GEOSPATIAL ENERGY MAP OF INDIA
USER GUIDE FOR FUNCTIONALITY TESTING AND EVALUATION
July 2020

Partner Institutions
- Ministry of Power
- Ministry of New and Renewable Energy
- Ministry of Coal
- Ministry of Petroleum and Natural Gases
- Department of Atomic Energy
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**Cover Image:** Earth Observations Group (EOG), NOAA/NCEI. *Night-time VIIRS Day/Night Band Composite (Version 1)*, March 2018.

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Executive Summary

- Geospatial energy map attempts to identify and locate all primary and secondary sources of energy and their transportation transmission networks to provide a comprehensive view of energy production and distribution in a country. Geographic Information System (GIS) of energy assets will be useful for ensuring real-time and integrated planning of energy sector of India, given its large geographical distribution and interdependence.

- The energy data in India is fragmented and scattered across multiple organisations. While different ministries may have detailed information, including maps, about their respective domain of expertise as per mandate, there is no consolidated energy map available in India that may provide a holistic picture of the entire energy sector. Mostly, the available maps are static (i.e. in PDF or JPG formats), and hence inhibit integration with the associated features of topography and other physical infrastructure. Moreover, they are not updated regularly and therefore are unable to provide real-time reliable information.

- NITI Aayog initiated the development of consolidated geospatial energy map of India in collaboration with Indian Space Research Organisation (ISRO). The GIS-based energy map is intended to provide valuable inputs for formulating policies such as National Energy Policy (NEP) and Vision Document, 2032, reviewing of such policy interventions and assisting Energy Ministries in policy formulation, besides encouraging private sector participation in the energy sector.

- Nodal Officers were appointed for coordinating data collection from five energy related ministries / departments viz. Ministry of Power, Ministry of Coal, Ministry of New and Renewable Energy, Ministry of Petroleum and Natural Gas, and Department of Atomic Energy. Nodal Officers compiled the data from multiple sources as per the requirement of energy map of India. The data received from different ministries were collated, validated, verified, corrected and organized by ISRO in a systematic database.

- ISRO developed the web-based geospatial energy map of India for visualization of spatial and non-spatial data on renewable and non-renewable power plants, oil and gas downstream sector, renewable energy potential, fossil fuel resources, and other energy assets in India. The access to geospatial energy portal is provided through login credentials for restricted authorized users only. The web-based geospatial energy map of India has been deployed on VEDAS Server at SAC, Ahmedabad.

- The web-GIS based geospatial energy map of India provides visualisation of static data of 23 thematic layers. The static data of all types of conventional power plants, including thermal (coal, diesel and natural gas), hydro and nuclear power plants, refineries, LNG terminals, LPG bottling plants, POL terminals, oil and gas wells, coal fields, coal blocks, district-wise data on renewable energy (including solar, wind, small hydro, biomass & waste to energy plants), electric sub-stations and transmission lines (data from about 38 utility companies organized), and solar energy resource potential have been organized and published on the energy map.
The major functionalities in the geospatial energy map of India include visualisation of static and dynamic data, interactive and user-friendly map navigation, pre-composed energy data views, basic feature attribute query, dynamic data visualisation, locating and filtering power plants by text-keywords, state-level energy data visualisation, thematic layer metadata information display, tabular view of attribute tables, and additional tools (upload KML/GPX files, area / distance measurement tools, and tools for feature drawing).

The geospatial energy portal also has provisions for displaying dynamic data. The dynamic data on power plants (monthly electricity generation), refineries (monthly production), and captive coal mines (monthly production and dispatch) have been included.

The web-based energy map provides access to several reference layers. These reference layers include Bhuwan WMS of village boundaries, transportation network and high-resolution satellite data, Cartosat-1 10.0 m DEM, and other base layers such as highways, railway lines, rivers, cities and administrative boundaries.

A three-tier data updating application has been developed that enables ‘edit-user’ to update attribute data (non-spatial), ‘nodal officer’ to approve or reject the changes, and ‘administrator’ to incorporate the changes in database.

The GIS-based energy map of India may be useful for wide range of applications such as policy development and planning, education and mass-awareness, encouraging public participation in resource development, environmental conservation and clean energy alternatives promotion, assisting in transparency in resource development and allocation, inter-sector, inter-state and international coordination / cooperation, market tracking and energy forecasting, investment guidance for financial institutions, disaster management and emergency response, and for promoting research and development in energy sector.

1.1 Introduction

- Geospatial energy portal provides interactive and user-friendly access to the energy map of India over internet.

- The website has been developed using open-source technologies. PostgreSQL (version 9.5) was used as database management system. GeoServer (version 2.11.2) was used for serving spatial data over web as OGC compliant Web Map Service (WMS), while OpenLayers (version 4.3.3) was used for displaying map data in web browsers. The website is currently deployed on VEDAS Servers at SAC, Ahmedabad.

- The major functionalities incorporated in the energy portal are:
  - Visualisation of static energy maps;
  - Interactive and user friendly map navigation;
  - Pre-defined energy data views;
  - Retrieval of feature information;
  - Dynamic data visualisation of power plants, captive coal mines and refineries;
  - Finding power plants by text-keyword;
  - Visualisation of state energy maps;
  - Drawing and measurement tools; and
  - Three-level mechanism for updating attribute data.

- Figure 1 shows the home page of geospatial energy portal. The portal currently permits unrestricted access to metadata, which enables visitors in obtaining basic information on the thematic layers included in the energy map of India.

![Energy Map of India](image)

**Figure 1: Geospatial Energy Portal Home Page**
The access to geographic data is currently restricted to authorized users only. The login screen requests for user name, password and captcha (figure 2).

![Energy Portal Login Page through VEDAS](image)

**Figure 2: Energy Portal Login Page through VEDAS**

The website currently uses the credentials of VEDAS portal for providing access. User is subsequently requested for permission to retrieve profile information from VEDAS account, which will aid in providing personalized content to end users in future.

![Request for Access to VEDAS Profile](image)

**Figure 3: Request for Access to VEDAS Profile**

The successful verification of user credentials will enable access to the geospatial energy map of India (figure 4). Accordingly, menu-bar displays a button linking to the maps.
Figure 4: Access to Geospatial Energy Portal on Successful Password Validation

- **About** section on home page provides a brief introduction to the website.

Figure 5: About Section

- Further details are provided on separate page explaining the need and utility of energy portal from the ‘More Info’ Link or the ‘About’ button on menu-bar (figure 6).
• **Data Snapshot** section on the home page retrieves feature count of the thematic layers (vector) populated in the GIS-based energy map (figure 7).

• **Data Partners** section on the home page mentions the ministries and department of Government of India that have contributed in development of this website (figure 8). The footer section provides useful links, including the links to NITI Aayog and ISRO.
Each ministry is hyperlinked to respective official website. The List of Nodal Officer is also provided below the information on Ministries (figure 9).

The metadata button on home page opens the metadata section. The list of thematic layers related to energy section is populated in the drop down control. The metadata of selected layer is displayed underneath (figure 10).
Figure 10: Metadata Search

- Disclaimer section can be accessed from the button provided in the menu-bar. It explains the limitation of data and its usability (figure 11).

Figure 11: Disclaimer
1.2 Spatial Data Visualisation

- The list of all thematic and reference layers is provided in collapsible hierarchical tree format as shown in figure 12. The layers are grouped in seven categories (nodes), viz. power plants, coal reserves, petroleum and natural gas, transmission and distribution layers, renewable energy resources, state-wise information, and reference layers.

![Energy Map of India](image)

**Figure 12: Static Geographic Data Visualisation**

- The power plants category includes conventional power plants (coal, diesel, natural gas, nuclear, hydro-electric, and pumped storage hydro-electric power plants), and district-wise installed capacity map of solar, wind, small hydro, biomass, waste to energy and all-combined renewable energy power plants.

- The coal reserves category includes maps of captive coalmines, washeries, coal blocks, coal fields, coal fields with estimated reserves, coal block ownership, coal block exploration status, and coal washeries.

- The petroleum and natural gas category includes refineries, LNG terminals, LPG bottling plants and POL terminals along with oil and gas wells.

- Transmission lines obtained from Open Street Map (OSM) along with dynamic point-cluster map of sub-stations is included under transmission and distribution lines category.

- The renewable energy resources included in the energy map provides Global Horizontal Irradiation (GHI) derived by NIWE as well as satellite derived annual average GHI based on data from 2009-2018.

- The reference maps include administrative boundaries and high-resolution satellite imageries obtained from Bhuvan Portal in addition to layers on infrastructure (airports, railway station, railways and highways) and natural resources (rivers and reservoirs).

- The legend of each layer can be viewed under the ‘Legend’ tab. Alternatively, the icon shown next to each layer also shows the legend of corresponding layer. The icon, shown alongside the legend icon, displays the metadata of corresponding layer in a pop-up window. Metadata provides relevant information of the thematic layer such as its name, feature type, contact information, concerned ministry, map scale, citation and survey year.
The website provides user-friendly interface with interactive navigation control (icon on map canvas for Zoom in and icon for zoom out) as shown in figure 14. The maximum scale at which a given map can be visualised is defined in the layer’s metadata as per database design. The layer / legend panel may be collapsed / minimized to increase the view area of map canvas.

Reference layers can be selected from the table of content of layers in Layers panel. The GIS-layers of Infrastructure, Administrative Boundaries and Natural Features can be
overlaid on the thematic layers. The high spatial resolution satellite imagery obtained from Bhuvan can be used as Base Map (figure 15).

Figure 15: Overlay Layers and Base Maps

- Latest Thermal Infrared (TIR) Image acquired by INSAT-3D satellite showing distribution of clouds in near-real time can be displayed (figure 16).

Figure 16: Real-time Weather Data Integration (Beta)

- Digital Elevation Model (DEM) with 10.0 m spatial resolution, derived from Cartosat-1 satellites of ISRO has been provided to depict terrain. (Figure 17)
The energy data is further grouped into ten pre-defined views: (1) conventional power plants; (2) biomass; (3) coal; (4) fossil fuel resources; (5) hydro-electric; (6) natural gas; (7) petroleum; (8) renewable energy power plants; (9) solar; and (10) wind. In each of these views, relevant layers are made visible while retaining the state of visibility of other layers.

Figure 18 shows thermal power plants based on coal, natural gas and diesel, hydro power plants and nuclear power plants, as part of the ‘conventional power plants’ map view.

The fossil fuel resources shows oil and natural gas wells, captive coalmines, coalfields and coal blocks. (Figure 19)
The energy portal also shows the state-wise information obtained from published reports. The state-wise estimated reserves of coal, lignite, natural gas and crude oil for years 2014 and 2015, as published in the Energy Statistics (MOSPI, 2016), are shown by proportionate-symbol maps. The state-wise renewable energy potential is shown as pie-chart indicating share of different sources of renewable energy on the basis of data provided in Energy Statistics (MOSPI, 2016). Similarly, mode-wise electricity generation, represented by pie-chart map, and energy consumption choropleth map, are derived from the All India Electricity Statistics (CEA, 2014). (Figure 20)
Data tables (icon 📊 on map canvas) and charts (icon ☰ on map canvas), based on data in Energy Statistic (MOSPI, 2016) and All India Electricity Statistics (CEA, 2014) used to generate these maps, can be viewed as shown in figure 21 and figure 22 respectively.

Figure 21: Tabular View of State-level Data

Figure 22: Chart View of Selected State-level Data
1.3 Query Functionalities

- The geospatial energy portal supports three types of queries for retrieval of required information: what-lies query, where-lies query, and state-level energy map query.

- The ‘what-lies’ query provides attribute information of a feature in the map at a given location. Figure 23 shows the attributes of a coal power plant located in Odisha state. User can also zoom-in to its location from the ‘Zoom to Feature’ button.

![Figure 23: Basic Feature Information of Conventional Power Plant](image)

- Figure 24 shows the feature information of district-wise solar power plants. The more info tab provides link to all solar power plants in the selected district.

![Figure 24: Basic Feature Information of District-wise Solar Power Plants](image)
- Figure 25 provides feature information of captive coalmines.

Figure 25: Basic Feature Information of Captive Coal Mines

- Figure 26 provides feature information of petroleum refineries.

Figure 26: Basic Feature Information of Refinery

- The additional details, such as list of renewable-energy power plants in a given district, coal reserves of a coal field, unit-wise details of power plants, and dynamic information (if available), can be retrieved from the hyperlinks to ‘More Info’.
Figure 27 shows detailed feature information of a power plant, unit details, location and dynamic information including monthly electricity generation, monthly plant load factor, monthly program and quarterly target achievement. This information may be downloaded as a PDF file.

The dynamic information is also provided for captive coal mines and crude oil refineries, in addition to the conventional power plants.

The monthly production and despatch information of captive coal mines for the financial years 2015-16 to 2019-20 has been provided as bar chart (figure 28).
• The monthly crude oil production of refineries from F.Y. 2011-12 to 2017-18 has also been provided (figure 29).

Figure 29: Dynamic Information on Crude Oil Refineries

• The new and renewable energy data is organised at district level. The feature information provides district-level attribute information such as name of district, number of power plants and their total installed capacity in the district. The detailed information on all power plants within a district is provided by hyperlink for more information in separate window with pagination providing controls for page navigation. Figure 30 shows the list of wind power plants in Jaisalmer district.

Figure 30: Detailed Feature Information of District-wise Wind Power Plants
• Text-keyword based filter has been provided to restrict the results in display. Figure 31 shows the list of wind power plants in Jaisalmer district, while filtering wind power plants owned by ‘Rajasthan Ren. Energy Corp. Ltd.’.

![Geospatial Energy Map of India](image)

**Figure 31: Text-keyword Filtering of Wind Power Plants**

• The text-keyword based search of power plants is only supported for conventional power plants. The text keyword is searched in the entire attribute table of selected power plant type to provide greater flexibility in querying the data. It may, therefore, be used for retrieving the location of a specific power plant by its name, locating power plants owned by a specific utility company, identifying power plants using specific technology, determining power plants in a given district or state, or any other similar information.

• The output of text-based query is tabulated with the information on name of power plant, utility company name and installed capacity. The output of query is also linked to the map, thereby opening the feature information of the selected record from the query output. The selected power plant is shown by a unique symbol on map (❤).

• Figure 32 shows coal power plants containing the text-keyword ‘vin’ to locate ‘Vindhyachal Thermal Power Plant’ in Madhya Pradesh state.

• Text-keyword based search may also be used to select all power plants operated by a particular utility company. Figure 33 lists all coal power plants operated by NTPC.
The state-wise energy map query masks all states other than the selected state, and zooms the map to the selected state. The list of states is populated in the dropdown list.

The query retains visibility status of all other thematic and reference layers. This type of query will be useful for preparing state-level energy map. Figure 34 shows geographic distribution of conventional power plants in Madhya Pradesh state.
1.4 Additional Tools

- The energy portal provides a set of additional tools that may be useful in performing various geographic tasks on the map canvas. The icon ((bottom right side of the map canvas shows (or hides) these tools as listed in table below.

**List of Additional Tools**

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- The file upload tool enables adding of a KML or GeoJSON file to the map. These files may be created using any GIS software like QGIS, ArcGIS etc., computer programs like Google Earth, or by GPS applications, including mobile phone devices.
Figure 35 shows the popup window opened for uploading KML or GeoJSON file, while figure 36 shows the uploaded KML file containing user information on the energy map. It is assumed that the KML and GeoJSON files are in geographic projection with WGS 1984 datum. This feature can be used for adding new information, such as upcoming power plants and infrastructure facilities, to the energy map. It may also be used to add any missing information to the map, or to check the location of new data prior to insertion in database.

Figure 35: Upload KML or GeoJSON Geometry Files

Figure 36: Uploaded File on Energy Map

The energy portal provides tools for drawing point, line or polygon features on the map canvas. As the map uses very high resolution satellite images as base map, drawing tools may be used to create location maps of proposed infrastructure projects, mapping assets
and for marking additional details on the map. The download tool can be used to subsequently retrieve these added features in KML or GeoJSON format (figure 37) for further analysis in other GIS software.

Figure 37: Drawing Tools

- The measurement tools enable computation of area (in square km) and distance (in km) on map canvas (figure 38).

Figure 38: Measurement Tools

- The tool box also provides navigation tools for zooming to full extent of India and zooming to an area defined by a user-drawn box. A rectangular graticule grid with a scale-defined spacing interval can be drawn on map for reference.
1.5 Updating of Attribute Data

- The access to energy map is currently provided at three levels of privileges, viz. ‘edit-user’, ‘nodal officer’ and ‘administrator’.

- The ‘administrator’ will have access to edit all thematic layers in the energy map. The ‘nodal officer’ and ‘edit-user’ are permitted to edit only the relevant layers. Thus, ‘edit-user’ and ‘nodal officer’ from Ministry of Power, for example, can edit all layers pertaining to conventional power plants except nuclear power plants.

- The update icon (/button) as shown in figure 39, is provided to ‘edit-user’, ‘nodal officer’ and ‘administrator’, who are authorized to edit the data. This will provide access to the attribute tables of thematic layers available for editing to a particular type of user.

![Image](image_url)

Figure 39: Initiating Attribute Data Editing

- An ‘edit-user’ can select the layer for editing, which will open corresponding attribute table (figure 40). Filter may be applied to select any particular record in the attribute table using text-keyword based search.

- The table row that needs to be edited can thus be selected and necessary changes be applied and submitted for approval (figure 41). Users with privileges of ‘nodal officer’ and ‘administrator’ may also edit attribute tables in similar manner. The changes made by ‘edit-user’ are submitted to ‘nodal officer’ for review.
The ‘nodal officer’ may accept or reject such changes to attribute table in the database after review and recording of observations (figure 42).
The changes by ‘nodal officer’ will be forwarded to the ‘administrator’ for review and approval. The changes approved by ‘administrator’ are incorporated in the energy map. Figure 43 shows changes in coal power plants, approved by the ‘nodal officer’ being accepted by the administrator.

The changes in installed capacity of a power plant from 2000 MW to 1000 MW are reflected in the data table and map immediately (figure 44).
Figure 44: Updated Feature Information on Map