



U.S. DEPARTMENT OF
ENERGY

Office of the Chief
Information Officer

Geospatial Analysis and the OpenCarto Framework: Spatial Analysis, Data Provision, and Decision Support at all Levels of Renewable Energy Development

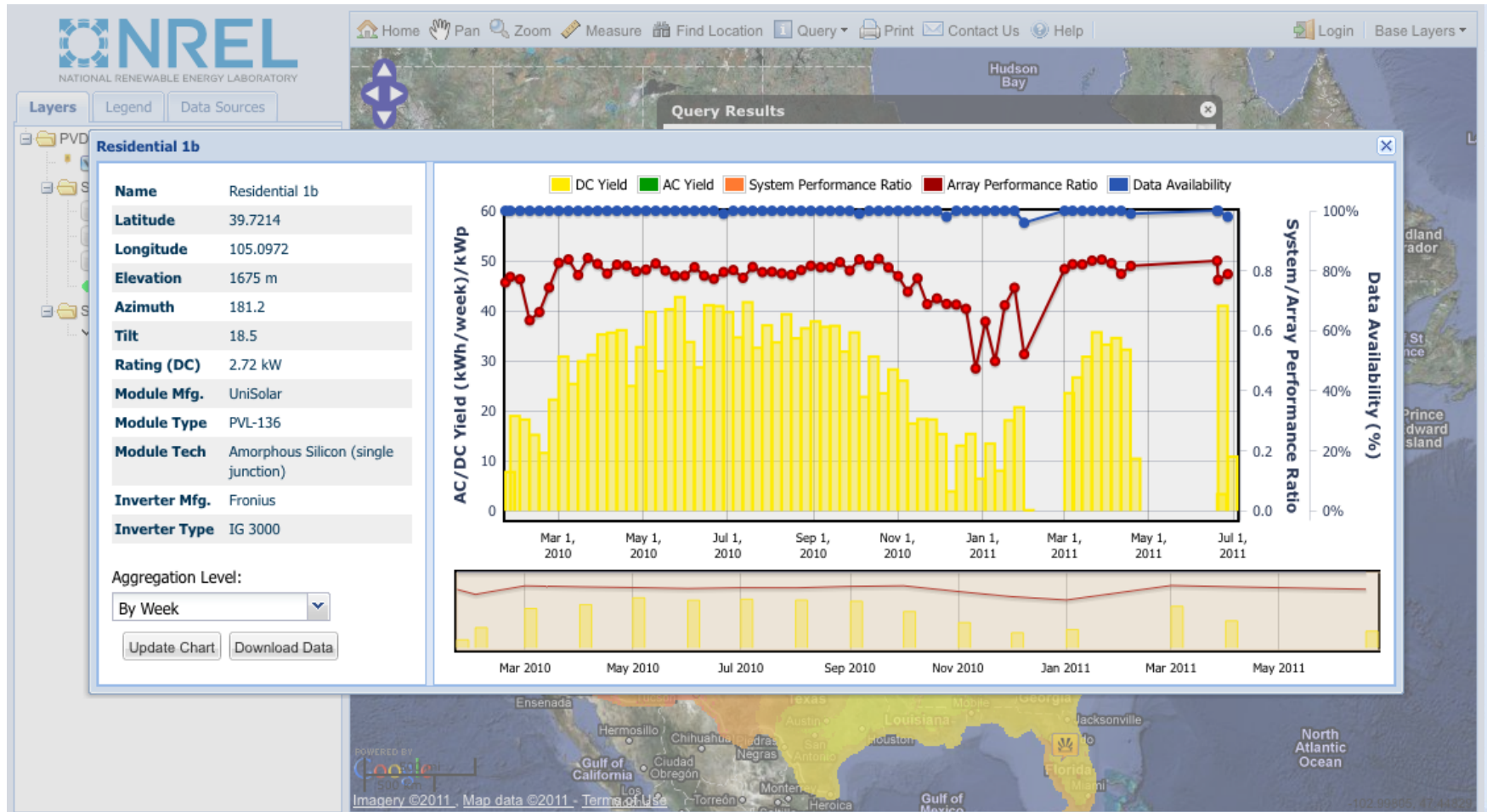


Dan Getman

August 16th, 2011

OpenCarto Framework

OpenCarto is a web based GIS framework designed to support analysis, visualization, and data exploration



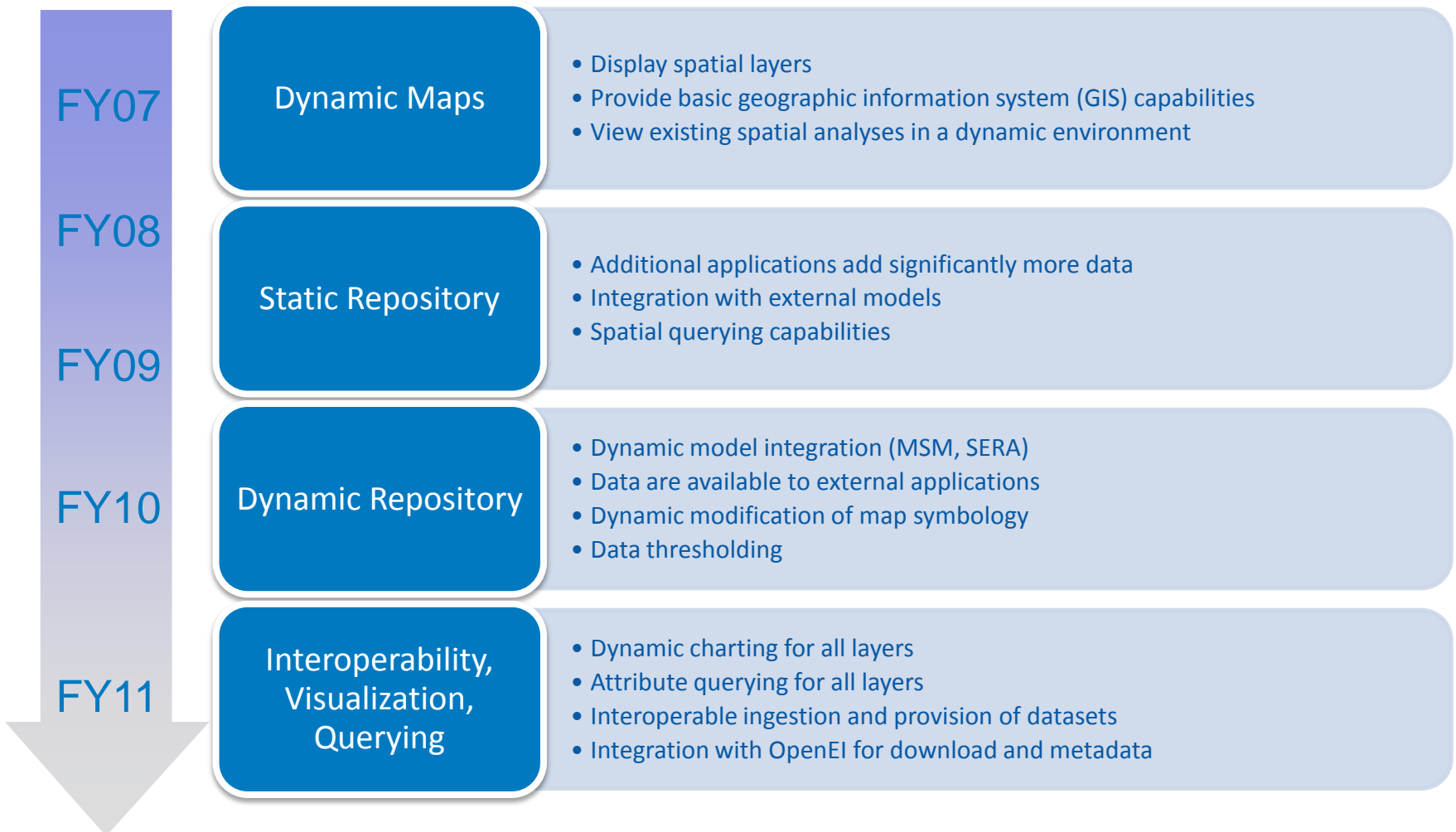
OpenCarto Framework

OpenCarto framework was made possible by collaboration at every level

- Project began as an LDRD
- Sponsored projects evolved the application into a framework
- Framework gained stability and adoption inside and outside of DOE
- Result of collaboration between
 - Internal and external funding
 - Multiple centers collaborating within NREL
 - Multiple sponsoring offices and agencies
 - Collaboration between domain expertise in several renewable technologies, software development, and spatial analysis

OpenCarto Framework

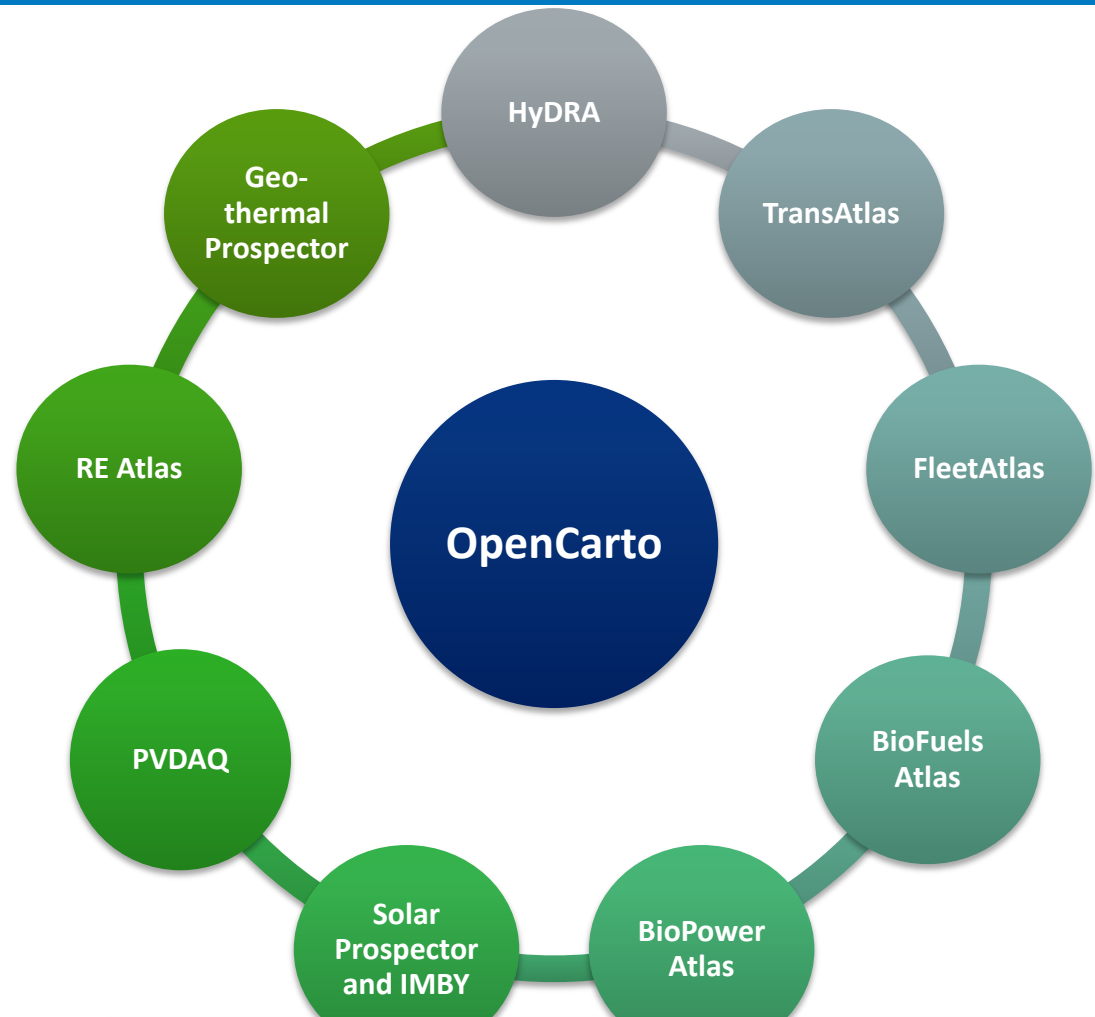
OpenCarto has evolved from a basic display of spatial data to a repository that provides hundreds of dynamic datasets to thousands of users



OpenCarto Framework

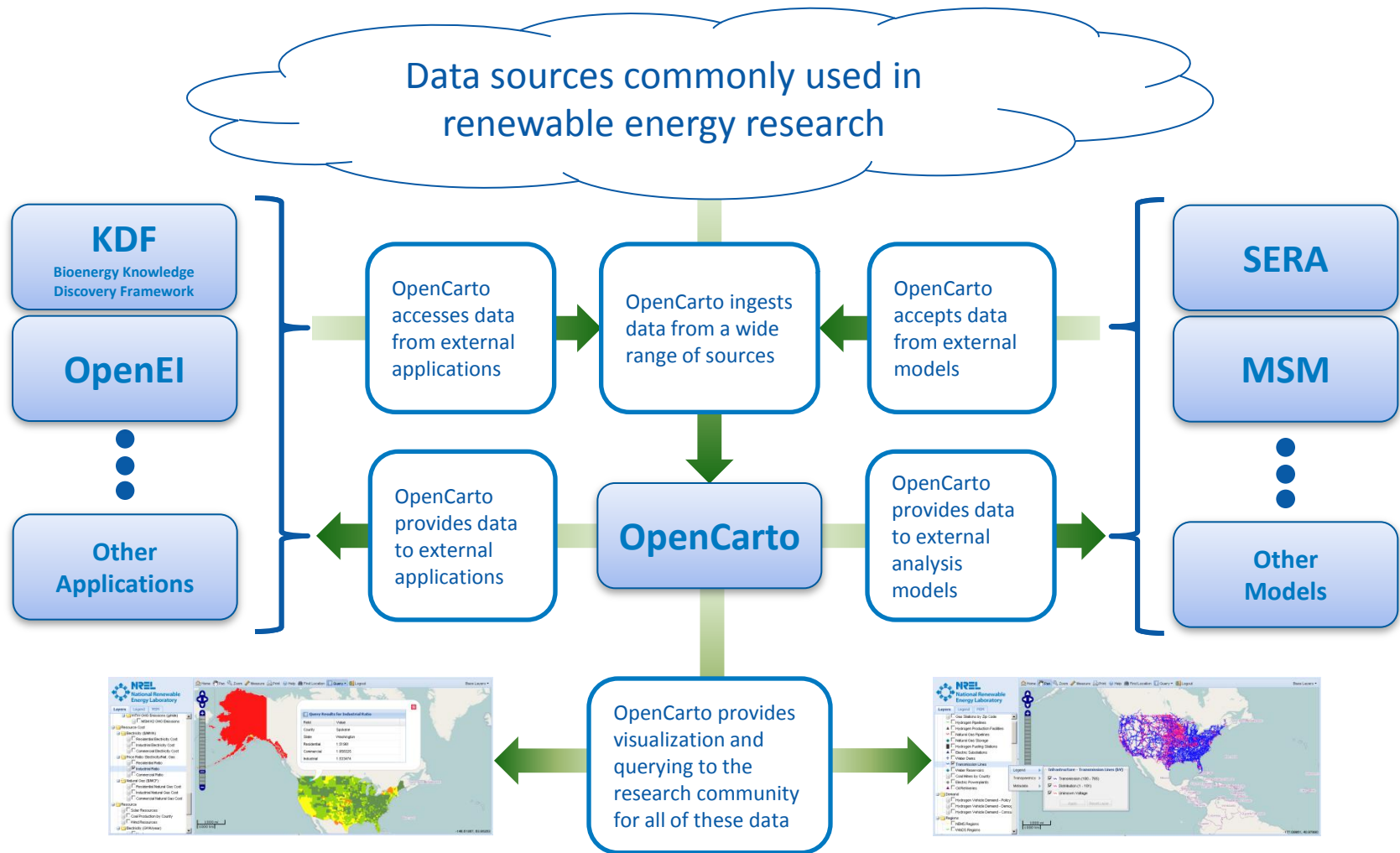
REAtlas is built on OpenCarto, a web-based GIS platform that hosts multiple web mapping tools funded by eight different clients.

Client	Tool
DOE Solar	IMBY PVDAQ Solar Power Prospector
DOE Hydrogen	HyDRA
DOE Biomass	BioFuels Atlas
DOE Clean Cities	TransAtlas
DOE FEMP	FleetAtlas
DOE Vehicle	FleetAtlas
DOE Geothermal	Geothermal Prospector
EPA	BioPower Atlas



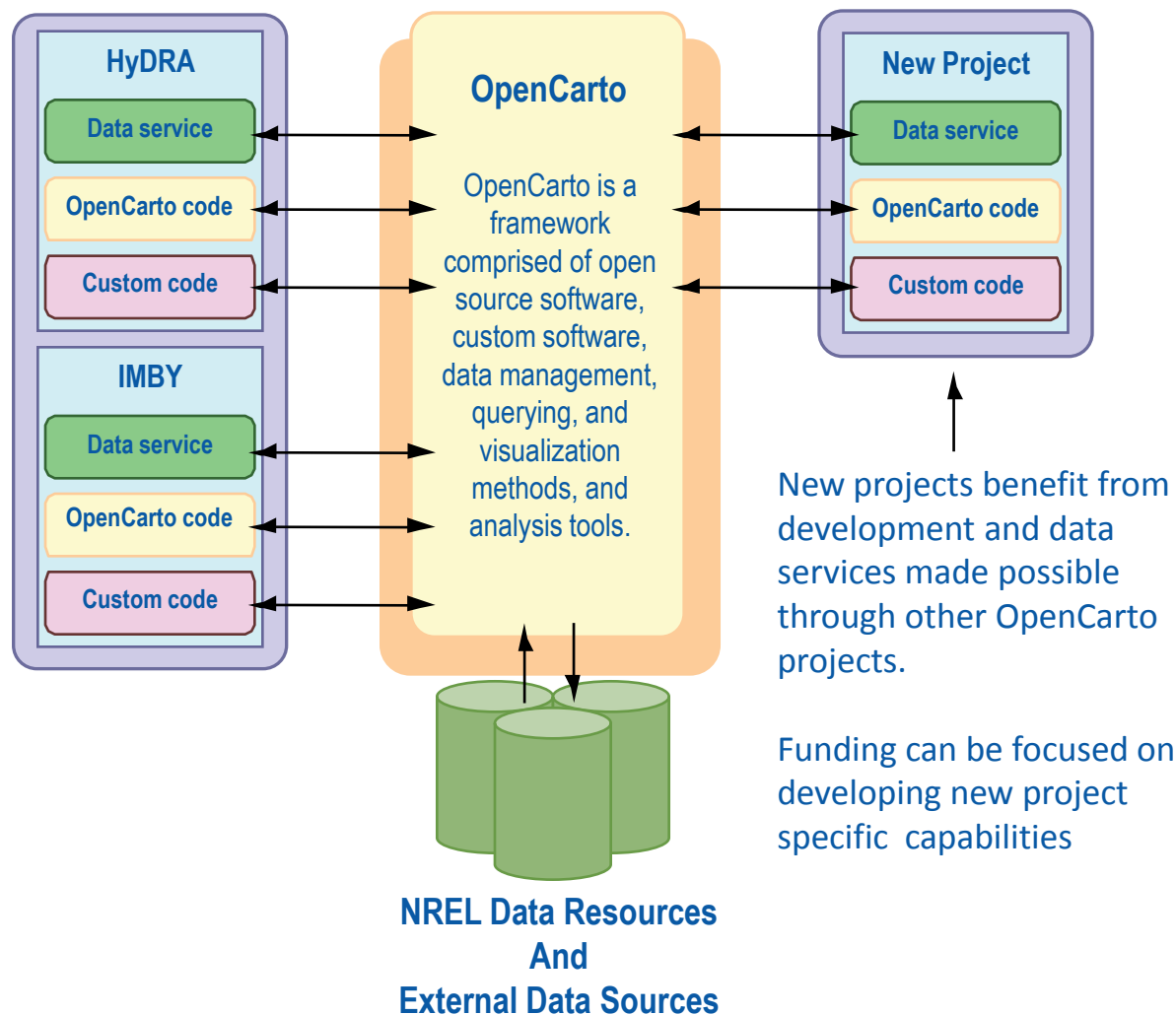
Tools are available at <http://maps.nrel.gov>

OpenCarto: Data Interoperability

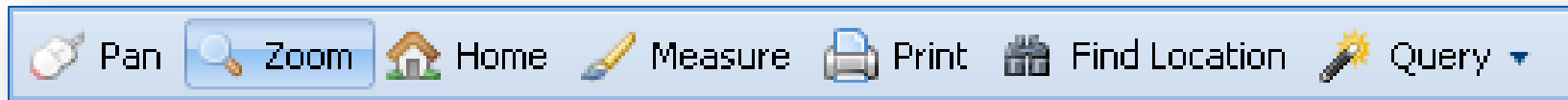


OpenCarto: Value Proposition

- No code duplication
- Enhancements and data sources easily shared
- Supports user authentication and role-based access control
- Uses existing geospatial standards
 - SLD
 - WMS
 - WFS
- Open Source Stack
 - MapServer
 - FeatureServer
 - TileCache
 - Ext-JS
 - OpenLayers
 - Postgres
 - Apache
 - Drupal



OpenCarto: Capabilities



- Standard Mapping Interface
 - Pan, Zoom, Measure
- Tree based layer navigation
- Print
- Find Location (Georeference)
- Query
 - Point, Region, Attribute
 - Results Downloadable to Excel
- Thresholding
- User-Selectable Thematic Maps
- Drag and Drop Layer Ordering
- Dynamic Layer Charting

OpenCarto: Metadata and Linking

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Layers Legend Data Sources

- PVDAQ
 - PVDAQ Contributed Sites
 - Solar Resources
 - Avg. Annual GHI
 - Avg. Annual DNI
 - Avg. Annual Tilt at Lat
 - NSRDB Locations
 - State/Local Borders
 - County Borders

Legend Transparency Metadata

Solar PV

Additional Info:
[NREL Solar Maps](#)
[NREL Solar Map Development](#)
[Solar Resource Assessment](#)
[NREL Open PV Project](#)
[Solar Prospector](#)

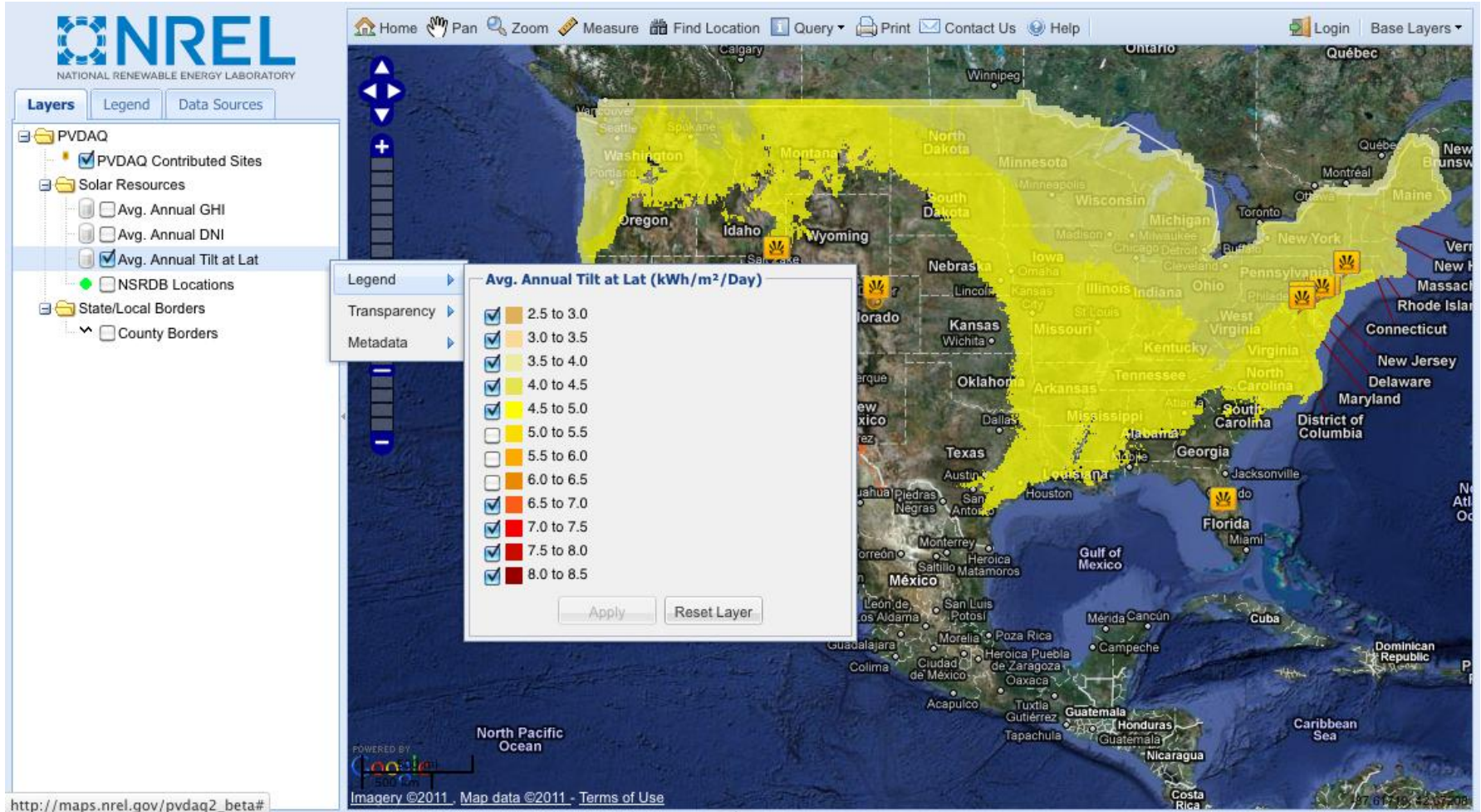
This data provides monthly average and annual average daily total solar resource averaged over surface cells of 0.1 degrees in both latitude and longitude, or about 10 km in size. The insolation values represent the resource available to fixed flat plate system tilted towards the equator at an angle equal to the latitude. The data are created using the SUNY Satellite Solar Radiation model (Perez, et al., 2002). The data are averaged from hourly model output over 8 years (1998-2005). This model uses hourly radiance images from geostationary weather satellites, daily snow cover data, and monthly averages of atmospheric water vapor, trace gases, and the amount of aerosols in the atmosphere to calculate the hourly total insolation (sun and sky) falling on a horizontal surface. The direct beam radiation is then calculated using the atmospheric water vapor, trace gases, and aerosols, which are derived from a variety of sources. Where possible, existing ground measurement stations are used to validate the data.

The data for Alaska was created using the Climatological Solar Radiation Model (Maxwell, George and Wilcox, 1998; George and Maxwell, 1999). This model uses information on cloud cover, atmospheric water vapor and trace gases, and the amount of aerosols in the atmosphere, to calculate the monthly average daily total insolation (sun and sky) falling on a horizontal surface. The cloud cover data used as input to the CSR model are an 8-year histogram (1985 - 1992) of monthly average cloud fraction provided for grid cells of approximately 40km x 40km in size. Thus, the spatial resolution of the CSR model output is defined by this database. The data were obtained from the National Climatic Data Center in Asheville, North Carolina, and were developed from the U.S. Air Force Real Time Nephelometer (RTNEPH) program. Atmospheric water vapor, trace gases, and aerosols are derived from a variety of sources, as summarized in the references. The procedures for converting the modeled global horizontal insolation into the insolation received by a flat plate collector at latitude tilt are described in Marion and Wilcox (1994).

POWERED BY
Imagery ©2011

http://maps.nrel.gov/pvdaq2_beta#

OpenCarto: Layer Thresholding



OpenCarto: Analysis

In My Backyard - National Renewable Energy Laboratory (NREL)

Pan Clear Map

Solar Simulation Results

Summary PV Generation Profile **Load & Generation** Utility Bill

Reduced Load Profile

kW

Time

■ System Output
■ Load Profile

Help...

The chart above shows your system generation compared with your site load. To zoom in on any part of the chart, click and drag over your area of interest. To move the chart data use the controls at the bottom of the graph window.

[View Duration Curve](#)

Load

Now compare your estimated solar electricity production with your electricity consumption.

Step 1. Select a load profile.

You may select a sample profile or upload your own custom load profile.

(A) Use a sample load profile.

Choose a city from the drop-down box below.

Sample Profile:

or

(B) Upload a load profile.

Click the Upload File button below. Then browse to locate your load profile document. For help click [here](#).

Step 2. Run load profile

Using sample load for Denver

Options

Location **Solar** Wind

Solar Electricity Estimator

To estimate the solar electricity you can produce, follow the steps below.

Step 1. Draw your system.

Use the zoom tool on the left of the map, if needed. Click the Draw button, and draw your solar array on the map. Click to add new points. Double-click to stop drawing.

If you make a mistake, click the Clear Map button at the top of the map to start over.

Step 2. Adjust the inputs.

Based on the size and location of your system IMBY suggests these inputs. To change these values, enter your information in the fields below. [Help](#)

Size (kW):

Derating:

Tilt angle (°):

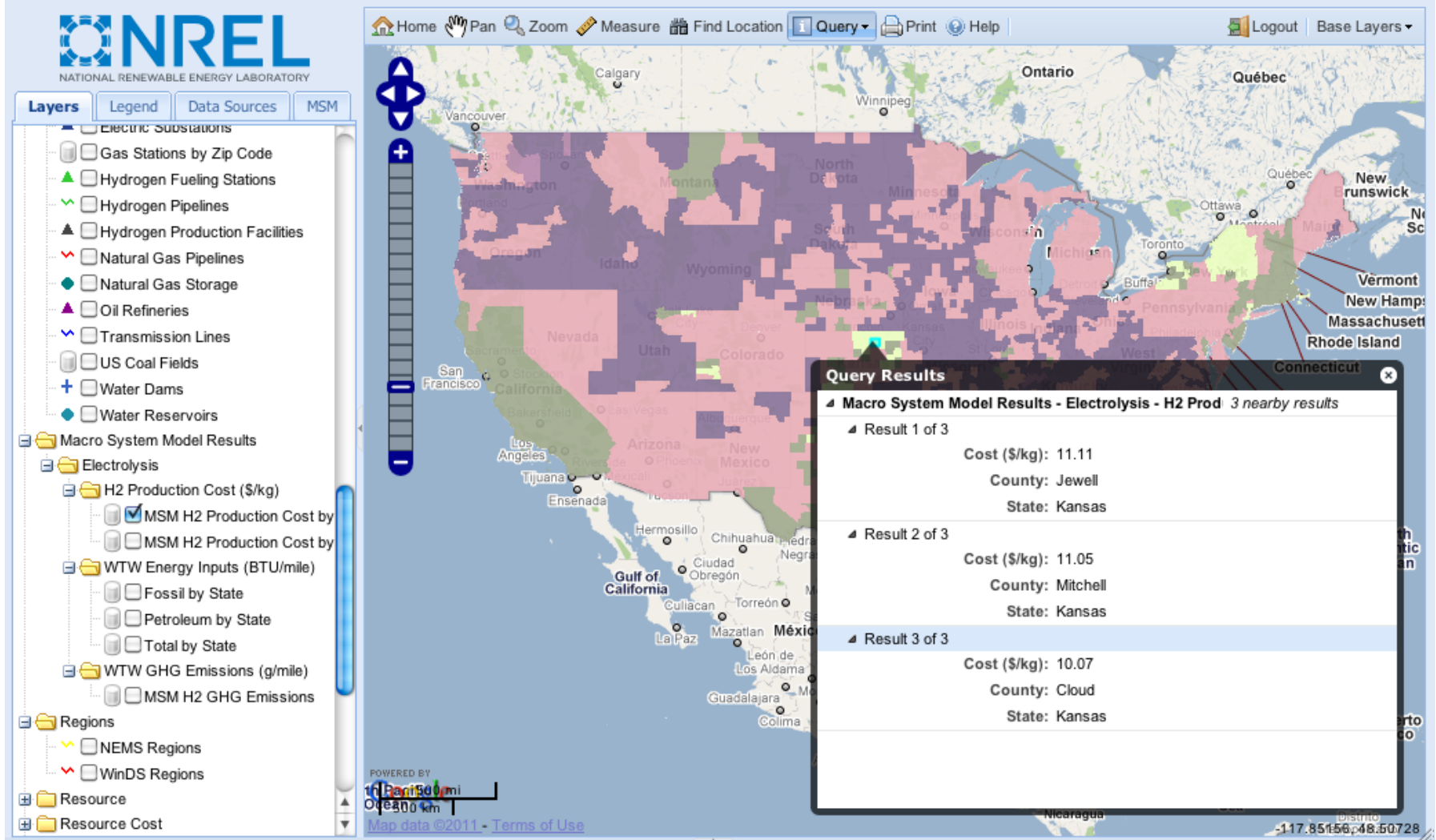
Azimuth angle (°):

Data year:

Step 3. Estimate your production.

Additional Options

OpenCarto: Analysis



Query Results

Macro System Model Results - Electrolysis - H2 Prod 3 nearby results

Result 1 of 3	Cost (\$/kg): 11.11
	County: Jewell
	State: Kansas
Result 2 of 3	Cost (\$/kg): 11.05
	County: Mitchell
	State: Kansas
Result 3 of 3	Cost (\$/kg): 10.07
	County: Cloud
	State: Kansas

OpenCarto: Analysis

The screenshot displays the OpenCarto web application interface. At the top left is the NREL logo (National Renewable Energy Laboratory). The main navigation bar includes Home, Pan, Zoom, Measure, Find Location, Query, Analysis, State View (set to California), Print, and Help. Below the navigation bar is a map of California with various cities and regions labeled. To the left of the map is a 'Layers' panel with a tree view showing 'Feedstocks' (Crops and Crop Residues) and 'Wood'. The 'Corn Stover' layer is checked. Below the map is a 'Summary: California' section with a 'Data Sources' link. Underneath is a 'Download Results' section containing three data tables: 'Fossil Fuel', 'Bioenergy Production & Infrastructure', and 'Feedstocks'.

Fossil Fuel	
Potential Petroleum Transpor...	4%
Gasoline (million gallons/year)	15,052
Diesel (million gallons/year)	2,728
Electricity (thousand MWh/y...	268,155
Natural Gas (million cubic feet)	2,362,224
Number of Power Plants	615
Power Capacity (nameplate, ...	64,691

Bioenergy Production & Infrastructure	
Link to California laws & incentiv All BioFuels	
Biodiesel Stations	35
E85 Stations	59
Ethanol Plants	7
Total Ethanol Capacity (millio...	242
Biodiesel Plants	9
Total Biodiesel Capacity (milli...	38

Feedstocks		
Feedstock	Tonnes/yr	Potential Ethanol ...
Bagasse	0	0
Barley Straw	27,852	2,303,370
Corn Cobs	28,203	2,369,014
Corn Stover	188,017	16,395,080
Forest Residues	1,797,977	113,092,742
Primary Mill Resi...	3,629,026	298,305,976

OpenCarto: Analysis

Solar Prospector | maps.nrel.gov - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://maps.nrel.gov/prospector

theSOURCE ERBSIC CSP CSP Projects maps.nrel.gov NREL Library Unit Conversion W/ Wikipedia Google ENR.com NG Weekly Update CSP Today

McAfee SiteAdvisor

Solar Prospector | maps.nrel.gov

NREL NATIONAL RENEWABLE ENERGY LABORATORY

Home Home | Pan Zoom Measure Find Location Query | Print Help Download Analysis Tools Feedback Base Layers

Layers Legend

- GIS Layers
 - Solar Study Areas
 - Solar Resources
 - Avg. Annual DNI
 - NSRDB Locations
 - Slope Filters
 - Environmental
 - Infrastructure
 - Land Ownership
 - State/Local Borders

Solar Resource Variability

Solar Resource Variability (32.29, -103.67)
Annual Mean: 6524

Wh / sq m / day

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

Max Mean Min

Close

Done

start

Inbox - Microsoft ... 2010-09 SolarPAC... Solar Power Pros... Solar Prospector ...

10:21 AM

OpenCarto: Services

The analysis available in IMBY, PVDAQ, OpenPV, and other applications is also available as API based services that provide the same data, and same analytical results, without the need for the application itself.

Industry is actively using these to develop their own applications

```
- inputs: {
  lat: "40.015",
  lon: "-105.27",
  system_size: "4.0",
  type: "res"
},
- outputs: {
  cost: 32676.591578681568,
  - incentives: {
    - all: [
      - {
        PV Com. Max. Rebate $: 15000,
        PV Com. Rebate $/kW: 1500,
        PV Com. Rebate Max. Size (kW): 25,
        PV NP/Govt Max. Rebate $: 15000,
        PV NP/Govt Rebate $/kW: 1500,
        code: "CO176F",
        gid: 63,
        memo: "4/22/10 added based on website and info provided by Jennifer Hampton BL...",
        notes: "The per-watt rebate rate specified below may be less if local incentives are available.",
        program_name: "Colorado - Commercial Renewable Energy Rebate Program",
        sector: "S",
        state: "Colorado",
        state_abbr: "CO",
        type: "State Rebate Program",
        web_active: "1"
      },
      - {
        PV Res. Rebate $/kW: 1500,
        code: "CO175F",
        gid: 64,
        memo: "4/20/10 added new program based on website BL...",
        notes: "Incentive amounts may be less if local incentives are available. Xcel and Black Hills customers not eligible for this incentive.",
        program_name: "Colorado - Residential Renewable Energy Rebate Program",
        sector: "S",
        state: "Colorado",
        state_abbr: "CO",
        type: "State Rebate Program",
        web_active: "1"
      },
      - {
        PV Com. Max. Rebate $: 200000,
        PV Com. PBI $/kWh: 0.07,
        PV Com. Rebate $/kW: 2000,
        PV Com. Rebate Max. Size (kW): 500,
        PV Com. Rebate Min. Size (kW): 0.5,
        PV NP/Govt Max. Rebate $: 200000,
        PV NP/Govt PBI $/kWh: 0.07,
        PV NP/Govt Rebate $/kW: 2000,
        PV PBI/FIT Duration (Years): 20,
        PV PBI/FIT Min. Size (kW): 10.01,
        PV Res. Max. Rebate $: 27000,
        PV Res. Rebate $/kW: 2700,
        PV Res. Rebate Max. Size (kW): 10,
        PV Res. Rebate Min. Size (kW): 0.5,
```


Discussion

Questions?

dan.getman@nrel.gov

Mapping at NREL

REAtlas

IMBY

HyDRA

BioFuels Atlas

Solar Prospector

PVDAQ

GeoREServ API

<http://maps.nrel.gov>

<http://maps.nrel.gov/reatlas>

<http://mercator.nrel.gov/imby>

<http://maps.nrel.gov/hydra>

<http://maps.nrel.gov/biomass>

<http://maps.nrel.gov/prospector>

<http://maps.nrel.gov/pvdaq>

<http://rpm.nrel.gov/docs/georeserv/>