DISTRICT HEATING

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Contests

Summary

District energy systems distribute steam, hot water and/or chilled water from a central plant to individual buildings through a network of pipes. This chapter deals with energy aspects concerning district energy systems, such as design, cost and the pollutants produced by the use of district heating systems. The design of the district heating systems, is very important as the designer should first determine the thermal load demand as well as the necessary installations while at the end should consider the constructional options regarding energy transfer from the generation site to the central distribution station.

1. Why District Heating?

Heat has been one of the basic human necessities since the dawn of civilization. For centuries, various methods for heat generation were employed but with little respect to comfort or cost. In particular, castles had great chimney-less fireplaces in which piles of logs were being burnt. Earlier, the Romans implemented methods for heating via circulation of air heated by primitive furnaces. Today's standards of comfort are such that partial heating of a new home is seldom tolerated.

Because of the numerous benefits of central heating, soon this method was extended in that the central boiler plant would serve a number of buildings conveniently grouped together. Today, extensive systems serve industrial and housing estates, hospitals, office blocks and so on, each covering a considerable area of land. Such systems are often referred to as “group heating systems”.

Group heating evolved naturally in existing towns, new towns or residential districts comprising several housing estates grouped together. This was the historical evolution of “district heating”. This term is used for large heat generation and distribution systems. Such systems are currently in use in many countries throughout the world.

District heating was first introduced by *Mr. Holly* who installed an experimental system in New York in 1877 in order to serve a few houses, shops and offices. This experimental work attracted a lot of attention and, soon, such plants were set up in other cities in the USA. A few years later, the American District Steam Co. was incorporated, which contributed greatly towards the development of district heating.

The municipal energy service was expanded substantially after the Second World War. District heating thus became of current interest, particularly in view of the municipal involvement in electric power.

Up to the end of 1940’s electric power generation in Sweden was particularly based on hydroelectric power, although other sources of generation became necessary as the electrical energy demand increased.

Towns in which interest was focused on district heating during the 1940’s had their own electric power utilities which generated electric power in relatively small hydro-electric power stations and/or steam power stations. As the increase in electrical energy consumption continued, the point was reached where no further exploitable sources of hydro-electric power were available and the alternatives were then either to purchase electric power or to build steam power stations. The most economical approach then proved to be the combined generation of electric power and heat in stations known as district heating power stations. So district heating systems were established in order to utilize the heat demand as a basis for economical electric power generation in district heating power stations.

In the introductory stages, it was thus the larger towns which constructed district heating networks in order to meet heat demand. The motivation lay in economic considerations. The number of towns in which district heating networks were established, gradually grew in the 1960s and especially during 1969 and 1970. District heating had then proved itself to be a sound economic alternative to individual heating. Even district heating by hot water boiler stations proved to be an economical alternative to individual heating.

Today, the district heating systems in use add up to several thousands in the USA, supplying a great variety of buildings in cities with high load density such as Chicago, Detroit, Philadelphia and Baltimore.

There are also many group heating systems in West Germany where, like in other European countries, the energy needs led to the adoption of a national fuel policy and, consequently, to the rapid expansion of district heating systems. Other countries where district heating has been adopted include France, Belgium, Denmark, Norway, Sweden, Poland and Finland. In Rome, the Vatican City is heated entirely on district steam. There are also a number of installations in the former USSR countries (the largest one in Moscow), Siberia and Far East.

During its successful course, district heating faced several challenges as is expected with any new technological breakthrough. In the early stages, some schemes had proven to be financially unstable due to inexperience, but recently district heating has been steadily growing. Recent improvements in design techniques and manufacturing processes rendered such systems more and more economical.

Many of the earliest installations exploited the exhaust steam produced at power stations, whilst others depended on the use of "live" steam delivered by a boiler plant. Later, developments in the use of high pressure hot water and the combination of heat and power generation were achieved.

At first, district heating systems were installed and operated by private or state (i.e. Eastern Block countries) enterprises that were also concerned about power supply. As district heating continued to expand, installation and management of such systems were undertaken by institutions, municipalities or the state itself. In some countries, contractors provide the fuel, operate the plant and maintain it on behalf of the owners.

The key factors that have contributed to the development of district heating are:

- Reduced local/regional air pollution
- Increased opportunities to use ozone-friendly cooling technologies
- Infrastructure upgrades that provide new jobs
- Enhanced opportunities for electric peak reduction through chilled water or ice storage
- Increased fuel flexibility and energy security
- Fuel savings and lower operational costs

District energy systems can use a diversity of energy resources, ranging from fossil fuels to renewable energies, to waste heat. They are sometimes called "community energy systems" because by linking the energy users of a community together district energy systems maximize efficiency and provide opportunities to connect generators of energy from waste (e.g. electric power plants) with consumers who can use this energy. The heat recovered through district energy can be converted to cooling using absorption chillers or steam turbine drive chillers.

Storage of chilled water or ice is an integral part of many district cooling systems. Storage allows cooling energy to be generated at night and to be used during the hottest part of the day, thereby helping management of the demand for electricity and reducing the need to build power plants.

The substantially lower cost of district heating, when compared to other methods for heat supply, has been the greatest incentive for its use. There are many factors affecting the economics of a district heat supply, but none is more significant than its capability of meeting the highest demands possible.

- **General considerations**

The increasing interest shown in the use of district heating is derived from a greater appreciation of its benefits to human productivity and comfort. Thus, in order to be completely satisfactory, a district heating service should provide sufficient heat when and where required, at the right price.

One of the first essentials to be considered is the size of the heat load and the distance to be covered between the central station and the consumers. Therefore, the density of the heat load in the area to be served must be assessed in order to ascertain whether it lies within the economical bounds for heat transfer. Consequently, the location of the central station and the density and nature of the buildings will determine whether a district heat supply can be economically provided or not.

Another very important factor is the nature of heat demand. Depending upon each class of consumers to be served, a decision should be made whether steam or hot water, or a combination of the two, is the best means for heat transfer.

The method to be used to control heat supply also depends, to some extent, upon the class of consumers to be served. When the heat supplier has full control, as may be the case in mainly residential areas, heat supply may be restricted to suit average needs and charged at a flat rate. Alternatively, consumers may be given full control, particularly in areas including residential as well as commercial and industrial facilities. In such case, heat supply would be available at all times and priced according to the amount of heat used by each consumer.

If hot water is used as the means for transferring heat to the consumers, special considerations need to be taken into account regarding the control method in order to achieve satisfactory results. In this case, if the consumers are mainly families, a simplified form of control may be applied to ensure adequate stability of water pressures and volumes in the supply circuit. If, on the other hand, commercial and industrial consumers with various types of equipment in their buildings are to be supplied as well, a more comprehensive control arrangement is required to ensure proper regulation of heat supply. In order to select the heat source to be used, all relevant factors need to be carefully examined since the success of the project depends upon the right choice for the heat generating plant. The location of the area to be served indicates the most appropriate and convenient type of heat generation. Some conditions may favor only heat generation; others may favor heat-power generation or even the use of nuclear power.

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Biographical Sketch

Mrs. Irene Koronaki is an associate of the Department of Building Applications. She is a Mechanical Engineer and obtained her PhD in the Thermal Section of the Mechanical Engineering department of the National Technical University of Athens. She has experience in the field of Energy Efficiency in the building sector, regarding both building shell and services. She has participated in several research EC programmes (THERMIE, JOULE, SAVE, CRAFT) during her collaboration with the University of Athens, Department of Physics, as also as a collaborator of CRES. She is a member of ASHRAE and a registered engineer (Technical Chamber of Greece).