Reasons Why District Energy Systems Were Not Extended in Spain

María EGUARAS MARTÍNEZ 1*, César MARTÍN-GÓMEZ 2.**

* Building Services and Energy Section, School of Architecture, Universidad de Navarra. PhD Student. (meguarasm@unav.es)
** Building Services and Energy Section, School of Architecture, Universidad de Navarra. Full Professor. (cmargom@unav.es)

Keywords: District Energy systems, management policies, town planning, urban infrastructure.

Abstract.

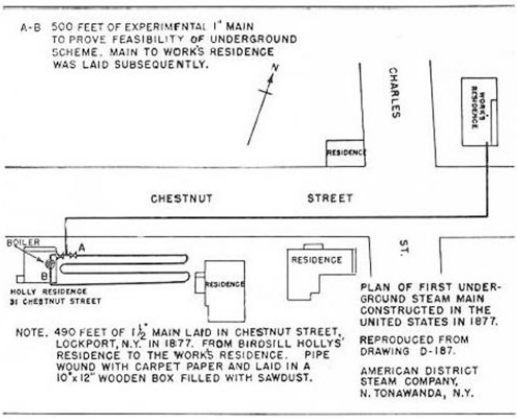
The influence of urban infrastructures in city planning is obvious. However, among all types of systems, those that are destined to supply thermal energy to the cities, there is no tradition in design and development in Spain, contrary to what happens in the United States or in other countries in Europe.
From a technical point of view, these systems present a proven effectiveness in countries with more than one hundred years of experience using these infrastructures. They have an efficiency of up to forty per cent higher compared to other isolated systems of energy production, implicating better fuel management with a consequent reduction of emissions of greenhouse gases into the atmosphere.
Regarding the social implications, they present great advantages such as lower maintenance costs, avoid the problems of heat outage, or risks of individual explosions or accidents. But above everything, they improve the urban air quality in many towns, since local boilers and high chimneys are replaced for single heat generation plants.
So, why this type of infrastructures has not had in Spain the same development as in other countries if the benefits seem clear as mentioned above?

1. Introduction. District Energy Systems

District Energy systems are defined as urban infrastructures that fulfill many city energy demands by and often citywide heat distribution network, which receives heat from one or many large heat-generation or transmission facilities.
This kind of systems has been developed throughout history differently across continents and countries. The major reasons are the different circumstances and conditions of the aspects as energy policies, with different regulations and legal requirements; energy prices and economic conditions for investment and finally the different weather conditions of countries.
Returning to the definition of district energy systems, such facilities are not recent solutions, as the oldest district heating system still in operation is located in Chaudes-Aigues, France in operation as early as the 14th century[1].

Birdsill Holly, an inventor and hydraulic engineer, is often credited with being the first to use district heating on a successful commercial basis. As a result of an experiment in 1876 involving a loop of steam pipes buried in his garden, Holly developed a steam supply system in October 1877. Several district heating systems were started in North American cities in the 1880s. In New York, the Manhattan steam system went into operation in 1882. It exists today as the steam division of ConEdison and provides steam for heating, hot water and air conditioning to approximately 1.800 customers.

Figure 1: The First District-Steam Lines. Holly´s Steam System.



Against what happened in America, the distributed energy does not reach Europe until the twentieth century, not because it is seen as something negative but because necessary investments to create a complete system of generation in existing cities. The earliest district heating system was built in Dresden in 1900, although it was not a commercial project[2]. Fernheizwerk Hamburg Gmbh initiated a commercial project for the city of Hamburg in 1921, which was followed by systems in Kiel in 1922, Leipzig in 1925, and Berlin in 1927. Outside Germany, district heating systems were started in Copenhagen in 1925, Paris and Reykjavik[3] in 1930, Utrecht in 1927, Zürich in 1933, and Stockholm and Helsinki in 1953.

In Russia[4], the first heat was delivered in St. Petersburg in 1924. Teploset Mosenergo was established in 1931 to manage heat distribution in Moscow, although the heat deliveries had begun in 1928, becoming the most extensive district heating system in the world before the St. Petersburg system.

As reflected by this information, district energy systems have been widespread in the Nordic countries, Russia, Eastern Europe or the U.S., however in Spain have failed to establish themselves as general solutions, and this despite the fact that there are several interesting examples developed in our country.

2. The Spanish Case

2.1. University City of Madrid

One of the first solutions of this type of infrastructure carried out in Spain and which is still in operation is the Thermal power plant of the University City of Madrid. It was designed in 1932 by the architect Manuel Sánchez Arcas in collaboration with the engineer Eduardo Torroja Miret[5] and advised by the Brown Boveri Company[6].

In the construction of the University City of Madrid, one of the most important technical problems was the thermal conditioning of the large and well-planned buildings. As a result of the previous studies, the Board Construction chose a single production plant with superheated water as heat carrier. The idea of establishing

a centralized heating plant on a university campus is not originally Spanish: other examples of this type had been carried abroad and there was numerous campus located in America or Europe, however, this initiative is the first time that was taken in Spain.
Besides this building, the thermal conditioning project of the University City, included 12 substations and the distribution network in form of galleries easily accessible throughout the route, with the aim of supply heat without interruption with low maintenance cost. The design took advantage of the knowledge acquired studying the models visited in several trips[7], specifically the Power House at Harvard[8], and Heating Plant in Berkeley[9].

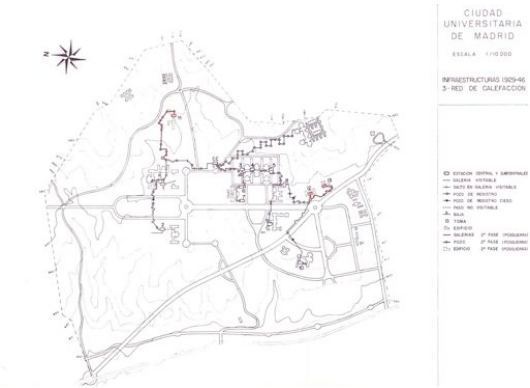


Figure 2: Plan of the University City of Madrid with the heat distribution network.

The Thermal power plant supplied heat to all buildings raised in the Campus until the fifties. Currently it is still working, changing the fuel source from coal (using at the first time), to natural gas, having used in intermediate time diesel oil. According to the inquiries made, the heat capacity is above the building demands which are still connected to it[10], despite that the price of thermal energy unit is lower than the cost of the energy produced in other buildings with single boilers.

2.2. Eduardo Torroja Construction Science Institute

The second example studied is the Thermal power plant of the 'Eduardo Torroja Construction Science Institute', designed in Madrid in 1948 by the architects Gónzalo Echegaray and Manuel Barbero in collaboration with the engineer Eduardo Torroja.
The project included a main building with four blocks and an annex building in which a concrete manufacturing facility pilot plant was established.
For the thermal conditioning, a single thermal power plant with hot water boilers has been placed externally to the buildings, under the coal silo shaped in form of a dodecahedron, that thought the passing of time it has become the hallmark of the institute. For the same reason, a single refrigeration plant[11] has been chosen for summer thermal conditioning. The distribution network is placed in the basement as a union between the buildings, in form of a gallery with direct access from the outside.
The implementation of such installations, in many aspects unusual in Spain is due to the valuable idea and experience of the director of the Institute D. Eduardo Torroja, and the intention of the building for research, which converts the building itself in a field of study, and the program responds to the ideas and theories that are discussed on it.

2.3. Pamplona District Heating System Preliminary Design

The following example is an ambitious proposal that the industrial engineer Joaquín Castiella rose in 1961 to provide heating for three different areas to be developed in the Pamplona[12] that never came to fruition despite having the political authorities support and providing a profitable economic study to the supplier of the service. Castiella himself explained his project in a letter addressed to the mayor of Pamplona[13] together with a set of plans, a technical report, a global budget and an economical study: It consists in a central facility of heat production, probably fed with nuclear energy, from where the heat is carried by the vehicle chosen, steam, or superheated water, through a network of pipes to buildings provided with a suitable heat exchanger.

The building owners pay the supplier company only for the heat consumed, determined by a heat meter, and simplify the cost to get that service. The city becomes clean and the company obtain tariffs with industrial profit, something perfectly feasible.

As seen above, much of the work of the engineer was not only to convince about the technical feasibility of the proposal, but on the economic viability of the solution. But if the political representatives approved and considered the solution exposed as very interesting why this ambitious project was not finally carried out despite all the advantages that it clearly showed.

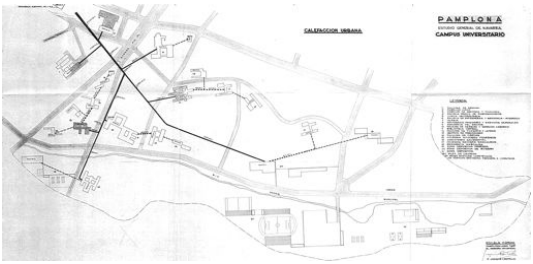


Figure 3: Plan of the preliminary design made by Joaquín Castiella.

2.4. Campus of the Public University of Navarra

Another example of district energy system is the Thermal power plant of the Public University of Navarra (UPNA) designed in 1989 by the architect Francisco Javier Sáenz de Oíza[14] in Pamplona. In this university campus, the heat is produced in a central power plant located in the northwest corner and carried in form of superheated water through a network formed by prefabricated concrete galleries, registrable and visitable along the tour, forming a closed distribution loop with reverse and open return. From this network the secondary circuit of each building will be supplied using a plate heat exchanger.

With the design of this Campus, Sáenz de Oíza finally succeeded in his homeland, after an extraordinary career in which he received numerous awards, including the Prince of Asturias and he perfectly reflected his concern about the American technique designing the campus in image and likeness of the American ones[15].

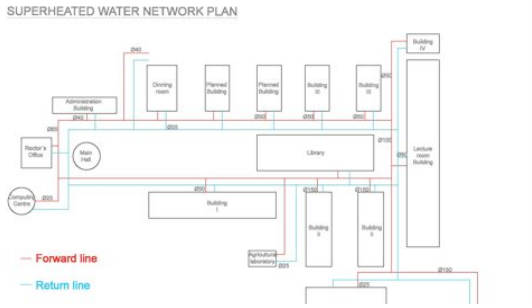


Figure 4: Plan of the distribution network designed by Sáenz de Oíza in the UPNA.

2.5. Fórum and 22@ District Energy System

Despite the urban importance of the examples mentioned above, it was not be until the turn of the century when the first Spanish district energy reference for European experts comes, the construction of the Forum in 2004 in Barcelona[16]. An innovative district cooling and heating plant with heat supply to a total area of 488.000 m2 in accordance with them most up-to-date environmental and economic policies. It constitutes a pioneer initiative which will support the principles of Forum 2004, since it will supply energy to the Forum Building, the Convention Centre, a University Campus, hotels with economically favourable air-conditioning and heating conditions and the needs of 800 dwellings in the 22@ neighbourhood.

This infrastructure was made possible through the foundation of Districlima S.A., shared by Cofely Spain SAU[17], Aguas de Barcelona[18], TERSA[19], ICAEN[20] and IDAE[21].

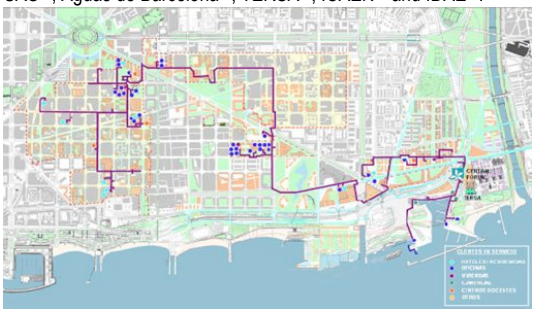


Figure 5: Urban heat distribution network in operation since 2004 in Barcelona.

2.6. ExpoZaragoza 2008

Taking as its starting point the installation of central heat production in Barcelona, other notable examples were made in Spain during the XXI century. One of the most interesting examples is the Thermal power plant of the ExpoZaragoza 2008.

Taking advantage of the opportunity of the International Exhibition ExpoZaragoza 2008 and the consequent urban development of Ranillas meander, the people in charge of the event decided to provide the new planned neighbourhood with a District Heating and Cooling infrastructure. The production plant can supply heat, hot water and air conditioning to all buildings that have been built with a total of 180,000 m2. It is located in a unique building of modern architecture designed by the architect Iñaki Alday. The energy distribution network is performed by buried pipes forming closed loops with a length of 5 kilometres between the plant and substations located in each building.

Figure 6: Aerial picture with the ExpoZaragoza 2008 energy distribution network.

Another examples recently built that endorse the splendour of these infrastructures during the current century are the biomass district heating system in Cuéllar, Segovia or the Justice town in Madrid which one of the buildings designed is a thermal power plant, that have had a great media coverage and have made such infrastructures become popular among the Spanish population such as environmentally friendly facilities.

3. Conclusions

The small number of urban projects with district heating system in Spain makes that the use of this technology is relegated to large urban development (university campus, hospital complexes, international exhibition centres…), as reflected in the examples above, in which such important issues as the planning of urban infrastructures or the sustainable growth of the city are essentials when designing new urban developments. The problem may be due to the dependence of the political decisions[22], the important long-term economic investment, the lack of support from private companies that promote these facilities or the disagreement of the parties involved... and this is, after analysing the project presented by Joaquín Castiella, the main reason why the idea was not performed, although the engineer assured the profitability of the company, the lack of economic resources in a time of great scarcity in all aspects.

The example of the thermal power station of the University City of Madrid, built some time ago, when the experts did not have enough knowledge to carried these facilities out in Spain and copied from other experiences made abroad should make us reflect on the need of this type of infrastructures with proven effectiveness after 80 years of operation.

Therefore, it is necessary that the technicians (town planners, architects, engineers) who are in charge of the development of cities have the adequate knowledge to design this type of infrastructures since that lack of knowledge can not be reason for the absence of these facilities. In the same manner, there are necessary civil servants and politicians with technical knowledge to manage the development of these complex infrastructures.

But besides this active management approach, the participation of energy service companies is key to promote such infrastructures. It is necessary to provide the capital that allows the development of them, with guaranteed performance and energy prices with significant advantages for consumers.

That is why, in this paper it is claimed that this type of projects has to be promoted by ESCOs, as a competitive solution not only for the power plant operator but also for the consumer, and hence for the city, encouraging the implementation of such systems with many advantages and contributing to the energy efficiency of the urban areas.

---

1 It is based on a geothermal heat source with a temperature of 82ºC. The hot water was partly distributed using drilled tree trunks as distribution pipes.

2 The main purpose of the system was to reduce the fire risk in 11 royal and public buildings located together in the old city centre and containing invaluable art treasures.

3 It is a geothermal district heating system, which today supplies almost all the 160,000 inhabitants with heat for space heating and domestic hot water.

4 A general utilization of cogeneration and district heating was outlined in the electrification plan in 1920 in order to reduce future fuel demand.

5 The Manager shall, under the general Architect Director of University City, D. M. Lopez Otero, was led by Eduardo Torroja in collaboration with D. Angel Petrirena, first and then D. Diego de los Ríos during the period of reconstruction.

6 The whole installation was carried out by Metzger, S.A., with main technical and industrial collaborations made by Caliqua for thermal facilities in general; the Maritime and Terrestrial Machinist; Brown Boveri, regarding the boilers that provided the most technologically advanced machinery, and in the masonry R . Beamonte.

7 Several members of the Construction Board visited universities around Europe and America.

8 This plant supplied heat to 120 buildings, some 800 meters far from the central core.

9 Designed by George W. Kelham and able to produce 250,000 pounds of steam per hour.

10 Including the Faculty of Law, Philosophy and Arts and the Faculty of Biological Sciences at the Complutense University of Madrid.
11 With compressors for 256,000 BTU/hr and a cold-water storage tank made of reinforced concrete, with a capacity of 110 cubic meters.
12 A housing development with 3,300 new subsidized dwellings for 13,500 people, the hospital complex as well as the university campus.
13 Letter of Joaquín Castiella to Miguel Javier Urmeneta, mayor of Pamplona, 3 July 1961.
14 Considered one of the most influential and admired architect in the Spanish architecture of the second half of the twentieth century.
15 This is reflected in the position of individual buildings in the vast green area and implementation of functional facilities such as district heating infrastructure, as he had learned after visiting many universities all around the world.
16 The most important District Heating and Cooling magazines as EuroHeat&Power or the DBDH association reflected and reported this development in 2004.
17 Belonging to the French energy giant GDF-Suez and with extensive experience in these projects, being an international leader in this type of realizations. It develops, for example, the highest European district cooling, located in the city of Paris and feeds hundreds of buildings, some as emblematic as the Louvre.
18 A hundred-year old company that distributes water in the City of Barcelona and with extensive experience managing concessions.
19 Waste treatment and Management Company that owns the incineration plant of municipal waste, which provides steam to the district heating system.
20 Catalonian Institute for Energy.
21 Institute for Energy Diversification and Saving, part of the Secretariat for Energy of the Spanish Government.
22 Since infrastructure such as require a future agreed project beyond one or two terms in office.

4. List of References

[1] Werner, Sven – *District Heating and Cooling*. Encyclopedia of Energy. Vol. 1 (2004), pp. 841-848.

[2] Frederiksen, Svend; Werner, Sven – *European District Heating and Cooling textbook*.

[3] Collins, John F. - *The history of District Heating*. District Energy. Vol. 44 (1959), pp. 154-161.

[4] http://www.coned.com/history/steam.asp 06/03/2013.

[5] New York Steam Corporation, *Fifty years of New York steam service: the Story of the Founding and Development of a Public Utility*, 1932.

[6] Fundación Caja de Arquitectos - *Manuel Sánchez-Arcas, arquitecto*. Colección Arquítemas. Vol. 12 (2003).

[7] Chías Navarro, Pilar – *La ciudad universitaria de Madrid*. Universidad Complutense de Madrid, 1986, pp. 113-128 and annex V.

[8] Laorden, José – *Instalaciones del edificio de Costillares*, Informes de la Construcción. Vol. 57 (1954).

[9] Castiella, Joaquín –*Anteproyecto de Calefacción Ubana en Pamplona*, 1961.

[10] VVAA - *Un anteproyecto de 1961 para la instalación de calefacción urbana en Pamplona*. Revista de Edificación. Vol. 36-37 (2009), pp. 110-117.

[11] Sáenz de Oíza, F. Javier – *Proyecto Campus Universidad Pública de Navarra*, 1989.

[12] Jorgensen, Christian – *District Energy for a futuristic Urban Development project*, EuroHeat&Power. Vol. 1 (2004), pp. 44-47.

[13] Rodríguez, Nieves – *Red urbana de calor y frío para ExpoZaragoza 2008*. Revista de Edificación. Vol. 38 (2008), pp. 97-103.

"Reasons why District Heating Systems were not extended in Spain".

María Eguaras, César Martín-Gómez.

39th World Congress on Housing Science Changing Needs, Adaptive Buildings, Smart Cities. Politecnico di Milano, Italia, 17-20 Septiembre 2013.

Volume 2, pp. 121-128. ISBN 9788864930206.