FINAL REPORT
TASK 4

SOUTH EAST EUROPE REGIONAL ENERGY MARKET SUPPORT (SEE REMS) PROJECT

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EXECUTIVE SUMMARY

This report documents the results of programs to install apartment level controls and heat allocators in three cities in Bulgaria: Sofia, Plovdiv, and Pernik. To help the reader better understand the situation before and during program implementation, the report outlines the following:

- Legal, regulatory, and institutional context, including tariff development and assistance to low income households in Bulgaria
- Pilot and demonstration projects on heat metering and billing
- Full-scale program implementation, including issues like the technical characteristics of the installed equipment, its ownership, accuracy, and reliability
- The concept of heat allocation, heat accounting, the frequency of reading consumption, the billing and collection processes and companies involved
- Consumer satisfaction with the program, complaints and dispute resolution process as well as consumer education
- Initial impediments to the program and their resolution

OVERVIEW

District heating service in Bulgaria is provided by 22 companies, 22 of which were state-owned as of 1996. These 22 companies served 750,000 apartments, with more than 1.5 million residents, or 20% of Bulgaria's population. At the time of this report, 3 of the original companies had ceased operation, 12 were privatized, 6 were prepared for privatization and Toplofikatsiya Sofia EAD, the largest, remained jointly owned by the municipality and the state.

Before 1998, a significant share of district heating substations were not equipped with commercial metering devices and as a result consumers could not be billed for actual consumption. Instead, they were billed on the basis of heated-space volume, a methodology prone to inaccuracy and providing no incentive for conservation at the end-user level. This situation changed later when a strategy for district heating, developed with the help of World Bank consultants, recommended heating control and accounting. In 2001 heat accounting and control became mandatory but implementation on the customer side was largely left until the last minute.

OBJECTIVES OF ANALYSIS

We analyzed consumption data to estimate the impact of heat accounting on the overall heat consumption by residential consumers. Detailed data were collected in Sofia, Plovdiv and Pernik for heating energy consumption before, during, and after implementation of heating accounting (HA) programs.

The consumption of clusters of substations which introduced HA during the same heating season was tracked for the periods immediately preceding and after introduction of HA. The replacement of old substations with new automatically-controlled substations was tracked as well, as an additional factor affecting consumption. The change in district heating tariffs each heating season was another factor in consumption behavior.

Data for the analysis were obtained from the district heating companies themselves as well as the Brunata Bulgaria Ltd. HA Company, which provided data about the substations of DH Company Sofia plc.

The final data set included information from:

DH Company Sofia (Brunata Bulgaria Ltd.)-418 substations

DH Company Plovdiv-628 substations

DH Company Pernik-387 substations

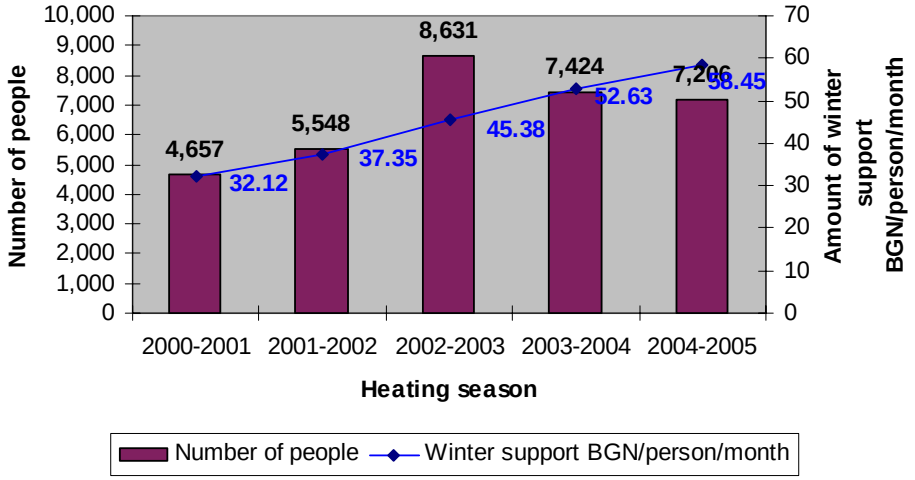
Where possible, curve-fit estimates to the obtained results were made. A regression analysis of the results was performed in order to identify the variables that had the strongest impact on residential heating energy consumption.

Finally, a customer satisfaction survey was conducted. In addition to tabulated results and numerical analyses, we put the results of the survey through a series of hypotheses tests to confirm or reject certain notions about consumer behavior. The study is supplemented with comprehensive annexes that detail excerpts from various laws, equipment technical specifications, sample results of pilot projects, and financial assistance offered by lenders. The annexes also contain detailed results of the regression analysis, the hypotheses tests, and the customer satisfaction survey.

LOW-INCOME CONSUMERS

The monthly amount of the assistance provided per person during the winter season is identical for all three DH companies (see Chart ES-1 for Plovdiv, as an example). The number of eligible citizens increased during the first three heating seasons covered by this review and peaked in 2002-2003 for all the three DH companies. During the next two heating seasons it diminished significantly, particularly in DH Company Sofia and DH Company Pernik.

Chart ES-1. Targeted winter support for low-income people – Toplofikatsiya Plovdiv



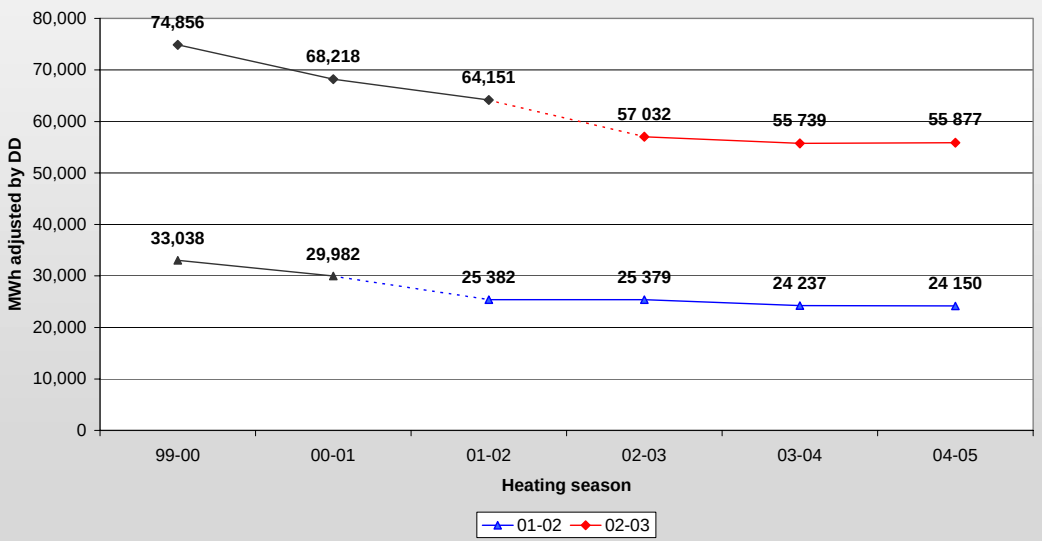
The number of eligible persons is a function of the allocation requirements specified in Ordinance No. 5 from 30 May 2003, modified April 2004 and April 2005. Thus, the HA does not directly impact the assistance provided to low-income consumers, although HA indirectly benefits low-income consumers (as it does all consumers) by allowing for consumer control of consumption and thus the resulting energy bills.

RESULTS

Our analysis indicates that the introduction of heat accounting had an impact on residential heat energy consumption. Installation of thermostatic radiator valves and radiator heat allocators allowed consumers to control and regulate their heat energy consumption. For example, Chart ES-2 shows the change in energy

consumption for space heating (in MW/h) only for substations using HA (122 in the 2001-2002 season and 259 in the 2002-2003 season). The black lines represent substations without heat accounting; the dotted lines mark the preceding periods of the latest season without, and the first heating season with, heat accounting. After the introduction of HA, consumption drops slightly, then stabilizes. This stabilization likely results from elimination of disconnections from the system, as consumer control of consumption increases satisfaction.

Chart ES-2. Change in heat energy consumption of substations (selected 381 pcs.) with heat accounting introduced in the following heating seasons (Toplofikatsiya Sofia)

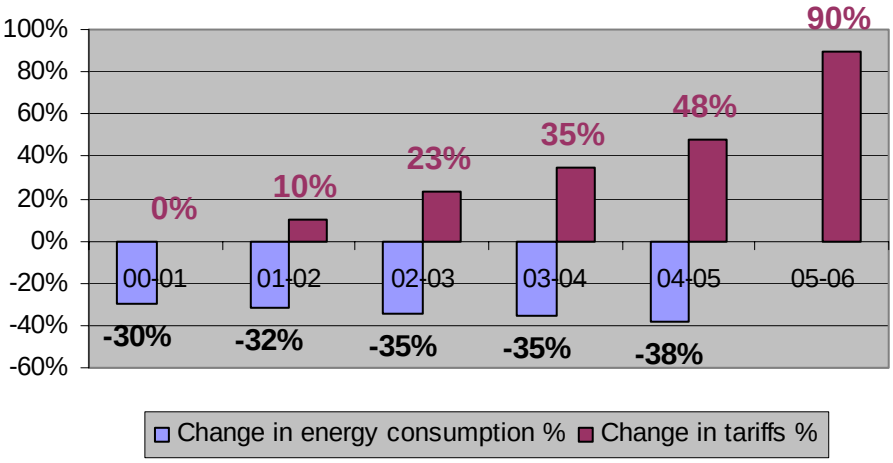


Source: Brunata Bulgaria Ltd.

Three heating seasons after implementation of HA, Toplofikatsiya Pernik actually witnessed an upswing in percentage of disconnected radiators. After two stable years of percentage connected, the DH company attributed the upswing to the need for the utility to disconnection consumers for non-payment (see chart 28 in the body of the report).

Generally, one expects diminished demand in the face of rising tariffs, which occurred simultaneously with institution of HA. Certainly decreased consumption was associated with rising tariffs in Bulgaria as well (see chart ES-3 for the Plovdiv example). At the same time, however, substations were being upgraded or replaced and household income levels were changing.

Chart ES-3. Change in heat energy consumption and heat tariff (in %) selected 628 substations – Toplofikatsiya Plovdiv



No significant change in the level of consumption was witnessed during the replacement of substations in Plovdiv (mainly during the 2002-2003 heating season). This implies that heat energy tariffs, legislative and regulatory requirements, and implementation of HA systems have a substantially higher impact on heat energy consumption.

Thus we are able to identify a positive correlation between decreased consumption and implementation of HA, but at the same time must recognize the likely contributions of other factors (rising tariffs, changing legislative and regulatory requirements, substation rehabilitation and replacement) to decreasing consumption. As these effects cannot be individually segregated and quantified in this ex post analysis, attribution of precise impacts to individual factors is not possible.

Regression analysis demonstrated that three main factors—introduction of the heat accounting system, modernization of substations, and heat tariff—influenced heat energy consumption **in each location in a different way**. The introduction of heat accounting systems led to a decrease in heating energy consumption in Sofia and Plovdiv, but not in Pernik. The regression analysis did not give any insight as to why heating energy consumption increased in Pernik.

In Plovdiv, all three factors caused a reduction in heating energy consumption. The rank of each factor, in descending order, is:

1. Introduction of heat accounting system
2. The heat tariff
3. Modernization of substations

In Pernik, only modernization of substations led to a decrease in consumption. Introduction of heat accounting and change in heat tariff led to an increase in heat energy consumption. The rank of each factor, in descending order, is:

1. Modernization of substations
2. Heat tariff
3. Introduction of heat accounting system

In Sofia, both introduction of heat accounting and change in heat tariff contributed to a decline in heat energy consumption, but modernization of substations led to an increase in consumption. The rank of each factor, in descending order, is:

1. Heat tariff
2. Modernization of substations
3. Introduction of heat accounting

RECOMMENDATIONS

We conclude with a set of recommendations for future program design and implementation, based on lessons learned from this analysis. We compiled a list of recommendations while conducting the interviews and analysis necessary for this study.

This list is not exhaustive, but can serve as an open-ended compilation of good practices for future programs.

Clearly define the role of all players involved in the program implementation[1]. Clarify any confusion early in the process.

A well structured customer education campaign is critical in the success of the program; educate and involve the media from the outset so that coverage of the program is balanced and informed

Allow enough time for information dissemination; account for the fact that changing the service culture and introducing obligations on the part of consumers creates negative reactions

Major developments, like changes in tariffs or changes in billing methodologies, should be staggered

In the program schedule, account for consumers' resistance to change

Disconnection of radiators places an additional cost burden on remaining utility customers and should be discouraged or prohibited

Foster creation of homeowners associations and supporting legislation

HA Companies should be licensed

Service fees should be collected by the DH Companies and transferred to HA Companies

Installation of TRVs shall be an integral part of the program

The Law must be enforced and penalties for violations must be levied

ACKNOWLEDGEMENT

Two Bulgarian companies made substantial contributions to this project:

The Center for Energy Efficiency, EnEffect, Sofia, oversaw the collection of heating energy consumption data, prepared numerical analyses, facilitated meetings in Bulgaria and drafted sections of this report

Alpha Research, Sofia, conducted the customer satisfaction survey, prepared regression analyses and performed hypotheses tests.

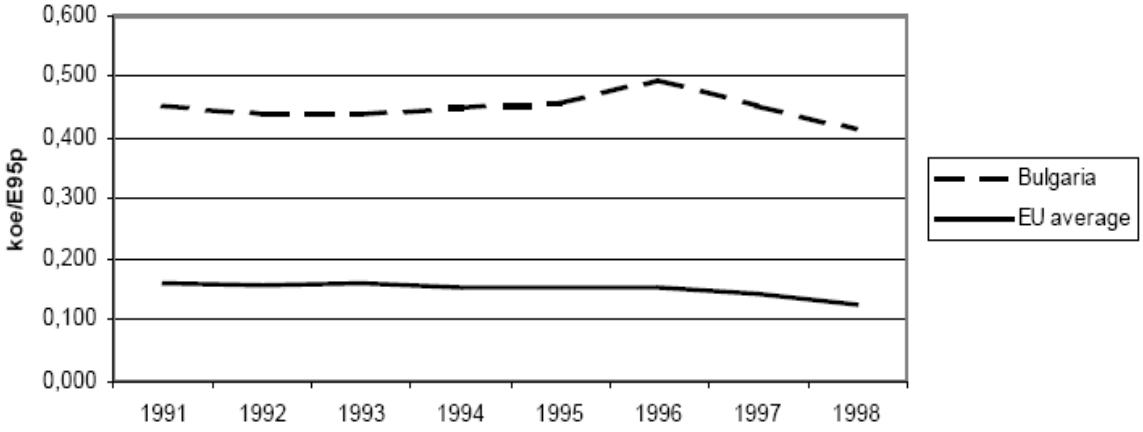
IRG gratefully acknowledges their substantive contributions to this project.

[1] A common misconception among the consumers about the role of HA Companies is that they are involved in tariffs increase.

THE BULGARIAN ECONOMY

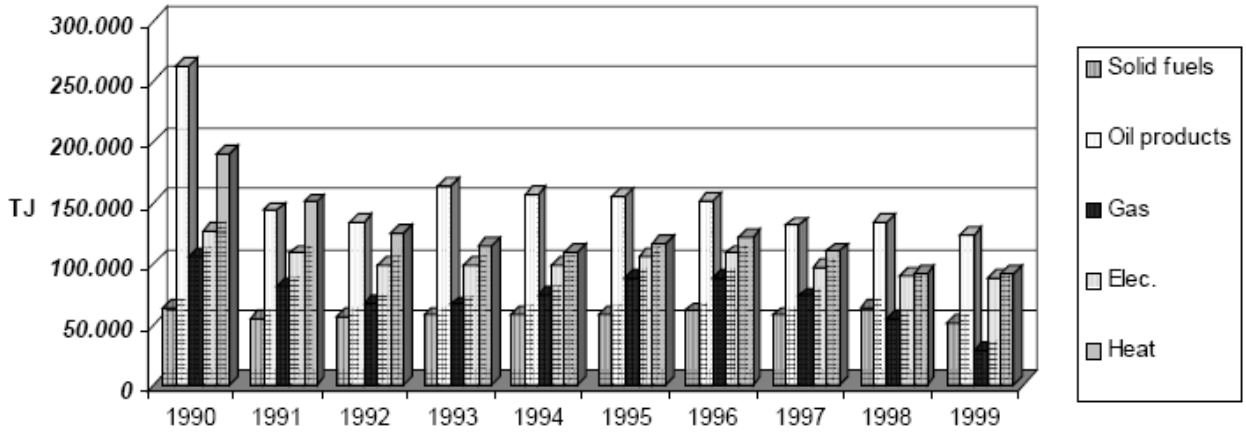
After 1990 Bulgaria started reforms for the implementation of a market economy. Energy prices have increased considerably during the last decade—a trend that continues today. The situation in the energy consuming sectors was challenging. When compared to other developed European countries, the energy intensity in Bulgaria was more than three times higher (Figure 1-1).

Figure 1-1. Comparison of final energy intensity[2]



Throughout the 90's the energy consumption in the energy sector declined, not because of rational energy use or the implementation of energy conservation measures but rather as a result of a contracting economy. During this time, the energy used for heating remained relatively constant (Figure 1-2).

Figure 1-2 Total final energy consumption per energy source[3]



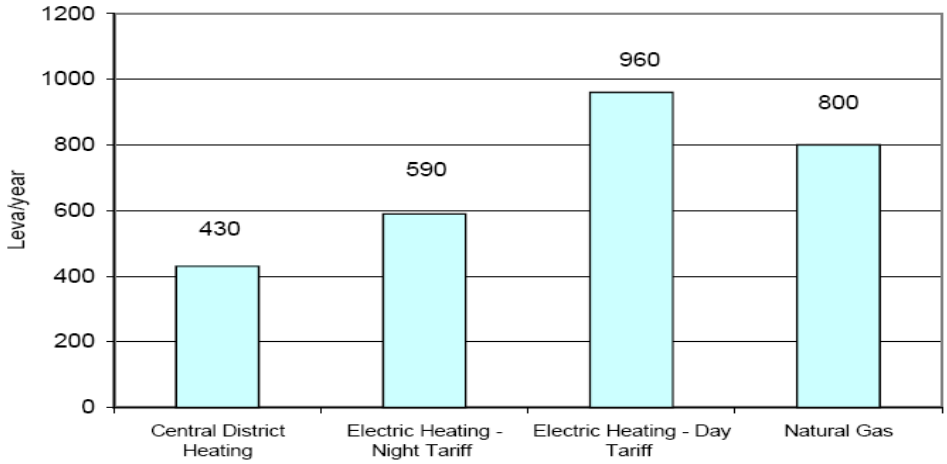
[2] National Energy Saving Program of Bulgaria. Study on the Possibility for and Implementation of Widespread Energy Saving Program in Bulgaria. State Energy Efficiency Agency, the Austrian Energy Agency, International Consulting on Energy. Vienna, December 2001.

[3] National Energy Saving Program of Bulgaria. Study on the Possibility for and Implementation of Widespread Energy Saving Program in Bulgaria. State Energy Efficiency Agency, the Austrian Energy Agency, International Consulting on Energy. Vienna, December 2001.

DISTRICT HEATING IN BULGARIA

In general, district heating is the least-cost option for providing space heating and domestic hot water for buildings in densely populated areas. The existing heating infrastructure, after appropriate rehabilitation and modernization, is the most effective option to meet residential heating needs (Figure 1).

Figure 1 Heating expenditures for an average residence[4]



In cities like Sofia, where natural gas is not available for residential consumption, the choice of fuels for heating purposes is limited.

DISTRICT HEATING COMPANIES

By 1996, district heating activities in Bulgaria were concentrated in 22 commercial companies. 21 of these companies were 100% state-owned. The biggest company, the Toplofikatsiya Sofia EAD (District Heating Company Sofia SP JSC), was owned by the municipality and the state. These companies supplied heat to more than 750,000 flats, with more than 1.55 million occupants, or about 20% of the country's population. The public buildings connected to the district heating networks had a heated space volume equal to that of about 240,000 standard flats.

[4] National Energy Saving Program of Bulgaria. Study on the Possibility for and Implementation of Widespread Energy Saving Program in Bulgaria. State Energy Efficiency Agency, the Austrian Energy Agency, International Consulting on Energy. Vienna, December 2001.

At the time of this report, the ownership of the district heating companies is as follows:

Table 1 District Heating Companies in Bulgaria and Current Ownership

No.	District Heating Company	Ownership
1	Sofia	52% municipally and 48% state-owned
2	Plovdiv	Prepared for privatization
3	Pleven	Privatized
4	Shumen	Prepared for privatization
5	Pravetz	Privatized
6	Pernik	Prepared for privatization
7	Sliven	Prepared for privatization
8	Gabrovo	Privatized
9	Kazanlak	Privatized
10	Russe	Prepared for privatization
11	Burgas	Privatized
12	Varna	Prepared for privatization
13	Vratsa	Privatized
14	Razgrad	Privatized
15	Lovech	Privatized
16	Veliko Tarnovo	Privatized
17	Yambol	Privatized
18	Loznitsa	Privatized
19	TEGE 21 Ltd Stamboliyski	Privatized with the municipality holding minority share
20	Samokov	Non-operational
21	Iskrets	Non-operational
22	Tryavna	Non-operational

TREATMENT OF LOW-INCOME HOUSEHOLDS

Heat Accounting (HA) Companies or District Heating (DH) Companies do not go out of their way to offer special treatment to low-income consumers. However, the companies will participate in existing programs, sponsored by others, to assist poor consumers.

This can lead to inconsistent, and unintended, results. For example, during pilot and demonstration projects, donor organizations financed metering and control equipment for low-income consumers. When donated thermostatic radiator control valves (TRVs) were simply delivered to qualified consumers and not installed, many of those TRVs ended up being sold on the street. The private companies were not active supporters of the program, enforcement was nonexistent, and equipment intended for later installation was instead diverted by the intended beneficiaries.

Donors financed installation of equipment for low-income households in Brunata (heat allocators), Razgrad (TRVs), and Gabrovo (heat allocators)[5].

Less formal initiatives to assist vulnerable consumers include verbal direction given by the Government to HA Companies to offer payment plans.

REHABILITATION OF DISTRICT HEATING COMPANIES' INFRASTRUCTURE

The most frequently implemented measures in the rehabilitation of district heating infrastructure have been the following:

Replacement of old direct-type substations with new indirect-type substations with automatic controls

Modernization of existing indirect-type substations and installation of automatic control systems

Introduction of variable speed pumps

Reduction of transmission losses:

- Radiation-by installing better pipe insulation or pre-insulated pipes for underground and overhead distribution networks, and insulation of pipelines and fittings in the distribution chambers
- Leakage-replacement of worn out transmission nets
- Replacement of old compensators with bellows seal-type compensators

Improvement of thermal efficiency of heat sources

The funding for modernization is usually provided by DH Company funds, World Bank, or other lenders.

DISTRICT HEATING TARIFFS

As was the case in other countries of Central and Eastern Europe, Bulgaria's utility tariffs were not cost-based nor were their utility services, especially district heating services, properly metered. The utility tariffs and, consequently, the utility bills did not send the right signals to affect end-use consumption and in no way promoted energy efficiency. The situation was further negatively affected by the fact that central heating systems lacked control devices that would allow users to adjust consumption to reflect the desired comfort level[6]. Subsidies from the state budget commonly supported district heating companies' operations.

In 1998, the DH tariffs covered only the fuel expenses of DH Companies[7]. Since then, pricing reform has been steadily introduced. The latest tariff increase (September 2005) was associated with the increase in oil prices. All but one DH Company increased their tariffs anything from 20% to 40%. The actual district heating tariffs for all DH Companies in Bulgaria are presented in Annex 4.

METERING AND BILLING

Until 1998, a significant share of district heating substations in the country were not equipped with commercial metering devices such as heat meters, and pricing was performed on the basis of heated-space volume. This approach was inaccurate and provided no incentive for energy conservation at the end-user level. There were no mechanisms and tools for billing individual consumers for their real heat consumption.

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[5] Both projects financed by PHARE-GEF.

[6] The overheating of apartments was commonly "regulated" by opening the windows.

[7] Meetings with Stefan Dochev-Director, Foreign and Public Relations and Information Service Administration, Marina Popova-Head of Department, Foreign and Public Relations and Information Service Administration, and Emil Antonov-Managing Director, Financing and Commercial Department in May and June 2005.

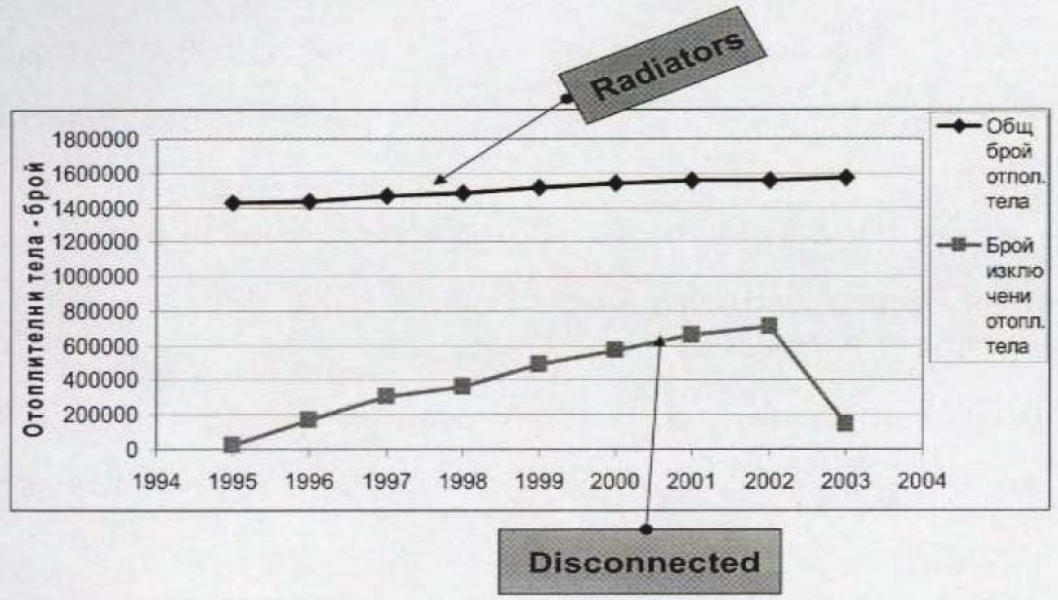
This situation changed later when a strategy for district heating, developed with the help of World Bank consultants, recommended heating control and accounting. In 2001 heat accounting and control became mandatory. However, implementation on the customer side was largely left until the last minute.[8]

[8] Some DH Companies took the initiative to implement metering and billing program before it became mandatory (DH Gabrovo, for example).

PILOT AND DEMONSTRATION PROJECTS OF HEAT METERING AND BILLING

Up until the 1980s, district heating bills were a small portion of the average household's budget in Bulgaria. However, in the face of increasing district heating tariffs in the mid 90's, consumer disconnections became more common. The Law for Power Engineering and Energy Efficiency established a 10% penalty (surcharge) on those consumers that did not install heat allocators on their radiators, prompting further disconnections. Massive disconnection of radiators peaked in 2002 (Figure 1-3). Further modifications to the Law in 2001 introduced heat accounting and prohibited voluntary disconnections.

Figure 1-3 Disconnection of radiators in Bulgaria[9]



Legend:

Y-axis: number of radiators

■ number of disconnected radiators

♦ total number of radiators

Prior to a full-scale implementation of heat accounting, there were several individual and small-scale projects which included installation of heat control and measuring equipment. Quite often these projects took a multi-pronged approach to addressing energy use by consumers and included implementation of a range of energy conservation measures.

[9] District Heating Bulgaria. Lubka Georgieva, Head of District Heating Department, Ministry of Energy and Energy Resources

IMPLEMENTATION AND PRELIMINARY RESULTS

INDIVIDUAL HEAT METERING SYSTEMS IMPLEMENTATION IN DISTRICT HEATED DWELLINGS IN BULGARIA[10]

This study, conducted during the 1992-1998 heating seasons, evaluated the change of energy consumption in carefully selected multi-family buildings in Kazanlak, Plovdiv, Pravec, Shumen, and Sofia. The buildings and apartments selected for the study were equipped with either substation-level meters only or substation-level meters, heat allocators, and control valves. Heat consumption was compared to the average heat consumption in remaining buildings in their respective cities. Sample results for the City of Kazanlak and Sofia are presented graphically in Annex 6. The study concluded that:

> The introduction of heat accounting in the test buildings with full metering and control at building and apartment level resulted in savings in heating energy use between 26% and 50% and only half that amount in buildings with substation level metering only.
>
> The use of thermostatic valves increased the level of savings
>
> The participants were able to control the energy consumption according to their payment ability
>
> It took time for the study participants to become familiar with the system

RENOVATION OF DISTRICT HEATING AND HEATING END USE IN GABROVO[11]

This project was implemented between 1998 and 2004 in the City of Gabrovo.

Toplofikatsiya Gabrovo became the second district heating company in Bulgaria (after Loznitsa) in which heat allocators were installed, and the first one in which heat accounting was implemented on such a scale. In total 20,160 heat allocators and 9,021 TRVs were installed. A few schemes of distributing free TRVs among consumers, including those receiving targeted energy assistance benefits, were tested. The degree of penetration of TRVs in the demonstration buildings reached 71 - 90%. The number of buildings with HA reached 60%. At the building level, 21 substations were either replaced or modernized to include control and monitoring devices. New expansion joints and a recirculation pump were installed in the distribution network.

The combined impact of these measures in reducing heat consumption (as compared to the base year of 1996) were as follows: 10% in 1999, 15% in 2000, 14% in 2001, and 15% in 2002. In total, over a period of four years, 37.9 GWh of heating energy and 388.8 MWh of electric energy were saved, at the total value over $1.482 mln. On the environmental side, the program resulted in 14,887 tons of CO_2 of greenhouse gas emission reduction. The impact of individual measures cannot be determined.

ENERGY EFFICIENCY AT END-USERS OF DISTRICT HEATING IN PLEVEN[12]

This project was implemented during 2000, when the amount of heat delivered to households in Plevin dropped 38% to 65% as households disconnected, largely due to financial distress. Energy efficiency measures implemented in six residential buildings and three public buildings included:

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[10] This study was financed by Brunata-Bulgaria.

[11] The project costs of $431,900 were financed by GEF/UNDP (25%), Toplofikatsiya Gabrovo Sole Proprietor Joint Stock Company (53%), and district heating end-users (22%). The project was implemented and evaluated by the Center for Energy Efficiency EnEffect, Toplofikatsiya Gabrovo SP JSCo, the Gabrovo Municipality, the Technical University of Sofia, the Energy Institute, equipment suppliers, engineering services providers and independent experts.

[12] This project was initiated at the request of the government of Bulgaria and was implemented in the framework of the Dutch program for collaboration with the countries of Central and Eastern Europe (PSO), financed by the Ministry of Economic Affairs of the Netherlands through the state agency SENTER International. Ameco Environmental Services executed the project in consortium with PEJA International B. V., Consulting Energy Production Systems from the Netherlands and its partner on the Bulgarian side-Center for Energy Efficiency EnEffect. The projects hosts were Toplofikatsiya Pleven, a joint stock company, and the Municipality of Pleven. The project cost was approximately EUR 420,000.

Heat allocators on individual radiators

Thermostatic control valves on individual radiators

Reflective screens behind radiators

Weather stripping of windows and doors

Thermal insulation of domestic hot water pipelines

Low-flow shower heads

Remote-read allocators and hot water meters (in selected apartments)

New automated substations (selected public buildings)

Compact fluorescent lights (selected public buildings)

SCADA systems in all substations

Sites were monitored on a monthly basis and remote data collection was done in real-time. Results have shown that the measures were very effective in reducing heating energy consumption. Analysis finds that:

Average energy consumption dropped by 30-35% compared to the previous heating season[13]

The average amount of heat needed to heat 1 m^3 of domestic hot water dropped by 30% or 658 MWh

Energy consumption in public buildings was about 30% of that during the preceding heating season

An overall improvement in comfort was noted in both residential and commercial facilities

All radiators were reconnected and consumers were able to control heat usage, including turning radiators off using the control valves.

INTRODUCTION OF CONSUMPTION-BASED BILLING IN SOFIA DISTRICT HEATING SYSTEM[14]

In 1998 the Austrian Federal Chancellery sponsored installation of TRV valves and heat cost allocators in 1,340 apartments. By the end of 2002, 500,000 apartments were equipped with TRVs. The annual savings were estimated to be EUR 100-150 per apartment, compared to a cost EUR 8 per heat allocator / apartment. The total energy savings was estimated at 600,000 MWh.

[13] Data have been evaluated for three groups: apartments where all radiators were used; apartments where one radiator was not used or was disconnected; and apartments where two or more radiators were turned off. The energy savings were highest in the first group and less significant in the third group.

[14] Based on Reiner Bahnmüller's presentation.

THE CHANGING REGULATORY, LEGAL AND INSTITUTIONAL CONTEXT

LEGAL BASIS FOR HEAT METERING AND CONSUMPTION-BASED BILLING PROGRAM

As a part of the process of accession to the European Union (EU), Bulgaria had to improve and harmonize its legislative framework with the legislation of EU member states. Several resulting laws were adopted that affected the energy sector, including the following.

- The Law for Power Engineering and Energy Efficiency was adopted in July 1999 and later modified and complemented in January 2000, December 2001, June 2002, and January 2003. The primary objective of the law was to improve energy efficiency in the country. The Law had several provisions that affected the development of heat accounting and metering in Bulgaria.
- The Energy Law provides an overall framework for harmonizing Bulgarian legislation with EU laws. It modified some provisions of the original Law for Power Engineering and Energy Efficiency and introduced new ones:
    - Heat transmission companies are responsible for heat transmission, transmission system operation, and retail supply of heat. These companies are licensed by SERC[15] and have three functions: construction and operation of networks, dispatch of producers and consumers; and supply of heat energy to all consumers connected to the network.
    - Customers supplied by the heat transmission companies are captive customers and the Law does not provide for third party access to the heat transmission grid (Art. 133).
    - Commercial companies engaged in metering, billing, and collection, i.e., share distribution of heat energy, within apartment buildings are responsible for retail sales, however, such companies are not licensed by SERC and the prices of their services are not regulated (Art. 140 and 146).
    - Voluntary associations of heat energy consumers in apartment buildings are not subject to licensing.
    - Voluntary associations may enter into heat supply contracts with the heat transmission companies at preferential prices set by SERC. Household consumers who do not form an association cannot take advantage of preferential prices offered under contracts with heat transmission companies. In such a case, the purchasing party to the heat supply contract is each individual consumer (Art. 151 and 152).
    - The full text of the portion of the Law related to heating energy supply issues is attached as Annex 2.

[15] Renamed in June 2005 as State Energy and Water Regulatory Commission (SEWRC).

- The Energy Efficiency Law was adopted by the 39th National Assembly on February 19, 2004. This law aimed at creation of the necessary conditions and mechanisms for taking advantage of the significant potential for improving energy efficiency both in manufacturing and among residential consumers. The full text of the Law is attached as Annex 3.

INSTITUTIONS DEALING WITH THE DISTRICT HEATING SECTOR

The responsibilities and authorities of three key organizations in Bulgaria relate directly to this study: the Ministry of Energy and Energy Resources, the State Energy and Water Regulatory Commission and the Ministry of Labor and Social Policy.

MINISTRY OF ENERGY AND ENERGY RESOURCES

The Ministry of Energy, later renamed the Ministry of Energy and Energy Resources (MEER)[16], through its Electrical and Thermal Power Division, is responsible for[17]:

Energy policy formulation, preparation of energy sector legislation

Representing the interests of the state (in its role as a shareholder)

Price setting, ensuring transparency, undertaking energy sector deregulation, promoting competition, liberalizing the energy markets, strengthening the role of SEWRC as a regulatory institution

Updating the energy sector development strategy and ensuring effective use of energy and energy resources

Elaborating short-term, medium-term, and long-term plans for general energy balance, generation programs, and transmission and distribution of electric and heat power

Contributing to analyses of electric and heat power generation, transmission and demand; utilization of renewable energy sources; export and import of electricity; management of electric and heat power projects

Issuing Ordinances regarding district heating

MEER was involved in and supported heating energy metering and accountancy even before it became obligatory. MEER oversees the heat accounting process regardless of the ownership of the district heating company. In the first two years of program implementation, HA Companies supplied information to MEER on a regular basis as part of their obligation; however, in the last three years they do so only at MEER's request.[18]

MINISTRY OF LABOR AND SOCIAL POLICY[19]

The Ministry of Labour and Social Policy (MLSP) is a body of Council of Ministers. In the field of incomes and living standard, MLSP is tasked to:

Analyze and assess the level of incomes and their social protection, living expenses, and poverty thresholds;

Develop and propose policy and mechanisms on issues related to labour remunerations and other incomes of population;

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[16] In August 2005 the Ministry of Energy and Energy Resources and Ministry of Economy merged into one agency-Ministry of Economy and Energy (MEE). Throughout the report the reference is made to role of MEER before the recent merger.

[17] http://www.doe.bg/cgi-bin/i.pl?l=2&p=456

[18] Meetings with Lubka Georgieva-Head of the District Heating Department, Mariana Stoeva-Senior Expert, and Dimtcho Marguitov-Head of Department in May 2005.

[19] http://www.mlsp.government.bg/en/functions/index.htm

Develop drafts of legislation in the field of state regulation of remunerations in real and public sectors;

Independently or jointly with other institutions and social partners develop and propose programmes and measures for improving the standard of living.

In the field of the social assistance, MLSP's responsibilities include:

Develop programmes for resolving social problems and reducing the unfavorable consequences of poverty;

Regulate the activity of institutions in the field of social assistance;

Encourage and support charity and humanitarian activity;

Encourage and supervise social services granting and the development of the social institutions network by businesses and non-for-profit organizations;

Organize and participate in the activity of the National Council for Social Services.

THE ENERGY EFFICIENCY AGENCY[20]

The Energy Efficiency Agency (EEA) is a state budget organization and an executive agency to MEER. EEA provides expert advice to ministries and administrations, branch organizations, regional administrations, and local government bodies in[21]:

Elaboration of programs and projects for energy efficiency improvement and usage of renewable energy resources

Transferring of technologies, knowledge, and experience in the area of energy efficiency and usage of renewable energy resources

Organization of seminars, conferences, and workshops

Co-financing for energy efficiency programs

Execution of projects for energy efficiency improvement and usage of renewable energy resources

Assurance for the delivery of qualified consultant services regarding European legislation and normative acts, labeling methods, energy saving, and usage of renewable energy resources

Performance of energy audits and evaluation of proposed solutions

REGULATION OF THE DISTRICT HEATING SECTOR[22]

The original Law on Energy established the State Energy Regulatory Commission, later renamed State Energy and Water Regulatory Commission[23] (SEWRC), in 1999. SEWRC's activities in the heating sector, as defined by the Energy Law and relevant to this project include:

Develops and controls compliance with rules on the supply of heat energy including quality of service standards; (Article 21, para 12)

Reviews complaints by consumers against licensees related to performance of the licensed activity (Article 22, para 1)

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[20] Formerly the State Energy Efficiency Agency. Renamed in 1999.

[21] http://www.seea.government.bg/index.jsp

[22] Meeting with Toma Giortchev-Member of the Commission, May 2005.

[23] February 2005.

Regulates prices at which producers sell heat energy to the heat transmission company and at which the heat transmission company sells heat energy to consumers (Article 30, para 1)

Approves general terms of contracts between heat transmission company and associations of heat energy consumers in apartment buildings representing consumers from apartment building common areas (Article 149, para 4); and,

Approves general terms, as proposed by the heat transmission company, of the sale of heat energy by the heat transmission company to heat energy consumers for household purposes (Article 150, para 1)

FULL SCALE PROGRAM IMPLEMENTATION

With the introduction of the new Energy Law, measuring the consumption of heating energy was mandatory in Bulgaria. However, the heating systems design -- typical of that in multi-family residential construction throughout Eastern Europe -- presented a significant barrier. Even now, with a very high level of installed metering equipment, there are still apartments where, for technical reasons, heat consumption cannot be measured.

METERING OPTIONS AT BUILDING AND APARTMENT LEVELS

In old buildings with single vertical piping, heat consumption can be metered at building level with heat meters installed directly on the substations which are located mainly in the basements. At individual apartments in these older systems, radiator-mounted heat allocators measure the heat released from radiators and these measurements are used to allocate heat costs to individual apartments. In the absence of heat allocators, the measurements can be taken using building-level heat meters and allocating heat costs to individual apartments by floor area or heated volume. In new buildings with horizontal internal piping, regular heat meters can be installed at individual apartments.

CONTROL EQUIPMENT

Two level controls are typically available. Building level controls, installed at the substation, adjust the temperature of supplied water according to outside temperature and building thermal characteristics. Apartment level controls require installation of control valve on each individual radiator. This valve controls the amount of hot water reaching the radiator and the amount of heat released by the radiator. Two types of valves can be used. Manual valves remain fixed in the last adjusted position until changed. Automatic thermostatic radiator control valves (TRV) automatically maintain a constant temperature in the room based on user-adjusted settings. TRVs have an upper limit above which adjustments are not possible.

SITUATION AT THE DISTRICT HEATING COMPANIES

Between 1990 and 1999, the demand for heat for industrial purposes declined by nearly 100,000 TJ (approximately 60%). The loss of industrial consumers led to inefficient use of district heating systems. Residential consumers, with their below cost tariffs and notorious non-payment problems, contributed further to the financial demise of the district heating companies. The state of heat generation and distribution infrastructure and its maintenance required immediate attention.

By the summer of 1997, heating energy was sold at the following pricing scheme[24]:

> For the residential sector: at a fixed price, determined and periodically amended by the Council of Ministers;
>
> For the business sector: at a limit price, covering costs for generation and supply of a unit of heat to the end user, with up to 7% profit margin per year;
>
> For public use, inclusive of municipal and other sites funded by the budget: at a fixed price until June 30, 1997, and a limited price as of July 1, 1997.

[24] Prices were determined as per the Law on District Heating Pricing and the Regulation for its application, as well as in accordance with Decree No. 194 of October 6, 1995, of the Council of Ministers, amended and supplemented by Decree No. 153 of June 2, 1996 of the Council of Ministers.

The difference between the fixed price and the companies' costs generated a planned loss, which was covered through subsidies from the state budget. This approach did not create incentives for the producer to improve heat generation efficiency and to reduce heat production costs. The subsidies were later steadily removed but it was not until 2005/2006 heating season that they were completely eliminated.

HEATING ENERGY TARIFFS

Price increases for district heating services in Bulgaria started in the 1990's. By the summer of 1997, the following pricing scheme was used[25]:

> For the residential sector: at a fixed price, determined and periodically amended by the Council of Ministers;
>
> For the business sector: at a limit price, covering costs for generation and supply of a unit of heat to the end user, with up to 7% profit margin per year;
>
> For public use, inclusive of municipal and other sites funded by the budget: at a fixed price until June 30, 1997, and a limited price as of July 1, 1997.

The difference between the fixed price and the companies' costs resulted in a financial loss which was covered through subsidies from the state budget. Thus heat producers had no incentive to improve generation efficiency and to reduce production costs.

The transition from a single tariff (BGN/MWh) to a two component (capacity and energy)[26] tariff occurred in April 2002, and was soon followed by two-block-consumption (below and above 250 kWh/month), two component (capacity and energy) tariffs for households in July 2002. In November 2004, the capacity fee based on the heated volume was replaced by a capacity fee based on the capacity of the installed equipment.

The last change in tariff structure, conversion to a single energy tariff, occurred during 2005[27]. While government subsidies were steadily reduced beginning in the late 1990s, it was not until the 2005/2006 heating season that they were completely eliminated. The latest tariff increase (September 2005) was associated with the increase in oil prices. All but one DH Company increased their tariffs; price increases ranged from 20% to 40%. The actual district heating tariffs for all DH Companies in Bulgaria are presented in Annex 4.

ASSISTANCE TO LOW-INCOME CONSUMERS[28]

The program for social assistance to low-income households for space heating, called Winter Supplemental Payment Program (WSP), was introduced in Bulgaria in 1995, and was later integrated into the larger application of the Social Assistance Act in 1998. During the 1998-1999 heating season, the Ministry of Labor and Social Policy (MLSP) undertook responsibility for financing and administering the program transferred MLSP funds from the state budget to municipal centers. With liberalization of energy prices demand for social assistance grew, constituting an increasing allocation of public funds.

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[25] Prices were determined as per the Law on District Heating Pricing and the Regulation for its application, as well as in accordance with Decree No. 194 of October 6, 1995, of the Council of Ministers, amended and supplemented by Decree No. 153 of June 2, 1996 of the Council of Ministers.

[26] Capacity fee in BGN/m^3/month, energy in BGN/MWh

[27] That process occurred at different months for individual DH Companies

[28] Meeting with Mrs. Minkowska-Chief of Department, Information Services, May 2005.

The state regulates the process and volume of assistance benefits through changes in eligibility criteria and level of monthly benefits[29]. The process is as follows:

> Every month the Regional Support Office[30] of MSLP sends information about qualified consumers to the district heating or electric companies. The DH Company confirms the validity and the final list is generated by MSLP and sent to the DH Company.
>
> The bill is prepared by the DH Company. There may be an adjustment since the previous month bill is based on the consumption estimate.
>
> The amount of WSP is applied. The qualified consumer pays the difference between the actual bill and the amount of WSP[31] or the actual bill, if it is less than the WSP.
>
> Within 20 days the person declaring the WSP eligibility status is checked.

MLSP has not addressed the issue of implementation of energy conservation measures among low-income consumers.

Recently the overall number of recipients has been going down; however, it is difficult to assess to what extent this is a result of higher eligibility requirements or increased income of the people. While the burden on the state budget to provide the space heating assistance is decreasing, the overall impact of heating-related expenditures on vulnerable consumers remains high due to the fact that housing costs increased in the past three years over 16% and the costs for heating increased over 20%.

Annex 5 presents the historical and present levels of social assistance for space heating. For a detailed description of the historical development of social assistance in Bulgaria, the reader is encouraged to review the USAID report "A Regional Review of Social Safety Net Approaches in Support of Energy Sector Reform".[32] Detailed analysis of WSP statistics in project sites is presented later in the text.

Beginning January 1, 2006, the level of social assistance has been increased, on average, by 5%, creating a problem for borderline recipients of winter assistance. They ended up being "pushed" above the maximum income threshold for winter assistance, and experienced a loss in benefits that considerably exceeded their increase in income.

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[29] Ordinance No. 5 dated May 5, 2003.

[30] There are 272 offices throughout the country.

[31] 60.45 BGN a month which is enough to cover the cost of heating one average room. Only 2-3% of all qualified consumers do not use the entire amount of WSP.

[32] Energy Reform and Social Protection in Bulgaria. Michael Philips et al for USAID, October 2003.

HA COMPANIES INTERVIEWED FOR THIS STUDY

BRUNATA BULGARIA, LTD.[33]

Brunata Bulgaria, Ltd. started operation in Bulgaria in 1992 with implementation of a pilot project in Sofia and Kazanlak. The project involved only consumers that specifically requested to be included. When the Energy Law became effective, in Brunata's opinion, the consumers in Bulgaria were not adequately prepared and even opposed its implementation. The Law also was problematic, since it imposed a tight deadline for the implementation phase.

Brunata estimates that it receives complaints from 1% of its consumers. The main issues involve estimated readings due to broken or tampered with heat allocators and high heating bills.

TECHEM[34]

Techem, a German company, is currently the largest HA Company in Bulgaria, with five offices in Sofia alone. The firm started commercial operation in Bulgaria in 1998 by implementing a pilot project financed by the Austrian Government. As part of the project, 1,500 households were equipped with metering and control equipment. During full-scale program implementation, Techem offered a payment plan to its customers for equipment purchase. It also considers renting of heat cost allocators.

90% of Techem's customers are satisfied with the program. The most frequent complaints are related to high bills and non-functioning equipment.

In Techem's opinion, those that disconnected radiators are either using electricity to heat the apartments or do not heat the apartments at all. The latter option is chosen by those that do not occupy the apartments in town on a regular basis and do not want to incur any costs while keeping them empty.

Techem's interaction with low-income customers involved installation of heat cost allocators paid by the donor organizations[35]. They also installed TRVs to qualified customers.[36]

According to Techem's estimates, 95% of consumers have heat allocators installed. **After introduction of heat accounting, the company observed a 20% decline in thermal energy consumption.**

TERMOKOMPLEKT[37]

Termokomplekt, a small locally owned company, designs heating network systems, installs pipelines and substations, and maintains heating installations. It was the first private company to install substations and has acquired 17,000 customers connected to 600 substations in Sofia over the past five years.

The primary complaints that Termokomplekt has received from consumers are related to high bills (in the range of 350 BGN) and malfunctioning equipment. One third of the complaints are forwarded to the DH Company for resolution.

20% of Termokomplekt's consumers have asked that their radiators be disconnected. 2-3% subsequently asked to be reconnected. Illegal reconnection of disconnected radiators and consequent theft of service is relatively rare.

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[33] Meetings with Madlen Hristova-Heat Accounting Director and Nickolai Zhechkov-Managing Director in May and June 2005.

[34] Meeting with Rumen Michailov-Director and Milena Stoyanova in June 2005.

[35] Techem issued installation confirmation documents to the customers who in turn were reimbursed by the Ministry of Labor and Social Policy.

[36] In Sofia, the tender winner gave TRVs to consumers without installing them. TRVs were offered to consumers based on the list provided by the Ministry of Labor and Social Policy.

[37] Meeting with Krassimir Christov-Director and Vladimir Vladimirov-Director in May 2005.

INITIAL IMPEDIMENTS AND THEIR RESOLUTION

EFFICIENCY OF HEAT DELIVERY

By attaching monetary values to actual heat delivery and consumption, heat metering and consumption-based billing is supposed to drive efficiency improvements in heat supply and motivate conservation among heat consumers. However, installing TRVs and implementing HA as well as improving the thermal properties of the building stock will contribute to lowering energy consumption but will not lead to fuel savings at the source if the supply system is not modernized to eliminate losses and inefficient operation. In other words, while consumers can manage their own consumption, they cannot control generation and distribution problems whose cost they are ultimately paying for. The maximum reduction in production costs and customer charges will be achieved when both the rehabilitation and modernization of both district heating systems and buildings are realized.

SERVICE CONTRACTS

Unresolved problems persist in the area of terms of service and contracts between HA companies and whatever is functioning in lieu of homeowners' associations. The framework contract proposed by the Confederation of Consumers was rejected by the association of HA Companies. Instead, they came up with their own version of a contract. It included legally questionable provisions that (a) require signature of a certain percentage of a building's residence if any individual customer in that building requests a billing adjustment and (b) asserted that absence of consumer objection to a contract is equivalent to a signed contract. Recently, the Deputy Minister of Energy agreed to form a working group to develop a mutually agreeable framework contract.

OBJECTION TO PROGRAM IMPLEMENTATION

At the advice of the Federation of Consumers in Bulgaria, approximately 40,000 consumers decided not to switch to heat accounting. Instead, these consumers are billed based on the previously used methodology (heated volume of the apartment) plus a 10% surcharge for not converting to heat accounting. According to the Federation of Consumers, the bills of these consumers are still lower than those of consumers that have equipment and heat accounting in place.

OTHER ISSUES

Other problems that originally had a negative impact on the program but were steadily eliminated included:

Quality of equipment installation

Quality of installed equipment

Varying and less than convenient schedule (for consumers) of equipment reading

SCOPE OF THIS STUDY

SITE SELECTION AND CHARACTERISTICS

Three sites were chosen for the case study: Sofia, Plovdiv and Pernik. Their individual descriptions follow.

SOFIA

Sofia is the capital and largest city of the Republic of Bulgaria, with a population of 1,203,680, and some 1,326,377 in the metropolitan area, the Capital Municipality. It is located in western Bulgaria, and covers a territory of 1,310 sq km. The average population density is 907 people per sq km and the average age of population is 38.3 years. Sofia is the major center of Bulgaria's economic life. The manufacturing sector of the economy, represented by over 800 large manufacturing plants, includes metal products (75% of the total output in the country), textiles, rubber and leather goods, printing (50% of output) and electronics (15% of output).[38]

Toplofikatsiya Sofia (DH Company Sofia) is the oldest heat and power supply system and third largest energy complex in Bulgaria. It has 310 MW electrical and 5,000 MW heat generation capacities. Its annual generation exceeds 1,000 GWh of electrical and 7,000 GWh of heat energy. That makes it the biggest heat and power supply system on the Balkan Peninsula. Over 15,000 buildings and 92% of residents use Toplofikatsiya-generated heat (district heat and hot water) distributed throughout over a 900 km long network, which grew from the original 26 km long system installed in the early 50's. DH Sofia serves 60% of all district heating consumers in Bulgaria.

The system is subdivided into four district heating regions, each with its own set of generating units. There are two power plants "Sofia" and "Sofia – Iztok", the two large boiler-only heating stations "Zemliane" and "Lyulin", as well as the ten regional boiler houses.

In 1992 the company was transformed into a commercial joint stock company with Metropolitan Municipality being the sole owner[39]. In 1996/1997, a master plan for an extensive technical rehabilitation of Toplofikatsiya Sofia to be financed by the World Bank was prepared. The actual modernization started in 2002 and has included replacement of pipelines, compensators, fittings, insulation of pipelines, replacement of substations, and installation of variable speed drive pumps. The details of the loan are presented in Annex 12.

DH Sofia's system is almost 60 years old and serves approximately 437,000 households. It was originally developed without metering devices. The only measurement that was conducted was on burnt fuel. From there the production of energy was calculated and after estimation and deduction of losses and dividing by the volume of heated dwellings the customer bills were derived.

DH Company Sofia has had heat metering and control pilot programs in place in various locations since 1993. Heat accounting was introduced for the first time in 1995-1996 while the installation of metering of the substations was done in the period of 1998-2002[40]. Currently, 97% of the flats have heat allocators in place. In total, there are 15,000 substations in the DH Company Sofia network.[41]

There are 16 HA Companies operating in Sofia.

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[38] http://en.wikipedia.org/

[39] As of the date of this report the DH Company Sofia is owned by the Municipality of Sofia and the MEE.

[40] It started during 1998/1999 and 1999/2000 heating periods when two tenders were issued for 10,000 and 15,000 meters respectively.

[41] Meetings with Stefan Dochev-Director, Foreign and Public Relations and Information Service Administration, Marina Popova-Head of Department, Foreign and Public Relations and Information Service Administration, and Emil Antonov-Managing Director, Financing and Commercial Department in May and June 2005.

PLOVDIV

Plovdiv is the second largest city in Bulgaria, with a population of 376,918. It is the administrative centre of Plovdiv Province in southern Bulgaria. The population density is 907 people/sq km. Plovdiv is the centre of the important Thracian agricultural region, and food processing is the most important industry. The city also produces machinery, textiles, and chemicals.[42]

The district heating system in Plovdiv was established in 1970 (DH Plovdiv). At first it was used for hot water distribution, nine years later it was also used for steam generation and distribution. There are two heating stations:

North—cogeneration, heat and power

South—steam and hot water

Consequently, the city is divided into North and South systems. During the summer months, only the North system remains operational. One of the operational problems that the company experiences is thermal load outside the heating season.

There are 44,000 residential customers and less than a dozen industrial consumers served by both systems. 90% of residential consumers are equipped with heat allocators; consumption of the remaining 10% is calculated by the company. All of the substations are metered. More than half of the consumers spend, on average, 50-70 BGN/month on heating bills. **After the introduction of heat accounting, consumption was reduced by 30% without a negative effect on consumer comfort**. The last heating bill is issued on July 15.

The power stations and the distribution networks are undergoing extensive rehabilitation. Since 2004, new automatic controls have been installed, old pumps are being replaced with variable speed drive pumps, and new heat exchangers are installed at the substations. At the power stations, rehabilitation is focused mainly on installing variable speed drive pumps. In addition, 1.5 km of new pre-insulated pipes have been installed in the distribution network. The investments, 8 mln BGN, are financed by the World Bank (50%), own funds (25%), and EBRD (25%).[43]

The major HA Companies operating in Plovdiv, and their respective market shares, are:

Nelbo-50%

Brunata-10%

Techem-10%.

The remaining 30% is shared by eight HA Companies. Nelbo reads the heat allocators every month while the remaining companies do it twice a year. 10-15% of installed heat allocators are evaporative type, the remaining are electronic. Out of 1,500 substations 1,380 are operational, the rest have been closed by consumers but they keep returning to the system.

Overheating, due to good automation, is no longer a problem. Underheating is addressed by checking system settings and eliminating possible damage.

[42] http://en.wikipedia.org/

[43] Meeting with Mirko Ugrinov-Executive Director in June 2005.

PERNIK[44]

Pernik is a city in western Bulgaria with a population of 92,627. The city developed rapidly as a centre for coal mining and heavy industry.[45]

The power plant in Pernik is the oldest in Bulgaria (DH Pernik). At the time of this writing it is still 100% state owned. Originally built in 1952, the first unit was subsequently expanded to five boilers and three turbines. Over time the electric capacity steadily decreased and emphasis was placed on district heating. At present, the primary consumers are residential users, budget organizations, and the municipality of Pernik.

In the past decade, the company experienced a dramatic decrease in the industrial consumer base—some industrial consumers refuse to take service, some do not exist anymore, some do not use heat at all, while others have switched to natural gas fired boilers. The thermal load dropped from 400 mln MWh_{th} in 1998 to a current steady level of 250 mln MWh_{th} (of which 180 mln MWh_{th} is residential). The installed capacity is sufficient to serve three times that load. The whole power and heat generation complex is five km away from the city center, illustrating the original concept of serving the industrial complex and building the power plants where the major consumptions centers were.

There are approximately 20,000 residential consumers on the system. DH Pernik serves 70% of the residential population, all large buildings but no single family houses. Not all consumers are either metered or use heat allocators. As reasons the company is quoting total disconnections[46] (the consumers continue using only hot water though), and technical difficulties preventing installation of the equipment. The last heating bill is issued on July 31.

The entire system has been undergoing an extensive $7 mln rehabilitation financed by the World Bank. As part of the effort, the following have been or are being accomplished:

700 substations have been replaced

12 km of 60 km distribution network is being replaced with pre-insulated pipes

Variable speed drive pumps are being installed

220 compensators have been replaced with expansion joints

Transmission losses have been reduced to 33%

The power stations have been equipped with new electro filters[47]

Old boilers are to be replaced with a brand new fluidized bed furnace

There are three HA Companies operating in Pernik. Their respective shares of the market (substation-based) are:

Techem-Direct-57%

Vitera-Ista-25%

Nelbo Engineering-18%

The process of installing heat allocators was completed in 2003. Techem and Nelbo offered TRVs and heat allocators as a package while Brunata offered a choice. 10-15% of heat allocators are evaporative type, the rest

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[44] Meeting with Rumen Arsov-Deputy Director General in June 2005.

[45] http://en.wikipedia.org/

[46] The primary reasons for total disconnections are either financial difficulties or preference to be separate from the neighbors. However, those consumers who are totally disconnected still have to pay for heating common areas. Some consumers return to service after being convinced that the consumption can be controlled.

[47] Low-quality local coal, with over 60% of ash content, is being burnt. The DH Company's objective is to lower the emission of airborne particulates from a present level of 200 mg to as low as 50 mg, thus exceeding the EU environmental standards.

are electronic. Nelbo Engineering reads the heat allocators every month, the other two companies read heat allocators twice a year. Substation-level meters are read every month.

CORRELATIONS INVESTIGATED

Seven potential correlations were analyzed statistically, to identify the impact of various vactors on the consumption of heating energy by the residential consumers.

The tested hypotheses were:

Hypothesis No. 1: Does the price of the heating energy have an impact on the consumption?

Hypothesis No. 2: Does the heating accounting system have an impact on the consumption

Hypothesis No. 3: Does the income of the households have an impact on the consumption of heating energy?

Hypothesis No. 4: Does price of the heating energy have an impact on the energy consumption by low-income consumers?

Hypothesis No. 5: Does heat accounting have an impact on the energy consumption by low-income consumers?

Hypothesis No. 6: Does price of heating energy have an impact on the energy consumption by non-low-income consumers?

Hypothesis No. 7: Does heat accounting have an impact on the energy consumption by non-low-income consumers?

ANALYSIS OF IMPACT OF HA ON HEAT CONSUMPTION

INTRODUCTION

The objective of this analysis was to track heat energy consumption for space heating for the purposes of studying the impact of the introduction of heat accounting. The analysis covers the residential sector subscribers of the DH Companies in the cities of Sofia, Plovdiv, and Pernik.

Heat energy consumption at the substation level was studied. The analysis includes a study of the changes in heat energy consumption only; the consumption of domestic hot water (DHW) is excluded.

METHODOLOGY

The methodology of the analysis envisages a study of the changes in heat energy consumption for space heating at the substation level before and after introduction of the heat accounting system. The heat energy consumption for space heating in kWh is adjusted for the degree-days for the respective heating season, taking into account the influence of climatic conditions. The consumption of clusters of substations which have introduced heat accounting during the same heating season is tracked for the periods before and after introduction of the system. At the same time, the analysis tracks the process of replacement of old substations with new automatically-controlled ones, performed during the same period, as an additional factor leading to changes in consumption. Another important factor is the change in district heating tariffs for every heating season.

ANALYSIS RESULTS

DH COMPANY SOFIA

THE PROCESS OF INTRODUCTION OF HEAT ACCOUNTING SYSTEM

Chart 2. Introduction of heat accounting in Toplofikatsiya Sofia – by number of substations

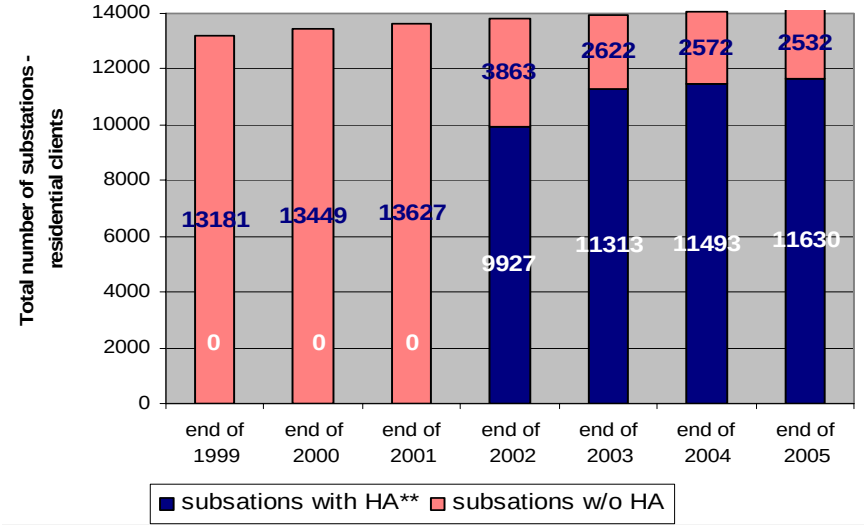


Chart 2 illustrates the process of introduction of the heat accounting system at the residential clients of DH Company Sofia. As evident from these, the process was implemented mainly during the period 2002-2003.

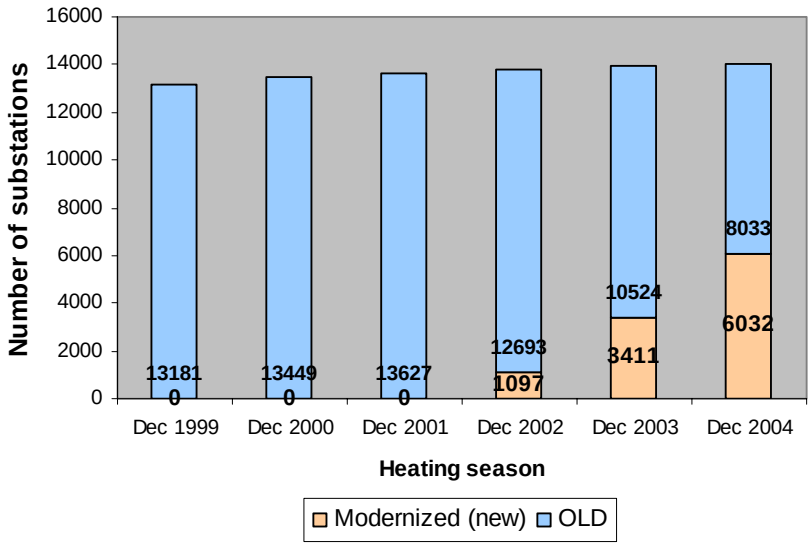
HEATING ENERGY TARIFFS

At the beginning of the period covered by the analysis a one-component tariff was in force and in 2002 a two-component tariff was enforced, comprising capacity fee and price for energy consumption. The charge for capacity was based on heated volume (BGN/m3) at the early stage of the introduction of the two-component tariff (April 2002) and has changed from the beginning of year 2005 when it is based on installed capacity (BGN/kW). From June 2002 till June 2005 the tariff for energy consumption is differentiated for the energy consumption up to 250 kWh/month and above.

THE PROCESS OF REPLACEMENT (UPGRADING) OF SUBSTATIONS

The major component of the analysis methodology was tracking the change in heat energy consumption for the purposes of studying the impact of the heat accounting system. With a view to getting more detailed data, and hence the opportunity for formulating more independent conclusions of the analysis, the process of replacement of substations, which was underway during the period under review, was also tracked. The reason for that is the impact of this factor on the total consumption because of the opportunity to achieve savings as a result of the technical performance characteristics of the new type of substations (automatic controls, electronic regulators, programmers, etc.). It is specifically this process that is illustrated on Chart 3.

Chart 3. Modernization (replacement) of substations in Toplofikatsiya Sofia



ANALYSIS OF AGGREGATE DATA ABOUT THE ENTIRE DISTRICT HEATING COMPANY – TOTAL HEAT ENERGY CONSUMPTION FOR SPACE HEATING BY THE RESIDENTIAL CUSTOMERS OF DH COMPANY SOFIA AND HEATING ENERGY TARIFFS

Table 3

Heating Season	Heat Consumption* of Residential Clients MWh	Heat Tariff BGN/MWh incl. VAT	Change in Energy Consumption %	Change in Tariffs %
2000-2001	3,071,250	36.41		
2001-2002	2,677,016	40.05	-13%	10%
2002-2003	2,616,424	44.05	-15%	21%
2003-2004	2,547,448	48.46	-17%	33%
2004-2005	2,483,521	53.64	-19%	47%
2005-2006		68.08		87%

The data in Table 3 represents the following:

The total heat energy consumption for space heating for residential clients of the company for the respective heating seasons as adjusted by degree days;

Heat energy tariffs for the residential clients including V.A.T. for the respective heating seasons.

It is worth noting here that for the purposes of investigation of tariff changes and identification of the trend all the tariffs have been presented as one-component ones, i.e. at the point of enforcement of the two-component tariff the latter has been presented as a re-calculated one-component tariff. The presented data is that of DH Company Sofia.

Presentation of the change of heat energy consumption for space heating in percentage and the tariffs for each heating season at assumed baseline the first heating season.

Chart 4. Trend of heat energy consumption and tariffs for residential clients – Toplofikatsiya Sofia

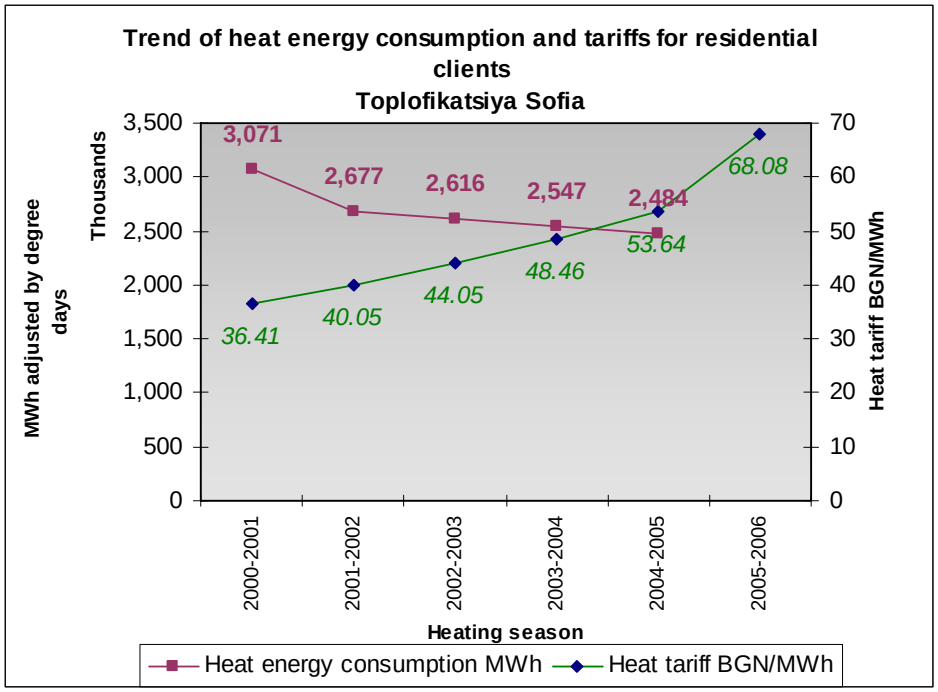
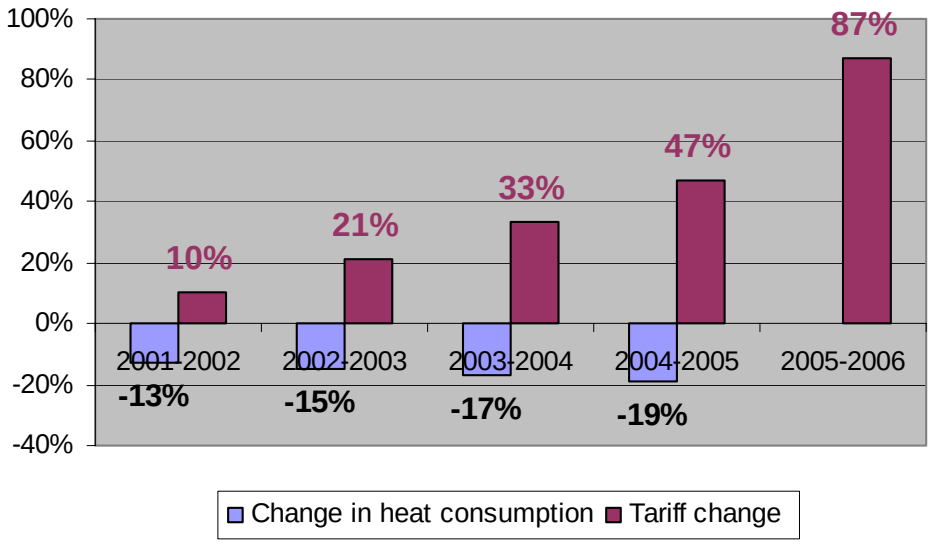


Chart 5. Toplofikatsiya Sofia



The data of Table 3 is illustrated also in Charts 4 and 5. As evident from Chart 4, a trend of reduction of heat energy consumption for space heating is observed for the entire period of analysis. The analysis does not assign the significant drop in heat energy consumption during the 2001-2002 heating season (2677 MWh) as compared to the 2000-2001 heating season (3071 MWh) to the introduction of the heat accounting system, which takes place mainly during the following season (2002-2003). This substantial drop may be assigned to the persistent customer resignation from DH service and dismounting of radiators due to the overall state of the national economy and rising heat energy tariffs . The data provided in the charts show a trend towards reduction of heat energy consumption, however at not that clearly manifested rates, and a relative stabilization of consumption at clearly manifested trend towards tariff increases. The conclusion that might be made is that the enforcement of the heat accounting system has played a regulatory role.

The presented data about DH Company Sofia provides a general picture of the developments on the company level and does not allow a detailed analysis aimed at investigation of the heat accounting system. Therefore, such an analysis would be possible on the basis of a selected number of data about the substations of the company, as submitted by Brunata Bulgaria Ltd.

ANALYSIS BASED ON DETAILED DATA FROM 418 SUBSTATIONS

The data for the analysis have been provided by the heat accounting company Brunata Bulgaria Ltd.

Heat energy consumption prior to and after the introduction of heat accounting

The figures in Table 4 include aggregated data for energy consumption for space heating (in MW/h) of substations in DH Company (DH) Sofia, grouped by seasons of introduction of heat accounting (HA).

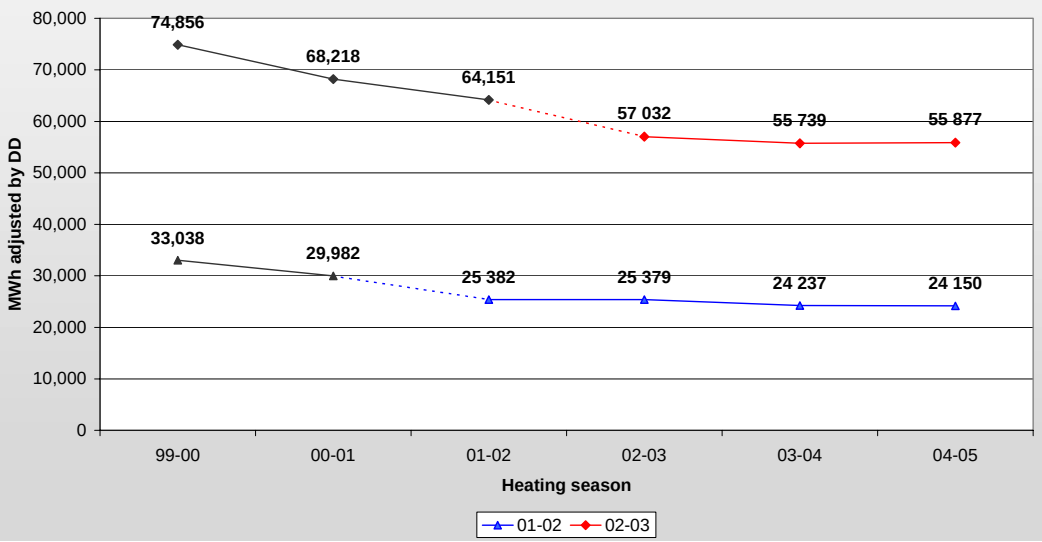
Table 4

Season of HA* in force	Heat energy consumption by heating seasons (MW/h)**							Number of Ss***
	98-99	99-00	00-01	01-02	02-03	03-04	04-05	
99-00	2 317	2 077	1 824	1 891	1 929	1 931	1 947	12
00-01		5220	4233	3991	4106	3913	3895	25
01-02		33038	29982	25382	25379	24237	24150	122
02-03		74856	68218	64151	57032	55739	55877	259
Total								418

Legend:
* HA - heat accounting
** Only heating, adjusted by degree-days
*** Ss - Substation
heating season **w/o** heat accounting
heating season **with** heat accounting

As evident from the table, the number of substations in which heat accounting was introduced during the 1999-2000 heating season was 12 and that for the other heating seasons respectively 25 (2000-2001), 122 (2001-2002) and 259 (2002-2003).

Chart 6. Change in heat energy consumption of substations (selected 381 pcs.) with heat accounting introduced in the following heating seasons (Toplofikatsiya Sofia)



Source: Brunata Bulgaria Ltd.

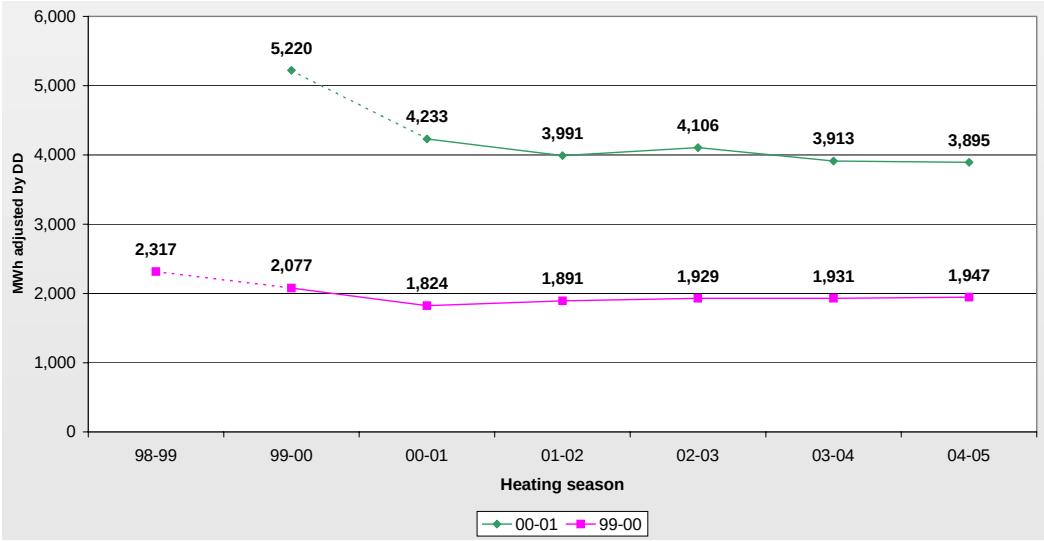
Chart 6 depicts the data presented in Table 4. It shows the change in energy consumption for space heating (in MW/h) only for a selected number of substations – 122 pcs. on HA in the season 2001-2002 and 259 pcs. on HA in the season 2002-2003.

The black lines show the consumption for those samples of substations, in which, during the specified heating seasons, no heat accounting had been introduced. The doted lines in the respective colors mark the preceding periods of the latest season without and the first heating season with heat accounting.

As evident from the two lines, after the introduction of the heat accounting system there is a period of certain "retention" of heat energy consumption and a trend towards stabilization of the levels during the following heating seasons. This trend may be explained by the influence of the system and the ability of the subscribers to control their consumption, as well as curtailing of the process of further resignation of subscribers from the DH services and further disconnection of radiators.

Analogous is the case represented on Chart 7, however for the sample of substations, in which heat accounting has been introduced during the heating seasons 1999-2000 (12 pcs.) and 2000-2001 (25 pcs.) respectively. The analysis of the chart leads to conclusions analogous to those about Chart 6.

Chart 7. Change in heat energy consumption of substations (selected 37 pcs.) with heat accounting introduced in the following heating seasons (Toplofikatsiya Sofia)



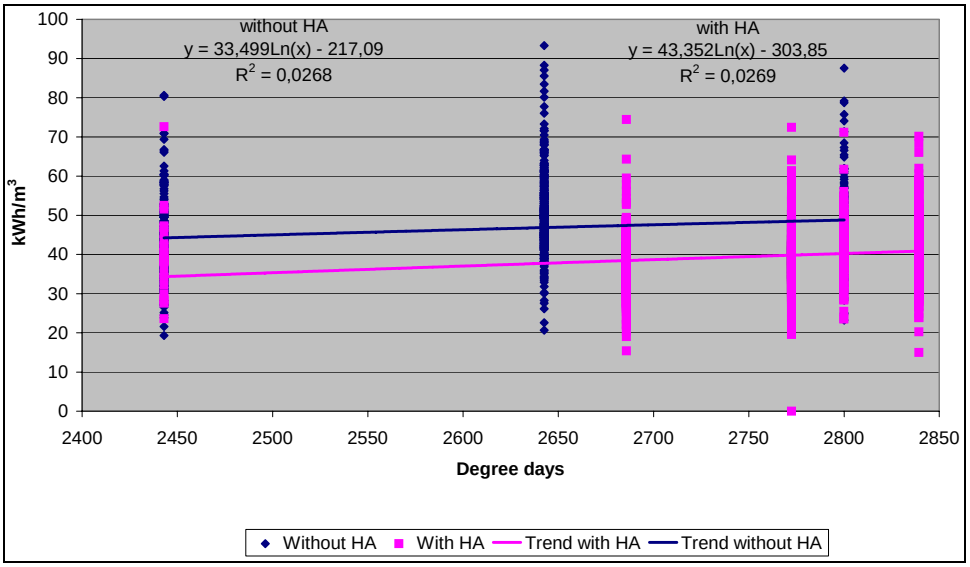
Source: Brunata Bulgaria Ltd.

Specific energy consumption for space heating (kWh/m³) based on the existence of heat accounting

The specific energy consumption for space heating by substations (kWh/m³) has been calculated on the basis of the submitted data. It has been calculated on the basis of the consumption during the respective heating season (real value, not adjusted by degree days) and the heated volume (design volume), belonging to the respective substation. The data applies to the same sample sizes of substations as those presented in Table 4, less those in which heat accounting has been introduced during the 1999-2000 heating season, since the latter have such a system already in place during the baseline season 1999-2000.

Chart 8 shows specific energy consumption adjusted by real degree days for the respective heating seasons and depending on the existence of a heat accounting system at the given substation by the respective season.

Chart 8. Specific energy consumption for heating (KWh/m³) – selected 406 substations – Toplofikatsiya Sofia



Source: Brunata Bulgaria Ltd.

As is evident in Chart 8, substations with HA (the values in pink and the respective trend in the same color) have lower specific consumption than those without such a system (dark blue). This is another indication of the influence of the system, namely control on and a possibility for limitation of consumption.

Based on the best-fit curves, the difference in heating energy consumption before and after HA implementation (the HA impact) may be approximated by the following equation:

$$\Delta E = -9.853 \ln(x) + 86.76$$

Where:

ΔE HA impact (kWh/m^3)
x number of degree-days

Reduced heated volume and consumed capacity

Reduced heated volume (m^3). Used heated space, obtained from information submitted by DH Company Sofia concerning the real heated volumes (operating/disconnected radiators in the premises) during the respective seasons.

Consumed capacity (kW). Real operating capacities (radiators) during the respective heating season.

Data about the reduced heated volume exist for the time prior to the introduction of the heat accounting system and after that point such information is not maintained anymore. That data was provided by Brunata Bulgaria Ltd on the bases of information from the database of Toplofikatsiya Sofia.

The information available after the point of introduction of heat accounting is related to the consumed capacity. It has been provided by Brunata Bulgaria Ltd.

The available data has an input information only about the following sample sizes: 42 substations, in which heat accounting had been introduced during the 2001-2002 heating season; 51 substations, in which heat accounting had been introduced during the 2002-2003 heating season.

On the basis of this data an additional analysis was conducted, showing the change in the real heated volume used (reduced) as compared to the full design volume of the substations till the point of introduction of heat accounting and study of the change in the consumed capacity after the introduction of the system.

Table 5

Number of Ss	Season of HA* in force	Reduced (used) heated volume m^3						Total designed heated volume m^3
		99-00	00-01	01-02	02-03	03-04	04-05	
42	01-02	111033	101173	96815				157164
51	02-03	207652	186065	174204	170293			303187

Table 6

Number of Ss	Season of HA* in force	Consumed capacity kW						Total installed capacity kW
		99-00	00-01	01-02	02-03	03-04	04-05	
42	01-02			4928	4855	4877	4750	5564
51	02-03				9074	8185	7841	9705

The data in Table 5 gives information about the reduced (really used) heated volume of the respective substations and that in Table 6 – the consumed capacity for the same substations after the introduction of the heat accounting system.

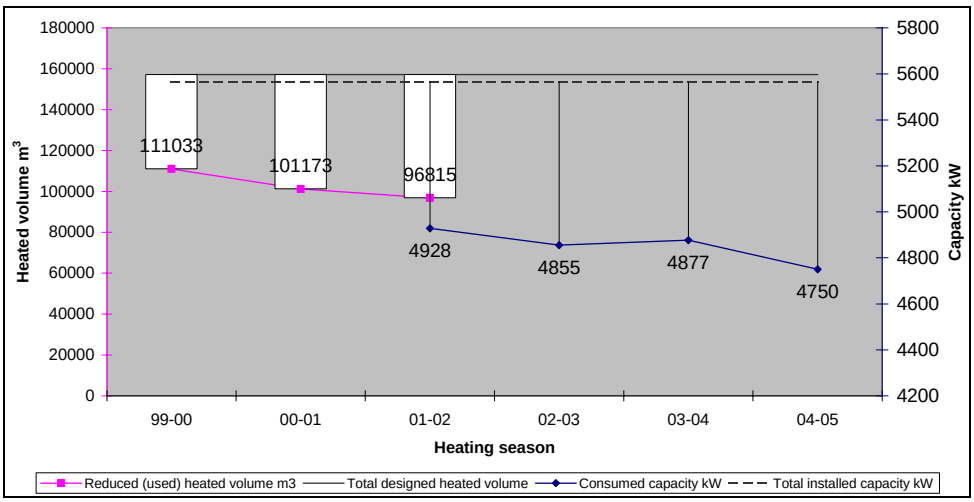
Similarly to the method of highlighting used in Table 4, the periods with and without heat accounting are marked in color:

heating season **w/o** heat accounting
heating season **with** heat accounting

The data in Tables 5 and 6 is further illustrated in Charts 9 and 10, respectively for the sample sizes of 42 and 51 substations in which heat accounting has been introduced during different heating seasons.

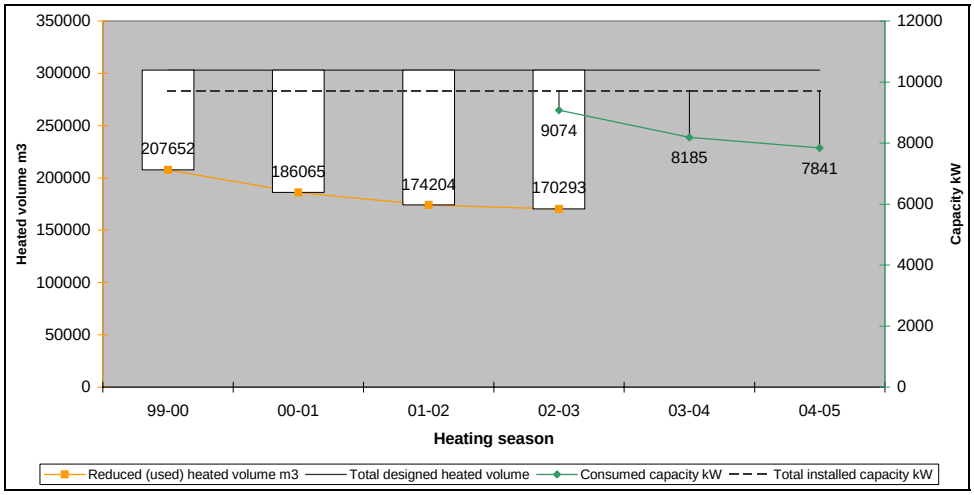
Illustrated on Chart 10 is the consumption for space heating of these sample sizes of substations.

Chart 9. Change in the used heated volume and consumed capacity – 42 pcs. substation introduced on heat accounting in heating season 2001-2002 – Toplofikatsiya Sofia



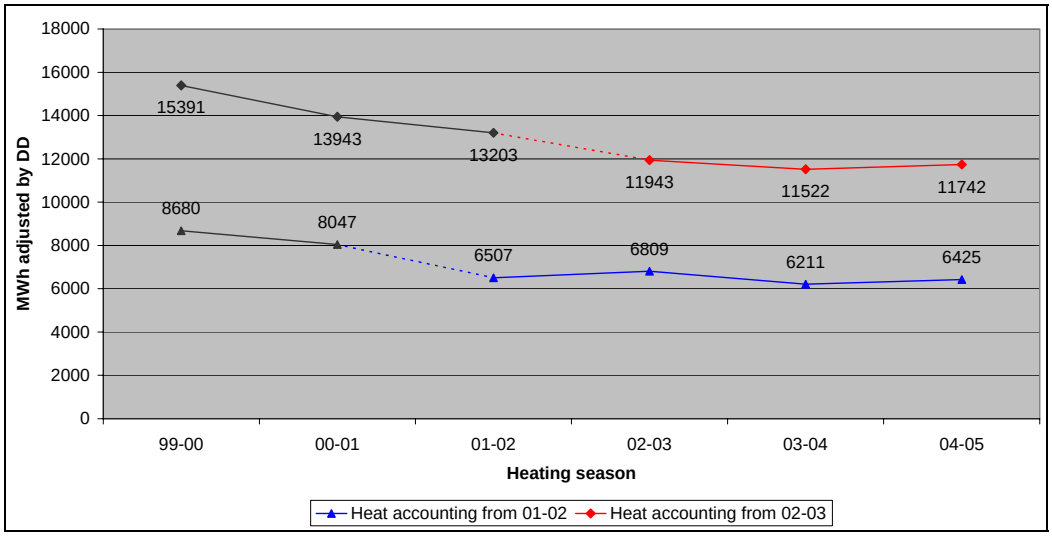
Source: Brunata Bulgaria Ltd.

Chart 10. Change in the used heated volume and consumed capacity – 51 pcs. substation introduced on heat accounting in heating season 2002-2003 – Toplofikatsiya Sofia



Source: Brunata Bulgaria Ltd.

Chart 11. Change in heat energy consumption of substations – 42 pcs. introduced on heat accounting in the heating seasons 2001-2001 and 51 pcs. in 2002-2003 – Toplofikatsiya Sofia



Source: Brunata Bulgaria Ltd.

The analysis of the above charts reveals that the really used (reduced) heated volume is significantly (almost twice) lower than the full design volume of the substations – the line in pink on Chart 9 and in orange on Chart 10. At the same time there is an evident trend of steady diminishing of that reduced volume for the heating seasons prior to the introduction of heat accounting, in other words a permanent process of resignation from the DH services and/or self-imposed limitations on the number of heated rooms.

After the point of introduction of the heat accounting system the consumed capacity (blue line on Chart 9 and green line on Chart 10) also shows a downward trend, however the percentage ratio with respect to the full installed capacity is significantly higher. This comes to indicate that the number of used capacities/radiators is significant and hence the heat accounting system has provided an opportunity for the consumer to make his/her own choice and for control on consumption.

DH COMPANY PLOVDIV

THE PROCESS OF INTRODUCTION OF HEAT ACCOUNTING

Chart 12. Introduction of heat accounting in Toplofikatsiya Plovdiv by number of substations

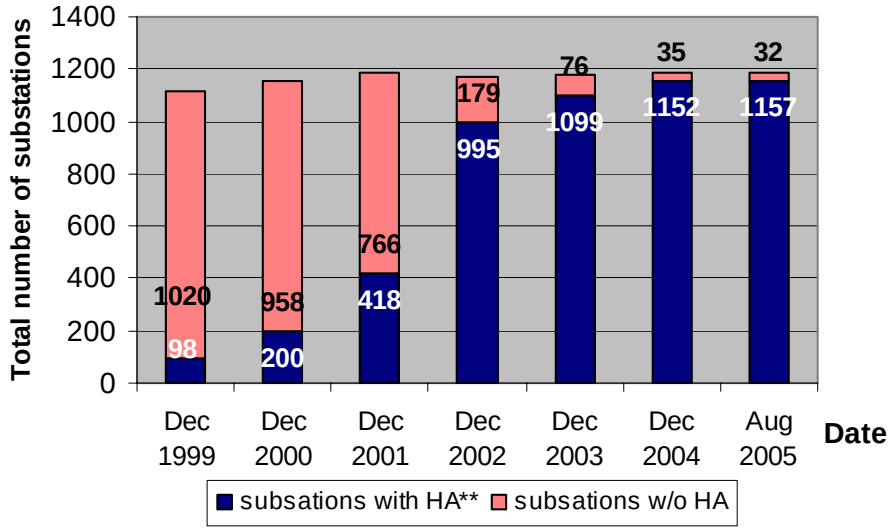
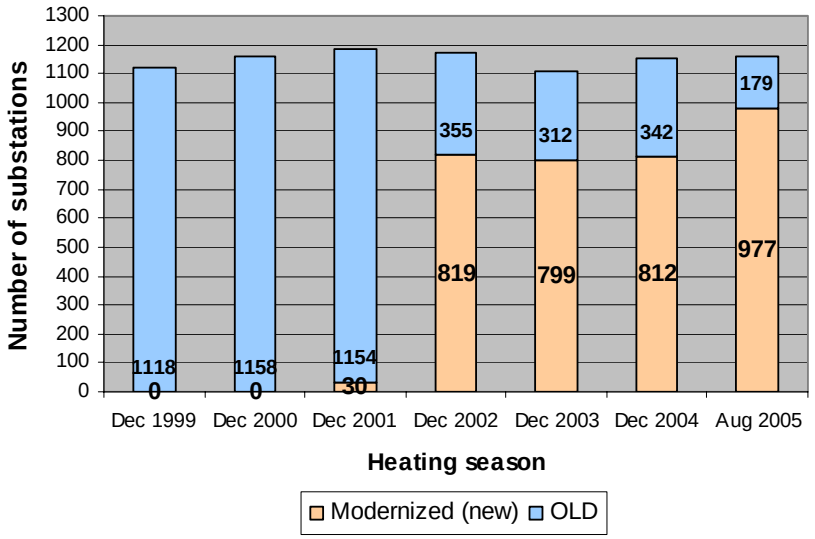


Chart 12 illustrates the process of introduction of heat accounting for the customers of DH Company Plovdiv. As different from DH Company Sofia, the process here started earlier, however as evident from the chart the system was fully introduced in all substations of the company also by the end of 2002.

THE PROCESS OF REPLACEMENT (UPGRADING) OF SUBSTATIONS

Chart 13. Modernization (replacement) of substations in Toplofikatsiya Plovdiv



As different from the case of DH Company Sofia, almost all the substations of DH Company Plovdiv have been replaced by new automated ones. This process was completed as early as by the end of 2002.

ANALYSIS BASED ON DETAILED DATA FROM 628 SUBSTATIONS

Heat energy consumption for space heating prior to and after the introduction of heat accounting

Table 9. Toplofikatsiya Plovdiv

Season of HA* in force	Heat Energy Consumption by heating seasons (MW/h)**							Number of Ss***
	99-00	00-01	01-02	02-03	03-04	04-05	Total	
00-01	26830	16697	16962	16633	17234	16535	110891	118
01-02	55468	40404	36305	36339	35624	34536	238676	201
02-03	89834	64102	64079	59046	58330	55707	391098	302
03-04	2120	1417	1288	1484	1507	1414	9230	7
Total	**174252**	**122621**	**118634**	**113502**	**112695**	**108191**	**749895**	**628**

Legend:
* HA - heat accounting
** Only heating, adjusted by degree-days
*** Ss - Substation

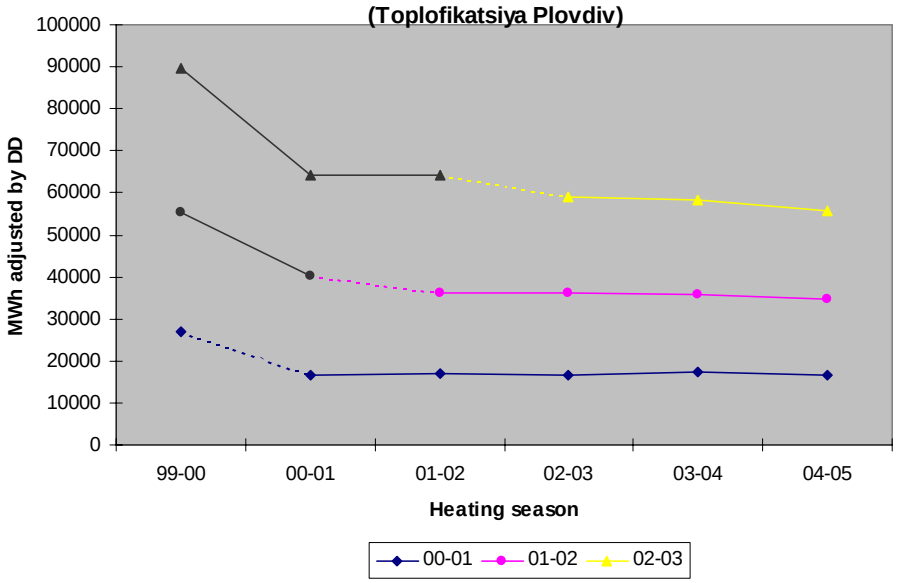
heating season **w/o** heat accounting

heating season **with** heat accounting

The figures in *Table 9* include aggregated data for energy consumption for space heating (in MW/h) of selected numbers of substations in DH Company Plovdiv, grouped by seasons of introduction of the heat accounting (HA).

From the data in the Table it is evident that the number of substations, in which heat accounting has been introduced during the 2000-2001 heating season, was 118, followed by 201 during 2001-2002, 302 (2002-2003) and only 7 in 2003-2004.

Chart 14. Change in heat energy consumption of substations (selected 621 pcs.) with heat accounting introduced in the following heating seasons



The figures from Table 9 are illustrated in Chart 14 less the data about the 7 substations in which heat accounting was introduced during the 2003-2004 heating season. These substations were discarded from the chart because of the fact that their number, respectively their consumption, is significantly lower than the rest

of the substation clusters and hence the graph of these values almost overlaps with the abscissa and gives no real visual idea.

The black lines on the charts show the consumption of these substation clusters during heating seasons in which the heat accounting system has not been introduced yet. Dotted lines in the respective colors mark the transition periods from the last season without heat accounting to the first heating season with heat accounting.

As evident from the chart, after the introduction of the heat accounting system a definite reduction and stabilization of the heat energy consumption levels for space heating sets in during the following heating seasons. This fact may be explained by the impact of the system and the customers' ability to control their consumption.

The analysis does not assign to the heat accounting system the significant drop in the consumption from the 1999-2000-level during the next 2000-2001 heating season. This drop may be explained by the provision of the legislation, according to which together with the mandatory introduction by law of the heat accounting system a further disconnection/dismounting of radiators in the customers' dwelling was not allowed anymore. It was namely during the 2000-2001 heating season that this regulatory measure was enforced. I.e. the drop during the preceding period may be explained specifically with the still continuing process of disconnection of radiators.

Chart 15. Replacement of substations Toplofikatsiya Plovdiv (selected 628 pcs.)

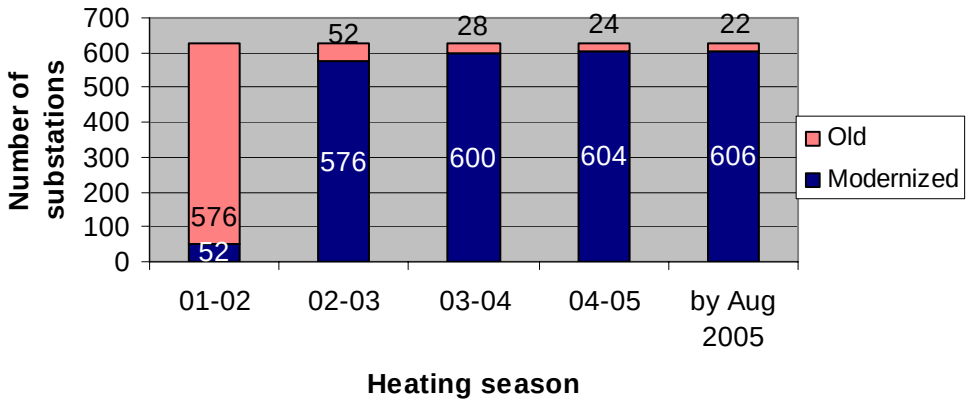


Chart 15 illustrates the process of replacement (upgrading) only for the selected 628 substations.
As one may easily find when comparing the figures from Chart 14, there is no significant change in the level of consumption after the replacement of the substations (mainly during the 2002-2003 heating season). This comes to indicate once more that irrespective of the possibilities for energy savings through the new upgraded substations, factors like heat energy tariffs, legislation and regulatory norm requirements, and the heat accounting system have a substantially higher impact on heat energy consumption.

Comparative analysis of the changes in energy consumption and heat energy tariffs for the period prior to and after the introduction of heat accounting

Table 10. Toplofikatsiya Plovdiv

Heating season	Heat energy consumption* MWh	Heat tariff BGN/MWh incl. VAT	Change in energy consumption %	Change in tariffs %
99-00	174,252	36.41		
00-01	122,621	36.41	-30%	0%
01-02	118,634	40.05	-32%	10%
02-03	113,502	44.75	-35%	23%

03-04	112,695	49.04	-35%	35%
04-05	108,191	53.90	-38	48%
05-06		69.12		90%

Note:
* Heat energy consumption adjusted by degree days – selected 628 substations

The data in Table 10 represents the following:

The total heat energy consumption for space heating of the selected 628 substations for the respective heating seasons, adjusted by degree days;

The heat energy tariffs for residential clients of DH Company Plovdiv, incl. V.A.T., for the respective heating seasons;

In this case, the same as in the case of the tariffs of DH Company Sofia, it is worth noting that for the purposes of studying the tariff changes and identifying the trend all the tariffs have been represented as one-component tariffs, i.e. at the point of enforcement of the two-component tariff it has been represented as a re-calculated one-component tariff. The data has been provided by DH Company Plovdiv.

The changes in percentage of the heat energy consumption for space heating and the tariffs for every heating season using the first heating season as a baseline.

Chart 16. Trend of heat energy consumption and tariffs for residential clients – selected 628 Substations – Toplofikatsiya Plovdiv

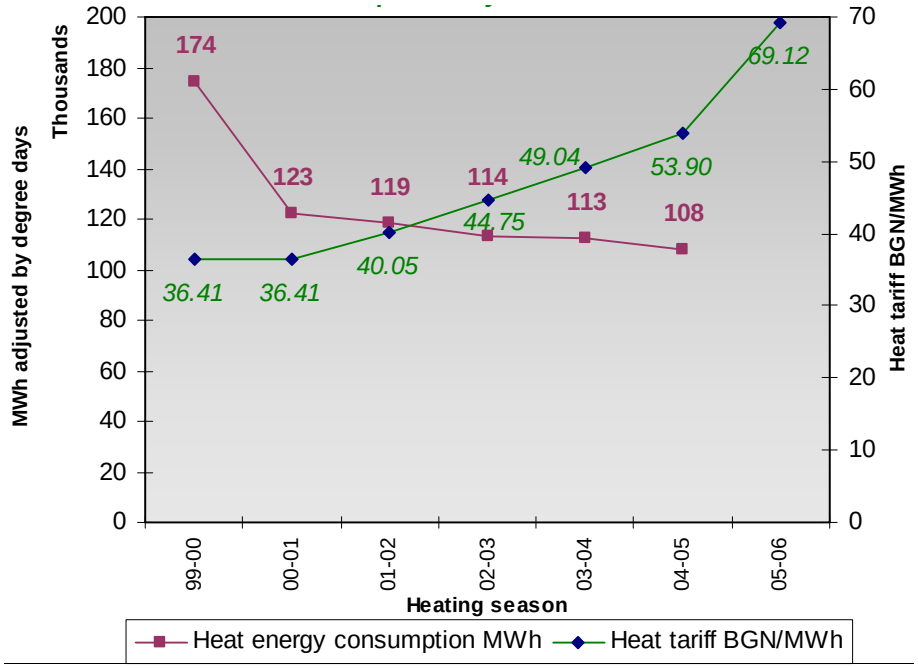
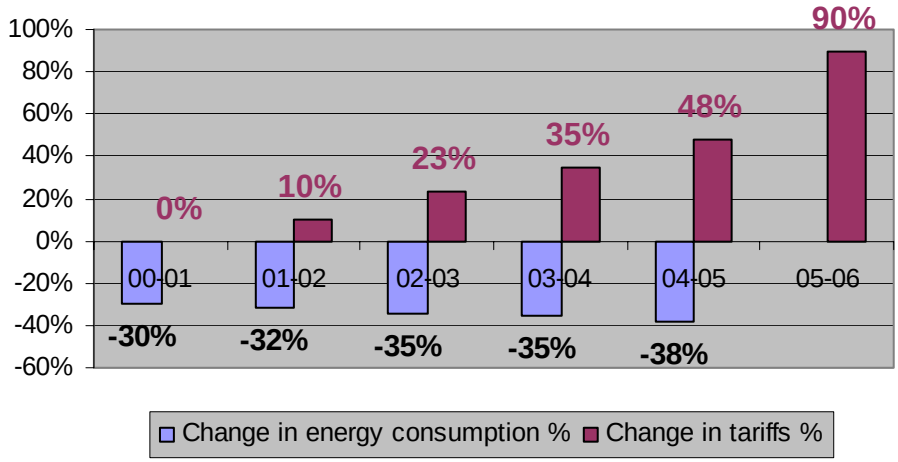


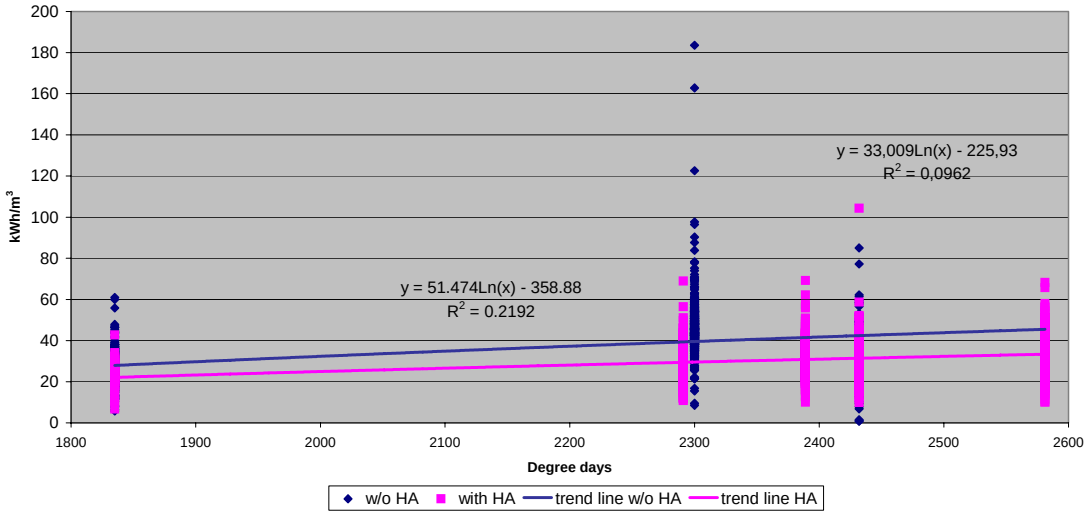
Chart 17. Change in heat energy consumption and heat tariff (in %) selected 628 substations – Toplofikatsiya Plovdiv



The figures from Table 10 are further illustrated in Charts 16 and 17. The analysis of the data from the Charts shows a trend towards reduction of heat energy consumption, however without strongly manifested drops, and a relative stabilization of consumption at a clearly manifested trend in tariff increase. The conclusion to be made is that with the introduction of the heat accounting system and thanks to one of its major advantages – the opportunity for individual control on energy consumption – it had become possible to retain relatively steady level of the quantity of heat energy consumed irrespective of the annual and substantial increases in the tariff of the service.

Specific energy consumption for space heating (kWh/m³) based on the existence of heat accounting

Chart 18. Specific energy consumption for heating (kWh/m^3) by substations with and without heat accounting- selected 628 substations – Toplofikatsiya Plovdiv



The specific energy consumption for space heating (kWh/m³) by substations has been calculated on the basis of the submitted data. It is based on the monthly consumption during the respective heating seasons (real value, unadjusted for degree days) and the heated volume – design volume, assigned to the respective substation. The data refers to the same clusters of substations presented in Table 9.

Chart 18 shows this specific energy consumption on the basis of the real degree days for the respective heating seasons and depending on the existence or not of heat accounting at the specific substation during the respective season.

As evident from the chart, and analogous to the analysis in the case of DH Company Sofia, the substations with heat accounting already in place (the values shown in pink and the respective trend in the same color) have lower specific consumption than those without such system (dark blue).

Based on the best-fit curves the difference in heating energy consumption before and after the HA implementation (the HA impact) may be approximated by the following equation:

$$\Delta E = 18.465 \ln(x) - 132.95$$

Where:
ΔE HA impact (kWh/m^3)
x number of degree-days

ANALYSIS OF ENERGY CONSUMPTION FOR SPACE HEATING AND DHW

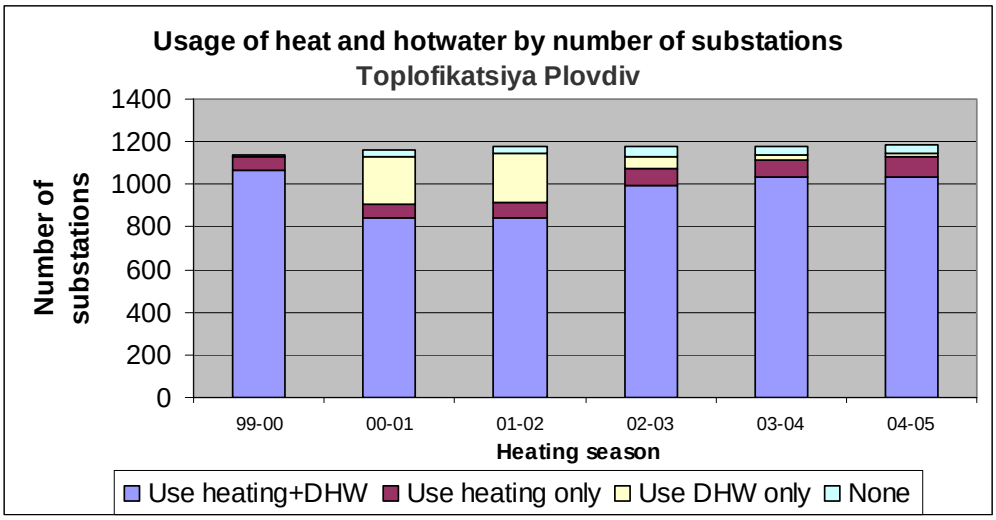
Table 11. Toplofikatsiya Plovdiv

Heating season	Total number of Ss*	Use heating + DHW	Use heating only	Use DHW only	None
99-00	1137	1064	62	8	3
00-01	1162	843	64	223	33
01-02	1181	846	69	234	33
02-03	1174	996	74	59	45
03-04	1175	1032	81	22	41
04-05	1188	1034	100	13	42

Ss* - Substation

The figures in Table 11 present information about the number of substations for residential clients of DH Company Plovdiv and their duty cycle during the respective heating seasons – use for space heating and DHW, for space heating only, for DHW only or full resignation of the services of the company. The data of the table is illustrated in Chart 19.

Chart 19. Usage of heat and hot water by number of substations Toplofikatsiya Plovdiv



The analysis of the data from Table 11 and Chart 19 shows that during the heating seasons 2000-2001 and 2001-2002 a significant share of the customers have used only DHW. At the same time a relatively constant

number of substations which did not use the services of the company at all from the 2000-2001 heating season till the last season covered by the analysis had been observed, as well as a constant number of those that use heat energy only for space heating. The number of substations, which had used only DHW during the 2002-2003 heating season, is diminishing at a growing pace, i.e. the customers are getting back to the "normal" use of DHW and space heating. The analysis of this chart in combination with Chart 12, which illustrates the process of introduction of the heat accounting system, has led to the conclusion that thanks to the characteristics inherent to the system the number of consumers has increased for the account of subscribers, who have previously used only the DHW service.

DH COMPANY PERNIK

THE PROCESS OF INTRODUCTION OF THE HEAT ACCOUNTING SYSTEM

Chart 20. Introduction of heat accounting in Toplofikatsiya Pernik – by number of substations

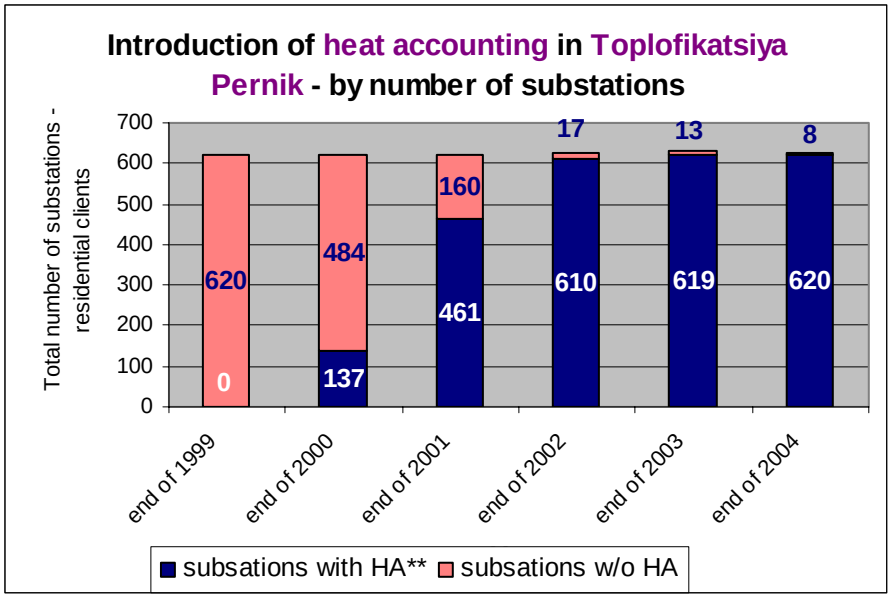
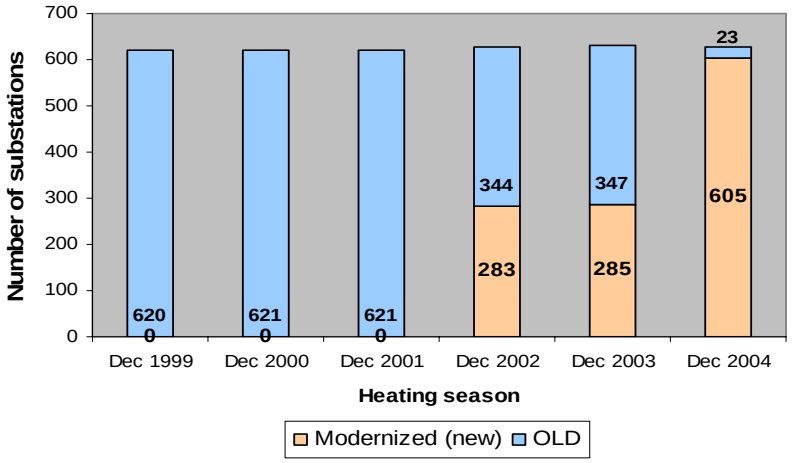


Chart 20 illustrates the process of introduction of heat accounting for the residential clients of DH Company Pernik. The same as in the case of DH Company Plovdiv, this process was completed by the end of 2002.

THE PROCESS OF REPLACEMENT (UPGRADING) OF SUBSTATIONS

Chart 21. Modernization (replacement) of substations in Toplofikatsiya Pernik



It is evident from Chart 21 that the process of replacement of substations has been finished by the end of 2004, as different from DH Company Plovdiv, where this process was in broad terms completed by the end of 2002.

ANALYSIS ON THE BASIS OF DETAILED DATA FROM 387 SUBSTATIONS

Heat energy consumption for space heating prior to and after the introduction of heat accounting

Table 14. Toplofikatsiya Pernik

Season of HA* in force	Heat Energy Consumption by heating seasons (MW/h)**							Number of Ss***
	99-00	00-01	01-02	02-03	03-04	04-05	Total	
00-01	23799	16431	21724	23910	20144	19722	125731	123
01-02	42384	30884	42023	44674	39606	36013	235584	207
02-03	11168	7549	10437	11398	10001	9848	60400	57
Total	**77351**	**54864**	**74184**	**79982**	**69751**	**65583**	**421716**	**387**

Legend:
* HA - heat accounting
** Only heating, adjusted by degree-days
*** Ss - Substation

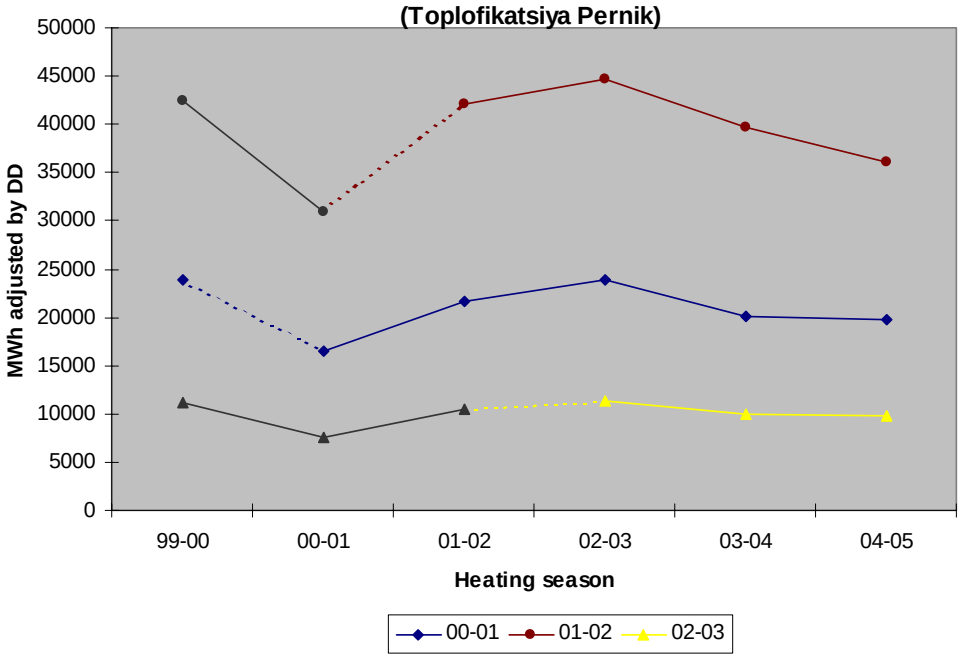
heating season **w/o** heat accounting

heating season **with** heat accounting

The figures in Table 14 include aggregated data for energy consumption for heating (in MW/h) of selected numbers of substations in DH Company Pernik, grouped by seasons of introduction of heat accounting (HA).

It is evident from the figures in the table above that the number of substations, in which heat accounting was introduced during the 2000-2001 heating season, was 123. During the 2001-2003 season their number is 207 and in 2002-2003 – 57.

Chart 22. Change in heat energy consumption of substations (selected 387 pcs.) with heat accounting introduced in the following heating seasons



The data from Table 14 is illustrated on Chart 22.

The same as on the charts for the other two companies, the lines in black show the consumption by these substation clusters during heating seasons in which heat accounting has not been installed yet. Dotted lines in the respective colors are used to mark the transitional periods from the last season without and the first season with heat accounting.

Similar as in the case of DH Company Plovdiv, a significant drop in heat energy consumption is noted for the 2000-2001 season. As different from DH Company Plovdiv, however, this drop was drastic and in the following heating seasons no "retention" but rather an increase was observed. It is important, however, to emphasize the reason for the tremendous drop during that particular season. The data submitted by DH Company Pernik show the energy consumption for heating space by substations but for the whole heating season. According to the information supplied by DH Company Pernik, due to the enforced by law mandatory introduction of heat accounting, during the said season the company has refused heat energy supply to customers, who have refused introduction of the system for their substations. At the point of installation of the needed equipment and introduction of heat accounting DH Company Pernik had resumed heat energy supply to these subscribers. For this reason during that season there is a large portion of substations, which in actual fact had not used heat energy during the full length of the heating season but rather during only part of it – the period after the introduction of heat accounting. It is namely for that reason, as well as because of the type of the data provided (amount of consumption for the entire heating season but not on monthly bases), that the analysis was not able to provide an explicit and definite answer to the actual cause of the said drop in consumption

The analysis of the chart cannot provide logical explanations about the change in the consumption and customers' behavior after the introduction of the system either, as was the case of DH Company Plovdiv and DH Company Sofia. As evident from the chart, after the introduction of heat accounting increase of energy consumption for heating space has been noted for almost each of the substation clusters but not reduction or stabilization.

Chart 23. Introduction of heat accounting in Toplofikatsiya Pernik – by number of substations (selected 387 pcs.)

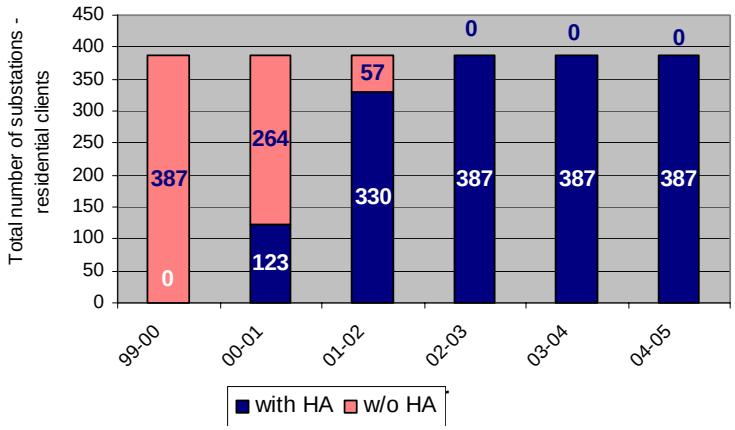
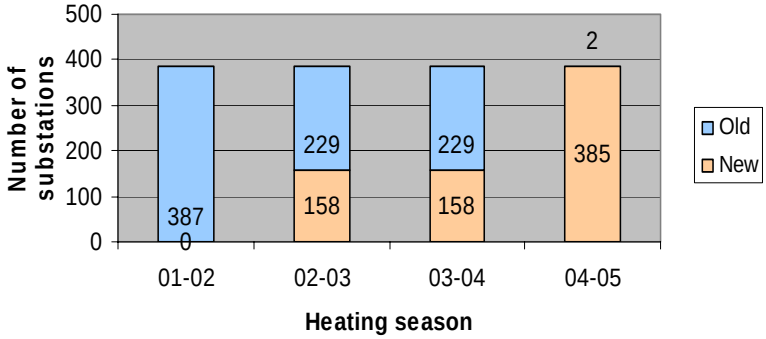


Chart 24. Replacement (upgrading) of substations in Toplofikatsiya Pernik – selected 387 pcs.



The simultaneous analysis of Charts 22, 23 and 24 gives us grounds to make the conclusion that since the 2002-2003 heating season, when heat accounting was introduced in all the substations of the given sample and nearly one half of them had been replaced by new ones, the consumption of the substations is characterized by a downward development trend.

This analysis, however, is not able to decide which of the factors specifically leads to this situation.

Comparative analysis of the changes in the consumption rates and heat energy tariffs during the period prior to and after the introduction of heat accounting

Table 15. Toplofikatsiya Pernik

Heating season	Heat energy consumption* MWh	Heat tariff BGN/MWh incl. VAT	Change in energy consumption %	Change in tariffs %
99-00	77,351	36.41		
00-01	54,864	36.41	-29%	0%
01-02	74,184	40.05	-4%	10%
02-03	79,982	42.48	3%	17%
03-04	69,751	46.72	-10%	28%
04-05	65,583	53.30	-15%	46%
05-06		62.36		71%

Note:
* Heat energy consumption adjusted by degree days – selected 387 substations

The data in Table 15 above represent the following:

The heat energy consumption total for space heating of the selected 387 substations for the respective heating seasons, adjusted by degree days;

The heat energy tariffs for the residential sector customers of DH Company Pernik, incl. V.A.T., for the respective heating seasons.

The same as in the case of the tariffs applied by the other DH companies, it is worth noting that for the purposes of studying of tariff changes and tracking of the trends all the tariffs have been presented as one-component prices, i.e. at the point of enforcement of the two-component tariff the latter is represented as a one-component one. The data has been submitted by DH Company Pernik.

Presentation of the change in heat energy consumption for space heating in percentage and the heat tariffs for every heating season using the first heating season as a baseline.

Chart 25. Trend of heat energy consumption and tariffs for residential clients – selected 387 substations Toplofikatsiya Pernik

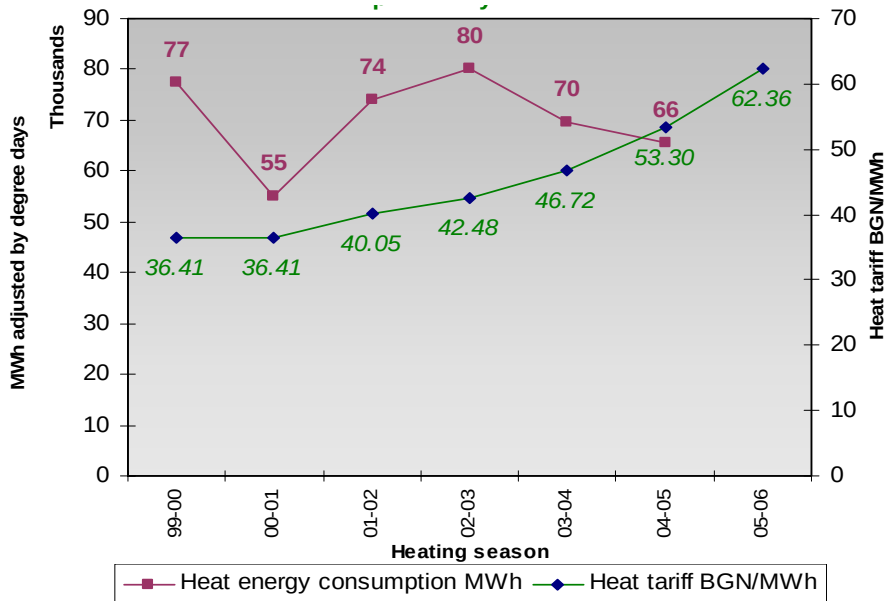
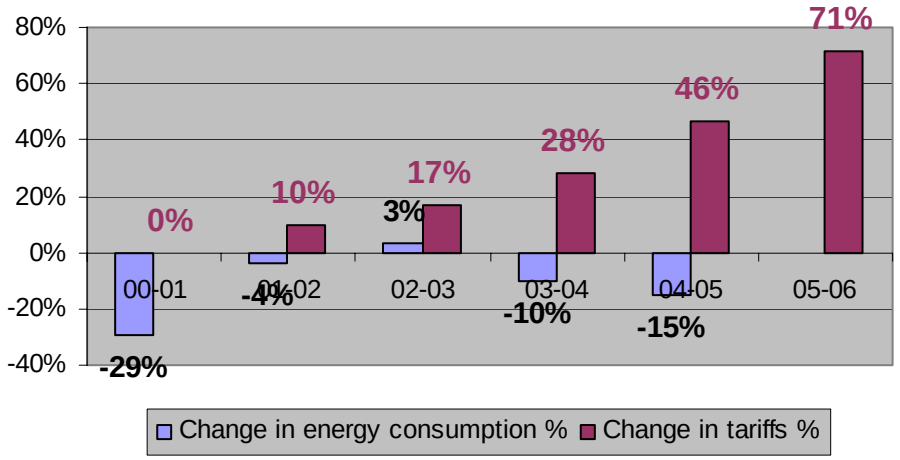


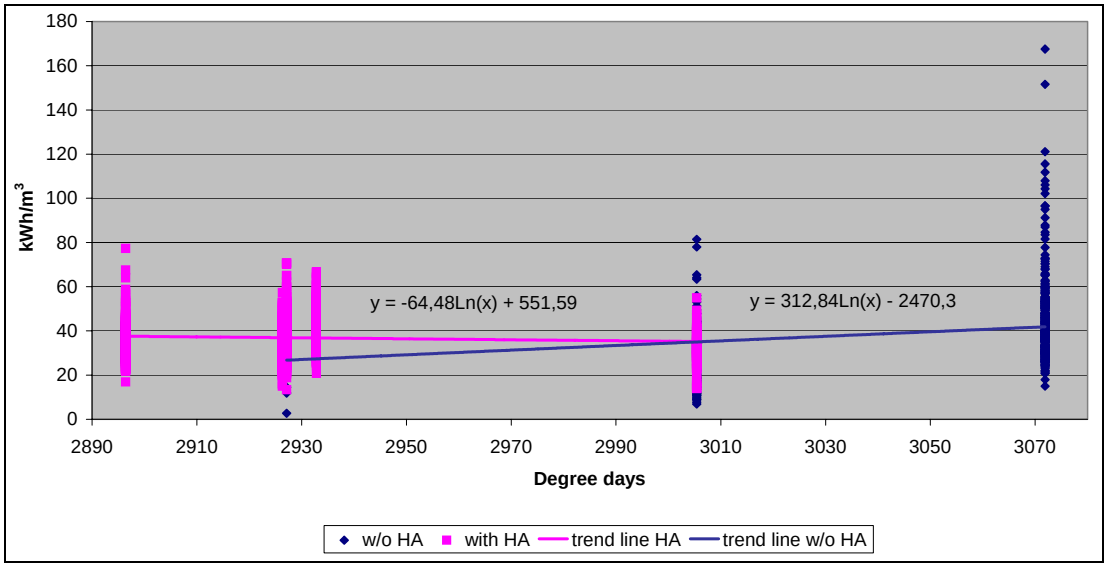
Chart 26. Change in heat energy consumption and heat tariff (in %) selected 387 substations Toplofikatsiya Pernik



The data from Table 15 has been illustrated also in Charts 25 and 26. The analysis of the charts shows fluctuation in heat energy consumption and a well-manifested trend towards tariff increases. The conclusion to be made is that heat energy consumption is not affected solely by the heat tariff.

Specific energy consumption for space heating (kWh/m³) based on the existence heat accounting

Chart 27. Specific energy consumption for heating (kWh/m³) by substations with and without heat accounting – selected 387 substations Toplofikatsiya Pernik



Illustrated on Chart 27, the same as in the case of the other two DH companies, is the specific energy consumption for space heating (kWh/m³) depending on the actual degree days for the respective heating seasons and the existence or not of heating accounting at the given substation during the respective season.

The figures apply for the same sample of 387 substations, which has been presented in Table 14.
As different from the same analysis for the other two DH companies, Sofia and Plovdiv, in this case we are not able to make the same analysis, namely that the substations with heat accounting in place (the values in pink and the respective trend in the same color) have lower specific energy consumption than those, in which this system has not been introduced as yet (dark blue). The most probable reason for that is the already described problem with the data about the energy consumption during the 2000-2001 heating season, when there was a large portion of substations, which in fact had not used heat energy during the entire heating season, but for part of it-after the introduction of the system

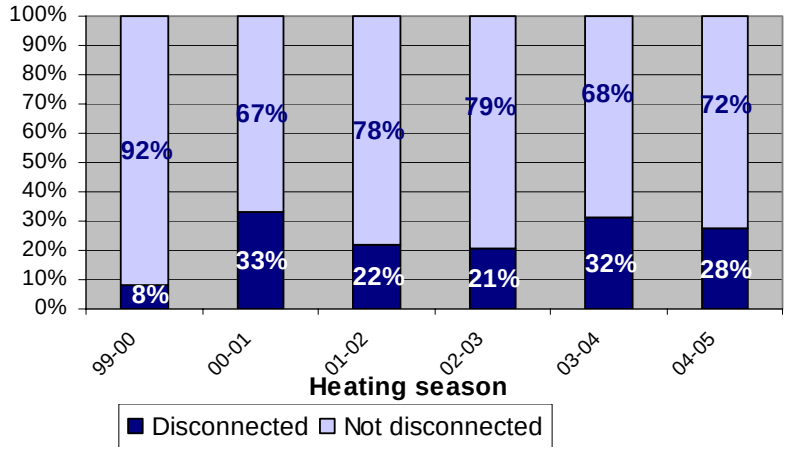
Based on the best-fit curves the difference in heating energy consumption before and after the HA implementation (the HA impact) may be approximated by the following equation:

$$\Delta E = 377.32 \ln(x) - 3{,}021.89$$

Where:
ΔE HA impact (kWh/m³)
x number of degree-days

Analysis of the percentage of disconnected heating units (radiators)
The data received from DH Company Pernik comprises also information about the percentage of disconnected radiators by substations by the beginning of every heating season. On the basis of this data an averaged percentage for the total sample of 387 studied substations for each heating season was calculated. The data is illustrated on Chart 28.

Chart 28. Average % of disconnected radiators Toplofikatsiya Pernik – (selected 387 substations)



The analysis of the above chart shows that this percentage was the highest during the 2000-2001 heating season. This is an additional factor for and explanation of the identified significant drop in the consumption of the customers during that heating season in addition to the above mentioned reasons (Please, refer to the analysis of Chart 22).

Another conclusion that may be made from Chart 28 is that after the general penetration of the heat accounting system near the beginning of the next heating season 2001-2002 (Re. to Chart 23) the percentage of disconnected radiators has diminished from an average of 33% during the 2000-2001 season to 22% and 21% during the 2001-2002 and 2002-2003 heating seasons respectively.

As evident from Chart 28, however, this percentage has again increased to 32% during the next heating season 2003-2004. The experts of DH Company Pernik explain this fact by the argument that during that season forced "disconnection" by the DH Company itself has been launched with respect to customers, who have failed to settle their overdue bills.

SUMMARY ANALYSES FOR ALL THE THREE DH COMPANIES – SOFIA, PLOVDIV AND PERNIK

HEAT ENERGY TARIFFS

Table 16

Heating Season	Tariff BGN/MWh			Change in tariffs %		
	Sofia	Pernik	Plovdiv	Sofia	Pernik	Plovdiv
1999-2000	36.41	36.41	36.41			
2000-2001	36.41	36.41	36.41	0%	0%	0%
2001-2002	40.05	40.05	40.05	10%	10%	10%
2002-2003	44.05	42.48	44.75	21%	17%	23%
2003-2004	48.46	46.72	49.04	33%	28%	35%
2004-2005	53.36	53.30	53.90	47%	46%	48%
2005-2006	68.09	62.36	69.12	87%	71%	90%

The data in Table 16 presents the changes in heat energy tariffs for residential clients of all three DH companies.

Here, as pointed out above, it is worth noting that for the purposes of tracking the trend all the tariffs have been presented as one-component ones, i.e. since the point of enforcement of the two-component tariff the latter has been presented as a recalculated one-component tariff. The specific values of the tariffs were presented in the sections above, in tables 2, 8 and 13 respectively.

Chart 29. Trend of heat tariff for residential clients: Toplofikatsiya Sofia, Pernik and Plovdiv

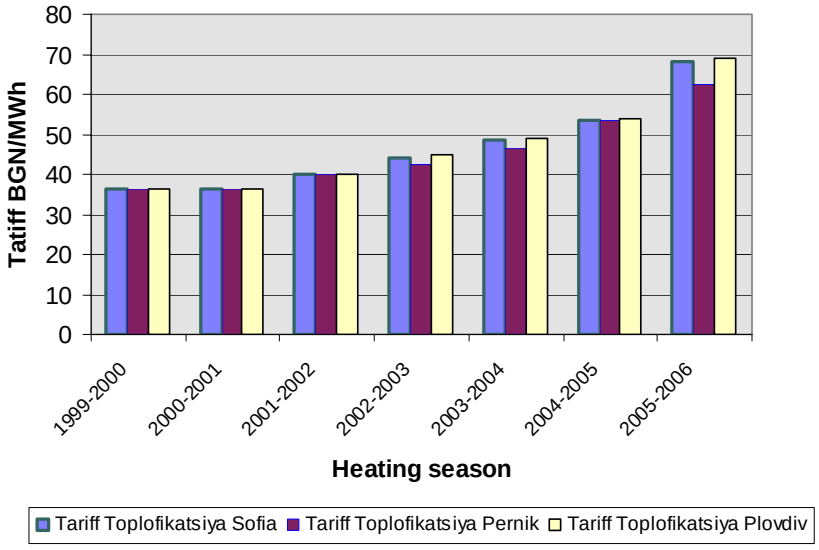


Chart 29, showing the change in the heat energy tariffs for all the three DH Companies, was composed on the basis of the data in Table 16. It is evident that as of the 2000-2001 heating season the tariffs follow an upward trend and during the last heating season covered by this review they were the highest for DH Company Plovdiv, followed by those for Sofia and Pernik.

Chart 30. Change in heat tariffs in % (baseline seasons 1999-2000) Toplofikatsiya Sofia, Plovdiv and Pernik

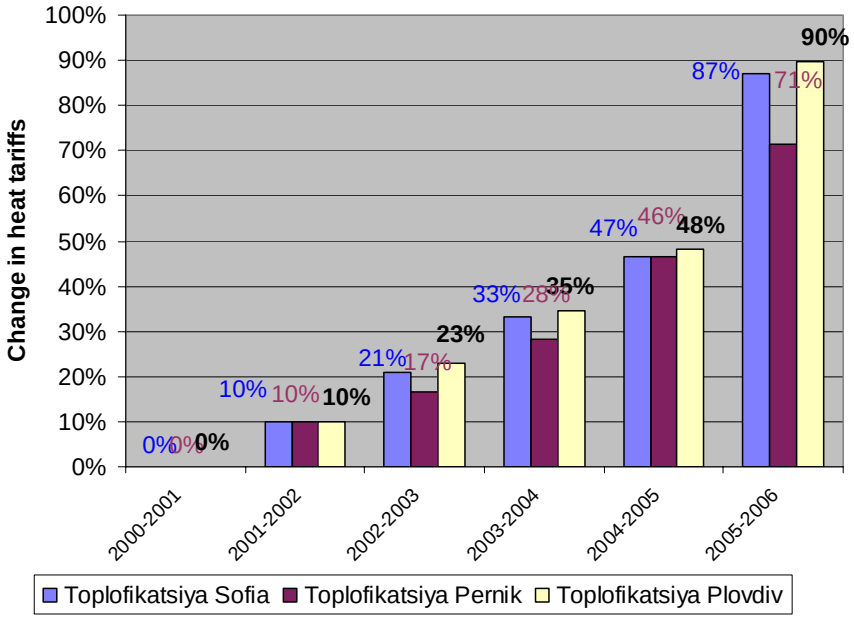


Chart 30 presents the same kind of information as Chart 29, however with respect to the relative changes of heat energy tariffs.

PURCHASING CAPACITY AS COMPARED TO THE TARIFFS OF HEAT ENERGY FOR SPACE HEATING

Table 17

	Heating Season						
	1999-2000	**2000-2001**	**2001-2002**	**2002-2003**	**2003-2004**	**2004-2005**	**2005-2006**
Sofia							
Average monthly income per member of household (in BGN)	132	148	153	161	168	190	207
Tariff BGN/MWh	36.41	36.41	40.05	44.05	48.46	53.36	68.09
Purchasing capacity MWh/month	3.63	4.06	3.83	3.65	3.47	3.56	3.04
Plovdiv							
Average monthly income per member of household (in BGN)	109	121	133	140	147	163	183
Tariff BGN/MWh	36.41	36.41	40.05	44.75	49.04	53.90	69.12
Purchasing capacity MWh/month	2.99	3.33	3.31	3.12	3.00	3.03	2.65

Pernik							
Average monthly income per member of household (in BGN)	100	110	116	117	124	136	153
Tariff BGN/MWh	36.41	36.41	40.05	42.48	46.72	53.30	62.36
Purchasing capacity MWh/month	2.76	3.03	2.90	2.75	2.66	2.55	2.46

Chart 31. Purchasing capacity for heat energy (district heating) in the following cities and heating seasons

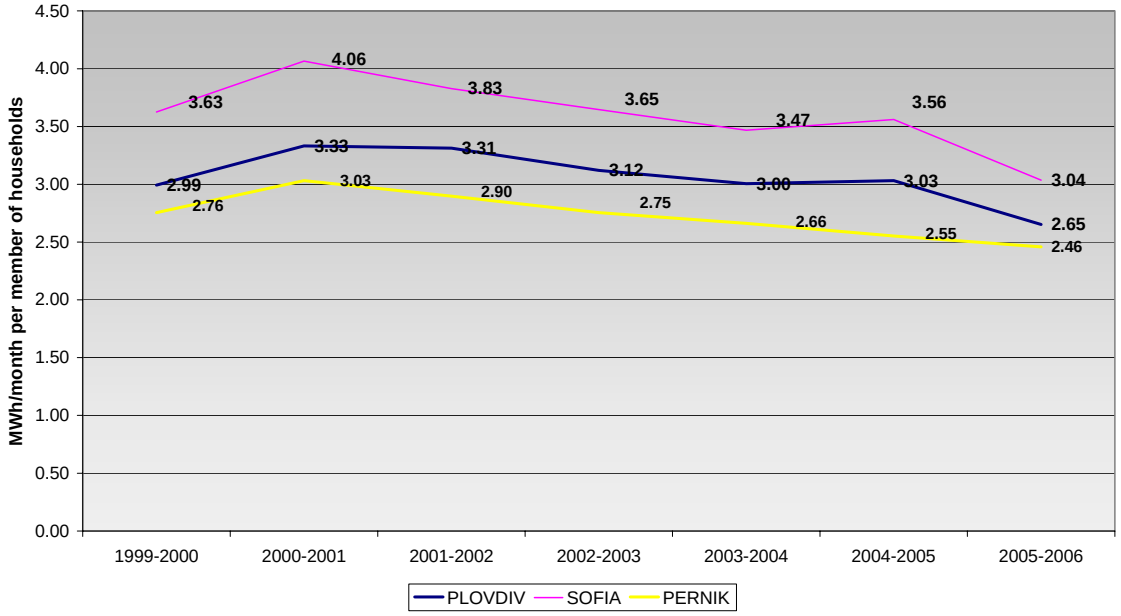


Chart 31 presents on the basis of the data quoted in Table 17 the conventionally formulated purchasing capacity of the population of the three cities with respect to the tariffs for the heat energy supplied by the three DH companies. The data about the average monthly income per household member by heating seasons has been calculated on the basis of the data quoted in Table 18 below, in which this income is presented as a total for the respective calendar year. The average monthly income for each heating season has been calculated on the basis of 2 months with heating on the average from one calendar year and 4 months with heating of the next calendar year, as component parts of the given heating season.

Table 18. Average monthly income per member of household (in BGN)

	Year							
	1999	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
Plovdiv	111	108	128	135	142	150	170	190
Sofia	116	140	152	154	164	170	200	210
Pernik	95	103	114	117	117	128	140	160

Note:
Source of the data – Alpha Research
Data for 2006 – based on the period Jan-April 2006

TARGETED WINTER SUPPORT FOR SPACE HEATING

Table 19. Targeted winter support – Toplofikatsiya Sofia

Heating Season	Number of people/heating season	Amount BGN/person/month	Total amount for winter supports BGN
2000-2001	13,019	32.12	418,170
2001-2002	13,484	37.35	503,627
2002-2003	17,856	45.38	810,305
2003-2004	11,313	52.63	595,403
2004-2005	10,339	58.45	604,315

Table 20. Targeted winter support – Toplofikatsiya Pernik

Heating Season	Number of people/heating season	Amount BGN/person/month	Total amount for winter supports BGN
2000-2001	1,241	32.12	39,861
2001-2002	1,423	37.35	53,149
2002-2003	1,692	45.38	76,783
2003-2004	957	52.63	50,367
2004-2005	823	58.45	48,104

Table 21. Targeted winter support – Toplofikatsiya Plovdiv

Heating Season	Number of people/heating season	Amount BGN/person/month	Total amount for winter supports BGN
2000-2001	4,657	32.12	149,583
2001-2002	5,548	37.35	207,218
2002-2003	8,631	45.38	391,675
2003-2004	7,424	52.63	390,725
2004-2005	7,206	58.45	421,191

The data in Tables 19, 20 and 21 provide information about the targeted winter support for space heating, allocated by the respective DH companies for low-income customers. The figures in Column 4 of the tables have been calculated on the basis of the number of eligible citizens and the monthly amount of the targeted support per person. Since this support is allocated for the full amount of the consumed heat energy and to the maximum amount defined in Column 3, the total amount of the allocated targeted winter support in the general case is lower than that shown in Column 4 (the calculated maximum amount).

Chart 32. Targeted winter support for low-income people – Toplofikatsiya Sofia

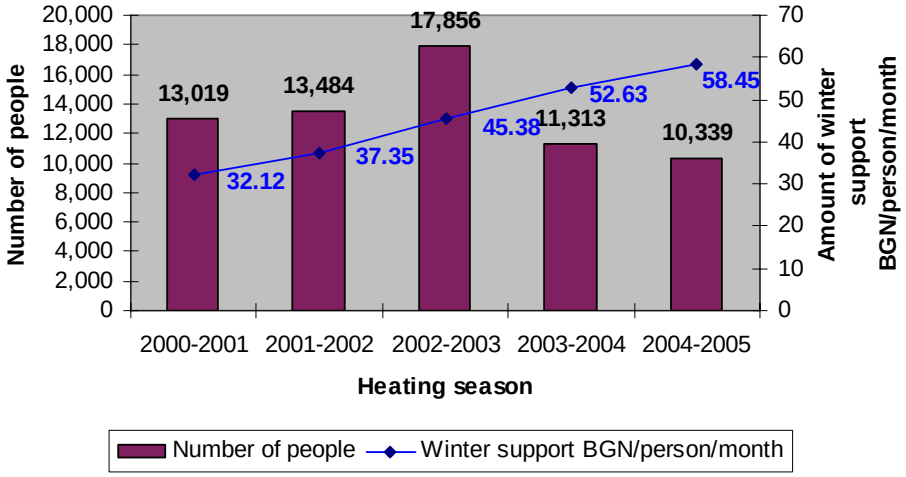


Chart 33. Targeted winter support for low-income people – Toplofikatsiya Plovdiv

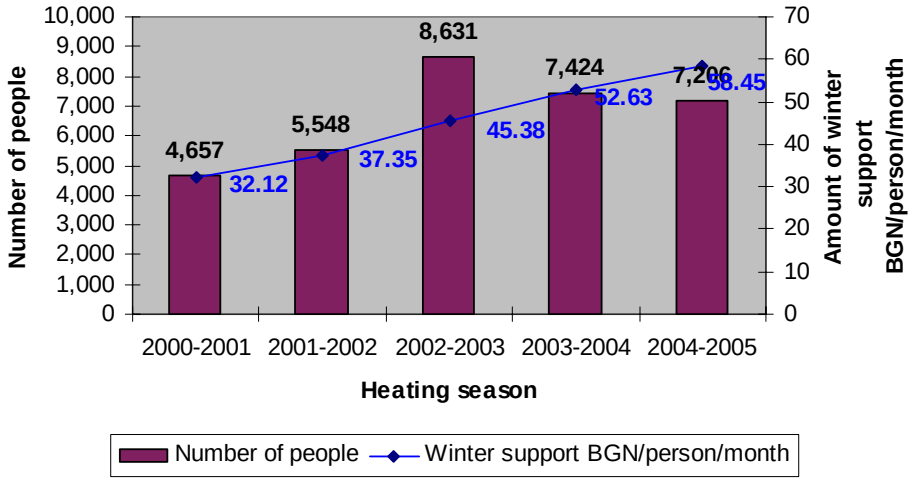
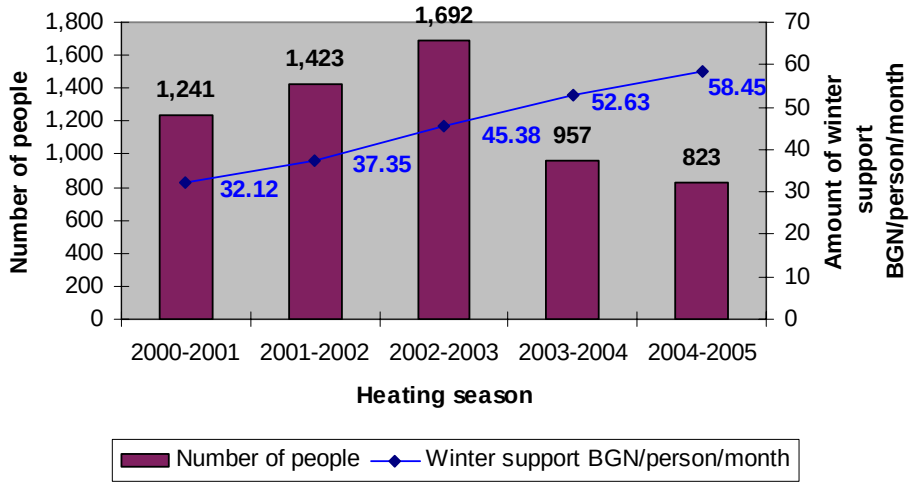


Chart 34. Targeted winter support for low-income people – Toplofikatsiya Pernik



The data of Columns 2 and 3 in Tables 19, 20 and 21 are illustrated on Charts 32, 33 and 34.

As evident from the tables and the charts the monthly amount of the targeted winter support per person is identical for all the three DH companies. The number of eligible citizens shows an increase during the first three heating seasons covered by this review and reaches its peak in 2002-2003 for all the three DH companies. During the next two heating seasons it diminishes significantly, above all in DH Company Sofia and DH Company Pernik.

The number of eligible persons is the function of the requirements for allocation of this support as defined by a by-law (Ordinance No. 5 from 30 May 2003 on terms and procedure for allocation of targeted social assistance benefits for space heating, modified April 2004 and April 2005). For this reason the heat accounting system does not have direct impact on the low-income consumers. The mode of influence of this system is the possibility of these customers to control their consumption and hence adjust their monthly energy costs to the amount of the available targeted winter support.

Chart 35. Trend of the total amount for winter supports – Toplofikatsiya Sofia

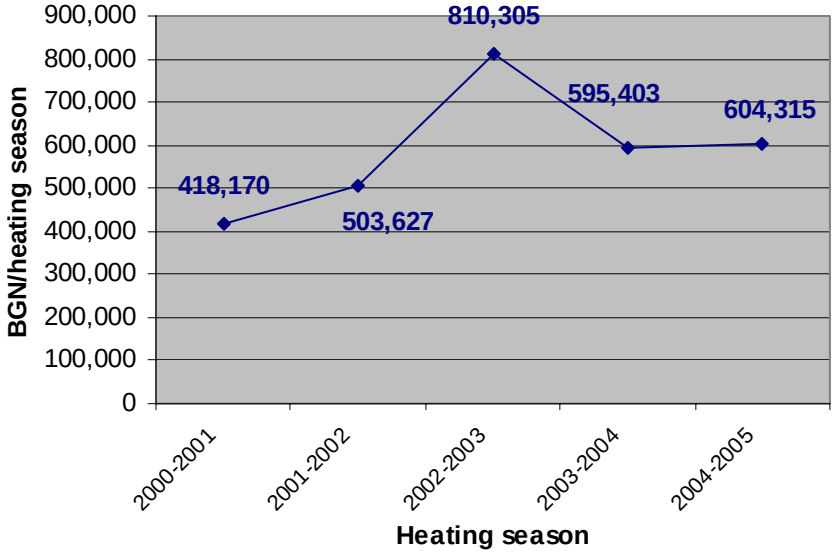


Chart 36. Trend of the total amount for targeted winter supports – Toplofikatsiya Plovdiv

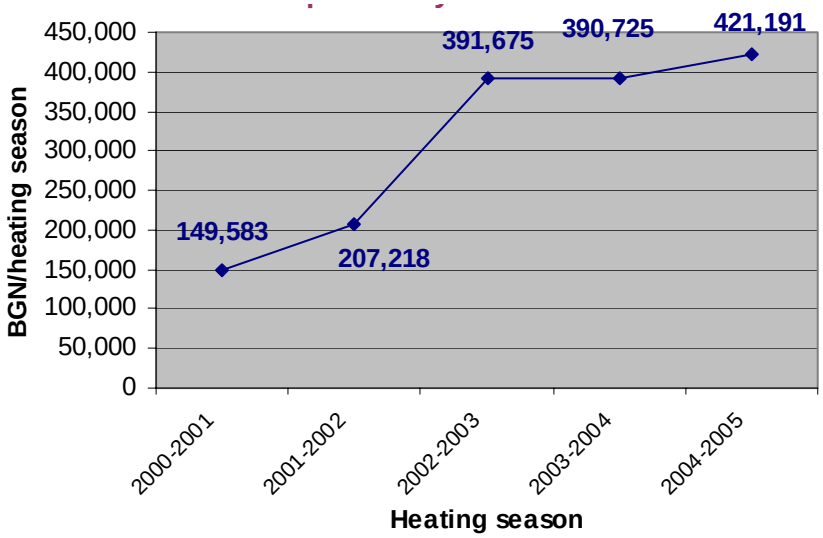
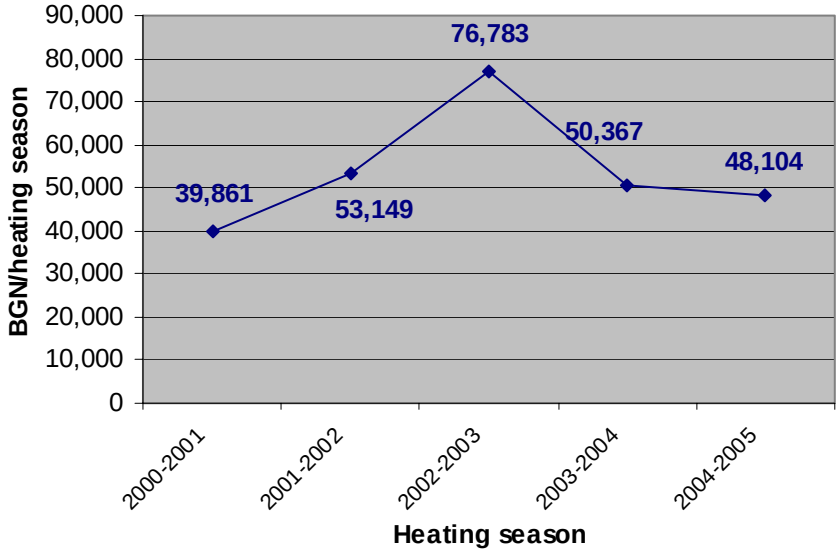


Chart 37. Trend of the total amount for winter supports – Toplofikatsiya Pernik



Charts 35, 36 and 37 have been designed on the basis of the data provided in Column 4 of Tables 19, 20 and 21, which show the total amount of the targeted winter support for the individual DH companies under review by heating seasons.

As a consequence of the increasing number of low-income customers and the growing monthly amount of the targeted winter support the total value of the amount of this support increases with every heating season until 2002-2003 for all the DH companies. Since then this total value diminishes for DH Company Sofia and DH Company Pernik, above all as the result from the significant drop in the number of eligible persons. In the case of Toplofikatsiya Plovdiv, however, the situation is different – because of the relatively small drop in the number of eligible persons and at the same time the increase in the amount of the monthly support during the 2004-2005 heating season the total amount of targeted winter support did not diminish but on the contrary – it had rather increased.

CONCLUSIONS

In conclusion, it may be said that the data from the analysis indicates that the introduction of heat accounting has had an impact on heat energy consumption by customers of DH companies. Thanks to one of the major characteristics of the system, namely that of individual control on consumption by the customers themselves through the installed equipment (thermostatic radiator valves and radiator heat allocators), consumers had the opportunity to control and regulate their heat energy consumption. The analysis does not say anything about the temperature comfort in the dwellings and it is quite probable that the reduced consumption and/or retention of the heat energy consumption levels might be somehow connected with a lower indoor temperature comfort. At the background of identified stable trend of increasing of the heat energy tariffs relatively balanced levels of heat energy consumption have been observed after the introduction of heat accounting. However, the simultaneous influence on heat energy consumption of a combination of interrelated factors, such as changes in heat energy tariffs, household income levels, rehabilitation measures (replacement/upgrading of substations) etc., and the heat accounting system create a significant problem for adequate determination of the exact impact of the heat accounting system in particular.

REGRESSION ANALYSIS OF RESIDENTIAL HEAT ENERGY CONSUMPTION

OBJECTIVE

The main objective of this part of the study was to measure the influence of a major single factor on the consumption of heat energy in the cities of Sofia, Pernik, and Plovdiv. The analysis focused on the consumption of residential clients. Heat energy consumption data at the substation level in residential buildings for the period of 2000–2005 were used.

The factors that were considered important included:

Date of introduction of heat accounting system

Modernization (replacement) of the substations

Price of heating energy (tariff)

Household income

Introduction of new Energy Law

Period

Factors such as household income, introduction of new Energy Law, and period were excluded from the analysis.

CHALLENGES

Several difficulties were experienced while conducting the regression analysis and interpreting its results. They fall into the following categories:

1. Post factum reporting. What we did in our documentation we reported what was done in three different DH systems without having any impact or control of how, when, where and how many measures (heat allocators, TRVs, substations) were installed. We did not have any true control group with which we could compare our results like it was done in the pilot studies described in earlier chapter (Pilot and Demonstration Projects of Heat Metering and Billing).

2. Aggregated vs. disaggregated data. Too many things happened at the same time. The quality and format of data did not allow us to identify exactly the timing (with the exception of modernization of substations) of the measures' installation. Therefore, we were unable to identify the impact of installation of each of the measures. We could only draw conclusions for the whole "package" of measures, although in many cases the completeness and timing of that "package" components' installation varied.[48]

[48] In most of the cases the introduction of HA system was connected with voluntary installation of TRV's, since the introduction of HA system under the law called for mandatory installation of the heat allocators but not TRV's. In other words, there have been cases of radiators equipped with allocators but not with TRV's. This situation is changing as the consumers develop appreciation for the roles that various devices play in the central heating system.

3. Compounded vs. individualized impact of the measures installed. This is further related to the issue described above. For instance, installation of TRVs, in most of the cases had impacted the behavior of an automatic control system of the newly installed substations with the compounded end effect being different from the sum of individual impacts of each measure installed independently. Again, the data we had did not allow us to determine the exact saving from TRVs alone. So, it might be said that introduction of the HA system happened in the same moment as installation of the TRVs but it would be wrong to draw the conclusions that savings after that moment are attributable only to the TRVs themselves, in technical meaning.

4. "Noise" from variety of ways the consumers were using the equipment or district heating services in general.

5. Focus primarily on the heat accounting. The primary objective of the study was to investigate the influence of the heat accounting system rather than the savings from specific equipment installed.

It is advisable that in order to "isolate" the impacts of various measures individually it may be better to rely on studies conducted by specialized firms like Brunata, Danfoss, Techem, etc. (as quoted in chapter Pilot and Demonstration Projects of Heat Metering and Billing). However, as a result of our study we were able to develop several sets of curves and equations for studied locations that may be helpful to the readers in estimating the impact, in energy units, of the whole set of measures. The results have been adjusted to and presented as a function of the degree days.

RESULTS

The regression analysis was performed for all three locations. It showed that the main factors—introduction of the heat accounting system, modernization of substations, and heat tariff—influenced heat energy consumption in each location in a different way.

In Plovdiv, all of the three factors caused a decrease of heating energy consumption. The rank of each factor, in descending order, is listed below:

1. Introduction of heat accounting system

2. The heat tariff

3. Modernization of substations

In Pernik, only modernization of substations led to a decrease in consumption. Introduction of heat accounting and heat tariff led to an increase in heat energy consumption. The rank of each factor, in descending order, is listed below:

1. Modernization of substations

2. Heat tariff

3. Introduction of heat accounting system

In Sofia, both introduction of heat accounting and change in heat tariffs led to a decrease in heat energy consumption, but modernization of substations led to an increase in consumption. The rank of each factor, in descending order, is listed below:

1. Heat tariff

2. Modernization of substations

3. Introduction of heat accounting

The introduction of heat accounting systems led to a decrease in heating energy consumption in Sofia and Plovdiv but not in Pernik.

Unfortunately, the regression analysis could measure only the quantitative change in heating energy consumption but did not give any insight as to why heating energy consumption increased in Pernik.

Detailed results as well as description of the methodology and models used in the regression analysis are presented in Annex 13.

CONCLUSIONS AND RECOMMENDATIONS

Heat accounting works. We have reached this conclusion based on interaction with all major players in the district heating sector. Whether or not it was implemented in the best possible way remains part of the ongoing debate. The ultimate objective that everybody pay for what they use has been accomplished.

The introduction of heat accounting occurred in parallel with installation of heat meters at the substations, as well as tariff increases. For many consumers, those events had a compounding effect and gave little time to get accustomed to new controls or shifting billing methodologies from volume-based to consumption-based. With so many things happening at the same time, the consumer had a challenging time distinguishing which measures are benefiting him and to what extent[49]. Very often, primarily due to limited understanding of the issues, they blamed the new improvements as the cause of their heating related problems[50].

Based on the interviews conducted, we have compiled a list of recommendations for any locality that is interested in the implementation of a heat metering and control program. The list is not exhaustive by any means and is intended to be open-ended with further contributions welcome. The recommendations are:

A well structured customer education campaign is critical in the success of the program

Allow enough time for information dissemination

TV broadcast is more effective than printed materials

Major developments, like changes in tariffs or changes in billing methodologies, should be staggered

Account for consumers' resistance to change and low pace of the program developments

Account for the fact that changing the service culture and introducing obligations on the consumer part creates negative reactions

Allowing total disconnection of radiators creates additional burden on remaining consumers, especially when it comes to absorbing heat losses. It should be discouraged or prohibited.

Media coverage should emphasize not only the bad cases which make an easy and long lasting impression on the viewers but should at least equally focus on good examples

The government should pay for TV campaign since the rates that they are being charged are much lower than those offered to businesses (Techem)

Foster creation of homeowners associations and supporting legislation

HA Companies should be licensed (Techem)

Service fees should be collected by the DH Companies and transferred to HA Companies

Installation of TRVs shall be an integral part of the program

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[49] Any savings realized through controlling consumption are "clouded" or negated by tariff increases.

[50] For example, residents of overheated buildings will end up paying more when they switch from volume to substation level metering since they will continue using more energy than necessary.

The complaint handling process, including dispute resolution, has to be publicized, explained and enforced

The penalties for violations of the terms of the Law have to be enforced

Clearly define the role of all players involved in the program implementation[51]. Clarify any misconception early in the process.

[51] A common misconception among the consumers about the role of HA Companies is that they are involved in tariffs increase.