



Green Power

GEO
100YEARS

Geothermal energy

When light
emerges
from deep
within the
Earth



Geothermal energy

When light emerges from deep within the Earth



All of Enel Green Power's geothermal numbers

Italy

Years of history

over **100**

Power plants

34

Efficient power

769

MW

Wells

490

MW

Steam pipelines

505

km

District heating plants

62

Heat provided per year

225

Tcal

Avoided CO₂

4

Mt/year

Avoided oil per year

1.1

MTEP

Production

5,5

TWh/year

Energy for

1,900,000

families



El Salvador

Partnership

194¹⁾

MW

Contribution to Country's
total energy needs

30%

USA

Binary cycle plant in operation

33

MW

Currently being developed

4²⁾

Plants

Steam pipelines laid

10³⁾

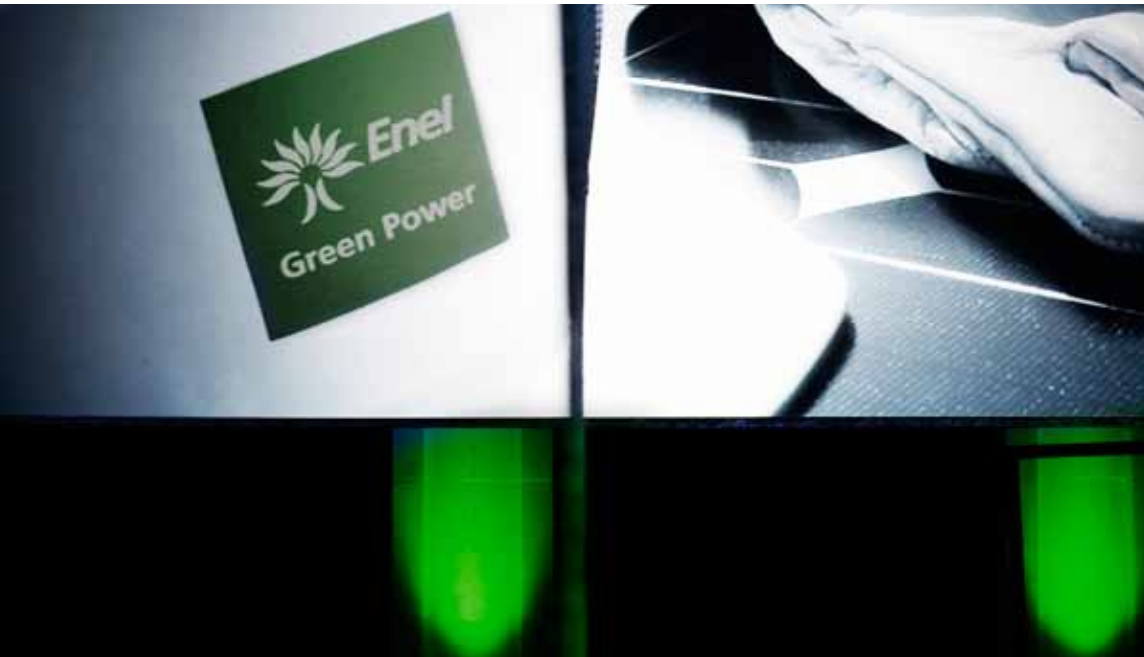
km

1) with the national electricity company

2) which are expected to produce an increase in capacity of 150 MW, in California, Utah and Nevada

3) for the power plant built in 2007

Enel Green Power



Founded in December 2008, Enel Green Power is the Enel Group subsidiary dedicated to the international development and management of power generation from renewable sources, operating in Europe and the Americas with an installed capacity of over 8,000 MW.

Enel Green Power is a world leader in the generation of renewable energy with 25.1 TWh of power generation in 2012. There are currently more than 700 plants in operation or under construction in 16 countries and the



generation mix includes the main renewable sources: wind, solar, hydroelectric, geothermal and biomass. Enel Green Power's goal is to increase the contribution of renewable sources in the energy mix for those countries it operates in, relying on the expertise acquired by the Enel Group over 50 years.

Through efficiency, energy savings and use of the best technologies, Enel Green Power aims to provide important support, so that everyone in the world has the necessary energy while respecting the environment and reducing the risks engendered by climate change.



Geothermal energy

Journey to the centre of the Earth

Just like hydraulic, wind or solar, geothermal energy is a natural, clean and renewable energy resource. The term “geothermal” derives from Greek and literally means heat from the Earth.

Geothermal energy thus refers to energy contained within our planet in the form of heat. In fact however, we can only make industrial use of the heat found concentrated in certain privileged areas, where magmatic fluid masses are present or in the process of cooling.

Geothermal resources available at accessible depths are contained in natural reservoirs in the form of steam or water at a high temperature, mostly rainwater, which heats up as it circulates through hot, permeable rock formations. If there are fractures in the earth’s crust (faults) or permeable rock outcrops, upon reaching the surface the water vapour may give rise to spectacular natural phenomena such as geysers, lagoons and hot springs.

Environmental protection and sustainable development

Geothermal energy is a response to environmental protection requirements and the need for sustainable development: it is a source that works constantly, exploiting natural heat from inside the Earth.

Worldwide installed capacity is expected to reach 46 GW by 2035, thanks to an average annual growth rate of over 6%*.

Italy is the country where geothermal energy was first exploited for industrial purposes, and it is still one of the primary producers of geothermoelectric energy in the world. Enel Green Power has historic experience in Tuscany where Prince Ginori-Conti succeeded in transforming the power of steam into electrical energy by powering five light bulbs in 1904.

*Source: World Energy Outlook 2012, New Policy Scenario



In 1913, in Larderello, the first geothermal plant began operating and it is celebrating its 100th anniversary in 2013: it is in Tuscany that Enel's renewable energies company manages one of the world's largest geothermal complexes with 34 plants for a net output of roughly 769 MW which produce over 5 TWh per year, equal to 26% of the region's energy needs and the average annual consumption of around 2 million Italian families. Moreover, Enel Green Power provides energy for heating for over 8,700 domestic and business users, and around 25 hectares of greenhouses.



Enel Green Power is a global leader in geothermal-electric energy and the only operator capable of covering the entire energy cycle, from exploration to the building and operation of power plants.

Enel Green Power is currently involved in strengthening its own position on the global scene through new initiatives abroad. One of these initiatives which is worthy of mention is in the United

States, where the two power plants at Stillwater and Salt Wells make use of one of the sector's most advanced technologies: binary cycle and medium-enthalpy. A variety of investment programmes are also currently being defined in numerous countries in Central and South America.





Full steam ahead with our projects

The development of renewable energy sources and geothermal energy in particular is a response to environmental protection requirements and the need for sustainable development, guidelines supported by global energy policies.

The global scenario imposes opting for a mix of energy sources that on the one hand allows for a reduction in environmental impact and on the other ensures the security of existing energy supplies, a primary goal together with that of reducing electricity production costs. Within this context, geothermal is increasingly taking on a role as a strategic resource in the energy balance of many countries. Enel Green Power aims to support this development through new projects implemented in harmony with the environment and landscape, in accordance with local energy strategies.

Latin America is playing a major role in this respect, where Enel Green Power has partnership agreements with the primary local energy operators.

In El Salvador Enel Green Power is a shareholder in La Geo in partnership with CEL, the state electricity provider. Enel Green Power completed its first geothermal plant abroad here in 2007, a 44 MW installation with an estimated production of 320 GWh/year. This plant alone produces 8% of the total energy in El Salvador, thus contributing to the country's sustainable development and energy security. In Chile surface explorations in more than 5 areas located in the country's northern and central regions have been completed with positive results, and a deep exploration project has been carried out in two areas in the region of Antofagasta that has

produced excellent results. Surface explorations are also underway in other areas in the regions of Arica Parinacota and Tarapacá. In Peru Enel Green Power has obtained 2 geothermal licences and will begin surface explorations in 2013. Enel is also assuming a prominent role in the United States in developing new geothermal projects. Two new geothermal plants are being completed in Nevada which will produce around 400 GWh annually using "binary cycle" technology. Furthermore, other projects planned in Utah and northern California will help consolidate Enel's presence in North America with roughly 150 MW of installed power.



From geothermal energy to electricity

The geothermal development project consists of various phases. The first consists of identifying a site with a promising geothermal reservoir: the subsoil is analysed by means of specific prospecting in order to evaluate its features. The next phase then involves deep exploration; if the indications provided by geoscientific tests are confirmed, the project proceeds with the user phase through production/re-injection wells and the building of geothermoelectric power plants or the transmission of steam to existing plants.





The drilling depth limit for economic viability is around 5,000 metres. The deep drilling phase also requires an environmental assessment study to determine the well's best positioning and optimize extraction operations. Steam is then transported from the wells to the geothermoelectric plant through steam pipelines made of insulated steel pipes. At the plant the steam is allowed to enter the turbine, a rotating machine that transforms part of the steam's energy content into mechanical energy. Finally the current generator or alternator turns the turbine's rotating mechanical energy into electricity. At the other end of the turbine, the steam passes into a condenser, where a cascade of water from the cooling towers cools it by means of condensation.



A part of the fluid thus obtained is reintroduced into the subsoil via special re-injection wells; the remainder evaporates in the cooling towers and is released into the atmosphere. Both the aqueducts which carry the fluids to the re-injection system and the electrical conductors which carry electricity to the transformer station start at the geothermal power plant. Binary cycle technology is often employed to make use of low temperature geothermal sources (between 120°C and 170°C).

In these systems, the geothermal fluid is used to vaporise a second fluid through a heat exchanger, at a lower boiling temperature compared to the water. After passing through the exchanger, the geothermal fluid returns to the re-injection well to be pumped back into the geothermal reservoir, thus contributing to the reservoir's sustainability.



In harmony with the environment

By their very nature Enel Green Power geothermal plants are a physical element of the landscape they inhabit. Indeed, they are born as shared projects within local communities and are an integral part of regional and/or national energy plans. The plants are located in tourism areas or nature parks; this is precisely why Enel Green Power designs and builds geothermal plants with a plan for their assimilation into the landscape that takes into account all integration aspects of the industrial plant with the surrounding environment. One concrete example of this strategy is the new AMIS technology (Mercury and Hydrogen Sulphide Reduction) which reduces a high percentage of the

mercury and hydrogen sulphide, thereby improving overall olfactory perception in areas adjacent to the plant without any additional residues at the end of the cycle. To this end Enel Green Power has implemented an environmental investment plan in recent years, in accordance with the environmentalization of its geothermal power plants with gaseous effluent treatment plants.

Architectonic factors are also considered extremely carefully: power plants such as Valle Secolo in the Larderello area or Bagnore in the Amiata area are primary examples of industrial architecture. Museum elements or pathways are integrated with historical or naturalistic routes, making the plants true centres in terms of industrial tourism.

Geothermal energy and developing the local area and landscape

In the course of history, geothermal energy has always been a resource with multiple uses: at the time of the Etruscans and Romans for instance, geothermal heat was used for thermal baths. Today, through a variety of fortunate intuitions and technological progress, geothermal energy is used for generating electricity as well as activities that allow for the development of new businesses, using low cost heat. This is the case in Tuscany, where floriculture businesses have been started up using geothermal power to heat greenhouses. The region of Tuscany is also home to geothermal agricultural and fish farming businesses.



Last but not least, Enel Green Power, with an important district heating network, fuels all houses in the surrounding municipalities, providing significant economic benefits and clean heat availability. Five municipalities are currently part of the district heating network (Pomarance, Castelnuovo Val di Cecina, Monterotondo Marittimo, Santa Fiora and Monteverdi Marittimo), with over 250,000 square metres of greenhouses, dairy and meat processing installations that use geothermal heat for their businesses. Technological assistance provided by Enel Green Power in order to develop similar initiatives will entail an investment close to 500 million Euros over the next



Today **geothermal energy** is used for generating electricity as well as activities that allow for the **development of new businesses**, using **low cost heat**





five years, attracting businesses and favouring the development of a green economy related to the intelligent use of heat from the earth.

The very same initiatives that are already consolidated in Italy are being started up in El Salvador, where residual hot water from power plants is used to feed fish farms. All over the world

direct uses have now reached 260,000 TJ/year, allowing for overall savings of 18 million tons of petroleum, with a consequent reduction in pollution and carbon dioxide emissions into the atmosphere. Direct uses have spread to 55 countries worldwide, for a capacity of 28,000 MWt.

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