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Making district heating happen: empowering users through fair metering

Policy paper on infrastructure



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Introductory notes

District heating (DH) systems in early transition countries require urgent investment in order to maintain current service levels for their consumers and avoid major breakdowns. In addition to this, customer heating demand and primary energy consumption for generation is considerably higher than in western Europe or Scandinavia. A lack of metering or consumption-based billing means that DH customers often have little incentive to reduce their consumption.

The EBRD is widely involved in the financing of heat generation and transmission infrastructure investments. The Bank has already set broad guidelines for financial sustainability in the sector in a previous policy paper, *“Making district heating happen: pathways to financial sustainability”*. This paper investigates specific solutions covering demand-side management policies of DH companies and consumption-based billing (CBB). Putting incentives in place for DH customers to implement demand-side measures in their properties while ensuring the financial sustainability of DH utility companies is vital to the health of the sector in the EBRD regions.

In early transition countries most DH systems are supply-driven and lack individual metering or controls. Central heat production is determined by the operators of the boiler plants according to technical standards and does not follow actual customer demand. Heat distribution is unbalanced and most apartments are either over- or under heated.

In order to develop DH systems in a sustainable way, planning and development must be based on consumers' actual heat demands. This leads to optimally sized heat generation, transmission and distribution infrastructure and, most importantly, heating bills that reflect actual consumption levels.

The DH sector urgently needs reforms that will move it towards more customer-oriented management. The implementation of CBB is the first step on the path to a demand-driven customer-oriented heat supply. Investment in the devices required to implement CBB – such as heat substations, central heat meters, thermostatic valves and heat cost allocators – is one of most attractive saving measures for DH companies.

The paper clearly defines the levels of CBB available in DH systems and explains the technical differences. It presents a roadmap of the necessary measures for implementing CBB in the most common types of DH systems. It discusses household, building and country-level impacts and identifies technical, legal and regulatory challenges, with examples of how they were overcome in other countries. The paper and its messages are intended for DH utility managers and government officials working on policy in the sector.

The policy paper was drafted following a seminar and workshop on “Introducing individual metering and demand-side measures in district heating systems in EBRD countries of operations” held in the summer of 2018, in Vilnius, Lithuania. Representatives from more than 10 countries participated in the event, where different issues related to CBB and demand-side measures (DSM) were presented and discussed.

We would like to thank the DH sector representatives from the countries of Belarus, Bosnia and Herzegovina, Kazakhstan, the Kyrgyz Republic, Lithuania, FYR Macedonia, Moldova, Romania, Serbia and Ukraine for their contributions, as well as Šarūnas Prieskienis from Ekotermija who acted as external consultants in the preparation of the paper.

This paper is one of a series of policy papers on the infrastructure sector prepared over the course of 2016, 2017 and 2018 that the EBRD has funded through its Infrastructure Project Preparation Facility (IPPF). The IPPF's mission is to disseminate good practice and knowledge in addition to preparing projects for economies where the EBRD invests.

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Abbreviations and glossary

CHS	Central heating substation: part of the district heating supply system that prepares, distributes and delivers heat and hot water to two or more buildings. From the centralised substation heat and hot water is supplied for buildings with four-pipe systems (two for hot water and two for heat for space heating)
CHP	Combined heat and power
CBB	Consumption-based billing
CDHS	Closed district heating system: all district heating water supplied to users' systems is returned to heat generation sources and hot water is prepared in heat exchangers in consumer-side heat substations.
DDS	Demand-driven district heating system
DSM	Demand-side measures
DH	District heating
EE	Energy efficiency
DHW	Domestic hot water
EBRD, the Bank	European Bank for Reconstruction and Development
EU	European Union
GCal	Gigacalories
GHG	Greenhouse gas emission
HCA	Heat cost allocator
IHS	Individual heating substation
IPPF	Infrastructure Project Preparation Facility
€	Euro
km	Kilometre
kWh	Kilowatt-hour
MWh	Megawatt-hour
ODHS	Open district heating system: where part of the heating water from the district heating network is directly used as hot water and is not returned to heat generation sources.
SCADA	Supervisory control and data acquisition
SDS	Supply-driven district heating system
UMTS	Universal Mobile Telecommunications System, a third-generation mobile cellular system for networks based on the GSM standard

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1. Executive summary

This paper looks at ways to promote consumption-based billing (CBB) and demand side management (DSM) in the district heating (DH) sector. It pursues this by identifying challenges and possible solutions and reforms relevant to the economies where the EBRD invests.

This paper was commissioned by the EBRD and has been prepared by Ekotermija in collaboration with the EBRD. The views presented in this paper reflect observations on the challenges in the EBRD regions as noted by participants at the seminar held during the course of the assignment. The paper is built on the experiences of different stakeholders from Bosnia and Herzegovina, FYR Macedonia, Kazakhstan, the Kyrgyz Republic, Moldova, Belarus, Ukraine, Serbia and Romania.

CBB and DSM have long been utilised in the electricity and gas sectors. The potential for CBB and DSM in the DH sector is less recognised and may be underestimated, in spite of the fact that countries that have implemented CBB and DSM in their DH sectors have demonstrated positive results. This paper explains the specifics of CBB and DSM in the DH sector and highlights the impacts of CBB and DSM for the affected stakeholders, that is, consumers, DH entities, state and local governments.

Progress in the implementation of individual consumption-based billing has been slow. Corresponding laws often only stipulate the implementation in parts, mostly limited to metering at the building level. In Serbia, for example, the law only requires installation of heat substations and central heat meters in new buildings. Despite the positive impacts and good economic results demonstrated in many countries, consumption-based billing is not widespread. This paper analyses the reasons for this peculiar phenomenon.

Through discussions with seminar participants, augmented by desktop research, this paper identifies issues that need to be addressed in the EBRD regions to empower consumers through implementation of CBB and DSM in the DH sector. The challenges are discussed in the following categories: technical, legal, financial and regulatory.

The vast majority of the challenges revealed reflect the incompleteness or absence of governance frameworks for CBB and DSM in the DH sectors of these economies. Significant improvement of CBB and DSM policies requires the development of proper legal and regulatory frameworks to enable and incentivise stakeholders to implement CBB and DSM reform.

Therefore, this paper identifies a longlist of policy options and aggregates them into a coherent set of recommendations in the form of a policy “roadmap”.

It is likely that central governments need to act as the driving force to promote the suggested changes, although involvement of other stakeholders, such as regulators, municipalities, DH companies, consumer associations, and so on, is essential to implement large-scale changes. This paper presents the necessary technical, organisational and regulatory actions to implement CBB and recommends the gradual implementation of the suggested reform in three main phases.

The first phase ends with the approval of the law on consumption-based billing for heating. The second phase is the implementation of the law. The third phase is the switch of supply to demand-driven DH companies.

The authors of the paper recognise that the specific timeframe of the roadmap must be developed individually for each country, subject to that country's specific environment and internal decision-making processes.

The next step for countries aiming to move forward with the recommendations of this paper is to assess the specific local challenges and determine a way to apply the suggested actions. This paper aims to guide decision makers through both steps.

2. Introduction

This paper aims to demonstrate experiences from countries that have transitioned from a generation-led DH sector to a consumer-demand-driven sector model; to identify barriers to switching to such a model in economies where the EBRD invests; and to suggest realistic measures for the main stakeholders to move from their present situation to reach a model where consumer bills more accurately reflect individual consumption.

It builds on the experiences and views expressed in the EBRD's recent seminar in Vilnius,¹ where discussions focused on the identification of key issues faced by these economies in the area of introducing CBB and DSM, empowering consumers and increasing the DH sector's sustainability and financial viability. The scope of the paper is the DH market, but neighbouring sectors are discussed where relevant.

2.1. Structure of the policy paper

- The remainder of this section sets out the framework used in this paper to analyse the potential for implementation of consumption-based billing and demand-side measures in the DH sector, including provision of a general understanding of CBB and DSM. It also outlines current practice and progress towards CBB and DSM implementation in DH systems by economies in the EBRD regions.
- Section 3 provides a roadmap of technical-organisational measures to establish efficient CBB in DH systems. The roadmap details the actions to be performed and average costs to be estimated under four main categories: (i) modernisation of pipe systems, moving from open district heating systems (ODHS) to closed district heating systems (CDHS) and installation of an IHS (individual heating substation) at building level; (ii) decentralisation of hot water supply; (iii) installation of IHS and heat meters at building level; (iv) introduction of apartment level heat cost allocators (HCAs) and controls and implementation of DSM in apartment buildings.
- Section 4 describes the effects of CBB on heat customers and DH companies. It also provides cost estimates for three levels of CBB and DSM installations – individual property level, building level and country level.
- Section 5 discusses the main challenges encountered when implementing CBB and DSM, including technical, legal, and regulatory challenges. A practical approach is used to identify challenges, which need to be addressed in order to establish a proper framework for CBB and DSM.
- Section 6 is a summary of the main principles, concepts and findings.

¹ A seminar and workshop on “Introducing individual metering and demand-side measures in district heating systems in EBRD countries of operations” held in the summer of 2018, in Vilnius, Lithuania.

2.2. Understanding consumption-based billing and demand-side management

The fundamental philosophy of the CBB model is that a consumer pays according to the services that they use or consume. CBB is the opposite of a subscription-based model under which consumers simply sign up for a service on a time-frame basis and enjoy infinite use for a flat rate.

The CBB model is well known and generally used for electricity or natural gas billing. When applied to DH, the consumption-based billing model enables consumers to pay for the thermal energy units they have actually used in their property. Naturally, CBB requires metering devices to be installed for billing to correctly reflect the amount of energy consumed.

In order to benefit fully from CBB, consumers should be able to control their own usage. This consumption control is an essential part of CBB. Therefore, when discussing CBB we refer to the entire system which starts with a building-level IHS and ends with thermostatic valves (with a heat meter or allocators) at an individual consumer's property. This type of CBB provides the highest degree of consumer empowerment and delivers the best results in terms of demand-side energy efficiency. Consumption-based billing does not guarantee energy efficiency per se; it is rather a necessary precondition to gain the financial benefits from DSM due to increased energy saving.

There are cases when only a building-level heat meter is installed at the IHS, which does not allow individual control by property owners within the building. This is called "consumption-based billing on a building level". This, still being a collective solution for all property owners of a given building, provides quite limited consumer empowerment and incentives for energy saving. This solution is still considered to be a form of CBB when the building is an organisational unit such as a commercial building with one owner, a school building, or a family house and so on. However, when building-level solutions are applied to multi-apartment buildings this should be considered the first step in the process. Note that in some cases additional improvements are needed to the building's internal heat distribution system to install and correctly operate such measurement systems. In this paper, when CBB on a building level is discussed, it is specifically highlighted.

Full CBB should cover metering of heat at an individual consumer level.

Figure 1. Three levels of heat consumption measurement

Technology level	Heat measurement point		Level of savings	Distribution of benefits
Building-level measurement	Meter at IHS	Measures heat supplied to the building	Potential to save at building level	Benefits of savings at the building level are distributed equally to apartments according to floor space
Apartment-level measurement through allocation	Meter at IHS	Measures heat supplied to the building	Potential to save at apartment level	Part of the benefits from the heat saved in the apartment is reflected in the apartment bill
	HCA's on the radiators	Allocation of consumed heat between the apartments		HCA's are less exact than heat meters but result in the same amount of savings
Apartment-level measurement through meters	Meter at IHS	Measures heat supplied to the building	Potential to save at apartment level	Nearly all the benefits from the heat saved in the apartment are reflected in the bill
	Meters for each apartment	Measures heat supplied to the apartment		

In older systems domestic hot water (DHW) is usually metered by a simple flow or hot water meter. Hot water meters work on the same principle as cold-water meters, but are designed for higher temperatures, up to 90°C. They are considerably cheaper than heat meters. The amount of heat consumed through DHW consumption is calculated based on the temperature and the volume of the hot water supplied. This type of metering is not as accurate as a heat meter because the DHW supply temperature is not constant. But it has the same effect in terms of savings by households as more precise metering with heat meters.

There are different concepts for DHW metering. A hot water meter can be linked to an apartment-level heat meter. In the case of vertical distribution systems, it can communicate with an IHS or central receiver in the building.

It should be noted that hot water meters and heat meters have different calibration periods. When one meter has to be removed, the other meter also has to be partly disassembled. Therefore, a separate solution is recommended, where the hot water meter autonomously communicates with the central data receiver.

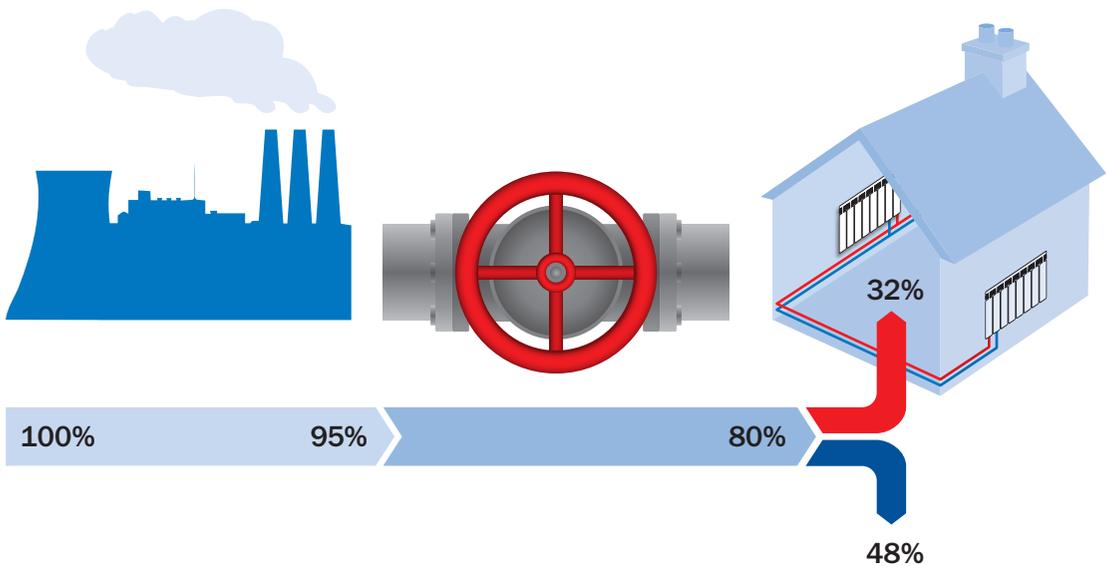
2.3. The context for the model of CBB and DSM in district heating

Historically, economies where the EBRD invests have had large-scale DH systems in urban areas. These systems help to achieve wider energy-sector goals, such as increasing the use of renewable energy sources, improving energy efficiency through employment of combined heat and power (CHP) sources, and reducing greenhouse gas (GHG) emissions and other pollutants. However, the widespread use of district heating is often offset by low competitiveness compared to other heating systems due to technical losses and a lack of consumer control. The district heating sector

currently faces a major challenge to survive in the heating market.

In a typical Lithuanian DH system, only 48 per cent of the primary fuel is used for space heating and hot water preparation; 52 per cent² of the primary fuel is used to cover heat losses in the production, transmission and demand side. The highest energy-saving potential is on the demand side (buildings), with losses of up to 32 per cent. The heat production and transmission phases have much lower energy efficiency potential.

Figure 2. Heat losses in district heating systems³



² Lithuanian District Heating Association data (2018).

³ Heat losses in pipes depend on a number of factors, such as quality of insulation, heat density, pipe diameter, flow, temperature, and so on. The diagram gives a general outline of the magnitude of the respective losses. Typical comparable heat losses in DH systems in western and northern Europe are about 8-15 per cent. The corresponding level is about 15-25 per cent in eastern Europe. Svend Frederiksen, Sven Werner, "District heating and Cooling", Studentlitteratur AB Lund (2013).

In addition to poor energy efficiency, many DH companies also have severe financial problems. These problems are mainly due to low payment discipline, sporadic disconnections of consumers, below-cost tariffs, theoretical heat consumption norms (kWh/m²) which do not correspond to realistic consumption, and the suspension of state subsidies. Increased energy efficiency and energy savings at the demand side through implementation of CBB and DSM, when applied alongside appropriate policy measures, can significantly improve the performance of the sector.

To analyse the current practice and progress towards CBB implementation in DH systems, a survey of nine countries in the EBRD regions was conducted in the framework of this policy paper. The survey revealed:

- Building-level CBB is developing rapidly in most of the countries analysed. Implementation levels differ, ranging from 100 per cent in Lithuania, 100 per cent in Bulgaria, 98 per cent in Bucharest (Romania), 95 per cent in FYR Macedonia, nearly 93 per cent in Poltava (Ukraine), 80 per cent overall in Ukraine, 63 per cent in Kazakhstan (ranging from 99.8 per cent in Astana to 27 per cent in Aktau), 30 per cent in Banja Luka (Bosnia and Herzegovina), 29 per cent in Bishkek (Kyrgyz Republic), and 27 per cent in Belgrade (Serbia) to 18 per cent in Sarajevo (Bosnia and Herzegovina).⁴
- Apartment-level CBB is still in the early stages of development in most of the countries analysed. In Bishkek (Kyrgyz Republic), only 0.039 per cent of heat sold is measured by apartment level meters, rising up to 5 per cent in Poltava (Ukraine). Pilot projects for apartment-level CBB are being implemented in Bosnia and Herzegovina, FYR Macedonia and Kazakhstan. In Bucharest (Romania), 32 per cent of heat is sold through apartment-level CBB, due to new legislation requiring apartment-level heat meters or heat allocators if metering devices cannot reasonably be installed. New buildings are required to install

apartment-level heat consumption meters in most of the analysed countries.

- Requirements for building-level heat meters and CBB are already in place in most of the countries analysed, but there are many factors delaying implementation at different stages. Apartment-level CBB in most of the countries is only applied in new (heat meters or HCAs) and renovated (HCAs) buildings. A lack of heat metering and CBB means that the majority of DH customers in the EBRD regions will see little or no reduction in their bills if they reduce their individual heat consumption; this means that consumers lack incentives to reduce their consumption and increase residential energy efficiency.
- In some economies where the EBRD invests, DH customers have average indoor temperatures of 25°C, even though the internationally recognised recommended indoor temperature is 21°C. In a climate like Kazakhstan, reducing indoor temperatures by 1°C can save around 4.5 per cent of annual space heating consumption; by simply reducing indoor temperatures to their recommended levels, consumption could be reduced by 18 per cent.
- Installation of an automated building-level IHS is one of the most economically feasible DSM. An IHS optimises heat supplied to the building in accordance with outside temperatures and building consumption. Installation of automated IHSs in most of the countries analysed is in the early stages of development. For example in Poltava (Ukraine) only 14 out of 1,438 buildings connected to DH are equipped with automated IHSs; in Banja Luka (Bosnia and Herzegovina) and Bishkek (Kyrgyz Republic) there are no automated IHSs. More progress is observed in other countries – for example in Skopje (FYR Macedonia) and Belgrade (Serbia) nearly 100 per cent of multi-apartment residential buildings have been equipped with automated IHSs.

⁴ Data and information from the participants of the EBRD international seminar “Infrastructure-EPG policy dialogue: Demand-side management in the District Heating sector. Introducing Individual Metering and Demand Side Measures in District Heating Systems in EBRD Countries of Operations” held in Vilnius, Lithuania 27-28 June 2018.

2.4. Objectives for the DH sector

This section provides the objectives that DH policy should ultimately aim to achieve and describes how CBB and DSM can help.

- **Financial and operational sustainability** – ability to cover current operational costs and expected future capital costs and earn a sufficient rate of return to secure access to capital for future investment needs (under the condition that the DH utility operates efficiently)
- **High quality of service** – continuity and reliability of DH service provision, and a consumer-focused DH utility
- **Operational efficiency** – increasing organisational, technical, and resource efficiency in order to eliminate historical inefficiencies and reduce the costs of DH service. Higher efficiency also results in reduced CO₂ emissions.

The main objective of this policy paper is to provide information for decision-makers on how to increase the competitiveness of DH and reduce bills for consumers by introducing CBB and DSM.

The descriptions, examples and case studies in this paper are intended to encourage governments to adopt a corresponding heating cost law and to support decision-makers in municipalities and DH companies to implement CBB.

Participants at the Vilnius seminar referred particularly to the need for legislation as well as regulatory measures to stimulate the necessary reforms for implementation of CBB.

3. Roadmap towards efficient consumption-based billing at the operational level

As stated earlier, this paper focuses on increasing the sustainability and commercial viability of the DH sector by enabling DH customers to reduce their heating bills through CBB and DSM. To illustrate the path towards CBB we assume a “worst case” starting point with no demand-side measures in place and then present the necessary steps and recommended sequence of interventions aimed at bringing a DH solution towards an end-point of cost-efficient consumption-based billing of individual end-users and apartments.⁵

3.1. Key components and concepts

Before presenting the roadmap it is helpful to clarify some of the key components and important concepts which characterise consumption-based billing.

3.1.1. Demand-driven heat supply

In a demand-driven DH system the level of heat production is based on consumer demand.

With CBB, consumers regulate their demand via thermostatic valves and the centralised heat production responds to changes in system demand. The thermostatic valves increase or decrease the flow of warm water through the radiators resulting in higher or lower return flow temperatures. The temperature of the return flow controls the heat production in the boiler. The main result is more efficient heat production, as heat is produced according to the needs of the consumers, no more, no less.

3.1.2. Individual heating substations

The principle of a DH substation is similar to substations used for electrical power supply. In electrical substations the voltage level is transformed from high to low or the reverse, in DH substations temperature and pressure are lowered. Lower temperatures and pressures permit less expensive installations in secondary networks and in buildings. Most DH substations are within buildings and are specific to each building. So less expensive pipes, sized for lower pressures, can be used within buildings. Apartment-level substations are a rather costly concept and are less common.

The latest generation of substations (including large-scale substations) are prefabricated; these IHS have defined technical specifications, described in the catalogues of their producers. Prefabricated, compact substations have reduced installation costs significantly. Different practices at the national level and even DH company level has led to a large variety of different designs of substations. Costs can be reduced significantly if substation designs are standardised.

An IHS may be equipped with an outdoor temperature sensor. The signals from the sensor control a valve so that the IHS absorbs heat from the DH network in line with the outside temperature.

Modern substations communicate with external units via internet or mobile data connections. Remote monitoring by a DH or dedicated service company allows it to use the advantages of central control and regulation systems, which makes immediate action possible if the consumption of heat or cooling is insufficient or unusual. So, for example, the effect of energy-saving measures in buildings can be monitored easily. This makes the use of IHSs an important planning tool for DH companies.

⁵ Before moving to heat consumption measurements at the building or apartment level there are other demand-side measures that can be implemented to improve DH system efficiency. This section presents a step-by-step roadmap of a journey to an efficient DH system with consumption-based billing. Every DH system should determine which step of the progress they are at currently and define the level of DH system development they intend to reach. The applicability of the proposed measures must be checked for each specific DH system.

3.1.3. Hydraulic separation

In a hydraulically open DH system the heat carrier (water) flows directly to consumers' taps and radiators. The water leaving the consumers' radiators flows back to the central boilers. With this system the

buildings' internal piping and radiators is operated at the same temperature as the district heating network. While this system has flaws, it is common where investment funding is limited.

Figure 3. Open-loop district heating system

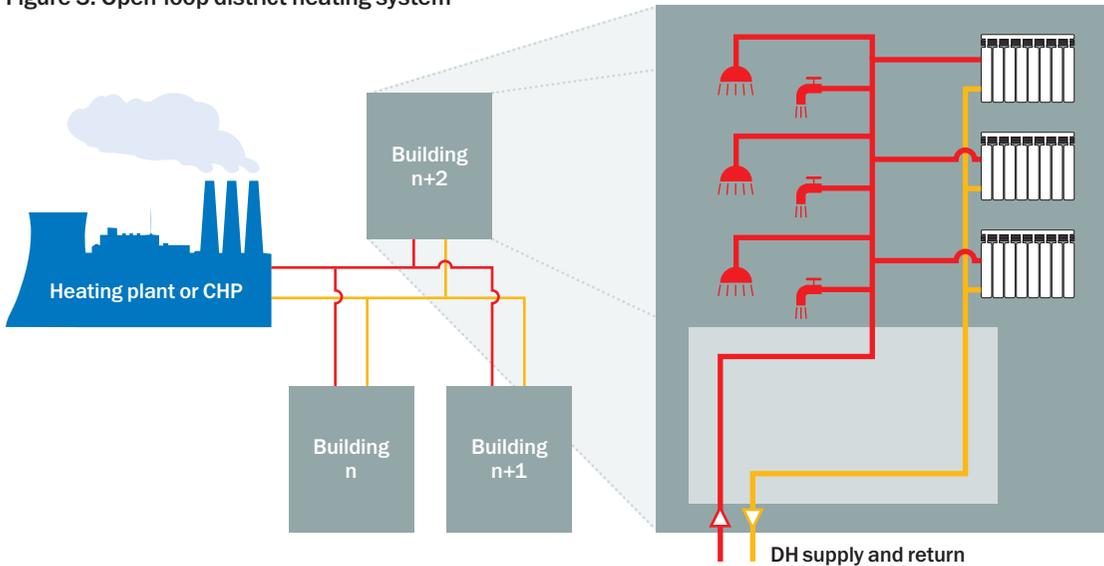
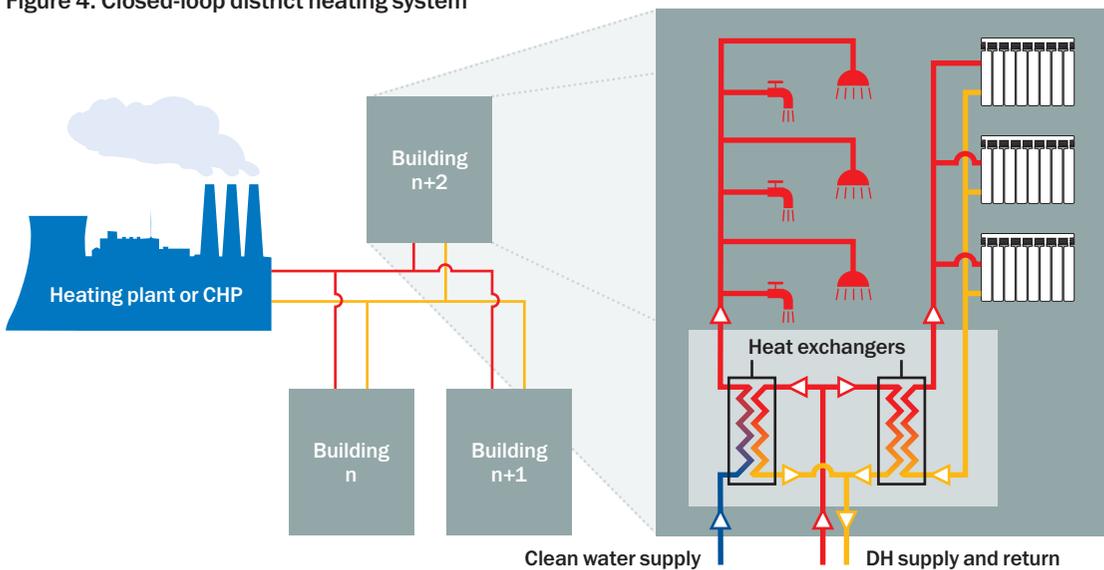


Figure 4. Closed-loop district heating system



The pressure level is determined by the pressure in the DH network and the supply temperature is controlled by means of weather compensation. Recirculation control limits the water temperature to protect people from being burnt when they touch a radiator.

In retrofitted open systems a differential pressure controller located in the supply or return line protects the equipment from high pressure and ensures that thermostatic valves function correctly.

An open system benefits from a simpler design resulting in lower investment and maintenance costs and lower heat transfer losses, which would occur at the heat exchanger.

In a closed system, there is hydraulic separation by means of a heat exchanger between the DH network and the building distribution system. This has the following advantages:

- Protection from pressure surges that may occur in the DH network.
- The heat distribution system and the radiators in the building can be dimensioned for lower pressures than DH networks. This is a special advantage if DH systems are operated in towns with significant variations in elevation.
- In case of leakages, the distribution system in the building is protected from significant damage because of the limited amount of water in the building's distribution system.
- As with leakage, theft of water from the network is more apparent in a closed system due to the limited amount of water in the building's distribution system.
- The pressure level is determined by an expansion vessel.
- The supply temperature is controlled by means of weather compensation.

Weather compensation, by mixing return water with the flow from the network, is a poor method for controlling the supply temperature. Thermostatic valves are better and will maximise the temperature difference across the substation.

3.1.4. Heat cost allocators

HCAs are attached to radiators and measure their individual consumption; they can be mechanical or electronic devices. The first generation of HCAs worked with a calibrated liquid in a capillary tube with a graduated scale, which evaporates due to the heat emitted by the radiator. The rate of evaporation is a function of the temperature of the radiator. Later generations of HCAs are electronic devices, where one or two temperature sensors measure the temperature difference between the radiator and the room air and a microcomputer calculates the heat output over a given period. Modern HCAs transmit their values by radio signals to a receiver outside the apartments. Radio transmission has the great advantage that the devices can be read without entering the apartments.

HCAs are used in buildings where the heating distribution circuit is of vertical type. Vertical circuits consist of multiple pairs of warm (flow) and colder (return flow) pipes that supply the radiators positioned directly above one another on each floor. So, every radiator on the same floor is connected to a distinct pair of vertical pipes.

Heat meters are very difficult to install on radiators in a vertical distribution circuit because they are:

- Bulky: it can be difficult to fit a meter on the flow pipe between the radiator and the wall.
- Expensive: in vertical distribution systems every radiator needs a heat meter. In addition, they have to be changed at defined points in time, which makes this measuring method even more expensive.

HCA do not directly measure the three fundamental physical quantities (temperatures at the inlet and outlet of the radiator, water flow through the radiator) involved in heat transfer. A HCA measures indirect physical quantities, such as the surface temperature of the radiator and the air temperature of the room. HCAs are calibrated in laboratories to specific types of radiators. In reality the thermal characteristics of the radiator do not correspond to the radiator used for calibration. Inside air formation, sediments and limescale change the thermal characteristics of a radiator. This makes it less accurate than a heat meter.

Despite their lower accuracy HCAs are widely used: they are comparatively cheap and most importantly they motivate heat consumers to save energy.

3.2. Roadmap of measures for existing networks or buildings

There are two types of CBB, depending on the number of heat consumers in the building. If the building contains one consumer (like many public buildings or a family house), one heat meter is sufficient.

In residential buildings with more than one heat consumer, the heat consumption of every customer must be metered. Here HCAs can be mounted on each radiator. This is common because most older residential buildings have a heat distribution system with vertical pipes. In a few cases (mainly new buildings), heat distribution is by means of horizontal circuits for each individual apartment. In these buildings, an individual heat meter can be mounted. The savings are equal in both cases.

For CBB to be accurate, heat metering and consumption control by thermostatic valves must be possible for every single consumer. True consumption-based billing on a building level is only possible if the building represents one consumer.

Measure 1A – modernisation of a DH system from “open” to “closed” and installation of automated IHS in buildings

- In an open system the heat carrier from the boilers is directly supplied to the buildings for heating and domestic hot water in a single circuit. In the new system heat transfer to the buildings is done via a heat exchanger. There are two circuits, one circuit for the heat carrier from the boilers through the heat exchanger of the buildings' IHS and back to the boilers and a second circuit in the building which supplies the radiators.
- Benefits of “closed systems” versus “open systems” are presented in the Panevėžys case study in Chapter 5.1.
- The cost of this system includes costs for an IHS and building-level heat meters.
- Installation and commissioning of an IHS takes less than three days. The costs for a typical 200-300 kW IHS are between €3,500-€8,000 without mounting (price varies according to equipment, producer and components for regulation).⁶ Structural criteria are important for the installation effort. The space for the IHS should be easily accessible and provide enough space. Mounting costs vary between €150-€300 per IHS depending on local conditions.
- The costs of central heat meters are about 7 to 8 per cent of the total price (IHS and meter).
- For a cost-efficient installation it is important that the DH companies have the right to enter the buildings, to install the IHS and heat meters.
- For new automated IHS to work efficiently it is important that DH companies or competent service companies have the right to operate and maintain the IHS and control the heat meters. Consumers have to pay for these services.

⁶ Prices are direct from the factory, excluding installation and VAT.

Measure 1B – Decentralisation of hot water supply from central or area substations and replacement with building-level automated IHS and building-level heat meters

- This point is similar to measure 1A in that closed systems replace open systems in buildings. If there is a domestic hot water supply from the central heat substation, then the four-pipe distribution system from the central heating substation (CHS) to the buildings is replaced by a two-pipe system.⁷
- Decentralisation of domestic hot water preparation is a switch from a four-pipe to a two-pipe system in the local heat distribution network. Additional heat losses from hot water pipes for DHW are therefore avoided. The hot water preparation is shifted from the CHS to the building's IHS.
- The costs depend on the technical condition of the old system.
- Installation time ranges from one week to four months per area substation dependent on the number of buildings served by the area substation. In Lithuania, in the city of Ignalina, decentralisation happened in 2008 when the hot water preparation, in two area substations, was shifted to 107 new building IHSs. The project budget was €594,000 and it was implemented (including detailed design and commissioning) within eight months. Heat losses were reduced by over 35 per cent.
- The benefits of this step include:
 - Reduced heat transmission losses and maintenance costs due to fewer pipes – two instead of four.
 - Alignment of the control of building heat consumption with building management.
- Please see the last two bullets under Measure 1A regarding IHS installation and operation which also apply here.

Measure 2 – Introduction of apartment-level HCAs and controls

- Consumption-based billing on the apartment level is possible even in older apartments that lack individual horizontal circuits for each apartment.
- The installation of HCAs partially depends on the heat distribution system. HCAs on radiators only make sense in combination with thermostatic valves. In one-pipe distribution systems thermostatic valves might be problematic. The most common distribution systems are presented in Chapter 5.1.
 - For the installation of HCAs in buildings with a one-pipe heat distribution system (see Figure 17: The three most popular building-level heat distribution systems in the EBRD regions), the necessary steps are shown below:
 - Flush the existing distribution system in the building
 - Achieve hydraulic balancing by using automatic balancing valves
 - Install heat sensors on return risers and thermal actuators on automatic balancing valves
 - Connect electronic controllers in the IHS to the thermal actuators
 - Replace manual valves with radiator thermostatic valves
 - Install bypass restriction
 - Install HCAs on radiators
 - Install signal amplifier in the staircase
 - Transfer data from a central data logger to the DH company or by sending the data to a portable receiver used by readers.
- Costs: A thermostatic valve costs about €20 and an HCA with radio data transfer €15. Mounting costs per radiator are about €4. Mounting costs in a one-pipe system are higher because an additional bypass has to be installed on each radiator (see Figures 8 and 9).

⁷ In a four-pipe system two pipes transport hot water for DHW supply and a further two pipes transport hot water for heating. This four-pipe system can be replaced by a two-pipe system, which transports hot water to the IHS in the building. In the IHS the hot water is split into two circuits in the building. One circuit supplies heat and one circuit supplies DHW indirectly through a heat exchanger.

- Advantages:
 - Individual temperature and heat consumption control for every flat
 - Transparent bills
 - In old-pipe systems it is up to three times cheaper than a replacement two-pipe system.

Measure 3 – Renovation of buildings

- Renovation of buildings means investment in demand-side measures that reduce building energy (heat and/or electricity) consumption.
- Most popular energy efficiency measures:
 - Modernisation of IHS
 - Modernisation (including balancing) of building heat and hot water distribution systems
 - Replacement or installation of ventilation systems (with heat recovery)
 - Roof insulation and replacement
 - Thermal insulation of outer walls (including the removal of defects)
 - Glazing of balconies or loggias, including reinforcement of existing balconies or loggias
 - Replacement of staircase door
 - Replacement of windows
 - Underfloor insulation.
- The building renovation costs depend on the implemented measures. On average, the cost of implementing one project is about €270,000.
- The duration of the project is usually 24 months including detailed design, construction permit, construction works and commissioning.
- Benefits of building renovation:
 - Increase in building value of up to 30 per cent
 - Up to 50 per cent reduction in heat consumption
 - The financial value of the resulting energy savings is normally greater than or equal to the cost of financing renovation
 - Extension of building lifetime by up to 30 years
 - Building maintenance costs are reduced by 80 per cent.
- Challenges:
 - Volatility of the legal environment
 - Insufficient administrative capacity: limited ability of apartment residents to prepare all necessary documents, to perform procurement of contract work, receive and administer credit repayment, and so on
 - Debtors and debts liquidation period
 - Use of uncertified insulation materials
 - Lack of timely financing
 - Long-lasting detailed design services and issuing of construction permits.

4. Impact of implementing consumption-based billing and demand-side measures

This section discusses the impacts of CBB and DSM on the DH consumer, DH entity, and state and the environment, and proposes potential accompanying measures.

4.1. Consumer-level impacts

The customer is at the centre of the corporate philosophy in this model.

One of the most important management principles in modern DH companies is a customer-oriented business approach. Many district heating companies in central and eastern Europe had, and continue to have, severe problems because their customers switched to other heat sources. These companies had, and still have, to manage a lot of fundamental changes and reforms, but the most important challenge is a customer-oriented strategy. Many customers have an incorrect view of the heating sector in their country due to the lack of information or communication policies in district heating companies. For instance, district heating is often mistakenly labelled as one of the most expensive heating systems.

Therefore, the ultimate principle is a customer-oriented business management approach: without the customer there is no district heating.

The change from generation to demand-driven mode should produce not only improved heat supply, efficiency and reliability, but should also ensure a better relationship with customers. Additional services may include:

- personalised technical advisory service for customers including proper operation of internal building installations
- better demand-side management, resulting in smaller heat losses and rationalisation of heat use
- heat supply cost-allocation services in multi-flat buildings and individual settlement account management for apartment residents; this normally increases DH company revenues and improves collection rates.

Consumption-based billing and demand-side measures empower consumers to control their consumption

Often DH systems in the EBRD regions are the only heating option where heat consumption cannot be controlled by customers, unlike gas or electric heating. In some of these economies, the inability to control consumption is paired with a poor quality of heating service – underheating, overheating, interruptions of heat and hot water supply, and so on.

Average consumers are left with the impression that DH is the most expensive form of heating because, in the absence of individual controls, their property consumes heat throughout the entire heating season. The inability to control their own consumption creates the feeling among consumers that they are forced to pay for heat they do not want or need.

Perceiving DH as mandatory, uncontrollable and expensive, consumers often turn to other options and disconnect from the system. For example, many customers complained about the inflexible character of DH service before CBB was implemented in Bulgaria between 2000-05. At the time, producers and vendors of split air conditioners successfully advertised their heaters as the systems with the lowest operational costs, ignoring the fact that district heating supplies heat all day long and the split units only run for a few hours in some of the rooms of the apartment. Some people use their mobile phones to switch their air conditioners on before they leave their office in the evening. During the night the air conditioners work at half power, delivering temperatures below 20°C, and they are switched off again in the morning.

However, in apartments with individual heaters, the ability to control consumption is well provided. Heating duration and volume may be adjusted to the tenants' needs.

If costs per energy unit (€/MWh) are compared in economies of the EBRD regions, just as in other countries, district heating is the most economically feasible option for space heating. Customers will only understand the real cost of DH if they are empowered to control their consumption.

Consumers should also be informed properly about the heat market and the average costs of heating systems.

Consumption-based billing provides transparency to bills

CBB means transparency. Clear and understandable bills are the key element for DH companies' communication with customers. Customers want transparency and cost control in their heating bills as well as regular updates on their consumption – realising that they can save only if they know how much they are consuming. With direct feedback, customers can adjust their consumption behaviour.

A clear and transparent means of providing fixed and variable charges in a bill aids transparency. Breaking down the cost components and listing or referencing those components in bills increase the openness of a DH entity in the eyes of the consumer. Bills supplemented with contact details are helpful if a customer has difficulties in understanding. It is good practice to compare heat consumption from the past years with recent consumption.

DH entities should set out in a heat supply agreement how charges may change. If the charges are based on a comparison or price index data sources and any assumptions behind the calculations must be clearly stated to ensure transparency.

Information shall also be easily obtainable on the heat provider's website. Transparency is an area that should not be underestimated because customer satisfaction can be enhanced considerably through improved communication.

Well-prepared information is a precondition for successful implementation of CBB

A side-effect of CBB is that properties with extraordinary levels of consumption may be revealed. Following the implementation of CBB in Bulgaria it was discovered that some properties had extra radiators connected to the system, some had even converted their balconies to “winter gardens” complete with an additional radiator. These were discovered during the roll-out of HCAs and thermostatic valves; the extra radiators were also fitted with an HCA and added to the official register. Unfortunately the higher consumption costs for these customers were not adequately explained and they developed negative views of CBB.

Protest is usually loud and hard to ignore while happy customers are normally quiet. These protests were popular highlights for the tabloid press and left a distorted understanding about CBB among the wider public. Many people were worried and felt insecure about this reform. It took several years to achieve widespread acceptance of the changes.

A well-prepared information campaign is a precondition for the successful implementation of CBB. This could be done via mass media, leaflets and also local information events with the heat customers. The effects of CBB can be demonstrated through energy audits of the buildings. The audits would demonstrate the effects of CBB and how significantly the actual heat consuming capacities differ from projected capacities.

Consumption-based billing results in higher heating costs for apartments with unfavourable locations in buildings

Apartments on the north side, ground and top floors, usually have comparatively higher heat losses. When billing is made on a flat-rate settlement based on square metres, an apartment’s location does not affect its heating bill. When CBB is implemented, and bills reflect the quantity of heat used in individual properties, heating bills for such properties could increase significantly. In contrast, heating bills for properties in favourable locations such as the south side of the building or in centre of the building having no outer walls, should decrease significantly.

Countervailing measures to deal with different heat losses due to an apartment’s location in the building may be applied to distribute the cost of heat losses through exterior walls. To address the distribution of heat losses in a building, specific methodologies for heat allocation inside a building are applied and correction factors are used for apartments with exposed locations compared with apartments with average heat losses. The use of corrective measures reduces the relationship between actual consumption and billing by a property, however it provides more social fairness.

Consumption-based billing may lead to tariff change

Changes in heating tariffs are always socially and politically sensitive, especially in those countries where a significant share of annual household spending is on heat. The savings achieved through implementation of CBB and DSM allow tariffs to be increased in a socially acceptable way, if the tariff increase is within the range of the energy savings.

Case study: Successful transformation from an inefficient, centrally regulated scheme to a customer-oriented heating service – Debrecen, Hungary

Debrecen, located in the northeast of Hungary has 210,000 inhabitants, with 39 per cent of them supplied by the municipal DH system.

The Debrecen DH Company faced a difficult situation following the end of central government subsidies in 1991; debts ballooned, tariffs increased steeply and further subsidies were required from the municipality. It was clear that the situation was not sustainable.

The municipality decided to reorient their focus away from production and switch to a demand-driven DH supply and began installing IHSs with building-level heat meters. This was done in 1991, before the relevant law on heat cost and heat metering had even passed parliament. In subsequent years, radiators in consumers' apartments were equipped with thermostatic valves and HCAs after a respective regulation was decided in the municipality. Installation was carried out by heat cost allocation service companies, who pre-financed the equipment.

The network was better balanced by dividing it into more sections, each served by a substation as well as improvements to building-level distribution systems. All the while, more and more households switched to consumption-based billing. All these measures reduced losses in the heat distribution network.

The district heating company managed to stabilise the heat price below inflation for all consumers. In addition to the network and DSM the DH Company also prioritised use of waste heat from the Debrecen CHP power plant, a biogas plant and a printing company. An increase in the number of connected customers resulted in more efficient network operation.

Customers were surveyed every two years. Between 1997 and 2002 the number of satisfied customers doubled. Besides technical measures such as reduced stoppages, the DH company also provided information on energy saving. These measures included meetings, leaflets, an energy advice centre, training and after-sales activities such as monitoring

the energy consumption of buildings. These analyses have been used for follow-up improvements. The leaflets describe improvements and future plans and detail how every Hungarian forint of income was used by the company. They also listed easy energy-saving measures such as how to handle a thermostatic valve, how rooms can be ventilated efficiently and examples of successful efficiency projects in buildings of the region. Simplified bills resulted in fewer questions and less pressure on the client service office.

Training of volunteers was offered as well as special training for the representatives of the customers' communities. Volunteers were trained to help their neighbours in realising energy efficiency measures. The volunteers' work was coordinated by the municipality.

The Energy Efficiency Advice Centre which operated between 1997 and 2000 was a very successful initiative. The office was situated in the city centre and was operated by the water, electricity, gas and DH utilities. In its successor organisation, the Client Service Office, customers can come and discuss any problems with heating and district heating. In 2000, 20,000 visitors received advice there, with this number tripling to nearly 60,000 in 2002.

The company was reorganised to improve efficiency, and staff levels were reduced from 348 to 101. The company's hierarchy was flattened so that there were only three levels, leading to a higher level of transparency within the company. Training programmes and study tours were introduced and adapted to fit staff training needs.

Higher service quality resulted in better customer satisfaction with much improved payment behaviour; by 2002 arrears were reduced by 70 per cent. Between 2001 and 2003 the market share for district heating in Debrecen increased by 16.5 per cent or 38 MW.

4.2. Impacts on the district heating company

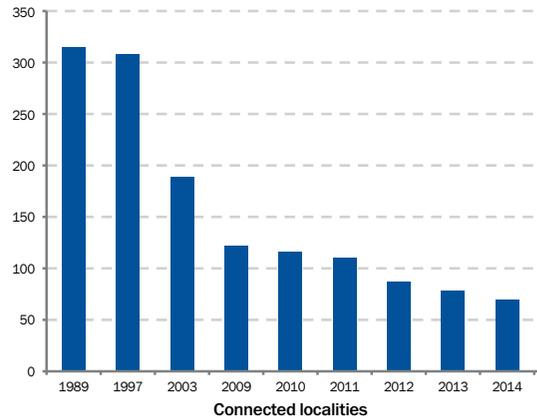
It is immediately striking that the older style of district heating systems prevalent in some economies where the EBRD invests are the only heating systems where heat consumption cannot be controlled by the systems' customers. This gives the wrong impression that district heating is the most expensive means of heating.

In addition, district heating companies without a customer-oriented management policy often have a low service quality. Production comes first, rather than consumers.

Dissatisfied customers pay irregularly and, in the end, may even disconnect from the network. If less than 60 per cent of the customers in a given building are supplied by district heating, then as a rule of thumb it is very difficult to stop the process of disconnection. The ever-shrinking remnant of district heating customers must pay for the heat losses of the entire heat distribution system. So, their heating bills get higher and higher. In the end this causes an avalanche of disconnections and the building is lost.

This is currently happening in Romania where a large number of DH consumers have switched to gas or even wood.

Figure 5. Change in the number of localities connected to DH in Romania



Source: Assessment of the national potential to implement high-efficiency cogeneration and efficient district heating and cooling, Romanian Ministry of Regional Development and Public Administration, Romanian Ministry of Energy

Note: From 2012 to 2016, in Romania, some 215,000 apartments disconnected from the centralised heating systems. However, the number of disconnections dropped from over 62,300 in 2012, to some 52,000 in 2013, and around 30,000 in 2014, then rose again to over 47,700 in 2015, and fell to 22,375 in 2016. A disconnection level of more than 50 per cent is found in approximately 21 per cent of the total number of localities that are still connected to DH. These DH systems will probably not survive.

In Romania subsidies for district heating have been dramatically reduced. Competition with natural gas has not been regulated and consumption-based billing has been implemented very hesitantly. This has resulted in the collapse of district heating systems as many households have switched to gas.

District heating systems without consumption-based billing are supply driven. Heat production does not follow customer demand. In order to ensure sufficient supply, more heat is produced than necessary, which results in a higher cost of supply.

When talking about consumption-based billing, we are always referring to the entire system, from the IHS to the thermostatic valves.

In many DH companies, customer service principles have not been embedded. In the absence of additional measures and regulations, this makes it difficult to limit or stop disconnections.

Therefore, it is surprising that consumption-based billing is not used everywhere.

A switch to a customer-oriented policy must be planned and implemented by the company's management. This is perhaps the largest challenge. Old habits must change, communication within the company has to improve, procedures must be adopted to establish a stable heat supply, a better attitude towards the customer and so on in order to transition to a modern demand-driven district heating system.

Customer benefits should come before process quality. Business volume as a benchmark for success is not enough, and the following questions should be asked:

- Does the business have a customer-oriented approach?
- How high is customer satisfaction?
- Is the organisation geared towards the customer?

Management must be able to view its own business from the standpoint of the customer. Doing so reveals that the following themes are paramount:

- Security of supply
- Contractual matters
- Fair pricing
- Collectability, sales figures, revenues
- Accounting – composition of the bill, mode of accounting
- Confidence in the business, confidence-building measures.

Instead of just producing and delivering heat and electricity, district heating companies must build a relationship with their customers. Customer and staff satisfaction is more important than profit, as once the former has been established, the latter will follow.

Advantages for a district heating company

The following diagram outlines the benefits of consumption-based billing for a DH company. Besides several benefits for the customers, consumption-based billing results in more efficient heat production and improves consumers' payment practice. DH companies reduce their costs of heat production and improve revenues.

Metering at the building level allows a more accurate detection of heat losses in the distribution network and lowers costs for maintenance; response times for major network repairs are reduced.

Usually customers draw a clear link between service quality and heat costs. If the service does not correspond to the heat costs, then the willingness to pay is low. When customers feel well cared for, the cost of heating is less important. Transparency of heat bills and a good service are the best measures to gain customer loyalty.

This results in a sequence of measures. First consumption-based billing should be implemented to enhance payment behaviour and the company's financial situation. Improved transparency is expected to motivate more customers to connect to the DH system. So, fixed costs, such as distribution losses, can be distributed among more customers, resulting in lower heat bills and more investments in the efficiency of heat production and distribution.

Figure 6. Financial sustainability through consumption-based billing



The change from generation to demand-driven mode should not only improve heat supply, efficiency and reliability, but should also ensure a better relationship with customers. Additional services may include:

- personalised technical advisory service to customers including proper operation of internal building installations
- better demand-side management resulting in lower heat losses, rationalisation of heat use
- provision of heat supply cost allocation services in multi-flat buildings and individual account management for apartment residents
- services connected with the operation of substations owned by customers and equipment inside buildings utilising the highly qualified technical personnel of the DH company
- information centre for energy efficiency.

Technical consequences

At first glance, consumption-based billing leads to lower heat sales. On the other hand, DH companies should expect that higher customer satisfaction, better heating quality and more confidence in the heat supplier results in the reconnection of households who had switched to other heat sources (such as electricity or gas).

In addition, the implementation of CBB is expected to free up network and generation capacity, which could be used to connect additional customers or reduce tariffs.

Peak loads are reduced as households do not use heating throughout the day. With thermostatic valves heat consumption is shifted to different periods of the day. This results in smoother boiler operation, as the peaks in the morning and evening get wider. This is very important for biomass boilers as they react very slowly to load changes. Excessive load changes can damage biomass boilers and result in thermal stresses burdening other parts of the district heating system.

Peak-load heat generation often uses more expensive fuels and requires investment in plant that is rarely operated; CBB results in lower fuel costs and reduced investment in generation capacity.

Exact data on demand from heat metering allows DH companies to improve the efficiency of heat generation, which results in lower supply costs. Improved efficiency, and the ability to adjust production to the real heat demand, improves the quality of heat supply. This requires individual automatic heating substations at the building level. Improved heat supply increases customer confidence and trust in the DH company which improves the payment behaviour of the customers. This creates a “win-win” cycle for both customers and DH companies

Figure 7. Win-win cycle for customer and DH company



CBB and DSM reveals thermal energy generation overcapacities

Consumption-based billing leads to average savings between 15 and 25 per cent, compared to levels under the previously prevailing flat-rate billing basis.⁸ Evidence from multiple EU countries demonstrates the potential savings that could be achieved through CBB and DSM.

Case study: Ignalina, Lithuania

The Ignalina case shows that measures must be coordinated with each other. Here, the boilers and DH network were renewed without considering the demand-reducing implementation of consumption-based billing, which was done later.

In the years before 2010 the following projects were implemented:

- Hot water preparation was decentralised by closing two centralised substations and installing 107 automated IHS
- Biomass boilers including condensing gas economisers were built to substitute for heavy fuel oil boilers
- The whole DH transmission network was modernised by installing new pre-insulated pipelines

From 2011-18 over 90 per cent of multiple apartment buildings and some major public buildings were renovated, with demand-side measures fitted. The possibility of reduced heat demand was not considered before the modernisation of heat production and heat transmission.

The implemented DSM had the following results:

- 35 per cent reduction in annual heat sales
- Overinvestments in heat production and also transmission system capacities
- 20 per cent increase in transmission heat losses due to oversized transmission and distribution networks compared to networks sized for the new consumption levels
- 25 per cent overcapacity in heat production facilities
- Inefficient heat production in summer and midseason with base level boiler loads below 20 per cent.

The results are negative because the energy-reducing effect of demand-side measures, which resulted in a lower heat capacity requirement, was not considered before the network generation and transmission upgrades.

⁸ “Effects of Consumption-Based Billing Depending on the Energy Qualities of Buildings in the EU”, Technische Universität Dresden, Faculty of Mechanical Science and Engineering, Institute of Power Engineering, Prof. C. Felsmann, Juliane Schmidt Politechnika Poznańska, Faculty of Civil and Environmental Engineering, Division of Water Supply and Environment Protection, Prof. T. Mróz, (Dec 2015). These savings in residential buildings can only be achieved if the customer can control his/her consumption.

CBB and DSM reveal the actual level of heat losses in DH networks

When CBB is implemented, heat meters are installed in central and building-level substations. This provides better information on heat flows through the DH network, which has following advantages:

- Knowledge about the amount and locations of heat losses
- Better allocation of funds for repairs in the DH network
- Shorter response periods in case of leakages
- Higher service quality of heat supply due to fewer heat supply cuts
- Greater customer satisfaction
- Better payment behaviour.

CBB and DSM help to secure revenue through improved consumer payment discipline

As shown above, the additional network information provided by CBB leads to greater customer satisfaction, which results in improved payment discipline (see the case studies for Debrecen and Plovdiv on pages 18 and 27).

CBB and DSM calls for changes in business practices of DH entity

The majority of district heating systems have been part of state structures incorporated into municipalities or the state energy sector.

In the past, most of the decisions were driven by politics; management was based on the principles of an administration. Managers usually just followed the decisions of the relevant ministry or municipal council. Often, operational aspects are still seen as the most important issues for the management strategy; that is, production and selling of megawatt hours is characteristically one of the main management tasks. There is still little experience with service aspects and consumer-oriented strategies.

The internal organisation of DH companies is hierarchical, with little or no transparency in decision-making, delegation of duties and responsibilities, clear accountability of responsibilities or coaching of staff members.

Through the process of privatisation a variety of different ownership forms developed, with different challenges for the management. To this day, many officially privatised companies, especially those with a majority public share, have preserved their former character, are in the process of internal reforms, and are significantly influenced by public administrators.

Operational aspects (procurement, production, supply, and so on) often remain the most important issue for a manager. Today however, the relationship to the end-user (as a real person) and the staff members has become more and more important.

For an internal management strategy, the following table exemplifies four important responsibilities of a manager:

Customer-oriented management
The relationship with the consumer is essential for achieving economic targets. This principle is also applicable as an internal strategy with reference to staff members. Customer-oriented management is thus systematically incorporated into the business strategy (the staff member is a consumer of the business).
Coaching
Coaching or supervision of staff members, to perform their duties and responsibilities
Leadership
Visions, short-, medium- and long-term strategies
Operational business
Essential technical aspects, control of the business, technical parameters, and so on

Aspects of the switch to a demand-driven heat supply are discussed in Chapters 2 and 3.

4.3. Projected state budget-level impacts

CBB and DSM objectively change demand for subsidies

In many economies where the EBRD invests heating tariffs are still below cost, with subsidies required from the state or municipal budget to make up the difference between the tariff and the actual cost of supplied heat. Subsidy payment is a burden to national finances; however, irregular subsidy payments to DH entities cause multiple issues for the sector, such as shortages of working capital, indebtedness to suppliers and vendors and difficulties retaining qualified personnel.

As demonstrated earlier, CBB and DSM are expected to result in significantly reduced energy consumption. Reduced energy consumption would require a review of heating tariffs and, probably, an increase in the heat transmission tariff to adjust to reduced demand and actual increased costs, due to a further increase in the share of fixed costs per MWh (or Gcal) sold.

The numerical example below demonstrates how reduced consumption impacts the state or municipal subsidy to cover the difference between tariff and cost. The input data is as follows:

- Floor area of apartment: 50 m²
- Specific heat consumption: 150 kWh/m²/year
- Heat tariff established: €45/MWh
- Cost of supplied heat: €60/MWh
- Subsidies to DH entity: 25 per cent of the costs incurred.

First consumption-based billing is implemented with following effects:

- The heat consumption and the heat costs are 20 per cent lower.
- The subsidies are reduced *pro rata*.

Figure 8. CBB impact on subsidies, shift of subsidies to finance saving measures

Basic data, situation before	
Floor area	50 m ²
Specific consumption-based billing	150 kWh/m ² year
Total consumption-based billing per year	7,500 kWh
Heat tariff	€45/MWh
Billed heat costs per year	€337.5
Real heat costs	€60/MWh
Real heat costs per year	€450
Subsidies	25% of the real heat costs
Total subsidies	€112.5

Basic data, situation after implementation of consumption-based billing, 20% savings	
Floor area	50 m ²
Specific consumption-based billing	120 kWh/m ² year
Total consumption-based billing per year	6,000 kWh
Heat tariff	€45/MWh
Billed heat costs per year	€270
Real heat costs	€60/MWh
Real heat costs per year	€360
Subsidies	25% of the real heat costs
Total subsidies	€90.0

In the second step the tariff is adopted, so that the savings from consumption-based billing are compensated. The customer now pays the same amount of money as they did before the implementation of consumption-based billing.

Adopting the tariff has following results:

- The heat tariff is now 25 per cent higher.
- The tariff increase is socially acceptable.
- The subsidies are dramatically reduced.
- The savings of subsidies are used for financing the devices for consumption-based billing.

Figure 9. CBB impact on subsidies, shift of subsidies to finance saving measures after new tariff

Basic data, situation after adoption of new tariff	
Floor area	50 m ²
Specific consumption-based billing	120 kWh/m ² year
Total consumption-based billing per year	6,000 kWh
Heat tariff	€56.25/MWh
Billed heat costs per year	€337.5
Real heat costs	€60/MWh
Real heat costs per year	€360
Subsidies	6% of the real heat costs
Total subsidies	€22.5

If the investment in consumption-based billing – four radiators with thermostatic valves and HCAs – is financed with the above savings of heat subsidies, the simple payback period will be approximately two years.

The implementation of such a strategy needs political effort; several state institutions must cooperate and show goodwill. The above-described strategy of combining measures can be very successful, if the existing subsidies for heat energy are used in increasing efficiency.

CBB and DSM enable governments to reallocate subsidies for heat consumption into investments for energy saving.

Myths about CBB

Consumption-based billing would result in lower heat sales and ruin the income of district heating companies

“Effects of Consumption-Based Billing Depending on the Energy Qualities of Buildings”, a German study from 2013,⁹ discusses several studies throughout Europe regarding the savings achieved by consumption-based billing. At first glance, CBB results in lower heat sales for the DH company, but this is compensated for by other effects which lead to greater financial sustainability. This has been shown in many countries in Europe (see the case studies for Debrecen and Plovdiv on pages 18 and 27).

CBB usually leads to better customer satisfaction: transparent bills showing actual consumption are the best confidence-building measure.

As a result, payment behaviour improves and evidence has shown that once CBB has been introduced many disconnected customers reconnect to their former DH supplier. The savings free up network and generation capacity to connect more customers.

⁹ “Effects of Consumption-Based Billing Depending on the Energy Qualities of Buildings”, Technische Universität Dresden, Faculty of Mechanical Science and Engineering, Institute of Power Engineering, Prof. C. Felsmann, Juliane Schmidt Politechnika Poznańska, Faculty of Civil and Environmental Engineering, Division of Water Supply and Environment Protection, Prof. T. Mróz (Dec 2015).

Due to the possibility of individual heat regulation by thermostatic valves, some heat consumption is shifted to other periods of the day. This results in lower peaks in heat demand and smoother operation of heat production.

In Central Asian countries such as Kazakhstan and the Kyrgyz Republic, there is a special situation, which makes the implementation of CBB more difficult. Here, heat distribution losses are currently underestimated, based on local norms. Much higher losses become apparent after CBB is implemented, because they can now be accurately measured. If all distribution losses were reflected in the heat tariff, costs for heating would be considerably higher, which would lead to massive protests from customers. This is the result of an out-of-date tariff policy. There is no causal relation between CBB and distribution losses following implementation of CBB; these losses must be financed by subsidies or through the tariffs with a plan to incentivise DH companies to reduce them over time.

CBB in this context means that the location of heat losses in the network can be identified; this allows operators to target infrastructure investment to where losses are highest.

A possible solution to the problem of low tariffs would be a reallocation of subsidies for heat to subsidies for financing CBB (see chapter above “Projected state budget-level impacts”).

Consumption-based billing is an ideal means to reduce subsidies in a socially acceptable way. The savings achieved buffer the tariff increases by reducing subsidies.

Consumption-based billing could cause higher bills for heating customers

In a payment plan with equal monthly payments, the monthly payments are calculated based on heating costs from the previous year. If the current winter is colder than in the previous year, then the customer pays less than his real consumption. This is compensated at the end of the heating season with a higher bill.

Of course, the reverse is also possible.

Consumption-based billing is not visible, so it is unattractive for municipal politicians

It seems that new biomass boilers or a small-scale CHP are more attractive than demand-side measures in buildings because of their visibility.

However, people tend to overlook the involvement of the heating customers. Information campaigns can make demand-side measures very visible. Hence, demand-side measures are similar to an energy efficiency campaign, which involves several thousand families in one city. Demand-side measures are the most visible measures for district heating companies.

Management issues

Consumption-based billing means transparency. If this and a customer-oriented strategy are not integrated within the management of the DH company, the potential of consumption-based billing cannot be fully realised. If the customer-oriented approach is not part of the business, it will be difficult to implement CBB and may require a fundamental rethink of the company's business strategy.

Management must be able to adapt its perspective, to view its own business from the standpoint of the customer. Instead of just producing and delivering heat and electricity, a customer relationship needs to be built. The change from generation to demand-driven mode should result in greater efficiency and reliability and a better relationship with the customers.

Case study: Reforms in management form the basis for a demand-driven DH – Plovdiv, Bulgaria



Plovdiv, located 140 kilometres southeast of Sofia on the Thracian plains in Bulgaria, has 350,000 inhabitants. About 30,000 households are supplied by the DH system. The DH company was bought by the Austrian utility EVN in 2007.

DH was unpopular with the people of Plovdiv; only 50 per cent of heating customers paid on time. The quality of service was low, and heat supply was often interrupted for long periods. There was no systematic billing process, so many customers accumulated substantial debts.

In 2004, consumption-based billing with metering devices and thermostatic valves was implemented in all apartments supplied by the DH company, but this reform was not reflected in the company's management strategy. Response times during supply disruptions were still too long. In the summer, for example, the supply of hot water was interrupted for weeks when the CHP plant switched to electricity-only production. Company decisions were based on orders from the directors, with no transparency.

A new management team was brought in; they realised that the company needed to introduce some basic processes. The organisation was

hierarchic and was controlled by top-down principles: opaque orders from the directors needed to be replaced by well-defined processes. Transparency is important and a good process defines the staff's responsibilities – who does what and when.

The next reforms were focused on the organisation. The employee hierarchy was flattened, encouraging staff participation in decision-making, problem-solving and strategic planning. Staff profiles were defined and an education and training programme began according to the identified needs of the company.

Disruptive customer relations factors were identified; the response time in case of damage in the network was shortened. One of the first measures was to refurbish the distribution network sections and shut-off valves, improving leak detection. The company also opened a new line of business, servicing building-level heat distribution systems. A much-improved general strategy for customer relations was developed including mass media and school campaigns; in 2016 a customer "hotline" was established.

Many district heating companies in central and eastern Europe suffer from irregular customer payments. Previously in Plovdiv only 50 per cent of customers paid regularly and there were many buildings with multiple disconnected apartments. As Section 4.2 mentions, buildings where more than 40 per cent of customers have disconnected are likely to completely disconnect from the DH network.

Following the customer service improvements, upgraded heat supply and new billing processes, the percentage of customers paying on time increased from 50 to 80 per cent. Less than 3 per cent of customers do not pay at all.

The most important point from the Plovdiv DH case study is that transparency within the company and in their customer relations resulted in greater trust and confidence and much-improved payment behaviour.

4.4. Socio-economic impact of consumption-based billing

It is no secret that transparency, high service quality, professional customer information and other confidence building measures are the best means to ensure customer loyalty.

Low costs are less important, as evidence shows that the most vulnerable people, such as retirees or low-income households, are the best and most regular payers. Most customers are looking for security of supply and want to be well looked after. This is shown by studies and experience from many countries such as Austria, Bulgaria and Lithuania.

Affordability

Raising tariffs is a difficult and socially delicate process; it should be accompanied by measures to reduce costs to the consumer. The implementation of a building energy efficiency programme to lower heat consumption and to increase affordability would take many years. Ideally, there are measures that make a tariff increase socially affordable and can be implemented in a short time, like consumption-based billing.

Many economies respond to the affordability concerns of households by subsidising heat costs. As described in Section 4.3, subsidies are often paid irregularly and do not improve the service quality of heating or customer confidence.

Consumption-based billing is ideal to compensate for increases in tariffs through savings in heat consumption. (These savings can only be achieved if the full metering and control chain up to the apartment level is implemented.) Important points to consider include the following.

- Cost-benefit effect: consumption-based billing has one of the highest cost-benefit effects of all energy-saving measures.
- Duration of implementation: planning and mounting works for the necessary devices can be finished in a short time. For a DH company with up to 50,000 customers this can be done within two years.¹⁰
- Confidence-building measure: consumption-based billing creates transparency and so improves trust and confidence in the DH supplier.
- Customers with lower budgets determine their expenses for heating by thermostatic valves.

Municipalities can play an important role in improving energy efficiency and affordability, but consumption-based billing should be the first step in an energy efficiency programme.

¹⁰ Experience from the implementation of consumption-based billing in Bulgaria (see Plovdiv case study).

Case study: A municipal energy efficiency programme – Šabac, Serbia

Šabac, located 90 kilometres west of Belgrade, has 53,000 inhabitants. About 7,500 households are served by the municipal DH system.

In 2010, the city of Šabac introduced a programme to subsidise insulation in residential buildings with a target of reducing energy consumption in the city by 1 per cent per year. When the programme began, the population was suspicious of the promised benefits; it took more than two years for a significant number of building owners to participate. After seeing the first examples of insulated buildings other buildings decided to participate.

To date, 114 DH-supplied buildings have been insulated (32 per cent of the floor area supplied by DH). The insulation programme is proceeding quickly, every year buildings corresponding to around 3 per cent of all DH supply are newly insulated. This is a high rate compared with other cities in Europe. Furthermore, all individual heating substations have been refurbished or completely renewed.

Building-level meters have been installed but only 11 per cent of residential DH customers are equipped with heat allocators and thermostatic valves. Instead of the 20 per cent savings expected from consumption control and heat metering at

apartment level, the achieved savings are about 10 per cent, which result mainly from the outdoor temperature control of the IHS.

The possible savings from thermal insulation are also only partly realised, because households cannot respond to the lower heat demand as they have no means of controlling their consumption.

The following advantages are expected if CBB is the first energy-saving measure implemented:

- Due to the accompanying information measures involved households are better informed about energy saving and may invest in energy efficiency measures in their properties.
- All other saving measures like wall insulation, energy efficient windows, insulation of the pipes in the buildings, distribution system and so on will result in higher savings.
- Poor households can now control their heat bills.

Although the city's insulation programme is a great support to households, especially those on a limited budget, the realised savings are lower than they could be as only 11 per cent of households have full consumption-based billing. This example shows that the first energy efficiency measure to be implemented should be consumption-based billing.

4.5. Environmental benefits

The United Nations' Sustainable Development Goals (SDGs) and the Paris Agreement on climate change have outlined clear ambitions and commitments to reducing greenhouse gas (GHG) emissions worldwide. Heating accounts for a significant percentage of the world's total GHG emissions. According to the International Energy Association, buildings represented 28 per cent of global energy-related GHG emissions in 2015 and a reduced use of energy for heating purposes will have a significant impact, playing an important part in the pursuit of global targets for reducing CO₂ emissions.

Optimal heat provision based on metered heat consumption and efficient DH systems, including insulation in residential buildings, can enable significant energy savings. The example presented in the table below shows how DSM and CBB alone can reduce heat consumption by almost 40 per cent, which illustrates how an ambitious roll-out of DSM and CBB is essential in the pursue of the SDGs.

Figure 10. CO₂ savings based on different fossil fuels

Fuel source for heat production	Emission factor (tonnes CO ₂ /MWh ¹¹)	Results for CBB and DSM implementation in 2,000 m ² residential building		
		Heat consumption before	Heat consumption after	CO ₂ savings, tonnes/year
Natural gas	0.20382	550 MWh	350 MWh	47.96
Coal	0.33858			79.67
Heavy fuel oil	0.27940			65.74

¹¹ 2007/589/EC: Commission Decision of 18 July 2007 establishing guidelines for the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council.

4.6. Accompanying technical measures

Hydraulic balancing

Hydraulic balancing is an additional DSM that should be considered if CBB is implemented. Water flows through the path of least resistance. In heating installations, there are different paths with different resistances. Hence, not all radiators are equally supplied with heat. It is necessary to distribute the heating water according to demand; this is called hydraulic balancing.

Older installations tend not to be balanced; radiators next to the circulation pump receive most of the heat energy. Radiators further away are not sufficiently supplied and therefore these rooms or apartments are not as warm as they should be. So, the circulation pump is oversized or the flow temperature is raised. This increases energy consumption and flow noises. Adjustable thermostatic valves can set the right amount of water to meet the heat demand. Circulation pumps, which are not frequency controlled and have oversized motors, should be replaced with efficient

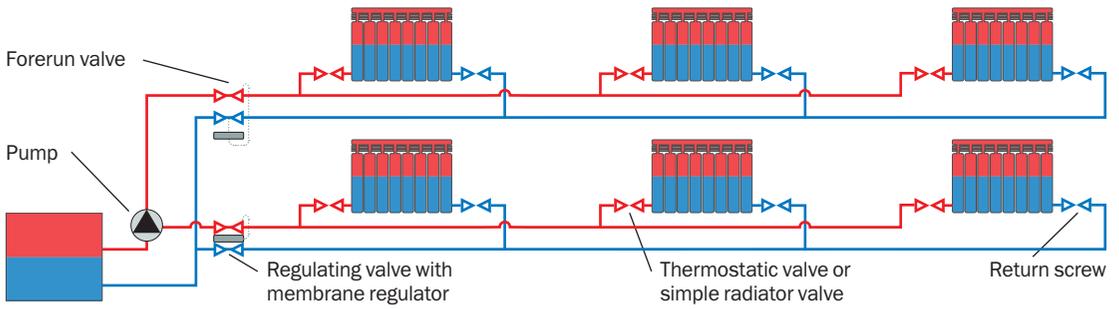
pumps.

Advantages of a hydraulically balanced system:

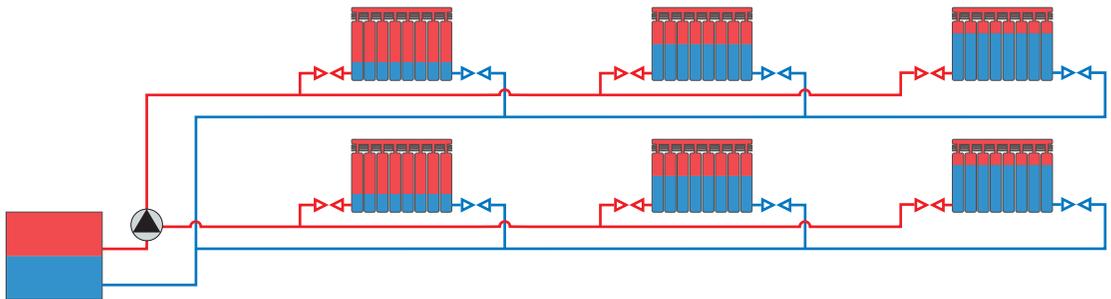
- Rooms are heated evenly
- Radiators respond quickly to new thermostatic valve settings
- Maximum frost protection safety
- No flow noise in the heating system
- Heating system or pump operates with maximum efficiency to save energy
- Increased system reliability
- Reduced energy consumption (about 10 kWh/m² heated floor area).

Figure 11. Hydraulic balanced systems – principle and advantages

Balanced system – The flow through all radiators is equal if all valves are open.



Unbalanced system



4.7. Economic assessment of CBB and DSM implementation

When considering investments in energy efficiency measures, the expected investment cost should be compared against the difference in energy costs between the baseline or “business as usual” scenario and the expected energy costs with the EE measures (over a specified timeframe). The measure is acceptable if the difference between savings and investment costs is zero or positive over the specified timeframe.

The following section provides a comparison of the costs of implementing different energy efficiency measures, including CBB and DSM, for a single kWh of energy, at conceptual level. It also reveals the expected costs of installing CBB for a household and an IHS for a building.

Comparative cost differences for energy efficiency measures per kWh

Like most solutions in the field of measuring and control technology, consumption-based billing has very good financial results; it is one of the most financially attractive measures.

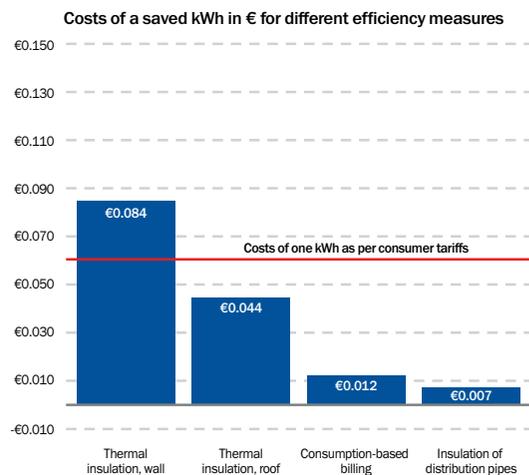
Some energy efficiency measures produce lower specific implementation costs per saved kWh than the cost of energy consumed. The values of Figure 12 are based on the author’s own calculations. The data used for implementation costs of energy saving measures and the heat tariff are from Serbia. The implementation costs in Serbia are on the same level as in Bulgaria, Romania and Ukraine.

Thermal insulation is the most expensive measure per kWh of energy saved. But thermal insulation measures are important as their implementation creates the highest savings and they will protect the building from further damage, mostly from rainwater and condensate.

In most economies where the EBRD invests the specific costs of thermal insulation (€/m²) are far lower than in Austria, Italy or Germany. Therefore, insulating buildings could be economically feasible.

Method of calculation: The considered period is 20 years. The specific costs for saved kWh of energy are calculated with the discounted investment and energy saved for a period of 20 years (discount rate 6 per cent). The average heat tariff during the analysed period of 20 years is calculated with a growth rate of 3 per cent. The heat losses are calculated with an average outside temperature of 6.5°C during the heating season.

Figure 12. “Saved heat” costs with different demand-side management



Expected installation costs for CBB

The costs to install consumption-based billing are addressed separately for a building and for an apartment, following the framework of understanding of CBB and DSM provided in Section 2.2.

Building level

The investment cost for IHS depends on its capacity and other factors; Figure 13 shows the investment (equipment plus installation) costs of installing an automated IHS with hot water preparation in Lithuania.

Figure 13. Example of IHS prices in Lithuania, 2018

Building area, m ²		1,500	3,000
Heating capacity		93	210
Hot water preparation capacity, kW		116	380
Price in € (excluding VAT)	Equipment, materials and manufacturing	5,771	9,923
	Installation	3,036	4,092
	Total	8,807	14,015

Apartment level

The investment necessary to equip an apartment with CBB is between €220 and €255. The tables below demonstrate a cost estimate in terms of necessary investments for CBB in an apartment having four radiators, 50 m² of heated space and DHW supplied by DH.

In the case of a two-pipe system, the cost estimate for CBB is €221 per apartment. In case of a one-pipe system, the cost estimate for CBB is €253 per apartment. In the latter case, an additional pipe is mounted¹² between the inlet and outlet of the radiator as a bypass.

The input data to conduct the estimate has been provided by HCA vendors. The total costs of a country-specific CBB project per apartment depends on the local standards of craftsmen; here, the estimate is based on data from Bulgaria and Serbia. According to heat cost allocating service companies the costs in Bulgaria, Romania, Serbia and Ukraine are comparable. In countries with a small energy efficiency market, mounting costs may be higher if installers have no experience or a monopoly position.

The estimated economic effect for such a CBB project is based on the costs per MWh of thermal energy saved: €12/MWh in case of two-pipe system, and €14/MWh in case of one-pipe system. In both cases, the investment is attractive in financial terms. For the calculation of economic effects, a specific heat consumption of 120 kWh/m²/year and heat tariff of 65 €/MWh was used.

The costs per MWh saved in the case of a DHW meter are 7 €/MWh.¹³ Hot water metering is one of the most financially attractive demand-side measures.

¹² In the case of one-pipe system, it is more cost efficient to mount a bypass at the radiator, since a three-way thermostatic valve costs between €40 and €50.

¹³ Basic data: yearly heat consumption for DHW of two tenants: 1.5 MWh, saving: 25 per cent.

Figure 14. Investment costs for one apartment¹⁴ with four radiators and one-pipe heat distribution system

Apartment with four radiators, one-pipe system	Unit costs (€)	Number of units	Costs (€)
Thermostatic valve	25	4	100
Heat cost allocator	15	4	60
Mounting costs per allocator	7	4	28
Mounting of bypass per radiator	8	4	32
Hot water meter	25	1	25
Mounting costs for hot water meter	8	1	8
Total costs (€)			253

Figure 15. Investment costs for one apartment¹⁵ with four radiators and two-pipe heat distribution system

Apartment with four radiators, two-pipe system	Unit costs (€)	Number of units	Costs (€)
Thermostatic valve	25	4	100
Heat cost allocator	15	4	60
Mounting costs per allocator	7	4	28
Hot water meter	25	1	25
Mounting costs for hot water meter	8	1	8
Total costs (€)			221

¹⁴ Heat substation costs are not included here in estimates. Their cost share per apartment depends on the number of apartments in a building and the total heat load.

¹⁵ Heat substation costs are not included here in estimates. Their cost share per apartment depends on the number of apartments in a building and the total heat load.

5. Challenges to the implementation of consumption-based billing

The section discusses legal, regulatory and technical challenges that are faced when introducing consumption-based billing.

5.1. Technical challenges

Transformation from supply-driven to demand-driven DH

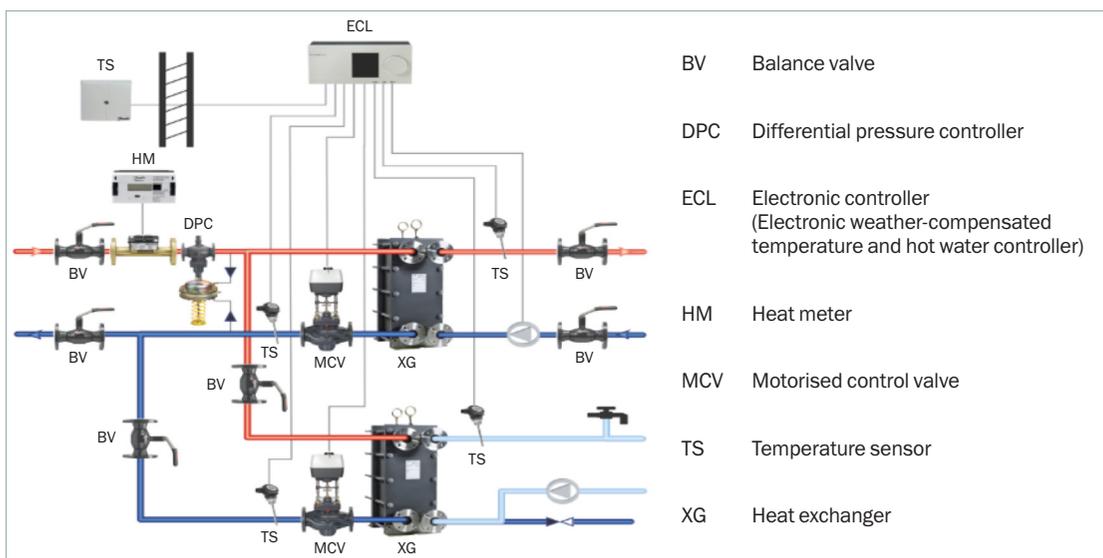
DH systems all over the world fall into two main categories: supply-driven district heating systems (SDSs) and demand-driven district heating systems (DDS). SDSs are normally found in central and eastern Europe and northern Asia; DDS in western Europe and increasingly other parts of Europe. The main difference between SDS and DDS lies in the system's operational concept.

In economies undergoing transition to open markets, DH systems are typically supply-driven. In an SDS, the generation plant determines the level of heat delivered to the customers. This approach often results in unbalanced supplies (production of thermal energy and delivery of heat to the consumer) against the realistic demand (quantity of heat needed by a property at a

given point in time). Imbalances arise due to limited customer metering information and a lack of controls within buildings. The customer has few options aside from venting excess heat by opening their windows when it is too hot or wearing additional layers when cold. It is understandable that overheating damages a state's economy if flat-rate billing is still applied and under-heating results in a lower quality of life for the consumer.

In demand-driven DH systems, the IHS is the key element. The IHS at each building, as is already the trend in countries in transition, is equipped with a temperature controller. The controller automatically adjusts the supply temperature of the secondary network according to the prevailing outdoor temperature and the building's specific heating needs at that time. Therefore, the substation takes only as much heat from the network as needed, thus providing the system with demand-driven control. In the demand-driven mode, the heat sources must follow the actual building needs, which are continually determined by the individual substations and adjust the heat output accordingly.

Figure 16. Individual heating substation



Transforming from SDS to DDS poses the following challenges:

- Actual heat losses in the transmission network are identified.
- Reductions in heat demand after DSM are implemented.

It is important to note that the move from a supply-driven to a demand-driven system is an important step in the implementation of CBB, but CBB is not truly in place until individual consumers are able to control and measure their own consumption.

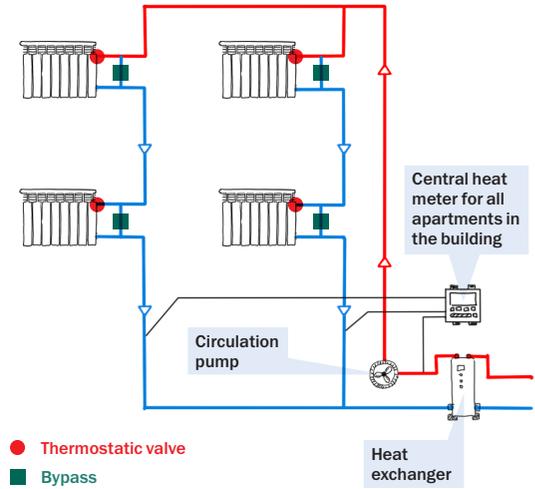
Transformation of inner systems in consumer buildings

The installation of thermostatic valves or HCAs may require minor or major building alterations, from relocating a single radiator up to replacing the entire heating system. Feasibility is a question of cost-effectiveness, as well as the degree of willingness of consumers to engage in such projects.

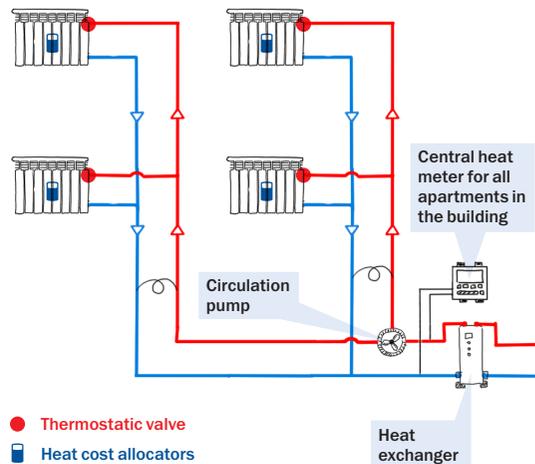
Buildings with a single pipe distribution system require modification, especially if the building has many floors. In buildings up to five floors thermostatic valves can be mounted without causing major problems in the hydraulic system.

Figure 17. The three most popular building-level heat distribution systems in the EBRD regions

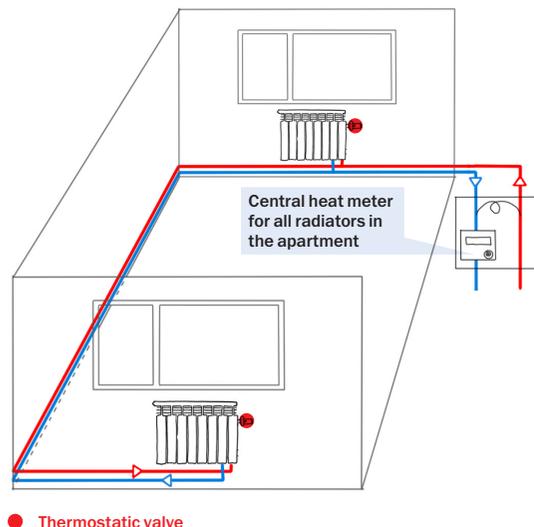
One-pipe system



Two-pipe system



Two-pipe horizontal system



In a single pipe system, thermostatic valves must be mounted with a bypass. Without this, thermostatic valves would shut-off the entire vertical heating circuit when they close themselves. With a bypass, thermostatic valves just reduce or open the flow to the radiator. It's possible to install a three-way thermostatic valve but they are around three times more expensive than an ordinary thermostatic valve and bypass arrangement!

In contrast to residential multi-apartment buildings, family houses, public and commercial buildings represent only one single client. Hence, the heat does not need to be allocated to different entities and HCAs are unnecessary in these buildings. Thermostatic valves are recommended in order to set temperatures according to needs in different rooms of the same building.

Figure 18. Thermostatic valve, HCA and bypass in a one-pipe system



The thermostatic valve is the last control unit of a DDS; the customer sets the desired temperature for each room of their apartment with thermostatic valves. Only with thermostatic valves can the full potential of efficiency measures be realised. **The whole package of technical equipment including heat substations, thermostatic valves and HCAs, is a functional unit.**

Case study: Changing the open hot water system to a closed system – Panevėžys, Lithuania

Panevėžys, located in northern Lithuania, has 110,000 inhabitants. Most of them are supplied by the municipal DH system. The system was changed from a traditional open system to a closed system over several years beginning in 1997 with the installation of new IHSs. The table below provides a comparative analysis of the CDHS and ODHS.

Open DH system	Closed DH system
The required temperature for space heating, domestic hot water and safety requirements cannot be ensured	Users are able to adjust the temperature of space heating according to their needs
High network water temperatures may damage water meters	Long term and reliable operation of heat meters
Increased chance of pipeline rupture due to high pressure in building-level pipelines	The required pressure is maintained
No hot water heater (heat exchanger) needed	Hot water heater (heat exchanger) is required and needs periodical cleaning
If the temperature regulator malfunctions, domestic hot water supply will stop because of possible high temperature water which could damage metering equipment or injure consumers	Reliable and steady supply of instant domestic hot water
The internal building system must be flushed out every two years	The internal building system must be flushed out every four years
Chemical water treatment increases the hot water price by €0.43/m ³	
200 m ³ of contaminated water reaches the environment every year due to anti-corrosion treatment of network water	Reduced environmental pollution due to a reduction in the amount of treated water that is released
Higher intensity of corrosion of pipelines and steel radiators	Lower intensity of corrosion of pipelines and steel radiators

Results: Following IHS renovation, residents saved €0.43 million during the heating season.

5.2. Legal challenges

A law providing for heat cost allocation and obligatory CBB of heat is the precondition for the implementation of CBB and DSM. A law of universal validity without exception would facilitate achieving the full potential of CBB and DSM, and avoid distortions from partial implementation. Hundreds of pilot projects and long-term experience from many European countries have demonstrated its effects, so it is recommended that CBB is legally mandated at a national level.

The following aspects, which are discussed in greater detail below, should be included in the scope of such a law:

- clear definition of what a heat customer is
- conditions for households, business entities, buildings, properties and so on
- heat consumption volumes shall be influenced or controlled by the user
- heat amount consumed shall be directly assignable to the object
- buildings with a minimum of, for example, four different customers or households
- valid for all central heating installations, which heat more than a minimum number of buildings (for example, three units).

Establishment of a proper set of requirements to meter and allocate heat consumption

A framework that enables the full realisation of CBB and DSM, establishes the mandatory allocation of heat consumed under the condition that a heat consumer can control their own consumption (for the most part). In order to avoid potential manipulations with the implementation of the provision and to ensure the transparency of the legal framework, the definition or criteria for economic feasibility should be established by legal acts as well. As an option, economic feasibility may legally be defined as a minimum amount of savings. If these savings are higher than the projected costs for the necessary equipment and its operation, metering and allocation is mandatory.

A legal framework for the proper implementation of CBB and DSM should define and enable a two-tier heat tariff model. The heat price should be split into two components: a consumption-dependent (variable) component and the access-type (fixed) component. A transparent framework would specify principles establishing limits for the price components. For example, the minimum share of the variable component may be 55 per cent and the maximum share 75 per cent. The shares of two-tier price components should be adapted to local conditions in the EBRD regions and properly reflect the structure of costs incurred by DH entities, especially those related to fuel. Under the framework model of a two-tier tariff, the accounting period must be defined as 12 months – such a period is established in most of the EU countries.

If DHW is supplied by a DH company, then the costs for heating and the costs for DHW must be separated.

Other aspects of the CBB and DSM framework, such as servicing and calibration periods of meters, locations for meters and regulations for assembly may not be within the scope of the law for consumption-based billing. These, mostly technical, aspects are described in the respective technical norms.

Developing transparent bills

The heating bill is one of the most important building blocks for the framework of CBB and DSM. The bill is the main instrument for communication between DH companies and their customers; it should be easy to understand.

The bill should contain the following information:

- beginning and end dates of the accounting period
- costs of heating and hot water, delivered to the building, in total, specified according to energy and other operation costs
- total heating area of the building (the economic unit)
- total consumption for the building (for the economic unit) – be it for heating or hot water
- heated floor space of the property in question
- for the property in question, determined consumption shares – be it for heating or hot water
- ratio between the variable (consumption dependent) energy costs and costs for the heated floor area
- prepayments made by consumer during the accounting period, if any
- place and the period at which the billing and document collection can be inspected
- for the purposes of comparison, consumption of the last accounting period(s), and actual costs of one MWh or kWh (calculated with the total variable and fixed costs), may be provided.

Establishing clear provisions over modalities of meter reading and billing

The transparent legal framework shall provide directions regarding the frequency of meter readings. A clearly established frequency will allow DH entities to develop proper billing arrangements, and consumers will have clear understanding of the terms of billing.

The reading of the central heat meter and allocators can be done on a monthly or yearly basis. In the case of monthly reading, the heat customer is billed every month according to his or her monthly consumption. In the case of annual reading, the monthly payments are equal and based on consumption of the previous year. At the end of the accounting period a negative or positive surplus of payments is adjusted (compensated) according to the actual costs of energy consumed.

If meters are read monthly then payments will fluctuate with higher bills during the heating season and lower bills during warmer months. Reading the meters once a year and monthly billing of equal sums enables households to better plan their expenses. However, additional payments at the end of the period may be necessary due to higher energy prices or colder winters and may be an unpleasant surprise for a consumer. Informing consumers in advance about expected additional payments is good practice.

Annual reading of meters and HCAs is common in EU countries.

Ownership of metering and allocating equipment

Deciding on ownership of metering and allocation of equipment, in the context of CBB and DSM, relates to initial investment, ensuring maintenance and replacing, calibration, testing, and so on. Generally, there could be three owners of such equipment: the DH entity, DH consumer, or an organisation representing DH consumers (such as an apartment building's owner association).

In the EBRD regions, due to the different requirements of legal acts, the ownership boundary between the DH entity and DH customer is defined differently; therefore the ownership of heat meters is managed in two ways:

1. Central heat meters at the IHS are the property of DH companies that operate and maintain the equipment. This type of ownership is used, for example, in Bosnia and Herzegovina, FYR Macedonia, Moldova, Lithuania, and Serbia.
2. Heat meters are owned by customers or their representative organisations and the operation and maintenance are either undertaken by customers or heat suppliers. This type of ownership and management is used in Belarus, Kazakhstan, the Kyrgyz Republic and Ukraine for example.

Heat meters, used for commercial accounting, must meet the requirements for reliability and accuracy, as well as proper maintenance and periodic calibration. Limiting installation to meters listed in the national registers of measuring instruments ensures that reliability and accuracy requirements are met. Operation and maintenance of meters is the responsibility of the entity who owns the meter. Initially in Lithuania, customers installed meters at their own expense, later, installation and ownership obligations were transferred to DH companies.

The change of ownership and responsibility in Lithuania revealed the following problems:

- It is more difficult to control the large scale roll-out of heat meters and achieve the planned implementation results in a timely fashion if consumers are in charge of the infrastructure
- Users were unwilling to cover additional financial costs related to installation and operation of heat meters
- Since the measuring devices belonged to a large number of users, it was difficult to ensure the necessary maintenance of all the devices and timely calibration.

Although heat meters were owned by the users, they were used by DH companies that required accurate and reliable meters in order to bill customers correctly. In Lithuania the issues were addressed by transferring ownership and maintenance to DH entities. The required expertise, constant monitoring of the state of meters and data transmission ensures that heat meters operate reliably. Usually heat meter installation and operating costs are included in a heat tariff. As these costs are only a small portion of the costs of DH services (usually up to 0.3-0.4 per cent of total costs), tariffs are minimally affected.

Case study: Implementation of building-level heat metering – Lithuania

In 1992, Lithuania began a widespread roll-out of building-level heat metering; users who switched from normative to metered billing received a 10 per cent tariff reduction for three years. The number of meters installed was disappointing and 80 per cent compensation of investment costs through reduced heat payments was introduced later the same year. Heat meters were owned by consumers, who were also responsible for maintenance and periodic calibration.

From 1993, all installation costs were compensated and both ownership and maintenance could be transferred to DH companies; meter installation targets were still not met. Therefore, in 1997 the government instructed DH companies to install heat meters in all buildings within a year. DH companies were responsible for the technical implementation of works and all costs related to installation and maintenance were included in the heat tariff. From 2003, DH companies have also been required to install individual heat meters for all consumers in newly constructed buildings. In old buildings DH companies should carry out installation of individual heat meters or HCAs depending on their technical feasibility and at consumers' request.

It took almost six years to achieve complete metering coverage at the building level, but the majority of meters were installed in the last year. This illustrates how important robust requirements and time frames are for the successful implementation of consumption-based billing.

Mitigating impacts on socially vulnerable households

In EU countries, vulnerable customers normally receive targeted financial support through special programmes funded by state or municipal budgets; this is the recommended approach. Lower tariffs subsidised by the DH company would result in less transparency.

As discussed in Section 4.1, apartments in exposed locations such as corners or top floors of buildings have higher heat consumption. In some countries (including Lithuania) there is a heat consumption reallocation system where neighbouring apartments compensate exposed apartments through correction factors applied to bills. However, the system is not widely practiced in Europe. In Germany, exposed apartments may have lower rents.

5.3. Regulatory challenges

Recognition of actual levels of technical losses in networks

Heat produced and supplied to a DH network equals the sum of heat sales to consumers and technical heat losses in the network. In order to calculate the heat tariff, volumes of all three components (production, losses and consumption) play a major role, as in order to calculate the tariff the revenue required by the DH entity is divided by heat volume produced by that entity.

In countries where CBB is in the early stages of development, the DH tariff is set by taking the following into account in terms of thermal energy volumes:

1. Projected demand by customers for space heating and hot water (measured and/or calculated with rules set by norms)
2. Technical heat losses in the transmission network (calculated with rules set by norms).

We have already discussed that switching DH billing from a normative-based to a consumption-based system would result in a significant reduction of billed heat sales in those buildings where heat meters are installed. This is because the normative heat consumption (kWh/m²) or a so-called “flat rate” still used in Kazakhstan, Ukraine and other countries is, on average, up to 30 per cent higher than the actual specific heat consumption (kWh/m²) of the building. The precise numbers may differ for individual buildings, and the 30 per cent average number represents statistical changes in billed consumption after heat meters have been installed and flat rate billing has been stopped.

At the same time, a visible increase of technical heat losses in the transmission network is normally observed. These increases in technical losses do not represent actual increases in lost energy, but it demonstrates that after CBB is implemented and technical heat losses are measured for the first time, the discrepancy between actual volumes and those set by norms can be seen.

Presented with evidence that technical losses are at significantly higher levels than those historically set by norms, a regulator would need to accommodate these losses in a new heat transmission tariff system. Accommodating higher technical losses would definitely increase the thermal energy transportation tariff, but not necessarily have a significant impact on overall heat tariff.

The regulatory switch from technical losses calculated by norms to losses determined by meters, especially if the difference is greater than 20 per cent, may be implemented in several ways, including:

- The regulator includes actual heat transmission losses in the tariff and sets a multi-year regulatory obligation to reduce these losses to target level (as in the case of Estonia); this option incentivises the DH company to invest in the heat transmission network in order to meet regulatory efficiency requirements. This is a sustainable way to deal with and reduce high heat losses.
- The regulator includes actual heat transmission losses in the tariff (as in Denmark); this option does not incentivise DH companies to reduce their heat losses and can be used only when actual losses are very close to estimated losses, as it is in Scandinavia.

The implementation of CBB and the necessary adjustments in regulations may offer a chance to assess the status quo of DH systems and develop long-term investment programmes to gradually improve the worn-out systems.

Case study: Reduced heat consumption (sales) after the introduction of consumption-based billing – Kostanay, Kazakhstan

In Kazakhstan a national programme for the development of consumption-based billing was approved and DH companies are obliged to install building-level heat meters. In Kostanay 71 per cent of residential buildings and 87 per cent of public buildings (connected to DH) were equipped with building-level heat meters at the end of 2016.

A significant reduction of heat sales for the buildings was observed where heat meters were installed. Below is a detailed analysis of heat sales for three different consumers where a building-level heat meter was installed: a residential building, a kindergarten and a commercial consumer.

- In the residential building the average actual heat consumption was reduced from 1,377 Gcal to 1,085 Gcal or 21.2 per cent in comparison with the previous year
- In the kindergarten the average heat consumption went from 807 Gcal to 584 Gcal, a reduction of 27.6 per cent
- For commercial customers, average consumption was reduced from 17.2 to 14.8 Gcal or 14 per cent.

The increase in the number of heating customers with metering devices allowed the DH company to get a more accurate picture of heat losses in the networks. With a low number of metered consumers, the percentage of actual heat losses did not exceed 18 per cent. Based on the results of 2016, when the share of metered customers was much higher, the actual heat losses were 22.56 per cent compared to the estimated heat loss share of 17.88 per cent.

In order to ensure financial stability of the Kostanay DH company, heating tariffs needed to be adjusted, but this was delayed, causing a few unprofitable years and disorder in loan repayment. With EBRD support, DH sector regulatory reform work in Kazakhstan started back in 2015, a new DH pricing methodology has been prepared and is waiting for approval. The new methodology anticipates how to deal with heat sales reductions post CBB implementation – after full-scale CBB is implemented actual losses are included in the tariff, but the reduction of heat losses is stimulated by additional profit potential in case actual losses are reduced.



Tariff reform is needed to adapt to a demand-driven system

The pursuit of cost-reflective tariffs may include a two-part tariff, where one component should seek to cover the fixed costs of the DH operations and a variable user fee should cover the variable costs of the DH operation.

If the fixed user fees fall short of covering the fixed costs – in other words, if the DH company relies too heavily on the consumption based revenue stream to

cover its fixed expenditures – then one would expect the DH company to struggle financially following the CBB-led reduction in heat sales. In such a case, to ensure the financial sustainability of the DH company, a tariff adjustment either in the form of increased fixed fees or a higher consumption-based tariff may be necessary.

In order to reflect the changes caused by demand-side reform properly, and not to disincentivise a DH entity from positive participation in these reforms,

the regulatory framework must properly recognise the projected dynamics of sales and provide targeted solutions incorporating the results of reform into tariff-making practice. This means that lower revenues for the DH entity, due to reduced heat consumption resulting from CBB and DSM implementation, must be adjusted with some compensatory mechanism by the regulator in order to secure the financial stability of the DH entity during the period of the mentioned reform.

The compensatory mechanism may be designed in numerous ways. A widely used option is a yearly heat revenue (or heat tariff) adjustment procedure, where any shortfall of regulated revenue caused by a reduction in heat sales over the last year is identified and included in the DH company's regulated revenue (or tariff) for the next year. The fundamental rationale for adjustments of this type is the following: the DH entity cannot objectively reduce fixed costs in proportion to heat sales reductions due to CBB in the short-term, and therefore the DH entity should not bear losses for uncontrollable factors. Recognising that the DH entity is one of the key stakeholders for implementing the planned reductions in energy consumption through CBB and DSM, the DH entity should be treated fairly alongside the other reform stakeholders.

Tariff reform to accommodate return and stimulation of investment

When the DH company is responsible for CBB and DSM reform, including massive IHS installation programmes, reliable and sustainable results are more likely to be achieved under a proper regulatory framework. In this case, recognising that reform will require significant investment, a proper regulatory framework shall, among other things: help the DH entity access finance, guarantee return on investment made, determine opportunities for return on investment, and introduce incentives to stimulate DH entities to implement reforms in a timely fashion. Transparent provisions are important to demonstrate to financial institutions the potential of the DH company to pay back the loans needed for investments into heat meters and IHSs. In other words, transparent rules must be set for the return of

capital and return on capital; the tariff-setting rules must ensure rational cost coverage; and in case the DH entity overperforms the agreed objectives, an extra financial return for this overachievement must be clearly established in advance.

In European practice, return on capital is ensured by including depreciation of new assets into the regulated yearly revenue of the DH entity. In order to create the additional cashflow needed for new investment, the projected investment into the long-term asset may be included in the tariff even before the asset unit is commissioned, by decision of the regulator. The depreciation period is established as a specific asset lifetime-based period, however, where there is a need to finance internal resources, the depreciation period may be shortened and/or designed so as to ensure payback at larger portions in the first years of exploitation and smaller portions for the last years of asset exploitation.

Transparent rules for return on capital are a key requirement for a favourable investment climate. In most western European examples, return on capital is usually based on Weighted Average Cost of Capital (WACC), under a Capital Asset Pricing Model (CAPM), which objectively reflects the market conditions and state of the national economy. Other models for return on capital are also possible, although less popular. Latvia and Poland have specific solutions for establishing return on capital investment, and Denmark has a prohibition in this regard. A variety of regulatory solutions are available, this decision may be country specific but it must be transparent and provided for by law.

5.4. District heating companies' role in the implementation of reforms

DH companies can take a major role in the implementation of consumption-based billing by developing investment programmes. In addition to the technical implementation of individual metering, DH companies can also be a driving force for energy efficiency information campaigns as shown in the case studies for Debrecen and Plovdiv on pages 18 and 27. These campaigns are one of the most important activities for heat consumers when consumption-based billing is implemented. This could be done by a pilot project or by using data from other systems where these elements and processes can demonstrate actual consumption changes and savings. DH companies have extensive databases with historical data on heat consumption which can be used to show the effect of consumption-based billing. Different channels can be used – information can be presented on the bills, on the website of the DH companies or through awareness campaigns. After implementation of an investment programme it is important to prepare monitoring programmes and to deliver information on results for the customers.

5.5. Practice of heat cost allocation in EU countries

This section provides an overview of common practices in heat cost allocation. Since November 2016, heat cost allocation or metering has been mandatory according to the European Energy Directive: “Member States shall introduce transparent rules on the allocation of the cost of thermal or hot water consumption.” An exception is the case in which CBB would have had an uneconomic outcome. That is the case when the costs for reading and maintaining the equipment would be more expensive than the achieved savings, for instance in an ultra-low energy building. Today, reading costs with radio signal transmitting devices are very low. According to property management companies, CBB is the preferred variant of billing, because it avoids conflicts between the residents.

By the end of 2016, 16 member states (out of 28) had introduced national rules on the allocation of space heating or hot water consumption in multi-apartment buildings supplied from a central heating system. Apart from Denmark and Estonia, no member states have introduced rules on space cooling allocation.

Information and acceptance

The right tariff model is critical to the acceptance of metering by customers. People have to be educated and informed about the system. Consumption-based billing does not create justice. The main principle is transparency and the motivation of heating clients to save energy.

Customers must be provided with thorough information on the new billing system when CBB is introduced.

The following points must be considered:¹⁶

- Permitted/recommended range of the share of variable and fixed costs of thermal energy provision; both for space heating and domestic hot water (DHW) preparation
- Use of correction factors
- Use of minimum and/or maximum individual heat cost thresholds
- Building common area cost allocation rules
- Use of default values or penalties for individual tenants/occupants to discourage denial of access to meter readers, tampering etc.

Variable and fixed costs of thermal energy supply

The variable costs directly reflect heat consumption, they depend on the customers' behaviour and weather conditions. They are the cost fraction, which can be reduced through consumption-based billing. They are allocated according to the reading of individual heat meters or allocators in the apartments.

Fixed costs are independent from the amount of thermal energy supplied. They include expenses for maintenance, reading and billing and they reflect heat losses of the buildings' internal heat distribution systems. The fixed costs are justified apart from cost accounting principles, by heat gains from neighbouring apartments and the heat distribution pipes extending through the house. This is also known as involuntary heat consumption.

The method of heat cost allocation may be specified in national legislation or can be subject to an agreement between the DH company and the heat

customer. The scope of the variable costs must be enough to motivate heat customers to save energy. The variable consumption-based component should be significant in order to achieve noticeable savings, usually the share of variable costs is between 50 and 70 per cent.

Calculating the share of variable and fixed costs on a case-by-case per building basis is practised in some member countries like Italy. This system might be more objective, but it is too complex, requiring a building energy audit. In the end the results, such as the savings and the acceptance by heat customers of CBB, are more important.

Regarding DHW, the consumption-based share could be higher as there is a higher correlation between individual consumption and total consumption. This is due to the fact that there are no additional factors to consider like heat transfer between apartments, heating of common areas and so on. If no water meters are installed, costs are allocated according to the number of occupants or with a flat rate (Bulgaria uses 140 litres per occupant per day).

It is better to leave some flexibility in the design of heat cost allocation, so DH companies can adapt the allocation method to their needs.

Correction factors

As highlighted in Sections 4.1 and 5.2, some apartments are more exposed to the cold due to their unfavourable location in a building. In order to compensate for this, some legislation prescribes correction factors. These factors are mandatory in three member countries (including Lithuania) and forbidden in three member countries; in other countries they are not regulated. The factors are calculated per room or per apartment.

¹⁶ L. Castellazzi, *Analysis of Member States' rules for allocating heating, cooling and hot water costs in multi-apartment/purpose buildings supplied from collective systems - Implementation of EED Article 9(3)*, EUR 28630 EN, Luxembourg: Publications Office of the European Union, 2017, ISBN 978-92-79-69286-4, doi:10.2760/40665, JRC10.

Minimum and/or maximum individual heat cost limits

Some apartments have a very convenient location with regard to heating, in the middle of a residential building surrounded by other apartments. In some cases these apartments may turn down their heating and receive “free” heat from their neighbours through the inner walls; this creates additional costs for the neighbouring apartments.

In response to this unfair situation, some member states have regulated heat cost limits. Therefore, residents in “warm” apartments contribute a minimum to the building’s heat costs. In the Czech Republic no tenants’ cost can exceed 200 per cent or be lower than 80 per cent of the average heating cost. In Hungary the maximum share of heating costs is limited to 250 per cent of the building average and in Slovenia the maximum share of heating costs is limited to 300 per cent of the average and the minimum level of consumption is 40 per cent of the average. The resulting differences are compensated between the apartments. This system does not exist in any other countries.

Heat cost allocation in common areas of buildings

If common areas in a building like a staircase, an entrance hall and other accessible rooms like a laundry room are equipped with radiators, these heating costs are included in the fixed share of the total heat costs.

There are different approaches to handling these heating costs. In Lithuania this is decided by each building owner on a case-by-case basis. In Austria, Denmark, France, Germany and Slovenia these costs are included in the total cost and then allocated according to the share of the respective living space.

Penalties and incentives

Heat cost allocation rules also include penalties and incentives to encourage heat customers to switch to consumption-based billing or to reduce the manipulation of heat meters or hindering their reading; the penalty fees can be very high. In Slovenia, apartments where consumption could not be measured because access was not granted, or a metering device had been manipulated, are charged 300 per cent of the average consumption. In Bulgaria, households that did not switch to consumption-based billing by a certain date paid 10 per cent extra. There may be different approaches to heat cost allocation, but one principle must be respected, the most important principle in consumption-based billing – transparency.

6. Recommendations

This section summarises the most important findings from this report as well as the most important principles and methods for the introduction of consumption-based billing.

Consumption-based billing includes the control of heat consumption at the consumer's level. In a residential building, the most common case, that means consumption control at all radiators. Otherwise consumption-based billing does not really make sense. Each point of heat transfer should be metered and controlled, only then can all advantages of this measure be realised or the DH supply be considered a customer-oriented business. CBB is key to implementing a demand-driven heat supply where heat production is efficiently adapted to the actual demands of the consumers.

It is immediately striking that the older style of district heating systems prevalent in some economies where the EBRD invests are the only heating system where consumption cannot be controlled by customers. This gives the incorrect impression that district heating is the most expensive means of heating. In addition, district heating companies without a customer-oriented management policy often put production first, resulting in a low quality of service.

This makes these DH systems less competitive than gas and even electricity (in some cases).

Concept and principles of consumption-based billing.

The main principle of CBB is transparency. A transparent bill based on real heat consumption is the most important instrument for communication between the DH company and its customers. Transparency should also be the guideline for implementing CBB. Heating customers should be thoroughly informed about all aspects of the new billing system such as the method for heat allocation, tariff structure and the billing procedure. This results in another principle – “keep it simple”; consumption-based billing is not a complicated science. Comprehensible procedures are the best way to maintain a relationship with customers that is based on trust. (See “Consumer-level impacts” and “Impacts on the DH company”)

Technically the IHS, central heat meter and radiator devices such as thermostatic valves and HCAs are one functional unit. If a state or a DH company wants to implement consumption-based billing, it should ensure that apartment buildings are equipped with a substation, central heat meter and HCAs and thermostatic valves at each radiator. It should be done in all residential buildings, where heat consumption is directly assignable to an apartment.

The key elements in implementing CBB are a clear law and a thorough provision of information to heating customers.

The law for CBB should be universally valid without exceptions.

Exceptions and partial implementation, for example only at the building level, must be avoided. If apartment-level implementation is not done and left to the residents, complete consumption-based billing may not be achieved. Therefore, measures must be taken to ensure that apartment-level implementation is prioritised. Building-level CBB alone is insufficient. The savings are lower, and the heat customer is unable to control their consumption, there are no transparent bills, and so on. All the main effects and principles such as transparency, building a customer relationship and triggering investments in energy efficiency are not realised.

A clear law and the full and fundamental education of customers are the key elements in implementing consumption-based billing.

In order to achieve major reform in the DH sector, the entire heat supply chain, from boilers to heat output, must be equipped with measuring and control devices. Only then can the following advantages be achieved:

- Efficient heat production
- Easier allocation of losses, shorter response times in case of damages
- Higher service quality
- Good customer relationship with the heat supplier
- Better payment behaviour
- Financial sustainability.

(See Figure 6. Financial sustainability through consumption-based billing.)

New management strategy for DH companies

For the DH company these challenges mean possibilities for a more efficient heat supply and a new view on its business. The new focus on heat services and customer orientation creates a stable relationship with the clients. The new customer-oriented management strategy is a big challenge for every company, because these reforms must also be reflected in the organisation of the company. Flattened hierarchical structures and transparent procedures are a good basis to motivate the staff and use its creative potentials. (See case studies on Debrecen and Plovdiv on pages 18 and 27.)

Consumption-based billing results in better information about losses in the DH network. This positive side-effect is sometimes seen as a disadvantage, as demonstrated in Kazakhstan. The perception of this information is that these losses were created by CBB, but the losses were already there and had to be paid for. Additional meters in the network are an advantage and highlight where targeted investments in network repairs are most needed.

Consumption-based billing is sometimes coupled with tariff rises. This can have disastrous consequences for customer trust if they are not informed that these are distinctly different reform steps. This can reduce trust; in Bulgaria the tariff was increased shortly after the introduction of consumption-based billing. At that time, customers' needs were not considered and they were not properly informed. This resulted in rumours and created a negative impression of CBB in customers' minds.

It is important not to try to reinvent the wheel. There are many DH companies all over Europe that have been operating successful CBB systems for years. It is better to adapt an existing methodology than design a bad one from scratch. And it is good practice to visit DH companies with long-term experience in consumption-based billing and demand-side management.

Consumption-based billing is the key measure for making the fundamental change from a supply- to a demand-driven heat supplier. Here, heat production corresponds to customer needs, this makes the DH supply more efficient. The whole system must be seen as a functional unit from the generation plant to the final heating customer. If the management of a supply-driven DH is focused on the heat output, the real purpose of DH, warm homes and the provision of DHW, is ignored. This leads to poor service quality, poor payment behaviour and customer disconnections; and without customers the DH entity cannot exist.

A demand-driven heat supply has many advantages:

- Customer loyalty – CBB is the best measure for customer loyalty
- Better affordability of heat services
- With improved service levels it is more socially acceptable to increase tariffs to cost-recovery level or reduce subsidies
- Disconnected customers are more likely to reconnect

- Improvement in customer payment behaviour
- Higher efficiency in heat supply
- Financially, consumption-based billing is one of the most attractive measures
- Information about heat losses in the DH network, results in targeted repairs
- Faster response times in case of damage to the network, easier leak detection
- Higher service quality
- CBB triggers investment in energy efficiency measures.

These effects result in higher revenues due to better payment behaviour, followed by improved financial sustainability. This will not happen on its own and requires the close involvement of the heat customers and the DH company alike.

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