sliders to reclassify scenario results by changing a few key parameters.

The map has two classification schemes, one represented by coloring the states and the other by the pie charts over each state. Clicking on the state will display a larger chart in the lower left of the display.

The larger chart displays values based on user selections. Clicking the chart type will change between several charting options.

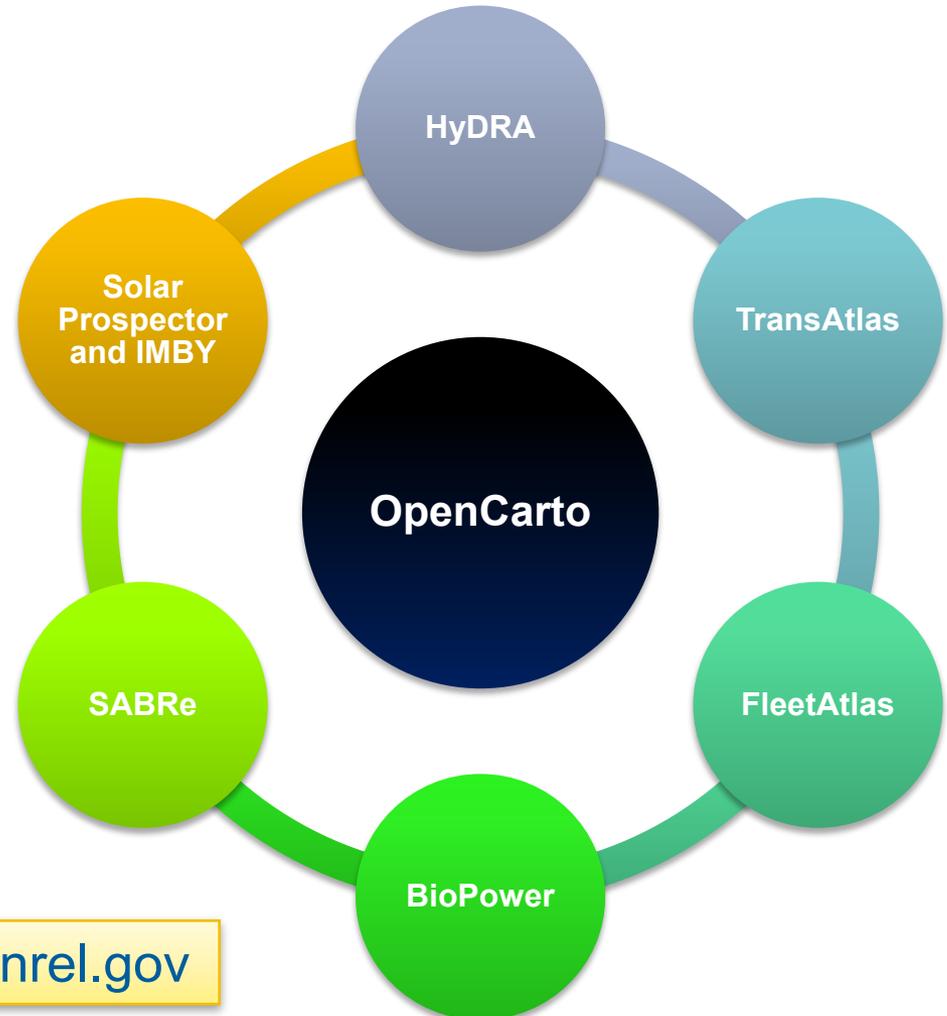


Temporal slider to allow users to visualize data changing over time.

Collaborations – OpenCarto Platform

HyDRA is built on OpenCarto, a web-based GIS platform that hosts six Web mapping tools funded by seven different clients.

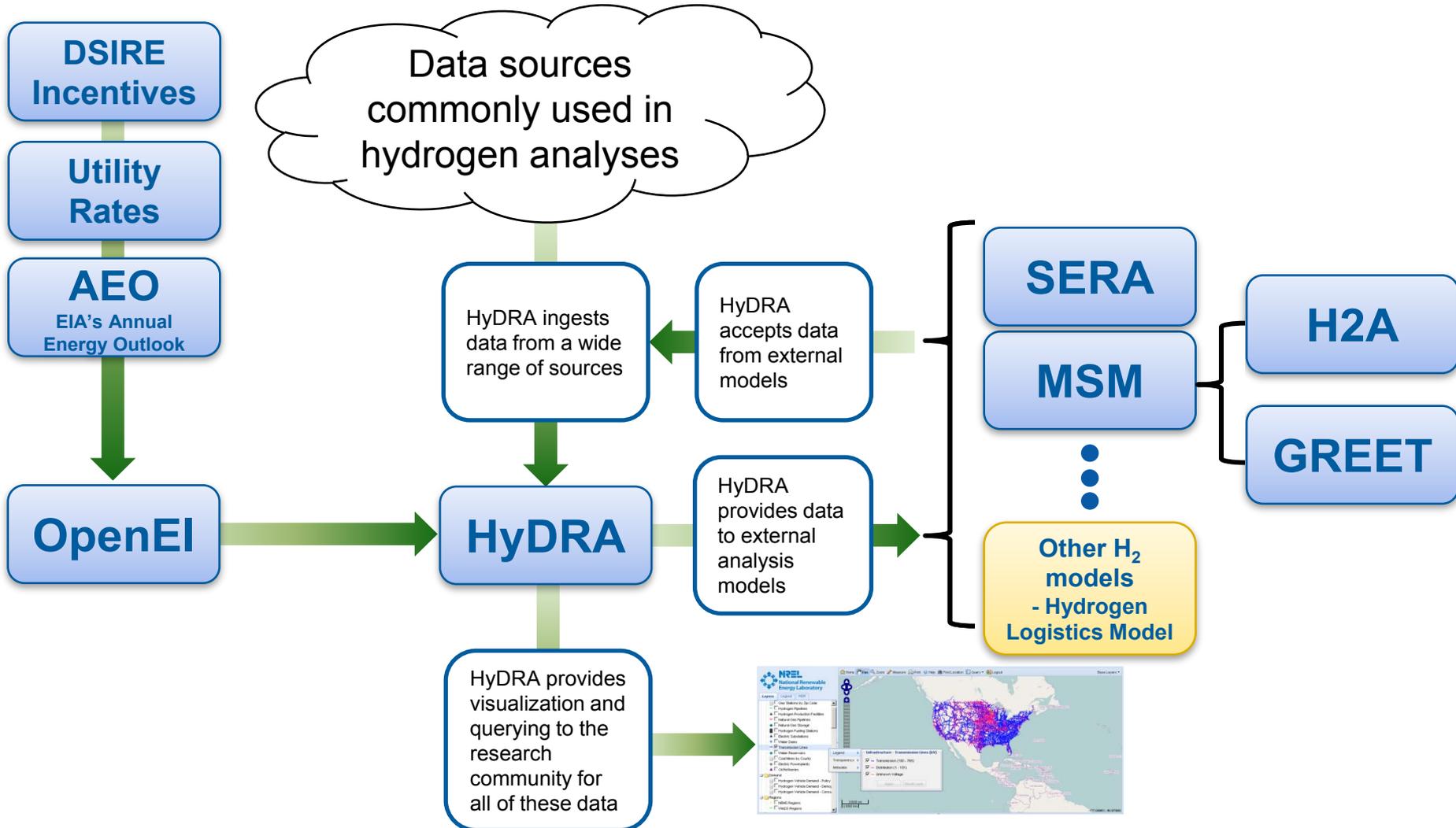
| Client | Tool |
|--------------------------|---------------------------------|
| DOE Hydrogen | HyDRA |
| DOE Biomass | BioPower and SABRe |
| DOE Clean Cities | TransAtlas |
| DOE FEMP | FleetAtlas |
| DOE Vehicle Technologies | FleetAtlas |
| DOE Solar | Solar Power Prospector and IMBY |
| EPA | Biopower |



Tools are available at <http://maps.nrel.gov>

Collaborations – Leveraging DOE funded projects

HyDRA integrates and collaborates with other DOE-funded programs to spread the benefit of investment in one project to many others.



Collaborations – HyDRA and External Data and Models

The development of the hydrogen infrastructure requires collaboration between researchers and analysts in various scientific domains. The interdependencies between domains results in a need for data sharing.

- Supporting interoperability between researchers and analysts focusing on the hydrogen infrastructure is a prominent goal of the work being done on the HyDRA project in FY10.
- System design changes have been implemented that allow HyDRA to accept data from and make data available to external models and applications. This development is focused on the SERA model and the Bioenergy KDF, but also includes collaboration with the OpenEI project, all of which are DOE-funded projects.

Proposed Future Work – FY11

Summary of functionality to be completed in FY11

- Data that are available in HyDRA are easily available in other data repositories
- Data that exist in other repositories are easily available in HyDRA
- Automatically update core datasets
- All datasets in HyDRA can now be queried based on both textual and spatial attributes
- All data in HyDRA are available to use in charting capability

Summary of Functionality that begins in FY11 and goes through FY12

- Development of the complex visualization prototype for exploring temporal and multivariate analysis results

FY 11 is focused on answering questions with data and providing visualizations of the results.

Proposed Future Work – FY12

- HyDRA as a collaboration tool
 - 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 market growth case studies, and nationwide hydrogen infrastructure rollout scenarios.
- Completion of the advanced visualization tool
 - The visualization tool that is being developed this FY will be focused mainly on exploring the results of NREL analysis. In its final version this tool will be available to open from within HyDRA and used to explore data from a wide range of sources.
- OpenCarto
 - Collaboration with multiple projects that support OpenCarto to improve support for office collaborate with a wide range of OpenCarto based projects to enhance the framework in FY12 to support
 - Easily integrating new geospatial technologies including advanced visualization and querying
 - More interaction through the user interface to support communication about data availability and quality
 - Long-term project support and data updates

Summary

Relevance

- Dynamic repository for spatial data inputs and spatial data results

Approach

- Web-based interactive GIS analysis reaching universities, government agencies, and industry
- Repository for 100+ datasets for analysis and integration

Accomplishments

- Finalized Interoperability
- Dataset querying and charting
- Groundwork for dataset updates
- Completion of complex data visualization prototype

Collaboration

- Six DOE programs and EPA collaborate to build the OpenCarto platform, on which HyDRA is built
- Integration with KDF and OpenEI

Future Work

- Complete temporal and multivariate dataset visualization
- Improvements to underlying OpenCarto framework
- Automate data acquisition, updating, and processing