SOCIAL AND ECONOMIC DIMENSIONS OF DISTRICT HEATING: A CASE STUDY

Electra Pitoska Electra[1], Anastasia Liana[1], Leandros Araviadis[2]

[1]Department of Accounting and Finance, University of Western Macedonia, Greece

[2]School of Civil Engineering, Faculty of Engineering, Aristotle University of Thessaloniki, Greece

Abstract

Among major contemporary issues, energy resources and sustainability have caused global concern, thus, emphasizing a more rational use of energy systems and renewable sources for power and heat generation systems, such as district heating. In Greece, energy resources and environmental issues have been given great emphasis. Recently, environmentally friendly policies have been focused on relevant laws, incentives for renewable energy implementation schemes, and applications of new technologies. In this context, there has been a considerable increase in the number of district heating units, and, as a consequence, in the variety of financial, environmental, and power generation benefits. Major district heating facilities have been established in various areas, among which Ptolemaida, Amyntaio, Kozani, Serres, and Megalopolis.

The present survey, which was carried out to investigate the socio-economic dimensions of district heating, was based on a representative sample from Ptolemaida, where winter is long, weather conditions are harsh, and district heating units are close to large PPC facilities.

The corpus of data was drawn from the analysis of a structured questionnaire comprised of two parts with 21 questions answered through social media by residents, in April and May 2019. The 401 questionnaires were analyzed, first, by employing descriptive statistics and, subsequently, via SPSS.

The research results demonstrate that, before district heating was introduced, heating generation mostly relied on oil-fired boiler systems, the heating cost of which was changeable in contrast to district heating prices, which are rather fixed, and, thus, affordable. In addition, the results indicated that a reduction in imported oil consumption is conducive to national economic growth.

Heating quality in district heating systems is considered fairly high mainly in terms of the high thermal efficiency it provides. District heating has greatly contributed to reducing pollutants and protecting the environment, especially in areas such as Ptolemaida, which is heavily affected.

Finally, the research also demonstrated that an overwhelming majority perceive the crisis as a great opportunity for fostering ecology awareness and the use of renewable energy.

Keywords: *socio-economic dimensions, district heating, Ptolemaida*

1. DISTRICT HEATING (DH)

District heating (DH) is the supply of thermal energy to buildings and sometimes to production processes through a network of insulated pipes. These pipes carry hot water, which in many cases is heated by the heat produced as a by-product of electricity production. District heating makes obsolete the installation of additional thermal energy production systems as it is produced and supplied centrally and delivered to end-users by installing terminals (collectors) inside the buildings

District heating in Greece covers only a small part of the final demand for space heating (0.2% in 2007) and the heat dissipated in the network comes from thermal power plants that use conventional fuels. The first small district heating installation in Greece took place in Ptolemaida in 1960, for the heating needs of the Public Power Corporation (PPC known in Greece as DEH) settlement in the Suburb of Eordaia from the Ptolemaida substation. Today, the cities of Kozani, Amynteo, Filotas and, Megalopolis are equipped with District Heating facilities that utilize the thermal load of the neighboring thermal power plants, while in Serres a corresponding role is played by a cogeneration unit of thermal and electricity.

The implementation and expansion of district heating is a priority in the European Union and is proposed as an appropriate technology for saving energy and heating/cooling costs, reducing greenhouse gases and energy dependence on imported fossil fuels., Therefore District Heating is mentioned and promoted as an environmentally friendly solution in several European directives, such as the Energy Performance of Buildings Directive (EPBD) and the Energy Efficient Design (EED).

The Nordic and Central European countries, which have a tradition in the application of district heating, have in recent years managed to further improve the energy, economic and environmental effect of such systems through the use of Renewable Energy Sources (RES). The exploitation of RES and the application of related technologies, mainly biomass and solar thermal systems, began as early as the 1990s, which has now led to the implementation of thermal energy and cooling applications in district heating/cooling networks entirely from RES.

The utilization of RES leads to significant benefits; local communities reap these benefits through coordinated and well-thought-out cooperative actions by increasing their incomes while developing new business activities that create new, high-level jobs. As a result, in many cases declining local communities are revitalized, industrial activities are being developed and both research and education are being strengthened. Typical good examples of this are the cities of Güssing in Austria, Marstal in Denmark, Nacka in Sweden, Milano in Italy, Burgos in Spain, Düsseldorf in Germany, Helsinki in Finland, Poderwijk in the Netherlands, and many others.

Ptolemaida started as a pilot project, the success of which was considered to be the reference point or model in Greece. The city of Kozani followed Ptolemaida's example and launched its system in 1993, as well as the city and the communities of the Amyntaio area that operated their DH system for the first time in the winter of 2004-05. Today, installations of district heating systems are being prepared in cities of Central and Eastern Macedonia and Thrace, which will utilize the gas pipelines passing through the region.

2. ADVANTAGES OF DISTRICT HEATING

Fossil fuels such as natural gas, oil, or coal (lignite) in power plants stations are mainly used for the production of electricity. The efficiency of electricity generation is usually around 40%, while the remaining 60% is the loss of heat dissipated in the form of superheated water or steam at temperatures between 120oC and 140oC. This superheated water or steam is employed to heat the water used in DH through a heat exchanger. At the beginning of the supply, the water has a temperature of about 100oC and at the return, after delivering energy to the heat exchanger, 40o - 60oC. In this way, significant economic and environmental benefits are achieved by utilizing exactly this heat source which, otherwise, would be released into the environment. Finally, with the application of DH, the standard degree of efficiency of electricity generation increases to 80%. The process of simultaneous production of electricity and useful thermal energy is defined as Combined Heat and Power Cogeneration (CHP). With the application of district heating, energy savings of more than 30% are achieved, provided that all the discarded heat is utilized.

The application of district heating achieves significant savings in heating about the direct combustion of any fossil fuel in individual heating units of buildings, as the heat used is quite cheap and any costs related to the management, transmission, and distribution of thermal energy. Furthermore, DH, as a central system, has better operation, quality, economic, and energy efficiency of heating due to the continuous monitoring and maintenance of the facilities compared to any autonomous heating system. In Greece, the cost of heating by DH systems is at least 50% lower compared to that of oil, while maintenance costs are almost zero for consumers because it is included in the cost of thermal energy provided.

Other important benefits that arise directly or indirectly from the application of district heating are:

- Foreign exchange savings as the most common fuels for heating, oil, and gas, are imported.

- The creation of jobs for specialized personnel of engineers, technicians, and administrative staff during the construction phase of the networks, as well as during the operation phase of the facilities.
- The low cost of installation and operation, the safety of facilities, and space savings in buildings as no boiler and fuel storage facilities are required.
- The lowest cost of production in greenhouses, dryers, etc. requiring heating

3. THE DISTRICT HEATING OF PTOLEMAIDA

The first application of district heating in Greece took place in the city of Ptolemaida, where oil was mainly used to heat buildings until 1993. Today 75% of the city's heat needs are met by lignite-fired power plants that serve two main functions: they both adjoin the city and co-generate electricity and heat (DETIP. http://goo.gl/B1R2wA).

The Municipal District Heating Company of Ptolemaida (known as DETIP), established in 1994, is the first in Greece purely municipal company with the responsibility of providing thermal energy needed by the city of Ptolemaida, while the cogeneration is managed by PPC. The municipality and DETIP have invested more than 60 million euros of public and own resources and are seeking the further expansion of the system, directly in the area of workers' housing and Nea Kardia and in the future in the communities of the Municipality of Eordea.

Buildings are connected to district heating systems after a contract is signed. According to this contract, the corresponding connection fee is determined per gross square meter of the space to be connected. The selling price of thermal energy is determined by the cost of heating oil. Under the connection contract, it cannot exceed 70%, while it can reach as low as 30% of the corresponding cost of heating oil. Due to the attractive pricing policy, DETIP ensured the rapid acceptance of district heating by the citizens of Ptolemaida.

Following the published data of DETIP, the selling price of thermal energy to consumers from 2014 to 2015 was 37.74 € / MWh DETIP («The current discount on DH to the consumer Exceeds 66% of the corresponding oil cost» http://goo.gl/ZUW4zm), while the supply price of thermal energy by PPC in 2012 was 9.87 € / MWh (Kalaitzidou Ioanna, Director of DETIP, 2012 «Prospects for the Development of a District Heating System in the Municipality of Eordea» https://goo.gl/J1cf6v). Therefore, the cost of supplying thermal energy by PPC represents about 26% of the cost of sale to consumers; while the remaining 74% is mainly the operating cost of the district heating network, i.e. staff costs, maintenance costs of electromechanical equipment, depreciation, or investments.

Based on the available data from DETIP during the winter from 2014 to 2015, the connected buildings & heated apartments amounted to 3860 and 14943 respectively, including 55 public buildings with an area of 102,000 m2. During the period 2013-14, the total annual billed load amounted to 159,131 MWh (with a reduction to the same number of buildings), while in the period 2014-15 it increased to 183,360 MWh. Respectively, the annual supply of thermal energy from PPC and the combustion of heating oil in the period 2013-14 was 208,273 MWh and 234,165 MWh in the period 2014-2015.

4. THE EMPIRICAL RESEARCH

4.1. The research methodology

This paper aims at investigating in practice the issues of economic and social dimensions of district heating. Therefore, field research was organized. The city of Ptolemaida was selected as the research field since it presents three interesting features: long winters with harsh weather conditions, it is located next to large power plants (PPC), and is the first city in Greece to implement a district heating system.

A properly structured questionnaire was prepared for the needs of the research. It was shared through social media due to the special conditions generated by the Covid 19. A total of 401 completed questionnaires were collected.

The questionnaire is comprised of two sections of questions and includes a total of 21 questions. The first section deals with demographic characteristics and involves gender, age, occupation, household members, and connection to District Heating. While the second section concerns the type and manner of heating, which regards the following: link with the heating space, the use of additional heating means, the type of heating before District Heating, the degree of satisfaction of the participants concerning their connection to District Heating, independence from oil, the necessity of district heating, its cost concerning oil, the ecological awareness and the possibility of re-selecting district heating.

4.2. Research findings

The survey involved mainly women (63.4%) and fewer men (36.6%). The age scale demonstrated higher participation of those aged 35 to 54 years (54,8%), followed by the ages of 25 -34 years (21,5%).59.4% of the participants are graduates of higher and Tertiary education and 36.1% are graduates of secondary education. The professional status of the participants shows range and variety including private employees (27.5%), civil servants (22.7%), self-employed (16%), unemployed (12%), and retirees. As far as their financial situation is concerned, 31.8% of the participants have an annual family income of 7,001 - 15,000€, 23.3% earn 15,001 - 25,000€, 21.5% earn no more than 7,000€. 15, 7% of the participants are wealthy employees and make 25,001-35,000€ and only 7.7% have an income over 35,001€.

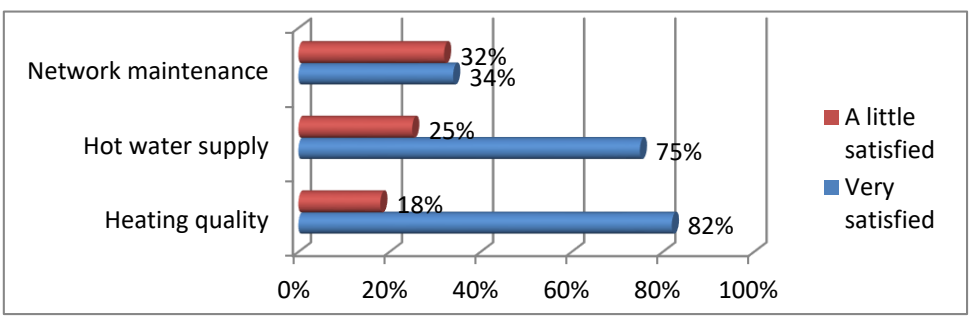
Moreover, the households of the participants in the research consist of 4 members (41.7%), 3 members (19.5%), 5 members (17.2%), 2 members (16.9%), and one person (4.7%).

The participants in the survey are mainly (77.7%) property owners, tenants at a rate of 15.1%, guests (7.3%), and the vast majority (92.8%) is connected to the network. The main priority for the respondents was the heating of their first/main residence (92.4%) and to a small percentage (5.7%) they connected to the heating of their second residence.

Until the installation of district heating, the most common type of heating was the boiler with an oil burner with a percentage of 81.8%. Fewer used as heating fireplaces, stoves, air conditioners, etc. Individual heating was used by 66.2% while central heating by 33,8%. After correlation with the SPSS program, it seems that 51.3% of the participants that have central heating use another type of heating along with district heating, to be more specific out of 51.3%, 18.3% use an inverter air conditioner, and 13% an oil boiler. 47.8% who have individual heating also use another type of heating, out of which 19% use the air conditioner inverter and 11.2% the fireplace.

One remarkable finding of the survey suggests that there is a high degree of customer satisfaction with the district heating services. To be more specific, consumers are very satisfied with the heating quality and the hot water supply. On the other hand, they were not particularly satisfied with the network maintenance. The degree of satisfaction is illustrated in the graph below:

Graph 1. Customer satisfaction degree



According to the answers, the participants recognize the high efficiency of District Heating in reducing pollutants and protecting the environment, as shown in the table below.

Table 1. Contribution to the environmental improvement

	None	Minimum	Average	Significant	Excellent
Pollutant Reduction	3%	7%	17%	38%	35%
Environmental Protection	2%	9%	16%	37%	36%

As far as the 24-hour availability and security are concerned, the vast majority express a high degree of satisfaction. Regarding the saving of storage space about other heat sources the opinion differ since 25% answered that they are extremely satisfied, 31% very much, 25% moderately satisfied and 19% are not satisfied. Furthermore, 73% of the participants are satisfied with the high thermal efficiency. The evaluation scale is shown in the following table

Table 2. Assessment of customer satisfaction

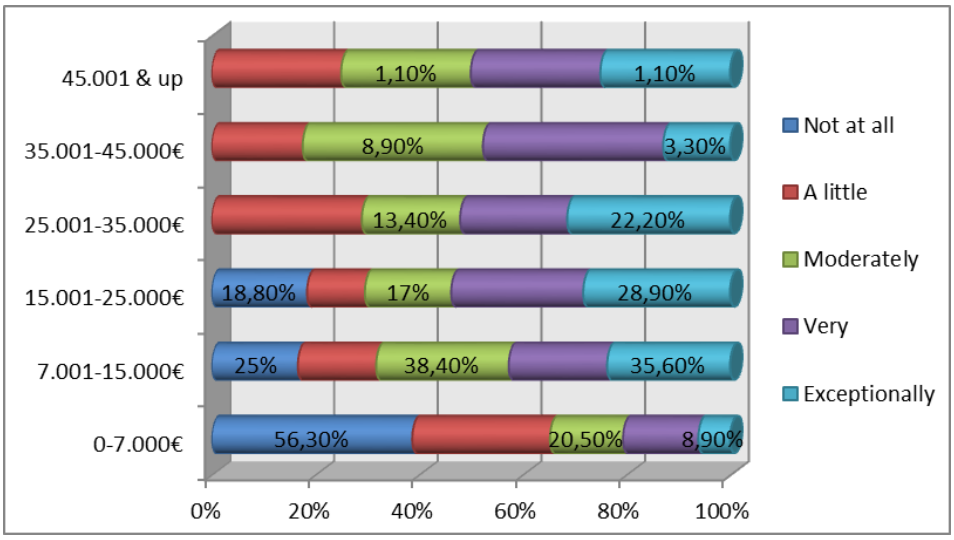
	Not at all	Little	Moderately	Very	Extremely
Safe Heating	1%	6%	12%	38%	43%
24-hour supply availability	4%	5%	13%	34%	44%
Saving storage space	7%	12%	25%	31%	25%
District Heating Thermal Efficiency	2%	7%	18%	34%	39%

The creation of new jobs due to district heating is a controversial issue. There is a considerable number of participants who believe that district heating does not create any new employment positions (15%) or create minimal jobs (17%). In terms of their expectations, 29% have moderate expectations, 21% high expectations, and only 15% exceptional.

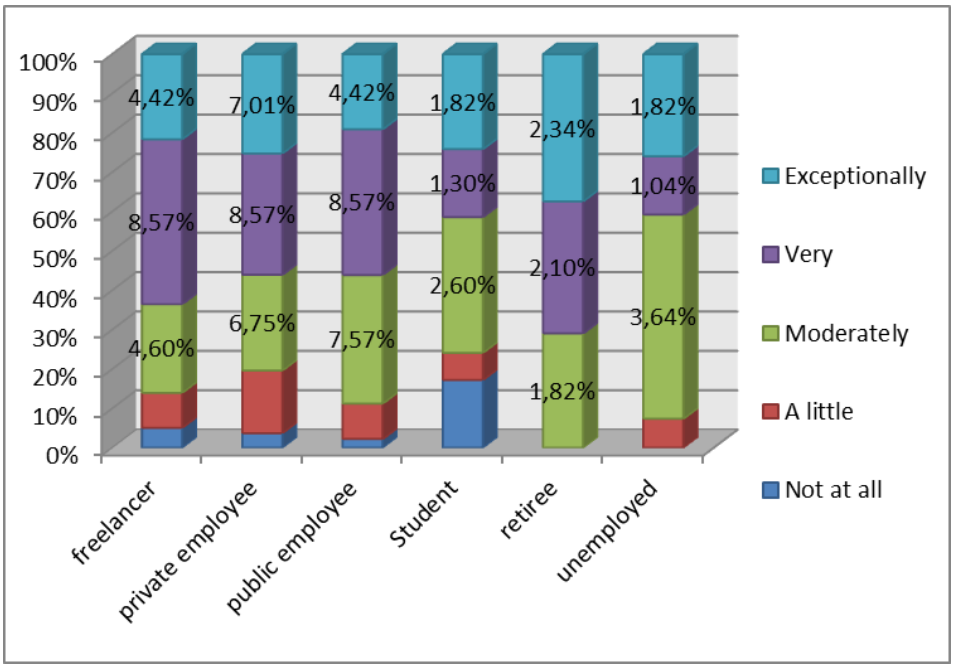
Although the pricing policy of district heating is determined by the cost of heating oil and cannot exceed 70% of its corresponding cost, there are participants (37%) who state they are moderately satisfied with the annual heating cost, as well as that 14% who are not satisfied. However, 49% are satisfied.

Regarding the annual heating costs, the majority (55%) consider that district heating is a cheap heating source of heating whereas 44% claim that they are not very satisfied. The correlation showed that the unemployed and retirees are mostly satisfied while the participants of the other occupations show a wide range of views. As for the possibility of settling the payment of heating costs, 59% said they were satisfied, 28% are mediocre and 13% are not. These findings are illustrated in the graphs below

Graph 2. Customer satisfaction based on the correlation between annual family income and cheap heating source



Graph 3. Customer satisfaction based on the correlation between occupation and cheap heating source



The price of district heating has remained stable since 2010 and most of the sample (56%) is positively satisfied with the DH fixed cost. However, 12% of the participants argue that they are not so satisfied, while 33% are moderately satisfied. Regarding the installation cost of district heating, they are moderately satisfied (38%), followed by the very satisfied (33%) and the dissatisfied (32%).

Based on the benefit of connecting and not using oil (it should be emphasized that the depreciation of the connection, always concerning oil, is very fast) the largest percentage of participants are moderately satisfied with the cost of the installation connection, regardless of income level

Oil dependence is considered a crucial factor by an extremely high rate. Additionally, according to the answers on whether the financial crisis affected their decision to connect with district heating, a range of estimates is recorded. 55.4% state that they were affected by the financial crisis, whereas 21.80% state that the financial crisis did not influence their decision at all and 5.5% that they were slightly affected. Respondents coming from all income classes, except those with an annual family income of more than 35,001 euros and above, believe that the financial crisis has helped a lot with the decision of households to connect to district heating.

Taking into account the fluctuating oil price and the stability of the price of district heating, 78,2% replied positively that the stable and lower cost of DH contributes to the reduction of the family budget. On the other hand, only 21.8% gave a neutral answer and a negative response.

The local community of Ptolemaida seems to have a positive view regarding the contribution of district heating to the economy of the state due to the reduced oil import. This is confirmed by the positive answer given by 69% of the sample. Only 9.3% have the opposite view. 81% of the participants consider that the time of the economic crisis is a good opportunity to promote ecological consciousness, regardless of their profession and income.

5. CONCLUSIONS

The implementation and expansion of district heating are a priority in the European Union. Hence, it is proposed as an appropriate technology for saving energy and heating/cooling costs, reducing greenhouse gases and energy dependence on imported fossil fuel

District heating is mentioned and promoted as an environmentally friendly solution in several European directives, such as the Directive on Energy Performance of Buildings Directive (EPBD) and the Energy Efficiency Directive (EED).

District heating (DH) in Greece covers only a small part of the final demand for space heating (0.2% in the year 2007) and the heat dissipated in the network comes from thermal power plants that use conventional fuels.

The first small DH installation in Greece took place in Ptolemaida in 1960.

The application of district heating achieves significant savings in heating costs compared to the direct combustion of any fossil fuel in individual heating units of the building. In addition to the above, it, has a better operation, quality, and economic and energy efficiency of heating due to continuous monitoring and maintenance of every autonomous heating system. Moreover, other important benefits that arise directly or indirectly from the application of district heating are:

- Foreign exchange savings as the most common fuels for heating, oil, and gas, are imported.
- The creation of jobs for specialized personnel of engineers, technicians, and administrative staff during the construction phase of the networks, as well as during the operation phase of the facilities.
- The low cost of installation and operation, the safety of facilities, and space savings in buildings since no boiler and fuel storage facilities are required.

Empirical research has shown a high degree of customer satisfaction with district heating services, heating quality, and hot water supply.

Citizens-consumers recognize the high efficiency of district heating in reducing pollution and protecting the environment and less its contribution to the creation of new jobs.

They are also satisfied with the 24-hour supply availability and security, but not so much with the space savings they have secured compared to previous oil heating.

The tariff policy of district heating is determined by the cost of heating oil, it cannot exceed 70% of its corresponding cost, resulting in significant savings in family budgets.

The majority consider that district heating is a cheap source of heating but they do not consider the cost of its installation very satisfactory.

Oil dependence is extremely important for both the individual and the national economy. This was especially evident during the economic crisis, when many households, especially those with lower incomes, rushed to connect to district heating.

The local community of Ptolemaida seems to have a positive view on the contribution of district heating to the economy of the state due to the reduced oil import.

Finally, the time of economic crisis is a good opportunity to promote ecological awareness.

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