Panorámica sobre la energía geotérmica en Italia

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Italy is a small country
but Italian geothermal power production is large from Bertani, WGC 2015
Geothermal power production in Italy

Italy is the 6th country in the world for installed power capacity, with two main geothermal areas, Larderello-Travale and Mt. Amiata.

916 MW of the 2.13 GW of European installed capacity comes from Italy.

In the 1960s the power industry was nationalised and all of these plants are still owned by the former government utility, now privitized: Enel (see next presentation)
Larderello, the first place in the history to produce geothermal power, is today the 4° geothermal field in the world for power production

from Bertani, WGC 2015
A favourable geological condition

The complex geodynamical framework, related to the convergence of Africa and Eurasia plates, is evidenced by young volcanisms, rift structures, shallow Moho discontinuity and reduced lithosphere thickness due to uprising asthenosphere and the delamination of crustal lithosphere in the western, Tyrrenian areas of Italy, and the thick orogenic belts of Appenines and Alps.
produce a high heat flow

Estimated Italian geothermal resources potentially harnessable within 5 km depth are in the range of 21 exajoule (about 500 MTOE) (UGI 2011).
Factor inducing strong lateral T changes at shallow depths

- high sedimentation rate (green)
- meteoric water infiltration (blue)
- geothermal low T convective systems (yellow and violet)
- volcanic areas and high T systems (orange)

**DATASET:**
- 2700 T grad. meas. (700 HF offshore),
- 255 new ENI boreholes (1980-96)

Est. Error: 5-20 mW m^-2

(Della Vedova et al., 2001)
- Predicted HF is significantly higher in South Apennines, Po basin, foreland areas
- Undisturbed HF in foreland is 45-55 mW m\(^{-2}\), compared to obs. 30-40 mW m\(^{-2}\)
- This implies higher deep contributions and transient components in these areas, suggesting younger tectonic ages
- The difference between N and S Apennines is less pronounced
- The deep thermal regime of Tuscany, Tyrrhenian Sea, Apennines and foredeep areas has not yet reached equilibrium
In 2010 geothermal resources were made available to private investors for electricity production, by introducing a competitive permit system. About 110 ‘research’ exploration permits were requested, and some tens were granted to mainly small renewable energy or geological consulting companies.
Main offshore volcanic areas
While some of the granted permits have progressed through initial geological studies and geophysical surveys, none have yet progressed to exploratory drilling and detailed resource assessment, despite encouraging initial results.

Main reasons:
- lack of sufficient finance to face drilling costs and risk
- lack of appropriate regulatory schemes and energy policies
Cumulated capacity of geothermal energy in the EU countries

From EurObserver 2007

- Power production
- Direct uses
- GSHP
Geothermal Heat production in Italy

<table>
<thead>
<tr>
<th>Sector of application</th>
<th>Capacity (MWt)</th>
<th>Energy/TJ/y</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>GSHP</td>
</tr>
<tr>
<td>Space heating</td>
<td>725</td>
<td>550</td>
</tr>
<tr>
<td>Thermal balneology</td>
<td>421</td>
<td></td>
</tr>
<tr>
<td>Agricultural use</td>
<td>69</td>
<td>14</td>
</tr>
<tr>
<td>Fish farming</td>
<td>122</td>
<td></td>
</tr>
<tr>
<td>Industrial process heat and minor uses</td>
<td>18</td>
<td>4</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>1355</strong></td>
<td><strong>568</strong></td>
</tr>
</tbody>
</table>

Direct Uses total 11,065 TJ/y
Space heating is in rapid expansion, in particular GSHP systems (increase of 120% in four year for GSHP and 16% by DH)

Most DHs are in geothermal power production areas.

Geothermal DH using deep wells are in:
• Ferrara in expansion
• Grado in development
• Vicenza proposed-in development

GSHP DH are expanding in Lombardia (Milano, Brescia)
On 2011 UGI (Unione Geotermica Italiana) made a study to estimate the possible contribution of the Earth’s heat to the coverage of national energy requirements by 2030, with steps by 2012, 2015, 2020, 2025 to be periodically updated.

The end goal of the study was to provide the Italian Government with factual elements on the possible medium-term deployment of this energy source in Italy.

**Scenario I**: current economic trend, use of mature production technologies, and prices of crude oil at source roughly three times higher than the average ones in 2010

**Scenario II**: economic trend driven by vigorous environmental policies, use of both mature and advanced production technologies, and prices of crude oil at source roughly four times higher than the average ones in 2010
Produzione lorda (TWh/a)

<table>
<thead>
<tr>
<th>Anno</th>
<th>Scenario 1</th>
<th>Scenario 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>5.3</td>
<td>6.0</td>
</tr>
<tr>
<td>2012</td>
<td>5.6</td>
<td>6.1</td>
</tr>
<tr>
<td>2015</td>
<td>6.0</td>
<td>6.9</td>
</tr>
<tr>
<td>2020</td>
<td>6.9</td>
<td>7.3</td>
</tr>
<tr>
<td>2025</td>
<td>8.0</td>
<td>9.5</td>
</tr>
<tr>
<td>2030</td>
<td>9.4</td>
<td>12.0</td>
</tr>
</tbody>
</table>
Produzione (TJ/a)

Scenarion I  | Scenarion II
---|---
2010: 12.600 | 14.700
2012: 14.430 | 17.930
2015: 19.040 | 26.350
2020: 30.660 | 51.700
2025: 40.500 |
2030: 65.200 |
Benefits expected from geothermal development

Technical and environmental benefits:
• Savings in terms of oil-equivalent (3.35-4.44 MTOE by 2030)
• Avoided CO₂ emissions (9.76-12.82 MT by 2030)
• Contribution to coverage of total energy consumption (1.5-2% by 2030, the actual value is 0.7%)

Economic-social and scientific benefits:
• New permanent jobs (100,000-200,000 new jobs by 2030)
• New investments (1,200-2,000 M€ by 2030)
• New R&D, in particular to develop unconventional geothermal systems
Measures at national and institutional level

- strong commitment by Government, political parties and institutions to enacting legislation in support of renewables (RES) and, in particular, of geothermal energy;
- National Energy Plan (NEP) including goals of development of all RES until 2030;
- secure and prolonged incentives for RES with no or minimum environmental impact;
- national legislation and specific guidelines aimed at harmonizing regional regulations on geothermal development;
- R&D programs with project objectives targeted at each RES;
- a special R&D project focused on “non-conventional geothermal systems”, to be implemented within 2020;
- systematic campaigns to build awareness among the public at large of the economic and environmental advantages of the Earth’s heat.
Measures at local and regional level

- Regional energy plans for all Italian Regions, quantitative targets for each RES, including geothermal, and relying on regulations specifically tailored to the development of direct uses;
- Regional surveys of energy-intensive areas in order to assess heat demand and quantify the expected share from geothermal development;
- Comparative market studies on demand for low temperature heat;
- Quantification of CO₂ emissions from the different sources of energy used for space heating;
- Replacement of old heating systems in at least half of public buildings with systems using RES and in particular natural heat;
- Financial incentives for installation of geothermal heating & cooling systems in new large buildings;
- Training of geothermal heat pump designers, installers and maintenance operators;
- Campaigns in schools to raise awareness of the Earth’s heat and its advantages.
Main requirements

- A comprehensive identification of resources and opportunities, as well as an accessible collection of data and information
- A clear and easy to follow regulation for authorizations in the exploration, drilling and exploitation phases of the project
- The promotion and dissemination of technology, values, economics
- Research and technological development
Projects and efforts: VIGOR

Evaluation of Geothermal Potential for the Regioni Convergenza

An Agreement between the Ministry for Economic Development and CNR, funded in the frame of POI for RES, targeting at development of geothermal demonstration projects (power production and direct uses)
THE PRODUCTS OF VIGOR

Valutazione del potenziale geotermico, redazione di mappe di potenziale e distribuzione di temperatura a varie profondità

Valutazione di dettaglio mediante geofisica in Sicilia

Analisi regime autorizzativo nazionale e regionale

Studio di accettabilità sociale sulla geotermia

Prodotti editoriali con descrizioni generali e tecniche

Sito web per la pubblicazione del materiale

8 studi di fattibilità completi

Shallow geothermal potential (GSHP, closed loop)
SHALLOW GEOTHERMAL POTENTIAL

Fourier’s Law

\[ T_g = T_m + \frac{\Phi}{\lambda} \cdot \frac{L}{2} \]

L = 100 m

Thermal energy that can be exchanged by a unit volume of ground for a reference GSHP plant

www.vigor-geotermia.it
SHALLOW GEOTHERMAL POTENTIAL

Thermal conductivity

Heat flow

Surface temperature

Thermal energy that can be exchanged by a unit volume of ground

Ground (50 m depth) temperature

Thermal conductivity

Total borehole length needed to satisfy H&C demand of a reference house (100 m²)

www.vigor-geotermia.it
Economic Technical Potential \( [MW/km^2] \)

Technical Potential for LCOE < threshold (200 €/MWh power, 9 €/GJ heat) and using expected flowrate from a doublet system.

Geothermal Potentials for a lifecycle of 30 years and different Recovery Factors (GP = TC x R / 30 years).

Thermal Energy produced by a technology \( (TC = H \times \text{technology efficiency}) \) per unit volume.

H is the maximum theoretically extractable heat in the reservoir per unit volume (thickness = 100 m).
Levelized Cost Of Energy [LCOE, €/MWe, €/JG]

Calculated for power, district heating and direct heat uses

Depends on:
- Drilling cost (depth, stimulation, pump, ...)
- Economic lifetime
- Flowrate & temperature
- Power surface facilities (O&M, plant investiment, ...)
- Complementary electricity/heat sales
- Economic factors (inflation, interest rate on debit, tax)

<table>
<thead>
<tr>
<th></th>
<th>Power product.</th>
<th>District heating</th>
<th>Direct uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tmin</td>
<td>120</td>
<td>80</td>
<td>45</td>
</tr>
<tr>
<td>T-reinject</td>
<td>80</td>
<td>40</td>
<td>35</td>
</tr>
<tr>
<td>Economic Model</td>
<td>power</td>
<td>heat</td>
<td>heat</td>
</tr>
<tr>
<td>LCOE &lt;</td>
<td>200 €/MWe</td>
<td>9 €/GJ</td>
<td>9 €/GJ</td>
</tr>
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</table>

Flowrate depends on transmissivity, delta pressure applied at reservoir level and viscosity

Specific routines redistributes the permeability according to Montecarlo simulation

From transmissivity average on drilled interval, cumulative probability of expected flowrate is considered
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Heat in place

DH

DH&C

Power production

- Economic-technical potential for power production
- Saved oil
- Saved CO₂ emissions
Valutazione del potenziale geotermico, redazione di mappe di potenziale e distribuzione di temperatura a varie profondità

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MAIN RESULTS

Potential recovered in the four Regions, to balance the four Coverage of application (direct uses may cover wide sectors of the territory, creating the required wide involvement in terms of occupation, market, business)

- Complete system approach *(from data to regulation to feasibility)*;
- Cooperation *(Ministry-CNR and then CNR-research institutes and universities)*;
- Project management quality *(integrated approach environment/territories/technologies)*;
- Promotion of local uses, by comprehensive presentation of opportunities;
- Identification of proper financial opportunities, from incentives to financial support.
The Geothermal Atlas Project provided for the *favourability* assessment of conventional and unconventional geothermal resources in Central and Southern Italy.

- Geothermal favourability maps relies on available data and refer to a territory favourable and suitable to have the geothermal resource in the underground.
  - In this study, areas are classified as more or less favourable for the potential use of geothermal technologies for *power production*
- ≠ geothermal potential (energy)
- Many studies have been carried out in the last 10 years with different approaches (e.g. Pro Ledesma), we developed the one we considered more suitable to our geological conditions
Atlante Geotermico and its Favourability maps

Da: Trumpy et al. (2015)
Many opportunities and many barriers to a complete development

New research project (DESCRAMBLE for superhot systems)
Regulation in discussion, possibly in development and optimization
Energy policy in development, following EU trends

Global assessment of the territory
Social engagement
R&D
Dissemination and promotion
Gracias
por su atención