DISTRICT HEATING SYSTEM MANAGEMENT GUIDE

dhcan

FOREWORD

The aim of this guide is to support the decision-makers (management and owners of district heating (DH) Companies) both in changing the DH system's operation philosophy and choice of optimal solutions. The proper management of DH Company activity should lead to the improvement of economy and efficiency of heat supply to the customers at a heat price that is competitive with other heating systems. The information included in this guide is not prepared as a handbook, but concentrates on the main issues to address when considering management matters.

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1. OWNERSHIP OF THE DH SYSTEM AND ITS ELEMENTS

Ownership changes in the DH Sector are connected with economic transformations which are part of the change to a market oriented national economy. Many different actors participate in the restructuring process, including central and local authorities as well as domestic and foreign economic entities, financial institutions, and commercial banks.

There is a wide range of different DH systems in Central and Eastern Europe (CEE) countries and European Union (EU) member countries; in general DH system development in CEE countries is larger than in EU member countries. However, in the transition economies of the CEE countries DH systems are often in a poor condition and standards of energy efficiency and economy are rather low.

There is also a fundamental difference between the efficiency and economy of the DH systems operated in EU member countries and CEE countries. This is caused mainly by the difference of DH system operation: 'demand driven' in the EU member countries and 'generation driven' in CEE countries. More detailed description of differences between 'demand' and 'generation' driven DH systems can be found in the 'Modernisation Guide', another DHCAN guide.

State owned heat sources and DH networks subordinated to central and local authorities are transformed into different economic entities, according to the legal basis existing in particular CEE countries. There are various forms of ownership in DH sector.

Usually large combined heat and power (CHP) and sometimes large heat only boilers (HOB) plants are operated as separate enterprises, owned by the State or privatised as joint stock companies fully or partly owned by foreign or domestic owners or co-owners. There are also industrial heat sources (CHP and HOB plants) which are owned and operated partly as the factory's property and also as a separate heat source. These separate heat producers sell heat to the DH networks operated by DH Companies. Sometimes those DH Companies also operate their own heat sources (usually local HOB plants and boilers in individual buildings).

DH networks are mainly owned by municipalities or by the State, and sometimes (eg in Poland) by housing co-operatives and private companies. Large DH networks supplied from large heat sources are usually operated as separate enterprises. Smaller DH networks are mainly operated together with the heat sources. Very small DH entities are often subordinated to communal authorities as budgetary units. There are also privatised DH companies (mainly limited companies, sometimes joint stock companies) fully or partly owned by foreign or domestic owners or co-owners.

Substations are owned both by DH network owners and by the owners of buildings supplied from DH networks. The buildings' internal heating equipment is owned by building owners. There are housing co-operatives and municipal entities, which own many buildings, private building owners, which own one or more buildings, as well as 'housing communities' which associate flat owners in multi-flat building as a common ownership of the building.

The process of ownership changes in the DH sector has been gradual and is often, though not always, associated with the injection of private money. The foundation of successful change is a transformation of management principles. These are affected by ownership, because in State-owned organisations a 'collective' responsibility led to politically instead of economically based management. More details of Ownership options are described in the 'Ownership Guide', which is another DHCAN guide.

2. DEPENDENCE OF ECONOMIC EFFECTS ON DH SYSTEM MANAGEMENT

The successful adaptation of DH system management is an important element in the overall economic and social transformation involved in moving to a market based economy. The DH sector plays a very important role both in country's energy balance and municipal services. Transformations of the sector involve changes in DH system management. The main changes include:

- **Ownership** changes connected with municipalities taking over state owned DH assets, and further establishing joint stock DH companies, selling shares or assets to private business, leasing by foreign or domestic companies or other solutions aimed at bringing in the private sector.
- **Organisational** changes connected with adaptation to a market economy, involving decentralisation of management, changes in ownership, rationalisation of employment etc.
- **Economic** changes, mainly connected with withdrawal of subsidies to heat supplied to different customer groups, undistorted prices, cost and income recording and book-keeping, implementation of billing and tariff systems based on metering and stimulating energy savings.
- **Environmental management improvements** of ecological management – reducing environmental pollution largely by means of more efficient heating plant, notably elimination of low efficiency local (individual) coal fired boilers without any flue gas cleaning equipment. Demand side measures are also important.

These changes have to be closely connected and supported by technical modernisation, as described in the 'Modernisation Guide', which is another of the DHCAN guides.

The main elements of the DH system are centralised heat sources, DH networks and substations. It is important that each element of the DH system is performing in an energy efficient way, so that improvements in one aspect are not wasted elsewhere. It can happen that energy savings in a heat source can be lost in the DH network with large heat and water losses or in substations with bad heat distribution control and irrational heat use in building internal installations. Therefore it is very important to consider to consider the sequence of improvements so that those changes which alter heat demand are implemented or at least considered before heat source modernisation.

Rational heat use in substations and buildings internal systems are vital for the efficient and economic functioning of the whole DH system.

The DH system should be treated as one technical circuit of heat delivery from different heat sources to the different customers and purposes (industrial, commercial, housing etc.).

The management of DH systems involves optimising the whole system. This is a complex task, especially where particular elements of a DH system are owned and operated by different DH companies or by customers, whose interests are sometimes contradictory.

It is very important to develop a common understanding among the owners of each DH system elements.

Lack of understanding and co-operation between operators of particular elements of DH system can lead to economic difficulties and lower efficiency.

It is very important for DH Companies in a market-based economy to develop good relations with customers and local authorities. Part of this also involves developing good relationships with local media.

The crucial aspects influencing customer opinions about DH Company activities are heat price and quality of service (reliability of heat supply and effective room temperature control). For local authorities key priorities are the economic viability of the DH Company, environmental issues and customer (electorate) satisfaction.

Past investment and energy policy in CEE countries has resulted in relatively low efficiency of heat generation and distribution, much higher heat losses in buildings than in EU countries, a lack of correlation between prices and costs, and subsidies from the state budget.

One of the most important factors influencing DH Company image both for customers and local authorities is increase of heat price.

In the past, heat prices were extremely low and consumers covered only a small part of the cost. The greater part of heat generation and transmission costs was covered by subsidies from central and municipal budgets.

Reduced subsidies (part of the necessary economic transformation) and consequent rapid increase of heat prices have been an ‘economic shock’ to heat consumers, especially households. Thus it is very important to minimise this increase (by better energy efficiency, for example).

3.1 Importance of public relations

The press, radio and TV are sometimes treated as ‘the fourth authority’. It is very important to have good relations with journalists, who can help to develop a better understanding by local authorities and individual consumers of the economic and technical problems which confront DH Companies, and to tell them about the potential benefits DH systems and their modernisation can bring. These issues are quite complex and difficult even for specialists educated in DH system operation.

The DH Company’s own public relations also plays a vital role in the educational understanding of environmental issues.

The DH Company’s own activity could include:

- publications about restructuring the DH Company, its plans for modernisation and expected results from an economic and environmental point of view, information about the company’s economic situation. More specialised information could include some background of the DH sector and comparisons with similar DH companies in other cities (eg benchmarking results)
- educational brochures containing information about the principles of DH system operation, main factors

influencing heat supply efficiency, heat generation and transmission costs, and environmental protection
- educational brochures containing information about simple demand-side measures for reducing heat consumption in households and residential buildings (a handbook for customers). These brochures could be issued by the national DH Association or by a group of DH Companies financed by associated Companies
- cooperation with schools (primary, secondary) and scouting organisations including excursions/lessons for young people to improve their knowledge and understanding of the current problems and environmental potential of DH systems
- organisation of 'DH Company open days' as a sort of educational 'open air party' for the public with presentations and guided tours to CHP or HOB plants and substations, to acquaint them with the technology of heat generation, transmission and distribution
- in-service training of the bigger DH consumers, municipality, etc.

The main aim of improving public relations should be rebuilding local authority and customer trust in the DH Company management.

3.2. Co-operation with customers

Customers will usually have to deal with several different departments of the DH Company. It would be much more convenient for customers if there was one single Customer Service Centre for all services and information/ advice. Where this has been implemented it is popular both with customers and DH Company employees.

The image of the DH Company also depends on the 'reaction time' to customer enquiries, complaints and compensations. The Customer Service Centre should help to speed up the response to customer needs.

DH networks require regular maintenance and service. In some cases it is necessary to disconnect from operation a certain part of the network for repairs. That is why new modern DH networks are developed with a 'ring' pipeline configuration that allows for network repairs without interruption of supply to customers. However most of the large DH schemes in CEE countries have been designed with 'radial' pipelines from the central heat source to substations. This configuration is inflexible and repairs also interrupt supply to customers.

For this reason service and maintenance repairs are scheduled for summer periods when there is demand only for domestic hot water and not for space heating. Nevertheless the supply interruption is still a significant issue affecting quality of service and customer satisfaction. In cases where heat is metered at the building level, the interruption of supply to customers decreases revenues and cash flow for the district heating utility. Thus the utility is economically motivated to minimise the period of disconnection.

In some countries there is also in place a regulation that limits the maximum allowed summer disconnection period, for example two weeks. If the DH system is to be competitive in terms of service quality, it should allow consumers not only to regulate heat consumption (with for example installed thermostatic radiator valves), but also to potentially eliminate the planned out-of-service summer interruptions. The configuration of existing district heating schemes thus represents a significant challenge when modernising DH networks.

Guaranteed accuracy in heat supply and quality and reliability of service provision is very important.

It is worth implementing a Quality Assurance System (QAS) audited and certified according to ISO 9002 requirements. This system is very useful for simplification of procedures and clarification of co-operation between departments of the DH Company and personal responsibility for work and decision-making. A DH Company with a QAS certificate is more credible to banks and potential trade partners, and its overall image is enhanced.

The DH system creates one circuit with hot water circulating from the heat source to the substations and back; after the substation a further network serves the buildings themselves with space heating and domestic hot water. Proper hydraulic regulation (division of water flow) and rational heat use in buildings' internal systems are important for an efficient and economically viable DH system. For this to be achieved, co-operation with heat consumers is necessary.

This is not an easy task, because it involves co-operation with a large number of customers. The problem is complicated because in CEE countries the term 'heat customer' in residential buildings has two meanings:

- in some countries/systems the customer is the building owner who has signed a heat supply contract with the DH Company and is paying the bill for heat supplied to the building (both for apartments and common areas like staircases and corridors) and then dividing purchased heat costs between apartment users in the building (eg in Poland)
- in other countries a heat customer can be every apartment owner in a multi-flat building, each having signed a heat supply contract and paying bills directly to the DH Company (eg in Lithuania); the customer may also have the choice to disconnect from the system.

The second solution causes a lot of difficulties because it is practically impossible to define the rights and obligations of the DH Company and the separate flat owner.

Buildings' internal systems are in fact an integral part of the building and are not owned and operated by the DH Company but are a joint ownership of all flat users in the building.

It is not possible for the individual flat owner to be responsible for proper hydraulic regulation and rational heat utilisation in the buildings' internal systems.

Heat penetrates through walls inside the building so proper measurement of heat supply to separate apartments is practically impossible.

Therefore there are good reasons not to provide individual heat supply contracts with flat owners. This avoids the problem of individual disconnections, which disturb the central heating and domestic hot water installations in the building. It also avoids the free rider

IMAGE OF THE COMPANY

problem. It further avoids the need for parallel heating and gas pipeline construction inside the buildings. It also allows rights, obligations, conditions of heat supply, and standards of services to be defined in a heat supply contract. This should be signed by the DH Company and the building owner or his representative.

The contract should be signed by each owner (of one or more buildings eg housing cooperative), house-owner association, company and other customer (but not by every individual apartment owner).

The contract should stipulate:

- **Scope of the contract** (types of service, parties, localities, ordered heat output and DH water flow, core services together with any additional services).
- **Ownership of the equipment** (heat meter and DH water flow limiting valve should be owned by the DH Company).
- **Maintenance responsibility** (defining the responsibility for maintenance and proper operation of substation and building internal installations)
- **Responsibilities of the DH Company** (heat supply quality standards, informing customers about scheduled maintenance and time of allowed interruptions in heat supply, informing customers about any malfunction of the DH system and expected duration of repair, optimisation of DH system work, minimisation of heat supply costs).
- **Rights of the DH Company** (access to substation rooms, heat tariff setting and application for its approval by the Energy Regulatory Authority, defining technical requirements for new substations and conditions of heat supply to new buildings, setting charges for additional services separately agreed with the customer). DH Companies should have the right to propose expropriation of property to the municipality if necessary to establish the pipelines and other equipment. The heat source should also be defined in an approved plan of DH system development.
- **Responsibilities of the customer** (proper operation, maintenance and rehabilitation of the building internal installations and other equipment owned by the customer; elimination according to DH Company request of inappropriate use of equipment operated by the customer; assistance in heat meter readings and punctual payments for the DH Company's services; ensuring access to the substation room for DH Company employees only).
- **Rights of the customer** (heat delivery according to defined conditions, requested testing of the heat meter, requested interruption of heat supply, changing of ordered heat demands resulting from upgrade of the building).

Previously, contracts signed with heat consumers defined only basic conditions of heat supply and payments. That kind of contract is not sufficient in a market-based economy and some disagreements arise. A more comprehensive heat supply contract is required to clarify and regulate all matters, which are or could be a source of disagreement or misunderstanding between the DH Company and its customers.

If different companies own the heat source and the DH network, the network owner (distributor) is a specific customer for the heat source owner (producer). The distributor purchases a large amount of heat from the producer and sells that heat to customers connected to the DH network.

Co-operation between producer and distributor should not be limited to operational and heat trading matters only.

Both parties should co-operate for long-term planning and optimisation of DH system development.

Co-operation between heat producer and distributor should be managed either by one common organisational body (eg committee, council), or by means of a complete and comprehensive bulk heat sale contract. This close cooperation between heat producers and distributors is particularly necessary at the present time, when heat demands are decreasing for a number of reasons. Both parties should work together to improve the whole DH system efficiency and economy in order to keep existing and attract new customers. Both parties should also co-operate in marketing and public relations.

The bulk heat sale contract should regulate heat trading and operational matters and should also define the principles of financing common investments. The contract should regulate the sharing between parties of the benefits achieved by the producer. These may include the development of cogeneration or increase of electricity generation in CHP plant resulting from decreased return water temperature due to more accurate heat supply control in substations.

The contract should also regulate matters connected with heat tariff implementation and changes of heat prices not only from both parties' points of view, but also from the final heat consumer's point of view. Such changes should be introduced at the same time eg once a year.

3.3 Ensuring good relations with the local authorities

The DH company will need to co-operate with the local authority for strategic long-term planning of heat supply in accordance with long-term physical planning and expected development of the municipality.

In some countries municipalities are obliged to prepare a Local Energy Plan or Heat Supply Plan. The plan will take into account expected changes in energy consumption as well as available energy resources, existing energy infrastructure and its technical condition. The plan will also consider possible competition between DH system and other heat supply systems (eg individual gas boilers). The companies which supply heat, gas and electricity also prepare their own strategic business plans, taking into account expected development of residential, industrial and commercial areas (potential customers) and the likely profitability of investments to supply those new areas.

Optimisation of the total cost of energy supply to customers (including heat, electricity, gas, oil) in the local energy plan is necessary in the transition period, when distortion of different fuels and energy prices still exists. Apart from that all 'network' systems constitute a 'natural monopoly' for which market forces are usually replaced by an independent

IMAGE OF THE COMPANY

regulator. In many CEE countries different energy sub-sectors are still subsidised, so the results of a 'free' competition between different 'network' energy sub-sectors (eg gas pipelines and DH network) are fictitious, because prices of compared energy carriers do not reflect real costs.

The main aim of local energy planning is optimisation of energy supply costs to the end users.

Local authorities play an important role in DH sector development and rehabilitation:

- ***they are responsible for planning and development***
- ***they are responsible for strategic planning of heat supply across the municipality***
- ***they are usually responsible for DH system development and rehabilitation (as its owner)***
- ***they represent the interests of individual heat consumers (their electorate).***

In several countries there is a legal base, which gives the local authority the right to divide the town into separate zones, each with only one available type of heat supply network. The decisions about 'zoning' of city areas should always be based on an economic and financial analysis worked out by an independent institution as part of long-term Local Energy Planning.

Planned development of the DH system should be connected with proper physical planning of heat sources and DH network development. The municipality should consider granting the DH Company free access to land and property owned by the municipality (if construction of a new pipeline or new heating plant is necessary). This should be taken into account during DH system development planning. In some cases expropriation of property may be necessary. Compensation for expropriation shall be based on independent evaluation of the expropriated assets when the plan is carried out.

The management of the DH Company should liaise closely with local authorities in important decision making (especially concerning investment problems).

The plan of the DH system development should be approved by the local authority as a part of the general physical plan of the municipality development.

The local authority, either as the DH company owner or custodian of the interests of the local population, is interested in the viability of the DH Company and its financial autonomy. The management of the DH Company should inform local authorities about all important matters influencing the economic situation of the Company. They should also confirm the municipality will give operational and financial autonomy to the DH Company management.

If a municipality is investing in DH system development or modernisation, the management of the DH Company should guarantee a reasonable return on the equity invested by the municipality. Co-operation between the DH Company management and the municipality is also very important when ownership changes are prepared (eg privatisation of the DH Company).

Environmental protection and in particular emission levels from heat sources are an important issue for the municipality. Changing the DH Company management orientation from the generation to the demand driven mode is a good way to improve environmental performance and therefore to enhance the 'green' image of the DH Company in local authority eyes.

3.4 Development of additional services for customers

The change from generation to demand-driven mode should produce not only improved heat supply efficiency and reliability, but also better relationships with the customers. In particular, additional services may include:

- DH Company's technical personnel advisory service to customers including proper operation of building internal installations, better Demand Side Management resulting in smaller heat losses, rationalisation of heat use.
- offer of additional services connected with heat supply cost allocation in multi-flat buildings and individual settlement of accounts with flat users (usually this brings not only additional income for the DH Company, but also a better collection rate),
- offer of additional services connected with the operation of substations owned by customers and equipment inside buildings: availability of highly qualified technical personnel of the DH Company.

3.5 Environmental aspects of DH system management

Transformation of the DH Company management philosophy from the generation to the demand driven mode usually results in reduced emissions. Key improvements include:

- increased boiler efficiency and integration of CHP, renewables etc
- improvement of the flue gas cleaning in special installations
- elimination of low efficiency coal fired boilers.

Apart from the actions connected with investments, implementation of Environmental Management Systems according to the ISO 14000 standard could be an effective way to improve the 'green' image of the DH Company in local authority and customer eyes. However the main reason for system implementation should be the change to a demand-driven system.

All these actions improve the green image of the DH Company and they provide a simple, cheap but large contribution to achieving Kyoto goals.

The integration of CHP is a particularly effective environmental measure.

Reduction of emissions gives the possibility to benefit from emissions trading.

The DH Company can implement capital-intensive improvements by means of Joint Venture projects.

4. ORGANISATIONAL AND TECHNICAL ASPECTS OF DH SYSTEM MANAGEMENT

DH Companies range widely in size and economic activity. Most DH companies sell heat generated from their own heating plant and transmit through their own DH networks. However, there are also DH Companies that purchase heat from producers as well as producing heat in their own heat sources. Some mainly large CHP plants are operated as a separate company selling heat to separate distribution companies.

The size of DH Companies ranges from very large companies with heat output capacity of thousands of MW to very small companies with a few MW or less. A small number of large companies sell a large amount of heat and a large number of small companies sell a little.

There is a considerable variation in the technical solutions used in DH systems and the age and technical condition of existing heat sources and networks ranges from the very old to the brand new. The age and technical condition of existing equipment are modernisation problems but also involve management issues. Specific management problems depend on the scope of economic activity of DH Company, and on the size of DH system owned by the Company.

4.1 Restructuring the DH system management

Usually DH companies in CEE countries not only operate heat sources and DH networks, but also carry out other services like transport, repairs, office cleaning, and guarding property. Experience in EU countries and restructured DH companies (eg in Poland) shows that it is more rational to focus on the core activity (heat supply) and contract out other activities.

The DH Company management should concentrate its effort on the basic activity concerning operation, modernisation and development of the DH system as well as optimisation of heat supply costs. The management will be able to select the best contractor (taking into account quality and price of services). It allows the cost of additional services to be reduced because specialised contractors will be employed according to actual needs only.

Organisational restructuring of the DH Company may involve implementing a Quality Assurance System (QAS) audited and certified according to ISO 9002 requirements. QAS implementation clarifies the obligations, rights and responsibilities of particular departments, sections and employees very often making DH Company management easier and more efficient. The QAS is recently implemented in several DH companies in Poland and corporate system development has moved towards Environmental Management Systems complying with the ISO 14000 standard. This provides a systematic way to improve the sustainability of DH and to focus company attention on the customer side.

One of the most effective ways of improving internal management is computerisation: implementation of personal computers connected to a common network.

There are specialised programs for bookkeeping and recording cost and income in each field of activity. It is necessary to take into account expected energy savings and its effect on cash-flow – resulting from modernisation of the DH system as well as buildings modernisation/demand side management). All these factors should be considered when setting heat tariffs.

Integrated management models based on specialised computer programs are usually helpful for the company's management and are particularly useful in larger DH companies. Computerisation can be very useful for optimisation of heat supply costs, and for restructuring. It allows oversized heat sources and DH networks to be optimised, reducing excessive energy losses. The main aim is to optimise heat supply costs and improve quality of service.

Evaluation of profitability of different fields of activity can be useful for planning DH system modernisation and development.

Another important problem for the DH Company management to solve is that of unpaid bills for heat supply and other services performed by the Company. If collection rates are too low, the economic viability of the DH Company will be in danger – so action is needed to improve collection rates.

After restructuring a DH Company becomes a self-financing entity.

4.2 Scope of DH company activity

The scope of a DH Company's business activities depends on:

- the number of separate DH systems operated and number of heat sources supplying separate or common DH networks
- extent of DH system integration or disintegration (operation of heat sources, DH networks and substations by one or more companies)
- territory of economic activity (one or more municipalities territory)
- additional (non-core) economic activities.

DH Companies can be divided into the following groups:

1. 'heat generators'
   DH companies operating heating plant (CHP or HOB plants) and selling heat to the DH network company
2. 'heat distributors'
   DH companies purchasing heat from 'heat generators', operating DH networks (or DH networks and substations) and selling heat to customers
3. 'heat generators and distributors'
   DH companies operating heat sources and DH networks (or DH networks and substations) and selling heat to customers
4. 'mixed' DH companies providing parallel activities listed in points 1 – 3.

A so-called ESCO (energy services company) may be created to carry out a DH system modernisation programme and operate the modernised system for a defined period, with an assured pay back and agreed profit. There are also 'multi-branch' companies selling heat and providing other activities (eg water supply, gas supply, public transport). Customers are usually responsible for building internals and sometimes the substations.

Some DH Companies supply only one locality (one municipality or its part) while others operate systems in many different localities (territory of different municipalities).

ORGANISATIONAL AND TECHNICAL ASPECTS OF DH SYSTEM MANAGEMENT

Large utility heat sources	• Old condensing power plants supplying heat as CHP plants • Condensing power plants adjusted to supply heat to the nearest cities • CHP plants established especially as heat sources for large cities • HOB plants established as a first stage towards CHP for large cities
Industrial heat sources (autoproducers)	• CHP plants supplying both parent industrial factories and DH networks • HOB plants supplying both parent industrial factories and DH networks
Municipal heat sources	• CHP plants supplying DH networks • HOB plants supplying DH networks or local heating systems

Independently from the scope of DH Company activity, system management should include not only economic and operational issues, but also a strategic vision of heat supply, environmental protection, long-term planning (Local Energy Planning), and increased competitiveness.

A very important element of DH system management is ensuring effective co-ordination and co-operation between operators of the particular elements of the DH system.

Vertically integrated DH systems (containing all elements) may find it easier to achieve proper co-ordination and co-operation between operators of the particular elements of the system. This is possible through a full description of rights and obligations for personnel operating the heat source, DH network and substations as well as one dispatching centre co-ordinating their work.

For unbundled DH systems additional effort is needed to achieve common understanding of the DH operational principles by separate operators of the particular elements. It means that heat supply contracts, signed between heat source and DH network owners and between DH network and substation owners should regulate all matters, which in vertically integrated DH systems are usually regulated by means of internal instructions.

4.2.1 Heat generation problems

Generally heat sources supplying DH networks can be divided as shown in the table (left).

The main management problems connected with heat generation concern optimisation of heat price, reliability of heat supply, and environmental protection.

Optimisation of heat price for customers connected to a DH network that is supplied from different heat sources with different heat prices needs implementation of the Optimal Load Division principle. This principle is, for instance, used by the Warsaw DH Company, which is buying heat from two large coal fired CHP plants and 1 large coal fired and 1 large heavy oil fired HOB plant, owned by Warsaw CHP Utility. The CHP plants operate all year round, while HOB plants operate in the heating season only. The largest amount of heat is generated in the CHP plant with the lowest heat price and for customers an average weighted price is calculated according to the principles defined by law (ordinance concerning heat tariff setting).

ORGANISATIONAL AND TECHNICAL ASPECTS OF DH SYSTEM MANAGEMENT

The average weighted heat price is based on fixed tariffs for particular heat sources operated by Warsaw CHP Utility and calculated according to formulas defined in heat tariff for distribution company (Warsaw DH Company).

Reliability of heat supply depends on reliability of basic fuel supply.

The proper choice of a basic fuel is important because the total fuel utilisation cost is the major cost component in heat generation.

The total cost connected with fuel utilisation comprises not only the cost of fuel but also the cost of transportation and storage (including fuel losses), environmental protection costs and, in the case of solid fuels, the cost of dust and slag transportation and storage. The basic fuel for supplying a DH system should be selected on the basis of a long-term analysis. The analysis should consider all available fuels, taking into account total costs of fuel utilisation including the cost of interruption of fuel supply (caused by road damages, strike etc). The analysis should also take into account the possibility of improving heat supply reliability by using two fuels (eg gas and oil) in the same boilers (combi-burners) and using different fuels for base and peak load boilers. Typically, the total fuel costs amounts to more than 50% of the heat generation cost balance.

The possibility for improving heat generation efficiency depends on type of heat source and fuel used. Improvement of energy efficiency in existing DH systems is usually concentrated on elimination or modernisation of low efficiency heat sources. This modernisation concerns mainly solid fuel fired heat sources and is achieved by means of automatic combustion control and automatic control of water flow rate and temperature according to the heat demand and condition of DH system operation.

Improving heat generation efficiency can substantially reduce fuel use and heat supply costs.

Modernisation of existing heat sources and implementation of cogeneration in new (mainly small scale) CHP plants offer the largest improvement in heat generation efficiency.

The energy efficiency of a cogeneration unit is usually 40% higher in comparison with separate generation of electricity at a condensing power plant and heat at a HOB plant (assuming the same fuel is used). This leads to a considerable reduction in fuel consumption, reducing total fuel cost and also reducing greenhouse gas and other harmful emissions. In condensing power plants a great part (often over 60%) of the fuel consumption is lost to the environment through chimney losses (directly to the atmosphere) and condensing losses (to seas, rivers and lakes). The advantages of CHP development are described in the 'The Case for District Heating', which is another of the DHCAN guides.

The high fuel efficiency of CHP plants gives a considerable benefit for the DH system with substantial positive impact on energy economy and environmental protection.

The size and type of the CHP plant should be optimised individually depending on the local circumstances including investment and operational costs, the price of electricity sold to the grid and environmental protection costs.

ORGANISATIONAL AND TECHNICAL ASPECTS OF DH SYSTEM MANAGEMENT

Solid fuel fired CHP plants are usually equipped with steam boilers generating high pressure and temperature steam and backpressure or extraction condensing type steam turbines connected with power generators. DH network water is heated both in heat exchangers supplied from turbines and peak boilers – depending on the required temperature. These plants are relatively expensive but can run on low-grade fuels so that operational costs are low.

Gas turbine CHP plants are equipped with natural gas or light-fuel oil-fired turbines connected with power generators. Hot flue gases from the turbines heat the DH network in recuperators. These plants are usually smaller and less expensive than solid-fuel-fired CHP plants, but their economic viability depends on stability of heat load (poor power to heat ratio on partial heat load) and electricity price.

Gas engine CHP plants are equipped with natural gas or light fuel oil fired piston engines connected with power generators. DH network water is heated both in engine cooling systems and in recuperators by hot exhaust gases. These plants are usually small and have usually a high power to heat ratio, but the engines need more maintenance than gas turbines (so maintenance costs are higher).

Usually the investment costs of CHP plant are higher than for HOB plant using the same fuel.

For cogeneration units to be cost effective, high running hours at full (peak) load are necessary. Cogeneration units should also be operated during summer when the heat load is low.

Cogeneration units should cover the base load with peak boilers covering the peak load. The optimal total heat output capacity of a number of cogeneration units supplying municipal DH systems is usually about 45-50% of the peak heat demand of the system. This optimisation of heat demand should be based on a long-term economic analysis, taking into account expected heat demand changes during a whole lifetime of the CHP plant.

Installation of a heat accumulator (large hot water tanks with thermal insulation) with CHP plant can be helpful in optimising plant operation, especially in cases when electricity price is differentiated for day, peak and night time. The heat accumulator can be discharged at a peak time, when the value of generated electricity is higher than at night.

Heat accumulators increase the flexibility of CHP plants. The accumulators can be new tanks or older oil-tanks can be reconstructed to heat accumulators.

At that time electricity generation in CHP plant can be maximised relying on the DH network to use the heat stored in the accumulator, which is charged during the night when electricity production can be decreased. The heat accumulator can also be useful as a feed water reservoir for the DH network eg in case of rapid pressure drop caused by pipeline damage and high water loss.

The best results of heat supply costs and efficiency optimisation can be achieved in a ‘ring-shaped’ DH system, which is densely looped and supplied from more than one heat source. The individual CHP and HOB plants in that DH system can be connected to various nodes of the DH network.

These plants can supply a DH network in parallel and their operation can be optimised, taking into account heat generation cost, environmental requirements, maintenance needs etc. Usually there should be at least one plant (usually CHP) that is able to supply the minimum heat load during the summer. Implementation of automatic load dispatching in such DH systems could be helpful in optimisation of heat supply costs, because it enables the use of low cost heat sources to be maximised and operation time of the more expensive heat sources to be reduced.

Parallel operation of different heat sources in a 'ring-shaped' DH system also improves the reliability of heat supply to the customers, because heat can be delivered from different heat sources and directions owing to the densely looped DH network. Effective automatic control of heat supply is very important and depends on accurate measurement as well as good control.

The reliability and efficiency of heat supply is much better in a 'ring-shaped' DH system than in a 'radial' DH system.

4.2.2 Specific management problems concerning heat transmission and distribution

The management problems concerning heat transmission are mainly connected with development, modernisation and operation of the DH network. In CEE countries the majority of the existing DH network is constructed underground (in concrete intransitive ducts) with the use of outdated technology based on on-site assembly works. Steel pipelines with anti-corrosive paint, fibrous material insulation, and asbestos-cement casing were in the past usually laid down on a concrete base covered by precast concrete shells.

A small proportion of DH networks were constructed above ground usually on low pillars. In un-modernised systems, 150°C in the primary and 70°C in the return line was common. Obsolete fittings and accessories with low reliability and tightness caused excessive water loss and high maintenance costs. Heat losses in the old DH networks are also relatively high, because thermal insulation of the pipes is often damaged or wet.

Nowadays modern technology is in use with pre-insulated pipes with plastic pipe cover and polyurethane thermal insulation. Water in pre-insulated pipes should not exceed 130°C (for a short time even up to 135°C). Plastic pre-insulated pipes are also available as a low-cost alternative for low-temperature networks (water temperatures up to 95°C). Pre-insulated pipes can be laid down directly into the ground (without ducts) or over ground. The modern technology of network construction is implemented together with modern fittings and accessories with high reliability and tightness.

Improvement of heat supply efficiency to the substations should be the main aim of effective heat transmission management.

Reduction of heat losses and heat carrier losses from DH pipelines is one of the most effective ways of improving heat supply efficiency.

Optimisation of water temperature in DH networks enables heat losses to be reduced.

Installation of pre-insulated pipes reduces heat losses and water losses in DH networks.

ORGANISATIONAL AND TECHNICAL ASPECTS OF DH SYSTEM MANAGEMENT

The high cost of DH network construction and the relatively low cost of heat transmission (compared with heat generation costs) means there is a long pay back period on investments connected with development and modernisation of the DH network. Thus the plan of DH network development and modernisation should be based on a long-term economic and financial analysis. The replacement of existing pipelines should be planned for several years, depending on the economic condition and financial situation of the DH Company. Particularly where funds are limited, modernisation of the pipe network should initially be confined to the worst 10% or so of the network.

An important aim of heat transmission management is the improvement of heat supply reliability in existing DH networks. The most effective ways to improve heat supply reliability are likely to involve dealing with corrosion problems in steel pipes and possible redundancy in the DH system. Steel pipe corrosion is one of the main causes of DH network damage, interruption in heat supply, high water loss and rapid pressure drop in the network.

Improving water quality and installing pre-insulated pipes are the best ways to avoid pipe corrosion.

Spare heat supply capacity is necessary both in case of a heat source breakdown and in case of damage to a section of the DH network. Reliability of heat supply depends on the DH network configuration and the possibility of heat supply from different heat sources. Reliability of heat supply is much higher in densely looped 'ring-shape' DH networks supplied from different heat sources. Heat supply can be guaranteed from a lower level of spare heat capacity owing to the possibility of water flow in each direction from different heat sources.

The principal management issue governing heat distribution according to customers' heat demands is the proper division of heat transported through DH network to substations.

Key elements in the DH system are the substations, in which a heat exchange takes place between water circulating in DH network and water flowing in space heating and domestic hot water systems of the buildings.

The 'hydraulic regulation' of the DH network is based on complex calculations to ensure adequate water flow rate for each substation. This regulation has usually been managed through a 'regulating orifice' (a diaphragm limiting the maximum water flow) installed at the connection point. In modern systems, it is more common to use limiting valves.

Buildings are connected to the network via different types of substations, which in general can be divided into the **single-function substations** (usually only space heating) and **multifunctional substations** (usually space heating and domestic warm water, but in some industrial and public facilities also ventilation and technological needs). Moreover, heat substations can be divided into **individual substations** (supplying a single building) and **group substations** (supplying more than one building).

In generation-driven DH Systems, which have constant water flow, heat supply to substations is usually regulated through changes of water temperature supplied from the heat source (so called quality regulation).

Improvement of the building's thermal insulation, installation of automatic heat supply control at the substations (weather controller and domestic hot water regulator), provision of heat meters and limiting valves have all to be considered when dealing with hydraulic regulation. Some customers are also installing Thermostatic Radiator Valves (TRVs), perhaps with individual cost allocators at the radiators and water meters at warm water cocks. This allows individual settlement with flat users based on specialised computer programmes.

Implementation of automatic control of heat supply to buildings causes variable water flow rate and changes of pressure in the DH network. The generation-driven mode of DH system operation is not able to deliver rational energy use both on supplying and receiving side.

In demand driven systems customers are able to regulate heat use according to individual need and be invoiced according to the amount of heat delivered to the substations.

Implementation of the demand-driven mode with variable water flow rate is a basic condition for efficient operation of the DH system.

The demand-driven mode of DH system operation (so called quality-quantity regulation of heat supply) can be introduced following modernisation of demand and supply side. The quality-quantity regulation is based on temperature regulation of water supplied from heat source to network, depending on weather conditions, and automatic control of flow rate (regulated in substations according to customer needs). The water flow rate is usually regulated through variable speed pumps, which are installed at heat sources and if necessary also in pumping stations located in different sections of the DH network. Installation of variable speed pumps brings a substantial reduction of electricity consumption and heat supply costs.

Implementation of the demand-driven mode should also involve installation of heat meters in substations. In some CEE countries there is an obligation to install heat meters in new buildings now being connected. This obligation extends to existing connected buildings when internal systems are modernised. Other existing buildings should also be gradually equipped with heat meters. This process usually takes several years; afterwards, customers can be billed on the basis of heat meter readings.

Demand-side measures are important because heat losses in older buildings in CEE countries are typically about 2 times higher than in EU countries with similar climatic conditions. During the last dozen or so years thermal protection requirements for buildings have been tightened both in CEE and EU countries and the difference is smaller.

Remote control and automatic dispatching can be very useful for optimising heat supply cost and ensuring reliable heat delivery to customers.

ORGANISATIONAL AND TECHNICAL ASPECTS OF DH SYSTEM MANAGEMENT

The financial viability of DH systems depends very much on a balance between costs of system operation, development and modernisation and sales revenues. The revenues are a function of heat sale and price as well as collection rate. The costs depend on various factors, which are often independent of DH system management (eg taxes, regulated fuel and energy prices).

The cost of DH system development and modernisation depends on investment cost, which is a function of scale and type of modernisation. Investment in heat sources depends on size (economy of scale) and type of plant, and is usually higher for solid fuel fired plants and lower in plants using gaseous and liquid fuels. Investment in DH networks also depends on the scope - usually the most profitable investments involve installation of automatic control both in heat sources and DH networks. Where there is not a radical improvement in efficiency, boiler and pipeline replacement involve long payback periods.

Operation and maintenance costs depend on:

- operational mode of the DH system
- size, type and technical condition of the heat sources
- size of network, distance of heat transmission, heat and water losses.

Total cost of fuel use is usually the most significant element of operational cost, in some cases amounting to 70% of the total cost of heat supply.

Labour cost depends on the size of the DH system (economy of scale), and types of heat source. Installation of automatic control of heat supply in heat sources and substations usually brings reduction of staff quantity, but maintenance of control devices needs highly qualified personnel. This is particularly the case for automatic control of combustion processes and heat supply in solid fuel fired heat sources. Heat sources using gaseous and liquid fuels can be operated even without permanent maintenance staff, but periodic service of boilers and other equipment needs high-qualified specialists. Modern, fully automated substations, can also be operated without permanent maintenance staff. Employment of highly qualified specialists is usually less cost-effective (sometimes even impossible) than establishing a contract with specialised service companies.

Maintenance costs depend mainly on size and operation cycle of heating plant and the types of fuel used, and DH network size and heat transmission distance. There are also local circumstances, eg a dirty environment increases maintenance costs. Solid fuel fired heat sources require more maintenance than liquid and gas fired ones. Frequent starting up and closing down increases thermal stress of equipment and increase maintenance needs and costs.

Other costs such as laws defining taxes and depreciation over which the DH Company has no influence. Insurance is new to CEE countries and can be added to the operational costs. Insurance may cover anything from equipment damage to loss of income, each with very different insurance costs.

5. ECONOMIC ASPECTS OF DH SYSTEM MANAGEMENT

The heat supply cost should be divided into fixed and variable costs.

The fixed costs are independent of operation time, heat generation and sale.

The variable costs depend on DH system operation time, heat generation and sale.

Implementation of a unified system of cost recording should help to set proper fixed and variable costs.

Comparison between particular DH systems is also possible.

Sometimes reducing the initial investment for modernisation may lead to higher operation and maintenance costs, worsening the total economy of the DH system and profitability of the investments. Thus analysis of the cost-effectiveness of modernisation should include all aspects.

It is very important to ensure heat supply costs are covered by customer payments. Collection rate should be monitored and there should be an effective procedure for customer payment.

5.1. Optimisation of heat generation, transmission and distribution costs

Heat supply costs include the costs of heat generation, transmission and distribution and its optimisation is relatively simple in a DH system with a radial network supplied from one heat source. Calculations are more complex to optimise heat supply costs when the DH network is looped.

The most difficult component of heat supply cost optimisation is the heat generation cost, which depends on fuel price and other variable factors. Optimisation of heat transmission and distribution costs is not so complicated, because fixed costs constitute most or all costs of heat delivery to the customers. Optimisation of heat generation costs should be performed according to the main principle that the unit generating cheapest heat should be operated as long time as possible and more costly heat should be generated only to cover peak loads.

Optimising heat generation costs is a complex task, especially for large DH systems supplied from different heat sources, because heat generation costs depend on many factors:

- changes of heat load during days and weeks in heating season, summer time and transitional periods (spring, autumn) as well as duration of basic and peak loads
- relation of different fuel prices
- taxes and environmental charges
- relation of heat prices generated in different heat sources, including industrial waste heat; and factors specific to CHP
- power to heat ratio, which depends on type and actual loading of the CHP plants
- price of electricity depending on the time of sales.

In the case of obligatory purchase of heat generated from renewable fuels, optimising the heat generation cost can be more complicated, because the heat price from renewable heat sources can be higher than from the ‘cheapest’ heat source using other fuels. In future, emissions trade and green certificates value should be also taken into consideration in heat generation cost optimisation.

The optimal heat generation costs should be calculated according to the least costs principle, taking into account all factors which influence heat generation costs.

Heat transmission and distribution costs depend on the total cost of network operation and maintenance including the cost of heat and water losses from the network transporting heat to the customers. These costs usually depend on the scope of services offered by the DH Company for different customers. The costs of heat transmission and distribution are lower for customers operating their own substations and higher for those who are operating only the internal systems in buildings. Differentiation of heat transmission and distribution costs also depends on local circumstances (ownership and organisation of heat supply) and should be reflected in heat tariffs.

Heat supply cost can be reduced by means of: automatic dispatching and remote control; automatic control of heat supply from heat sources to network, and from network to substations (customers).

When analysing total heat supply costs in a DH system some comparisons (benchmarking) should be made with heat supply costs in other similar DH companies. Comparisons should also be made with alternatives from competing energy suppliers (eg individual gas heaters or boilers).

5.2. Seasonal changes of heat sale – income and costs balancing

The heat load of a DH system depends mainly on weather conditions and customer needs. Variations of outside temperature and other atmospheric conditions (wind, solar heat, and humidity) cause substantial changes of heat load during the heating season; during the summer changes of domestic hot water consumption causes variations of heat load.

Peak load in the winter is usually much higher than during the summer, especially in municipal DH systems supplying heat to households and public buildings for heating and domestic hot water purposes. It can happen that heat is supplied to customers only during a heating season, because buildings are not equipped with domestic hot water installations (gas or electric water heaters are in use), but usually the summer peak load amounts to about 10-15 % of winter peak load.

The difference between winter and summer peak loads is not so large in DH systems supplying heat to factories, but in these systems seasonal changes of heat load are still visible.

Variations of peak load cause changes of amount of heat generated and a substantial difference between heat sale and income in months of heating season and in summer months.

It is common for DH systems to experience a difficult financial situation during the summer. This is due to seasonal changes of heat sale: in summer months income is usually very low - or even zero if heat is supplied for heating needs only and a ‘one-part’ tariff (heat price only) is in use. Simultaneously maintenance works and repairs are usually carried out during the summer, when the heat load is low (or zero) and the greater part of equipment (or whole DH system) is not in use. Also, fuel is often purchased and stored in summer when fuel is cheaper (seasonal price reductions) to decrease heat generation costs and total heat supply costs.

If monthly income during summer time is not covering monthly expenses for maintenance, repairs, fuel purchase, and other fixed and variable costs, and there are no additional financial resources available, a short-term bank loan may be necessary. This causes an increase of heat supply costs, especially because short-term bank loans have quite high interest rates. To avoid unnecessary increases of heat supply costs a heat tariff structure should be analysed taking into account income and costs balancing during the year and summer time.

In Denmark for instance, DH companies estimate once a year the heat demand for each consumer. Based on this estimation and the tariff (fixed and variable part) the total costs for DH supplied to the consumer for the coming year is calculated. The total bill is split up in 10 equal parts (bills) and they are sent to the consumer. Once a month – except July and December – the consumer pays one of the bills. At the end of the heating season the meter is read and the final bill based on the actual DH consumption is calculated. If the estimated payment is higher than the bill based on the actual consumption, the consumer will get money back. If the opposite is the situation, the consumer will get a new 'equalize bill'.

The seasonal character of heat sales affects the financial situation of the DH Companies.

The main management problem concerns income and cost balancing. The costs and income should be balanced on the basis of both the whole year and the summer months when income is several times lower and fixed costs are usually higher.

Increasing the collection rate is very important for monthly cost and income balancing.

In some CEE countries legislative framework and administrative procedures for customer payment exist, together with action against non-paying customers and social support for poor families (eg in Poland).

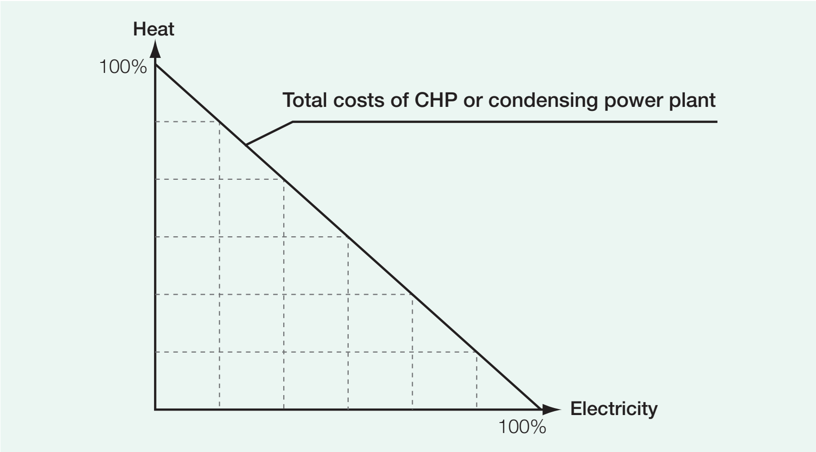
5.3 Combined heat and power generation

Combined heat and power generation is possible in CHP plants with different type of cogeneration units and in condensing power plants selling heat to DH networks.

The heat supplied to a DH network depends on the customers' heat demands. For CHP plant, power generation is a function of heat generation in cogeneration units. The heat load of condensing power plant and the amount of heat supplied to a DH network are also functions of customer heat demand. However, power generation in condensing power plant is lower because part of the steam is not used for electricity generation but is extracted from turbine for heat generation.

The basic economic problem in cogeneration of heat and electricity is connected with price calculation of heat and electricity generated by the same equipment or plants. The cost allocation in CHP and power plants between heat and electricity is a complicated problem and various principles of heat and electricity price calculation are in use.

ECONOMIC ASPECTS OF DH SYSTEM MANAGEMENT



There are many different ways of electricity and heat cost allocation in CHP plant.

Selection of the proper allocation method shall follow the energy policy in a particular country as well as local circumstances and requirements of the energy market.

The general idea of heat price calculation in CHP plants should be based on the avoided costs method, comparing CHP plant total costs with total costs of separate generation of heat and electricity, using the same fuel.

The price of heat generated in condensing power plants should be calculated on the basis of the real cost of heat generation. This should include the cost of heat generating equipment, operation and maintenance (heat exchangers, circulating pumps) as well as value of 'lost' electricity (reduced amount of sold electricity in comparison with condensing cycle) calculated according to an average price of electricity generated in that power plant.

The principal idea of the total cost allocation is shown in the graph above.

The graph demonstrates the problem of the total costs allocation and possible solutions in fact concerns shifting costs from one side to the other while keeping the total costs constant. Theoretically it could be assumed that when the market price of electricity is high, the income from its sale would cover the total costs of heat and electricity generation, and heat could be treated as a waste product, which costs 'nothing'. In practice there is a rule that an increase of electricity price is resulting in the decrease of heat price and vice-versa (at constant total costs).

The price of electricity generated in CHP plant should be competitive with the price of electricity available in the same locality from a power grid with the same voltage.

The total cost allocation to electricity and heat creates the basis for heat and electricity price calculation. This is connected with pricing policy and decision making about the transfer of benefit resulting from combined heat and electricity generation to the CHP plant and DH network. The share of the benefit should be flexible, depending on the economic situation for the CHP plant and DH network. If investments are concentrated on CHP plant development or modernisation a greater part of the benefit should be transferred to the CHP plant. If investment is mainly for DH network development and modernisation, almost the whole benefit should be transferred to the DH network. Sometimes it may be possible to help finance small-scale CHP plants using the benefit from combined heat and electricity generation in existing CHP plants together with other available financial resources.

5.4 Pricing policy of DH Company

Customer payments for heat delivery were calculated in the past not on the basis of measured heat consumption, but as a 'lump sum' (per m^2 or per person). Recently a great effort (financial and organisational) has been made in CEE countries to equip substations with heat meters.

The pricing policy of DH Companies usually depends on the general pricing policy of a particular country, but there are some common rules and principles for setting heat tariffs and settling customers accounts which should be helpful in improving management of DH systems.

One of the main issues for pricing policy is optimisation of heat supply costs owing to development of combined heat and power generation and economic load division between heat sources supplying common DH network.

Optimisation of heat supply costs is important for pricing policy in DH systems supplied from different heat sources as well as in cases when many different DH networks and heat sources are operated in the same town (municipality).

In a common DH network that is supplied from different heat sources, the average heat price should be calculated according to the share of heat supply from each plant. It should be connected with optimisation of heat supply costs through economic load division between different heat sources. However, the heat price can be differentiated for various customer groups according to the extent of transmission services (substation operation or not). Differentiation of heat price is also possible for 'large' and 'small' customers depending on the size of heat demand (economy of scale).

Calculation of the average heat price for various customer groups supplied from different DH networks and heat sources operated by one DH Company leads to situation in which customers supplied from a 'cheaper' DH system subsidise customers supplied from a 'more expensive' DH system in the same town (municipality).

Pricing policy should in principle be based on the cost of heat supply and elimination of cross-subsidising between different customer groups.

An additional management problem arises in the case when a DH Company operates a common network and purchases heat from one or more heat sources owned by different companies. In that case co-operation between heat source and DH network owners is needed. This is necessary to avoid unsynchronised changes of heat price resulting in repeating changes of average heat price during a year. The best solution in that situation would be the introduction of new (changed) prices at the same time by all companies.

Co-operation between heat producers and distributors is important in DH system operation and pricing policy as well as marketing and planning of DH system development and modernisation. The benefit of co-operation between heat producer and distributor is heat supply cost optimisation.

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Benefits can be achieved from common marketing activity and co-financing of necessary investments which increase heat sales. Such investments could be elimination or replacement of HOB plants by modern ones or small-scale CHP plant, and connection of new customers to the DH network Profitability of DH network development and operation depends strongly on heat demand density.

The main factors influencing a potential new customer's interest in connection to a DH network are usually heat price and connection fee. Other arguments may also convince a customer about the advantages of DH systems: clean air and environment, link between heat use and customer payment (reduction of charges owing to rationalisation of heat use by customers). Some DH Companies (eg in Poland) abandon or reduce the connection fee to a symbolic payment because new customers mean a long-term extra heat sale. This usually stimulates more customers to join and is in the long-term usually profitable for the DH Company.

Similar arguments should be used to reconnect former (lost) customers or connect new customers (currently using individual heating systems) to the DH network. In the case of customers operating a local HOB or other heating system it can sometimes be profitable for the DH Company to invest in a substation and even the internal system in the building. This mainly concerns larger buildings with relatively high heat demands.

However the most important element of DH Company pricing policy is a proper heat tariff system The heat tariff should satisfy the conditions in the table (left).

Condition	Description
Full cost coverage	The tariff should be based on justified costs and reasonable profit
Cost structure reflective	The tariff should cover fixed and variable costs in summer time and during the heating season, taking into account taxes and obligatory fees
Competitiveness	The tariff should offer a competitive option of heat supply to customers who are profitable for the DH Company
Simplicity	The tariff should be easily understood by customers who are not familiar with heat supply business and technology
Incentive to cost reduction	The competition or independent 'Regulator' should stipulate that DH Companies rationalise their operation and optimise heat supply costs
Incentive to conserve energy	The tariff should be an incentive to reduce required water pressure, supply and return temperatures and water flow, saving energy and raising heat supply efficiency

The tariff components should be based on real cost structure and justified changes of elementary costs in comparison with historical costs. The tariff should be transparent and simple to administrate. A tariff structure where fixed costs are reflected in the fixed part of the tariff and variable costs are reflected in the variable part of the tariff will minimize the cash-flow problems for the DH companies.

Implementation of the new heat tariff system should be accompanied by a broad campaign informing customers about the principles of tariff setting and the new billing system. Customers should understand not only the principles of settlements for delivered heat but also know their responsibilities and how they can influence their heat bill and its particular elements.

In some cases it can be difficult to simultaneously meet all these (above) criteria and the DH Company should select any priorities for heat tariff design according to local circumstances.

In a market-based economy the heat tariff should be based on the measurement of heat delivered to the substation. The new heat tariff based on metered heat consumption (sales) should not be implemented until all customers are equipped with heat meters and real data is available about heat sales and losses in the DH network.

Heat and water losses in DH networks are usually a very important factor influencing heat transmission costs and heat price: if the new 'metered' tariff were to be introduced before real data collection and analysis, the heat price would be calculated on estimated rather than real data (estimated heat losses are usually lower than real ones). It could cause financial loss for the DH Company, because heat customers would be motivated to save energy resulting in lower heat sales and the lower income may not be sufficient to cover the total cost of heat supply.

Heat tariff design is much more than a simple calculation of heat price based on planned heat supply costs and planned heat sales. The heat tariff should balance supplier and customer interests and eliminate cross subsidising.

An optimal heat tariff system should mean justified costs of heat supply are covered by customer payments calculated according to real heat use and should protect customers against unjustified payments.

The tariff should cover fixed and variable costs during summer time and the heating season.

The seasonal character of heat supply means that heat tariffs should have at least two components reflecting the cost structure and financial situation of the DH Company during the heating season and summer time. The tariff should also provide motivation for the customer to conserve energy. This is possible by means of a so-called two-part tariff, which has two components:

1 The **fixed charge** covering the cost of capital, permanent staff, taxes and part of maintenance, should be calculated according to maximum heat demand (eg ordered water flow, volume of building).
2 The **variable charge** covering the cost of fuel, water, electricity and heat purchase, and the remaining part of the maintenance cost, should be calculated according to the measured amount of heat delivered to the substation supplying the customer's building.

ECONOMIC ASPECTS OF DH SYSTEM MANAGEMENT

The charge calculation should include a fair profit for the DH Company allowing for long- term planning development and modernisation of the DH system.

By contrast, a one-part tariff, which is sometimes preferred for its simplicity, can cause financial instability of the DH Company during the summer time and in the event of heat demand decreasing following DSM measures in customers' buildings.

The pricing policy of DH Companies in CEE countries is usually supervised by an 'independent regulator' (government or municipal body), which is responsible for proper balancing of the different interests of the heat source and network operators (owners) and the heat customers. The main principles of heat tariff setting are usually defined in legal acts but the regulator often sets out guidelines and instructions for tariff design and adjustment. The regulator has the right to approve or disapprove the tariffs designed by the DH Company.

Pricing policy should be supported by social policy to reduce amount of unpaid heat bills and increase collection rate in DH systems.

6. TOOLS FOR IMPROVEMENT OF DH SYSTEM MANAGEMENT

There are several tools which can assist DH system management. Benchmarking tools enable a DH Company to compare technical and economic parameters with those of other (similar) companies. Comparison of data collected in an integrated computer system gives information about the basic differences between compared DH companies and enables exchange of experiences and best practice. Implementation of the benchmarking system needs co-operation between DH companies and coordination by the DH association (or other organisation) both in individual countries and in other interested EU and CEE countries.

For strategic (long-term) planning it could be helpful to use modern tools:

- electronic (computer) mapping of DH systems based on city mapping, including heat density mapping, areas supplied by DH system, planned development of DH networks and connection of new customers,
- computer calculating programmes for optimisation of scope and timetable of various parts of DH system modernisation and development,
- computer – calculating programmes for heat tariff setting.

Computerisation of the DH Company is very useful for optimisation of DH system operation. The integrated computer system together with complex calculating programmes is able to support different departments' work and assure proper exchange of data and information inside the company. It enables management to continuously supervise the financial status of the DH Company, and includes investment costs planning, bookkeeping and recording of costs for each element of the DH system and each customer group.

Computerisation is a useful tool for evaluating the economic effect of the different scope of investments in heat sources and DH networks. It is also a convenient tool for a permanent supervision of DH system operation including measurements of heat carrier parameters, remote control etc.

When these systems are implemented it is also necessary to establish an ongoing training programme both for the DH Company's staff and managers.

This guide was written by Witold Cherubin, Polish National Energy Conservation Agency (KAPE), with review carried out by the DHCAN project team (see page 2).

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