HyDRA: Hydrogen Demand and Resource Analysis Tool

Johanna Levene
National Renewable Energy Laboratory
May 19, 2009
Project ID: AN_01_Levene

This presentation does not contain any proprietary, confidential, or otherwise restricted information
Overview

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

**Budget**
- Total project funding – 100% DOE share
  - Funding for FY 2008 – $249K
  - Funding for FY 2009 – $266K

**Barriers**
- Systems Analysis Barriers
  - Stove-piped/siloed analytical capability
  - Inconsistent data, assumptions, and guidelines
  - Suite of models and tools

**Partners**
- NREL project with support from A Mountain Top, LLC, for programming expertise
Relevance – What is GIS analysis?

- GIS = Geographic Information System
- GIS is fundamentally used to answer questions and make decisions. To use GIS properly, it is important to know what you want to ask and follow a disciplined process for getting the answer. (Source: ESRI)
- The power of a GIS comes from the ability to relate different information in a spatial context and to reach a conclusion about this relationship. (Source: USGS)
- The result is not an answer, but a map.
Relevance – Objective

Develop a web-based GIS tool to allow analysts, decision makers, and general users to view, download, and analyze hydrogen demand, resource, and infrastructure data spatially and dynamically.

- HyDRA is designed to display and aggregate the results of spatial analyses.
- It is a repository for spatial data inputs and spatial data results.

To access HyDRA, go to http://rpm.nrel.gov and request a login.
Approach – Comparing GIS analyses

Static maps provide great analyses, good information, but…

Wouldn’t it be nice to be able to compare the data interactively?
Where do hydrogen demand and resource overlap?
Can I use the underlying data?
Approach – Interactive GIS analyses

Hydrogen demand and methane wastewater resource overlap in large metropolitan regions across the country.
Approach – Basic analysis: Natural gas cost

Analysis: Natural gas cost data ($/MCF) is aggregated by county.

HyDRA provides interactive capabilities
- Can view maps for industrial, commercial, residential
- Data can be downloaded for use in other analyses
Analysis: Hydrogen via commercial forecourt SMR ($/kg) is calculated using county-by-county natural gas rates in H2A

- Combines county natural gas cost with H2A standard assumptions
  - Varies only natural gas cost
  - Next step: vary other H2A parameters
Approach – Analysis of Hydrogen in Missouri

Hydrogen from Forecourt Industrial SMR
- $5.78 Industrial SMR
- $4.54 Commercial SMR
- $4.65 Industrial Electrolysis

Commercial SMR is cheapest

In Saline county, Missouri forecourt hydrogen cost ($/kg)
- $5.78 Industrial SMR
- $4.54 Commercial SMR
- $4.65 Industrial Electrolysis
## Approach – FY09 Milestones

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Application Milestones</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| Manual MSM integration | Restrict access to sensitive data in old architecture | Key capabilities in new architecture  
  - Thresholding  
  - Querying  
  - Print  
  - Restrict access to sensitive data | Graphing  
  - Buffering  
  - Plan for dynamic integration with other models |
| Initial release of new architecture | | | |

<table>
<thead>
<tr>
<th>Data Milestones</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• 45 datasets in old architecture</td>
<td>• 64 datasets in old architecture</td>
<td>• 31 datasets in new architecture</td>
<td>• 70+ datasets in new architecture</td>
</tr>
<tr>
<td>• 19 datasets in new architecture</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Accomplishments - WTW energy and GHG emissions

Goal: Determine regional well-to-wheel (WTW) energy inputs and greenhouse gas emissions

Plan: Integrate HyDRA with the Hydrogen Macro System Model (MSM).
   - Cost from H2A model
   - Energy and GHG from GREET

Step 1:
Manually integrate electrolysis costs
   - County by county analysis
   - Allows us to validate integration with known results
   - Input: county industrial electric rates from HyDRA
   - Output: county forecourt electrolysis cost from H2A via MSM
Accomplishments – WTW energy and GHG emissions

Step 2: Build new forecourt electrolysis WTW GHG emissions and total, fossil, and petroleum energy input layers for HyDRA
Accomplishments – Rearchitecture framework

Framework developed by Chris Helm (GIS) Witt Sparks (CTTS) Mike Hostetler (subcontract)

Goal: to be able to quickly develop and deploy web-based GIS applications
Accomplishments – Rearchitecture

Improved user experience
- Layers are cached
- Google maps layers provide familiar look and feel
- Interaction with checkboxes, buttons, and right click
- You can see Alaska and Hawaii!

More robust architecture
- Single data store for all layers
- Capable of dynamic layer creation
- Capable of dynamic integration with other models
Accomplishments – Interactive analysis

An example of using HyDRA to do an interactive analysis:

• Where are the cheapest places I can produce hydrogen via electrolysis today?
  – Inexpensive electricity
  – Inexpensive forecourt electrolysis

• Where is there also good demand for this hydrogen?

• Where are there low WTW greenhouse gas emissions, and energy inputs?
Accomplishments – Interactive analysis

- Electricity price less than $50/MWh
- High to very good demand
- Total GHG energy usage by state < 8,000 Btu/mile
Accomplishments – Interactive analysis

HyDRA allows you to view underlying county-level data.

- Industrial electric rates range from $70-$18/MWh
- Forecourt industrial electrolysis ranges from $3.65-$6.75/kg
Accomplishments – Interactive analysis

HyDRA allows you to download data for use in your own analyses.
Accomplishments – Interactive analysis

HyDRA allows you to view data for a specific county using the point query.

For Jefferson County:
- Electric rates range from $45.65-$69.86/MWh
- Forecourt electrolysis hydrogen production ranges from $5.29-$6.74/kg
Accomplishments – Interactive analysis

Point query can allow you to compare data for the same county.

For Jefferson County:
- Natural gas rates range from $10.21-$11.79/MCF
- Forecourt SMR hydrogen production ranges from $4.50-$4.21/kg
- Forecourt electrolysis hydrogen production ranges from $5.29-$6.74/kg
Accomplishments – What else?

**Now**

Where should I put hydrogen stations? Are there already stations there?
Is there a hydrogen production facility nearby?

**Coming Soon**

What kind of renewable energy sources could I use to produce my hydrogen?
Are there transmission lines near my new station?
  What voltage?
Are there natural gas pipelines near my new station?
  What diameter?

**Future**

What about central hydrogen production?
Are there laws and incentives that could help me?
Is this an alternative-fuel-friendly location?
Collaboration – What is HyDRA’s role?

- **Goal:** standard for the display of spatial hydrogen analyses
  - Repository for input data
  - Repository for results
- **Integrate with other hydrogen models for detailed analysis and data processing results**
  - MSM
  - TIAx Geo-Spatial Analysis of Hydrogen Production, Infrastructure and Feedstock Costs and Availability
  - HyDS ME (future)
  - Hydrogen delivery (future)
  - Feedstock delivery (future)
Collaboration – Moving past hydrogen

HyDRA architecture supports other renewable energy and alternative fuel applications.

Not funded by hydrogen, but hydrogen benefits from layers and functionality:

- Alternative Fuel Stations
- Solar photovoltaic (PV)
- Concentrated solar power (CSP)
- Biopower
- Diesel exhaust fluid (DEF)
- Ethanol plants
- Fleet analysis
- Wind
Future Work – Proposed

FY09
- Incorporate all datasets into new architecture
- Generate dynamic layers
- Complete basic analysis functions
  - Graphing
  - Changing underlying assumptions
  - Buffering

FY10
- Integrate with other hydrogen models and analyses
  - Build layers where appropriate
  - Display model results where appropriate
    - “Sneakernet”
    - Dynamic integration
- Create out-of-the-box case studies, similar to H2A
- Continue to build, enhance, and implement new data layers
Future Work – MSM integration

Programmatically integrate cost and emissions analysis
Analyze other spatially varying cost and emissions data
<table>
<thead>
<tr>
<th>Summary</th>
</tr>
</thead>
</table>
| **Relevance** | • Display and aggregate the results of spatial analyses  
• Repository for spatial data inputs and spatial data results |
| **Approach** | • Web-based interactive GIS analysis  
• 60+ spatial datasets related to hydrogen |
| **Accomplishments** | • Integration with Macro System Model  
• Rearchitecture  
• Interactive analysis capability |
| **Collaboration** | • Hydrogen repository for spatial input data and results  
• Architecture supports other renewable energy and alternative fuel applications |
| **Future Work** | • Dynamic integration with other hydrogen models  
• Out-of-the-box case studies  
• New data layers |