HyDRA: Hydrogen Demand and Resource Analysis Tool

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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

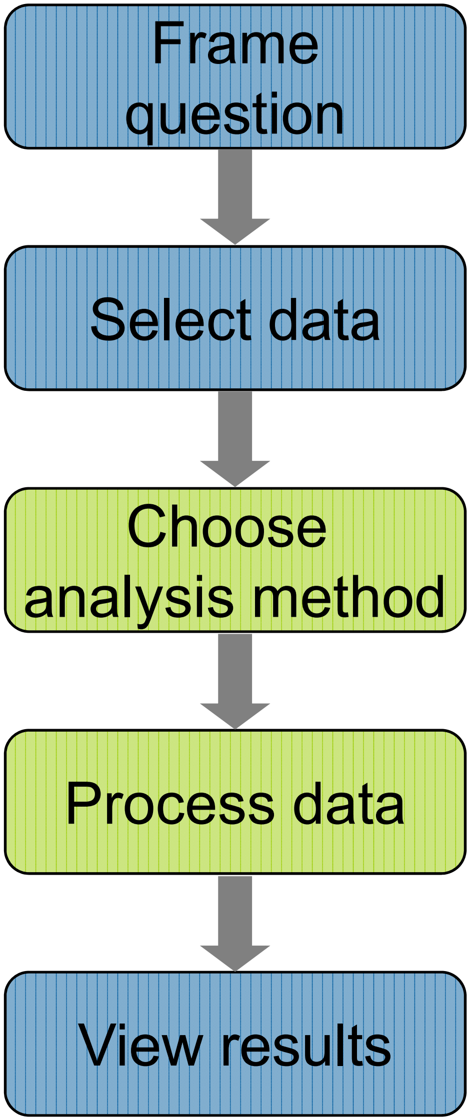
Suite of models and tools

Partners

NREL project with support from *A Mountain Top, LLC,* for programming expertise

Relevance – What is GIS analysis?

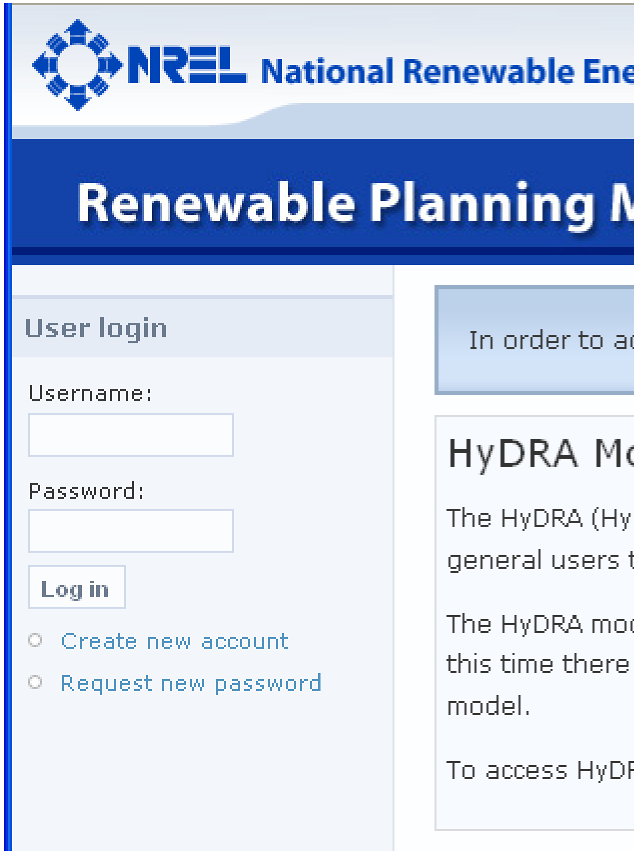
- GIS = Geographic Information System
- GIS is fundamentally used to answer questions and make decisions. To use GIS properly, it is important to know what you want to ask and follow a disciplined process for getting the answer. (Source: ESRI)
- The power of a GIS comes from the ability to relate different 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

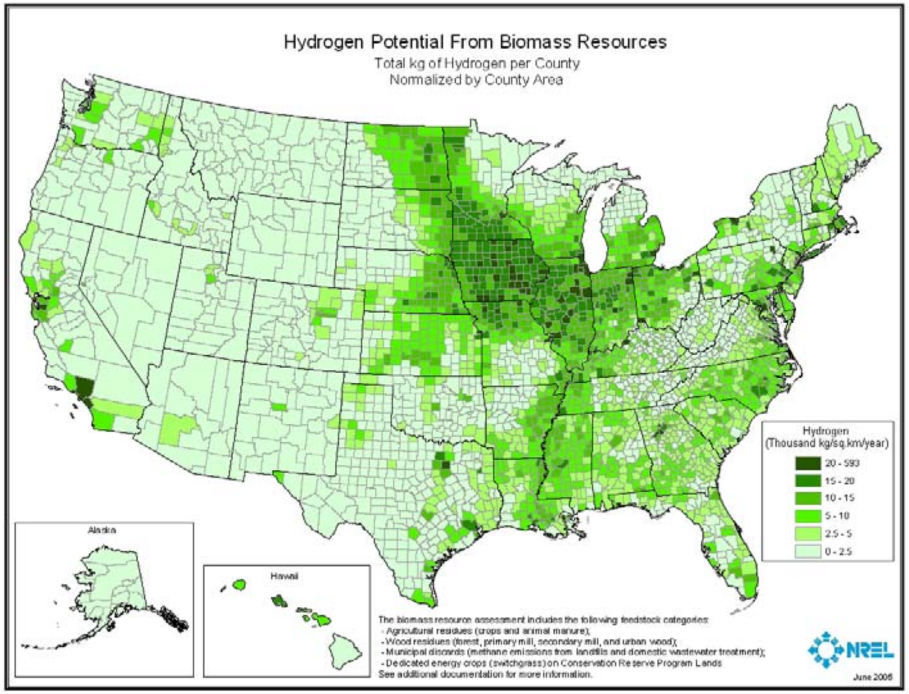
Develop a web-based GIS tool to allow analysts, decision makers, and general users to view, download, and analyze hydrogen demand, resource, and infrastructure data spatially and dynamically.

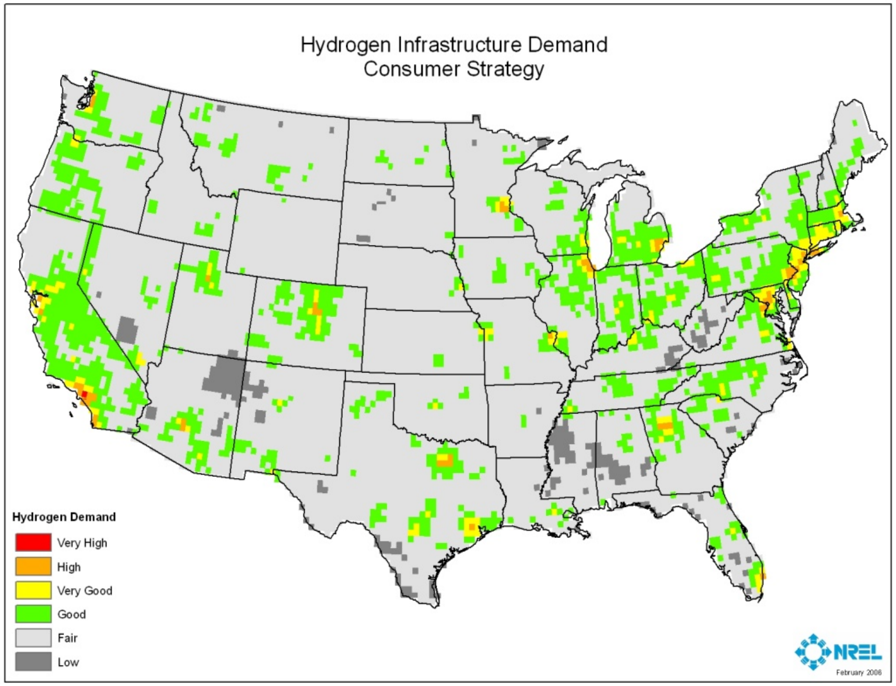
- HyDRA is designed to display and aggregate the results of spatial analyses.
- It is a repository for spatial data inputs and spatial data results.



To access HyDRA, go to http://rpm.nrel.gov and request a login.

Approach – Comparing GIS analyses

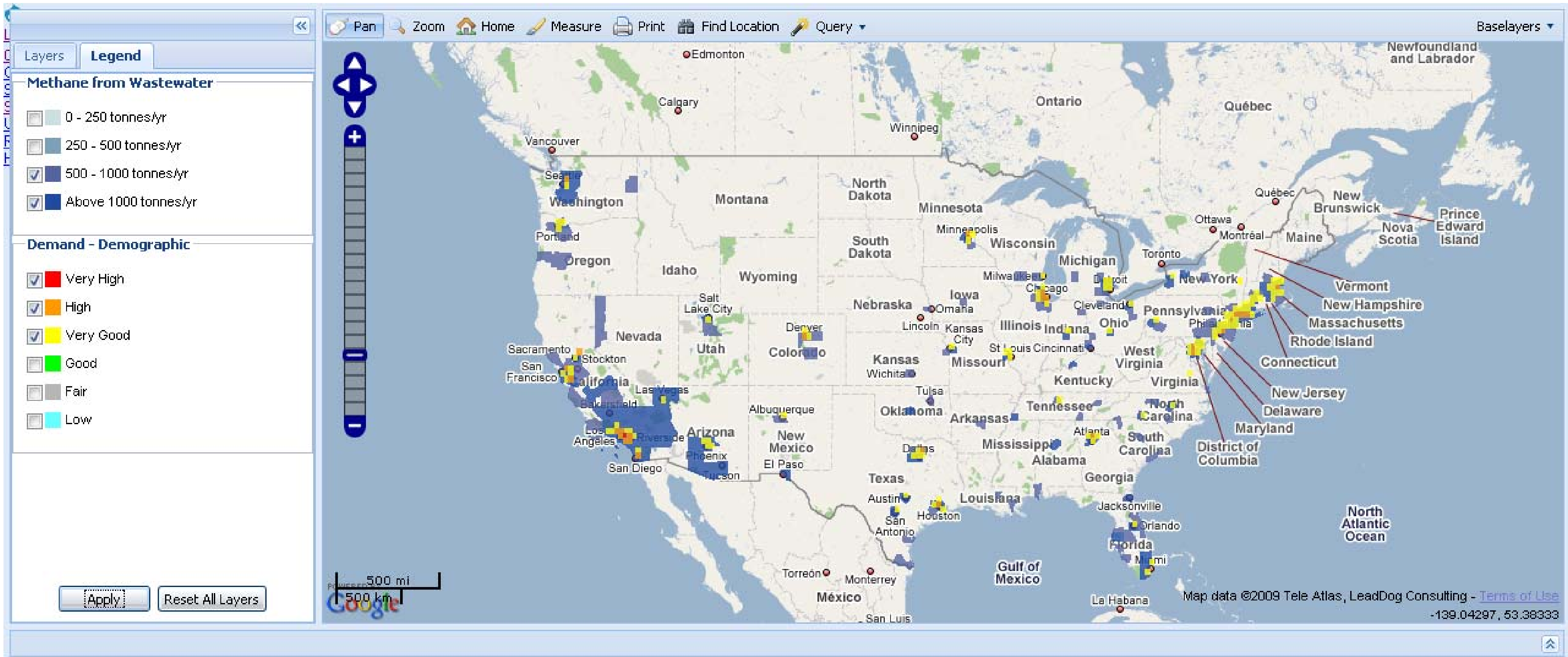




Static maps provide great analyses, good information, but…

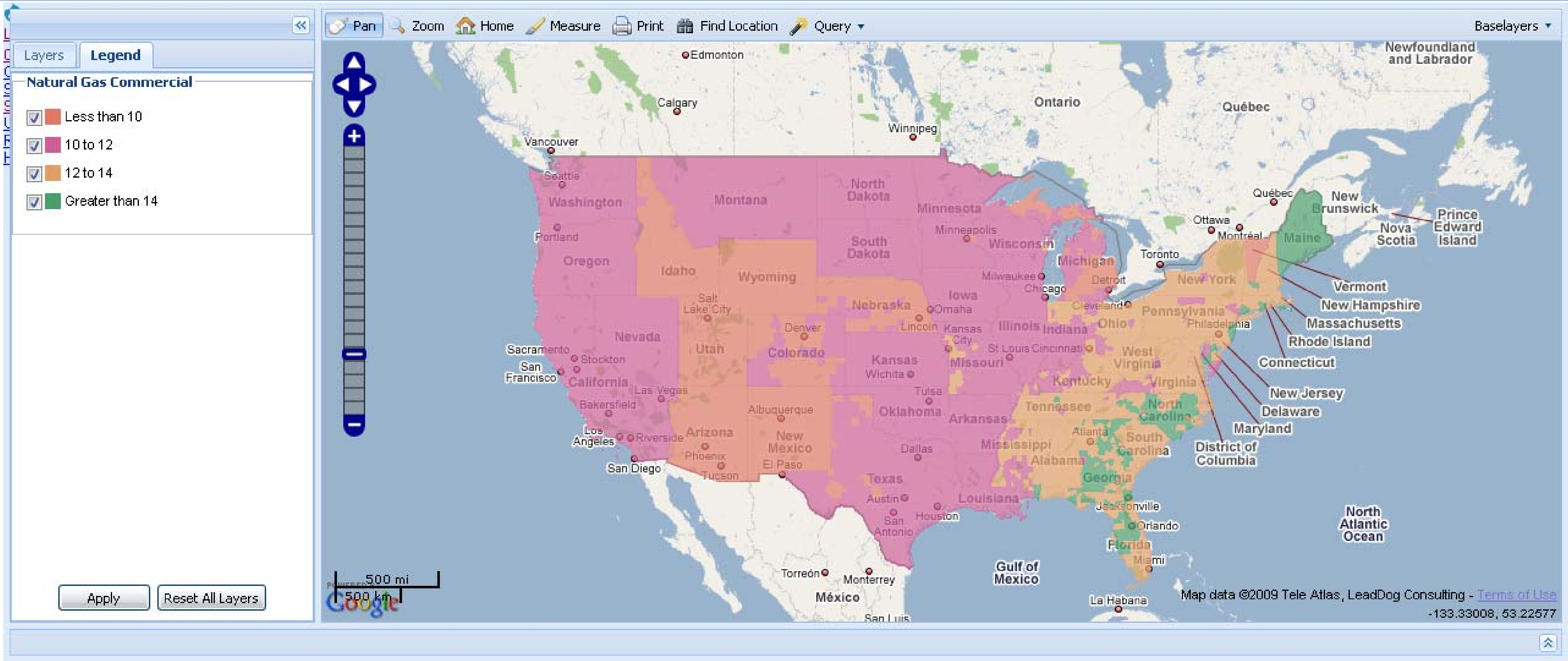
Wouldn't it be nice to be able to compare the data interactively?
Where do hydrogen demand and resource overlap?
Can I use the underlying data?

Approach – Interactive GIS analyses



Hydrogen demand and methane wastewater resource overlap in large metropolitan regions across the country.

Approach – Basic analysis: Natural gas cost

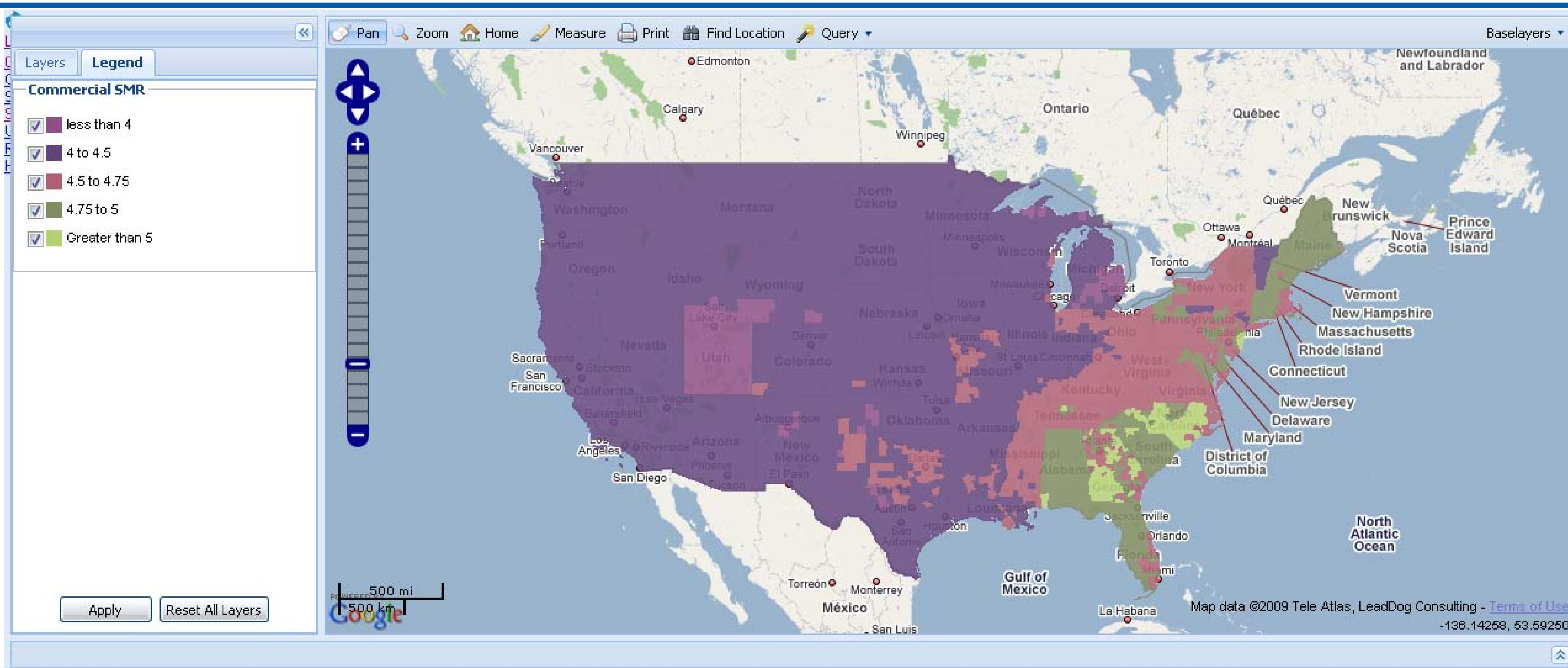


Analysis: Natural gas cost data ($/MCF) is aggregated by county.

HyDRA provides interactive capabilities

- Can view maps for industrial, commercial, residential
- Data can be downloaded for use in other analyses

Approach – Hydrogen cost via commercial forecourt SMR

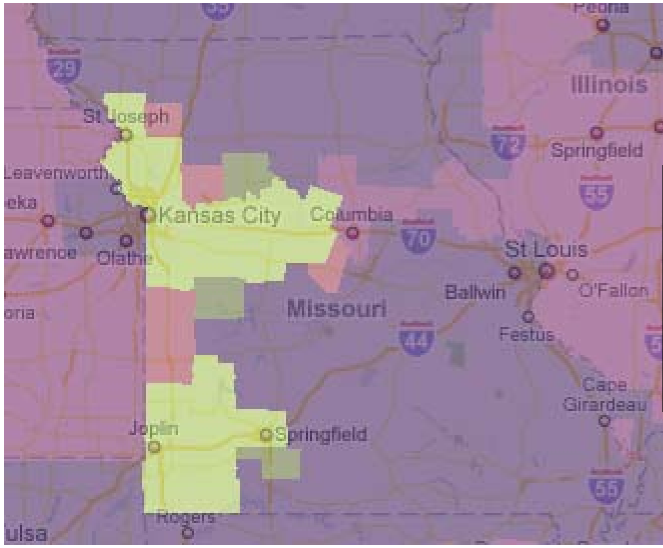


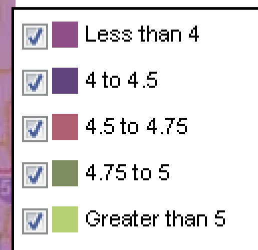
Analysis: Hydrogen via commercial forecourt SMR ($/kg) is calculated using county-by-county natural gas rates in H2A

- Combines county natural gas cost with H2A standard assumptions
  - Varies only natural gas cost
  - Next step: vary other H2A parameters

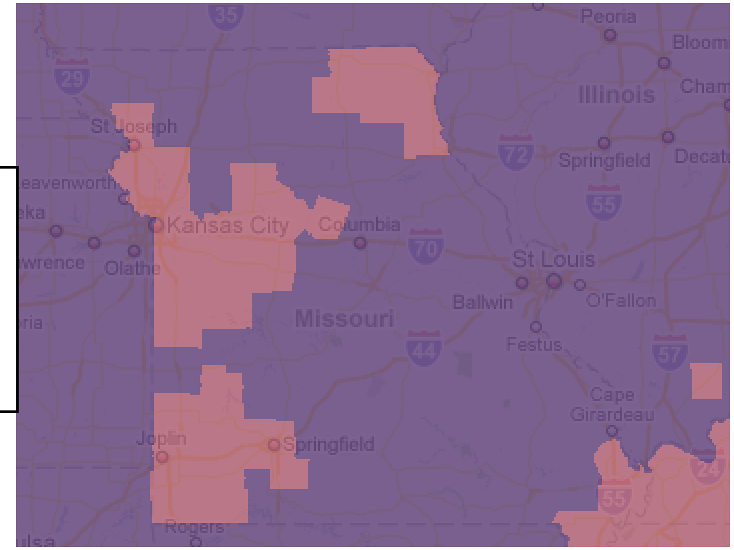
Approach – Analysis of Hydrogen in Missouri

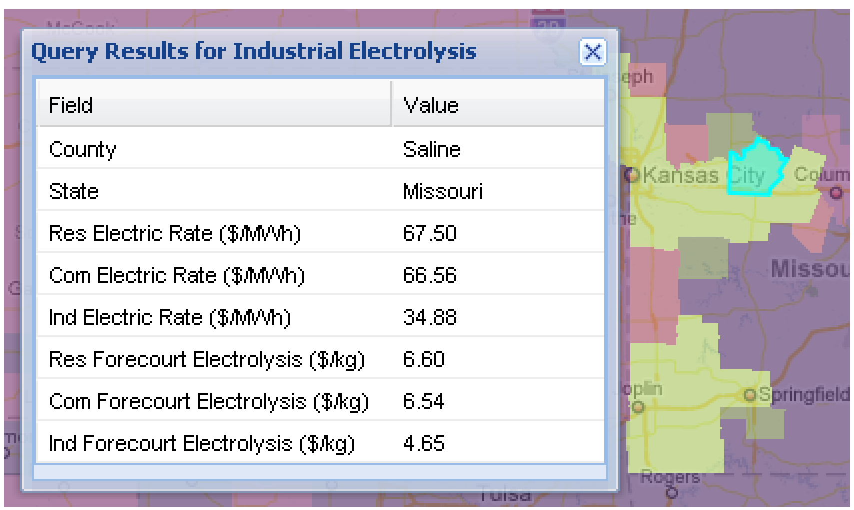
Hydrogen from Forecourt Industrial SMR





Hydrogen from Forecourt Commercial SMR





Query Results for Industrial Electrolysis

Field	Value
County	Saline
State	Missouri
Res Electric Rate ($/MWh)	67.50
Com Electric Rate ($/MWh)	66.56
Ind Electric Rate ($/MWh)	34.88
Res Forecourt Electrolysis ($/kg)	6.60
Com Forecourt Electrolysis ($/kg)	6.54
Ind Forecourt Electrolysis ($/kg)	4.65

In Saline county, Missouri forecourt hydrogen cost ($/kg)

- $5.78 Industrial SMR
- $4.54 Commercial SMR
- $4.65 Industrial Electrolysis

Commercial SMR is cheapest

Approach – FY09 Milestones

August 2008	September 2008	March 2009	September 2009
Application Milestones			
Manual MSM integration	Restrict access to sensitive data in old architecture Initial release of new architecture	Key capabilities in new architecture • Thresholding • Querying • Print • Restrict access to sensitive data	• Graphing • Buffering • Plan for dynamic integration with other models
Data Milestones			
• 45 datasets in old architecture	• 64 datasets in old architecture • 19 datasets in new architecture	• 31 datasets in new architecture	• 70+ datasets in new architecture

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

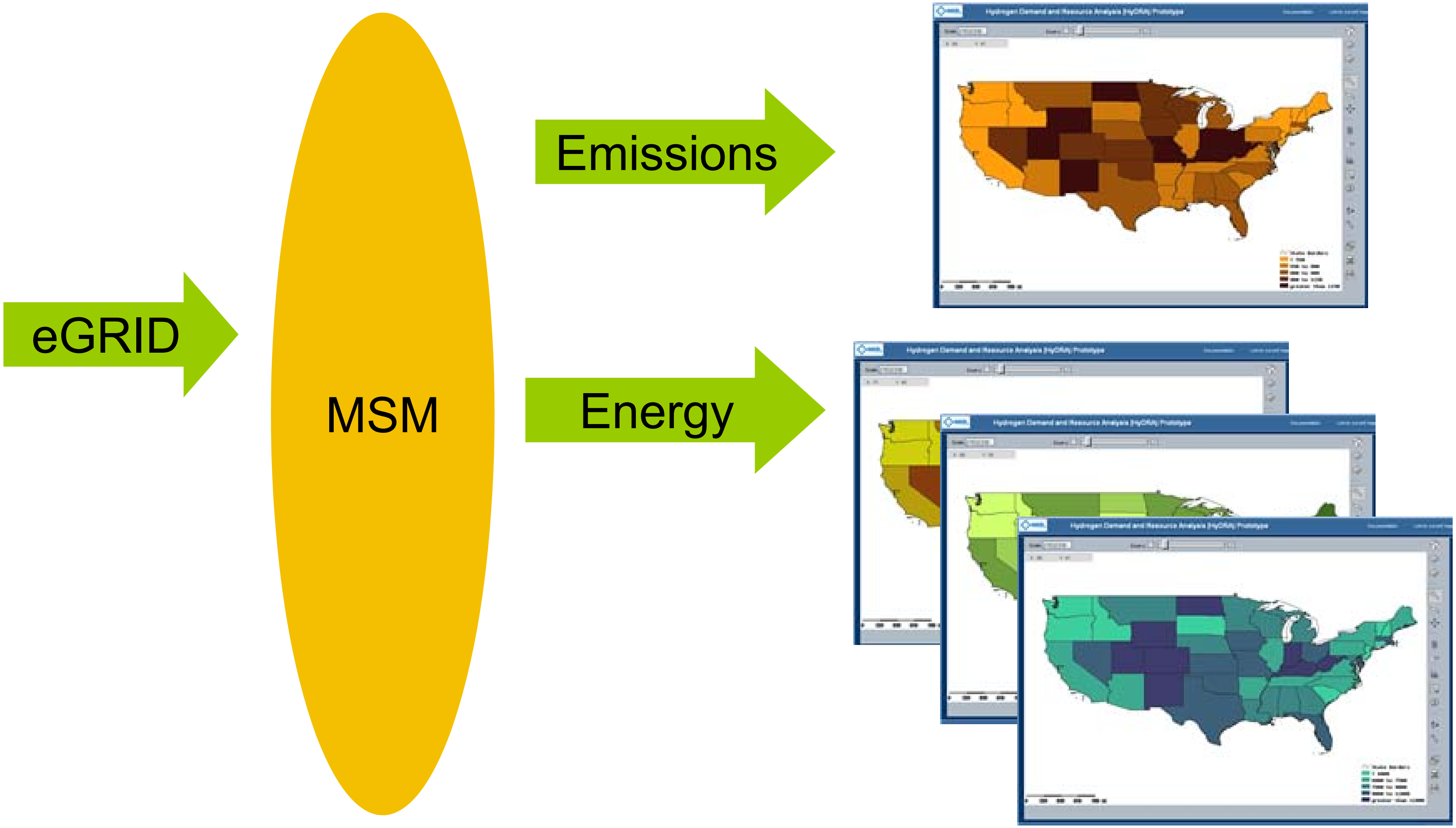
Step 1:

Manually integrate electrolysis costs

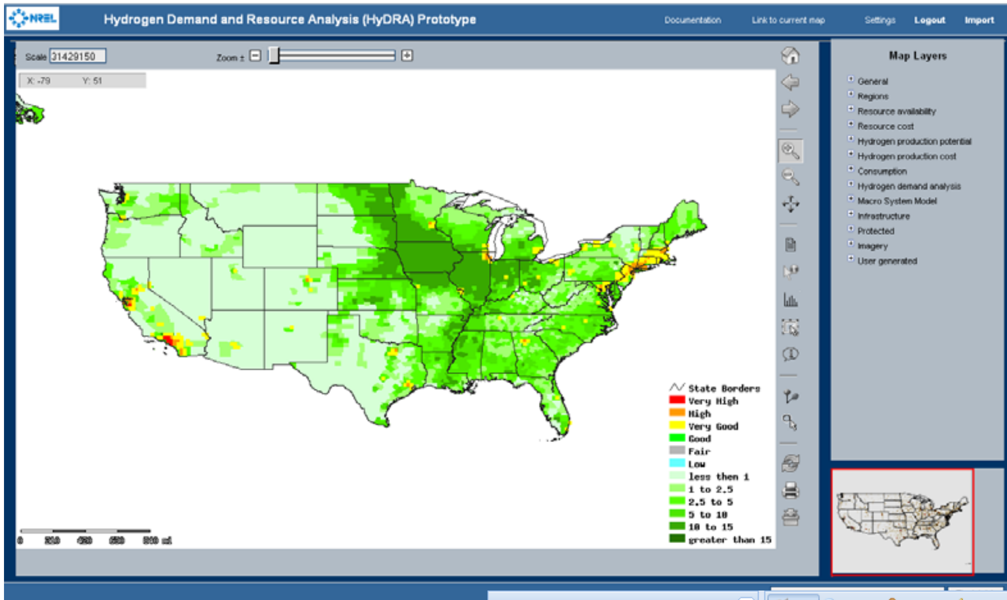
- County by county analysis
- Allows us to validate integration with known results
- Input: county industrial electric rates from HyDRA
- Output: county forecourt electrolysis cost from H2A via MSM

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



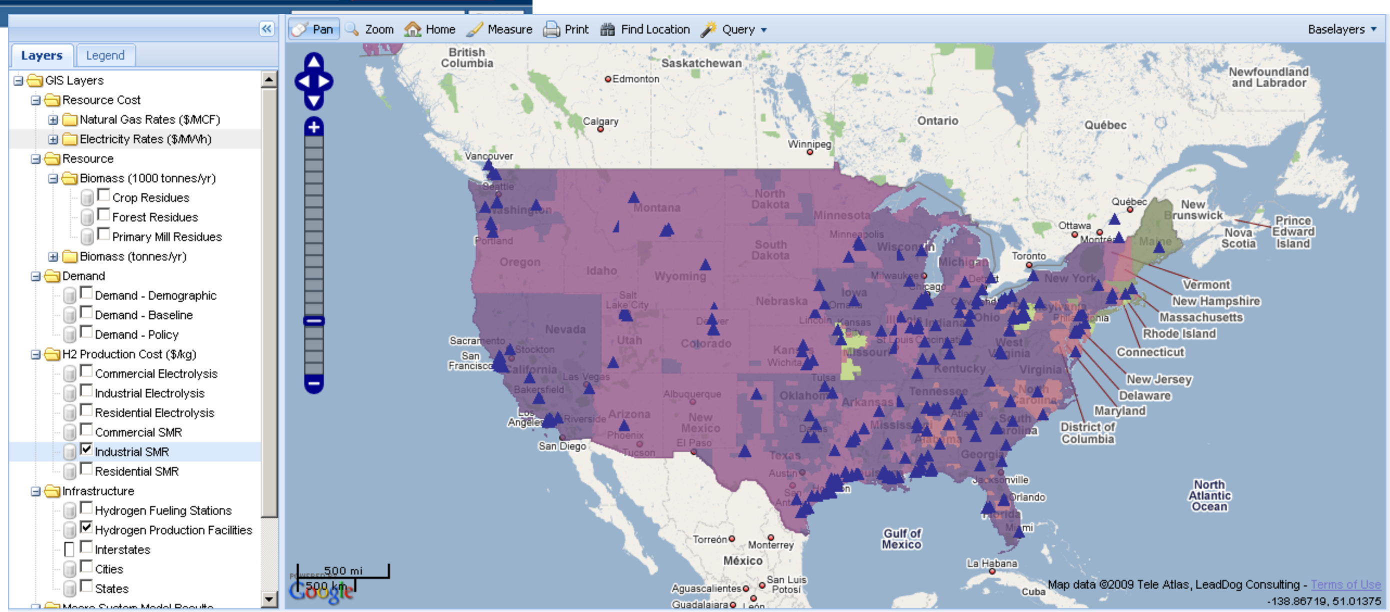
Framework developed by

Chris Helm (GIS)

Witt Sparks (CTTS)

Mike Hostetler (subcontract)

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



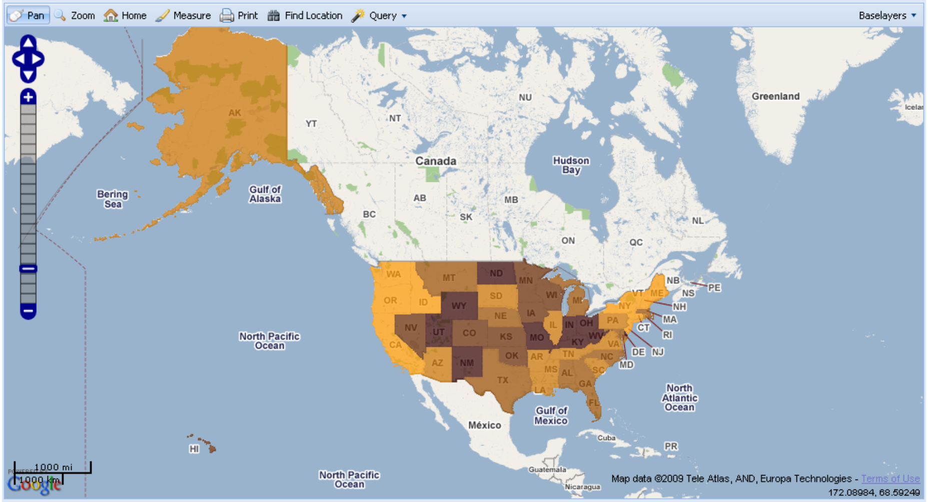
Accomplishments – Rearchitecture

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

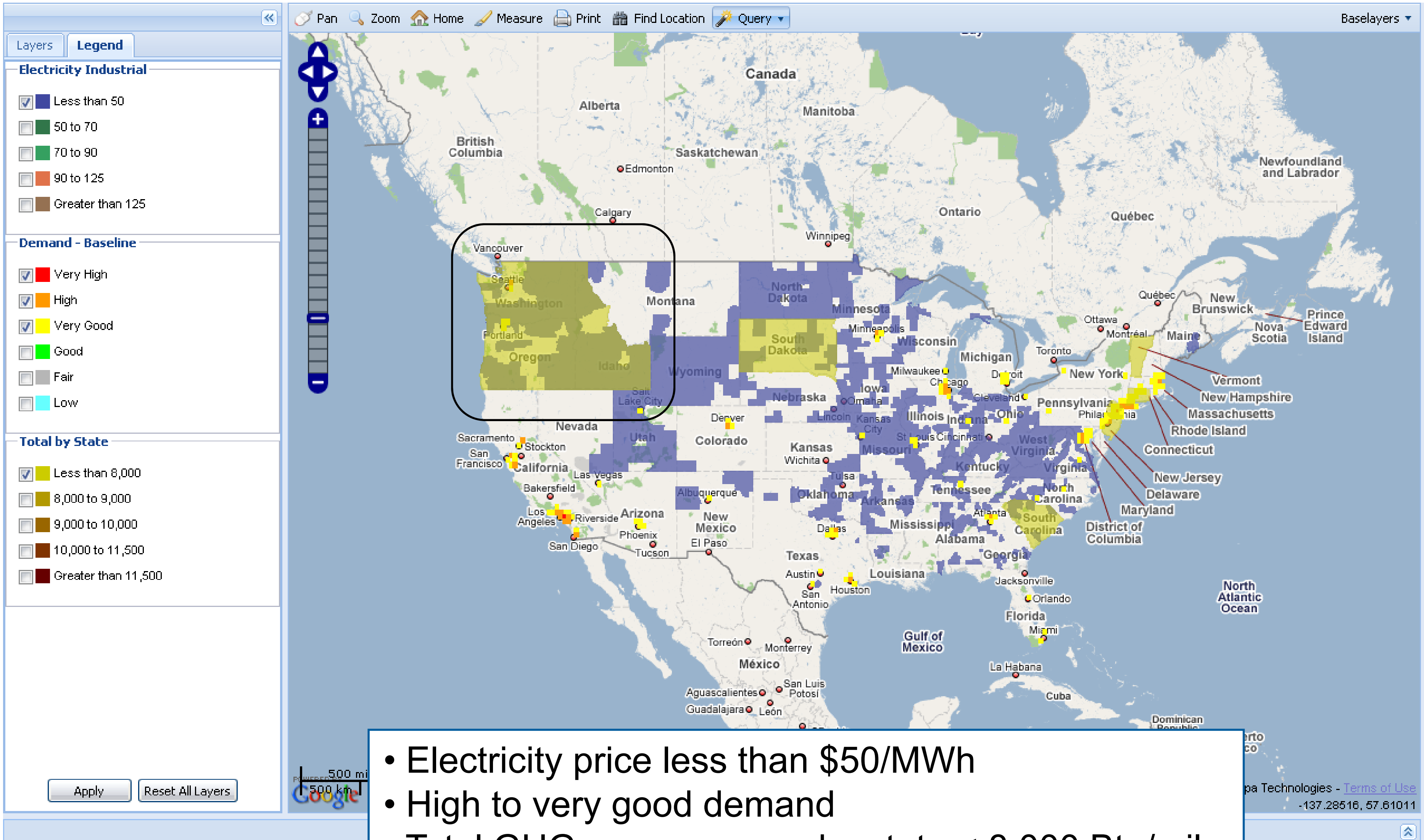


Accomplishments – Interactive analysis

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

Pan | Zoom | Home | Measure | Print | Find Location | Query | Baselayers

Layers | **Legend**

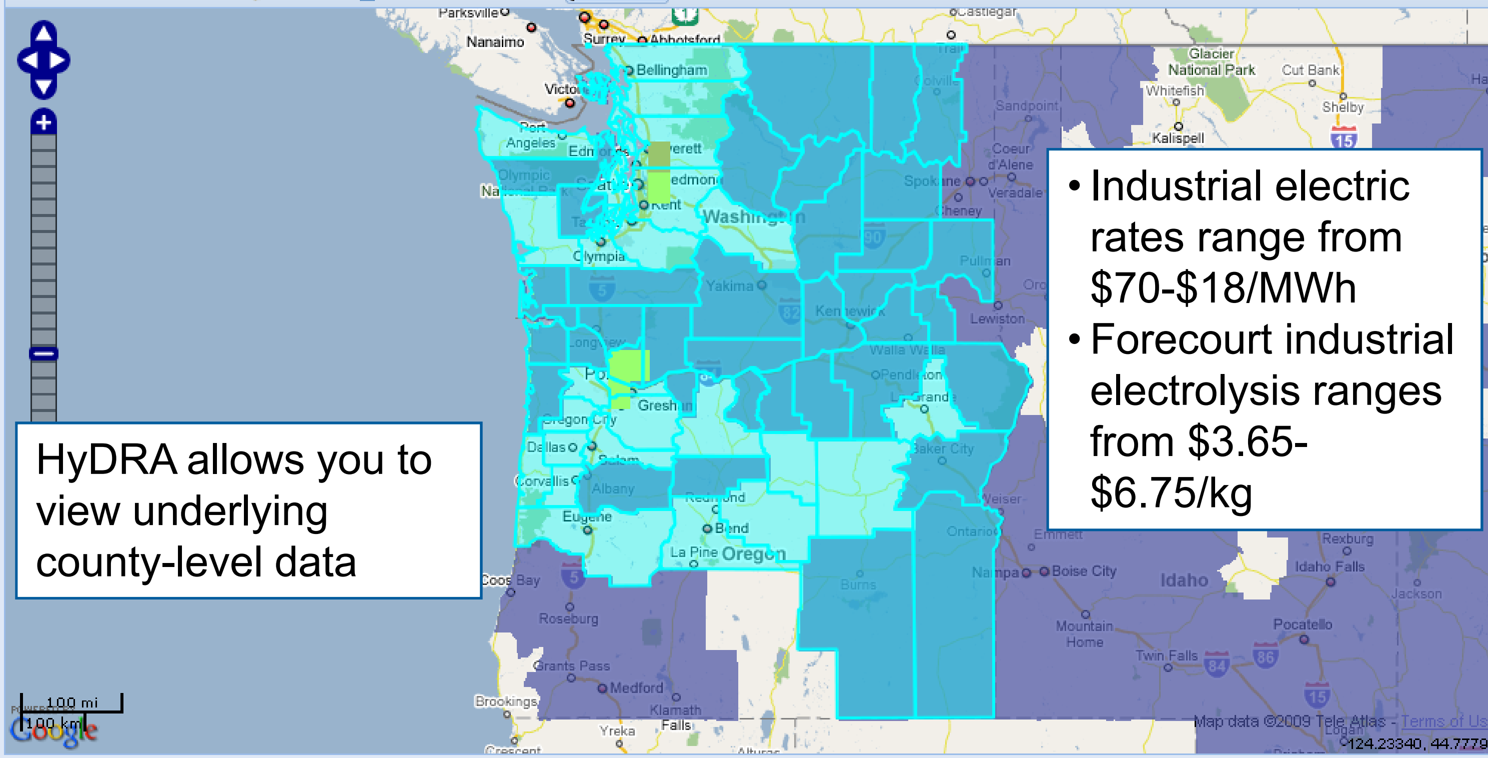
Electricity Industrial

- [x] Less than 50
- [ ] 50 to 70
- [ ] 70 to 90
- [ ] 90 to 125
- [ ] Greater than 125

Demand - Baseline

- [x] Very High
- [x] High
- [x] Very Good
- [ ] Good
- [ ] Fair
- [ ] Low

Apply | Reset All Layers



HyDRA allows you to view underlying county-level data

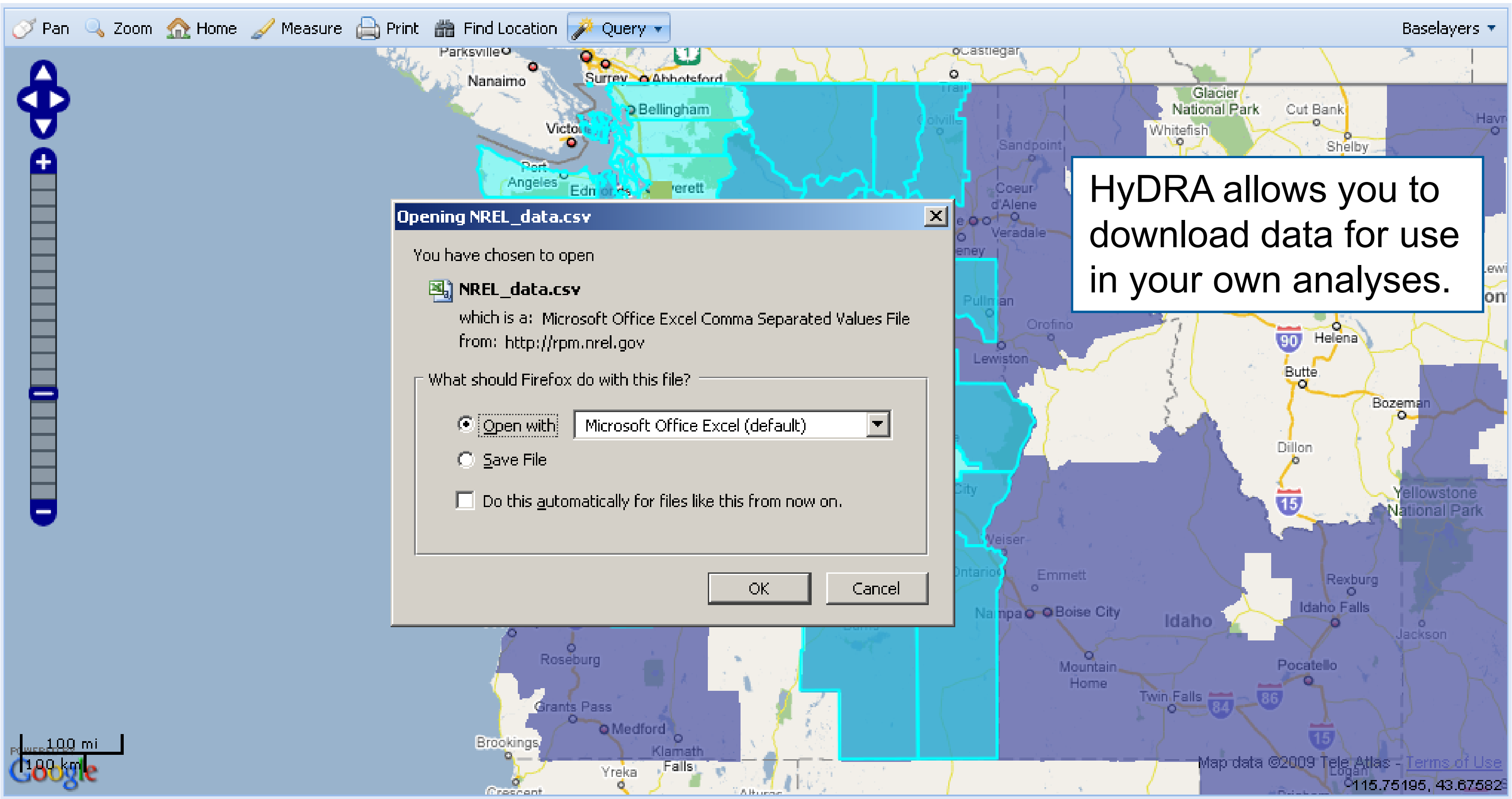
- Industrial electric rates range from $70-$18/MWh
- Forecourt industrial electrolysis ranges from $3.65-$6.75/kg

Electricity Industrial

Download

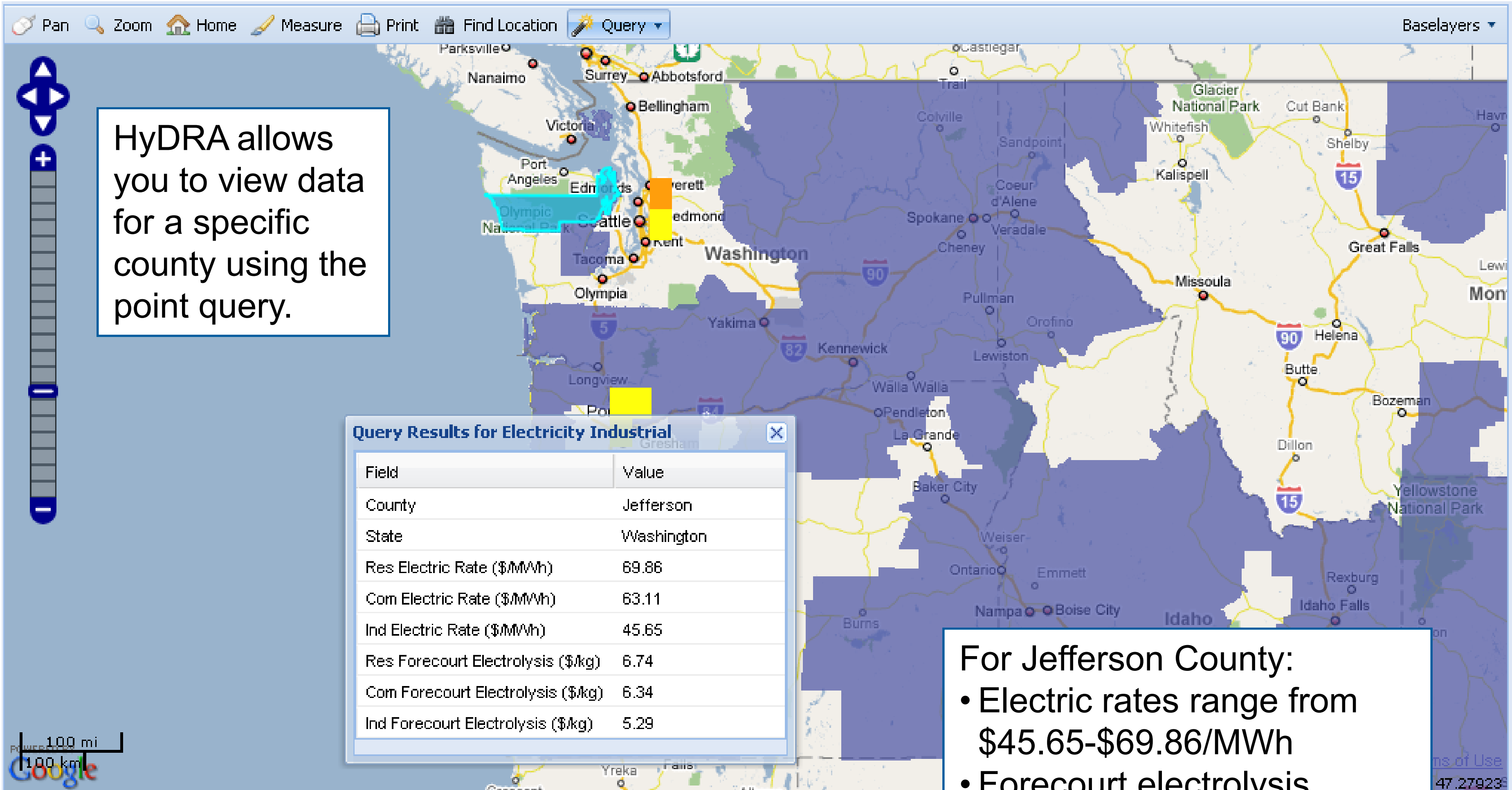
County	State	Res Electric Rate ($/MWh)	Com Electric Rate ($/MWh)	Ind Electric Rate ($/MWh)	Res Forecourt Electrolysis ($/kg)	Com Forecourt Electrolysis ($/kg)	Ind Forecourt Electrolysis ($/kg)
Stevens	Washington	57.37	58.68	41.27	5.99	6.07	5.03
Okanogan	Washington	56.94	52.58	44.50	5.97	5.71	5.23
Ferry	Washington	73.00	70.73	43.65	6.92	6.79	5.18
Whatcom	Washington	67.03	73.82	68.63	6.57	6.97	6.66
Chelan	Washington	30.09	32.08	20.09	4.37	4.49	3.77
San Juan	Washington	89.40	66.79	40.00	7.90	6.55	4.96

Accomplishments – Interactive analysis



HyDRA allows you to download data for use in your own analyses.

Accomplishments – Interactive analysis

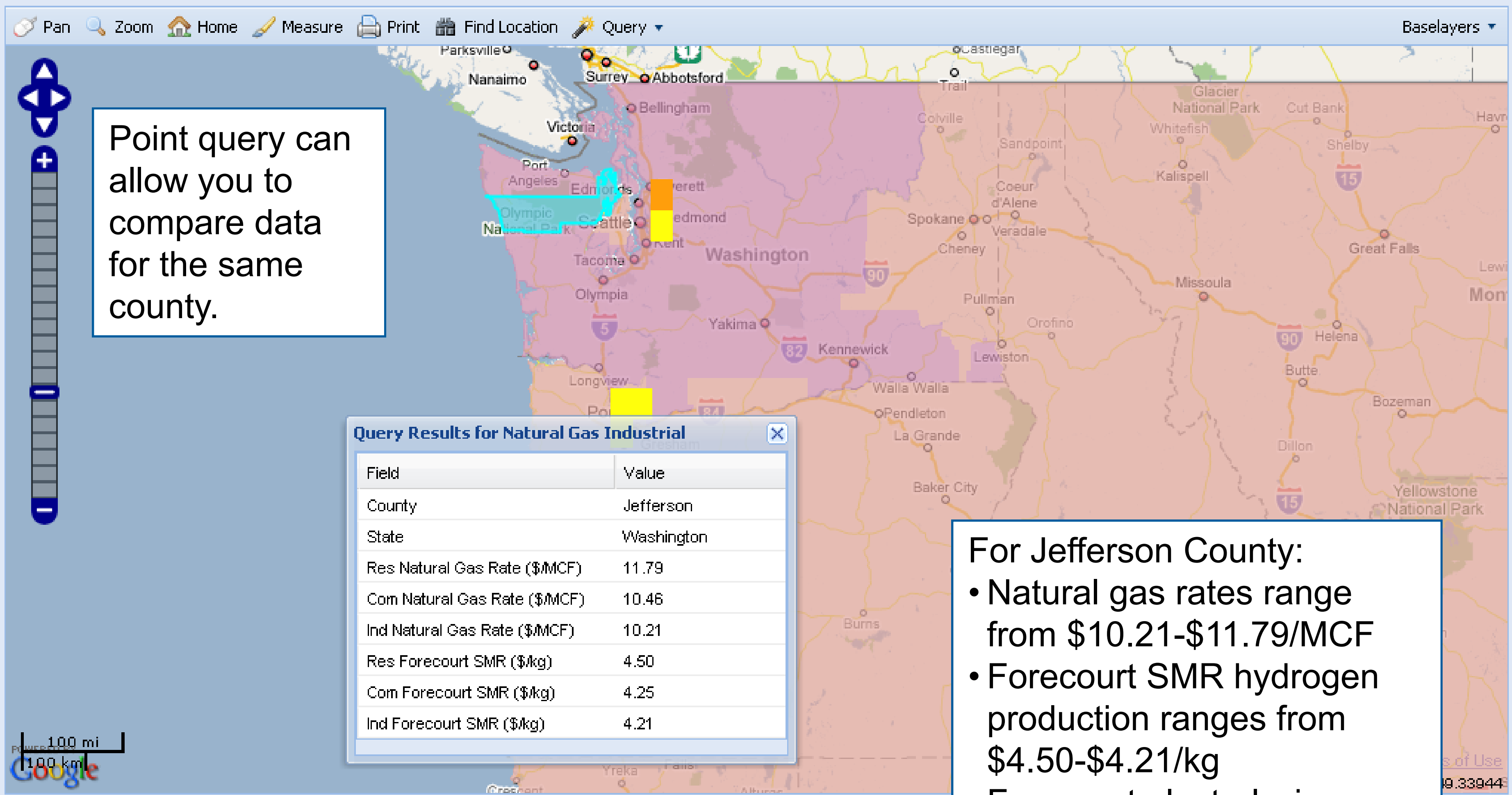


HyDRA allows you to view data for a specific county using the point query.

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



Field	Value
County	Jefferson
State	Washington
Res Natural Gas Rate ($/MCF)	11.79
Com Natural Gas Rate ($/MCF)	10.46
Ind Natural Gas Rate ($/MCF)	10.21
Res Forecourt SMR ($/kg)	4.50
Com Forecourt SMR ($/kg)	4.25
Ind Forecourt SMR ($/kg)	4.21

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

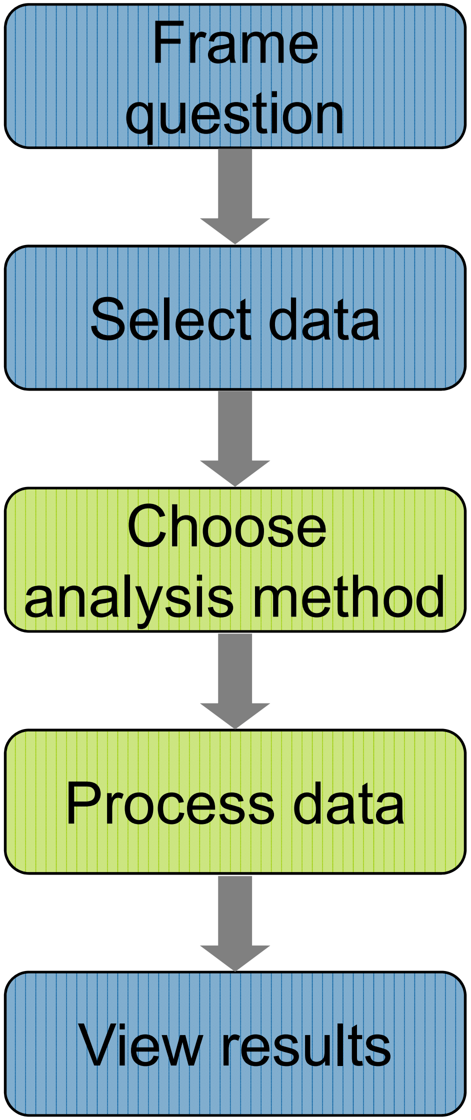
What about central hydrogen production?

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)

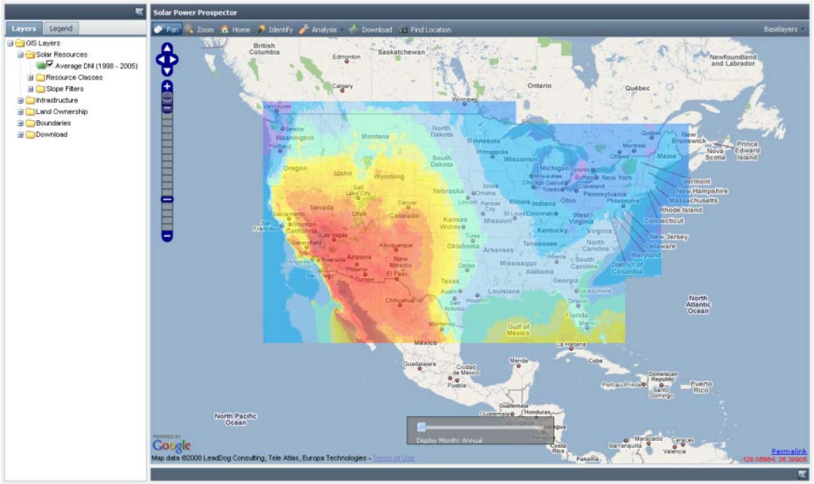


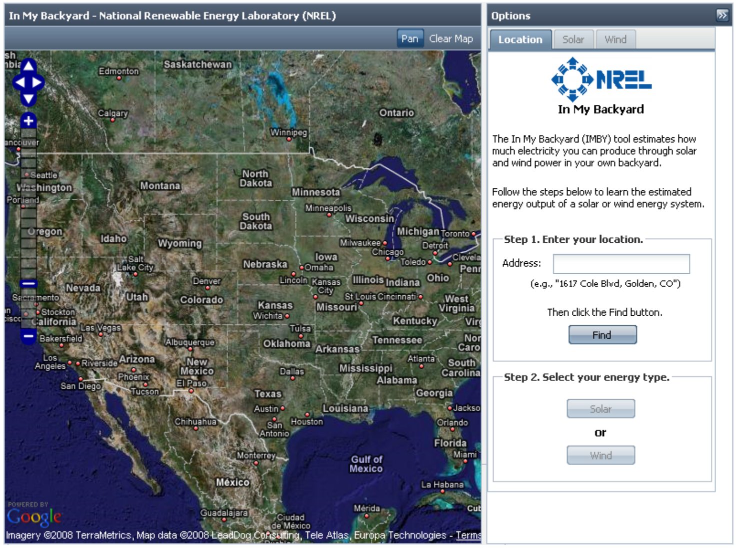
Collaboration – Moving past hydrogen

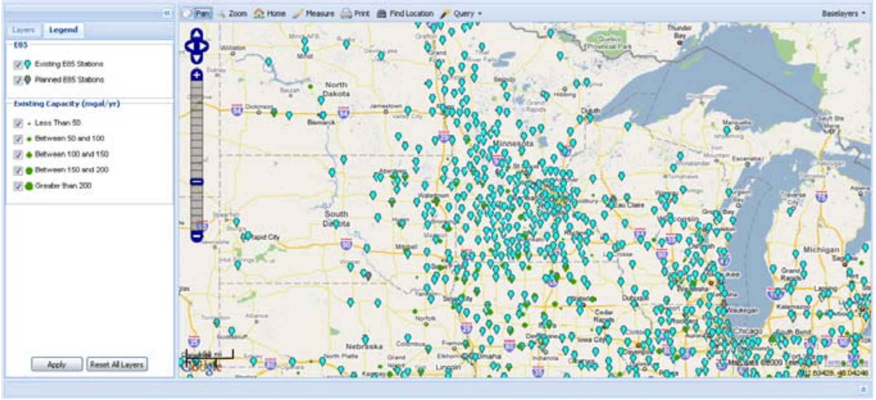
HyDRA architecture supports other renewable energy and alternative fuel applications.

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

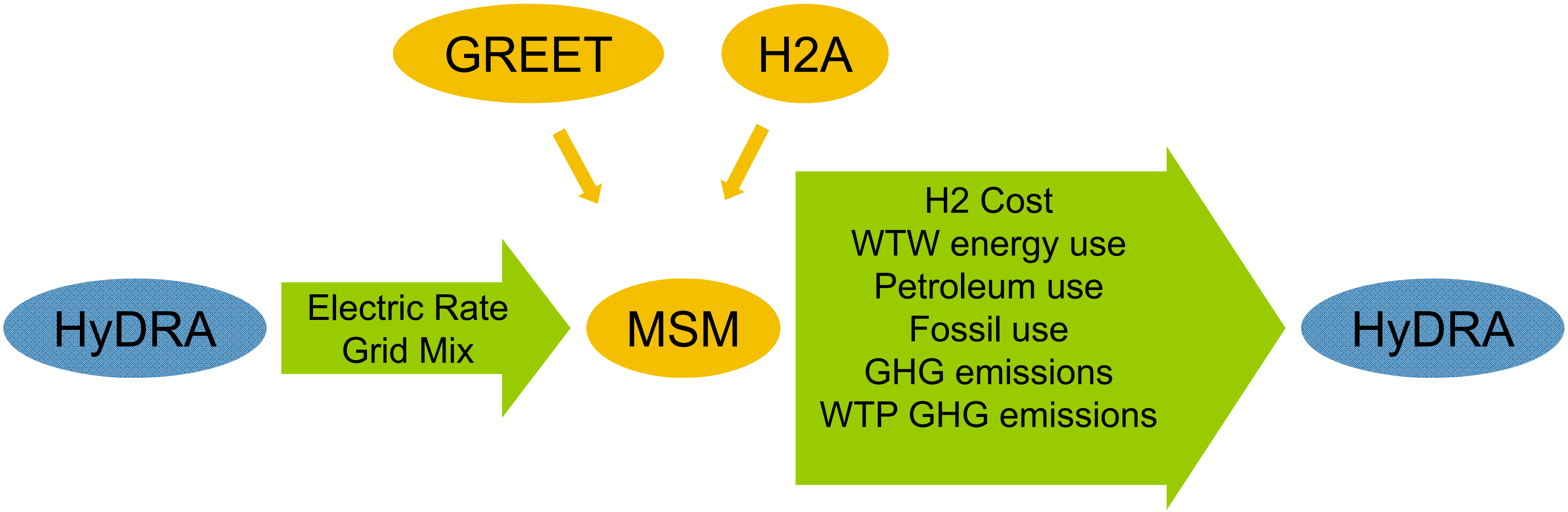
- Incorporate all datasets into new architecture
- Generate dynamic layers
- Complete basic analysis functions
  - Graphing
  - Changing underlying assumptions
  - Buffering

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



Summary

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