ITALIAN GEOTHERMAL DISTRICT HEATING SYSTEMS

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SUMMARY

Italy has large geothermal resources, both high and low temperature. It is the most important producer of geothermal electricity in Europe, but it also uses its lower enthalpy fluids in spas, agriculture, industry and district heating. The main plants for this last application are briefly described.

ITALY'S GEOTHERMAL SETTING AND DIRECT USE STATISTICS

The Italian territory is characterized geologically by two mountain ranges: the Alps and the Apennines. The latter constitutes the backbone of the peninsula and separates an outer foredeep to the east, with basins which can be defined as "cold" if compared with the average temperature of the earth, from an inner "hot" Tyrrhenian belt, with back-arc basins. The Alps limit to the north, the "cold" Po basin (Fig. 1).

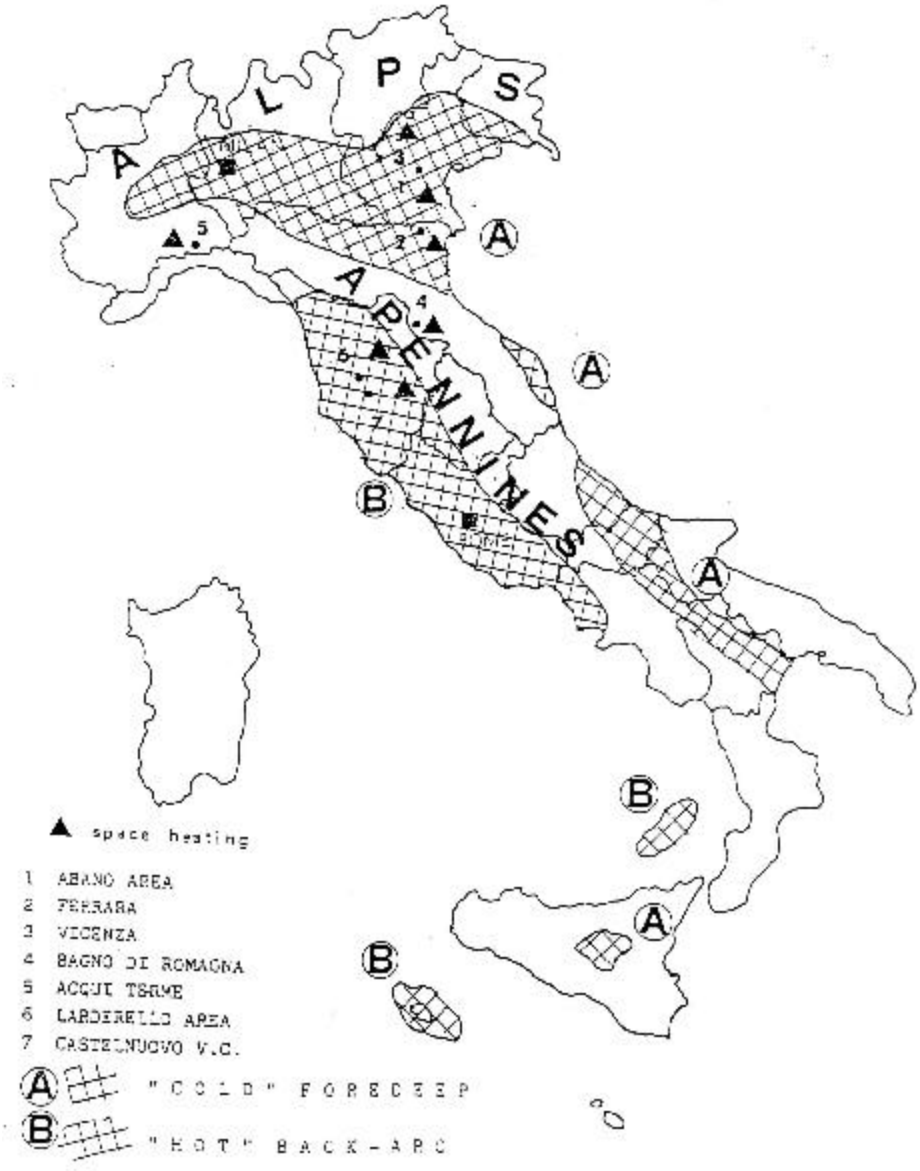

Figure 1. Italy geothermal scheme and space heating plants.

The "hot" Tyrrhenian belt is associated with young mainly intrusive magmatism in Tuscany and volcanism in Latium and Campania. Geothermal gradient may reach 5-20ºC/100 m; maximum temperature in some wells exceed 400ºC. Geothermal targets in the area are mainly high-enthalpy resources used for electricity production, but low-enthalpy prospects are also important at the edge of the main thermal anomalies or as cascaded use from geo-power plants. The outer "cold" foredeep induces a number of sedimentary basins from the most important Po basin in the north to the Adriatic coastal belt and to central Sicily. These basins are filled with a thick sedimentary sequence consisting of Quaternary and Tertiary clastics overlying a Mesozoic carbonate section. Geothermal gradients (2-3ºC/100 m) are typical of subsident basins and commercial prospects are low- and medium-enthalpy fluid applications. Concerning Italian direct uses, projects for the equivalent of 240,000 TOE/y are operational, of which 125,000 are for therapeutically-related uses in spas; 60,000 for greenhouses and fish farming; 40,000 for residential heating, and about 15,000 for industrial purposes.

A large portion of civil space heating uses is concentrated in the Abano spa resort area, in northeast Italy. As regards district heating, the most important plants are those of Ferrara and Vicenza in the eastern Po Valley which started operation in 1990. Smaller DH systems are installed in the Tuscany geothermal steam fields area and in the lesser spa towns of Bagno di Romagna (northeast Apennines) and Acqui Terme (Piedmont).

The main plants are briefly described below (locations in Fig. 1).

ABANO AREA (Po Valley, Veneto)

This area concentrates the largest consumption of geothermal energy for building heating, and is the most important example of integrated use of this energy for health, recreation and residential heating purposes in Europe. The spa area for Abano, extending for about 23 km^2, is located on the Euganea volcanic district, mostly at its eastern edge; several small towns with many hotels and resorts dedicated to the health and relax business are concentrated in the area, famous since ancient times for its hot springs.

Most hotels in Abano and Montegrotto have their own wells (2 or 3) and are equipped with spa facilities (Fig. 2). Some 230 wells produce by pumping 3,600 m^3/h of 65 to 87ºC low salinity water during the five months of the main tourist season (yearly average yearly production 2,500 m^3/h). Average well depth is 300-400 m, with some reaching 700 m. Completion is open-hole in fractured Upper Mesozoic limestone.

Geothermal water is used for curative treatments, in swimming pools and to heat buildings and provide domestic hot water. Heat for these last two purposes is transferred through plate or shell-and-tube heat exchangers to a fresh water network. Back-up conventional boilers are seldom installed and emergency needs are generally taken care of by connecting to nearby wells. To regulate the flow, hot and cold water storage tanks are commonly set up. The exhaust water, at a temperature of about 40-45ºC, is discharged at surface. In total about 120 hotels in the Abano area are fitted with geothermal spa facilities. Total heated volume is around 2.5 million m^3, equivalent to 12,500 standard flats, in addition to 200 swimming pools.

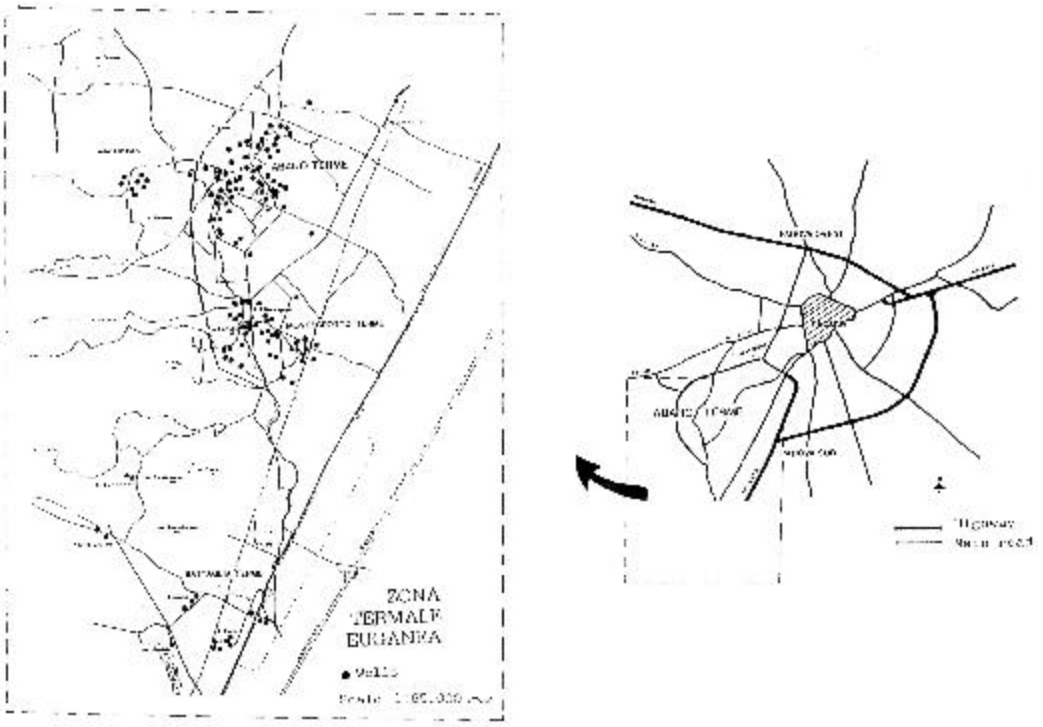

Figure 2. Wells in the Abano Terme area.

Substituted energy is estimated about 25,000 TOE/y for building heating and sanitary water, and 90,000 TOE/y for therapeutical and recreational uses.

FERRARA (Po Valley, Emilia)

The Ferrara geothermal field was discovered in 1956, as a result of oil and gas exploration by AGIP, the then national oil company. Well Casaglia 1 drilled to the depth of 3,379 m without finding hydrocarbons evidenced the presence of 100°C salt (65 g/l) water starting at about 1,100 m in fractured Mesozoic carbonates within a vary large structural high. In 1981, after reentering and testing successfully the well, it was completed for geothermal production under a joint venture with the national utility ENEL. In the same year, a new well (Casaglia 2, about 1 km from Casaglia 1, and 1,960 m deep) was drilled and tested up to 400 m^3/h of fluid on pump.

After signing a preliminary heat sale contract in 1983 with the Ferrara Municipality, which undertook to gradually build the downstream heating plant and DH network, the first geothermal heat delivery took place in 1990. The initial production facilities consisted of Casaglia 2 used as producer (at the rate of 200 m^3/h on pump) and well Casaglia 1 acting as reinjector, both with open-hole completion. In 1995, a second producer (Casaglia 3) was drilled, parallel and few meters from Casaglia 2 to 2,000 m, doubling the field's flow rate. The surface equipment works in a closed circuit at 18 bar pressure. Anti-corrosion additives are injected in the producing wells; while, bactericides are mixed with the reinjected fluid. After a filtering unit, a set of titanium plate heat exchangers pass the available heat to a freshwater circuit belonging to the municipality feeding the DH system.

A pre-insulated steel double line, 2 km long, conveys the heated 95°C freshwater to the municipal heat plant, halfway between the production wells and the town, then carries the fluid back, cooled to an average of 60°C to the AGIP-ENEL heat exchangers. The heat plant (Fig. 3) is composed of the geo-system terminal, peak-load and back-up gas boilers, hot and cold water regulating storage tanks, a 150-ton/day solid waste incinerator and an inter-connecting pump station.

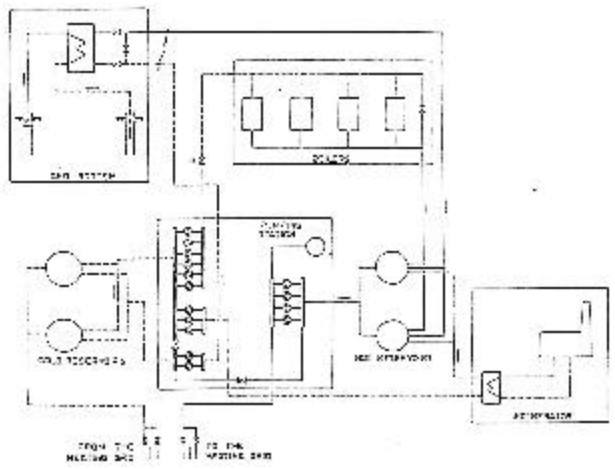

Figure 3. Ferrara heat plant.

A co-generation unit was added in 1999.

The DH network covers an extensive area along the central axis of Ferrara town, starting from its northwest outskirts. A 30-km grid of double preinsulated steel pipes connects 270 large users for a total of 2.7 million m^3 of heated space. Optimization of the return temperature is being investigated and the network is being expanded.

Geothermal energy currently provides 5,000 TOE/y of the energy needed, corresponding to almost 60% of the total, as compared to about 20% each originating from the incinerator and the gas boilers.

Figure 4. Ferrara hot reservoir with solid waste incinerator in the background.

Figure 5. Ferrara pumping plant.

VICENZA (Po Valley, Veneto)

Hot freshwater in Mesozoic limestones was discovered by AGIP in 1977 in an oil and gas well (Villaverla 1) located 14 km north of the town of Vicenza. A detailed technical evaluation indicated that the resource should extend to Vicenza and, after signing a preliminary sale agreement with the local municipal company, AIM, AGIP and ENEL in a joint-venture drilled a well in 1983 located within the town limits. Vicenza 1 was successfully completed open-holed in Mesozoic limestone at 2,150 m, producing by pumping up to 125 m^3/h of 67°C freshwater with a limited amount of H_2S.

After the granting of an exploitation lease and signing in 1985 a contract for the purchase of the hot water, AIM built the heat plant and the DH network between 1988 and 1991. Geothermal heating began in winter 1990. The heat plant is quite complex and included, after plate heat exchangers to isolate the geothermal fluid, dual-power (gas or electricity) heat pumps with heat recovery components, cooling towers, peak and back-up gas boilers, and a pumping system. The DH network consists in a 7.4 km double preinsulated steel pipeline and a parallel one-way sanitary hot-water line fed by 20 m^3/h of geothermal fluid. Inlet-outlet DH temperatures are 90-60°C.

The geothermal fluid was discharged in the town drain works at 20-25°C. The DH system services 74 main users, heating 1.33 million m^3 of space. Geothermal energy use with gas heat pumps amounts to about 2,700 TOE/y.

Because of technical problems with the heat pumps and a dispute over the geothermal water sale price, use of the geo-heat is suspended after a few years and the DH system operates with co-generating units installed in 1996. Solution of the controversy is imminent and could lead to resumption of the geothermal operations.

Figure 6. Overview of the city of Vicenza.

Figure 7. Vicenza heat pumps.

BAGNO DI ROMAGNA (Northeastern Apennine, Emilia-Romagna)

The municipality of this small spa town with 45°C springs, which has exclusive rights on the use of the resource, decided in the 80s to develop a geothermal DH system. The availability of sufficient amount of resources was verified by drilling some very shallow wells which evidenced a potential of over 200 m^3/h of 30-40°C nearly freshwater in fractured sandstones of Miocene age. Well No. 3, 50 m deep, completed with slotted liner for a production by pumping of 90 m^3/h of 37°C water, was selected to feed the DH system. The well is located only 400 m from the main spring; however, no interference occurs. The heat plant consists of gas-electric heat pumps with heat recuperator, co-generation units, and gas-gasoil back-up boilers. A network of 9-km two-way preinsulated steel pipelines connects several hotels and houses with about 190 substations for a heated space of 220,000 m^3. HE inlet temperature is 80°C and return 60°C. Spent geothermal water is rejected at 20°C in a nearby river. The system was built in 1983-86 and went on stream in 1987. Geothermal energy output is about 500 TOE/y.

Ongoing expansion of the grid will double the connected heated space by the end of 1999.

ACQUI TERME (Northwest Italy, Piedmont)

Acqui is a spa town with a quite hot spring (La Bollente) with a temperature of 70°C and a free-flow rate of 33 m^3/h. A private operator uses the resource for therapeutical purposes. During 1986-87, the municipality developed a DH plant and grid to utilize the Bollente spring water in periods when the spa facilities are closed (spring, autumn and part of winter). The heat station consists of a steel plate heat exchanger, gas-fed heat pumps with heat recuperator and gas-fueled boilers for peaking and backup. The DH network is a 2.2 km two-way preinsulated steel line, with input temperature of the water 80°C and outlet 60°C. It connects public buildings with 11 substations for a total of 130,000 m^3 of heat space. Design temperature of the spent geothermal fluid is 35°C with an expected energy output of around 300 TOE/y. Heat delivery started in 1988, but because authorization for the energy use of the spring water has not yet been granted, the DH network is fed provisionally by conventional boilers.

TUSCANY

In several west Tuscany towns, ENEL utilizes part of the steam available from power generation or, more often, steam unsuitable for electricity production because of low pressure or temperature, for direct uses (mainly space heating). Geothermal energy supplied to several centralized and district heating plants in the ENEL area amounts to about 7,000 TOE/year.

The largest share (70%) is utilized in the Pomarance Municipality where DH systems are installed in four suburbs (Larderello, Montecerboli, Serrazzano and Lustignano). In Larderello, offices and living quarters of ENEL are served directly; while, the other heat systems are owned and operated

by the municipality. The main fluid used is power-plant grade steam at 160-200°C tapped from the steam lines; while, in Lustignano, 170°C steam from a dedicated well is employed. Heat is transferred to the DH water circuits via shell-and-tube heat exchangers. Return temperature is 70 to 95°C.

A small DH system serves the town of Monterotondo Marittimo using 95°C steam with a return temperature of 70°C.

Other small geothermal DH networks are developed in the Castelnuovo V.C. Municipality, downtown and in the Sasso Pisano suburb.

The downtown heat plant was completed in 1987, being fed with high-grade steam tapped from the pipeline to the Castelnuovo power station.

The plant was recently refitted to use low-pressure 105°C steam from shallow wells and a separate distribution line for domestic hot water was laid down. Steam from the power station network will be used for peaking.. The Sasso heat plant owned by ENEL (while the DH network belongs to the municipality) was completed in 1994-95. It serves 150 dwellings for a total of 50,000 m^3. Low pressure 105°C steam from refitted shallow wells is fed into a shell-and-tube heat exchanger to cover base load needs of the DH system. Peak demand is met by steam tapped from the Sasso Pisano power station feeder line, through as second shell-and-tube heat exchanger. The plant has a gas disposal unit and the spent geothermal fluid is reinjected at 70°C (Fig. 8).

GROUND-SOURCE HEAT PUMPS

Contrary to several central and northern European countries (including Switzerland), Italy has very few systems of this type.

POSSIBLE NEW DEVELOPMENTS

Most of the action is concentrated in Tuscany, where installation of geothermal DH units in the town center of Pomarance and in the S. Dalmazio suburb started in 1999. ENEL will also provide geothermal heat for the Santa Fiora Municipality DH system (for a total of 2,400 TOE/y) and has proposed a similar arrangement for the town of Piancastagnaio. Use would be made of hot water effluents from power plants and of steam not suited for electricity production.

Outside Tuscany, the Grado Municipality, on the Veneto coast (northeast Italy) is interested in a DH project involving also some spa use. The system would be fed by 50-60°C water from a well to be drilled to the depth of 1,000 m, in the town center, tapping a Mesozoic limestone reservoir.

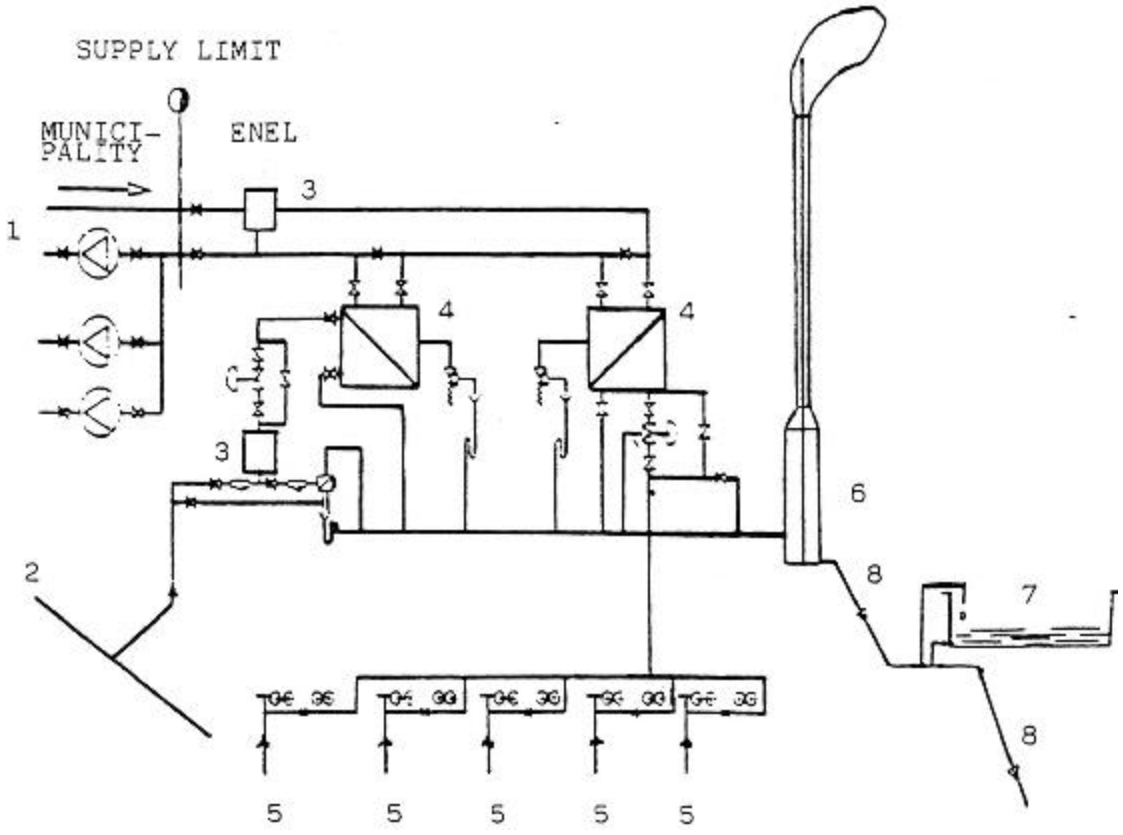

Figure 8. ***Sasso heat plant scheme: 1) to/from DH grid, 2) power steam line, 3) heat meter, 4) heat exchanger, 5) shallow production wells, 6) gas disposal, 7) pond and 8) to reinjection wells.***