Status and Perspectives of Italian District Heating and Cooling in a Changing Market

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ABSTRACT

District Heating (DH) served more than 170 municipalities in Italy in 2014; most of them are in the northern regions. DH delivers space heating to about 315 million m^3, thanks to 4000 km of networks. The average growth rate of this service is more than 7% per year, since 2000.

Natural Gas represent more than 70% of the Primary Energy used to operate DH systems, while coal has a marginal role and other fossil fuels are negligible. The heat recovery from Waste-to-Energy plants represents the second energy source, followed by bioenergy, mainly in the form of biomass.

Both Waste-to-Energy recovery and bioenergy are rapidly growing in the recent years, thanks to the European and Italian policies. Conversely, the huge potential of geothermal and solar thermal are still inadequately exploited in Italy (only about 1% of Primary Energy), due to the high up-front investment costs and the technical inexperience, respectively.

Beyond the birth of new DH systems, a major boost to the development of the sector is given by the partial conversion to renewable sources also for systems born with fossil fuels as the only energy source. In this paper, we give some examples of this positive trend.

Finally, DH systems have still a large potential to grow in Italy. Recent European directives and strategies highlight the importance of its spread, but it is often hampered by national decrees and technical standards.

1. INTRODUCTION

Heating and Cooling currently represent half of the European Union's final energy consumption and it is essential that EU acts in this sector to reach its energy and climate targets, developing a common Heating & Cooling Strategy (EU, 2016).

DH is one key element to this strategy, since it is able to reduce Primary Energy (PE) consumption and atmospheric emissions, to link H&C with electricity system and get advantages for both, also recovering and exploiting waste heat from industry and other renewable sources such as deep geothermal.

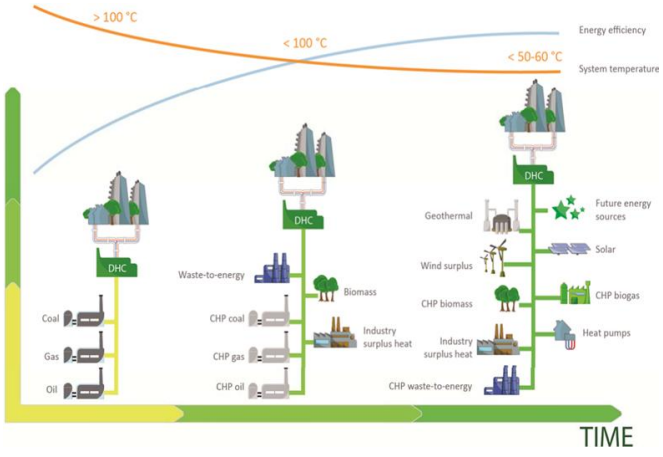

Figure 1: The evolution of sources and network temperatures in District Heating systems.

In order to achieve all these benefits, DH is evolving:

- from a conventional system based on fossil-fired Power Plants and High Temperature networks (left side in Figure 1);
- to a complex system based on the integration of several different sources (e.g. Waste to Energy plants, Solar Thermal, electric Heat Pumps), which require Low Temperature networks, thermal heat storages and a smart logic to be efficiently managed (right side).

2. STATUS AND PERSPECTIVES



Figure 2: The distribution of DH systems in Italy (circle dimension is function of the space heating).

Italian DH systems served more than 170 municipalities in 2014; as shown in Figure 2; most of them are in the northern regions, which account for 98% of the total heated space.

DH served about 315 million m^3 of houses and offices in 2014 (Figure 3), thanks to 4'000 km of networks. The share of heat served by DH is less than 4% still today (elaboration of Italian and European statistical data), but the average growth rate of DH service is consistent: +7.3 % per year, since the year 2000 to 2014 (AIRU, 2015).

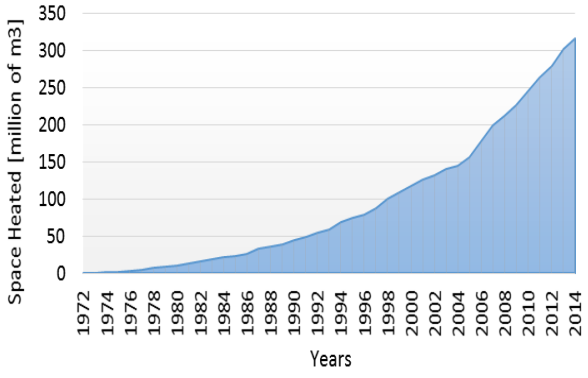

Figure 3: The growth of DH service in Italy from 1972 to today.

DH plants produced 34.0 EJ of thermal energy in 2014 (an exceptionally mild year), supplying to users 27.9 EJ_t for Space Heating, Domestic Hot Water or Cooling Energy production and process uses; the network loss was 17%.

According to the AIRU's estimations, this service allowed (year 2014) to reduce by 25% the Primary Energy consumption and by 29% the CO_2 emissions, compared to the alternative production systems: this means it avoided 442 ktoe of consumption and 1,386 kt of CO_2 emission (AIRU, 2015).

Figure 4 summarizes the power capacity of the different type of plants feeding the Italian DHC networks. Excluding the integration boilers, typically used few hours in a year to cover peak loads, or in case of faults and maintenance, the prevalent units are conventional Power Plant with heat recovery (1'140 MW of installed thermal power) and combined heat and power (CHP) plants dedicated to DH systems (1'132 MW_t): both fossil–fuelled.

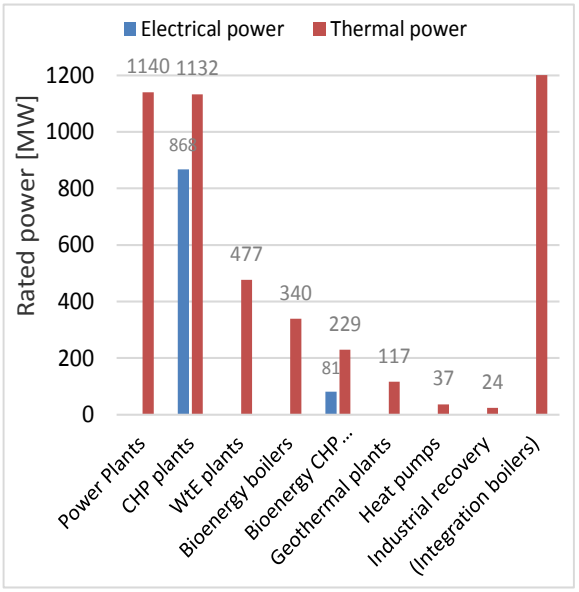

Figure 4: Rated electrical and thermal power of DH systems units (2014).

All the 14 Italian Waste-to-Energy (WtE) plants supporting DH networks operate in CHP mode; they represent a total thermal power of 477 MW. Boiler and CHP (mainly external combustion ORC) powered by bioenergy also give a very important share of installed power: 569 MW.

The geothermal energy source is abundant in the Italian context, but till now it is concentrated in the Tuscan area and in very few other cases (Ferrara, Vicenza, Grado), with 117 MW available for DH networks. This is achieved thanks to geothermal wells for DH purpose and, locally, by substations that take part of the heat from steam pipelines for DH use.

Finally, heat pumps and direct heat recovery from industrial sites do not have an important role in 2014, with a total thermal power of about 50 MW. So far, the Italian DH systems are still based on fossil fuels.

Figure 5 shows as the Natural Gas is the most widely used fossil fuel, representing about 72% of the total PE used to operate DH systems; coal has a marginal role (< 3%) and other fossil fuels are negligible.

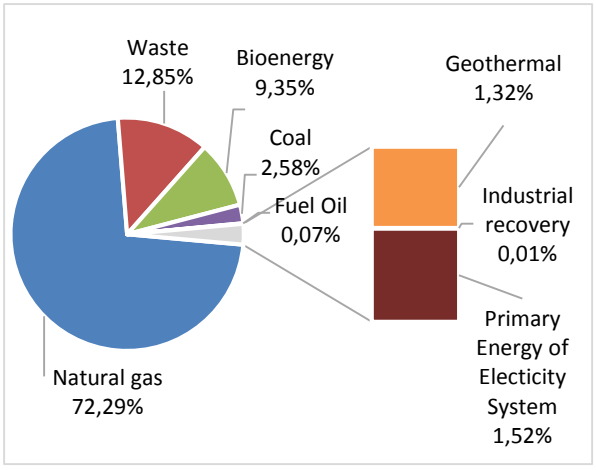

Figure 5: Energy sources used by DHC plants (2014).

The heat recovery from WtE plants represents the second energy source (13%), followed by total-renewable fuels (9%), very often in the form of solid biomass (wood). Geothermal source represents more than 1% of the total energy sources, while the waste heat recovered from industrial sites was negligible (no large plants active in 2014).

Analysing the types of heat fed into the Italian DH network in 2014, we can draw a positive picture: Figure 6 shows that more than 75% of heat comes from cogeneration and/or renewable sources. Specifically, 67% was from cogeneration (thereof 17% renewable), 6% from bioenergy and 3% from geothermal sources. Heat pumps and heat recovery represents less than 1%.

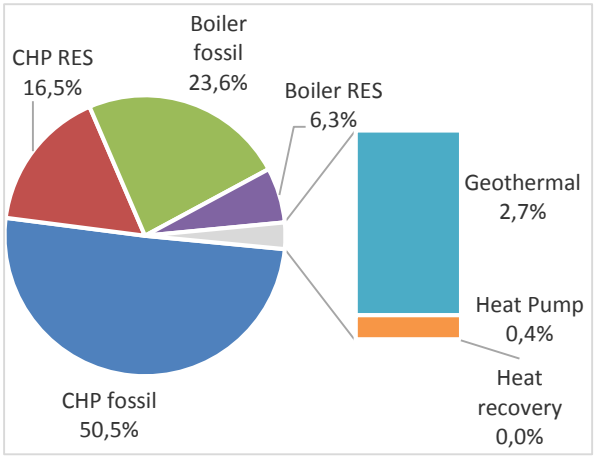

Figure 6: Heat sources fed into DH network (2014).

The recent and very recent trend of Italian DH systems is very interesting in terms of future perspectives. WtE recovery and bioenergy are rapidly growing in the recent years, thanks to the European and Italian policies: we have more than 80 DH systems based on bioenergy boilers and/or CHP. They are localized in rural areas, typically in mountain valleys, and they are often very recent: nearly 70 of these were realized after 2000.

On the other hand, the huge potential of Italian direct renewable sources, geothermal and solar, is still inadequately exploited (only 1% of PE, Figure 6), respectively due to the high up-front investment costs and to the technical inexperience. The good news is that the change is underway, with some players interested in the design and development of hybrid system.

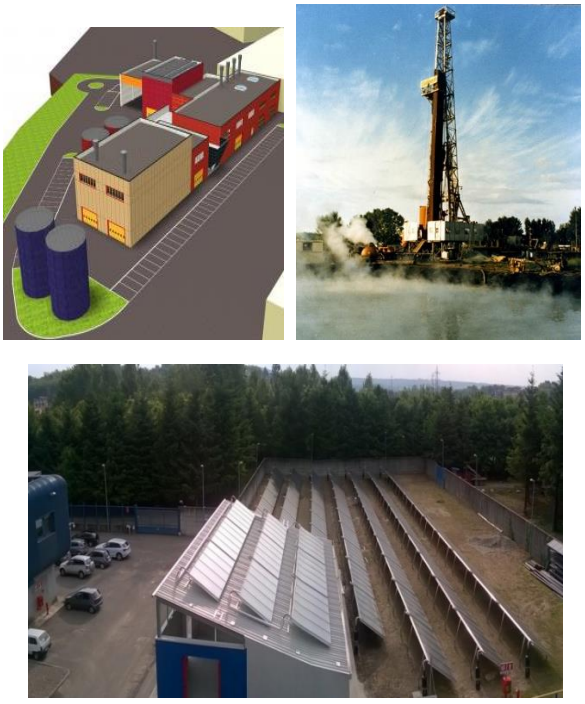

Figure 7: a) the new DH plant of Aosta; b) the geothermal well of Vicenza and c) the solar field of Varese (Telcha, 2016; Varese, 2016).

An example is the new DH plant of Aosta (Figure 7a), which is able to recover up to 17.5 MW of heat from a steelworks thanks to a large Heat Pump. More important in terms of impact on DH sector, is the fact that we are already witnessing the partial conversion to renewable sources of existing DH systems born with natural gas as the only energy source:

- Lodi and Mirandola, since the year 2013, use also heat generated by bioenergy CHP plants (ORC/ICE), which are owned by third parties;
- Vicenza obtained in 2013, after several years, the authorization to recover heat from an inactive geothermal well (Figure 7b);
- Parma finally began in 2014 to distribute heat with the WtE plant, for which the DH network was designed;

- Varese started in 2015 to integrate heat production with a 1'000 m^2 large solar thermal field (Figure 7c);
- Sesto San Giovanni (near Milano) and Brescia began in the recent months to recover heat from industrial sites, respectively a glassworks and a steelworks;
- Grado (Gorizia) is optimizing the new geothermal DH system to serve a larger number of public buildings (Della Vedova et al., 2015).

3. DHC ITALIAN POTENTIAL

In the 2014 AIRU (Italian District Heating Association) and Legambiente[1] (Italian Association for the Environmental Protection) carried out a joint study aimed to evaluate the potential of DH diffusion in Italy and the relative benefits in terms of Primary Energy saved and CO_2 emission avoided (AIRU, Legambiente , 2014).

This study analyses the DH state of the art in 2012, then evaluates its potential diffusion in the larger cities (with more than 25'000 inhabitants), according to a methodology developed by the Italian Research Energy Centre CESI[2] (GAME - SVALTER project and relative results, e.g. (CESI, 2005)). It takes into account accurate visual analysis of some reference cities, the general acquisition factors achieved by DH operators and other experience-based considerations.

The analysis concluded that DH has a large growing potential in Italy. There is a great techno economic opportunity to reach a Space Heating 5.5 times greater than the one in 2012 (Figure 8): the incremental part is more than 1'100 million of m^3 (approximately 370 km^2 in terms of heated floor area).

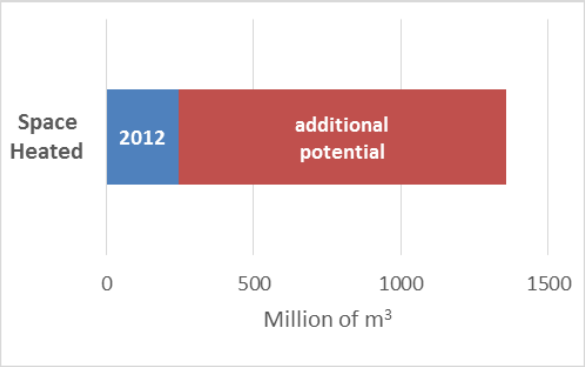

Figure 8: The Space Heating by DH systems in 2012 and the additional potential.

The additional potential is going to develop where DH systems are almost exclusively present today: in the Northern part of the country (Figure 9). On the other hand, a substantial share (38%) is also expected to come from the medium-large cities of the central and southern regions of Italy.

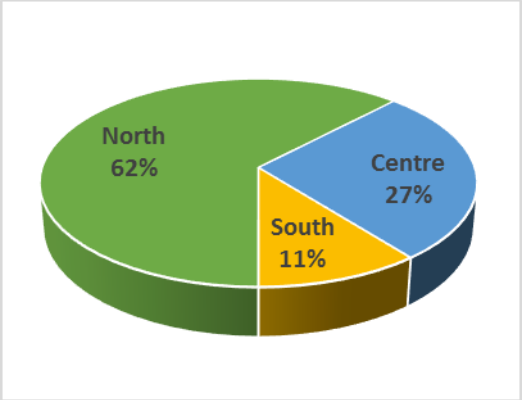

Figure 9: The share of the DH additional potential among Italian regions.

The study evaluates also how this additional DH networks could be fed and the related benefits, according to a methodology developed by AIRU and ENEA (Italian National Agency for New Technologies, Energy and Sustainable Economic Development) (ENEA, 2009). The results of the exploitation of this potential for DH growth could bring another 1'064 ktep of Primary Energy saved and 5'343 kt of CO_2 emission avoided.

4. BARRIERS TO THE DEVELOPMENT AND CONCLUDING REMARKS

Italy has to overcome a number of barriers, mainly legislative at national level, to maintain its growing rate (7 % per year) and to develop its large DH potential. The law 102 of 2014 transposes the European Energy Efficiency Directive and is very in support of the DH. It states that Member States have to assess the national DH potential and then adopt policies to reach it (art.10); the companies near a DH network, subject to energy audit, must furthermore evaluate DH solutions as an option (art.8). The application of these principles, however, is often hampered by national decrees and technical standards.

The Ministerial Decree 26th June 2015, defining the methodology for calculating the energy performance of buildings, indicates a default Primary Energy Factor extremely penalizing for the DH systems (PEF = 1.5, much higher than a very old boiler!). DH operators have to declare this default value if the real one can not be certified by accredited companies. The certification methodology, not yet complete and usable to date, is based on "alternative production method" whose reference coefficients seem to penalize particularly the large and efficient CHP systems (e.g. cogeneration Combined Cycle Gas Turbine).

The expansion and connection to new users of existing DH networks which prove to save Primary Energy, compared to alternative system (i.e. gas boiler), are in most cases not yet able to get an incentive via the

[1] http://international.legambiente.it/
[2] http://www.cesiricerca.it

Energy Efficiency Titles mechanism (GME, 2016), because of a recent modification of the national law.

Excluding renewable-sourced DH systems, no support is granted to the connection of users to DH networks, creating an inequity situation in a market where the competitors are subsidized. Heat Pumps and gas boilers, as an example, could ask for a tax reduction or a partial investment refund (GSE, 2016).

Finally, DH suffers long and complicated bureaucratic procedures for authorizations and concessions, particularly in the case of the geothermal source.

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