Palazzo Lombardia - Geothermal heat pump capacity world record for a single building conditioning

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ABSTRACT

The complex named "Palazzo Lombardia" in Milan is the new headquarters of Region Lombardia.

This is the largest building in the world fully heated by means only of geothermal sources, represented by ground water with the utilization of heat pumps.

The overall thermal power of the heat pumps is 6,3 MW.

The heat pumps are reversible and in summer contribute to the production of chilled water for the cooling of the complex.

The paper describes the main features of the installation and its technical characteristics.

1. INTRODUCTION

The paper deals with the following subjects:

- Description of the building
- Characteristics of the geothermal source
- Choice of the type of the geothermal source to be utilized
- Characteristics of the geothermal plant and of the installation

2. DESCRIPTION OF THE BUILDING

Palazzo Lombardia is located in Milan, not far from the center of the town and close to the main railway station.

The construction is very recent, as it has been completed and entered into operation in 2010. The whole construction required 3 years.

The function of the building consists of collecting and centralizing the offices of Region Lombardia in only one building. For this reason in the complex 3.000 employees are working.

The surface of the utilized spaces is 190.000 m^2 in total; among them 140.000 m^2 are heated and air conditioned, the other 50.000 m^2 are used for services (parking, technical rooms,….).

In the complex there are also an auditorium with 375 places, a conference room with 500 places, a space for events at the last floor, an exhibition space and commercial activities at levels +00 and +01 (at present: a 2.500 m^2 gymnasium, n.3 restaurants, a pizza restaurant, a nursery, a telephone shop, an ice cream shop, a supermarket, a shop for sport articles and under way there is the realization of a post office and of a multifunction medical clinic). About 4.500 people (considering employees, visitors and others) every day are present in the Palazzo Lombardia complex.

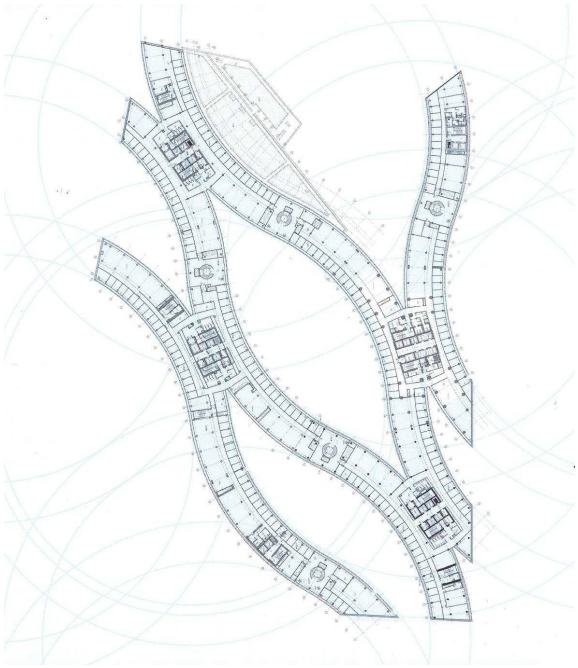

Figure 1: Palazzo Lombardia, architectural configuration of the building

The building consists of n.6 building blocks connected the one to the other, each with a height of 9 floors. One of the blocks, however, has a section with a 40-floor tower, whose height is more than 160 m.

The building has also 3 underground floors, mainly devoted to the services of the building (parkings, storage rooms, technical rooms).

The whole building complex is characterized by the presence of a double glass wall, which allows to minimize the winter heating needs reducing the required thermal power down to 6,3 MW.

The summer refrigerating need is about 13 MW.

Figure 2: Palazzo Lombardia, overall picture of the complex

Regarding heat distribution systems, which consist mainly of chilled beams and air handling unit heat exchangers circuits, the delivery and return temperatures are respectively 48/40 ° C.

The choice of these heating systems and of the above mentioned operating temperatures for the heating plant have been decided in order to make the installation suitable for the utilization of a renewable energy source for the heating purposes of the building, and specifically geothermal water, which in this case is represented by ground water.

The design has been developed so that the building is fully heated by using the heat from ground water through heat pumps.

Today, Palazzo Lombardia is the largest building in the world fully heated with geothermal sources.

Figure 3: Palazzo Lombardia, tower view

3. CHARACTERISTICS OF THE GEOTHERMAL SOURCE

The province of Milan and specifically the area of the town are very rich from the point of view of availability of geothermal sources.

Substantially, there are two different types of underground water.

The first type is represented by ground water, which is available nearly everywhere, at a depth comprised between 20 and 50 m, with a temperature of about 15°C.

The abundance and the level of ground water in the last years in Milan had a significant increase, following to the strong reduction of its utilization by a certain number of industries (in particular, steel industries) for cooling purposes in the northern part of the town, which closed their activity. For this reason, now in certain parts of the town the level of ground water is so high that it is necessary to have pumping out systems for the dewatering of underground parts of the buildings.

The second type is represented by deeper sources, which can be found in the different areas at a depth in the range between 500 and 2.000 m with estimated temperatures in the range between 40°C and 70°C.

4. CHOICE OF THE TYPE OF THE GEOTHERMAL SOURCE TO BE UTILIZED

Among the above possibilities, the choice was in favour of the use of ground water.

This choice comes out from several reasons:

- Wide availability of this type of source
- Certainty about the availability of the source, without any mining risk
- Strong reduction of drilling costs
- Water represented by soft water, without any problem with some salt content, which on the

contrary could be involved by the use of deeper sources

- Need in any case for the use of a heat pump system
- Much simpler procedures for the application for the authorization for the use of underground sources.

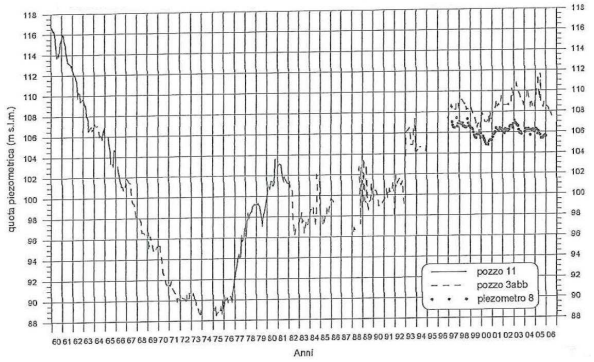

Figure 4: Ground water level in the last 50 years for the area of Milan

The available data show the progressive lowering of the levels characteristic of the 60's and recorded until the first half of the 70's (-28m), due to the excessive draw rate from the aquifer during this period.

Due to the strong rainfalls in 1976-1977 there has been a significant increase in the groundwater level, which reached its top in 1980-81 and was followed by a period of relative stability.

From 1992 until the end of 1997 there has been a significant rise in groundwater levels (+9 m), the cause of which can be found in a number of factors such as an increase in the effective charge which affected the medium and high plain, the gradual deepening of the drinking water supply wells, due to the pollution of the upper aquifer and the decrease in industrial withdrawals in urban and suburban areas.

From 1998 there has been a new gradual decreasing trend (-3 m), interrupted by raising, after the October 2000 and November 2002 flooding (+4 m).

5. CHARACTERISTICS OF THE GEOTHERMAL PLANT AND OF THE INSTALLATION

The winter heat production is assigned to n. 3 heat pumps with a capacity of 2.150 kW each, extracting heat from ground water and feeding low temperature circuits. The heat pumps adopted are single stage units, with a screw type compressor.

In order to supply ground water, n. 8 wells were drilled under the building foundations, producing 40 l/s each, for a total of 320 l/s. The depth of the wells is 50 m.

During winter the ground water is cooled from 15 °C to min 6 °C by means of the above heat pumps, while in summer it is used for chillers condensers cooling (among the chillers there are also the above mentioned heat pumps, operating in a reversible mode).

The heat pumps COP (coefficient of performance) is about 4.5 in winter mode and about 6 in summer mode.

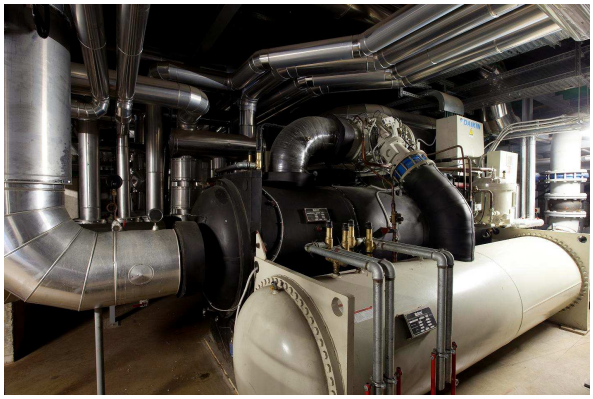

Figure 4: Palazzo Lombardia, heat pumps

This means that in winter about 78% of the heat produced by heat pumps is free, as it is taken from ground water (i.e. endogenous renewable resource).

The ground water discharge after use is on surface, by delivery to the underground Martesana ditch.

Heat pumps, except in extraordinary and particular operating conditions, are able to fully meet the winter heating load and therefore the conventional boilers installed will act only as reserve units. In fact, the boilers are operated only in case that the ground water discharge in Martesana is prevented, due to unavailability of the water receptor and, consequently, the heat pumps can't be used for lack of ground water flow to the evaporator.

Only to give an example, in the last winter season the overall operation hours in each months for the boilers were the following:

- October 2012 13 hours
- November 2012 10 hours
- December 2012 150 hours
- January 2013 7 hours
- February 2013 6 hours
- March 2013 5 hours

The time above indicated includes also the minimum time required every week for the start-up and functionality tests on the boilers. The higher value of boiler operation in December is due to a technical problem for a transient period.

Regarding heat distribution systems, which consist mainly of chilled beams and air handling unit heat exchangers circuits, the delivery and return temperatures are respectively 48/40 ° C.

The chilled water production for summer air conditioning, in addition to heat pumps, is obtained by other water cooled chillers equipped with centrifugal compressor.

During summer, both heat pumps' and chillers' condensers will be cooled first with ground water. In case of ground water unavailability (an exceptional situation limited to a really small number of hours per year) or not sufficient flow, cooling towers will be used.

In Table 1, the design data of the installation are summarized.

Table 1: Design data of the installation

n. of production wells	8
Wells depth	50 m
Groundwater flow	8 x 40 l/s = 320 l/s
Groundwater temperature (inlet / outlet)	15 / 6 °C
Groundwater discharge	surface channel
n. of heat pumps	3
Compressor type	Screw
Thermal capacity	3 x 2.150 kW
Winter heat need coverage by means of heat pumps	100%

Figure 5: Palazzo Lombardia, other picture of the heat production station

Acknowledgements

Photos: Archivio Infrastrutture Lombarde S.p.A.