

## The web-oriented framework of the world geothermal production database: a business intelligence platform for wide data distribution and analysis

Eugenio Trumphy<sup>1</sup>, Ruggero Bertani<sup>2</sup>, Adele Manzella<sup>1</sup>, Marietta Sander<sup>3</sup>,

<sup>1</sup> Institute of Geosciences and Georesources – National Research Council of Italy, Via Moruzzi 1 – 56124 PISA, Italy

<sup>2</sup>ENEL Green Power, Italy

<sup>3</sup> International Geothermal Association (IGA), Secretariat c/o Bochum University of Applied Sciences, Germany

e.trumphy@igg.cnr.it

**Keywords:** geothermal energy, power generation, direct uses, installed capacity, data organisation.

### ABSTRACT

The Global Geothermal Energy Database (GGED) of the International Geothermal Association (IGA) is a web application based on a database containing global and country-specific geothermal information, and refers to both electricity generation and direct use of geothermal heat. The application, built using an open-source Business Intelligence platform, can be accessed through the IGA website. The application functionalities are:

- the database “list of information” regarding geothermal fields and plants, direct uses, geothermal turbine manufactures and geothermal companies;
- the “reports”, with predefined aggregation of useful data in a standard format;
- the “chart”, producing pie charts and bar diagrams of data, which can be dynamically sorted and aggregated.
- the “maps”, using a webGIS tool for geothermal fields location, allows also to browse the maps, to zoom, to measure distance, to pan and to query for further analysis.

Aggregation and filtering are options to summarise and organise data for direct use, power plants by region, category and operative status and GEA code. An on-line help document is downloadable from the menu of the application.

### 1. INTRODUCTION

Through the IGA website you can access the IGA Global Geothermal Energy Database. The GGED was developed by the IGA in cooperation with the Institute of Geoscience and Earth Resources (CNR), Italy. Updates are conducted by the CNR following the regular content update of IGA.

Indeed, geothermal data are periodically collected by the IGA: on the occasion of the World Geothermal Congresses, organised every five years, each country is invited to provide updated data regarding geothermal uses, both for power and thermal production.

The topic of this paper is the general description of data management of such a wide dataset in an easy-to-access way through the web interface, the database organisation and the basic functionalities.

### 2. CONTENT DATA

The IGA GGED contains information on the main basic elements that belongs to geothermal system (Dickson and Fanelli 2003): geothermal field, geothermal plant and direct uses.

Geothermal fields are classified according to the presence of plants in operation and those in development where projects are at different stages of realisation. The most important attributes of the geothermal field are the installed capacity (MWe), produced energy (GWh) and the associated operating company.

Geothermal plants are classified on the base of the utilisation of the geothermal reservoir fluid, as binary, single flash, double flash, dry steam or back pressure plants, accordingly to its thermo-dynamic state.

Each plant belongs to a “plant owner” (the company who operate the facilities). Other important information refer to the turbine, being the major equipment installed on the facility. The turbine, identified by a manufacturer, has some characteristics classified in the database:

- the installed and running capacity;
- the produced energy;
- the status (decommissioned, in operation or planned);
- the Commission Operating Date (COD).

Direct heat use is probably the oldest, most versatile and also the most common form of utilisation of geothermal energy; a complete list of the utilisations classified by IGA and requested on the occasion of country updates is shown in the Tab. 1. While the location of each single application is seldom available, direct utilisation have been summed up and referred to the country, providing, as relevant data, the installed capacity (MWth) and the annual production (TJ/year).

**Table 1: Direct uses of geothermal heat in the IGA database.**

| Category of uses           |
|----------------------------|
| Individual space heating   |
| District heating           |
| Air conditioning (cooling) |
| Greenhouse                 |
| Fish farming               |
| Animal farming             |
| Agricultural drying        |
| Industrial process heat    |
| Snow melting               |
| Bathing and Swimming       |
| Geothermal heat pumps      |
| Other uses                 |

## 2. SYSTEM ARCHITECTURE

The IGA geothermal data are stored in PostgreSQL, the world's most advanced open-source Relational Database Management System (RDBMS), in a 'normalised' format (Codd 1970), and runs on a GNU-Linux server. The functionalities of the web application are provided by SpagoBI platform. SpagoBI is a complete suite for development of Business Intelligence project in an Open Source integrated environment.

## 3. WEB APPLICATION FUNCTIONALITIES

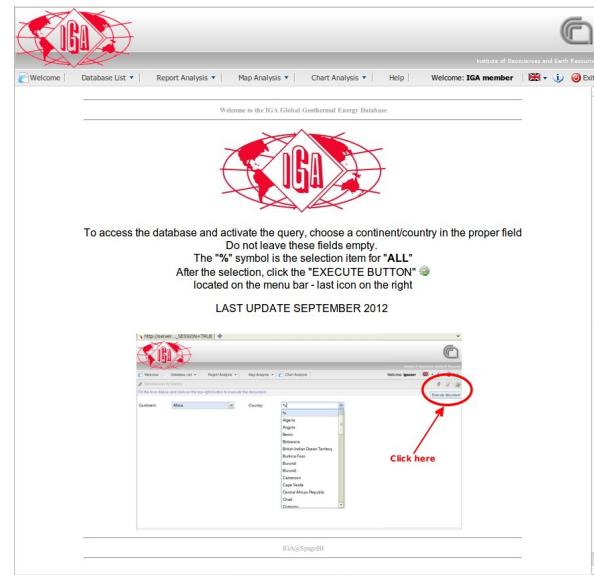
The database can be accessed from the IGA web site, following the navigation link "Geothermal Energy", then clicking "Geothermal Energy Database", or directly following the link:

[http://vmigg.iit.cnr.it/SpagoBI/servlet/AdapterHTTP?PAGE=LoginPage&NEW\\_SESSION=TRUE](http://vmigg.iit.cnr.it/SpagoBI/servlet/AdapterHTTP?PAGE=LoginPage&NEW_SESSION=TRUE).

On the login page you can either log in as visitor (user name: "visitor", password: "visitor") or as IGA member. Login as a visitor does not provide full access to the database list and the Google earth map in

the section map analyses. Once logged in, the navigation bar offers the following options, see Fig.1:

- i) Database list,
- ii) Report analysis,
- iii) Map analysis,
- iv) Chart analysis,
- v) Online help described below.



**Figure 1: Welcome page of the IGA Global Geothermal Energy Database, the navigation bar is visible under the banner at the top.**

### 3.1 Database list

This function allows the access to information in the following list format:

- geothermal fields and plants by country,
- direct use by country or by category,
- geothermal turbine manufactures (see Fig. 2),
- geothermal companies.

The screenshot shows a table titled 'Manufacturer' with columns: Company Name, Nation, Installed Unit, and Installed Capacity [MW]. The data includes entries for Alstom, Areva, Associated Electrical Industries, Barber Nichols Inc, British Thompson Houston, Elliot, Enex, Fag, General Electric, Nuevo Pignone, GMK, Harbin, Kaluga Turbine Works, Kvaerner, MHI, Makrotok, Mitsubishi, ORMAT, Parsons, Peter Brotherhood, Qizheng, Siemens, Toshiba, UTC, and Worthington. The total capacity for the table is 1547.5 MW.

| Manufacturer                     |             |                |                         |      |
|----------------------------------|-------------|----------------|-------------------------|------|
| Company Name                     | Nation      | Installed Unit | Installed Capacity [MW] |      |
| Alstom                           | France      | 11             | 154.7                   |      |
| Areva                            | France      | 72             | 155.7                   |      |
| Associated Electrical Industries | New Zealand | 3              | 98.0                    |      |
| Barber Nichols Inc               | USA         | 4              | 2.3                     |      |
| British Thompson Houston         | UK          | 8              | 81.6                    |      |
| Elliot                           | New Zealand | 3              | 12.5                    |      |
| Enex                             | Iceland     | 2              | 1.1                     |      |
| Fag                              | Denmark     | 61             | 2423.4                  |      |
| General Electric                 | USA         | 23             | 532.5                   |      |
| Nuevo Pignone                    | Italy       | 1              | 0.2                     |      |
| GMK                              | Germany     | 2              | 11.3                    |      |
| Harbin                           | China       | 1              | 81.9                    |      |
| Kaluga Turbine Works             | Russia      | 11             | 3.5                     |      |
| Kvaerner                         | Norway      | 3              | 15.5                    |      |
| MHI                              | Japan       | 6              | 72.0                    |      |
| Makrotok                         | Mexico      | 1              | 5.0                     |      |
| Mitsubishi                       | Japan       | 100            | 2881.8                  |      |
| ORMAT                            | Israel      | 175            | 1234.1                  |      |
| Parsons                          | New Zealand | 1              | 5.0                     |      |
| Peter Brotherhood                | UK          | 1              | 0.0                     |      |
| Qizheng                          | China       | 9              | 62.0                    |      |
| Siemens                          | Germany     | 2              | 3.6                     |      |
| Toshiba                          | Japan       | 44             | 2746.2                  |      |
| Turbine Air System               | USA         | 2              | 8.4                     |      |
| UTC                              | TurboGen    | USA            | 58                      | 18.3 |
| Worthington                      | USA         | 1              | 14.4                    |      |

Figure 2: Data Base List for Turbine Manufacturer.

### 3.2 Report analysis

This function produces several standard reports; one of the most important is the power plants, according to their operational status by country, with evaluation of the partial values (see Fig. 3 for an example. The total values of a country are in blue) and the Grand Total values (see in Fig. 4 the Grand Total calculated for all the items in red) of the installed capacity and produced energy, as well as the number of units.

### 3.3 Map analysis

The World maps show the location of geothermal fields and power plants; direct uses are associated to the country itself. It is possible to select a country or to load a WMS map to overlay the map. The control panel allows the user to select different background layers and activate the one named 'Overlay' to visualise some information of the IGA database. Moreover, the 'Analysis' option let the user select the indicator field, the classification method, the number of classes and their display colour, see Fig. 5.

The screenshot shows a table titled 'Geothermal Plants in Operation by Categories' for Australia. The data includes entries for Birdsville, QLD and Innamincka, SA. The table has columns: Geothermal Field, Plant Name, Unit, COD, Typology, Field Owner, Plant Owner, Manufacturer, Installed Capacity [MW], Running Capacity [MW], and Produced Energy [GWh/year]. Summary rows for Birdsville, QLD and Innamincka, SA provide total values for capacity and energy.

| Geothermal Field  | Plant Name | Unit | COD  | Typology | Field Owner  | Plant Owner  | Manufacturer      | Installed Capacity [MW] | Running Capacity [MW] | Produced Energy [GWh/year] |
|---|------------|------|------|----------|--------------|--------------|-------------------|-------------------------|-----------------------|----------------------------|
| <b>Australia</b>  |            |      |      |          |              |              |                   |                         |                       |                            |
| Birdsville, QLD   | Birdsville | 1    | 1992 | Binary   | Ergon Energy | Ergon Energy |                   | 0.1                     | 0.0                   | 0.5                        |
| <b>Birdsville, QLD Total Installed Capacity [MW]</b>    |            |      |      |          |              |              |                   |                         |                       | 0.1                        |
| <b>Birdsville, QLD Total Produced Energy [GWh/year]</b> |            |      |      |          |              |              |                   |                         |                       | 0.5                        |
| <b>Birdsville, QLD Total Number of Units</b>            |            |      |      |          |              |              |                   |                         |                       | 1                          |
| Innamincka, SA  | Habanero   | 1    | 2009 | Binary   | Geodynamics  | Geodynamics  | Peter Brotherhood | 1.0                     | 0.0                   | 0.0                        |
| <b>Innamincka, SA Total Installed Capacity [MW]</b>     |            |      |      |          |              |              |                   |                         |                       | 1.0                        |
| <b>Innamincka, SA Total Produced Energy [GWh/year]</b>  |            |      |      |          |              |              |                   |                         |                       | 0.0                        |
| <b>Innamincka, SA Total Number of Units</b>             |            |      |      |          |              |              |                   |                         |                       | 1                          |
| <b>Australia Total Installed Capacity [MW]</b>          |            |      |      |          |              |              |                   |                         |                       | 1.1                        |
| <b>Australia Total Produced Energy [GWh/year]</b>       |            |      |      |          |              |              |                   |                         |                       | 0.5                        |
| <b>Australia Total Units</b>                            |            |      |      |          |              |              |                   |                         |                       | 2                          |
| <b>Austria</b>  |            |      |      |          |              |              |                   |                         |                       |                            |

Figure 3: Geothermal plants in Operation by category report, in blue the result of the country total query.

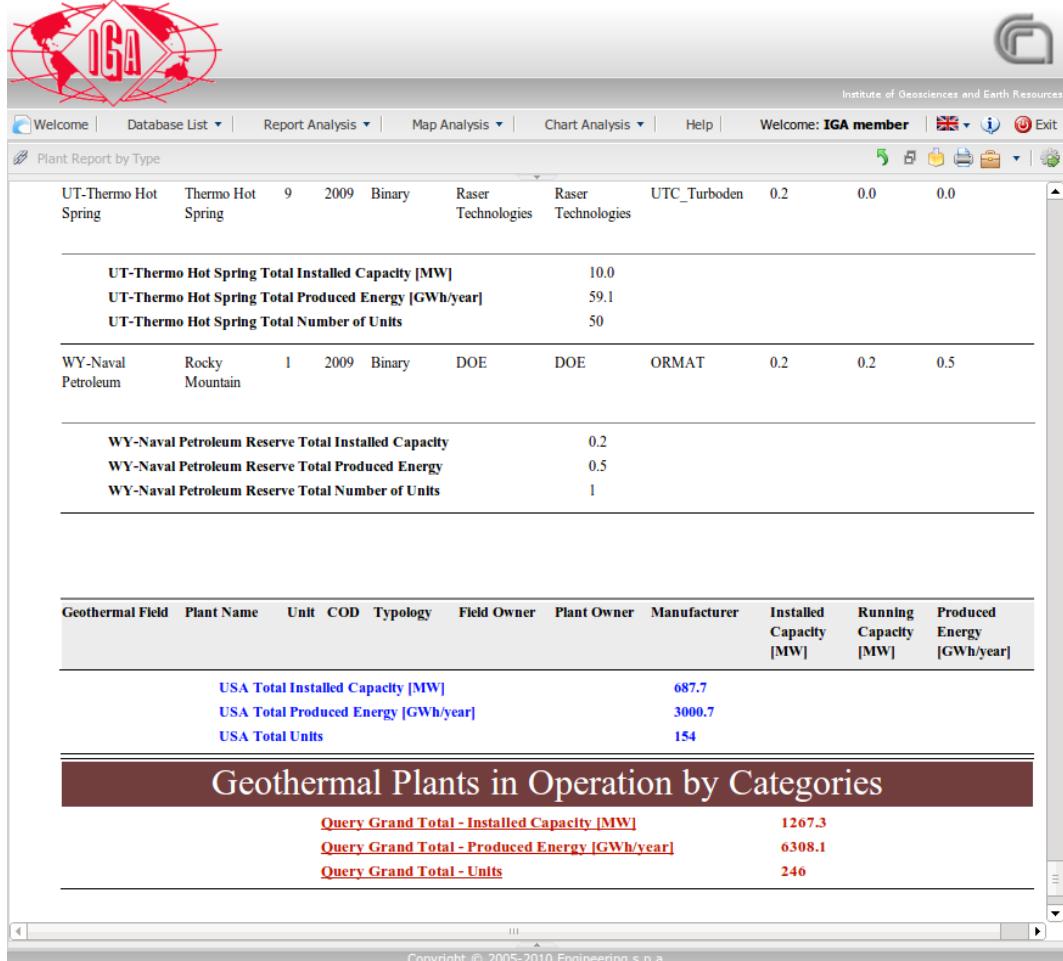


Figure 4: Geothermal plants in Operation by category report, in red the result of the grand total query.

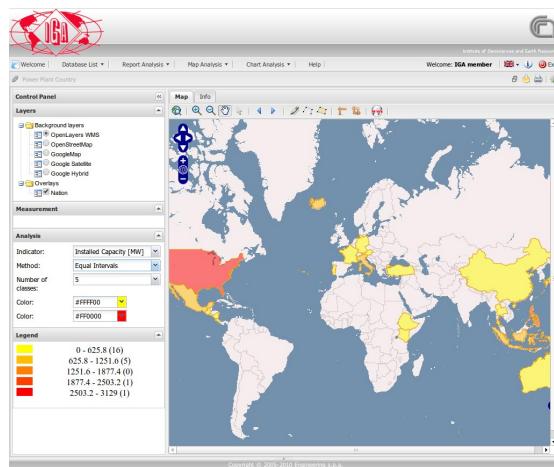


Figure 5: Installed Capacity classified by 5 classes.

By clicking on the country (or on the circle representing the geothermal fields), a balloon showing some detailed information is visualised, see Fig. 6. The user can also follow the link 'Details' (in blue) or

the tab 'Info' (above the map tools) to load the table containing some further information, see Fig. 7.



Figure 6: Info balloon containing some main details of the country clicked.

Figure 7: Information table related to the investigated country.

### 3.4 Chart analysis

This function produces standard graphical output of the installed capacity and the produced energy, sorted by:

- plant owner,
- field owner,
- manufacturer,
- country.

By this application it is possible to select (or deselect) one indicator using the check box and the 'Apply' button. When the chart has many values on the X-axis, a sliding bar may appear at the bottom of the chart, and the user can move on the right or on the left to browse the chart information, see Fig. 8.

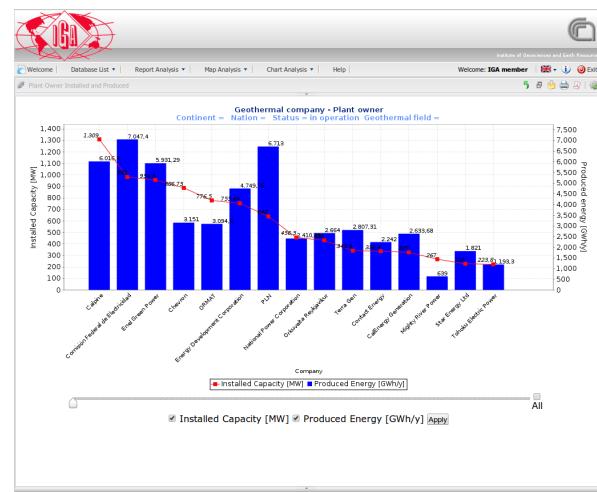


Figure 8: Plant Owner chart, in red the installed capacity, in blue the produced energy.

The help function provides the database querying instructions and explains the tools of the menu bar.

#### 4. CONCLUSIONS

This web-based database is an important example of organisation and access to widely distributed data, and allows analysing, synthesising and quickly interpreting stored data.

The collected data of electricity production by geothermal power plants and by direct use of the geothermal heat on a global scale makes the IGA geothermal database unique in its public form. Furthermore, the geographical distribution, such as the geothermal fields location, increase the quality of this data collection.

The database, in its public form and even more for IGA members, provides an important source of information regarding the use of geothermal resources around the world, which is useful for the energy policy planning and exploitation programming.

#### REFERENCES

Codd, E.F.: A relational model of data for large shared data banks. Communications of the Association of Computing Machinery 13 (6), (1970), 377-387.

Dickson, M. H. and Fanelli, M.: Geothermal energy. Utilisation and technology. UNESCO Publishing, Paris, France, (Eds.) (2003), 205 pp.

SpagoBI documentation

<http://spagobi-info.eng.it/SpagoBISiteITA/target/docs/index.html>, [accessed 12 April 2010]

SpagoBI web-site

<http://www.spagobiworld.org/xwiki/bin/view/SpagoBI/>  
[accessed 05 April 2010]

PostGIS reference

<http://postgis.refractions.net/documentation/manual-1.5/>  
[accessed 01 February 2010]

PostGIS web-site <http://postgis.refractions.net/>  
[accessed 01 February 2010]

PostgreSQL references

<http://www.postgresql.org/docs/8.3/interactive/index.html>  
[accessed 01 february 2010]

PostgreSQL web-site <http://www.postgresql.org/>  
[accessed 01 February 2010]

SpagoBI wiki, the place where you can find useful information on SpagoBI

<http://wiki.spagobi.org/xwiki/bin/view/Main>  
[accessed 15 April 2010]