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Geothermal Heat Pump Systems for Multi Apartment Buildings: Some Case Studies in Italy and Project Management Implications

Davide Maritan

Geotherm srl Earth Energy Systems, via Fornace 8 – 37038 Soave (Verona) Italy

maritand@geotherm.it

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ABSTRACT

In ground source (geothermal) heat pump systems, when the thermal loads of the buildings become high, complexity increases not in a linear mode and it can be divided into two types: technical and managerial complexity. This paper presents two 150 and 40 kW multifamily projects in Italy. Here we analyze the technical bottlenecks we encountered and the management problems we had to solve.

1. INTRODUCTION

Literature world-wide about GSHPs may appear subdivided in three areas: market analysis, technical and design analysis (heat pumps or ground loop heat exchangers), successful case studies. Poor documentation can be found about bottlenecks, problems or management issues. In this paper we will discuss about two GSHP systems for multifamily buildings that started in 2006-2007, both today completed and working. Writing this paper is for us an occasion to reconsider the two projects, in a different angle of view.

In Europe, like some other southern countries, Italy has been one of the last to show interest in GSHPs; the reasons should probably be found in some aspects: mild climate, because of the Mediterranean closed sea, some different approaches to the heating solutions (good diffusion of a network of natural gas); a general culture that erroneously identifies electricity for heating with electric resistance, with an immediate callback to high running costs; low interest in renewable energies (Maritan and Panizzolo, 2008).

In this country, GSHPs are today a niche market, where statistical analysis and real number of applications are difficult to determine. Probably the main reason is that firms that operate in this technology are diffident and they dislike to give informations about the number and characteristics of the projects they did or they over estimate the number of their customers. Economic crisis of the last year and a political approach not clear about energy seem to have reduced the growth of this market, mainly in the vertical loop applications, because of the high costs of installation.

In the last twelve years we have been involved both in the geothermal design and in the technical supply of residential single or semidetached houses GSHP systems (from 7 kW to 50 kW) and multifamily buildings systems (from 35 to 150 kW). In addiction we did feasibility studies or the design of commercial or institutional ground loop heat exchangers (GLHEs) fields and plants up to 400 kW. Our experience says a simple fact, that things can change significantly, when we interact with the final customer (end user) or we have to manage projects, where builders or other different actors are involved; this aspect is normally not correlated to the thermal loads of the building.

2. CASE 1 – MULTIFAMILY 150 KW GSHP SYSTEM

The first project is characterized of a thermal load of 150 kW, covered by 9 heat pumps; about 40 flats are fully heated with geothermal heat pumps and they are divided into three blocks buildings, called F1, F2 and F3; each block has three heating only heat pumps (capacity from 14 to 17 kW each); the borehole field consists of 47 boreholes 50 m deep with double U-bends HDPE100 32 mm diameter. GLHEs; thermal enhanced grout was used to seal boreholes and distance holders were installed about every 10 m of borehole, to keep the distance between the pipes and to improve performance. First heat pumps were activated in middle 2008.

Figure 1: Front side of one of the three aligned residential buildings.

2.1 Technical Description

In this project we followed a reliability oriented design approach; we decided to split the systems in a number of subsystems: against single heat pump systems, high modularity gives lower complexity, standardization of the equipment, easier installation, easier start up, easier control, higher reliability, better reaction to heat pump faults.

Each system can be described as it follows:

- 3 heat pumps, each output varying from 14 kW to 17 kW;
- every heat pump is connected to an independent but close to each other ground loop of 5 to 6 boreholes. Every group of probes is driven to inlet and outlet collectors with flow controls; this allows to set the desired flow rate to the circuit;

- in the technical rooms (three in total) the heat pumps are connected in parallel to a 750 liters buffer tank; from the buffer tank, a variable speed pump pumps water through the main lines to the flats. Every flat has a control of the energy supplied for heating and hot water and some thermostats that open two-way valves. The heating curve is set in the technical room with the controls of the heat pumps. Hot water is provided by three 500 liters hot water tanks with internal copper spiral heat exchangers.

Figure 2: One of the three technical rooms; you can see heat pumps and 750l buffer tank.

2.2 People

In this section we will summarize main professionals and installers involved. These three multi apartments buildings were financially supported by one of our previous customers (we supplied two GSHPs for him and for her sister houses). He started a commercial firm with the target to build and sell environmentally friendly flats in the Milano area (north west of Italy). We can schematize people involved as it follows:

- Main contractor: financial support and commercial activity.

- Builder firm: they did building works and excavations; a contract was signed between main contractor and builder, to receive the three buildings completed, without ground loop system and technical rooms equipments. Their approach to GSHPs was a little skeptic although their main interest was to be covered in additional related costs.

- Architects: they were new to the ground source heat pumps concepts.

- Ground loop and heat pumps: in this project we had to split two activities: a) through our engineering, full design of the ground loop field and, in a second time, of the technical room and official works management; b) supplying the geothermal vertical heat exchangers, thermally enhanced grout, main collectors, and flow regulators, no toxic propylene glycol, heat pumps, hot water tanks, buffer tanks. We had to give our customer (the main contractor) a complete support in the interaction with the local government. Finally we did the start up of the system.

- Electrical engineer and electrician: they did together design and installation of the electric lines.

- Thermal engineer: he designed the radiant floor and the hot and cold water connections. We had several problems in this area. Builder had to change this professional during the design stage: he had to abandon the project because he retired from activity due to age. The builder choose another one but his approach to the GSHPs technology was so negative, we had to decide to get in addiction all the technical room design and installation management. He did the design of the radiant floor and the other pipes inside the buildings but he did not provide any kind of project management and he disappeared at the start up, claiming other money from the main contractor, to be involved.

- Plumber: he did all the hot and cold water connections and the radiant floor system for each apartment, laying the main lines down to each of the three technical rooms. He refused to assembly and install technical equipment in these rooms and to be involved in the borehole array horizontal connections, so we had to find another plumber, relaxed and reliable, for these two sections of the works.

- 2nd dedicated plumber: we selected, together with the customer, a little firm, we knew from a previous project. They supplied and installed all the horizontal polyethylene lines, needed for the three boreholes arrays. They installed the main geothermal collectors and all the equipment in the technical rooms. They helped our engineering in the start up of the entire system.

- Driller (at least): this firm drilled both the fields of case 1 and case 2. They followed our reliability and quality program, checking and testing each geothermal probe, after insertion. They injected thermally enhanced grout with a portable grout pump. Driller caused three different problems: a) low attention to maintain the correct position of the boreholes in comparison to the design with the result: lot of our energy spent in controls; b) one borehole collapsed and a ground heat exchanger lost; c) 47 boreholes drilled: at the horizontal lines deployment stage we found a big trouble. The last geothermal probe installed (!) was discovered not of the correct length: 2nd plumber, during horizontal pipe connections, found that the borehole stopped at 24 m but nobody of the drilling company had told this to us: what we discovered was that the crew, who did all the boreholes, at the last hole probably decided to stop at this depth because it was Friday; they all live in the South, very far away from the works site and they were very stressed and tired after some months of drilling in the same site. They tried to cancel the length numbers impressed in the geothermal probes each meter, not to allow anybody to find the correct depth. Obviously they had to drill again a new borehole. And we had to review all the last boreholes field, to verify in detail the correct length of the pipes installed!

– Local council and public relationships: we got limitations in the depth of the boreholes, during the design stage, because of new procedures adopted: in this project we had to re-design the system four times, because of the variable, conservative and cautious evaluations, coming from the technical office of the local council: the first aquifer was polluted and the public technicians thought that the GLHEs had not to be positioned at a depth more than -50 m (the base of the aquifer): the result was from the initial design of 21 (!) boreholes we moved to 47, with big design problems, to manage the position of the boreholes in the space allowed and the horizontal lines layout (Maritan and Panizzolo, 2008). The big risk was to have a borehole array as dense as an "Emmenthal cheese".

Figure 3: One of the three closed boreholes fields (F1 building): the 4th from the left is the incorrect depth borehole n.47.

3. CASE 2 – MULTIFAMILY 40 KW GSHP SYSTEM

The second system heats and cools a IXX century old historic building in the north west of Italy. Nine apartments are heated with radiant floor and 3 heat pumps (two of 11 kW and one of 14 kW output) provide the 40 kW of capacity needed. The boreholes array consists of 7 boreholes 100 m deep with double U-bend HDPE100 32 mm diameter. GLHEs; thermal enhanced grout and distance holders were used. Geothermal natural passive cooling provides about half of the cooling needed and an air to water chiller covers the peak loads.

Figure 4: Outside park of the building; vertical geothermal probes are installed under garages.

3.1 Technical Description

In this second case we followed the same modular approach of the first one; the main difference is in the technical room, were the heat pumps are completely independent one from each other.

Each system can be described as it follows:

– 3 heat pumps, two of 11 kW, one of 14 kW output;

– every heat pump is connected to an independent ground loop of 2 to 3 boreholes. Every group of probes is driven to inlet and outlet collectors with flow controls;

– in the technical room the heat pumps are connected to separate buffer tanks; from each buffer tank three variable speed pump pumps water through the three main lines to the flats. In this way a specific number of flats is heated by a specific heat pump. Like Case 1 all the flats have their own control for energy and hot/cold water consumption. Hot water is provided by three 300 to 500 liters hot water tanks;

– during summer period cooling is obtained with water to water fans and air ducts; with a plate heat exchanger water mixed with propylene glycol exchanges heat with the heating main pipes, that serve now as cooling main lines. This passive, natural and moderate cooling does not involve heat pump compressor starting. Temperature of the undisturbed ground varies from 13°C to 14°C.

Figure 5: Wide view of the technical room equipment.

3.2 People

We can see here that professionals involved in this project are lower in number than Case 1.

– Main contractor and builder: financial support and commercial activity. The builder was controlled by the main contractor. Different firm but same people. They did building works and excavations. From the beginning they were focused to choose a GSHP system; installation costs were the only reason for worries. General manager was the owner of one of the flats and he demonstrated a strong character, with the ability to give free hands to the specialists. We had some reliability bottlenecks about the ways builder held in stock the ground loop pipes: crews laid down the polyethylene coils unwrapping them, taking off the pallets and disseminating them all around: because of this simple problem we had to substitute two geothermal probes, damaged.

– Architects: they were very well oriented to high efficiency heat pumps and we were comfortable with them for all the project. The head of the architects team is the owner of one flat: he was directly involved as final customer.

– Ground loop and heat pumps: in this case, we supplied the geothermal system, like in project 1. We did the design of the ground loop and we gave the suggestions to optimize the tech room design but we did not sign officially the schemes: thermal engineer collected our technical suggestions and designs, interacted with us but, here, he played the role of the main technical manager. As in case 1 we carried a good supervision of the GSHP system installation.

- Electrician: same like case 1, they installed the electric lines. We had no problems from them.

- Thermal engineer: he designed the radiant floor, the technical room and the hot and cold water connections. He was relaxed and optimistic; he received our suggestions with open mind. He did all the official technical schemes and our engineering was involved as his consultant.

- Plumber: he installed all the plumbing equipment, including the technical room, main collectors and all the horizontal pipes, that completed the groundwork. We started a good professional relationship that is still working.

- Driller: it was the firm of case 1. Their work was characterized of sufficient reliability. They followed our quality requests, testing each geothermal probe after insertion. But the work in this case was smaller and the crew was not so stressed, like project 1.

4. CONCLUSION

Some lessons can be obtained from the bottlenecks we encountered in these two projects, especially from the first one.

- Designers must be very careful about relationships with local public or government technicians. They could not have the experience about GSHPs. They could change opinions (and create new limits), during and not before the start up of the design stage or during installation.

- More the managers are more the time is wasted. We discovered that personal characters and relationships are crucial, sometimes, for a successful installation in big projects. Especially this is true if someone plays a role against the adoption of the technology.

- In big projects a clear, GSHPs experienced, main technical manager is needed, with the power to take decisions by his own; without a guide or a manager, two o three technicians or professionals, that have to discuss how their technical systems can interact together, may sometimes create huge bottlenecks.

- In vertical applications a good control of the drillers involved must be done. And this is more true when big projects are done. The drilling company can be the best in the market but it is made by men and women. If final responsibility, that the system works, is not of the driller, this company must prove clearly that the pipes are installed at the right depth. Actual strategy of our company is that driller must leave the pipes coming out from the ground, with the length numbers visible or, in case of edge cutting, because of the drilling rig, it must provide photos or other clear proofs. This is an absolute prerequisite.

REFERENCES

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