Geothermal energy in Italy: a long history and a variety of applications

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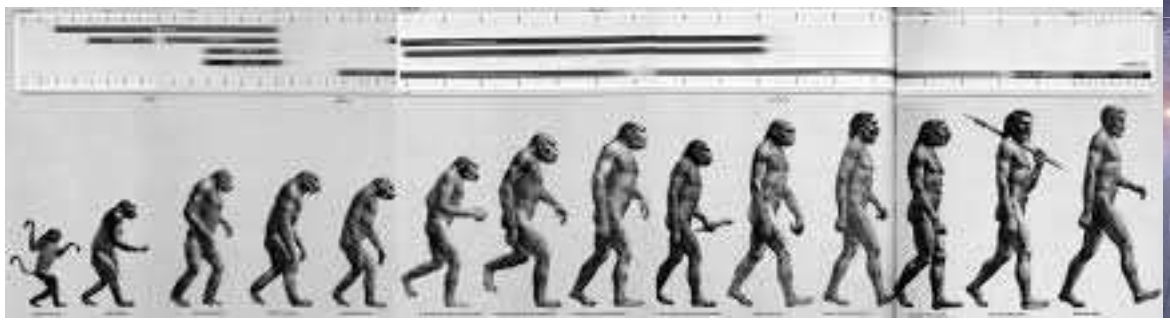
Some history



How can we date the first use of geothermal fluids?
Most probably Homo Sapiens was not the first to enjoy thermal waters…

Some history

Jigokudani (meaning “Hell’s Valley”) Monkey Park is a famous hot spring area near Nagano, Japan. It is famous for its large population of wild Snow Monkeys that go to the valley during the winter when snow covers the park to sit in the warm waters of the onsen (hot springs), and return to the security of the forests in the evenings.

Who wouldn’t???

Some history: Romans

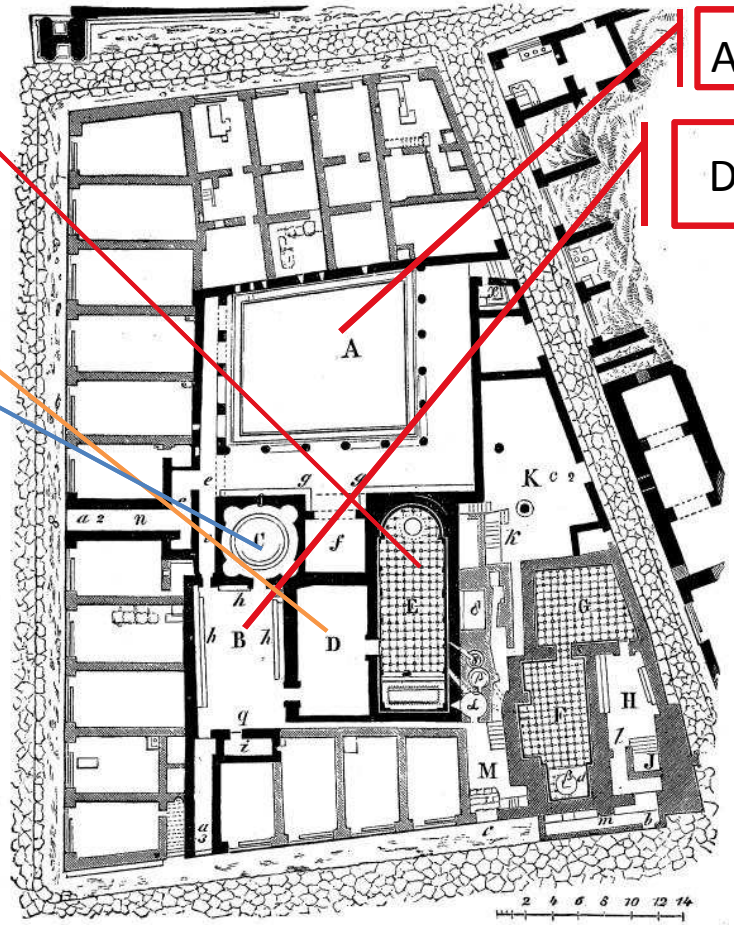
Baths for bathing and relaxing were a common feature of Roman cities throughout the empire. The often huge bath complexes included a wide diversity of rooms offering different temperatures and facilities such as swimming pools and places to read, relax, and socialise.

Public baths were a feature of ancient Greek towns but were usually limited to a series of hip-baths. The Romans expanded the idea to incorporate a wide array of facilities and baths became common and **public** in even the smaller towns of the Roman world, where they were often located near the forum.

In addition to public baths, wealthy citizens often had their own private baths constructed as a part of their villa.

Romans and their “thermae”

A public bath was built around three principal rooms: the caldarium (hot bath), the tepidarium (warm bath) and the frigidarium (cold bath). Some thermae also featured steam baths: the sudatorium, a moist steam bath, and the laconicum, a dry steam bath much like a modern sauna.
Baths sprang up all over the empire. Where natural hot springs existed (e.g in Bath, England, Băile Herculane, Romania or Serdica, Bulgaria) thermae were built around them. Alternatively, a system of hypocausta (from hypo "below" and kaio "to burn") were utilised to heat the piped water from a furnace (praefurnium).



Plan of the Old Baths at Pompeii. (Overbeck.)

Atrium

Dressing room

Some history

Romans were famous but didn't invent the baths.

Greek baths also employed heating system but, as was typical of the Romans, they took an idea and improved upon it for maximum efficiency. The huge fires from the furnaces sent warm air under the raised floor (*suspensurae*) which stood on narrow pillars (*pilae*) of solid stone, hollow cylinders, or polygonal or circular bricks. The floors were paved over with 60 cm square tiles (*bipedales*) which were then covered in decorative mosaics.

Some history: Romans

Romans took the idea of natural hot waters for healing and recreational purposes from Etruscans, who fighted Latins and were eventually absorbed by the Roman growing Republic in the III century BC.

Tuscany, the main etruscan area, and northen Latium were rich of hot springs and etruscan thermal baths.

Romans exported the idea of spas all over their large emperial area, but they were also looking for metals and precious elements, of which hydrothermal alterations are rich: thermal areas became interesting to conquer!

Some history: Renaissence

The decadence of Romans implied also the decadence of thermal bathing.
Direct use of geothermal fuids (as well as hygienic habits) reduced with time, and there is little to mention in Middle Age.

Spas were treated in a scientific way only starting in the Renaissance, when *De Thermis* book was published by Andrea Bacci (Venice, 1571).
The interest in spas and hydrothermal by-products (Borax, Allumen, Sulfur) then increased and proceeded till our time.


DE THERMIS
ANDREÆ BACCII
ELPIDIANI.
LIBRI SEPTEM.
OPUS LOCUPLETISSIMUM
IN QUO AGITUR
ACCESSIT NUNC LIBER OCTAVUS
EDITIO NOVISSIMA.
PATAVII. M. DCCXI.

After the succes of the first modern large spa in Bath, England (an old roman "therma") in 1827, large thermal districts were built in Ischia and Abano, and thermal industries has grown up to our time, providing a large contribution to italian turistic economy.

Some history: Larderello

The earliest industrial exploitation in the world began in 1827 in Larderello (Tuscany), Italy.
François Larderel, a french who arrived to Italy following Bonaparte's arms, had the idea to optimize the process for extracting the boric acid. Instead of burning the woods for heating and evaporating the naturally flowing waters, he and his brother invented a way to use the natural heat of the fluids extracted from the underground.

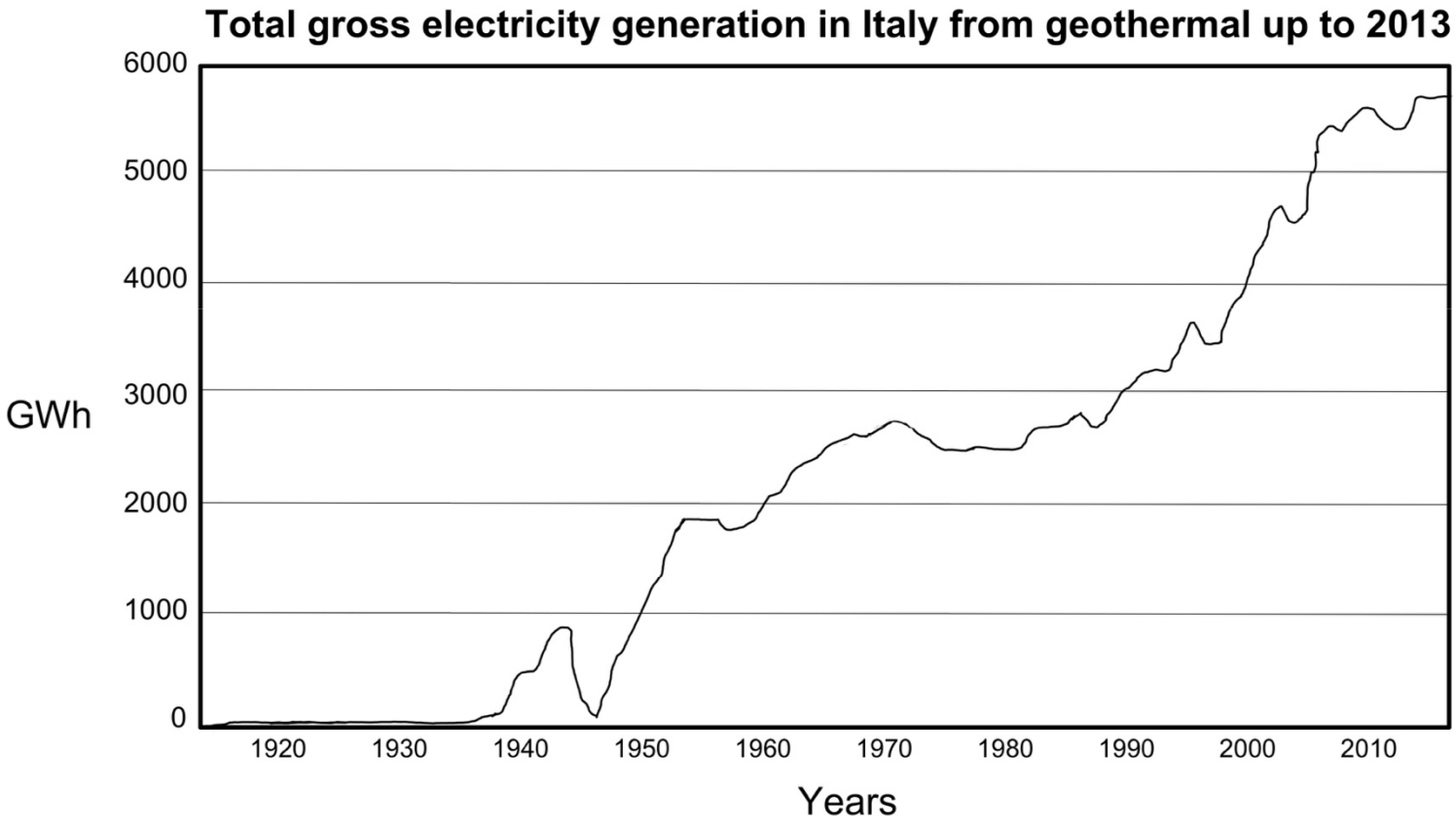
Larderello, an industrial and modern village, was born. Up to 1875 Larderello industry was the largest boric producer in the world.

Some history: power production

When boric acid was produced more economically in other areas of the world the economic crisis hit Larderello.

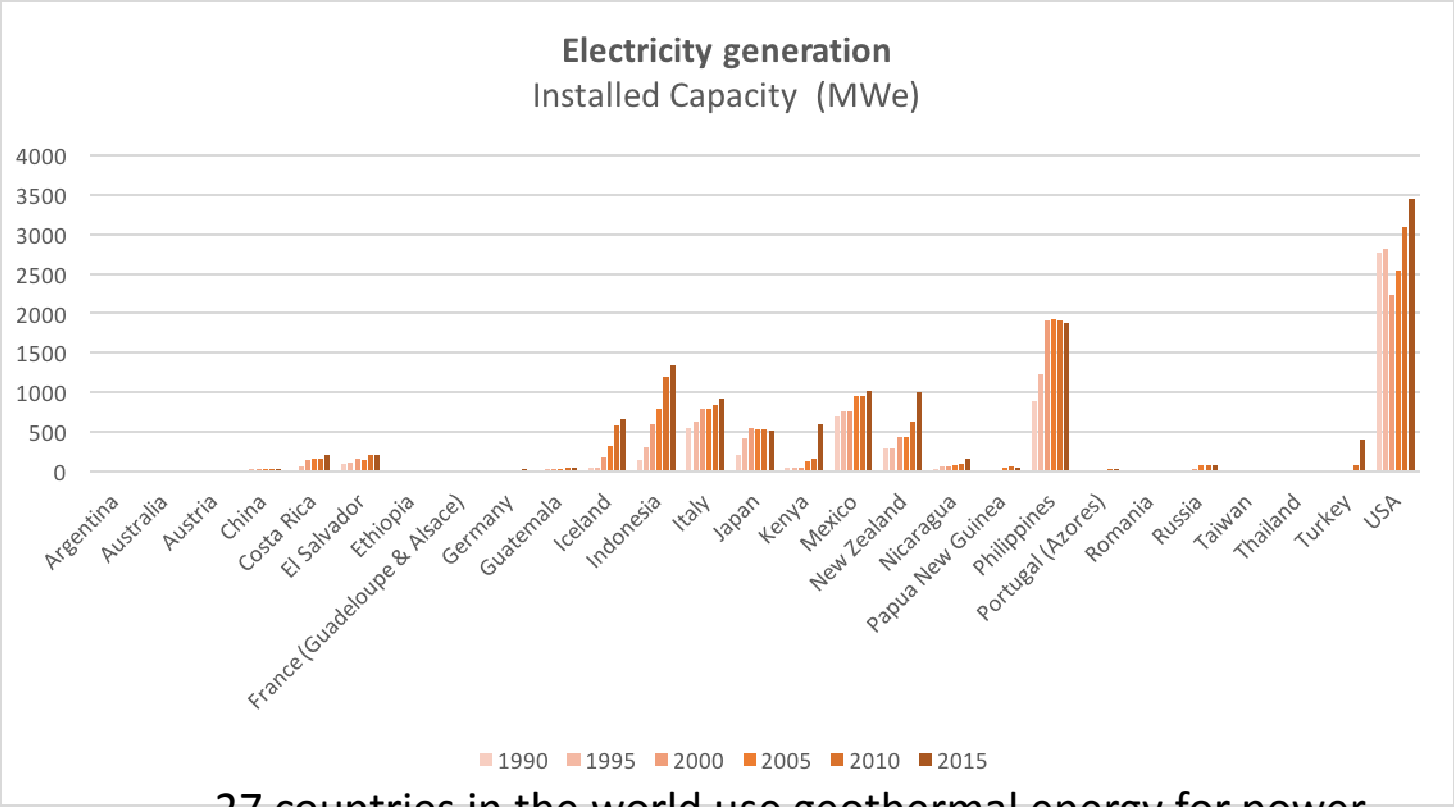
On 1904 prince Piero Ginori Conte (who married a descendent of Larderel) had the idea to use the thermal energy of the fluids to generate power. The first geothermal power production in the world then started in Larderello on 1913, with a capacity of 250 kW.

Some history



Since then power production increased, stopped only by the Second WW

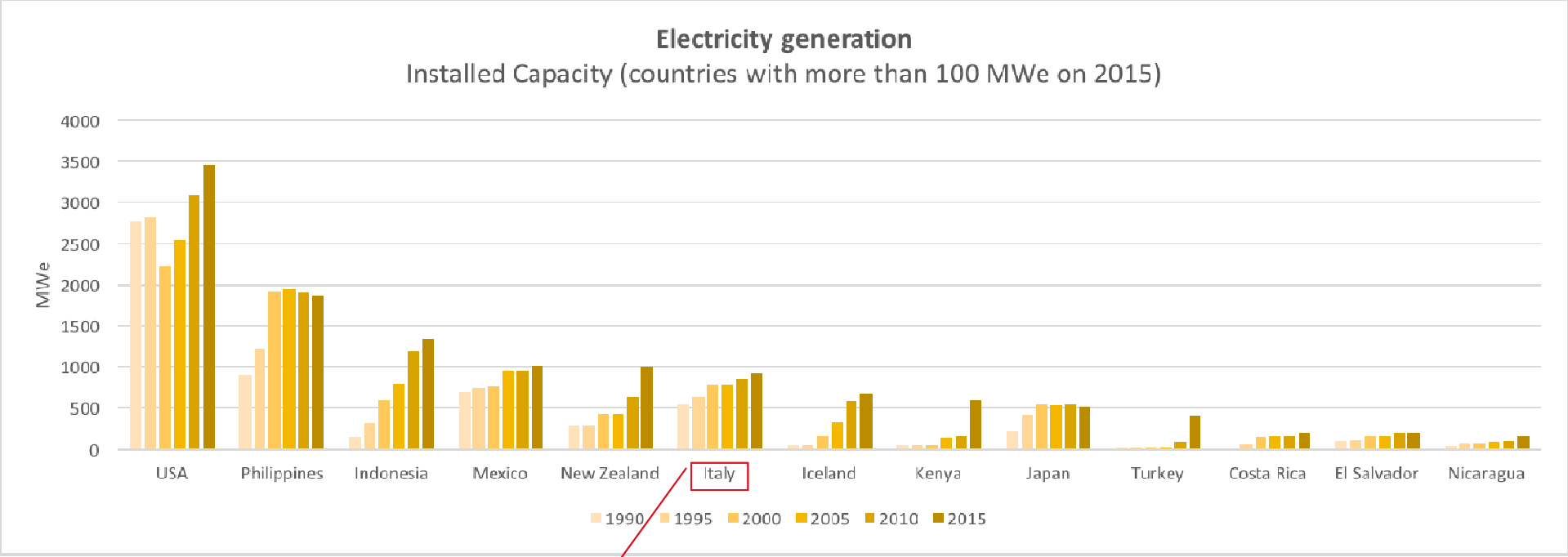
Power production



27 countries in the world use geothermal energy for power production (from WGC2015 data)

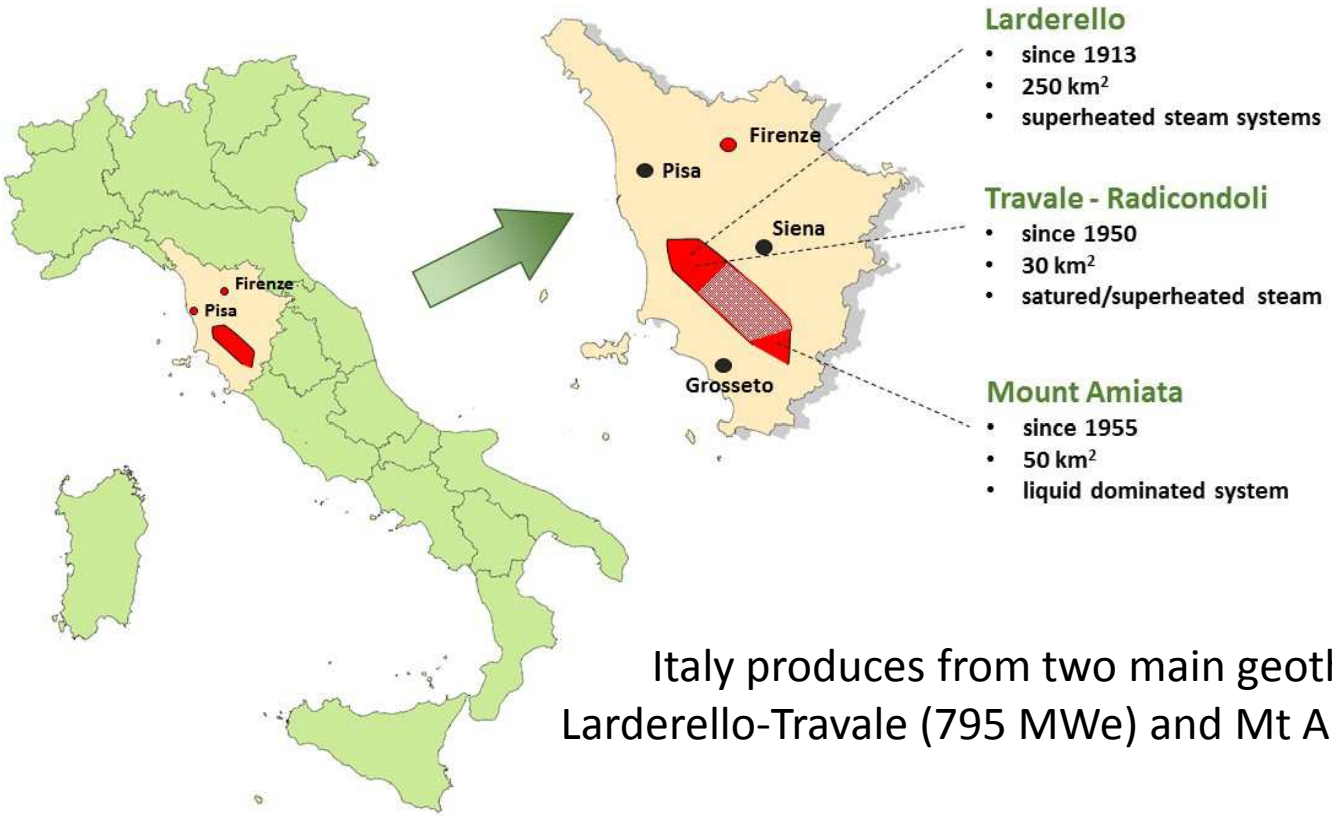
12.7 GWe

Power production



Italy is at the 6° position in the world for power production

Geothermal power production in Italy



Italy produces from two main geothermal areas, Larderello-Travale (795 MWe) and Mt Amiata (121 MWe).

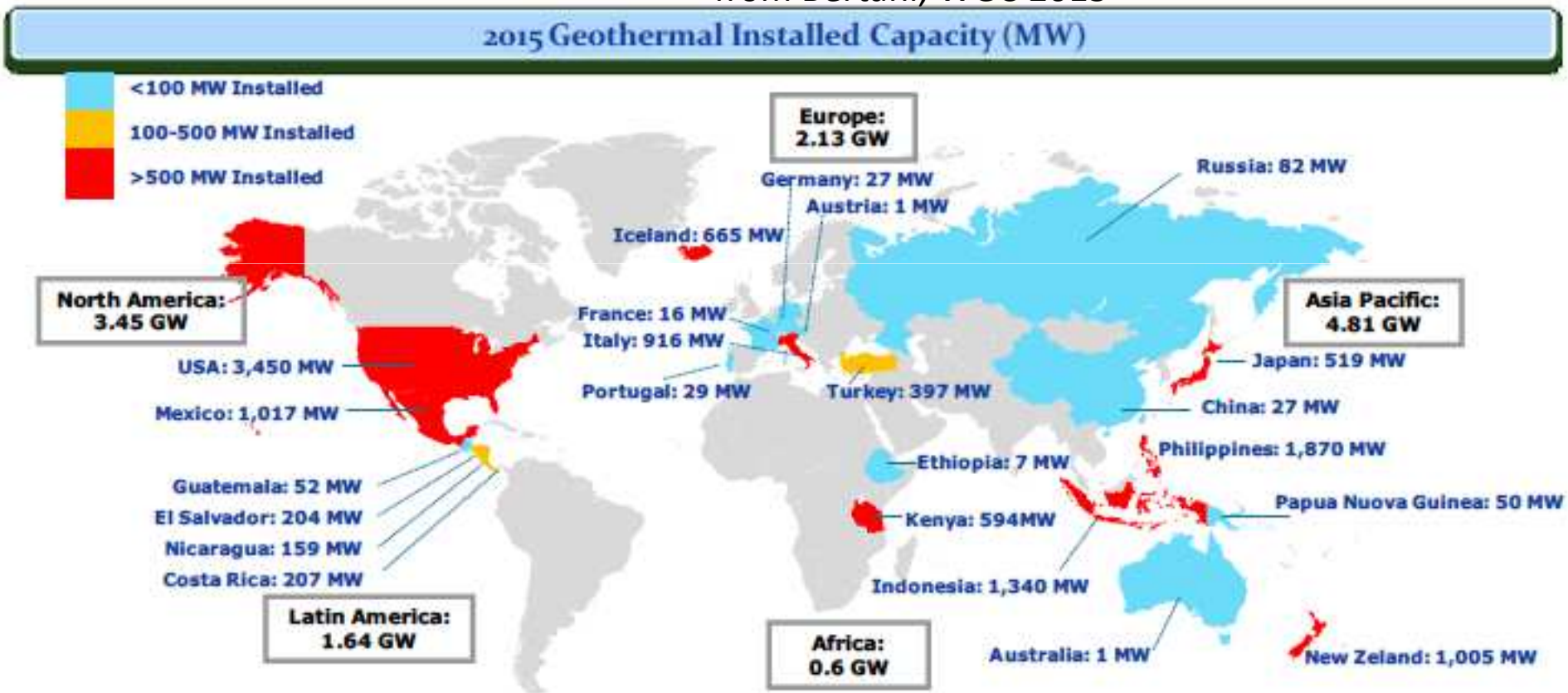
The first binary power plant in Italy was recently realized, on the liquid separated stream from the primary flash; the first hybrid project with a biomass heater has been launched, increasing the output power from 12 MWe to 17 MWe

Geothermal power production in Italy

- External color blends with landscape
- Architectural elements

Power production

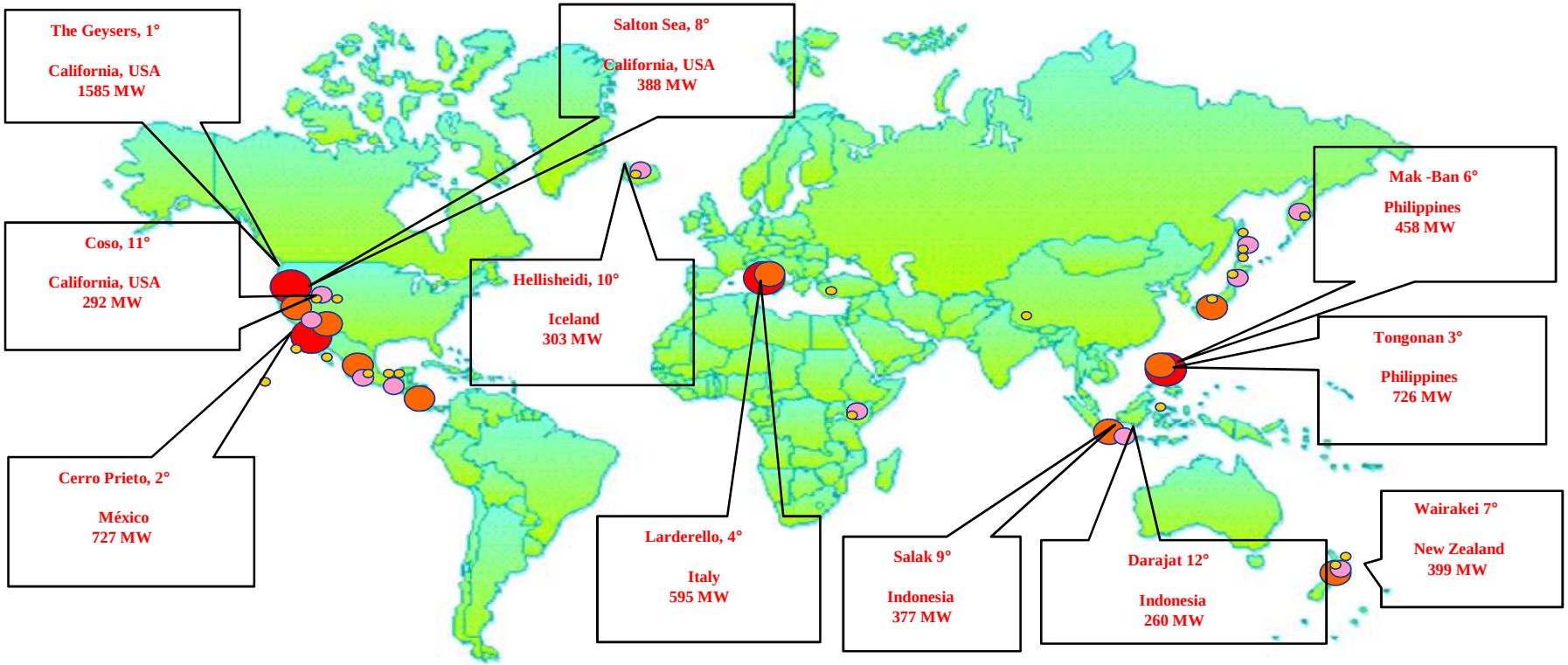
from Bertani, WGC 2015



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

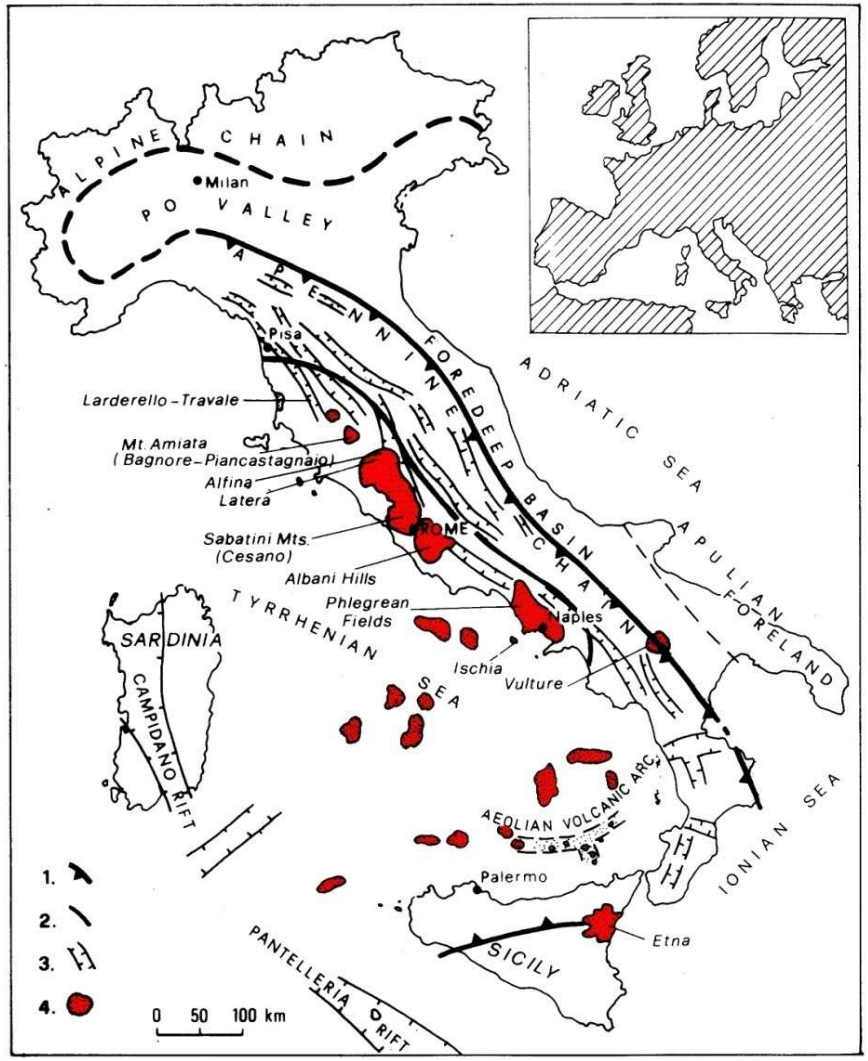
Power production

Larderello is today the 4° geothermal field in the world for power production



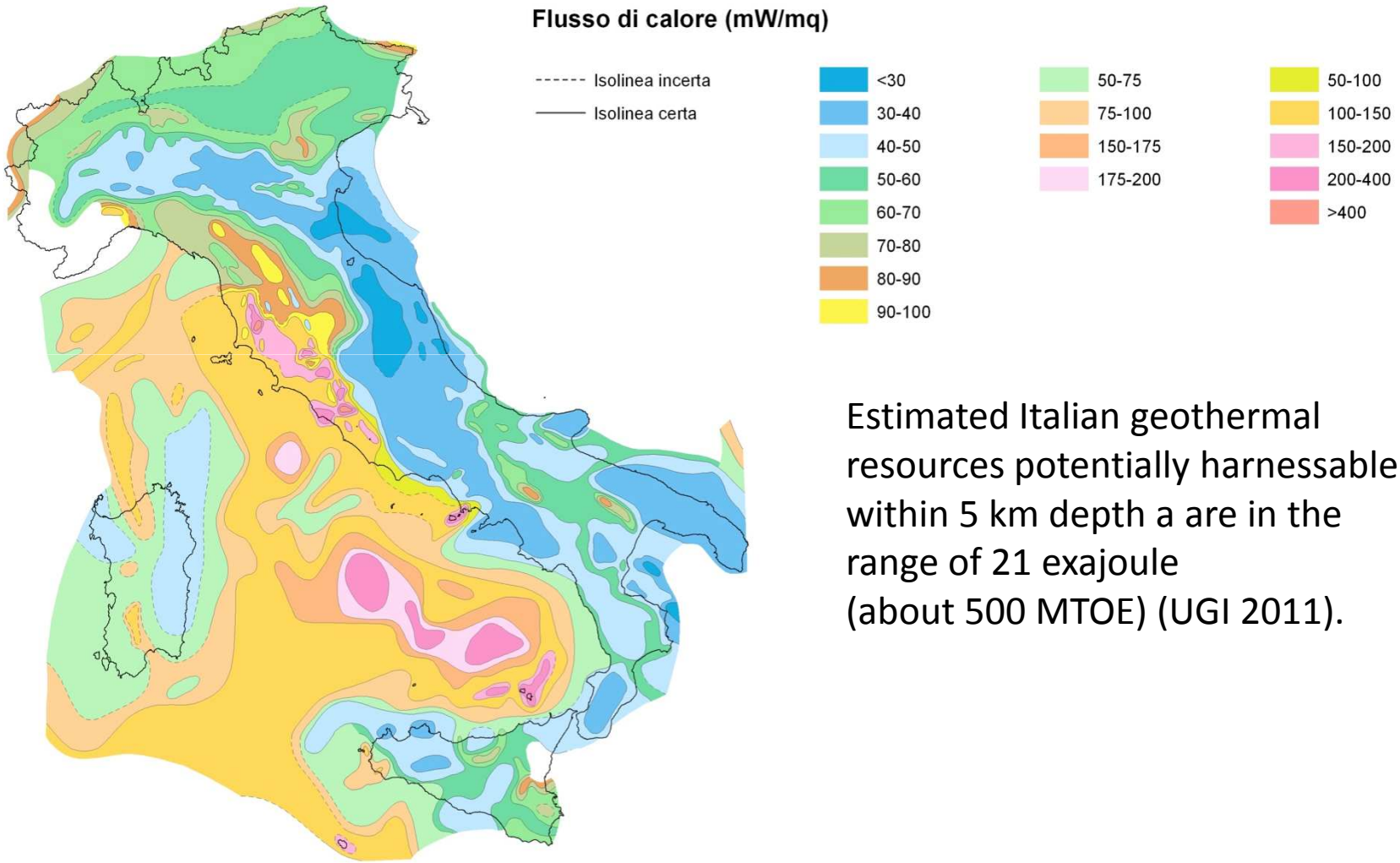
from Bertani, WGC 2015

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.

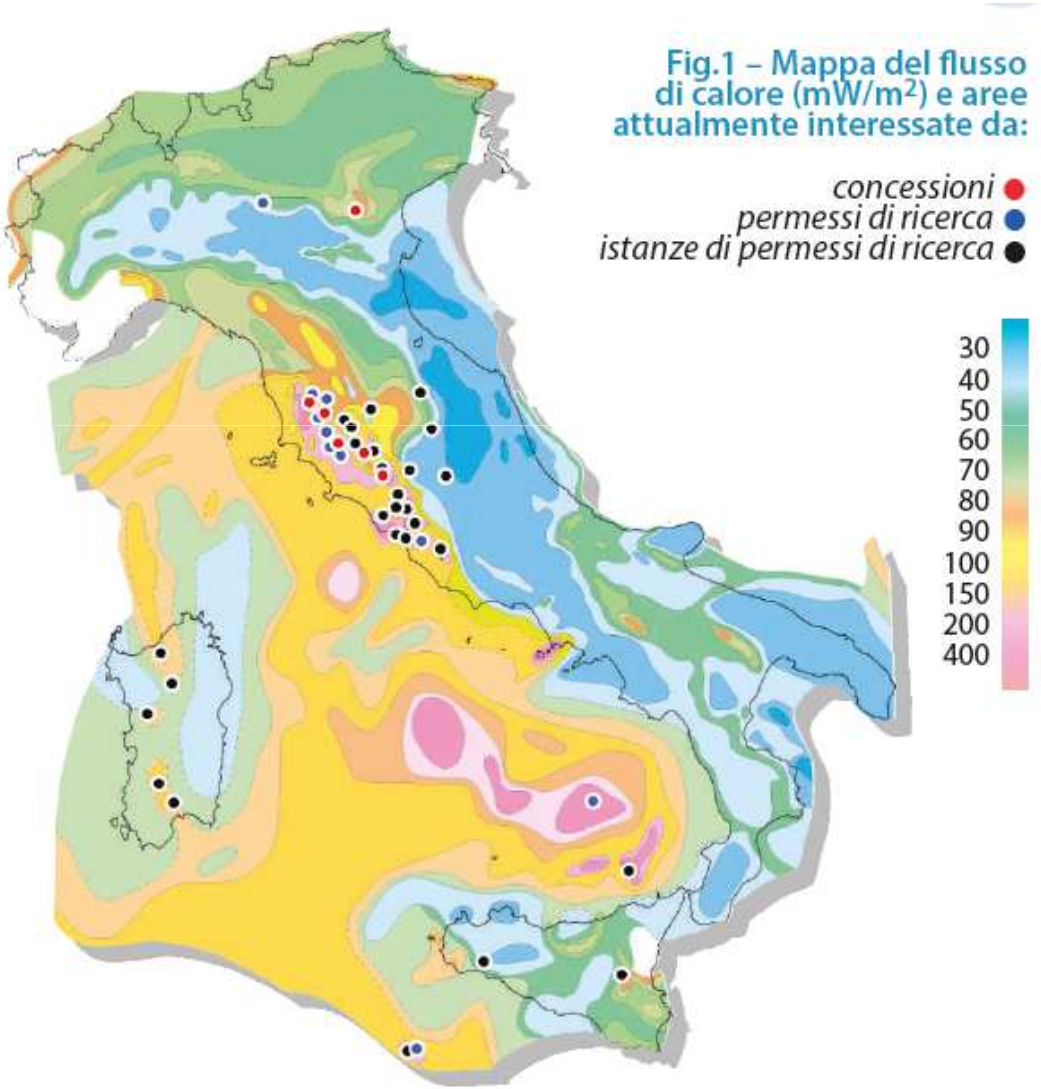
produce a high heat flow



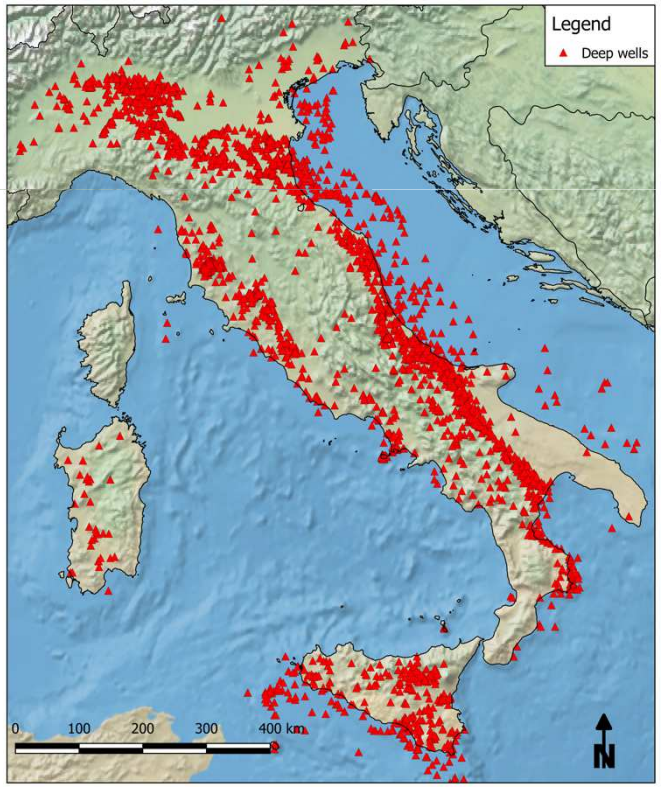
Estimated Italian geothermal resources potentially harnessable within 5 km depth a are in the range of 21 exajoule (about 500 MTOE) (UGI 2011).

Power production and CHP

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.



Estimated temperature at 2 km depth

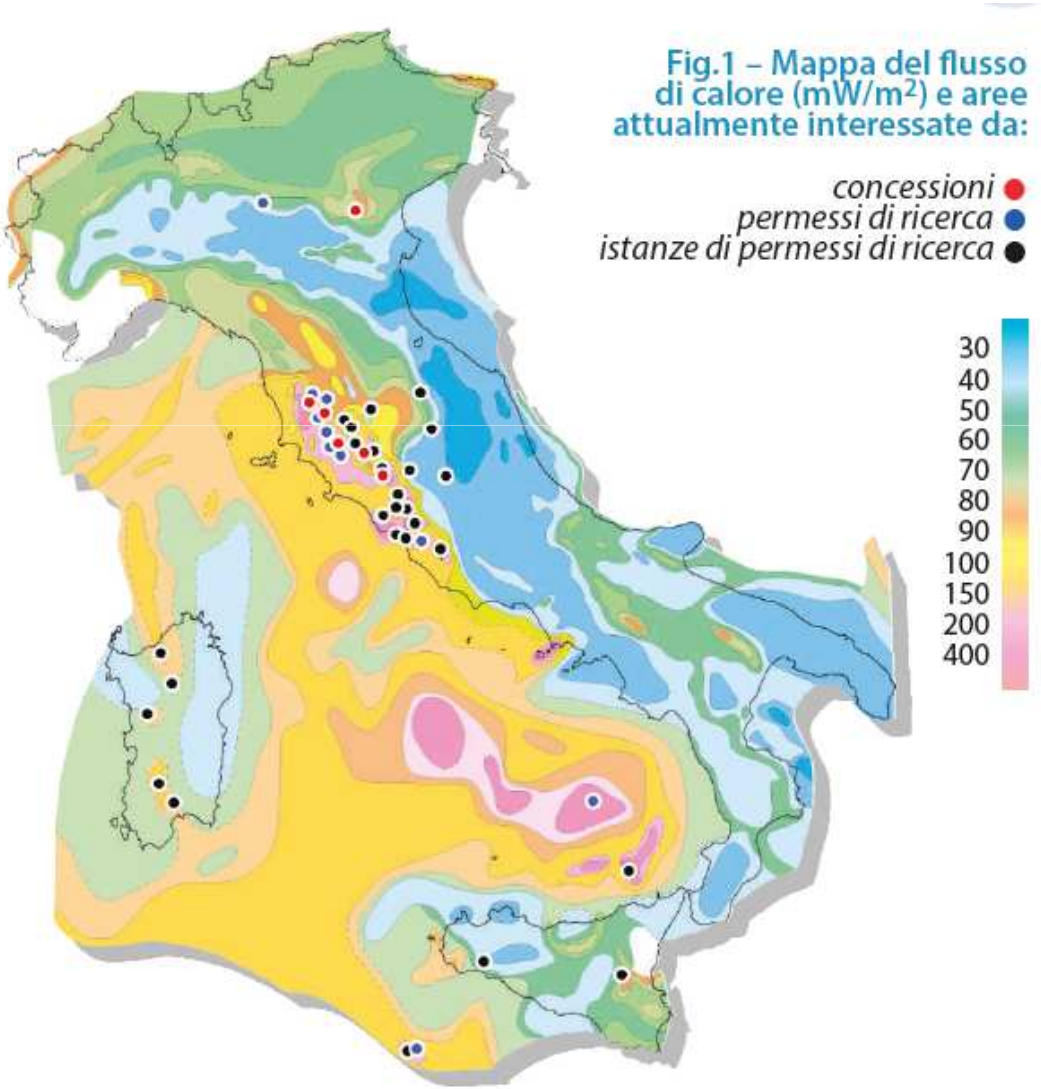


Direct information from the deep underground comes from deep wells, which are not evenly distributed.

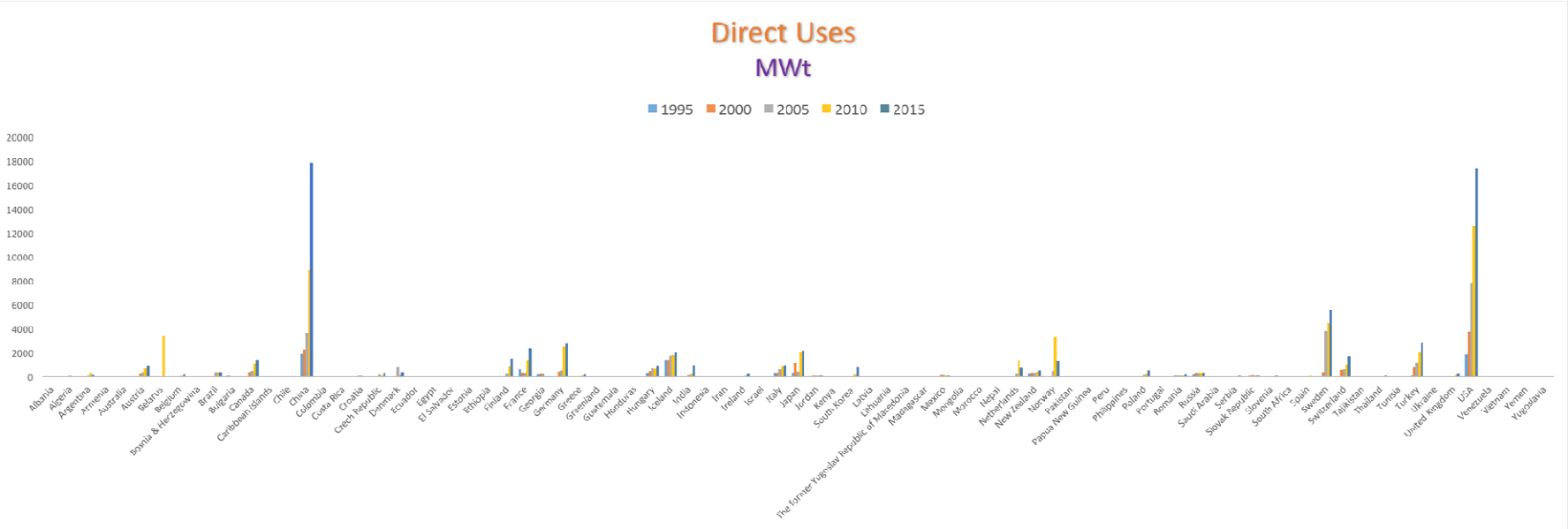
Main offshore volcanic areas

Power production and CHP

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.



Direct uses of heat

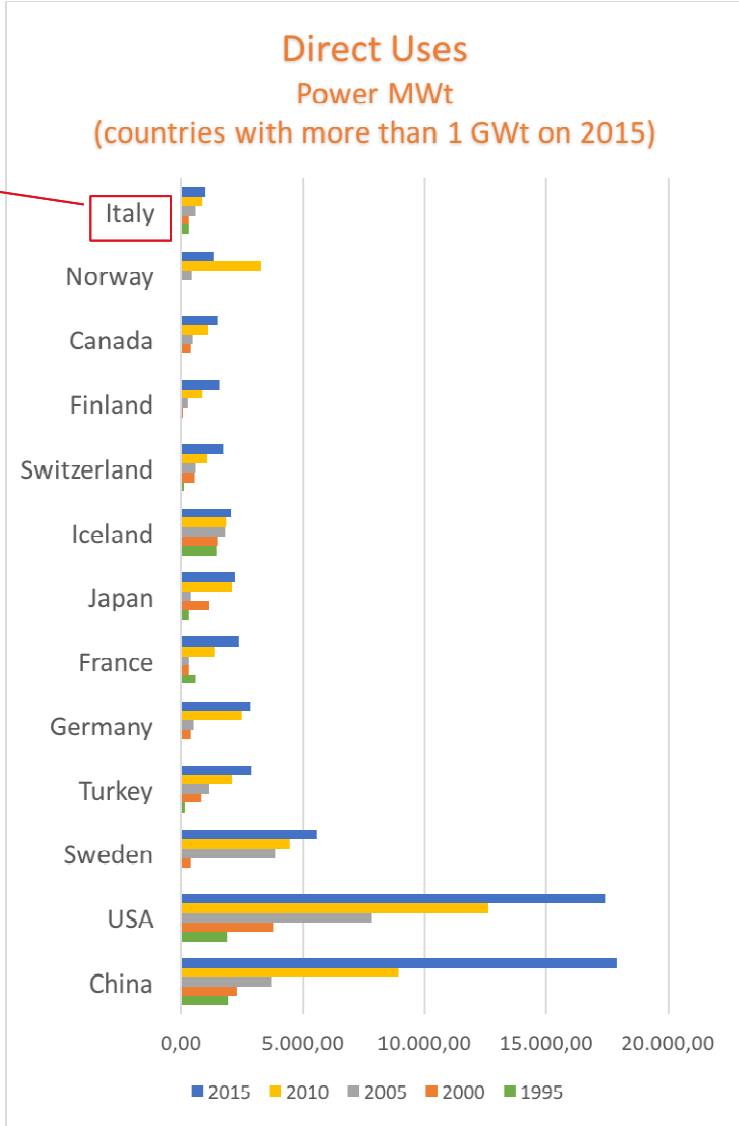


83 countries in the world use geothermal energy for direct use of heat (from WGC2015 data)

70.3 GWt

Direct uses of heat

Italy is at the 13° position in the world for thermal production



Space heating is in rapid expansion, in particular GSHP systems (increase of 120% in four year for GSHP and 16% by DH)

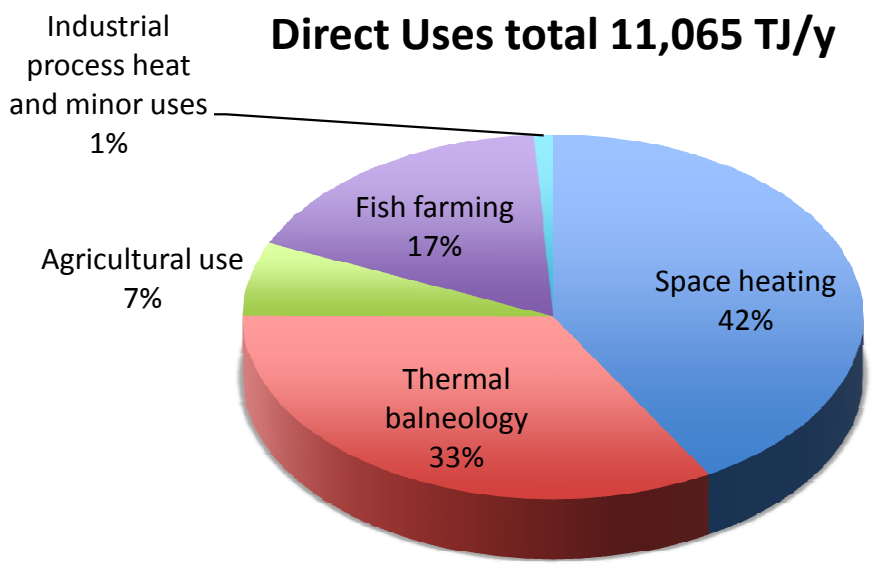
Most DHs are in geothermal power production areas.

Geothermal DH using deep wells are in:

- Ferrara in expansion
- Grado in development
- Vicenza proposed-in development

Direct uses of heat

Sector of application	Capacity (MWt)			Energy /TJ/y)		
	Total	***GSHP***	***DH***	***Total***	***GSHP***	***DH***
Space heating	725	550	92	4607	3211	683
Thermal balneology	421			3698		
Agricultural use	69	14		725	82	
Fish farming	122			1927		
Industrial process heat and minor uses	18	4		108	25	
TOTAL	**1355**	**568**	**92**	**11065**	**3318**	**683**



UNIONE GEOTERMICA ITALIANA

WGC2015

Direct uses of heat

37% of the heat is delivered to greenhouses

Perspectives

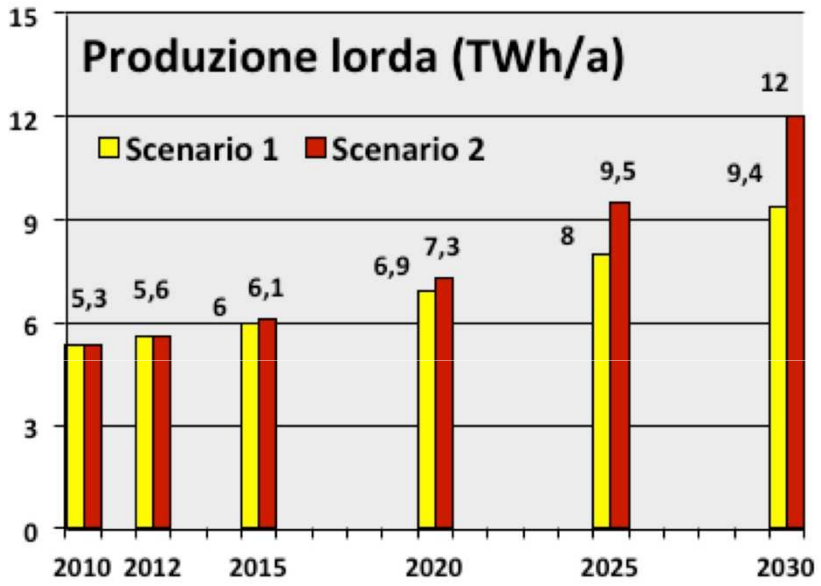
On 2011 UGI (Unione Geotermica Italiana) made a study to estimate the possible contribution of the Earth's heat to the coverage of national energy requirements by 2030, with steps by 2012, 2015, 2020, 2025 to be periodically updated.

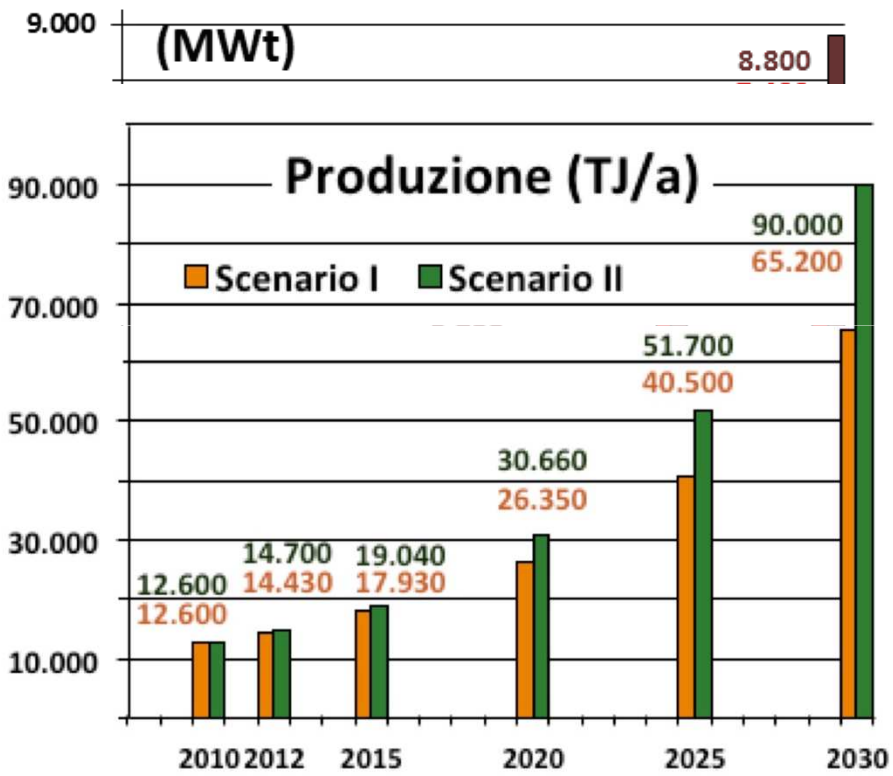
The end goal of the study was to provide the Italian Government with factual elements on the possible medium-term deployment of this energy source in Italy.

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 source roughly four times higher than the average ones in 2010

Perspectives





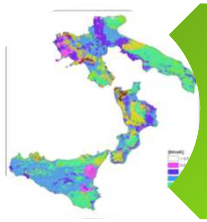
Measures at national and institutional level

- 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 CO_2 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.

CNR contribution to geothermal sector



A comprehensive identification of resources and opportunities, as well as an accessible collection of data and information

A description of 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

Atlante Geotermico and its Favourability maps

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)

http://atlante.igg.cnr.it

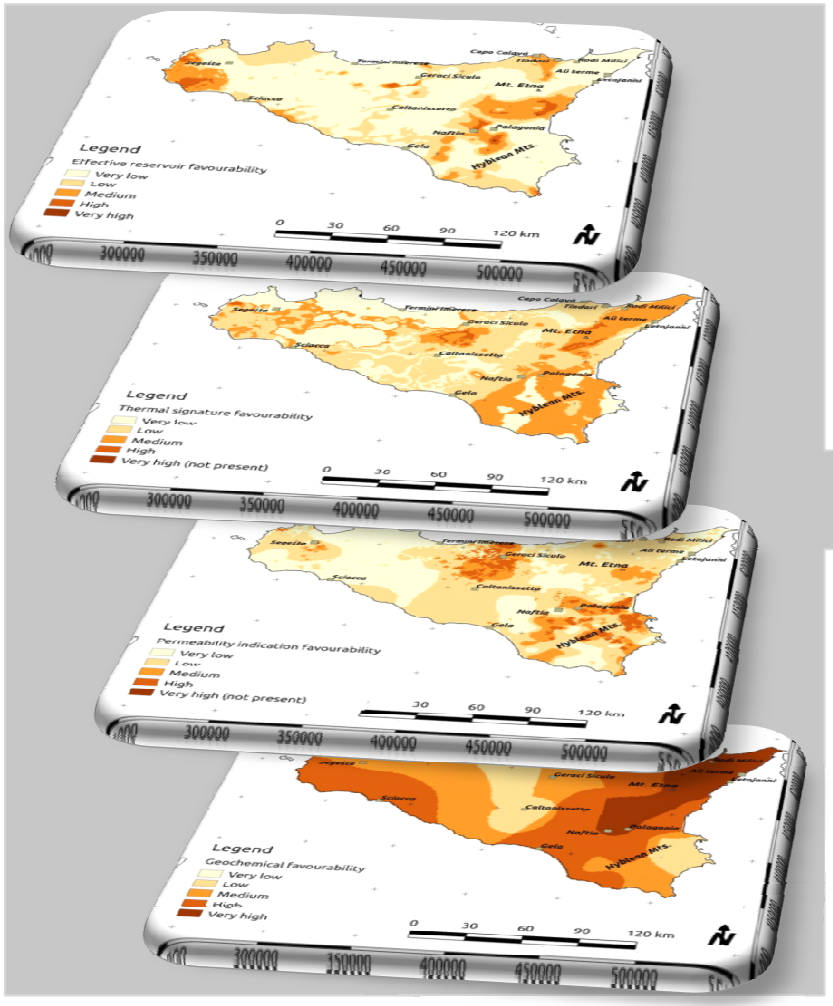
Atlante Geotermico and its Favourability maps

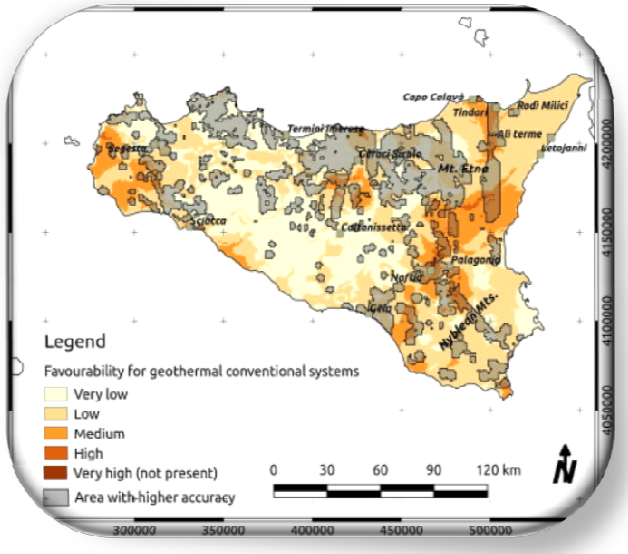
Effective reservoir

Reservoir top temperature

Permebility distribution

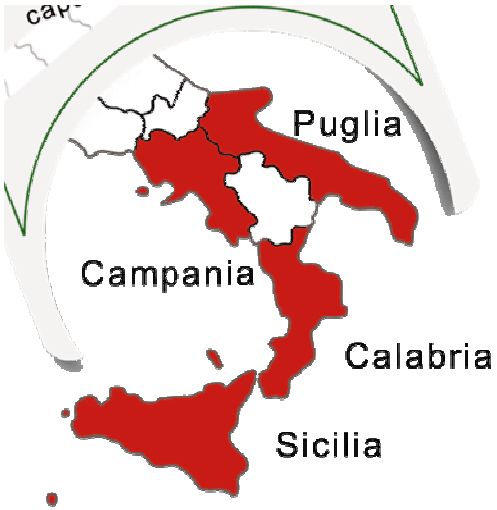
Geochemical information





Trumpy et al. (2015)
Geothermics, 56, 1–16

Projects and efforts: VIGOR



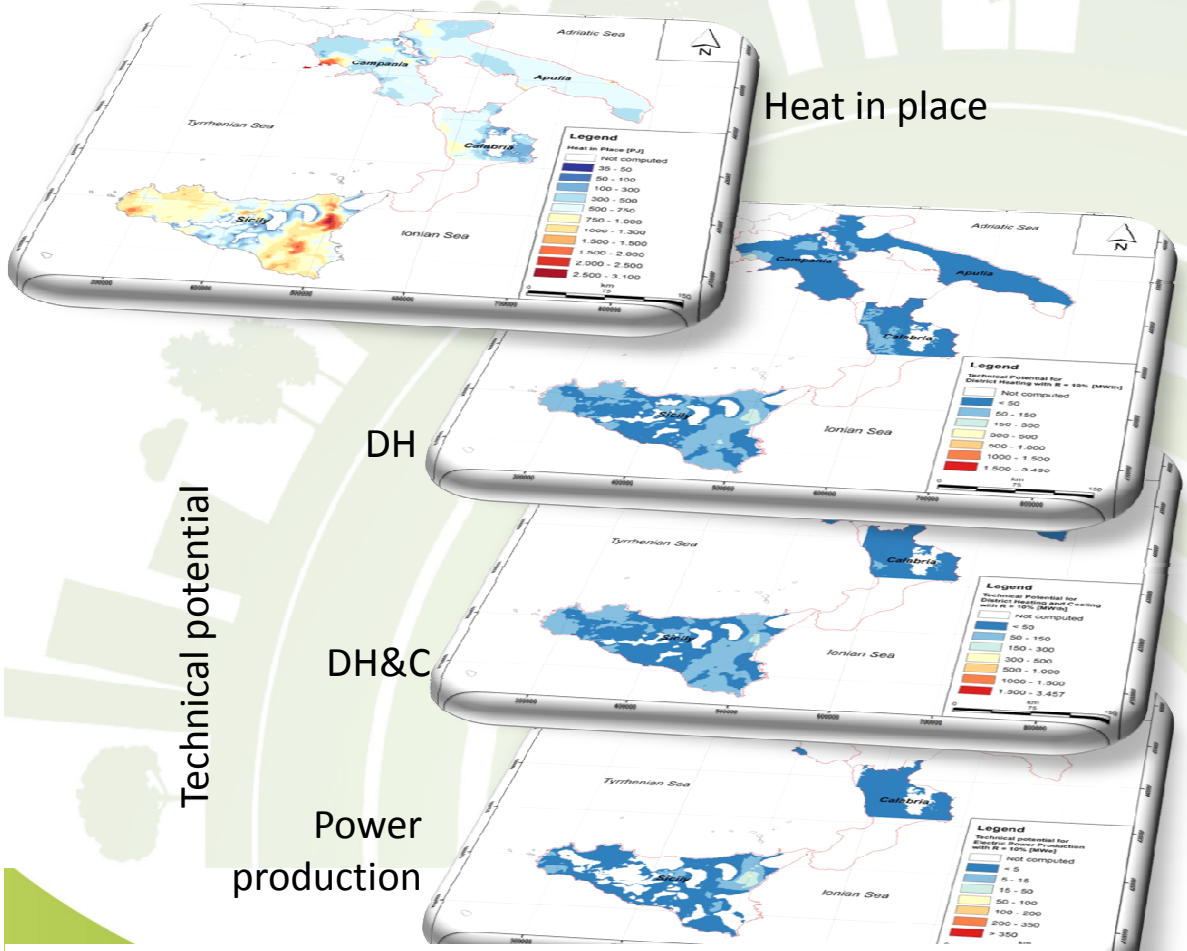
VIGOR
ENERGIA DALLA TERRA

Evaluation of Geothermal Potential for the *Regioni Convergenza*

http://www.vigor-geotermia.it

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



- Geothermal potential maps
- Temperature distribution at various depths
- Updated geothermal database

- Detailed geothermal investigation by EM airborne geophysics
- Analysis of the regulation for geothermal plants (National and regional, 4 regions)
- Social acceptance analysis
- Leaflet and informative books regarding geothermal energy
- Website
- 8 feasibility studies, including technical, economic analyses, regulaive aspects

- **Economic-technical potential MW/km²**
- **Saved oil**
- **Saved CO_2 emissions**

Trumpy et al. (2016)
Energy, 103, 167-181

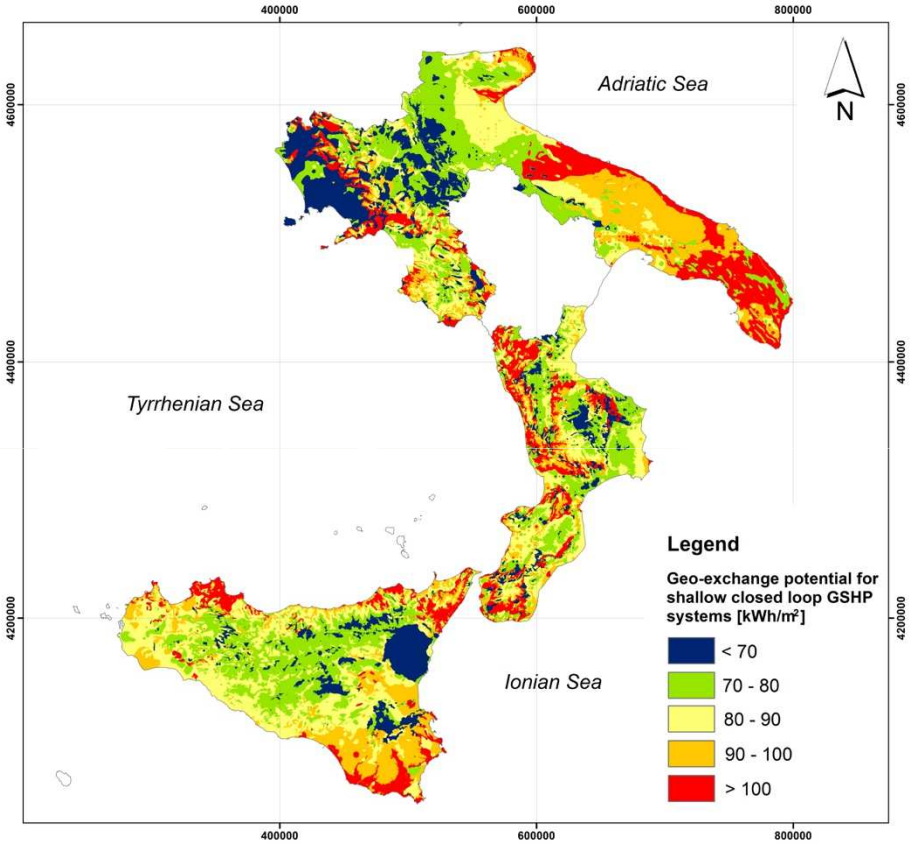
www.vigor-geotermia.it

Programma Operativo Interregionale
ENERGIE RINNOVABILI E RISPARMIO ENERGETICO
2007 - 2013
Una scelta illuminata

UNIONE EUROPEA
Fondo Europeo di Sviluppo Regionale

QSN 2007-2013
QUADRO STRATEGICO NAZIONALE

THE PRODUCTS OF VIGOR



Shallow geothermal potential (GSHP, closed loop)

Galgaro et al. (2015) Geothermics, 57, 173–184

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Thank you
for your attention

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National Research Council of Italy

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