GUIDE

MODERNIZATION

OF DISTRICT HEATING SYSTEMS

BASED ON SMALL/MEDIUM CHP
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GUIDELINES

FOR MODERNISATION OF
DISTRICT HEATING SYSTEMS
BASED ON SMALL/MEDIUM CHP

2004
NOTE

The term cogeneration expresses synthetically the technological process of combined production of heat and power for industrial or domestic use, and is common to technical literature in EU countries. Over the past years it became popular by being referred to in the media in relation to energy issues frequently.

This Guide endeavours to identify the present problems of cogeneration and DH in the context of energy markets evolution in Romania and some European countries. On the other hand, we had in view the social dimension of present DH problems in Romania, and we issued new approaches.

The case studies depicted in the relevant chapter have been carefully selected to illustrate recent evolutions, or show a high potential of applicability to Romania.

Elaboration of the PP-EE by municipalities according to Law 199/2000 will be the opportunity to identify and compare the options for rehabilitation of local DH systems. For that reason the second part of this Guide aims to be a synthesis of both the authors’ experience and available studies concerning the assessment of DH systems and the specific technical, financial or managerial parameters used to fundament local strategies. At the final, a questionnaire has been proposed to support the formulation of the specific goals of municipal energy efficiency policies.

It is not our intention to present cogeneration as a miraculous solution, but to convince people of the high potential of efficiency of the cogeneration systems as sources within district heating and as a basis for sustainable development of local communities. Only the feasibility study can correlate the specific technical solutions with financing aspects and be the basis for elaboration of a development strategy for the local energy system.

LIST OF TERMS AND ABBREVIATIONS

<table>
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<th>Term</th>
<th>Definition</th>
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<td>Cogeneration</td>
<td>Combined production of heat and power (thermal and electric energy) (also called CHP) in a complex, but unitary installation, which can shift priority of operation based on heat, respectively power demand.</td>
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<tr>
<td>DH</td>
<td>District heating</td>
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<tr>
<td>Sustainable development</td>
<td>Strategy through which communities aim economic development for satisfying the needs of today without jeopardizing the capacity of next generations to satisfy theirs. Within this frame, communities utilize any resources efficiently, develop efficient infrastructures, protect and improve the quality of life and develop prosperity-generating economic activities.</td>
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<tr>
<td>National Reference Price</td>
<td>The regulated and subsidized heat tariff that people connected to DH must pay for supply of heat to dwellings.</td>
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<td>PP-EE</td>
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I. GENERAL ASPECTS

1.1. Scope of guide

This Guide is intended to assist the decision-makers involved in administrating, operating or in formulating the strategies for DH evolution, in the recently approved legislative framework. Arguments will be shown for promoting small/medium scale combined heat and power generation for urban DH systems.

The owners and managers of public buildings or condominium dwellings can find herein elements to increase awareness and support educated decision-making.

Although this is not a detailed manual for implementation of cogeneration in DH, we hope to contribute to the understanding of present situation, of the prospective and necessity to propose a medium/long term vision for this sector.

1.2. The specific legislative framework in Romania and EU

1.2.1. The romanian Government Ordinance OG 73/2002

The Government Ordinance OG 73/2002 defines the legal framework for establishing, organising, managing, regulating, financing, monitoring and controlling the operation of DH public services in villages, towns and cities. [1]

This Ordinance stipulates that public DH systems, defined as local interest energy services, are ruled, coordinated and controlled by the authorities of local public administration, who must diagnose the present status and formulate an evolution strategy in consensus with the principles of sustainable development of local community.

The activity of DH services is regulated by ANRSC (Romanian Municipal Public Utilities Regulatory Authority). In case the operator of the source has cogeneration equipment, its activity is regulated by ANRE (Romanian Energy Regulatory Authority).

Presentation

Below are the provisions of the Government Ordinance OG 73/2002 [1] which are relevant for our guide.

The principles that must rule the activity of local interest energy services are:

♦ Local autonomy
♦ Decentralisation of public services
♦ Responsibilities towards customers
♦ Ensuring quality and continuity of services
♦ Efficient management of public or private assets
♦ Ensuring energy efficiency
♦ Ensuring competitive environment
♦ Promoting inter-town association
♦ Promoting public-private partnership
♦ Correlating demand with resources
♦ Preserving environment and sustainable development
♦ Free access to information about public services
♦ Participation and consultation of customers

Local energy services are managed and directed through local operators licensed by ANRSC or ANRE, according to the law.

The way the local energy services are organised and operate must be focussed on:

♦ Ensuring competition
♦ Improving energy efficiency
♦ Ensuring transparency of prices and tariffs for thermal energy
♦ Stimulating the involvement of private sector
♦ Meeting local and global environmental objectives

The local public authorities can manage this activity directly, indirectly or can delegate it. The public authorities keep the
prerogatives to adopt policies and strategies for development of services and programs for development of local interest energy systems, as well as to monitor, control and supervise these activities.

The approval of local strategy for development of local interest energy services, of the regulations for their organisation and operation, of criteria and procedures to control is a prerogative of local councils exclusively, county councils or General Council of Bucharest City, as appropriate.

**Comments**

Government Ordinance OG 73/2003 gives local authorities full responsibility to ensure DH services.

The principles that must govern this activity, listed in the Ordinance, define the objectives of rehabilitation/development strategy and the operation of these systems. These principles are generous, promoting sustainable development, environment protection, resource management. Inter-municipal association and public-private partnership are recommended. These principles are implemented in the description of organisation and operation of these services.

**The Ordinance does not promote explicitly heat production in cogeneration.** However, the Ordinance offers enough support for arguments to promote cogeneration. For example, it stipulates the necessity that the DH system meets the local and national environmental protection objectives. One of these objectives will be the limitation of greenhouse gas emissions, which is the main advantage of cogeneration as opposed to separate generation of heat and power.

It is also important that the Ordinance promotes the stimulation of private sector participation and inter-town association. These can contribute to the diversification of financing sources for the rehabilitation/development of these systems.

This governmental ordinance does not promote or recommend

**1.2.2. EU Directive 2004/8/EC regarding promotion of cogeneration based on useful heat demand**

The main argument in favour of cogeneration is reduction of primary fuel use and consequently of greenhouse gas emissions – strategic direction for EU energy and environment policy. Promoting cogeneration is one way for EU countries to meet the objectives assumed through the Kyoto Protocol.

Romania also signed the Kyoto Protocol on climate change.

We consider this strategic direction must be adopted by our country as well, given the present context when heat and power generation systems need upgrade which involves massive investments. Romania must take advantage of this situation for promoting solutions not only for solving the problems on a short-term basis, but to ensure the **sustainable development of energy systems.**

**Presentation**

The objective of EU Directive 2004/8/EC is promotion of cogeneration based on heat demand and on primary fuel savings in EU countries.

It defines cogeneration in agreement with other specific EU regulations, it establishes the framework and the means for offering guarantee of origin for electricity produced in cogeneration and asks member countries to ensure objective, transparent and non discriminatory procedures for: (a) access to the electricity grid; (b) tariff structure; (c) administration.

The member states shall identify by February 2006 all potential for useful heating/cooling demands suitable for application of high efficiency cogeneration (including micro-cogeneration under 50 kWt) and analyse the barriers which may prevent realization of this potential.
Specified barriers include price/cost of access to fuels, grid issues, administrative procedures and lack of internalization of external costs of energy. Every four years the states shall evaluate the progress towards increasing the share of high efficiency cogeneration and the action taken for its promotion.

The directive establishes calculation procedures for:

(a) the primary energy savings by cogeneration (related to the environmental impact);

(b) the quantity of electricity from cogeneration (related to the guarantee of origin of electricity from high-efficiency cogeneration).

The Directive does not intend to level the electricity share produced in cogeneration in member countries, but to promote CHP in all cases where potential for energy saving and CO2 emissions reduction is identified and where it is economically justified. There is no individual target for member countries specified.

Comments

As emission reduction is the major argument in cogeneration promotion, financial mechanisms were created and are in force for co-financing cogeneration projects in Europe (see Chapter 5.2 item 8). These mechanisms are based on the evaluation of costs to be paid by the society for fighting the environmental impact of emissions. The Directive identifies the lack of internalization of the environmental costs in energy price as a barrier to cogeneration progress, indirectly admitting that we are in a transition period to the moment when external costs of energy production are internalised, that is, included in the selling price of energy.

At that moment (which is not specified), the advantages of CHP over conventional technologies will be valued under market conditions. Until then, CHP is subject to the evolutions on the energy market as it looks nowadays.

The Directive does not contain additional obligations to those established at Kyoto for EU countries or candidate countries. It is difficult to estimate the impact of the Directive on cogeneration evolution on short term, but we see this as one step forward to the future of this technical solution.

1.2.3. Romanian Law 199/2000 regarding energy efficiency

In 1998, Romania signed the Energy Chart Treaty, which stipulates at art. 8 that the parties shall implement programs for increasing energy efficiency, including also – as a recommendation – "supporting and promoting cogeneration and actions for increasing energy efficiency in DH systems".

In this context, Law 199/2000 republished in 2002 [2] establishes the obligation for companies with annual energy consumption greater than 1000 TEP as well as for local authorities of towns with population over 20,000 to set an Energy Efficiency Master Plan (MEEMP). This must include actions for reduction of energy consumption for heating and air conditioning, lighting, transportation and economic activities. These Plans address the entire energy flow: production – transport – distribution – consumption and shall include actions for:

- promotion of small/medium scale CHP and necessary measures for increasing the efficiency of heat production, transport and distribution systems (art. 6, paragraph “f”)

- evaluation of negative environmental impact (art. 6, paragraph “h”)

New constructions or rehabilitation of existing buildings will be approved only if the projects meet the applicable energy efficiency standards (art. 12)

The legislation stipulates some fiscal incentives for people who invest in thermal rehabilitation of buildings – tax exemption for design approval and for issue of
building energy certificate, deduction of up to 200 EUR/tax payer from annual income tax for 2004.

This law establishes Romanian Energy Efficiency Fund, which has already co-financed some DH modernisation projects.

ARCE is the national autonomous authority responsible for elaborating (along with Ministry of Industry and Resources) and implementing the national energy efficiency policy. ARCE is currently finalising its own internal procedures

1.3. Medium term energy strategy of Romania (2003-2015)

The Road Map in energy field in Romania [3] is the basis for “Energy” chapter negotiation in Romania’s accession to EU and stipulates the strategic directions of Government’s energy policy and evolution steps of production, consumption and specific market regulations for 2003 – 2015, based on several probable scenarios.

Wholesale electricity market is structured in two components:
- competitive market
- regulated market

In the regulated market, the transactions with electricity are done based on regulated contracts (with regulated prices and limited quantities). The contracts for electricity produced in cogeneration are also regulated contracts.

A total opening of the market is foreseen starting in 2007. From that moment on the regulated prices will apply only to the customers which prefer regulated tariffs. Natural gas market will have a similar evolution and will be totally open by 2007.

An important component of energy sector restructuring is regulating of non-discriminatory access of third parties to the electricity transport system as well as to the natural gas network.

In 2003-2004, ANRE will maintain the existing obligation for the grid operator “Electrica” to purchase the electricity produced in cogeneration, according to the heat supplied to DH systems (residential customers), at regulated prices. ANRE is due to establish the mechanisms for internalisation of external costs for environment protection.

The residential customers will pay thermal energy at a national reference price which will be permanently adjusted to the fuel price. The local authorities will perform studies for the optimisation of heating alternatives in communities. Direct financial support for low-income residential customers will be maintained.

In 2005-2007 ANRE will reduce gradually the electricity production/distribution companies’ obligation of taking electricity produced in cogeneration plants, based upon the results of studies and programs of rehabilitation, modernisation and investments in heat supplying systems to residential customers. Appropriate mechanism resulting from the EU Directive for promotion of cogeneration will be implemented.

During this period the residential heat consumers will continue to pay a national reference tariff, but the necessity of maintaining this tariff will be periodically revised. Obligation for the grid to purchase electricity produced in cogeneration through specific mechanisms will act.

Low-income residential customers will receive direct subsidies.

In 2008-2015 ANRE will reduce gradually the electricity production/distribution operators’ obligation to purchase electricity produced in cogeneration plants, based on the results of studies and programs of rehabilitation, modernisation and investment in heat supplying systems to residential customers. Measures resulting from EU Directive on promotion of cogeneration will be implemented.

Until a decision upon continuation of national reference tariff will be made, the heat invoice will show costs with thermal energy, established by prices regulated by the relevant Authority, based on the principle of justified marginal costs.
Low-income residential customers will receive direct subsidies.

**Comments**

Promotion of cogeneration is specified only in [5], with no concrete effects. The new strategy Road Map [3] does not contain reference to cogeneration promotion except implementing provisions of EU Directive regarding cogeneration promotion.

The problem of supplying heat to residential customers shall be the local authorities’ competence exclusively. These will have to optimise heat supply solutions for local communities.

As the energy market opens, the obligation for the electricity distributors to buy electricity produced in cogeneration by plants supplying DH systems will address lower and lower amounts of electricity.

However, an important component supporting cogeneration promotion will be the mechanism for internalisation of external costs for environment protection, which must be issued by ANRE by 2008.

**1.4. National Strategy for Centralized Produced and Distributed Heat Supply of Localities**

The strategy—presented on June 1st 2004 was elaborated by the Romanian Government and aims modernisation of district heating systems in Romania, on a time span by 2017.

The tenants of dwellings connected to the DH system may choose to disconnect, meeting the requirements of Order 42-2004 of the Ministry of Economy and Commerce regarding boiler authorisation. All existing boilers below 70 kW must be authorised by December 1st 2004.

The following terms and objectives are established:

- June 30th 2006 – completion of metering for all connected buildings, financing provided by the DH operator
- June 30th 2007 – implementation of individual metering and cost allocation systems in all the connected apartments; individual contracting of DH services (on tenants’ expense, with 30% support from the Government)
- 2007 – Gradual elimination of subsidies directed to the heat producer and redirection of funds to the DH rehabilitation programs and low-income consumers support.
- “Introduction of small and medium CHP as an optimal solution for modernisation of DH systems and reduction of heating costs”.

2. DH SYSTEMS AND COGENERATION

2.1. Heating in Romania

Romania’s location in the temperate–continental climate zone with excessive influences, as well as the current level of civilisation lead to the fact that 40% of primary energy used in Romania is for heating of public buildings, individual dwellings and domestic hot water. This amount justifies the constant interest for the issue of heating in Romanian society.

By the end of the 19th century wood was nearly the only fuel used for heating in Romania. In 1938 wood was 26% of the heating fuels. Nowadays, heating is supplied using the entire range of fossil fuels, renewables (wood, wood waste, geothermal energy) and, to a smaller extent, nuclear energy and electricity.

The share of each heating alternative by number of dwellings is shown in Fig. 1 [10]

The design outdoor temperature for civil heating installations of buildings with permanent occupation ranges from -12°C on Black Sea Coast and far south-west to –21°C on large areas in eastern Transylvania and Northern Moldavia. The average heating season ranges 160 – 232 days/year, with 3000-5000 degree-days. The above data proves heating is a vital necessity in Romania, with a strong social impact.

The Government’s policy for heating endeavoured to ensure affordability for the population, providing various subsidies and direct financial aid (for social cases).

2.2. DH–The concept of local energy system

A district heating system is where thermal energy is supplied by a specialised installation, through a heating agent transported and distributed to several heat consumers.

From the prospective of the thermal energy production, the centralised/distributed controversy (specific rather to the electric energy market) turns into the centralised/individual controversy. For the zones with high occupancy density, such as dwellings in multi-story buildings, the issue has been settled a long time ago in favour of centralised production of heat, due to multiple and obvious advantages:

(a) provides a healthy, unpolluted climate in the dwelling zones, by locating the thermal plants near the city limits and erecting high enough chimneys for pollutant dispersion;
(b) avoids stocking and handling of fuels and combustion products in highly populated zones;
(c) makes possible the use of high thermal efficiency technologies (such as cogeneration), which are not competitively available at individual scale;
(d) makes possible the use of fuels otherwise unusable individually (such as municipal wastes, biomass etc.)
(e) makes possible the use of alternative fuels to fossil fuels: renewable resources available locally, municipal wastes, wood wastes, of which some cannot be utilised efficiently or cannot be used at all individually.

(f) avoids use of fuels and combustion systems by masses of people who do not have the relevant technical skills.

Given these circumstances, the question which the experts had to address was not if DH should be implemented, but to what extent it can be economically extended.

The main part of a DH system is the transport (sometimes including also distribution) network. This is the central element that can connect various thermal energy consumers with producers using different technologies and different resources (fossil fuels, locally available renewables, municipal wastes, wood wastes, heat pumps) which cannot be used efficiently or used at all separately. The positive environmental impact of using alternative resources instead of fossil fuels is very important.

Following technological advances, the name DH is about to become incomplete, because in EU there are already in operation DH networks that provide also Cooling for the summertime.

Compared to the individual heating alternative, the customer connected to a DH system inherently accepts some limitation of thermal comfort due to the system’s incapacity to operate economically under certain low loads. On the other hand, anywhere in the world the system cannot operate without some natural heat losses (which can be maintained economically below 6-8%) and heating agent losses (2-4%). Even so, everywhere in developed countries where market economy works, DH provides affordable heat and hot water at prices lower or equal than the individual heating alternatives, if applied carefully.

All the above make DH an important factor in implementing local energy policies for:

(a) ensuring energy supply security, using local resources as much as possible; (b) population’s access to affordable energy; (c) reducing environmental impact of energy production.

Governement’s Ordinance 73/2002 defines the Local Interest Energy System (which is the scope of Ordinance) as an infrastructure through which Local Interest Energy Services are ensured. These include all the actions and activities at local administrative level which are supervised, co-ordinated and controlled by local administration authorities in order to ensure DH for heat and hot water to dwellings, public buildings, social-cultural buildings and companies.

The components of local interest energy system which are connected through the common technological and functional process include:

- thermal and/or cogeneration plants as sources
- transport network of heating agent
- local thermal plants/heating substations
- substations
- distribution network
- auxiliary constructions and installations
- measuring/control/automation systems
- metering devices and connections at customer level

This Ordinance [1] identifies four types of activities related to the energy services: (a) energy production; (b) energy transport; (c) energy distribution; (d) energy supply. These activities are carried out by specialised companies (or operators), licensed in accordance with the law. At the two end of this chain of activities there are: the energy resource to be transformed into heat, and the customers (whose demands must be satisfied at economic and quality conditions stipulated contractually and meeting the principles of sustainable development).
2.3. Cogeneration principle

Cogeneration is simultaneous production of heat and electricity in a technological installation specifically meant for this purpose. Here are the two essential advantages coming from the experience accumulated so far and which differentiate cogeneration from classic solutions of heat and power production by combustion of fuels. These advantages will help us understand why so many efforts are involved globally for cogeneration promotion.

(a) **Primary fuel savings** Combined production of heat and electricity is considerably more efficient than producing same quantities of heat and electricity separately in classic thermal plants and power plants, respectively. In other words, for the same amounts of energies to end user, we may use with up to 32% less primary fuel if produced in cogeneration instead of classic plants, using same fuels.

(b) **Polluting Emissions Reduction**. Any reduction in primary fuel consumption leads to a reduction of polluting emissions accordingly. From here comes the idea that cogeneration development can be an important tool in meeting international programs for pollution and CO2 emissions reduction. Most countries assumed objectives of progressive reduction of CO2 emissions by 2012 through the Kyoto Protocol.

2.4. DH and cogeneration

Cogeneration is relatively widely extended in DH systems worldwide (for instance 70% in EU member states and 52% in EEC). Here are some reasons:

(a) DH has to compete with individual heating alternatives, while it has a handicap of up to 8% accepted losses in the transport network. This calls for high-efficiency of heat generation technologies. Cogeneration is one of them.

(b) In urban zones, thermal load coexists with electric load for domestic or industrial consumers – which

![Fig. 2  Cogeneration benefits](image)
cogeneration systems can cover locally. This avoids losses due to long-distance transport of electricity through the national grid to the consumption point. In other words, cogeneration goes hand-in-hand with the concept of distributed generation of electric energy. An important element requiring periodic analysis is the sizing of thermal load capacity of cogeneration equipment correlated with peak thermal load. This ratio is called coefficient of cogeneration.

Theoretically, a heating project reaches its maximum CO2 emissions reduction potential by sizing the cogeneration equipment to cover the entire thermal load. This way the entire heat supplied to the consumers is produced in cogeneration. But it is quite an economically inefficient approach because:

(a) electric energy is supplied variably, according the thermal load – a disadvantage for electricity grid, which must have the means to handle this variable mode of generation

(b) given the shape of average heating curve in Romania, this determines a 40-50% annual utilisation factor of maximum power – a major disadvantage for the project feasibility;

New cogeneration implementation in DH modernisation projects over the past years was rather an exception. This was because replacing old boilers with new ones and replacing/rehabilitation of distribution network (the minimal investment solution which currently ensures 30-50% savings in operating costs) was attractive enough under the specific economic conditions.

2.5. DH and Cogeneration in Europe

Today, cogeneration saves Europe around 350 million tones of carbon dioxide emission and reduces the dependence on primary energy sources by 1200 PJ per year. Cogeneration is thus an excellent energy supply option wherever feasible and this is why it has been identified as a key technical solution to improve European environment, by reducing the impact of global climate change and reducing local emissions, such as particulate matter, sulphur and nitrogen oxides. [9]

In comparison with 1999, DH production in most EU countries has grown. The largest increases were registered in Italy (7.4% per year), Austria (7.4% per year) and Sweden (6% in the last two years).

In CEE countries two specific aspects should be mentioned: while in relative terms the DH share in the residential market has remained as the same level as in 1999, DH production decreased significantly. This is partly due to energy savings on the demand side, particularly in the residential sector, but also - and mainly - to recent investments in network modernisation and to unfair competition with individual gas heating - where cross-subsidies between large and small customers and political interference in setting tariffs have affected the balance.

Particularly in Romania along with production decrease, a significant change has occurred in DH share from 31% in 1999 to 29% in 2002/2003 (and probably 25% in 2004). Switching of customers to individual heating lead to disconnection of 21% flats from a total of 2,700,000.

While the DH share in the residential heat market is generally higher in CEE countries, the proportion of CHP in DH production is lower than in EU countries (an average of 52% compared with 67%). The further development of DH schemes in combination with CHP in CEE countries could thus result in a significant improvement in energy efficiency, with higher energy savings and reduced carbon dioxide emissions.

The CHP/DH is generally recognized as an effective instrument to increase security of energy supply and improve the global environment.

In the EU, district heating prices remained relatively stable (in comparison with 1999) despite fluctuations in oil and gas prices. In CEE countries they increased, due to the
removal of subsidies, in view of adapting of the Acquis Communautaire. In most CEE countries DH prices are still significantly lower than in EU Member States (this is the case also for Romania), but in few CEE countries (Czech Republic, Hungary, Lithuania) they are approaching the same level.

The energy path would steadily move away from fossil fuels towards renewable energy sources over the coming decades, and would make greater use of natural gas during the transition. Greater emphasis shall be placed on decentralised energy sources including on-site cogeneration systems and small-scale renewable energy measures.

In most of EU countries a specific law for DH is not foreseen in the legislative framework (except in Denmark). District Heating is considered as a business function, driven mainly by market forces. However, CHP/DH fulfils tasks of general economic interest, mainly in relation to environmental policies.

Countries like the Netherlands and Sweden rely on fiscal/taxation incentives in order to promote CHP/DH, while Germany, Austria and Denmark provide support to efficient CHP schemes through legislation. Renewables are also promoted through both policy and regulatory/legislative measures.

As part of the accession process to the EU, most CEE countries have passed energy laws to create a general framework for the energy sector and to support market liberalisation and the introduction of competition in line with the EU Directives.

Some of the CEE countries have developed specific DH/heat legislation. For example, Hungary issued a DH law and Estonia is preparing one. In Croatia and Lithuania, DH aspects are addressed in heat laws. In the Czech Republic and Romania, DH/CHP is seen as part of energy conservation policy and a cost-effective tool for implementing energy efficiency measures. In Bulgaria, Hungary, Romania, Latvia and Slovakia, the DH sector is considered a public service and is regulated as such.

As a conclusion, we may consider that the main engines of cogeneration development in Europe are:

- Governments’ energy policies, which support the investment in cogeneration through legislative/financial measures;
- National targets to reduce CO2 emissions;
- Need for installation of new generation capacities following the increase of electricity demand;
- Trends in price evolution on energy market: when natural gas price drops and electricity price increases.

### 2.6. DH and cogeneration in Romania

Cogeneration has been developing in Romania in the 50s in industrial-only applications, in the context of the plan for increasing the national electricity production. Cogeneration for urban heating applications started in 1960 and developed after 1970 following the high increase pace of both electricity demand and construction of block-type, condominium dwellings. These ensure favourable economic conditions for DH installations through the high density of heat demand.

A typical application was the cogeneration unit with steam boiler and 50 MWe turbine with condensation in heat exchangers which produce heating agent (hot water) for DH. Optimisation studies performed in the 60s and the 70s estimated that sizing the cogeneration system at 45-60% of heating load is the solution that provides an acceptable load factor year-round so that equipment has a reasonable financial return period. The peak load is met with hot water boilers. At the end of the 70s the whole equipment of 50 MWe cogeneration unit was manufactured in Romania.

In winter 2003/2004, 188 municipalities in Romania, with a total number of 2.131.906 DH-connected apartments of the 2.700.000 originally connected by design, had the DH system ready for operation [10]. A number
of 26 municipalities operate cogeneration plants installed before 1989.

A 50% cogeneration factor, correlated with the average shape of annual heating curve in Romania, leads (theoretically) to a share of 80-85% of the heat supplied over a year that is produced in cogeneration - the rest of 15-20% should come from peak boilers. Actually, because of poor technical condition of cogeneration units and lower repair costs of peak boilers, the share of heat supplied by peak boilers is much higher today.

All recent small scale cogeneration for DH in Romania are pilot actions. The designed cogeneration factor is low (10% of the heat demand estimated at the beginning of project), which shows: (a) the will to reduce the problems related to the interface with the grid ("export" of electricity); (b) uncertainty concerning the heat demand evolution under present circumstances; (c) low feasibility of projects, which results in choice of minimal investment alternative. The replication capacity of these pilot projects was null.

DH has become a critical problem in Romania. DH systems' state of wear and outdating, lack of management and of financial resources for maintenance and modernisation, poor thermal insulation of existing buildings, transport and distribution loss and lack of metering result in high heating bills for population and suspicion about billed amounts.

There is estimated a 50-60% reduction potential of the current consumption.

Delay in starting programs for solving DH problem, the continuous degrading of services' quality and increasing of heating bills determined population's distrust in DH systems. Approximately 21% of district-heated apartments are presently disconnected.

About 70% of the disconnected chose individual heating with gas-fired boilers for block or apartment. This phenomenon is favoured where this fuel is available, while natural gas price in Romania is still very low.

International Monetary Fund country report for Romania – Nov. 2003 "Fourth Review Under the Stand-By Arrangement and Request for Waiver of Performance Criteria – Staff Report", appendix IV - "The Conundrum of Romania's district heating system", shows that the system is highly inefficient and expensive, owing to large technical losses and weak market incentives. Households do not have the possibility of regulating the quantity of heat they receive, as there is a lack of regulatory devices and meters. Subsidies to producers discourage actions for cost reduction and investments for improving efficiency. Heat losses of DH systems were the equivalent of 0.25% of GDP in 2002 as a result of weal collections, that is approximately 112 million Euro. Producer subsidies and means-tested transfers to low-income households were equivalent to 0.66% of GDP [29].

Stronger actions to improve financial discipline across the sector are needed. These include an acceleration of metering and firmer measures against bad-payers. Finally, a case can be made for switching completely from producer subsidies to means-tested support to households, which would strengthen incentives to cut costs and improve efficiency.

The Government lacks a clear strategy. Efforts are now focused on several sizeable projects to upgrade generation and reduce losses [29], but their cost-efficiency remains to be assessed only after demand side actions will be implemented.

An assessment of DH system rehabilitation in Romania estimates an amount of 3900 million EUR. Effects or efficiency are not mentioned or whether the load demand was estimated after the implementation of all efficiency-increasing measures at consumer level.

On the other hand, thermal rehabilitation and energy efficient upgrade of dwellings in Romania require large amounts of funds (lightly estimated at 7-10 billion EUR),
given that 78% of existing dwellings are more than 25 years old. Modernisation actions are in progress (for instance the metering programs in Bucharest and some other cities) but the rhythm is very slow and the number of project insufficient.

2.7. DH and cogeneration in the context of energy market

Everywhere in the world where cogeneration has a relevant share in the thermal and electric energy, in EU or in Eastern Europe, an intervention in this respect of local or central authorities can be identified. Therefore, energy policies played a major role in the history of cogeneration development in different countries.

Important urban agglomerations in Europe and worldwide use DH with various extents. In Eastern Europe most cities have DH. Where it operates in market conditions, DH is a major factor on the local heating markets as it ensures competition for various thermal energy producers.

By definition the evolution of cogeneration systems is connected to three components of energy market: (a) Electric energy market; (b) Heating market; (c) Primary fuels market – oil, coal, natural gas, biomass, domestic waste.

The opening of energy markets (electricity market and natural gas market mainly), which started by political decision of EU in the 90s and will be completed in 2005 (according to present programs) was meant to stimulate competition in the field.

There is a trend on the electricity market in Europe for reducing the tariffs for domestic and industrial customers. On the natural gas market there has been an increase of tariffs after y2000 as an effect of European regulations which connect the prices of natural gas and oil. Unfortunately, both trends are adverse to the feasibility of cogeneration projects, requiring supplementary financial effort for promoting this technology.

Comments

Presently, in Romania the national electricity grid operator must purchase the electricity produced by the 16 most important cogeneration plants – even though the energy tariffs approved by ANRE are higher than the ones of the existing condensing units. These cogeneration plants would not be competitive under free market conditions.

Investments in the entire electric and thermal energy sector in the countries with a market economy are currently (years 2003-2004) in stand by [4]. The EU Directive on cogeneration [6] do not provide new and strong instruments to promote cogeneration under present (2004) circumstances, but for the future: a major change in favour of cogeneration is expected when the principle of including the environmental costs of fuels (the so-called internalisation of external costs) in the tariffs will be applied. Probably here is the point where the actions of cogeneration promoters must focus. This can be accomplished:

(a) by political decision only
MODERNISATION OF DISTRICT HEATING SYSTEMS BASED ON SMALL / MEDIUM CHP

(b) when the economy and society are prepared for this step

Romania, 2003). This explains the insignificant market share. It is used most often for spaces with non-permanent occupation or as backup or peak alternative for dwellings with other heating systems.

**Heat pumps** are installations based on a refrigeration cycle, which transfers heat from the ambient (air, soil, river water, lakes or aquifers) to a higher potential – that is, a temperature to allow heating of occupied spaces. The principle has been known for a long time (1912), but the pace of technologic evolution as well as the low cost of fossil fuels made heat pumps competitive after the oil crisis in the 70’s only. Presently these are used more and more, providing the advantage that same equipment can supply heating in winter and cooling in summer for dwellings and public spaces. The average seasonal heating coefficient of geothermal heat pumps, for example, goes frequently as high as 4 – for 1 kWh electricity such equipment provides 4 kWh of heat. Considering energy prices in Romania, 2003, this means *heating with heat pumps can cost as low as heating with gas (under certain conditions)* – this fact qualifies the heat pump alternative (relatively poorly known in Romania) for a strong promotion by all means.

(c) if there is a consensus on the correct evaluation of these external costs and an European regulation is issued

DH is in direct competition with other heating alternatives on the market:

(a) Individual heating with fossil fuel fired boiler (natural gas, LPG, fractions of oil processing, coal) or wood fired boiler.

**Comments**

Biomass-based heating is actively promoted in EU as means of efficient use of local resources and of increasing the energy security in each community. Wood waste (solid or sawdust), agricultural vegetable wastes, wood of rapid-growth trees (cultivated in alternative lots with multiannual cycle) are renewable, have a significant share in Denmark, Great Britain, Netherlands, Germany and are used both individually and for peak load boilers in DH.

(b) Individual heating with electric energy (directly) or with heat pumps

**Comments**

**Electric heating** based on direct conversion of electricity into heat requires the lowest specific investment, is the cleanest locally, but is four times more expensive than natural gas heating (in

**Fig. 3 Heating cost ratio for different alternatives compared to natural gas heating in Romania (January 2004)**

- Electric
- Individual LPG boiler
- Individual petrol boiler
- DH (national reference price)
- Geothermal heat pumps
- Individual natural gas boiler

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17
Collective heating was the first form of DH in Romanian cities, applied for all the multi-story buildings erected before 1960.

In EU countries the price of heating fuels for domestic customers is generally higher (as high as twice, for natural gas) than the price for industrial customers (including also the thermal energy producers). This price ratio – determined somewhat by the opening of energy markets, as well as by the national policies – makes individual heating more expensive than connecting to the DH – where this alternative exists. Given the DH is the framework for competition among different heat producers, based on different technologies and resources, this leads to lower prices of heat in DH.

In Romania, the natural gas regulated price for domestic and industrial customers has been the same over the last years, after a long period when the price for industrial customers had been significantly higher because of crossed subsidies. In 2003 a price differentiation started, which was generated by the opening of the natural gas market and, on the other hand, by the periodic increase of regulated tariff for domestic customers. The effects of this evolution tend to become significant for reduction of the strong competition of natural gas towards DH, but generally until 2004 the DH could hardly handle this competition.

In this context, in Romania – more than other East-European countries – there is a trend for disconnection from DH. About 21% of the dwellings supplied by design from DH decided to disconnect. This is an average number for the entire country showing that natural gas network is still lacking in many towns and cities. Besides the financial aspects (heating cost) mentioned above, there are also other factors that explain the dimension of disconnecting phenomenon:

(a) Low quality of services provided by DH;
(b) The desire of dwelling owners in condominium-type buildings to separate from common services of the building;
(c) Legislative inconsistency as concerns the living in condominium-type buildings;
(d) Families moving from city dwellings back to the country;
(e) Pauperisation of some categories of population;
(f) The aggressive marketing of individual heating equipment distributors and especially the significant price reduction for these installations in Romania, which made them affordable for low-income families;
(g) The direct financial interest of the gas company in having a direct
relationship with the customers, thus bypassing companies like “Thermal Plant” or “Heating Company”, which are traditionally bad-payers.

Presently, as well as on a medium term [3], the customers are paying a national reference price for heat supplied by DH, established and adjusted periodically by the Romanian Government. We consider this financial mechanism aims three objectives for this period of transition to a functional market:

(a) The necessity to ensure affordability of heating for the population connected to DH system;

(b) Reduction of customers’ attraction towards alternative solutions to DH and consequently stopping the phenomenon of disconnection in order to give a chance to the future of DH systems;

(c) Maintaining a reasonable margin from the real heat production costs in DH (variable by case) in order to match with the budget possibilities to finance subsidies.

Comments

The real heat production costs in DH are always higher than the national reference price paid by the domestic end users. The difference is a subsidy from the central and local budgets to the heat producer. This mechanism is an important source of payment delays at national scale, because resources for the subsidies are not always available. Besides this subsidy, the low-income population can receive direct aid for heating in the winter.

Recent modifications of legislation concerning living in condominium-type buildings require the owners who want to disconnect from the DH to pay a monthly fee agreed with the owners’ association representative as a financial compensation for the effects of disconnection upon the other owners. It was also established erection of individual chimneys to exhaust flue gas above the top of the building. All the above will make the families who want to disconnect from the DH think twice before proceeding as such.

2.8. The heat consumer in the present context and in the future

Consultation of Romanian heat consumer connected to DH regarding the investment programs for system modernisation is rather an exception. All the modernisation projects after 1990 have included existing thermal plants or cogeneration plants, substations and partially the transport/distribution network of DH. The metering at building connection limit has been usually left on last position on the activity list, therefore it has often remained without financing. Individual metering is nearly inexistent. (However steps in improving this issue are (slowly) taken – see Bucharest program for connected buildings staircase metering, that is in progress).

Companies or “Regie”’s that provide local heating services, focused so far on heat production, are facing a difficult exam: for surviving, they must switch their focus from heat production to heat consumer. This is a change that not many companies will be able to accomplish. The maturity test of this change will be regaining consumer’s trust and turning the relationship with him into a partnership.

Becoming DH connected heat consumer in Romania was not a choice, but an assumption of the current standard in heating of dwellings in condominium-type buildings. It shows that an apartment is connected to DH because “that’s the way it used to be at the time” – when for example the heating bill was 5-7% of an average family’s annual income. The same average family had to pay 15-25% of its annual income for these services in 2003.

Comments

In Bulgaria, Czech Republic, Poland law does not permit disconnection from DH. In Hungary, this is permitted exceptionally.
and only at the ends of the distribution networks.

The inevitable disadvantages of DH systems have been many times emphasised by their progressive loss of performance, generated by: (a) unprofessional operation, (b) lack of maintenance funds, (c) poor quality or insufficient fuel, (d) uncontrolled expansion in the territory; (e) natural and moral ageing of materials and equipment.

After 1990, as the living standard for lots of people dropped, living in a block, besides the already-existing suspicion on correct allocation of heating expenses among apartments, gives a further reason of frustration: in the same block there are families who afford to pay the heating and other utility bills or consider it a priority and other families who do not afford it or have other priorities. This situation results in debts to the utility companies and interruption of utility supply to the entire building.

The above-mentioned factors created the feeling of entrapment in a “no way out” situation. This feeling is potentially dangerous because: (a) for some people, it can lead to the idea that state’s intervention is the only mechanism able to protect them in this situation; (b) others tend to get out of this situation through the first open door they see, without looking back and not paying attention to what they are getting in.

Added the lack of clear strategies of the authorities, the above lines can explain people’s search – individually or collectively – for accessible solutions and the disconnection trend determined by the opening of individual heating boilers market after 1995.

No feasibility studies or payback evaluations are performed at this level and the consumer is not interested in environmental issues, in saving primary resources or in global energy efficiency. Consumer’s first scope is to solve the heating problem the way he can afford.

The repeated attempts of the authorities to enforce strict requirements for installation of individual heating boilers in apartments were considered by the public as barriers to individual freedom of choosing between two technical solutions, both legally accepted at a certain moment.

It is our belief that the evolution of all factors shown in chapter 2 indicate that some of the existing DH systems, operating acceptably as concerns real heat production costs, have a real potential to be maintained and operated in the future, provided that a program is implemented. This program must include:

(a) Approaching the heat consumer on basis of marketing principles, gaining his trust.

Comments

Companies that operate DH systems must assume the role of service provider, therefore to carry out promotion and marketing activities. They must know their customers, advise them and meet their needs.

Ways must be found to explain the customers the correct calculation of the heating alternative operating costs, which should include investment recovery within a reasonable period (maximum 10 years), the authorised periodic boiler inspection, the monthly fee to the owner’s association as compensation for the effects of disconnection.

We agree the opinion of more and more specialists who believe that focusing the modernisation/rehabilitation investments exclusively on production, transport and heating substations is an incomplete approach, which can jeopardise DH on a short/medium term by reducing the investment recovery because of the disconnection phenomenon and decreasing of number of customers.

(b) The heat consumer who is still connected to the DH system and who is maybe thinking of disconnection must be offered:
(1) immediate implementation of means that make him feel he has control over the service he pays for;

(2) the certainty that staying connected to the DH system is the most convenient alternative with respect to the quality/price ratio on a short/medium term.

Comments
Facts show that disconnection continues even after important investments in heating system rehabilitation are accomplished, which show people’s lack of trust in these. Therefore, it is mandatory that any rehabilitation investment includes an individual means of control/metering that allows consumer to remove suspicion and have control over the service he pays for.

The consumer who is willing to pay for an alternative heating system must be convinced he can get the same effect by involving financially in the modernisation/rehabilitation of the DH system he is connected to, with a sum lower than the one required for the installation of an individual heating boiler.

(c) The concern towards environment must be an important argument in promoting DH (even though, unfortunately, this is not a major concern of common people in Romania, but it is explainable).

Insistently bringing up environmental issues to people’s attention leads to a change in attitude in this respect.

3. SMALL/MEDIUM COGENERATION

3.1. Definition and characteristics
CHP plant is generally classified by reference to the electrical output. Small-scale CHP usually refers to units with electrical outputs of up to 1 MWe, while medium-scale CHP plant rises up to 40 MWe.

The overall efficiency that (in favourable conditions) can reach 90% is available for CHP plants, but applies also to small/medium-scale CHP (small differences are possible due to the type of scheme).

Today, there are many solutions for small/medium-scale CHP with well-established technology. A properly designed small/medium-scale CHP plants achieve payback periods of between 3 and 8 years (lower figures are for small-scale: 3 to 5 years). [14] Still the life cycle cost assessment is the method we recommend to compare projects.

There is no doubt about heat price competitiveness, but it must be known that capital costs and running costs are slightly higher than for large scale CHP plants (generally capital cost decreases for higher unit sizing). It is very important to achieve a good return by electricity sales.

Small/medium-scale CHP plants are suitable for widespread applications, from different individual building types to small district households. The most important factors to choose the type of the CHP plant are:

- The characteristics and performances match the site load requirements,
- The available fuel,
- The parameters required by the end-user.

There are various concepts allowing a process to be carried out on the basis of cogeneration, based on different equipment.

The most important types of plants are outlined in the table below [8]:
MODERNISATION OF DISTRICT HEATING SYSTEMS BASED ON SMALL / MEDIUM CHP

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<thead>
<tr>
<th>COMBINED HEAT AND POWER (CHP)</th>
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<tr>
<td>Steam cycle</td>
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<td>Gas turbine cycle</td>
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Technologies like steam turbine cycle, gas turbine cycle, gas and steam turbine cycle or diesel and gas engine process are ready for the market from long time ago. Besides them, technologies like those in alternative processes and innovative processes are in different development stages or testing phases.

Particularly, the small-scale CHP unit associated with decentralised plants concept, led to development of standard packaged units. A block heat and power plant is a CHP plant, which is completely installed, delivered and run as a “block”.

3.2. Implementing small/medium CHP

3.2.1. Small/medium CHP in Europe

CHP is the alternative to small/medium capacity boilers used for heating of blocks, public buildings, commercial buildings because of rational primary energy utilisation and reduction of environmental pollution. The most important cogeneration capacities were erected by interconnection of small schemes, often developed in incipient phase with boilers only.

In Europe, small/medium CHP developed significantly in the early 90’s. The following trends appeared:

♦ use of renewable resources
♦ promoting small CHP installed directly at consumer
♦ promoting decentralisation for both heat and power generation

An example of small/medium CHP evolution is England, where 900 units with a total power of 120 MW have been operating since 1994, while in 2000 there were 4,632 Mwe installed capacity [14]. These capacities are installed at individual consumers or in small DH networks.

Even though there are factors that slow down the pace of cogeneration implementation (decreasing trend of electricity price and increase of natural gas price), it still remains an option to be considered in the future.

3.2.2. Opportunity of implementation in Romania

Unlike many countries in Europe which have been promoting cogeneration in general and small/medium CHP over the last years and where cogeneration was not spread 15-20 years ago, in Romania large CHP (for both industrial and domestic use) was developed. For Romania, the cogeneration issue is one of revaluation of this technology, of affirming as a viable source for residential customers under real market conditions.

DH and cogeneration development projects were optimised according to the parameters at that time: fuel price, low share fuel imports in 1965-1970, technologies and insulation materials available etc. All these parameters have been changing essentially over the last 30-35 years, which calls for a new optimisation
Existing CHP installations are based on large units (generally over 50Mwe) and their rehabilitation or future development will be difficult after decentralisation process of the existing power companies.

These systems are designed following old standards and some of them are oversized, which calls for a reevaluation of heat load for DH rehabilitation, for a correct sizing and avoiding supplementary investments. Besides, lifetime for the equipment in most of these plants is close to the end. In most cases, rehabilitation cannot be justified economically.

New solutions of small/medium scale cogeneration, possible to be developed at local level, may be a realistic approach.

Cities with large distribution networks have either several boiler plants supplying heat to the DH system or a large cogeneration plant supplying heat to the consumers through heating substations, or a combination of cogeneration plant, boiler plants and substations. Splitting of large networks into subsystems and using heating plants or substations for implementing small/medium CHP must be explored for the promotion of new solutions.

The following solutions may be of interest for small/medium scale cogeneration in Romania:

- internal combustion reciprocating engine generator are particularly suitable for operating as base-load units in CHP schemes up to 10 MW. Some installations are already in operation and they can be used as demonstration projects, for both technical and financial demonstration of project cost-effectiveness
- for the moment incineration plants are not developed, but for the future waste incineration plants could represent a major opportunity to develop a CHP project, because most of the cost of the plant will be financed by the refuse disposal contract and electricity sales;
- utilisation of biogas from urban waste deposits in small engines for cogeneration is to be considered;

The present legislative framework gives local authorities the right and obligation to establish the appropriate strategy for the community heating, and meet the requirements of environmental protection and sustainable development. Legislation does not restrict cogeneration development, but it neither provides incentives for promotion (except purchase obligation for the electricity produced by 16 DH cogeneration plants that were recently undertaken by different local authorities from the operator "Termoelectrica").

The Sibiu and Botosani small CHP/DH projects demonstrate that this solution can work in the given conditions in Romania.

Under these circumstances small/medium cogeneration is an interesting option for DH modernisation, whose opportunity to implement should be evaluated on a case by case basis.

Expressed in specific investment figures, small-scale CHP plant is generally more expensive to build and maintain. The viability of CHP projects depends on obtaining the best income from the electricity sold and ensuring that the advantages of a location closer to the demand point are recognised in the commercial agreements.

For any specific project, the choice of the type and capacity of the initial base load CHP plant will be influenced by:

- local refuse disposal policy;
- local industrial waste heat sources;
- availability and price of alternative fuels;
- adequate electricity revenues under a power sales agreement;
- potential for thermal energy storage; there are two principal reasons for using thermal storage in conjunction
Modernisation of district heating systems based on small / medium CHP

with CHP plant: i) to enable the CHP plant to maximise electricity revenues; ii) to minimize fuel use in peak boilers;

- standby electricity generating capacity requirements;
- type and location of peak/standby boilers;

3.2.3. Promotion of small/medium CHP in Romania

There are some facts that are barriers to cogeneration development in Romania [18]:

1) Choice of cogeneration is significantly determined by the price policy for fossil fuels. An arbitrarily differentiated price policy – based on criteria other than economic – distorts the specific costs of heat production and makes the economic analysis of technical solutions difficult. The natural gas price policy advantages individual or decentralised heating compared to any other heating alternative, including cogeneration.

2) Maintaining the national reference price as a unique value for heat in DH systems all over the country discourages cogeneration. Producers and distributors were not stimulated to act on production costs, because the difference between the real and the national cost was subsidised from the budget. Therefore, it does not affect heat producer’s and distributor’s cost-effectiveness.

3) The risk for a new cogeneration to be unsuccessful is greater than for a boiler-only alternative, where the investment is lower.

4) Not including the environmental taxes in the energy price impedes cogeneration.

5) Economic inefficiency and consumer’s distrust towards DH (including cogeneration) due to:

- lack of metering which results in network losses being paid by the consumer
- lack of control systems in the heating substations to correlate the heat quantity and quality with customers’ variable demands
- the monopoly policy of large production and distribution companies and the lack of transparency regarding costs of production, transport and distribution
- lack of possibility for consumer to decide for himself when he needs heat; there is no individual contract between consumer and supplier
- consumers’ negative reaction towards everything related to “living in common”, after 50 years of common property and common decisions.
- lack of national and local strategy concerning heat supply policy, in conjunction with the poor energy-saving behaviour of consumers.

Small cogeneration has lower chance to be an eligible gas consumer and negotiate (downwards) the price of natural gas

Although Romania seems not prepared yet for wide scale implementation of small/medium CHP, this solution must be promoted along with improvement of the legislation in this field and implementation of the market.

Decentralised CHP may be implemented in steps, reducing the initial investment cost. Where complete equipment replacement is necessary there can be installed for the beginning new efficient boilers as peak equipment, then the base cogeneration equipment. If existing boilers can still be operated satisfactorily for a time, modernization may begin with installation of base cogeneration equipment.

Presently there are several pilot projects in operation in Romania. (A selection is presented in Chapter 6 – Case studies.)
4. BASIC ELEMENTS SUPPORTING DECISION OF MODERNISATION WITH SMALL / MEDIUM CHP EQUIPMENT

4.1. Feasibility study [7]

Typical elements and factors that need to be considered for the assessment of technical and economical viability of CH, compared with other possible options. Options should be compared using sound economic principles, always ensuring that full life-cycle costing is used. [7]

4.1.1. Main directions to orient feasibility study [7]
(see also previous chapters)

1). Heat and electricity demand assessment (evaluation of market for heat, and power and a new possible market for cooling):

a. Identification of possible partners – authorities, associations of tenants, large hospitals and schools and all of which can contribute to establish a core load for DH system. This works for every new system, but also for existing systems that shall be modernised.

b. It is important that all cost-effective energy saving measures for the buildings either be implemented, or at least considered, before determining the useful heat demand, in order to avoid overcapacity installation.

c. Necessary data could be obtained from historical data regarding existing building, or by energy modelling techniques for new buildings, according to development strategy of urban area provided by the municipality.

d. The variation of heat demand is also important, and some evaluation by direct metering are recommended with instrumentation installed within the building.

e. It is important to consider future effects of different factors on demand profiles:
   - metering and charging tariffs; presently non metered system for heat supply could be modernised, and a change to metered supply normally leads to significant reduction in heat use;
   - liberalisation of electricity market will facilitate to sell electricity direct to residents connected to DH;
   - increasing demand for cooling could be a solution for utilisation of surplus heat in summer period;

2). Heating systems assessment within buildings:

a. For connected buildings the operating temperature and pressures need to be reconsidered in meeting current and future needs.

b. A program of works that will enhance existing systems and adapt them to the new DH solution for rehabilitation could be necessary;

c. There are a number of ways of generating domestic hot water from DH system. The most energy-efficient scheme will involve taking advantage of the low temperature of the cold water feed so as to cool the DH return as close as possible to this temperature.

3). Heat/CHP plant assessment – aspects to be covered are:

a. fuel choice, contract flexibility, security of supply;

b. interfaces with fuel, electricity (for CHP) and DH infrastructure;

c. standby capacities;

d. operating and maintenance costs;

e. thermal storage and heat dumping in allowing the CHP units a greater flexibility;

f. level of penetration of new technologies: pre-insulated pipes, condensing boilers, etc.
4). Heat distribution system assessment:
   a. utilisation of a dedicated computer software is very important;
   b. identification of major constraints to routes (examination of other utility services drawings to avoid damages);

4.1.2. Optimisation phase:

This is the most complex phase of the feasibility study, where the various options available for rehabilitation of DH need to be compared on the basis of maximising net present value or internal rate of return. Some of the possible optimisation issues are:

1) Operating temperature: a high flow temperature will determine a low flow rate and hence a smaller pipe diameter, but it is needed a more expensive building connections, and also a higher heat production cost;

2) Operating pressure: pumping cost need to be considered, particularly for large systems, where higher pressure reduce the amount of booster pumping required.

3) Heat meters: the installation of heat meters will result in lower building energy use and by consequence in reduced operating costs. But the most important impact of heat meters utilisation could be to achieve market acceptability by resident and project developers;

4) Building heating systems: the rehabilitation or replacement of some parts of building heating installations will involve additional cost, but it may be justified by the positive impact on the rest of the system, or in increased heat sales (deposits inside the pipes or radiators results in an increased need for power in pumping system and in an reduced heat transfer inside the building);

5) Building weatherisation could create a financial advantage by reducing peak heat demand and accordingly the capacity of thermal plant (usually heat only boilers) and distribution network.

Marginal cost of heat needs to be taken into the consideration in this evaluation.

4.1.3. Revenues from sales of heat and electricity

1) A good understanding of a customer’s current and future cost for conventional/individual heating is required in order to evaluate the maximum heat sales income available;

2) Some consideration should be given to assessing the level of bad debt;

3) In case of CHP utilisation it is vital to obtain the maximum income from the electricity produced, because, by general estimation, 10% increase in electricity sales will improve internal rate of return (IRR) of the investment by 2%, whereas a 10% in increase heat sales will improve IRR only by 1%;

4) Some options for selling electricity produced in CHP are (specific options following liberalisation of electricity market):
   a. Sale in bulk to the host Public electricity supplier;
   b. Sale to another electricity supplier;
   c. Direct sale to customer as second tier supplier, according to the national regulation of electricity market;
   d. Sale under renewable energy regulation provisions (only for waste used as fuel);
   e. Sale as an on-site generator to other customer on the same site;

Note: The impact of these options could be used in a sensitivity analysis;

It is recommended to market heat and electricity together to customer on the community heating scheme, for benefiting of common metering and charging.
arrangements. In this case additional arrangements will be required: for times when the generation is less or more than customer demand, payment for use-of-system/new cables installation, etc.;

**4.1.4. Development program**

Development program is a specific output for feasibility study missing in a lot of Romanian studies elaborated from now; this is very important to enable advance planning of subsequent stages; a summary of this program is as follows:

1. Need for further site investigations: ground conditions, structural surveys, etc.
2. Planning applications;
3. National and municipal regulation application;
4. Preparation of invitation for tender;
5. Tender period;
6. Short listing for: construction companies, energy developer companies, operating companies, etc.;
7. Assessment of tenders and final negotiations of contracts;
8. Supervision during construction /rehabilitation;
9. Commissioning and testing;
10. Operation and maintenance.

**4.1.5. Economic appraisals**

Two important problems are to be included:

1) Economic calculations: cash flow, annual capital expenditure, operations and maintenance expenditure, annual revenues;

2) Alternatives comparison using simple payback period, net present value (NPV), internal rate of return (IRR);

**Note:**

The alternative with highest NPV will be selected and the IRR must be greater than the minimum required by the project developer, taking account of risk in the project.

A financial appraisal could be recommended for calculation of tax implications and debt cover ratios.

**4.2. CHP types and principle schematics**

**4.2.1. Steam turbine CHP plants [8]**

CHP plant is likely to be in the medium range, using simpler steam cycles and less extreme steam conditions. The emphasis may be more on achieving high plant availability and low construction costs rather than small gains in the efficiency of electricity generation, because the main economic justification arises from the CHP operation.

Two options may be taken into account, to employ a back-pressure steam turbine or an extraction-condensing turbine.
Simple back-pressure sets, using hot water as the primary heat distribution medium, can expand to low pressures and temperatures to give a good balance between power and heat output. On this cycle electricity production is linked with heat production. Auxiliary cooling can be used to damp heat so that electrical output can be maintained in summer.

The extraction-condensing plant has a higher electrical efficiency but is more complex. It has the advantage that electrical output can be maintained when the heat load is not available. The extra capital cost for the low pressure turbine, condenser and condenser cooling system has to be recovered by the sales of this additional electricity generation.

**Advantages**
- Basically every fuel can be used.
- Well-established technology.
- Size of plant is not limited.

**Disadvantages**
- Low electrical plant efficiency.
- Bad part load performance.
- CHP plants with steam turbine apply in the range 1-40 MW, with steam parameters of 30-70 bar and 400-500 °C.

4.2.2. Gas turbine CHP plants [8]

Initially, gas turbines have been used to meet peak load conditions in power systems. Now usually, modern gas turbines specially developed for continuous operation are appropriate plant for base-load CHP/CH duty as well. Excess oxygen in the exhaust gases may support auxiliary firing in the waste heat boilers, which provides an efficient means of supplying peak heat demand.

Design flue-gas temperature is constrained by consideration of acid deposition (if sulphur is present in the fuel), by saturation point and by plume dispersal requirements for planning consent. The
design of the waste heat boiler surface will be determined based on flow and return temperatures.

There are possible many types of schemes based on different gas turbine types.

4.2.3. Internal combustion (IC) reciprocating engine generator [8]

IC engine plants are particularly suitable for operating as base-load units in CHP/CH schemes up to about 10 MWe.

Heat can be recovered from the exhaust gases, engine jacket cooling water, the lubricating oil cooler and super-charger air intercooler, by a heat recovery circuit. This increase the overall efficiency from 36-38% for generation only, to as high as 90% if all the reject heat sources are collected to a secondary circuit distributing heating water at about 90 °C. Heat recovery is maximised if the return temperature is low enough to recover heat from the turbocharger aftercooler.

Lower return water temperature will enable more heat to be recovered, so the average cost of heat will be less. If the return water temperature is not low enough for engine and oil cooling, part of the heat needs to be vented off and an overall efficiency remains low. Year-round return temperatures must be low enough to provide jacket and oil cooling, so IC engines are very suitable for low-temperature heating systems.

The variation in the cost of heat with flow temperature is not significant, as most of the heat is recovered from the exhaust gas path by a waste heat boiler subject to large differential approach temperatures. With IC engines (and gas turbines), heat recovery does not sacrifice power yield, as is the case with the steam turbine process.

Two- and four-stroke, medium speed (500-600 rpm), supercharged compression ignition engines are available and suitable for CHP usage. An exhaust super-charged engine produces higher exhaust temperatures over the load range, and gives higher efficiency under part-load conditions, than a normally aspirated engine. The heat rejected to exhaust and jacket is almost constant between full-load and half-load and the power generation efficiencies are also more constant at part-load.

At a smaller scale, up to 5MWe, spark-ignition gas engines are available. Although not as efficient as the larger compression-ignition plant, their capital cost is relatively low and they provide the same benefit of good part-load efficiency.

IC engines can be adapted for use with a range of fuels, from natural gas to light distillates, and to heavy fuel oil.

**Advantages.**

- Power and heat are generated right at the site where they are needed and thus big transmission losses like they occur in DH networks can be prevented.
- Overall efficiency of IC engine plants amounts to 85% and more referring to the end user. Thus its efficiency is up to 10% higher than in conventional DH plant.

- Reduction of primary energy consumption with the help of high efficiency through waste heat utilization of exhaust gases and of engine cooling.

- Modular design is possible.

- Many providers available.

**Disadvantages**

- High temperature heat supply is not possible (temperature level of waste heat is too low).

### 4.2.4. Combined-cycle CHP plants [8]

A combined cycle is normally based on using waste heat from a gas turbine single-cycle electricity generating plant, to rise steam and produce further work or electricity from a steam turbine. The combined-cycle process is highly efficient: in electricity-only operation 50% and in CHP operation as high as 85%.

Excess oxygen in the exhaust gases may support auxiliary firing in the waste heat boilers raising steam for the steam turbine, giving some additional capacity provided that appropriate allowances have been made for the steam turbine and generator. Auxiliary firing is a more efficient method of raising steam than in conventional boilers as the air is preheated.

Due to high efficiency and competitive investment cost per capacity, combined-cycle plants are commonly constructed instead of conventional steam-cycle plants, where fuels suitable for gas turbine (e.g. natural gas) are available. Optimization of the combined-cycle plant for CHP generation follows a similar pattern to that for steam turbine plant operation, because any heat taken off from the steam turbine will result in a reduction in electrical output. However, in CHP operation about one third of the heat recovery can be obtained from the gas turbine waste heat boiler, at a temperature well suited for DH supply but not adequate for steam raising for the turbine and thus not sacrificing the power yield.

**Advantages**

- High electrical efficiency
- Well-established technology

**Disadvantages**

- Expensive operation
- Suitable for higher electrical output

![CHP with combined cycle](image)

CHP operation as high as 85%.

4.3. **Economic aspects**

The specific investment in cogeneration is relatively high, this is why careful sizing of equipment in correlation with peak heat load is required. The seasonal peak load is usually handled with another source (classic boiler). On the other hand, the relatively high specific investment requires finding financial incentives in order to
ensure the competitiveness of this solution. Maximisation of cogeneration benefits in DH applications can be attained by sizing the system based upon heating load and not upon electricity. Under these circumstances, experience shows that acceptable feasibility is obtained when a permanent “relief” is provided for the supplemental electricity – which exceeds consumer’s needs by far. Regulating the access to the grid and the contractual terms for electricity supply to the grid are main barriers for cogeneration development.

Promotion of an investment in this field must be based on thorough studies with real data about the analysed area. Studies will show what solutions are affordable for a local community in order to solve DH problem using cogeneration and will point out the appropriate time to start the investment.

Market economic principles must be used for establishing the solutions for increasing DH systems efficiency. Any solution must ensure DH operation, as well as recovery of investment and operating expenses, and profit.

It is very important that market is not artificially influenced – as it is in Romania. It is partially true that these interventions can be explained through the social component. Very few people can afford the real cost of utilities.

There is an opinion among the investors that financing DH system is inappropriate. This is why these investments must be performed where economic conditions are suitable. Any alternative solutions – in case cogeneration is not feasible - must be based upon feasibility studies.

The table below shows specific data from some particular small/medium CHP equipment. Data are according to [8] and are not relevant to compare various solutions.

<table>
<thead>
<tr>
<th>Plant</th>
<th>Unit</th>
<th>Steam Turbine</th>
<th>Gas Turbine</th>
<th>Micro Turbine</th>
<th>Thermal Engine</th>
<th>Combined Cycle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size</td>
<td>kWe</td>
<td>1000</td>
<td>20,000</td>
<td>30-75</td>
<td>30-75</td>
<td>40,000</td>
</tr>
<tr>
<td>Specific investment costs</td>
<td>EUR/kWhe</td>
<td>1500</td>
<td>1200</td>
<td>650-1100</td>
<td>1250-1800</td>
<td>800</td>
</tr>
<tr>
<td>Specific maintenance costs</td>
<td>EUR/kWhe</td>
<td>0.007</td>
<td>0.007</td>
<td>0.005-0.007</td>
<td>0.2-0.3</td>
<td>0.007-0.011</td>
</tr>
<tr>
<td>Overall efficiency</td>
<td>%</td>
<td>70-85</td>
<td>70-92</td>
<td>70-90</td>
<td>52-57</td>
<td>85-90</td>
</tr>
<tr>
<td>Emissions (NOx)</td>
<td>Mg/Nm</td>
<td>450-600</td>
<td>25</td>
<td>20</td>
<td>100-250</td>
<td>25</td>
</tr>
</tbody>
</table>
5. ORGANIZATION AND FINANCING OF DH MODERNISATION PROJECTS WITH SMALL / MEDIUM CHP

5.1. Organization of projects

Document [1] specifies in the process of delegation of the local energy system administration to some economic entity, the local authority remain responsible for the elaboration of strategies and implementation of investment programmes.

The logic of [1] assumes for the local authority (that have the exclusive obligation to formulate strategies) the consultation with the local community when elaborating strategies and programmes.

5.2. Financing modernisation projects

The magnitude of funds estimated for DH modernisation, lack of credible strategies, the limited legislative framework and the poor payment capability of the beneficiaries – population – are the main factors that justify “the lack of funds' commonly indicated as the cause for the present condition of DH systems. Low project feasibility kept the private financing entities away from this sector.

There are many reasons (the most important one seems to be sharing risk among several financing parties) for using complex financing schemes for implementing investments in DH system including:

- local public authority (directly or indirectly through the local budget)
- funds from the state budget
- banks
- foreign financing entities (funds available based on financial mechanisms or international programs with precise objectives)
- private investment funds
- Own funds of economic operators within DH sector

Organising multiple financing investment programs requires highly qualified specialised management, which local authorities do not have currently.

1. Direct local budget allocation

2. Institutionalisation of local credit through periodic issue of municipal bonds on a short/medium term.

In Romania, issuing of municipal bonds started relatively late compared to other East-European countries, because the legislative framework appeared in 2001 only (OMF 1987/2001, CNVM – Romanian National Securities Commission - regulations). The source for loan reimbursement is the local budget. By 2004, about 20 municipalities used this financing tool ever since – most are low-value and are rather trials of this mechanisms. According to the law, the loan cannot exceed 20% of municipality’s income over the financing period – therefore important limitations for small towns. The most representative: Oradea and Timisoara by value (almost 3 mil. EUR each), Deva by maturity period (1.5 mil EUR over 5 years).

There is already a quotation for each municipality based on rigorous criteria concerning the risk of municipal bonds, which shows the trend towards formation of a market of such investments. The local credit will become an important way to finance the public services modernisation as the local economy grows, population’s incomes increase and the managerial capability of local authority develops.

3. Allocation from state budget

This way of financing will not be used for DH modernisation anymore.

4. Bank loan

Although the market conditions are not fulfilled, the DH modernisation projects in Romania involved Romanian and foreign banks in complex financing schemes. An important reason was the sovereign guarantee for the loans. As the sovereign guarantee is going to be limited to carefully
selected cases, the bank loan will be available only where local guarantees can be offered and where market studies show a superior capacity of loan reimbursement.

5. Financial leasing, based on a contract with specified duration

This financing has been used for its simplicity and because it is applicable within the existing legislative framework. There is a positive experience in this respect.

6. European programs of financial assistance to EU acceding countries.

Significant in this respect is the PHARE program which provided co-financing of DH rehabilitation projects in Ploiesti, Buzau, Fagaras, Pascani and Oltenita.

7. USAID programs (Independent agency of the US Federal Government)

for supporting economic growth, agriculture, trade, health.

8. International funds available through the mechanisms established by the Kyoto Protocol on climate change

In December 1997 in Kyoto, the industrialised countries negotiated the limits for reduction of greenhouse gases (CO2 mainly), establishing reduction terms and amounts for every country. This objective can be met not only through internal projects, but through international actions as well. Developed countries can report emission reduction obtained through investments in other cosignatory countries (possibly less developed ones, where due to outdated technologies and poor condition of technological equipment, the investment per ton of CO2 reduced is significantly lower than an investment in the developed country and having the same effect).

The Kyoto Protocol stipulates three financing mechanisms:

(a) Clean Development Mechanism;
(b) Joint Implementation;
(c) International Emissions Trading.

The volume of CO2 emissions reduced is calculated in accordance with the specific procedures elaborated by the European Commission, by authorised entities which study the project to be implemented.


10. Other private investment funds

Private investment funds are already involved in buying municipal bonds – the only means of financing investment projects through free market mechanisms.

11. Own funds of economic operators within DH sector

Involvement of these companies in financing the investments, even though on a low scale, shows their direct interest in continuing DH operation.

12. An important financing source – not turned to good account because of mentalities yet to be overcome and of lack of real market management/marketing – is the individual consumers’ availability to invest for improving their home thermal comfort. After all, the beneficiary of the efforts for DH modernisation is the end-user (either dwelling, public building or company). The financial involvement of end-user would be the proof of rebuilding the trust between the customer and the heating services provider and helps reducing financing costs of modernisation projects.
5.2. Procurement aspects

Procurement of equipment and materials to be used, as well as of design, installation, commissioning for the modernisation projects is governed by the legislation regarding public acquisitions (Government Emergency Ordinance OUG 60/2001) which promotes several principles:

(a) free competition and nondiscriminatory access of any product supplier, work contractor or service provider to the process of awarding the public acquisition contract;

(b) efficient use of public funds, that is contract awarding based on economic criteria;

(c) transparency

(d) equal treatment

(e) confidentiality (bidder’s commercial secret and intellectual property are guaranteed)

6. CASE STUDIES.

6.1. Case study – ROMANIA

Thermal rehabilitation of DH system in Fagaras

Location

The city of Fagaras is located in Brasov County (Region of Development 7 – Center). DH system was designed to supply thermal energy to the 10,512 block apartments and public buildings in the city.

The strategy of local authorities

Since 1998, Fagaras has been included in a complex financing program (“Joint Implementation” type, total value 88.7 mil USD) engaged by EBRD, Romanian Government, other international donors and local distribution Companies. The scope of the program was modernisation of heating plants and associated hot water distribution systems.

City of Fagaras was included in this financing program due to favourable ranking in a study that had analysed the feasibility of investment in DH system modernisation for a large group of cities/towns in Romania (of which first five had been selected). Besides the objective of improving the quality of services, it was estimated that the proposed investment would reduce NOx emissions with up to 75% and CO₂ with up to 69% compared to the situation shown in the feasibility study.

Technical abstract

The modernisation program completed in 2001 (design, installation, equipment procurement, commissioning) was carried out with Romanian specialised subcontractors, under the supervision of EBRD consultants.

The main selection criterion of the technical solution was the minimum cost of thermal energy over the feasibility period analysed.

The eight heating plants were provided with 22 gas-fired hot water boilers (95°C/75°C) with capacities ranging 7-16 MWt and total installed capacity of 86 MWt,
which ensured the heat demand as per original design. Stainless steel plate heat exchangers and modern pumping systems with constant or variable speed were installed. 18.5 km of distribution networks were replaced, amounting 57 km of buried preinsulated piping. Metering devices were installed for all the 372 connections (at building limits). Interior distribution piping in buildings was not rehabilitated and no metering/individual control device at apartment level was installed.

The city has a well-developed gas network.

**Energy tariffs**

The billing price of thermal energy produced with the new installations, approved by ANRSC for 2003, is 1,265,415 ROL/Gcal, of which 547,224 ROL is the EBRD portion for loan reimbursement. The population pays the national reference price of 672.268 ROL/Gcal established by the Government for the year 2003 and winter 2003/2004. The difference between the price paid by the population and the real price approved by ANRSC and EBRD is a subsidy supported from the central and the municipal budgets according to the law.

**Evolutions after project implementation**

During the implementation of the modernisation project a continuous increase in number of apartments requiring the disconnection from the DH system. The majority of disconnected apartments installed the alternative system - wall hung gas-fired boiler or individual gas-fired convectors - but there are also apartments with no alternative system installed.

Effective 2002 the system was completely modernised and operable. However, the process of apartment disconnection from DH system continued and went up to 40.63% - that means 4,271 disconnected apartments.

The 2003 subsidy for the 6,241 connected to the DH system is 593.147 ROL/Gcal and can reach 40 billion ROL.

**Comments**

Given the spread of natural gas network in the city, the population may choose between utilisation of individual gas-fired systems and DH system for heating and domestic hot water. A simple calculation shows an average cost of 530.000 lei/Gcal (* - in average prices 2003) for heat produced with a modern individual wall-hung boiler firing natural gas, which is 21% less than the national reference price and 26% lower than the operation tariff of 718.191 ROL/Gcal* (the loan reimbursement portion not included) approved for the local DH system

The phenomenon of disconnection may be considered a manifestation of the existence of a real market, which offers two options: (a) Remaining connected to the DH system; (b) Installing an individual gas-fired system. The second alternative is favoured by the low price of natural gas on the Romanian energy market.

We consider that a main cause of disconnecting continuation is the lack of individual metering and control devices for the final consumer, not provided through the modernisation project. As a matter of fact, the local authority established installation of thermostatic control valves and cost allocators as an immediate priority: 500 apartments are already provided with such devices and great efforts are being made for urgent completion of this program.

On the other hand, assuming that 70% of disconnected apartments have an alternative heating system with an approximate initial investment of 1,100 EUR, this gives an amount of 3.3 mil EUR which could have been a financing source of this project in a market-oriented approach.
6.2. Case study – ROMANIA

NUONSIB – Urban cogeneration pilot project for the rehabilitation of the Thermal Plant Hipodrom, Sibiu municipality

Location

The Sibiu Municipality is the main city of Sibiu county. The Sibiu county is part of the Development Region no. 7 – Center, which is situated in the piedemont area of the South Carpathian mountain range.

Strategy of local authorities

Originally, a number of 32,700 flats have been connected to the Municipal District Heating System, which includes a number of 36 sub-systems/islands, supplied with heat by 29 thermal plants, equipped with hot water boilers fuelled with natural gas, and a number of 7 sub-stations. The total installed capacity of the system equals 340 MWth.

The Local Council of Sibiu Municipality and the Dutch Company NUON, have registered a joint venture company for the implementation of a pilot rehabilitation/operation project for one of the existing 29 thermal plants and the associated district heating network. The selected boiler plant was CT6, located near the Hipodrom neighbourhood. Initially the two partners had equal shares in the venture, but presently the Dutch partner owns a major share.

Currently, around 21,000 flats are still connected to the municipal district heating system, which is operated by SC ENERGIE TERMICA SA. This share company is owned entirely by the local municipality.

Technical summary

The rehabilitation project started in year 1996. At that time the thermal plant CT6 supplied heat and hot water to 24 apartment buildings, with 1,500 flats, a kindergarten building, a high-school building and a number of stores. At the beginning, all circulation pumps, the piping network, and the I&C equipment have been replaced. At the same time, have been installed two Waukesha-Stamford Diesel co-generation units, fuelled with natural gas. There have been also installed two new hot water boilers, manufactured by the Romanian company SIETA and equipped high performance Weishaupt natural gas burners. At the time of the commissioning, the cogeneration units had a share of 20% of the peak heat demand. In year 2003, about 40% of the delivered heat was produced in co-generation, with an overall efficiency of 85%. Here are the major components of the rehabilitation project:

In addition, the major shareholder NUON obtained a grant from the Dutch Government for the complete replacement of building distribution piping and installation of meters/controls. This is a PSO type project, approved by SENTER, a Dutch governmental agency. Implementation started in year 2003 and is performed by NUON Energy Romania. This project covers 70% of the consumers in the CT6 system. The strategic technical approach was to replace the multiple vertical building distribution network with a horizontal distribution network, which allows the individual metering and control of each apartment.

| Installation of two co-generation Diesel units, fuelled with natural gas | 2 x (475 kWel + 700 kWth) |
| Installation of new hot water boilers (in steps) | 1 x 3 Gcal/h (year 2000) 2 x 1,5 Gcal/h (year 2002) |
| Installation of the water treatment plant | |
| Modernization of the circulation pumps, thermal plant piping network and I&C and electrical systems | Year 1996-1997 |
| Installation of plate-type heat exchangers | Year 1996-1997 |
| Replacement of 70% of the distribution network piping | Pre-insulated pipes ready to be installed in the soil 1998-2002 |

Project financing

The initial investment (two co-generation units, plate-type heat exchangers, new circulation pumps, I&C equipment) developed in 1996 was entirely financed by NUON. Further investments (water treatment plant, three new peak boilers, network replacement) were financed from the cash flow of the project.

The modernization of building distribution systems is currently in progress. This separate subproject is financed by a grant in the frame of the PSO program of the Dutch Government. For obtaining this grant, the NUON Energy Romania - the local representative of the Dutch NUON partner - offered free consultancy.
**Energy tariffs**

On a yearly basis, the retail heat and electricity tariffs are approved by the Romanian regulatory body, ANRE. The calculation of the tariffs is done in accordance with ANRE published methodology. In accordance with the Romanian law provisions, the electricity distribution company Electrica SA has to buy the electricity produced by the cogeneration units. The NUONSIB heat tariff resulted always around the national reference price (currently established by the Romanian Government at 672,000 ROL), at times being under this regulated price. The producer receives the legal subsidy for the time period when its price was over the national reference price.

**Evolution after the project implementation**

A continuous reduction of the heat demand in the district heating systems, which can be described as severe, was observed. This resulted in a reduction of the natural gas consumption.

![Natural gas consumption (1000 cubic m)](image)

During the period 1999-2001 NUON Energy undertook actions directed to its clients, aiming to show the need and urgency to modernize the building heat distribution system, with financing by the tenants in the condominium. However, even if the flat tenants understood the necessity of these works, they did not succeed to raise the necessary funds for get to work. This being the case, starting with 2001, NUON Energy performed free assistance to the condominium associates for access to a grant of the Dutch Government. This approach was successful, and in 2003 the modernization of the building distribution for about 70% of the apartments connected to the DH.

On the other side, an estimate shows that the modernization of the building distribution system and the installation of thermostatic valves will result in the decrease of the yearly heat consumption for a standard flat with 25% (from 14 Gcal/year to 10.5 Gcal/year), and, consequently, to the reduction of the heat delivered by NUONSIB. This will result in the increase of the heat fixed cost, and consequently the heat price increase by 12%. Finally, the individual heat consumer will have to pay about 16% less for the heating and hot water allover the year.

**Comments**

NUON could not afford to practice heat tariffs substantially lower than the Romanian national reference price. Moreover, the fact that the modernization of the building distribution system was not part of the project from the very beginning, resulted in progress of disconnection process. The producer, facing the reality of losing customers, took actions to find financing for the rehabilitation of the building distribution systems. Finally, the producer succeeded, at a large extent, but not at the pace that would have been required to stop the trend of disconnection.
It has to be mentioned that the financial contribution of the local municipality to this project was, until now, null.

The production cost, the investment return and the profit - tailored to a value which has to allow more investments - resulted in a heat price which competes successfully with the individual gas fired boiler heat cost. Unfortunately, even if modernization of building distribution system is less costly for the flat owner as compared with the installation cost of an individual heating equipment, the first is more difficult to implement because of the bad co-operation of the members of the condominium association. Because of the reduction of the heat delivery and of the number of customers, the heat unit cost increased. This was a predictable evolution, which, however, did not result in higher overall costs for the end users.

Finally, there is a last aspect to be addressed, which is not controlled by the heat producer and distribution company, but by the regulatory body. This is related to the need to implement the two components heat tariff, with one fixed component and one variable component. This would create the legal basis for the individual contracts between the heat provider and the individual heat customer.

To get out of this deadlock the operator NUON needs to re-evaluate strategy. The steps are the following: (a) the urgent finalization of the modernization of the building distribution systems, action that has to be closely related to the progress of the legal frame towards implementation of individual contracts based on the two component heat tariff; (b) the enlargement of the customer base which has to be performed as a market oriented action; (c) prevention of further disconnections, by actions targeted to the existing customers, that must be explained that individual heating tends to become more expensive that DH as far as natural gas price increases; (c) promotion of the real partnership and improvement of the co-operation of the two share holders of NUONSIB.

6.3. Case study – ROMANIA

Modernization of local DH thermal plant SC TERMICA Botoşani by implementation of small CHP

Location

The Botoşani Municipality is the main city of Botoşani county - part of the Development Region no. 1 – North East, which is situated in the northern part of Moldova.

Strategy of local authorities

A number of 33,460 flats have been connected to the Municipal District Heating System by design. A Thermal Plant (boilers only, operating on fuel #6 and natural gas) supplies hot water presently to a number of 46 substations (from an initial total of 49). Every substation distributes heat/domestic hot water to 300-1900 apartments, as well as to public buildings. The total designed installed capacity of the substations equals 338 MWt.

The DH system is operated by SC TERMICA SA in the name of the local authority. From the 46 substations in operation, in the latest 10 years a number of 4 were completely modernized and 27 partly modernized. A number of 15 substations remain to be rehabilitated as soon as financing is available.

Disconnection rate from DH is about 15%. It is to mention that the region is rated, as per recent national and European statistics, among the poorest in Romania and in Europe as concerns the living standard of the people. Despite that, the city in general is a model of how many things can be done with few money and much heart.

The picture below represents the schematic of Botoşani DH system.
Technical summary

Both the mayor of the City (April 2004) and the manager of SC TERMICA are members of COGEN Romania (a Romanian NGO that promotes cogeneration). This may explain the interest of the local authority to implement since year 2000, together with the Romanian National Institute for Thermal Engines, a municipal project for modernization of the DH boiler plant.

A less capital intensive technical solution for modernization was selected, as anyone can see. Two gas turbines (2 x 2 MWe) were installed. They are second hand airplane motor jets, both of them adapted by the Institute for Thermal Engines COMOTI for energy generating purpose. Two existing hot water boilers were adapted to act like heat recovery hot water boilers, receiving hot gas from the gas turbines. Both turbines and boilers burn natural gas.

Each turbine+boiler group provide 2 Mwe + 5,5 MWt in cogeneration only conditions, with an overall efficiency of 77%. The boilers maintained a post combustion additional capacity of 11,6 MWt each, that rises the group efficiency at full load to 89%.

Real maximum winter load of DH system is far less than the installed transfer capacity of the substations ( 338 MWt ), reaching no more than 200 MWt. Related to this limit, CHP only capacity is 5,5%. Adding postcombustion, it reaches 17%. This ratio ensures full capacity operation of the CHP plant all over the year, providing maximum amount of operating hours. Group #1 has already returned the investment (estimated at 1,5 years by design) and group#2 will be in the similar position next year.

Evolutions

Project was finalized in 2003. DH had to face a disconnection trend that reached 15% in late 2003. This rate is lower than the national average of 21%, but the DH operator SC TERMICA understood the market signals still in time and began since 2002 installation of heat metering at the building level, in parallel with termostatic valve+heat cost allocators installation in the apartments. In June 2004 as much as 90% of buildings have building heat meter and 30% of connected apartments have individual control implemented. All these local measures, together with the national macroeconomic evolutions lead to a spectacular drop of disconnection requests in 2004, compared with the same period in 2002.
6.4. Case study – UK

Barkantine CHP and DH Scheme

Location
The Barkantine Estate is situated in East London, in the London Borough of Tower Hamlets. Predominantly residential, it comprises a mixture of high rise and low-rise dwellings built in the 1950s and 1960s. The Estate had a mixture of individual heating systems and district heating supplying homes with warm-air partial central heating. The heating systems were in a poor state of repair and regeneration was needed.

The strategy of local authorities
Initially the local Council had intended to replace the district heating scheme with individual boilers. However, the Council’s Energy Efficiency Unit were concerned about this for two reasons:

- Environmental impact of individual boilers (compared with district heating supplied by Combined Heat Power)
- High running costs of individual boilers (compared with district heating supplied by Combined Heat Power)

Also, the Council had a strategy to preserve and modernise district heating. The Energy Efficiency Unit was therefore keen to examine the option for DH with CHP. They realised that the key to this was to consult the tenants themselves.

Tenant consultation
The tenants originally wanted to have DH removed and replaced with individual boilers. This was because the old system was inefficient and given them a poor service.

There followed an Estate-wide period of consultation. This was done by means of:

- Open meetings with residents
- Setting up of a Tenants’ Advisory Service

- An exhibition was set up with the Council, potential equipment suppliers and utilities.

As a result of this the residents were persuaded that a modern DH system with CHP would be much more reliable and responsive than the existing DH system. They also realised that the price they would pay, based on efficient CHP generation would be significantly lower than if they chose individual gas boilers.

The residents’ original doubts were completely turned round when the first high-rise blocks were supplied their new system. In fact the residents requested that the scheme should be expended to include more homes than was originally planned!

Technical abstract
A full option appraisal of the possible heating systems was conducted and the following arrangements were decided upon:

- DH with CHP supplying 706 homes, a school and a sports centre
- Heating in homes set at 21 °C in living rooms, 18 °C in bedrooms
- Individual heat metering and controls

The plant selected to deliver this consists of:

- CHP gas-fired reciprocating engine of electrical capacity 1.4 Mwe
- Back up boilers in energy centre and in high-rise blocks
- 2 heat storage tanks each 125 m$^3$

The CHP was sized on the basis of the winter heating load; this allowed a larger CHP unit to be used than the more usual practice for small-scale CHP of sizing to summer domestic hot water requirement. This allows more electricity to be generated.

The electricity from the CHP is also supplied to the local residents. This enables a better revenue stream for the electricity than by selling to the Grid, which is not
MODERNISATION OF DISTRICT HEATING SYSTEMS BASED ON SMALL / MEDIUM CHP

structured to recognise the benefit of embedded electricity generation.

The anticipated key performance figures for the full completed scheme are:

- CHP engine electrical efficiency: 39%
- Annual Heat production: 10,483 MWh
- Annual Electricity Production: 8,457 MWh
- Overall Efficiency: 78.3%
- Annual carbon dioxide emission reduction: 2,435 Tonnes
- Annual Primary Energy Use Reduction: 6,653 MWh

The vehicle for regeneration

Realising that the solution they selected is more capital intensive than the alternatives, LBTH decided to engage with the private sector. The private sector offers the following advantages:

- Specific experience of similar projects and energy markets
- Assistance in developing the project concept
- Risk transfer from public sector
- Risk taken by private sector who are able to manage risk more effectively
- Payment to private sector dependent on performance

This scheme also secured financial support from the Government under its Private Finance Initiative (PFI). The support recognises the benefits to the public sector (above) in terms of value-for-money through their innovation and management skills. However, PFI is not the same as privatisation – rather it is a public-private partnership, in this case between LBTH and their selected private partner, EDF Energy (formally London electricity Group).

It is essential that any private sector partner:

- Understands the Local Authority’s policy objectives
- Is adequately experienced in the Energy Services field
- Is fully committed to the success of the project
- Is willing to engage with the local community.

LBTH and EDF Energy worked together to set up the project, market it to the community, and assist with the securing of PFI support. In order to take operate the scheme, a new Energy Services company (ESCO) was set up. Called the Barkantine Heat and Power Company (BHPC), it is wholly owned subsidiary of EDF Energy.

LBTH wanted to maintain some influence over BHPC in order to safeguard the interest of customers and to deliver benefits to the community. They have achieved this by:

- Negotiating profit sharing to benefits the residents: excess profits made by BHPC are to be fed back to pay for further energy efficiency measures;
- A residents committee has been formed comprising 5 residents, 1 council representative, and 2 BHPC representatives to keep a watch on service provision;
- Incorporating a clause in their contract with BHPC which requires the approval of LBTH before the scheme can be extended or reduced, tariffs can be altered, or selling on interest in BHPC.

Success of scheme

The CHP became operational in early 2001 currently serving 540 dwellings with affordable warmth and electricity. New heating means have been laid, new heat exchangers installed, together with prepayment meters and radiators in flats.

The remaining 160 homes will be connected during the next two years, and the scheme also has capacity for further expansion.

This system supplies residents with:
7. CONCLUSIONS

7.1. Evolutions of DH sector over the last decade have been generated by:

(a) Incapacity of the Governments and local authorities to ensure financing of modernisation investments as the extremely poor technical condition of the DH systems required;

(b) The organisational inertia and the incapacity of DH operators (monopolies) to restructure and to act on market conditions;

(c) The financial incapacity of most people to pay the heating tariffs generated by huge operational loss or the necessity of DH modernisation investment return/financial costs.

The above-mentioned conditions delayed the implementation of market principles and required permanent intervention of the Government in order to reduce the social impact, through financial mechanisms (subsidies, regulated prices) which determined population and companies to take decisions that are not sustainable in the long term.

The amount of 21% disconnected dwellings represents, in fact, the extent of DH heat market opening (unregulated!) with natural gas as an alternative. This figure shows partly the current limit of customers’ financial affordability and the current natural gas network capacity and extent.

7.2. Cogeneration development was and still is overwhelmingly influenced by the governments’ energy policies. The opening of energy markets and the current trend of prices did not bring benefits to cogeneration. At the same time, the technology evolution makes cogeneration more and more competitive due to the reduction of specific investment and operating/maintenance costs;

7.3. The chance for development of small cogeneration for DH in Romania in the short/medium term depend essentially upon:
MODERNISATION OF DISTRICT HEATING SYSTEMS BASED ON SMALL / MEDIUM CHP

(a) maintaining the existing DH systems in small towns, which are most exposed to irreversible shutdown in the absence of rehabilitation programs and financial resources;

(b) Possibility of splitting subsystems within large DH systems in important cities which afforded to have performed rehabilitation investments in the last decade;

(c) Operating the DH systems in market conditions, with Government’s intervention only exceptionally in order to avoid irreversible shutdown of these systems;

(d) Increasing the population’s financial capacity (the living standard);

(e) Acceptance of distributed generation and non discriminatory access to the grid of the small/medium CHP generated electricity.

(f) Dissemination of performance of the already operating modernized small CHP/DH plants.

7.4. Individual control & metering, the only way for the customer to acknowledge consumed energy without suspicion and to have control over the service he pays for, is an essential factor that guarantees success of modernisation projects and grounds the increase of confidence and reliability on DH.

7.5. The actions to ensure the future of DH systems are:

(a) Regaining consumers’ trust in the public heating service, by shifting operators’ priority from production to customer. Periodic visits to the condominium-type buildings and organising seminars;

(b) Advise to consumer; Explaining the correct calculation for the evaluation of heating alternatives available. Explaining the necessity to perform maintenance to the interior distribution network in buildings and apartments. Explaining the important role of building weatherisation for reducing the heating bill. Popularisation of current systems used for allocation of heating bill among tenants, based on consumption indicated by DH connection meter.

(c) Convincing the consumers to get involved into financing schemes for DH modernisation. The consumer must be made aware that the time has come for making a choice that requires a financial effort:

1) He disconnects from DH system and chooses an individual heating alternative on a short/medium term (requires financial effort: for natural gas connection, boiler installation, re-install distribution within the apartment, authorize the installations);

2) Remains connected to DH, with a long-term prospective for both the individual and the community (because the existing DH systems are close to the end of their lifetime and need investments for modernisation that increase tariffs).

No matter the solution, the consumer must make a financial effort. If the consumer is convinced that DH can provide comfort with a lower investment and lower operating cost, then the future of DH is secured, and cogeneration has a prospective in this context.

(d) Establishing the DH modernisation program and strategy along with the consumers

7.6. Difficulties in organising large-scale projects in DH sector, as well as the introduction of local authority responsibility regarding DH, increase the chances for emerging and development of small/medium projects and favours the implementation of small scale cogeneration. In this context, urgent identification of the systems and subsystems that meet the premises for DH
MODERNISATION OF DISTRICT HEATING SYSTEMS BASED ON SMALL / MEDIUM CHP

operation in market conditions is a priority, where:

(a) The local authorities and the local operator strive for regaining consumers’ trust in the public heating service and in its future;

(b) There is a proven consensus of all the parties involved (authorities, operators, majority of consumers) on implementing a program for the system modernisation and to get involved financially in this action.

7.7. Individual heating of condominium-type apartments is a short/medium term solution. Lifetime of gas-fired wall-hung heating boilers is 10-12 years, then the owner has to make a new investment. He can be regained at that moment as a district heating consumer if he will be offered an attractive reconnection alternative.
## Reference List

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<th>Author/Publisher</th>
<th>Date/Location</th>
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<td>2</td>
<td>Energy efficiency Law 199/2000</td>
<td>MO nr.734 on 8.10 2002</td>
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<td>DH services in winter of 2002/2003</td>
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<td>APER Workshop &quot;Promotion of Household Energy Efficiency Concept&quot;</td>
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<td>Guide 3 – Introduction to small scale combined heat and power – ETSU – UK</td>
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<td>Technical issues of small scale CHP (V. Athanasovici, and others)</td>
<td>Magazine «Energetica» nr.7/2001</td>
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<td>ISPE Issue nr.3/2001;</td>
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<td>Romania Demand Side District Heating Energy Conservation Project – EBRD/MVV</td>
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<td>Finacial Manual for Municipalities in CEEC`s (Zeman si colectiv)</td>
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<td>28</td>
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<td>World Bank Annual Report on Romania</td>
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A.1. Basic elements for establishing Municipal Energy Efficiency Master Plan (MEEMP)

For a municipality, being able to play a dynamic role in urban energy planning implies to act at different levels, especially those of:
- energy production and the optimum utilisation of local and renewable energy sources
- energy distribution
- energy consumption in the public and private sector

Because the municipalities are close to the inhabitants and economic actors, they represent the ideal level for giving a new dimension to energy policy:
- by analysing the needs and resulting demands for energy in order to define an appropriate supply policy and also exploit local energy sources as much as possible;
- by integrating this action within the framework of economic and social development through the creation of new activities.

General directions for action are related to:
- seek to reduce consumption per inhabitant, energy municipal service or company (without reducing energy service quality) and undertake necessary actions to achieve this (demand side management- DSM);
- adjust production and supply to the final energy demand (least cost planning- LCP)

According to Romanian Law no.199/2000 [2] published after modification in Official Monitor, part I no.734 from 8.10.2002 local authorities having more than 20,000 inhabitants are obliged to establish MEEMP. The role of this type of document is:
- to fundament medium and long term options regarding municipal energy services with special provisions on energy efficiency and rational use of energy, based on technical and economic evaluations;
- to create necessary connection between national energy strategy (including energy efficiency strategy) and local options for energy supply;
- to facilitate the access of local authorities to financial and fiscal incentives offered by Government for energy conservation, based on transparency and non-discrimination;

This chapter is focused on a structured methodology for establishing MEEMP in order to:
- offer a general document for debates between local authorities representatives and consultancy companies involved in preparing MEEMP;
- ensure a minimal content for MEEMPs and a possibility for a transparent selection of those eligible for fiscal and financial incentives mentioned in legislation in force;
- facilitate the realisation of different analyses, synthesis and creation of data basis at national level regarding energy consumption in municipal sector;

Taking into the account the progress in European integration process and the interest to transfer the European experience in Romania, similar documents and studies, established by European experts participating in technical assistance
contracts financed by European Commission, in member countries or in Romania, have been considered in elaboration of this chapter.

MEEMPs is an instrument for an integrated approach of municipal energy services, which usually are implemented by different companies and they should emphasise the very well known 5 functions of the municipality in energy sector [13]:

♦ consumer;
♦ producer/transporter/distributor;
♦ project developer;
♦ local regulator of energy market;
♦ motivator of local consumers for an environmental friendly behaviour, including efficient use of energy;

The last four functions have been recently introduced in the specific legislative framework for local authorities and to exercise them it is necessary a capacity building effort and a qualified activity.

Heating and lighting buildings, operating equipment, managing a public outdoor lighting system and a fleet of municipal vehicles is the role of “the municipality as energy consumer”.

Main activities as consumer:

a) for buildings:
♦ carry out energy audits;
♦ carry out feasibility studies;
♦ draw up a long term plan for action including: insulation, temperature monitoring, renovation of heating installation, consumption metering and monitoring per building and if it is possible per function (heating, lighting), remote management of equipment (tele-metering, remote alarms, remote controls);
♦ inform those concerned and train specialists;

b) for vehicles
♦ carry out an audit of the fleet vehicles (see provisions of the Law no.199/2000) [2];
♦ implement consumption metering and monitoring per vehicle;
♦ develop preventive maintenance;
♦ adopt a fleet renewal policy;

c) for public outdoor lighting:
♦ draw up a long term improvement plan following an audit of the existing installations;
♦ generalise the use of low consumption lamps;
♦ carry out preventive maintenance;
♦ develop metering for power supply point and monitoring consumption;

Producing and distributing energy and water to the inhabitants and the various economic actors is the role of “the municipality as energy producer and distributor”

Main activities as producer / distributor:

a) in terms of production:
♦ carry out energy audit of installation;
♦ carry out feasibility study (see above the structure and orientations for feasibility study);
♦ improve performances for production installations;
♦ select energy sources depending on their economic, social and environmental relevance;
♦ utilise renewable energy sources (wood/waste wood, solar, wind, micro-hydro);
♦ develop combined heat and power systems;
♦ seek efficient utilisation of urban waste (incineration);
♦ adjust production to a controlled final demand;

b) in terms of supply and distribution
♦ carry out energy audit of installation;
♦ improve efficiency of water and heat distribution circuits;
♦ place statutory operating contracts (e.g. gas and electricity distribution), which benefit the municipality and inhabitants;
MODERNISATION OF DISTRICT HEATING SYSTEMS BASED ON SMALL / MEDIUM CHP

- develop a simple metering and billing system for the users which encourage control over consumption;
- achieve integrated planning of energy networks;
- optimise the system infrastructure in order to avoid surplus investment cost;

The choice of development and town planning largely determine the energy consumption of all the actors of the city for the city and particularly for their travel. Taking these actors into account is the role of "the municipality as city regulator/developer"

Main activities as regulator/developer:

a) in terms of development:
   - create data basis on energy consumption;
   - assess the impact of various development scenarios;
   - integrate systematically the concept of "energy efficiency" into projects specifications;

b) in terms of local regulations:
   - regulate DH and CHP development;
   - regulate public transport routes by facilitating bus-tramway-bicycle-foot and make using them easier and safer;
   - regulate existing municipality’s subsidies (55% for thermal energy) to encourage individual initiative for building insulation and heat installation rehabilitation;

Overall energy consumption is simply the result of individual consumption which itself is the result of a large number of isolated/common private and public decisions.

Enabling improved cost effectiveness of the municipality’s investments and seeking to involve these scattered actors by encouraging their actions is the role of "the municipality as motivator"

Main activities as motivator:

a) in terms of information and public awareness schemes;

- establishment of an information office on energy matters, including possible assistance or financial support;
- issuing a municipal newsletter;
- promotion of demonstration projects;

b) in terms of incentives:
   - assistance for energy audits in buildings in a preliminary phase of existing national regulation implementation;
   - new approaches in urban planning / construction permits;
   - assistance for rational use of water.

TEST
Are you prepared to establish your Municipal Energy Efficiency Master Plan?
See Annex 1 and try to fill in the questionnaire

A complex approach of local energy development involves the evaluation of different aspects such as:

- analysis of energy use in district heating;
- analysis of energy use for water pumping and waste water treatment and disposal;
- analysis of energy use for public lighting;
- analysis of energy use in urban public transport;

According to our experience, for a big number of municipalities this is also the priority list established by consideration of local impact of these sectors and by emergency solutions needed.

Some specific elements such as limited financing sources, projects cost-effectiveness or limited capacity to attract other financial resources could play an important role in modifying the previous priority list.

In this context it is very important to establish not only a comprehensive MEEMP,
but to continue this work with creation of feasibility studies for selected objectives in all of 4 mentioned sectors and, by comparison of technical and economic indicators, to fundament a clear decision regarding:

- priority field of action;
- priority project;
- implementation priority of different components in acceptable financial terms;

A.1.1. Analysis of energy use in heating and hot water supply

Community heating is where a number of buildings or dwellings are heated from a central source. This provides economies of scale and diversification of loads. Together with combined heat and power (CHP) plant, community heating/district heating (CH/DH) offers:

- environmental benefits: greatly reduced carbon dioxide emissions arising from the high efficiency of CHP/CH scheme;
- affordable heat for residents and other users;
- new opportunity for local supply of electricity to residents and other users;

Feasibility Study [7] – typical elements and factors that need to be considered for the assessment of technical and economical viability of CH, compared with other possible options. Options should be compared using sound economic principles, always ensuring that full life-cycle costing is used.

I). Main directions to orient feasibility study [7]:
1. Heat and electricity demand assessment (evaluation of market for heat, and power and a new possible market for cooling);
2. Heating systems assessment within buildings;
3. Central plant assessment;
4. Heat distribution system assessment;

II). Optimization phase

This is the most complex phase of the feasibility study, where the various options available for rehabilitation of DH need to be compared on the basis of maximising net present value or internal rate of return.

III). Revenues from sales of heat and electricity:

a. A good understanding of a customer’s current and future cost for conventional/individual heating is required in order to evaluate the maximum heat sales income available;

b. Some consideration should be given to assessing the level of bad debt;

c. In case of CHP utilisation it is vital to obtain the maximum income from the electricity produced, because, by general estimation, 10% increase in electricity sales will improve internal rate of return (IRR) of the investment by 2%, whereas a 10% in increase heat sales will improve IRR only by 1%;

d. Some options for selling electricity produced in CHP are (specific options following liberalisation of electricity market)

Note: The impact of these options could be used in a sensitivity analysis;

It is recommended to market heat and electricity together to customer on the community heating scheme, for benefiting of common metering and charging arrangements. In this case additional arrangements will be required: for times when the generation is less or more than customer demand, payment for use-of-system/new wiring, etc.;

IV). Development program:

This is a specific output for feasibility study missing in a lot of Romanian studies elaborated nowadays; this is very important for enabling advanced planning of subsequent stages;

V). Economic appraisals

Two important problems are to be included:

a. Economic calculations: cash flow, annual capital expenditure, operations and
maintenance expenditure, annual revenues;
b. Alternatives comparison using simple payback period, net present value (NPV), internal rate of return (IRR);

**A.2. Methodology for assessment of municipal energy services [25]**

The biggest part of current investment for rehabilitation of heat and hot water services are focused in some general objectives such as:

- reduce the thermal energy consumption by decreasing losses at the end user level and meet increasing demand for heat without necessarily increasing supply;
- increase the overall efficiency of the local heating company and accompany local economic development while keeping financing requirements within sustainable level;
- reduce reliance on fuel imports and alleviate their impact on the foreign trade balance by promoting demand-side energy conservation investments;
- alleviate the environmental consequences of thermal energy production and use;

A possible methodology for having a comprehensive and relevant analysis of current situation of DH systems should include following steps [25]:

- assessment of five technical indicators, each scoring from 0 to 5 points – maximum achievable 25 points;
- assessment of five financial indicators, each scoring from 0 to 5 points – maximum achievable 25 points;
- assessment of three managerial capability indicators, each scoring 0 to 5 points – maximum achievable 15 points;

The total score of each criterion is normalised by dividing the total score by the number of indicators. Once the normalised score had been calculated, the evaluator could apply different weights to calculate the result of ranking process.

This type of indicators represent only our suggestion, but different other indicators could be used, and different weights could be accepted according to priorities of national and local authorities or local companies. In this context it is important to select the indicators by respecting some general rules such as:

- **clearness:** the indicator must unambiguously describe a relevant property of the system;
- **simplicity:** the information should be made available within the time period dedicated for this scope;
- **general:** the indicator must describe properties and features that all district heating systems have;
- **objectiveness:** that the indicator should exhibit such that an unbiased evaluation is possible;
- **quantifiable:** the indicator must describe quantifiable parameters and not be prone to unfair judgement;
- **non-discriminating:** the indicator must not offer any grounds of discrimination for example, between small and large district heating systems;

Due to the lack of well-structured data basis in the municipal companies for heating, water, lighting or public transport different methods for collecting data could be used:

- analysis of existing design and operational data;
- on site inspection;
- interviews and discussions with representative persons from local companies or municipality’s departments;

Presentation of technical, financial and managerial indicators are given in the chapter A.3.3.
A.3. Priorities and limits in solving energy problems. The necessity for a long term perspective

A.3.1. Priority level of rehabilitation of heating system in comparison with other options in energy sector

Establishment of priority level for infrastructure modernisation in different municipal energy services sub-sectors should be based on following criteria:

- criterion no. 1: the impact of cost/benefit ratio on municipal budget after modernisation process;
- criterion no. 2: social impact of modernisation process on connected households to DH system regarding their comfort and income;

The analysis according to criterion no. 1 should consider the following aspects:

- reduction of operation expenses (fuel cost, electricity, maintenance, spare parts, etc.) for the sub-sector which is subject for evaluation: heating, water supply, public lighting, urban transport;
- reduction of subsidies for heating

The analysis according to criteria no. 2 is determined by the continuous increase of the share of payment for energy services in total household expenditure (see table A.1), and by the high share of heating in total household energy consumption (see table A.2)

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<tr>
<td>Employees</td>
<td>17.9%</td>
<td>21.6%</td>
<td>25.2%</td>
<td>27.2%</td>
<td>+52%</td>
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<tr>
<td>Retired people</td>
<td>20.5%</td>
<td>23.5%</td>
<td>27.2%</td>
<td>28.1%</td>
<td>+37%</td>
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<tr>
<td>Total population</td>
<td>18.9%</td>
<td>21.8%</td>
<td>25.5%</td>
<td>26.9%</td>
<td>+42%</td>
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<th>Household Type/Consumption type</th>
<th>Heating</th>
<th>Hot water</th>
<th>Cooking</th>
<th>Lighting/Appliances</th>
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<td>Apartment in block connected to CH system (urban)</td>
<td>55.5%</td>
<td>19.5%</td>
<td>9.7%</td>
<td>13.9%</td>
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<tr>
<td>Apartment in block with individual boiler (urban)</td>
<td>49.6%</td>
<td>20.7%</td>
<td>19.0%</td>
<td>10.6%</td>
</tr>
<tr>
<td>Individual house with stove (urban)</td>
<td>73.2%</td>
<td>3.5%</td>
<td>16.2%</td>
<td>7.0%</td>
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<tr>
<td>Apartment in block with individual boiler (rural)</td>
<td>56.3%</td>
<td>22.2%</td>
<td>11.2%</td>
<td>10.2%</td>
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<tr>
<td>Individual house with stove (rural)</td>
<td>65.8%</td>
<td>6.4%</td>
<td>16.4%</td>
<td>11.4%</td>
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<tr>
<td>Other house with stove (rural)</td>
<td>67.9%</td>
<td>5.8%</td>
<td>14.8%</td>
<td>11.5%</td>
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A.3.2 Defining the option for centralized / individual heating – limiting the areas for specific heating systems – density indicators

There is a different approach in European countries for establishing a centralised heating system depending on climate, access to various type of energy sources, specific energy and environmental protection policy. The market share of District heating is different from country to country [12]: Denmark 50%, Finland 44%, Sweden 31%, Germany 12%, Netherlands 3% and in the same time the market share in Romania was about 31% with a diminishing trend to 25% as a result of disconnection process, being developed
especially in urban area. It is important to observe that country having domestic natural gas or light liquid fuel reserve or cheap electricity have a limited share for District heating.

For this reason, in the decision making process only experience of countries having similar conditions with Romania could be considered as relevant model. One basic condition is the mixture of fuels available for district heating, including cogeneration, as presented in Table A.3 [12].

**Table A.3** Share of different type of fuel used in CH/CHP

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<thead>
<tr>
<th>Type of fuel /Country</th>
<th>Finland</th>
<th>Germany</th>
<th>Romania</th>
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<tr>
<td>Coal</td>
<td>37%</td>
<td>51.45%</td>
<td>12%</td>
<td>9%</td>
</tr>
<tr>
<td>Heavy oil</td>
<td>9%</td>
<td>11.1%</td>
<td>25.8%</td>
<td>13%</td>
</tr>
<tr>
<td>Natural gas</td>
<td>26%</td>
<td>30.3%</td>
<td>54.1%</td>
<td>7%</td>
</tr>
<tr>
<td>Waste</td>
<td>0%</td>
<td>4.1%</td>
<td>4.4%</td>
<td>9%</td>
</tr>
<tr>
<td>Other fuels</td>
<td>28%</td>
<td>3.1%</td>
<td>3.7%</td>
<td>62%</td>
</tr>
</tbody>
</table>

Despite the fact that Romania has biggest share of natural gas in heat production, performance of related installations are modest and for this reason:

- there is an important potential for energy savings by implementation of modern technology (including small and medium cogeneration – that must be promoted);

These favourable conditions are in connection with different other factor such as [12]:

- over sizing (15-30%) of installations having an old design, which implies a thorough reconsideration of heat demand in order to minimise DH rehabilitation investment by a correct design;

- actual specific heat consumption of buildings in Romanian urban and rural area is 54-180% higher than the average (360 MJ/m², year) for buildings in developed countries having similar climate conditions; the difference is determined by low level of thermal insulation;

- the standard consumption for domestic hot water (110 l/day, person) has to be reconsidered in comparison with the standard consumption of 60-70 l/day, person utilised in developed countries;

The projects for the development of DH systems have been optimised according to a set of the specific parameters accepted at that time: fuel price, reduced share of fuel import in 1965-1970, available technologies and materials, etc. All these parameters dramatically changed in the last 30-35 years, and a new optimisation process is needed meaning to redesign all of them.

The main parameters to be considered in evaluation of opportunity for DH systems are:

- the density of heat consumers;
- size of heat demand;
- number of degree-days;

In order to facilitate decision process and a DH modernisation that include cogeneration option, some specific values for main indicators are presented below (density indicators) [12]:

**Density ratio** calculated by division of total households surface by total DH area is an important indicator for preliminary evaluation of heat demand.

The following values can be used for verification:

- 0.4 – 1.0 for urban areas;
MODERNISATION OF DISTRICT HEATING SYSTEMS BASED ON SMALL / MEDIUM CHP

♦ 0.3 – 1.0 for households in industrial areas;
♦ 0.15 – 0.6 for residential areas;

Economic evaluation has shown that the connection to DH is recommended if total building surface is more than 200,000m²/ km², or the ratio density higher than 0.25 (buildings with more than two apartments and occupied surface greater than 1500m²).

There are other possibilities to estimate the cost-effectiveness for connection to DH network [12]:
♦ for urban areas with block of flats:
  ♦ minimum thermal capacity demand > 12 MW/ km²;
  ♦ minimum heat demand > 36GWh / year, km²;
♦ for urban areas with public and commercial buildings:
  ♦ minimum thermal capacity demand > 15 MW/ km²;
  ♦ minimum heat demand > 27 GWh / year, km²;
♦ for urban areas with industrial buildings:
  ♦ minimum thermal capacity demand > 36 MW/ km²;
  ♦ minimum heat demand > 54 GWh / year, km²;

In order to preliminary evaluate the heat demand for heating before detailed professional calculation, informative data could be considered as following:
♦ households with 1-6 families – 55 kWh / m³;
♦ blocks of flats – 45 kWh / m³;
♦ public buildings –31 kWh / m³;
♦ industrial buildings – 24 kWh / m³;

Similarly for preliminary evaluation of heat demand for domestic hot water informative data are:
♦ households – 12 kWh / m³;
♦ schools – 3 kWh / m³;
♦ social buildings – 7 kWh / m³;
♦ other public buildings – 4 kWh / m³;

A.3.3 Basic elements to fundament decision for DH rehabilitation

The decision to rehabilitate the DH system should be based on planning activity for energy sector according to modern planning methods such as:

1. Establishing performance indicators in order to:
♦ Identification of main directions;
♦ Implementation of success monitoring procedure;
♦ Facilitate the comparison;

For establishing performance indicators some specific aspects should be considered [12]:
♦ their capacity to satisfy economic criteria;
♦ their capacity to reflect items of present interest;
♦ to have a limited number of indicators;

2. Demand Side Management (DSM) has the role to put energy saving potential (including avoided capacities) in operation by different services offered by the supplier to the consumer:
  ♦ Consultancy to inform the consumer about possibilities to reduce energy consumption, including suggestions regarding access to financing sources or governmental fiscal and financial incentives for energy saving;
  ♦ Operational assistance, including 24h/day emergency services, or highly specialised operations for maintenance of big consumer installations;
  ♦ Billing services including data collection and transmission;
  ♦ Design / installation / financing of some modernisation activities on consumer side for consumption reduction or for avoiding new expensive peak capacities;

3. Least Cost Planning (LCP) and Integrated Resource Planning. To implement this planning procedures presume that the company should not consider final energy demand greater
than the existing one and to make efforts to increase the efficiency of its installations and to contribute for customer energy saving; the new capacities should be accepted only after successful harnessing of energy saving potential; According to this methods investment for energy saving and investments for new capacities must be well balanced.

LCP/IRP provides an energy planning for a specific objective or a specific area (municipality) by considering all available energy resources and priority zones for dedicated types of energy could be established (DH, gas, etc.)

In Romania the new law for energy efficiency no.199/2000 art. 14.a.b.c introduced the legal base for utilisation of DSM, LCP, IRP. For the implementation of these methods in local energy planning specific local regulation has to be issued.

**Indicators for technical evaluation of DH systems [25]**

**Informative values for technical indicators**

As an example for heating and hot water services the technical indicators could be:

- **Specific water losses** - calculated by annual water losses divided by total length of pipeline \(\text{[m}^3/\text{hkm]}\); **normal value**: 0.05-0.1 \(\text{m}^3/\text{h,km}\) for middle-aged distribution network. Any values greater than 0.1 \(\text{m}^3/\text{h,km}\) have to be judged as poor or even very poor and indicate the existence of numerous leaks and large-scale corrosion damage.

**Measures to be taken**:
- very first measure – draining and drying all channels;
- replacement of pipelines sections;
- retrofitting of appropriate water treatment facilities;

For CHP 4% of usual water flow could be considered in design of water treatment capacities [12].

- **Specific heat losses** – calculated by annual heat losses divided by total annual heat sold \([\%]\); **normal value**: 8-10\% for normal hooded concrete channels;

**Measures to be taken**:
- replacement with pre-insulates pipes;

- **Specific heat demand** – calculated by total heat demand divided by total length of pipeline \([\text{MW/ km]}\); **normal value**: 2.5MW/km.

**Measures to be taken**:
- medium length of pipeline for each thermal substation – calculate by total length of pipeline loops divided by the number of thermal substations(PT) \([\text{km/substation]}\); **recommended value**: 4.5-5 km/PT

**Measures to be taken**:
- by using modern network configuration technologies, the installation of PTs should be avoided as often as possible. Ideally networks should operate entirely without PTs, since they required high personnel costs and induce supplementary losses; removed PTs should be replaced by compact house substations connected directly to the transport network.

- **Specific electricity consumption** – calculated by annual electricity consumption divided by heat sold \([\text{kWh}_\text{e}/\text{MWh}_\text{t]}\); **normal value**: 12-20kWh/MWh.

**Measures to be taken**:
- by using modern pumping and operating technologies the specific pumping consumption only could be reduced with 5-8 kWh/MWh.

An example of technical analysis in different Romanian towns can be seen in table A.4, using the methodology proposed in chapter 3.2.
Different other indicators should be considered:

Specific indicators for boiler houses: (estimated at 5% interest rate, 20 years normal operational duration and 1997 price level for Finland [12]) can be found in table below:

Table A.5 Specific indicators for boiler house

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>Informative value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal plant capacity</td>
<td>MW</td>
<td>2</td>
</tr>
<tr>
<td>Maximum pressure</td>
<td>bar</td>
<td>10</td>
</tr>
<tr>
<td>Max. temperature</td>
<td>°C</td>
<td>120</td>
</tr>
<tr>
<td>Boiler efficiency</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>- natural gas</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- heavy fuel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- coal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- wood waste</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Building volume</td>
<td>m³</td>
<td></td>
</tr>
<tr>
<td>- natural gas</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- heavy fuel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- coal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- wood waste</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fuel deposit volume</td>
<td>m³</td>
<td></td>
</tr>
<tr>
<td>- natural gas</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- heavy fuel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- coal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- wood waste</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water consumption</td>
<td>m³/ MWh</td>
<td></td>
</tr>
<tr>
<td>- natural gas</td>
<td>0.006</td>
<td>0.06</td>
</tr>
<tr>
<td>- heavy fuel</td>
<td>0.06</td>
<td>0.06</td>
</tr>
<tr>
<td>- coal</td>
<td>-</td>
<td>0.06</td>
</tr>
<tr>
<td>- wood waste</td>
<td>0.06</td>
<td>0.06</td>
</tr>
<tr>
<td>Electricity consumption</td>
<td>kWh/MWh</td>
<td></td>
</tr>
<tr>
<td>- natural gas</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>- heavy fuel</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>- coal</td>
<td>-</td>
<td>23</td>
</tr>
<tr>
<td>- wood waste</td>
<td>18</td>
<td>23</td>
</tr>
<tr>
<td>Specific investment</td>
<td>USD/kW</td>
<td></td>
</tr>
<tr>
<td>- natural gas</td>
<td>240</td>
<td>144</td>
</tr>
<tr>
<td>- heavy fuel</td>
<td>240</td>
<td>144</td>
</tr>
<tr>
<td>- coal</td>
<td>-</td>
<td>554</td>
</tr>
<tr>
<td>- wood waste</td>
<td>606</td>
<td>672</td>
</tr>
<tr>
<td>Fixed operation cost</td>
<td>USD/kW</td>
<td></td>
</tr>
</tbody>
</table>
### MODERNISATION OF DISTRICT HEATING SYSTEMS BASED ON SMALL / MEDIUM CHP

#### Parameter Units Informative value

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>2</th>
<th>5</th>
<th>15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal plant capacity</td>
<td>MW</td>
<td>2</td>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td>Maximum pressure</td>
<td>bar</td>
<td>10</td>
<td>10</td>
<td>16</td>
</tr>
<tr>
<td>Max. temperature</td>
<td>°C</td>
<td>120</td>
<td>120</td>
<td>120</td>
</tr>
<tr>
<td>• natural gas</td>
<td></td>
<td>28.4</td>
<td>22.4</td>
<td>22.4</td>
</tr>
<tr>
<td>• heavy fuel</td>
<td></td>
<td>15.4</td>
<td>7.0</td>
<td>5.8</td>
</tr>
<tr>
<td>• coal</td>
<td></td>
<td>-</td>
<td>31.2</td>
<td>18.4</td>
</tr>
<tr>
<td>• wood waste</td>
<td></td>
<td>35.4</td>
<td>31.6</td>
<td>17.8</td>
</tr>
<tr>
<td>Fuel price</td>
<td>USD/MWh</td>
<td>13</td>
<td>13</td>
<td>13</td>
</tr>
<tr>
<td>• natural gas</td>
<td></td>
<td>16</td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td>• heavy fuel</td>
<td></td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>• coal</td>
<td></td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Heat production cost</td>
<td>USD/MWh</td>
<td>21.8</td>
<td>18.6</td>
<td>17.4</td>
</tr>
<tr>
<td>• natural gas</td>
<td></td>
<td>27.4</td>
<td>23.2</td>
<td>22.0</td>
</tr>
<tr>
<td>• heavy fuel</td>
<td></td>
<td>-</td>
<td>30.2</td>
<td>25.0</td>
</tr>
<tr>
<td>• coal</td>
<td></td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>• wood waste</td>
<td></td>
<td>31.8</td>
<td>32.4</td>
<td>26.0</td>
</tr>
</tbody>
</table>

In the preliminary evaluation it should be considered that CHP usually covers 50 – 60% from thermal power demand and 80-90% from annual heat demand.

In order to be able to preliminary evaluate and compare the indicators for capacity availability, some usual values from Denmark and Finland (countries with large experience) are presented in table A.6 [12]

#### Table A.6 Specific indicators for CHP

<table>
<thead>
<tr>
<th>Fuel type./CHP capacity</th>
<th>Number of CHP</th>
<th>Denmark</th>
<th>Finland</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F1 [%]</td>
<td>F2 [%]</td>
<td>F3 [%]</td>
</tr>
<tr>
<td>Gas, oil</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50-99</td>
<td>3</td>
<td>94.7</td>
<td>3.6</td>
</tr>
<tr>
<td>100-199</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>200-400</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50-99</td>
<td>6</td>
<td>78.2</td>
<td>13.3</td>
</tr>
<tr>
<td>100-199</td>
<td></td>
<td>4</td>
<td>78.7</td>
</tr>
<tr>
<td>200-400</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wood waste</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50-99</td>
<td>8</td>
<td>93.6</td>
<td>4.5</td>
</tr>
<tr>
<td>100-199</td>
<td></td>
<td>7</td>
<td>84.0</td>
</tr>
<tr>
<td>200-400</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note:
- F1 – availability indicator = E1/E2;
- E1 – annual max. energy at available capacity;
- E2 – annual max. energy at max. capacity;
- F2 – indicator for planned shut-down of installation=E3/E2;
- E3 – annual energy losses by planned shut-down;
- F3 – indicator for accidental shut-down=E4+E5/E2
- E4 – annual energy losses by accidental shut-down;
- E5 – annual energy losses by maintenance shut-down;

In the first two years and after 20 years of operation bigger values of F2 and F3 are expected;

Specific indicators for network piping:

The pipes from a DH transport and distribution network have a specific importance in rehabilitation decision because all these components accounts for 50% (average) from total investment.
Piping rehabilitation pipes network should be based on a preliminary qualified reconsideration of existing heat demand for the analysed area and for future development (there is a very well known bad effect of disconnection process in Romania on over sizing of rehabilitated pipes).

The main types of European network are:
- radial network – specific for small DH systems; the accidental shut-down could affect important areas; the future development is difficult and for this reason the design for maximum future capacity is recommended from the beginning;
- ring network – is useful for large heat supply areas, usually in the big towns with different CHP; high investment cost could be justified by the increased safety of heat supply;
- multiple-ring network – is an improved variant of ring network, which offers a minimum two possibilities for heat supply meaning a more increased supply safety; but more investment is needed;

Regarding new available technologies, the pre-insulated pipes, using plastic materials, are usually utilized for temperatures of 120 C (continuous operation mode), and 140 C (variable operation mode)[12].

Testing conditions are mentioned in European standard EN 253.

An important element in reducing the network execution cost is the methodology for pipes underground location. The Western European methodology shows good results in diminishing mounting cost with 30%, and has the following aspects:
- a minimum depth underground;
- no specific underground inclination for pipes;
- direct mounting of fittings (fixtures) underground; no specific works are needed;
- no fixed points in the system;
- no maximum length restrictions for pipes;

The very recent technologies are able to further reduce the mounting cost by:
- cold mounting process;
- mixture of river sands to cover the pipes without additional operation to compress the sand;

In the specific situation of network rehabilitation different variants of pipes location are recommended:
- in the upper side of the existing channel, without removing the old pipes;
- in the lateral side of the existing channel, without removing the old pipes;
- in the existing channel after removing of the old pipes;
- completely new construction in the existing or new places;

Some informal data regarding life-cycle period of time, maintenance cost and starting operation cost (% from total investment) are available in table below [12] – specific data for comparison with European companies:

<table>
<thead>
<tr>
<th>Main element</th>
<th>Life-cycle period (years)</th>
<th>Maintenance cost [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel pipe, pre-insulated and cold mounted</td>
<td>45</td>
<td>1.5</td>
</tr>
<tr>
<td>Return pipe</td>
<td>30</td>
<td>2.0</td>
</tr>
</tbody>
</table>
b) Thermal substations (ST):

<table>
<thead>
<tr>
<th>ST component</th>
<th>Life-cycle period (years)</th>
<th>Starting operation Cost [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pumps and connection pipes</td>
<td>30</td>
<td>2</td>
</tr>
<tr>
<td>Fittings</td>
<td>20</td>
<td>1.5</td>
</tr>
<tr>
<td>Heat exchangers</td>
<td>12-20</td>
<td>2</td>
</tr>
<tr>
<td>Controls</td>
<td>12</td>
<td>3</td>
</tr>
<tr>
<td>Expansion vessels</td>
<td>15</td>
<td>0</td>
</tr>
</tbody>
</table>

The energy consumption for circulation pumps is around 20-30 kWh/MWh. In this context the cost-effectiveness of variable speed drive systems implementation to replace present control system seems to be interesting.

An economic evaluation shows that a reduction of water pressure with 1 bar/km could be acceptable [12].

Related heat losses in transport pipes (calculated by reporting to total delivered heat) are relatively low in winter period (3%) and important in summer period (25%) when the network is operated at partial load, only for domestic hot water [12].

Water treatment has an important role in reduction of operation cost. A 1 mm deposit on heating transfer surfaces determines a supplementary fuel consumption of 10%. In order to avoid the negative effects of different suspensions (ferrous or calcium mud) it is recommended to filter a minimum 5% from total return water flow by using a magnetic filter with bag.

Financial indicators for DH evaluation [25]

Informative values for financial indicators [12]

Two categories of financial indicators are currently considered:

- one category for estimation of financial situation in local supply company in order to understand the eligibility for commercial credits:
  - another category for estimation of "project bank feasibility" as presented in the methodology for feasibility studies;

A comprehensive estimation of financial position of the local supply company could be undertaken by considering different financial indicators:

- share of subsidies to total heat sales (annual subsidies divided by total heat sales);
- share of unpaid bills to total heat sales, calculated by annual amount of non-paid bills divided by total heat sales; According to our experience, cities having no more than 10-12% unpaid bills have a real chance to be accepted in investment programs.

Note: The aggregate collection rate of main heat producers was below 80% in Romania (2003) [29].
- unit cost for sold heat;
- share of average heat bill per apartment to average income, calculated as total heat billed per block of flats divided by the number of tenants and by the average income per apartment; a share up to 5% in the average income is considered socially acceptable [25] (because the households have to pay also for electricity, natural gas for cooking, etc), but the real present figures could be 2-4 times more;
Considering that energy costs will increase even due to reduction in subsidies for the end user, a socially equitable solution should be implemented, and on the other hand, complex technical and economic measures have to be taken in order to avoid solely passing the costs, resulting from the waste of energy due to inefficient heating systems, onto the end user.

Introduction of metering and control systems, including thermostatic regulating valves and heat cost allocators in the apartments, could be a very efficient way to balance the costs and to offer a guaranty for private investors interested in financing rehabilitation programs for DH.

- share of heat consumed by industrial, commercial and public institution to total heat sold. The experience of different East European countries has shown that, this parameter plays an important role in establishing a good decision for DH rehabilitation: if significant part of industry diminish their production, as result of general restructuring and privatisation process, or switch over their own heat capacity this may cause essential sale losses for the energy supply company, and may induce supplementary fixed costs to the bill for population.

The importance of industrial heat consumption is higher in the decision process to install cogeneration units in DH, because is less depending on the external temperature and generally requires a constant heat consumption.

Unfortunately a lack of a local strategy in this sector determined a strong disconnection process of the existing industrial consumers and a poor marketing policy from local supply company do not motivate new or former consumer to be connected and to participate in the rehabilitation program for DH.

Based on financial data provided by feasibility study the following investment indicators could be used:

- investment cost to saved energy, calculated as total investment cost divided by total energy saved, in USD / saved Gcal per year; The EBRD calculation in 1995 for 14 cities has shown the values for this indicator between 4-31 USD/ saved Gcal per year. As a comparison, a similar case in Poland had 10 USD/ saved Gcal per year.
- saved energy to total heat sales, calculated as estimated saving potential divided by total estimated heat sales;

An example of financial analysis in different Romanian towns can be seen in table A.7 using the methodology proposed in chapter A.2.

### Table A.7 Financial analysis

<table>
<thead>
<tr>
<th>Town no.</th>
<th>Share of subsidies %</th>
<th>Share of unpaid bills %</th>
<th>Cost of heat USD/MWh</th>
<th>Household heat expenses/income %</th>
<th>Other cons./Population cons. %</th>
<th>Total financial score %</th>
</tr>
</thead>
<tbody>
<tr>
<td>no.1</td>
<td>11.44</td>
<td>14.15</td>
<td>8.29</td>
<td>5.3</td>
<td>12.98</td>
<td>21</td>
</tr>
<tr>
<td>no.2</td>
<td>29.19</td>
<td>38.03</td>
<td>10.76</td>
<td>7.11</td>
<td>7.96</td>
<td>17</td>
</tr>
<tr>
<td>no.3</td>
<td>4.76</td>
<td>28.14</td>
<td>12.23</td>
<td>10.5</td>
<td>40.66</td>
<td>13</td>
</tr>
<tr>
<td>no.4</td>
<td>30.65</td>
<td>57.74</td>
<td>13.92</td>
<td>9.46</td>
<td>44.87</td>
<td>7</td>
</tr>
</tbody>
</table>

Management indicators:

Management capability in local supply companies is also important in ensuring the success of the rehabilitation project. In this context specific management indicators should be established:
management team concept for a future energy supply; according to the recent legislation the responsibility for heat supply is transferred to local authorities.

management team attitude towards competing within a more competitive environment; a big challenge is to compensate the impact of a very active marketing policy implemented by the natural gas companies and equipment suppliers in favour of installing small individual boilers.

management team investment and financial planning strategy;

Some managerial characteristics identified by us in different local companies are:

- interesting strategic planning with emphasis on technical solutions, and less on sales and prices estimates;
- only few companies try to evaluate their profit on long-term basis;
- a big number of companies are able to perform feasibility studies and financial plans;
- some municipalities and their local companies facing big difficulties in operating DH decided to stop efforts for rehabilitation and allow people to act on their capability to install different individual heating sources;

In the specific conditions of Romania modern management could play a very important role in increasing operational performances of actual systems, but also in DH promotion in competition with individual heating systems, which are rapidly developed in absence of adequate regulations.

In this context a modern marketing focused on increasing market share of DH must have the following objectives:

- identification of target groups and relevant persons involved in establishment of heat supply options;
- private consumers;
- industrial consumers (including small and medium sized enterprises), when the responsible person in charge for energy has an important role;
- regulation authorities for energy market with clear responsibilities in ensuring fair competition, tariff transparency and necessary regulations for national and local strategy implementation;
- market evaluation based on following aspects:
  - potential consumers awareness about local heating company and DH advantages;
  - consumers perception and assumption as concerns thermal comfort;
  - main criteria used by consumer in selection of heating system;
  - who are the potential consumer ready to take a decision for the next period of time, or for long term;
  - what are the heating market segments: the components of a heterogeneous market in partial homogenous markets, for which a well focused offer could be provided;
- implementation of the concept for "market-mix" – a simple comparison of expenses for heating is not favourable for DH systems; it is important to increase the visibility of different other factors by:
  - supply policy – providing requested services together with heat by using DSM concept;
  - consulting;
  - 24 hours services;
  - billing services based on metering devices;
  - performance contracting;
  - sales policy – a specialised structure of customer department is needed in order to address specific group of consumers by using modern instruments such as: data basis, software, etc.
  - support for other market partners: common training, common promotional activity for relevant equipment, etc.
  - communication policy – relevant target groups has to be considered (not only customers) which are able to
influence customer choice: media, educational system, etc.

### A.4 Evaluation methodology for DH rehabilitation

Having all necessary data regarding the indicators different weighting options could be proposed according to the priorities or criteria of local energy policy. A model to use this methodology is presented below:

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Option no.1</th>
<th>Option no.2</th>
<th>Option no.X</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical</td>
<td>20%</td>
<td>30%</td>
<td>X,%</td>
</tr>
<tr>
<td>Financial</td>
<td>30%</td>
<td>30%</td>
<td>X,%</td>
</tr>
<tr>
<td>Investment (Feasibility Study)</td>
<td>40%</td>
<td>30%</td>
<td>X,%</td>
</tr>
<tr>
<td>Management</td>
<td>10%</td>
<td>10%</td>
<td>X,%</td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

For a selected option a more detailed evaluation or a detailed feasibility study will be necessary after negotiations with regulators, banks, international financial institutions, etc.
ANNEX 1

TEST for establishment of municipality energy efficiency plan [26]

**Note:** This questionnaire is not an indicator of performance. It has been designed as an interrogative tool to help drawing up the specific problem of energy efficiency in municipal energy policy.

1. Concerning municipal buildings

**What we know?**

<table>
<thead>
<tr>
<th>QUESTION</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>- the entire estate belonging to the municipality and placed under its authority</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- the surface to be heated per building (and for all the buildings)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- the volume to be heated per building (and for all the buildings)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- the thermal characteristics of the buildings (losses, requirements, condition of installation)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- consumption per building and per use (heating, lighting, others)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- consumption per major sectors (schools, cultural facilities, administration)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- consumption per type of energy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- the cost of the energy consumed and the share of energy in the municipal budget</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- the pollutant emission generated by this consumption</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- the public and private arrangements for financial aid towards energy management</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**What we carry out?**

<table>
<thead>
<tr>
<th>QUESTION</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>- periodic reading of the meters (annually, quarterly, monthly, in real time)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- computerised monitoring of the main consumption indicators per building</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- an annual balance of consumption (and savings made), both overall and per building</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- comparison over time(per building)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- comparison with other buildings in the estate with similar use</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- comparison with the buildings of other municipalities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- the periodic dissemination of the results obtained to the elected representatives and the population</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- the drawing up of the specification for new constructions, systematically integrating an energy simulation</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### What we have available?

<table>
<thead>
<tr>
<th>QUESTION</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>- an elected representative responsible for the energy consumed in the municipality buildings</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- a municipal technical team specialised in this sector (buildings)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- a series of quantified objectives for energy and financial savings and reduction of pollutant emissions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- a long term improvement program</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- an annual budget for energy management works</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- concrete results of works on insulation, renovation of heating equipment; control / programming, cogeneration, remote management</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 2. Concerning energy distribution in the city:

#### What we know?

<table>
<thead>
<tr>
<th>QUESTION</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>- the city overall consumption</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- the distribution of consumption per sector: housing, services, industry, transport</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- the distribution of consumption per district</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- the distribution of consumption per type of energy: electricity, gas, heat, fuel oil, etc.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- the share of energy produced locally</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- the share of energy produced using local resources(urban waste, wo, wood, bio-gas, hydroelectricity)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- the pollutant emissions generated by the city energy consumption</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- the trend of different indicators</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- the exact content of the contracts placed with the energy distributors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- the legal and financial arrangements most suited to our situation</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### What we carry out (or have been carried out by others)?

<table>
<thead>
<tr>
<th>QUESTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>- a report on the progress of consumption per sector and per type of energy</td>
</tr>
<tr>
<td>- comparison with the data of other cities</td>
</tr>
<tr>
<td>- regular monitoring of the technical and energy performances of energy production and distribution installations</td>
</tr>
<tr>
<td>- the use of local resources for energy production (wo, wood, bio-gas,</td>
</tr>
</tbody>
</table>
What we have available?

<table>
<thead>
<tr>
<th>QUESTION</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>- quantified objectives related to the improvement of local public and</td>
<td></td>
<td></td>
</tr>
<tr>
<td>private production</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- a cogeneration development plan for the city</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- a renewable energy development plan</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- quantified objectives for reduction of energy consumption and pollutant</td>
<td></td>
<td></td>
</tr>
<tr>
<td>emission</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- an elected representative responsible for energy supply</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- a municipal technical team specialised in energy and in relations with</td>
<td></td>
<td></td>
</tr>
<tr>
<td>statutory companies</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- an action plan to organise the supply and distribution of different</td>
<td></td>
<td></td>
</tr>
<tr>
<td>forms of energy</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. Concerning the consumption of population and activities:

What we know?

<table>
<thead>
<tr>
<th>QUESTION</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>- the public and private actors involved in development and city planning</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- the associations representing tenants, owners, consumers, environmental protection</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- the main problems encountered by energy consumers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- the level of reaction of local opinion with regard to energy efficiency activity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- the actions carried out by private and public participants throughout the city</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- the structures and arrangements intended to aid and support energy management schemes</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

What we carry out; (or have been carried out by others)?

<table>
<thead>
<tr>
<th>QUESTION</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>- energy impact calculations concerning the choice of development and transport</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- choices of development and transport which systematically integrate an energy dimension</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
- periodic meetings between managers of different municipal services
- the regular dissemination of information on energy efficiency to the decision-makers and population
- the systematic distribution of information to all applicants for building permits
- regular visits to efficient municipal installation serving the public
- regular meetings with the different participants of the city interested in energy
- actions concerning the population, in order to make them aware of economic technologies and practices (demand side management, low consumption lamps, solar heating, insulation, control, etc.)
- regular relations with regional and national energy management agencies

What we have available?

<table>
<thead>
<tr>
<th>QUESTION</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>- an elected representative responsible for energy consumption and pollutant emissions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- a municipal technical team with the same responsibility</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- local regulations for urban planning and development which integrate energy efficiency standards</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- an independent energy advice centre open to the public</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- a document presenting the city objectives concerning energy efficiency</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- documents presenting successful actions in the city and their results</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- a specialised “energy efficiency / environment” heading in the municipal journal</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>