Efficient Implementation of DH Technology for Domestic Heating in Greece

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Abstract

District heating was first used in Greece in 1994, implementing Combined Heat & Power technology to supply consumers with thermal energy. When the new projects being developed today are completed, the total installed nominal capacity is expected to exceed 300 MWₜₜ, of which almost 85% is covered by the existing coal fired power plants and the remaining 16% which is mainly for peak load is covered by the use of diesel and LPG. Today the number of consumers is more than 25,000 while the number of buildings connected is more than 6,000. District heating technology is a particularly attractive choice for Greece, mainly because of its competitive pricing policy and the low cost of initial installation. With the liberation of the energy market and the development of the gas distribution network in Greece, this technology is expected to expand offering significant energy and environmental benefits in the country.

1. Introduction

District heating is an efficient and environmentally friendly energy technology that involves the production, transportation and distribution of hot water for domestic heating. It has been used in Greece since 1994 and two installations are today in operation (Kozani and Ptolemais), while two more installations are under construction in the towns of Amynteo and Megalopolis. The main characteristics of the urban areas served by this technology are the adverse climate conditions due to their high altitude and also their vicinity to lignite fired power plants, which are the main source of thermal energy used for district heating installations in Greece.

Up to now, the most common form of heating in Greece has been individual central heating. Each system serves only one building and uses in the vast majority of buildings, heating oil (diesel). The development of DH systems and consequently the reduction of the atmospheric emissions in the
cities of Ptolemais and Kozani (as well as in Amynteo and Megalopolis in the near future) during the winter time is significant for environmental improvement of in the area concerned. The substitution of heating oil with district heating contributes to the reduction of atmospheric emissions.

2. **Current Status of District Heating Sector in Greece**

2.1 **Introduction**

The population of Greece is 10.964 million. Greece lies between the latitudes 35 and 42. In general, the climate is mild Mediterranean, although it varies according to the latitude, the vicinity to the sea and the geomorphology of each region. The segregation of the country into three geographical zones, considering their climatic conditions and according to existing regulations for heat insulation, as defined by the Presidential Decree, (The Official Gazette 362/4.7.79), is shown in Figure 1. Taking as basic temperature 18°C, the number of heating degree-days in Zone A, which is the warmest zone, is below 900, in Zone B it ranges between 900 and 1300, and in Zone C it is above 1300.

**Figure 1.** The three geographical zones of Greece (Zones A, B, C) according to their climatic conditions
The mean value of the energy required for the heating and hot water production in older of the existing buildings, due to their insufficient insulation, is significantly increased compared to the energy requirements of new buildings, which are constructed in accordance with new regulations, Table 1.

**Table 1.** Representative values of the energy behavior of the existing and new buildings with hot water production, in three major Greek towns

<table>
<thead>
<tr>
<th>Building Type</th>
<th>Unit</th>
<th>Chania (Zone A)</th>
<th>Athens (Zone B)</th>
<th>Thessaloniki (Zone C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insulated four-floor building</td>
<td>kWh/m².a</td>
<td>41.0</td>
<td>52.0</td>
<td>68.0</td>
</tr>
<tr>
<td>Four-floor building</td>
<td>kWh/m².a</td>
<td>86.0 (mean value)</td>
<td>127.0</td>
<td>191.0</td>
</tr>
</tbody>
</table>

### 2.2 District Heating Sector

In Greece district heating is used almost exclusively for heating private and public buildings in urban areas with relatively high population density. From 1994 to today the total heat capacity covered by district heating networks has increased significantly and by over 65% in the last 5 years. The heating load covered by district systems is shown in Figure 2.

At the same time the number of district heating customers followed a corresponding upwards trend as shown in Figure 3.
Figure 2. Heating Load covered by District heating systems in Greece

Figure 3. Buildings connected to the District Heating Networks in Greece
Heating requirements in Greece are covered mainly by use of Diesel oil. Only recently the use of natural gas has begun to be promoted in big cities situated near to the main distribution pipe-line (Athens, Thessalonici, Komotini) with a view to reducing environmental impact and administration costs. It is not possible to determine the exact participation of the various energy fuels in covering the demand of the air-conditioning loads. From the available data, the following estimates can be drawn up:

- Heating diesel, which meets the demands of buildings central heating systems, covers the majority of heating loads. Even though there are available data for the annual consumption of heavy oil for heating, they cannot be considered reliable because large proportions of heavy oil, due to their low price, are used for other applications apart from heating. However, the data for heating diesel sales are reliable. During 1999 a total of 3,173,401 tons were used, covering about 51.5% of the heating energy requirements.

- The cooling loads are almost exclusively covered by electricity. There are no available data for the individual housing consumption of electricity. Assuming that approximately 1/3 of the total electricity consumed by the houses and office buildings concerns the conditioning of the area and the production of hot water, its participation in the coverage of conditioning loads, in 1998, is estimated at 12.0%.

- According to the two district heating companies, operating in Greece, their total energy consumption, in 1998 was around 275.4 MWh or 0.8% of the total energy consumed for the air conditioning of buildings.

- The participation of biomass (8%) mainly concerns firewood used for house heating in the countryside.

Figure 4 shows the participation of each fuel in covering buildings conditioning requirements.
The participation of various energy fuels in the conditioning of the buildings

- **Electricity**: 34.8%
- **Biomass**: 8%
- **Solid and liquid fuels**: 1%
- **Solar energy**: 4%
- **District heating**: 0.8%
- **Diesel**: 51.5%

**Figure 4. Participation of fuels in the conditioning of the buildings - 1998**

### 2.3 Short description of the existing District Heating Systems

Today there are two district heating installations in operation in Greece, located in the towns of Kozani and Ptolemais as shown in the previous map. The thermal energy requirements for their operation come from the nearby lignite fired power plants belonging to the Public Power Corporation, which is the main electricity producer in Greece. The lignite mined in these areas is the main country’s energy source and is used for 82% of primary energy production. Since it is a domestic fuel it is a low cost energy source when compared with imported fuels (oil, natural gas, hard coal, LPG etc).

#### District Heating system of Ptolemais

It was founded in 1994 by the Municipality of Ptolemais. It is a private company and has been operating since January 1995 as an independent municipal enterprise for producing and distributing thermal energy to domestic consumers. The company has recently started to branch into other activities by creating greenhouses and by supplying private agricultural activities with thermal energy. Today, the internal distribution network for B’ and C’ zones having been completed, the number of buildings served is 1.653 which corresponds to 993,691 m² heated and of total volume of 2,913,116 m³. The apartments served were 8,853 by February 2003. The required thermal capacity for those consumers is 99.25 MW<sub>th</sub> and has the potential to increase to 146.02 MW<sub>th</sub> due to new consumers. In the near future it is foreseen that 475 new buildings with a total heated volume of 518,880 m³ and required heating load of 12,50 MW<sub>th</sub> will be supplied.
District Heating system of Kozani

Kozani’s district heating system started in 1993 and today serves more than 17,000 customers who rent or own their apartments. The total surface area heated amounts today to 1,625,000 m². The contracted heat capacity amounts to 224,360 Mcal/h, of which about 5% covers the public sector. The installed thermal power for serving the base load today is 70 MWth, which comes from units 3 and 4 of Ag. Dimitrios lignite fired power station located 15 km from the town. The hot water distributed by the primary network has outgoing – return temperatures of 120°C – 95°C respectively. The transport and distribution to the customers’ thermal substations is carried out with the help of 3 pumps. The peak load is covered by 3 boilers equipped with oil and LPG burners with a capacity of 10 MWth each and another one with a capacity of 27.5 MWth. The total distribution network has a length of 285 km while in the town of Kozani 3,500 consumer thermal substations have been placed. The company responsible for operating the system is the Municipal District heating Company of Kozani.

3 Energy, Taxation and Pricing Policy

3.1 Pricing policy

The pricing policy followed by the District heating companies in the towns of Kozani and Ptolemais since they started operating has been determined by the following factors.

- The legal status and the public welfare character of the companies,
- Their economic viability,
- The attraction of new customers to their district heating networks,
- The covering of the financial and operating requirements of the companies, and finally
- The parameters that determine the energy market on a national level and especially the cost of diesel oil.

Bearing in mind the above, the selling price of thermal energy for the companies’ consumers is about 65% of its production cost using heating oil. So as to determine the final cost, the length of the heating period – 7 months in both towns – and the efficiency of boilers (0.85 – 0.90%) were taken into consideration. In practice the benefit for consumers so far for the installations’ operation has been more than 40% if we take into account the fact that the boilers which were replaced were old and poorly maintained and therefore inefficient, Table 2. As is indicated in
Figure 5, the cost of the district heating systems operation is significantly low. This cost results from the low cost energy supplied from PPC to the Municipal Enterprises, which are carrying out the management of the systems, and also from the attempt of Municipality Enterprises to attract the interest of consumers.

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>Lower Heating Value</th>
<th>Without VAT 18%</th>
<th>VAT 18% Included</th>
</tr>
</thead>
<tbody>
<tr>
<td>District Heating</td>
<td>25,30</td>
<td>29,85</td>
<td></td>
</tr>
<tr>
<td>Briquettes</td>
<td>14260 KJ/kg</td>
<td>11,20</td>
<td>13,22</td>
</tr>
<tr>
<td>Firewood</td>
<td>18800 KJ/kg</td>
<td>13,00</td>
<td>15,34</td>
</tr>
<tr>
<td>Diesel</td>
<td>42700 / LT</td>
<td>27,82</td>
<td>32,83</td>
</tr>
<tr>
<td>LPG</td>
<td>45720 / Kg</td>
<td>29,90</td>
<td>35,28</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>36000 / Nm³</td>
<td>38,19</td>
<td>45,06</td>
</tr>
</tbody>
</table>

With the improvement of standards of living, although they show lower prices, solid fuels are not preferable due to the difficulties of using and storing. The fuel that is almost exclusively used in the central heating of Greek buildings is heating oil (diesel), which has a significantly lower price than electricity and the installations for heating production are not expensive. The utilization of a cheap night electricity rate for heating is possible only if serious investments for the enhancement of the electrical installations and the purchase of heat accumulator take place. It is expected that natural gas will cover, in the near future; significant conditioning loads, substituting, heating oil and electricity.
Figure 5. Fuel types and their cost per thermal energy unit – Prices for 2000

3.2 Energy taxation

In Greece fuel prices are burdened with the Value Added Tax (VAT 18%). District heating is also subjected to 18% VAT. Heating oil is subsidised by the state to a significant extent during winter period, which reduces its price by up to 50%. Since 2001 there have been taxes on activities in the energy sector. These taxes are income form the Energy Regulation Authority and include:

a. reciprocal lump sum tax when the operating licenses are issued,

b. Reciprocal annual tax based on consumption or power produced.

A reciprocal annual tax is imposed on natural gas (0,18€ / 1000 Nm$^3$) and on diesel (0,15 € / 1000 l). These taxes are charged to fuel importers and are incorporated in the selling prices of the final products.

4. Environmental Aspects

It has been proved that the district heating systems have made a significant contribution to reductions of gas emissions in the cities of Kozani and Ptolemais during the winter period. Based on data collected from the Municipal enterprise of Ptolemais, the average smoke concentration in the air during January 1988 (before DH) was 58 µg/m$^3$, while in January 1995 (after DH) was 13...
µg/m³. The relevant values for SO₂ were 55 µg/m³ and 19 µg/m³, respectively. As for Kozani the average smoke concentration in the air during January of 1988 was 62 µg/m³, while in January 1995 it was 22 µg/m³. The relevant values for SO2 were 170 µg/m³ and 15 µg/m³. The sulphur contained in heating oil and also the deficient combustion conditions in small central heating boilers in towns are to a large extent the factors responsible for the concentration of sulphur oxides, nitrogen oxides and particulate matter in the towns’ atmosphere, which have adverse effects on public health and also at the environment.

In addition, when there is no wind the atmosphere id divide into layers, which comprise relative smooth isothermal surfaces. When the temperature of the layers of air increases form the earth’s surface towards the upper layers we have the greenhouse effect. As a result of this, the pollutant emissions from low-level central heating chimneys in towns are not diffused and therefore they appear as pollution, which makes the environments in towns much worse. On the other hand the concentrated emissions of pollutants from tall chimneys are usually diffused in the higher atmosphere layers not causing serious problems.

5. **Energy Conservation Measures**

The Greek Ministry of the Environment, Planning and Public Works has carried out the project “Activities Plan 2001”. Main target of this project is to motivate the use of both active and passive energy conservation measures, including the use of improved insulation systems in new and existing buildings. Within the above framework, by ministerial decision, regulations will be laid down for the rational use and saving of energy which replace the existing insulation regulations. This measure aims to improve energy efficiencies of buildings in order to save energy and protect the environment. The new regulations will apply to all the new buildings and also to the existing ones as far as reviewing necessary interventions for the improvement of their energy efficiency is concerned. The use of DH systems is expected to play an important role in achieving the above aims. According to the Ministry of the Environment, an average 60% of energy saving will be achieved in Greek buildings if the regulations for heat insulation are applied.
6. Additional Laws, Regulations and Arrangements

6.1 Legal status of current District Heating companies

In Greece today the exclusive District Heating operators are the municipal companies, which have either added thermal energy distribution to their existing field of activities (Municipal District Heating Company of Kozani) or were founded by the Municipalities exclusively for that purpose (Municipal District Heating of Ptolemais). The primary aim of these companies is to ensure their viability through their expansion of their activities and through more efficient exploitation of existing resources. Although the legal status allows and subsidizes the foundation and operation of private district heating companies, this has not so far been possible. The main reasons are the high initial investment costs for the construction of units producing both electrical and thermal energy and also the reduced competitiveness due to the use of alternative fuels other than lignite (diesel, natural gas and LPG).

6.2 Current status of energy market in Greece

The energy market in Greece is controlled by the Energy Regulation Authority founded in 1999, which aimed at achieving a legal framework for free and healthy competition so that consumers would enjoy better and cheaper services. The same law foresees the setting up of an Electrical Energy Administration Authority and the free exploitation and production of electricity produced by renewable energy sources, combined heat and power technology as well as from conventional fuels. The main legislation regarding the field of energy production is law 2244/95 (Adjustment of energy production matters from renewable energy sources and by conventional fuels). This law gave strong financial incentives for the development of energy investment, providing a stable business environment for long term contracts for the purchase of electricity.

6.3 Financing opportunities of District Heating and Combined Heat & Power projects

The main source of funding for the development of DH system is the Business Competitiveness Program. The state subsidy for projects in this program ranges from 30 to 45% of the total investment budget. Alternatively, energy investments of this kind can be funded by the country’s new development law (N.2601/98). The subsidies in this case range from 15-40% depending on their geographical area. This law is being reviewed at this time.
7. Future Trends

Promotional activities in the field of district heating and combined heat & power generation are focused on the construction of new plants in residential areas nearby the PPC’s thermal power plants or in energy intensive industries which produce sufficient quantities of burnable waste. The Energy Business Plant of the Ministry of Development supports the relevant investments.

Two more district heating systems will operate, in the near future, which will be supplied by PPC’s lignite-fired power plants, with the co-generation of heating and electricity (one in Amynteo, West Macedonia and another in Megalopolis, Peloponnisos). Additionally, serious attempts have been made for the installation of individual co-generation units, which will be based on domestic fuels, for the district heating of small towns. To maintain the competitiveness of the district heating systems, changes in the management of the enterprises have to be taken into consideration.

From 1977 to 1990 the building stock in Kozani prefecture, where the two existing district heating systems are located, grew at an average rate of 6.5m³/capita.annum. This value, which is very close to the national rate of building stock growth, varies significantly from year to year. After the earthquake of the May 1995, the construction of new buildings and the renovation of old ones has been increased dramatically and has reached almost the rate of 9m³/capita.annum.

However, the rate of growth of building stock is not closely connected with the rate of expansion of the district heating systems. The new connections to the DH systems correspond mainly to customers in suburbs and other areas where the two networks are gradually expanded. Moreover, the anticipated fast growth of the DH sector in Greece is expected due to the construction of new systems rather than the growth of the existing ones. Most buildings in Greece are characterized by the insufficient heat insulation of their cells, which results in significant wastage of heat and energy.

8. Conclusions

Statistics show that an ever-growing number of domestic consumers are choosing to be connected to the existing district heating networks. The main reasons for this are the long term competitive pricing policy, the absence of administrative costs and the low initial investment cost in comparison to that of purchasing an oil fired boiler. The present lack of extended gas pipe distribution network for domestic consumption in the big cities of northern Greece has resulted in
limited development of district heating networks in urban areas located near to the existing coal fired power plants. However the liberation of the electricity market combined with the continuously growing share of natural gas in the domestic energy market will dramatically change the landscape in the energy sector and will allow the more widespread use of this technology in the north of the country. It is expected that the Greek government’s economic measures regarding energy saving and efficient energy utilization will be of particular help in achieving the above target.

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