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

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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*

<table>
<thead>
<tr>
<th>FY07</th>
<th>Dynamic Maps</th>
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<tbody>
<tr>
<td></td>
<td>• Display spatial layers</td>
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<td>• Provide basic geographic information system (GIS) capabilities</td>
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<td>• View existing spatial analyses in a dynamic environment</td>
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<tr>
<th>FY08</th>
<th>Static Repository</th>
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<tbody>
<tr>
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<td>• Additional applications add significantly more data</td>
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<td>• Integration with external models</td>
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<td>• Spatial querying capabilities</td>
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<tr>
<th>FY09</th>
<th>Dynamic Repository</th>
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<tr>
<td></td>
<td>• Dynamic model integration (MSM, SERA)</td>
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<td>• Data are available to external applications</td>
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<td>• Dynamic modification of map symbology</td>
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<td>• Data thresholding</td>
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<tr>
<th>FY10</th>
<th>Interoperability, Visualization, Querying</th>
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<tr>
<td></td>
<td>• Dynamic charting for all layers</td>
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<td>• Attribute querying for all layers</td>
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<td>• Interoperable ingestion and provision of datasets</td>
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<td>• Integration with OpenEI for download and metadata</td>
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| FY11    |                                      |
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**OpenCarto Framework**

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

<table>
<thead>
<tr>
<th>Client</th>
<th>Tool</th>
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<tbody>
<tr>
<td>DOE Solar</td>
<td>IMBY</td>
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<td></td>
<td>PVDAQ</td>
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<td></td>
<td>Solar Power Prospector</td>
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<tr>
<td>DOE Hydrogen</td>
<td>HyDRA</td>
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<td>DOE Biomass</td>
<td>BioFuels Atlas</td>
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<tr>
<td>DOE Clean Cities</td>
<td>TransAtlas</td>
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<tr>
<td>DOE FEMP</td>
<td>FleetAtlas</td>
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<tr>
<td>DOE Vehicle</td>
<td>FleetAtlas</td>
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<tr>
<td>DOE Geothermal</td>
<td>Geothermal Prospector</td>
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<tr>
<td>EPA</td>
<td>BioPower Atlas</td>
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</table>

Tools are available at http://maps.nrel.gov
OpenCarto: Data Interoperability

Data sources commonly used in renewable energy research

- KDF (Bioenergy Knowledge Discovery Framework)
- OpenEI
- Other Applications
- OpenCarto ingests data from a wide range of sources
  - OpenCarto accepts data from external models
  - OpenCarto provides data to external analysis models
  - OpenCarto provides visualization and querying to the research community for all of these data
- SERA
- MSM
- Other Models
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

New projects benefit from development and data services made possible through other OpenCarto projects.

Funding can be focused on developing new project specific capabilities
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

Solar PV

Additional Info:
- NREL Solar Maps
- NREL Solar Map Development
- NREL 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 16 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 6 years (1998-2003). 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, Georges and Wilcox, 1998; Georges 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 Nephosatistics (RT-NETH) 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).

http://maps.nrel.gov/pvdaq2_beta
OpenCarto: Layer Thresholding
OpenCarto: Analysis

Innovation for Our Energy Future
OpenCarto: Analysis

Innovation for Our Energy Future
OpenCarto: Analysis
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.
Discussion

Questions?
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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/