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Belgrade Heat Metering Strategy

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Heat Metering Assessment and Strategy for the City of Belgrade

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This document does not in any way reflect the official opinion of UN Environment on any matter described in the document.

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List of frequently used acronyms and abbreviations

AMR	Automated meter reading
COP	Conference of Parties
DH	District heating
EBITDA	Earnings before interest, taxes, depreciation, and amortization
EC	European Commission
ESCO	Energy Service Company
EU	European Union
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	Greenhouse gas
JP	Japan
LPAA	Lima-Paris Action Agenda
MRV	Monitoring, Reporting and Verification
NGO	Non-governmental organization
NPSC	National Project Steering Committee
PBC	Pay by consumption
RA	Rapid Assessment
RES	Renewable energy sources
SAA	Stabilization and Association Agreement
SI	*Système international* (international measurement units)
UK	United Kingdom
US	United States
VAT	Value-added tax

Contents

1. Introduction

City of Belgrade is one of the four pilot cities under the UN Environment District Energy in Cities Initiative. One of the activities performed in Belgrade includes the undertaking of heat metering assessment and development of the metering strategy. The main objective of the metering assessment is to provide analysis, training and support to the City and the local district heating company ("the Company") to rehabilitate, modernise and expand district energy in Belgrade. This document has been produced done in close cooperation and consultation with the City, the Company, the Initiative, and its partners.

1.1 Scope and main goals

In order to identify the energy efficiency priorities in district heating (DH) in Belgrade, in 2016 a detailed District Heating Development Strategy ("the DH Strategy") was developed by the Company for the period of 2015-2025. To achieve the desired energy efficiency increase goals the list of priority areas was set. One of these areas covers energy metering, as without measuring of consumed energy the overall progress on increasing energy efficiency cannot be identified and calculated. In line with the DH Strategy, "square meter" based billing is to be turned into consumption-based billing and in that way encourage end users to use energy less and more efficiently. However, the change in billing makes an impact on many processes in the Company influencing the Company's profit level, heat energy tariff structure and level, vulnerable consumers group, and legal-regulatory environment. This document analyses and describes the status quo, overall processes, the DH Strategy and necessary steps for heat metering implementation in Belgrade.

1.2 Key stakeholders and beneficiaries

The end user is considered as the main stakeholder and beneficiary in the DH system. Only fulfilling the needs of the end user the optimal balance between other stakeholders, i.e. local and/or national government, private sector, DH companies, and other institutions/organisations can be made. Lack of balance between the stakeholders can lead to increased energy consumption, high energy prices and lower energy efficiency due to used old and not properly maintained technologies. In order to supply sufficient energy for the needs of the end users, they should have close two-way communication and cooperation with the national/local government, DH utility and the private sector. The participation of the private sector is crucial as it may create value for the public authority that holds political responsibility for the provision, helps to bring global experiences, to bring access to best private sector management practices, new technologies (for example in relation to energy efficiency, demand-side management, renewable energy-based, combined heat and power (CHP) plants, District Heating digitalisation, innovations and etc.), to bring investment funds through capital markets or fulfil financial contributions, which can be difficult to obtain for DH companies owned solely by local governments[1]. On the other side, the dominant role of the private sector can roll-out heat energy prices to infinite level, so national governments by the help of regulatory institution set up the legislation and regulatory mechanisms to prevent that and keep the balance on the scale for all stakeholders. The end user is, however, not the only beneficiary, as other stakeholders benefit in different ways: private sector can make the desired profit level, the national/local governments can ensure reliability of supplied energy, etc.

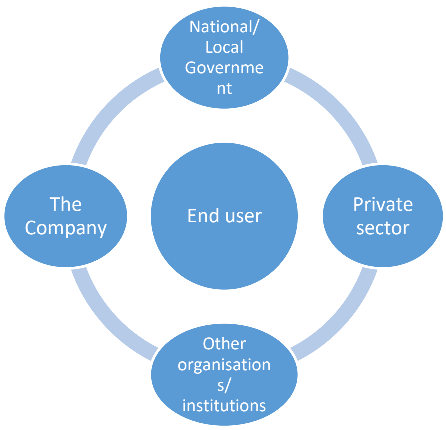


Figure 1. Main stakeholders and beneficiaries

[1] Unlocking the Potential for Private Sector Participation in District Heating. International Finance Corporation 2014

2. Heat metering in the context of reduction of energy consumption and GHG emissions

Energy consumption in the countries of the European Union (EU) slowly decreased between 2007 and 2014. During 2015 energy consumption has increased partially due to a colder winter and lower fuel prices, and the consumption of primary energy has raised by 1.5% compared to the previous year. Nearly in all EU Member States primary energy consumption during post-recession period 2009-2015 has decreased, so economic growth and recovery can be achieved without increased demand in energy consumption.

Even small reduction of final energy consumption for customers going through all energy production, transition and consumption chain leads to greater primary energy savings and reduction of greenhouse gas (GHG) emissions, increase in Gross Domestic Product (GDP) and creation of new jobs, as the energy efficiency facilitates sustainable economy development and expansion of construction sector in general. Energy efficiency not only reduces air pollution but brings many other benefits to the country and its residents, including securing energy supply, lowering bills for heating and hot water, reducing energy poverty, integrating and utilising waist heat, improving living conditions and comfort level inside buildings, etc.

Without understanding where and when within a building energy is consumed it is not possible to effectively manage energy consumption. The necessity of reduction of energy consumption and associated GHG emissions from buildings acts as a catalyst in the increasing installation of meters and sensors for monitoring heat energy use and indoor environmental conditions inside buildings. Energy metering and the metering strategy do not reduce energy bills by itself, however, it is the first major step towards managing energy consumption, providing visibility of the energy and water consumption that is used inside buildings to facilitate behaviour change within the end users and encourage them to consume less energy. Implementation of energy metering strategy requires establishment of the system for precise measurement and collection of consumed energy data. Existing billing systems invoicing according to square meters of the building are economically unacceptable, socially unfair and lead to technological regress preventing efficient energy use. The practical examples show that individual energy metering influences consumer behaviour at all levels: building and flat level. In older buildings after individual metering for every end user by the help of the heat cost allocators were installed, the energy consumption decreased: in Germany the energy consumption has decreased by 13-15%, in Denmark by 11-34%, in Finland 8%, in Lithuania 25%.[2] Figure 2 presents the case in Lithuania of individual apartment level metering implementation then after statistical analysis and energy consumption assessment according to Actual Energy Consumption Class methodology was identified that the Actual Energy Consumption Class in analysed old type multi-apartment buildings dropped down by 25% from 7,1 to 5,3 value.

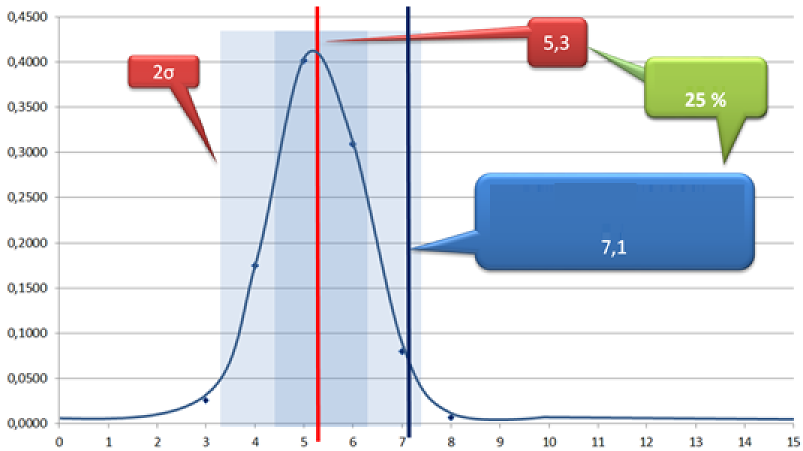


Figure 2. Statistical analysis of energy consumption in multi-flat buildings with and without individual flat level heat metering

The amount of saved energy is dependent on the country income level as the countries with lower GDP and income level tend to save more, but also on the climatic conditions as countries with longer heating season can

[2] Šilumos apskaitos prietaisų ar šilumos daliklių įrengimo centralizuotai šiluma ir (ar) vėsuma aprūpinamų gyvenamųjų namų vidaus šildymo ir (ar) vėsinimo sistemose techninių ir ekonominių galimybių vertinimas. LEI. 2015

accumulate bigger total savings, as well as on their cultural and historical experiences causing specific behaviour. In order to encourage customers to use less energy the country level heat energy tariff systems facilitating efficient energy use for energy production, transition and consumption have to be created or updated. The customers fully understanding the tariff systems for energy production, transition and consumption see the positive results on decreased billing and energy utility companies have to work economically motivated by increasing overall efficiency in operation.

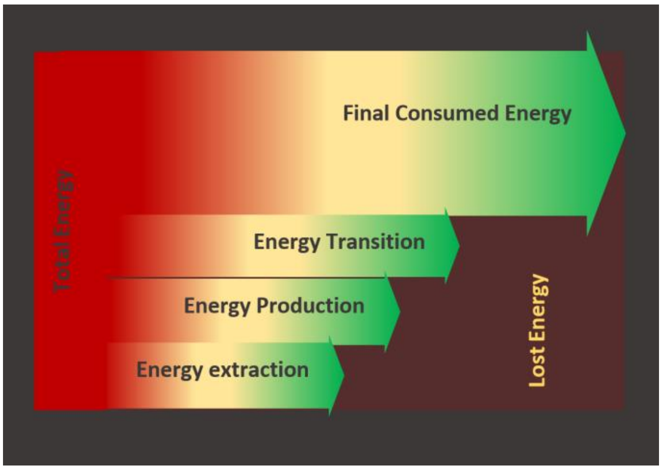


Figure 3. Total and energy lost in different phases

3. Objectives and necessary steps

Heat energy metering helps increase energy efficiency and consume less primary energy resources. A heat metering strategy supports local and state/national decision makers to update and adjust existing policy and regulatory framework in order to accommodate heat metering implementation.

To ensure the implementation of the heat energy metering the following key steps should be considered:

–	Assess the existing legal and regulatory framework for heat energy metering; identify limitations and necessary improvements; define necessary legal framework adjustments; facilitate regulatory compliance and baselining
–	Collect accurate energy consumption data of every building; energy consumption combines energy consumption for space heating and hot water
–	Invoice customers based on actual energy consumption for space heating and hot water on building level
–	Collect energy consumption data in a user-friendly manner and understandable for all parties
–	Encourage customers to use energy in a more efficient way, and have the Company form an invoice for customers presenting:
	• Amount of actual consumed energy per month in a building [MWh]
	• Amount of actual consumed energy per month per 1 m^2 of a building [kWh/m^2]
	• Standardised unified energy consumption per month per 1 m^2 of a building with eliminated climatic conditions (outside air temperature and number of heating days) [$Wh/m^2/DD$, where DD - is the number of Degree Days per month]
–	Encourage end users to use less energy; facilitate technical upgrade of heating and hot water engineering systems to consume less energy within building limits
–	After implementation of building level energy metering encourage end users to implement energy metering of every end user (flat level)
–	Develop guidelines for engineering technology producers for technical engineering upgrades within buildings
–	Assess the impact on the Company after transferring to consumption-based billing:
	• Economic impact on the revenue level
	• Economic impact on the profit level
	• Economic impact on the cash flow during the year, putting attention that after implementation of consumption-based billing, the revenue during non-heating months will decrease and the

	Company may see reduction in financial incomes to cover CAPEX and OPEX, so binary heat energy tariff with fixed constant and variable part should be considered
	• Economic impact of connecting potential new customers
	• Potential positive effect on the customer behaviour in respect to higher payments collection rate, financial sustainability and etc.
–	Assess impact on the end user after transferring to consumption-based billing; special attention should be placed on payments during the coldest months and consider the possibility to offer monthly payments with fixed constant part
–	Define the energy price tariff methodology principles necessary to avoid negative effects for the Company after implementation of metering, eliminating risk of profit decrease after revenue decrease and facilitating profit based on the capital and investment. The building level metering gives a possibility to identify more precisely actual heat losses in the District Heating network pipelines, so based on that can be built all District Heating network rehabilitation program and strategy. To avoid situation then District Heating company would include all existing DH pipe network heat losses even if they are above the theoretical highest limit, the heating price methodology have to define the theoretical DH pipe network heat losses and limits of tolerance and the DH company have to be encouraged to steadily bring down these losses with passing years
–	Define the billing methodology principles for the supplied and metered heat energy according to actual heat energy consumption in a building (distribution of heat for premises heating, hot water preparation, hot water circulation, identification of share for premises heating in flats and in other areas as basement, staircase, etc.)
–	Define billing methodology principles according to actual heat energy consumption for apartments with implemented billing for every end user (flats in the corners, flats in upper floors, energy share for flats and other premises as basement, staircase, and hot water)
–	Define the role of government and municipalities in energy metering process
–	Define the role of organizations (the Company, facility management companies, etc.) performing everyday energy systems operation and maintenance
–	Define principles applied for the vulnerable and most sensitive consumer groups with low income and/or high-energy consumption due to a poor building passive and active energy systems efficiency
–	Define the technical and metrological requirements for the heat energy and hot water meters
–	Define requirements for the installation of heat energy and hot water meters
–	Define requirements for the periodic heat energy and hot water meters maintenance and metrological tests
–	Obtain and maintain influence on the design and investment decisions
–	Improve operational efficiency of the energy systems

The implementation of the key steps should be done jointly by the City of Belgrade and the Company.

The metering strategy is implemented in three main steps:

1. Legal and regulatory – development of the necessary legal and regulatory framework
2. Billing – development of the most adequate billing and tariffing models
3. Technical – instalment and operation of heat meters

4. Recommendations

In order to achieve energy efficiency targets through implementing heat metering, a set of recommendations should be taken into consideration by all stakeholders, including the local/national decision makers, the Company, private sector and end users.

4.1 Implementation of necessary legal framework

Assessment of an existing legal and regulatory environment for heat energy metering should be made identifying existing limitations and necessary improvements. The legislation should be applied for the following bodies:

- The DH Company
- Consumers
- State institution responsible for heat energy prices and tariffing regulations – Energy Agency
- The City
- National Metrology Institute

4.2 Installation of the heat meters

The installation of heat energy meters and consumption-based billing encourage customers to use less energy. The Company should be responsible to supply heat energy of specified technical parameters in line with defined limits of responsibility in the building. Usually the limits of responsibility are confined to the location where the heat meter is installed.

Figure 4. Limits of DH Company responsibility

The Company should install and perform regular maintenance of heat meters and hot water meters. The regular maintenance includes ensuring the compliance with metrological requirements, and the Company is responsible to regularly bring heat meters and hot water meters for metrological inspection. The costs of meters, meters installation, regular maintenance and regular metrological inspection should be included in the Company's tariff structure regulated by the national regulatory institution for heat energy prices and tariff methodology and approved by the municipality. The representatives of Company should be able to visit their installed equipment in the building without any obstacles and the building owners should ensure the possibility to get into these premises. The consumers should be obliged to pay for heat supply according to consumed and billed amount of energy. The heat and hot water meters should be installed according to country defined metrological requirements. The international measurement units (SI) for metering devices should be used. The first metrological inspection for the equipment should be made after it was manufactured or repaired. Later periodical inspection should be performed and extraordinary inspection can be made as required.

4.3 Billing and tariff setting

The government should be involved in setting heat prices to restrict monopoly earnings and protect the benefits of the end users. National government should be responsible for the development of energy pricing and billing methodologies and standards for the supervision of the local heating industry in general, while municipal agencies should be responsible for setting heat prices.

To improve the cash flow situation of heating companies, provide reasonable continuity and planning security and avoid overt political influence on heat prices, the government should issue a regulation allowing partial automatic heat price adjustments in case of large primary energy source (coal, gas, biomass, etc.) price increase. The automatic heat price adjustment balances the interests of heat suppliers and consumers in the process of setting heat prices. In a case the regulators have in mind only the interests of consumers by maintaining low tariffs, regulators will affect heat suppliers by reducing their revenues and profit level. This will negatively influence heat supplier's ability to adequately maintain heat supply infrastructure and finance investment programs.

The main issues in determining heat prices for a regulated industry are what the cost basis should be, how the profit margin would be determined, what the price structure should be. Profit related to costs creates incentives to inflate costs and efficient companies that manage to reduce costs would be punished with lower profits, so profit margins based on asset value are particularly important.

4.3.1 Transition to new tariff system

For the transition to new tariff system the following should be taken into consideration:

- National government should be responsible for the development of energy pricing and billing methodologies and standards for the supervision of the local heating industry in general
- Municipality should be responsible for setting heat prices
- The heat energy pricing can be under political influence as politicians may tend to get more political bonuses keeping the same heat prices for the customers even if the fuel price increases putting these extra costs under the additional debt line or stopping all necessary investments and repair work decreasing the reliability of all District Heating System, so the automatic price adjustment depending on the fuel price in the market variation, operation and maintenance costs should be made
- With help of heat energy tariff methodology, the upper profit level limit for the Company should be fixed
- The heat energy metering can increase the overall DH system energy efficiency and decrease energy consumption, so the Company profit should be based not on the revenue but the operation/maintenance and assets value facilitating the increase of investments and proper maintenance of utilities. To prevent overinvestment for the higher profit reason, all investments should be agreed and coordinated with the City. To avoid the political influence on the prices the long-term investment strategy should be prepared and approved by the City and the Company
- It is recommended to use the same heat energy tariff for the residential and non-residential customers. If the necessity exists to apply different heat energy prices it can be made by setting different taxation system, for example applying lower VAT level for residential sector
- The transition to consumption-based billing may lead to lower cash flow during non-heating season. However, the Company still operates the DH system, repairs it and performs maintenance, so the cash flow shortages can make a negative effect. Besides the short term loans the binary heat energy tariff from fixed part and variable consumption based part can be applied
- The data base of vulnerable consumers should be made and constantly maintained. The subsidies for vulnerable consumers should not negatively influence the payments of other customers

4.3.2 Financial mechanisms

The Company should install heat energy and hot water meters and keep proper maintenance of the equipment. These costs should be included into the heat energy tariff structure defined by the regulator and the heat energy tariff methodology. Setting the Company profit level based on the asset value and the investment, the Company will be motivated to invest into metering devices to keep higher profit level. The subsidies for the metering devices installation are not worldwide common.

The private partnership participation is possible by applying ESCO or other models principles (ESCO is not the most applied widely for the individual metering). For example, a private company can invest in the metering equipment installation and maintenance for the fixed time period and share savings proportionally with customers. The savings can be calculated by comparing the payment level before and after metering. After project termination, all installed metering equipment can be transferred to the Company.

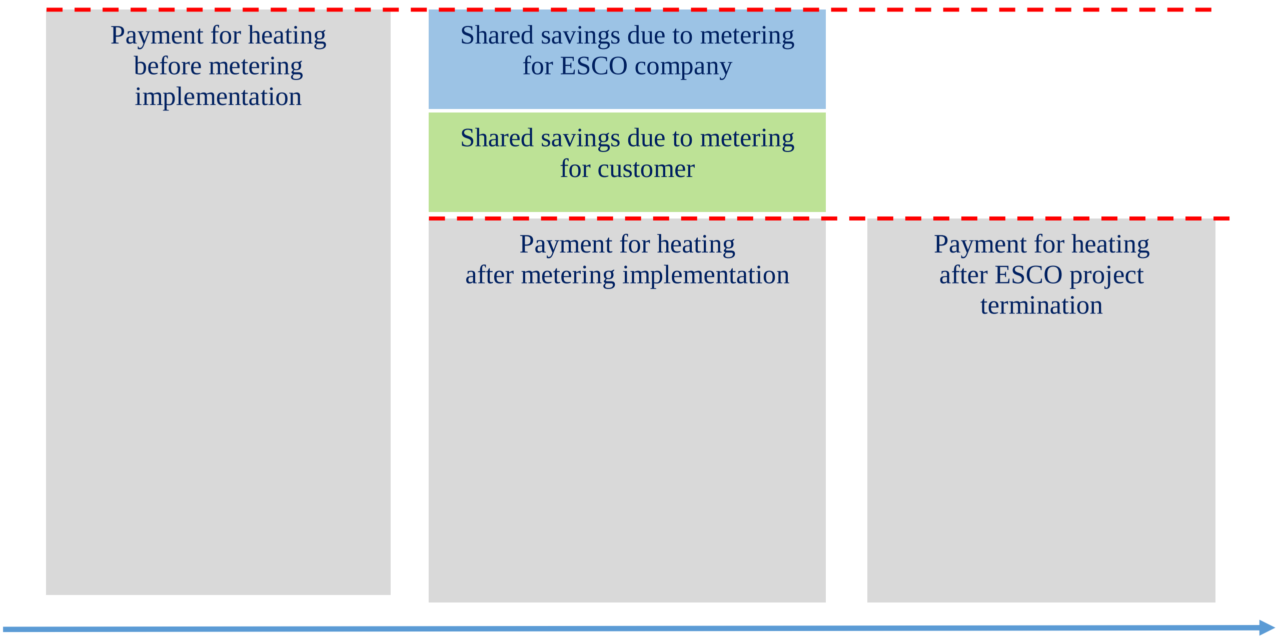


Figure 5. Payments for heating before metering, savings during ESCO contract and payments after ESCO project termination

4.4 End users

Customers should be legally obliged to pay for the supplied and invoiced heat energy. The customers have to ensure premises to install building level heat meters and should be responsible for the safety of these premises.

4.4.1 Poor housing conditions and vulnerable consumer groups

Energy poverty is defined when individuals or households are not able to adequately heat or provide other required energy services in their flats or homes at affordable cost. This problem exists as across many EU Member States, as in countries of developing economies too. In many cases fuel poverty is defined when expenditures make more than 10% from the income, but in the developing countries fuel poverty is at much higher rates and customers are much more sensitive to price increase. It is estimated that less than a third of EU Member States recognize energy poverty at an official level. Only four countries as UK, Ireland, France and Cyprus have legislated these definitions.

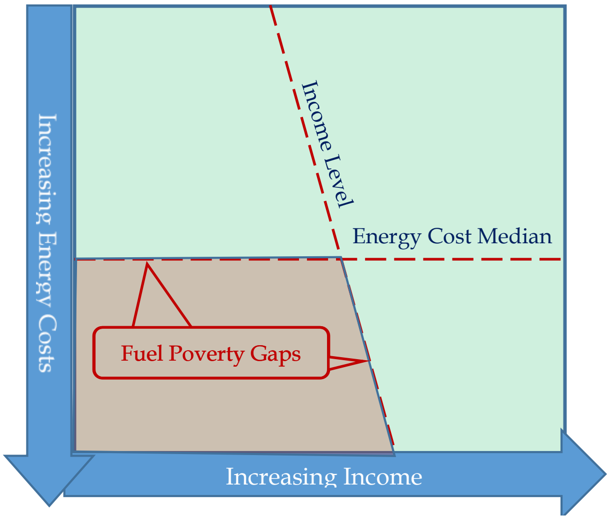


Figure 6. Energy poverty indicators dependence on the income and energy costs

Fuel poverty is usually due to a rising energy prices, poor energy efficient homes and recessionary impacts on national and regional economies. The statistics on income and living conditions show that 54 million European citizens (10.8% of the EU population) were unable to keep their home adequately warm in 2012. Similar numbers being reported with regard to the late payment of utility bills or presence of poor housing conditions. This problem is more highlighted in Central Eastern and Southern Europe. Governments and national regulators have to protect the most vulnerable customers falling into energy poverty.

Financial interventions are a very important means to protect vulnerable consumers in short-term period. The social welfare system should be used to identify recipients of support and distribute payments, but needs to be balanced against administrative complexity. Countries usually have many different financial mechanisms that vary from social welfare payments, direct payments to specific groups (e.g. elderly or retired people), to social tariffs ensuring vulnerable consumers can access the most affordable energy.

National regulatory authorities and heat supply companies play strong roles in consumer protection measures in regulated markets and should operate in a way that does not disadvantage vulnerable consumers by identifying them, guaranteeing supply and establishing codes of conduct for market players. The latter should be determined based on country or city level indices and indicators which would serve as parameters to define energy poverty.

Energy efficiency measures focusing on building's passive (walls, windows, roof, etc.) and active (engineering systems inside building as heating and hot water systems, energy metering and other systems) system retrofits are very important part of a strategy to address energy poverty. Energy efficiency measures facilitate energy consumption reduction and improves affordability for lower income households.

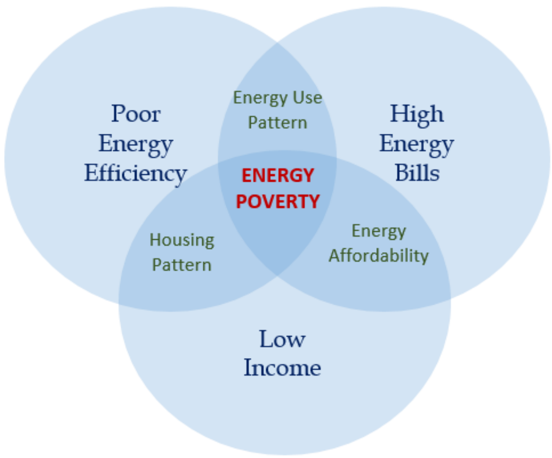


Figure 7. Energy Poverty constituent parts and indicators

Information provision is also a very important factor, greater awareness of energy poverty and how to tackle it could come through the wider use of metering. After metering becomes more the norm, it becomes important to disseminate how this technology can help to protect consumers and increase energy use affordability.

It is recommended to develop a database of measures related to vulnerable consumer protection and energy poverty, to support actions that promote the targeting of energy efficiency measures to address energy poverty, to develop data reporting mechanisms to measure energy poverty.

Customers have to be educated about how they are using energy and how behaviour change can influence energy use. The involvement of tenants in the process is also important.

4.4.2 Communication with end users

Communication with end users when introducing heat metering is crucial. Increasing awareness on how energy efficiency can be reached is necessary in order to maintain the good practice of heat metering and to ensure it is economically beneficial for both the end users and the Company.

It is recommended the end users are being informed about the implementation of the measures before the measures take place so to make sure the end users are aware of all the aspects of the process, and most importantly, the way the consumption will be billed and how it can affect end users' financial status. Open phone lines and local utility offices should be made available for the consumers for more information. Awareness raising campaigns on energy efficiency best practices could be performed educating general population, as well as on possible retrofitting measures that can be undertaken to reduce energy consumption.

4.5 Action plan

The following recommendations and actions should be taken into consideration:

No.	Activity	Responsible
1.	Define the role of government and municipalities in the energy metering process.	Energy regulator
2.	Define the role of organizations (energy utility companies, facility management companies, etc.) performing everyday energy system operation and maintenance.	Energy regulator
3.	Define energy pricing and billing methodologies and standards based on consumption-based billing	Energy regulator
4.	Municipality is responsible to set heat prices	The City
5.	Automatic price adjustment made depending on the fuel price in the market variation, operation and maintenance costs	The City
6.	Upper profit level limit for the Company fixed based on the heat energy tariff methodology	The City
7.	Long-term investment strategy is prepared and approved by the City and Company.	The City and the Company
8.	Apply different heat energy prices by setting different taxation systems, e.g. applying lower VAT level for residential sector, if it's not possible to have same heat energy tariff for the residential and non-residential costumers.	The City and the Company
9.	Define energy price tariff methodology principles necessary to avoid negative effects of the consumption-based billing for the Company	Energy regulator
10.	Apply short term loans and/or the binary heat energy tariff consisted of the fixed part and variable consumption based part in order to avoid cash flow shortages of the Company.	The Company
11.	Common country and city level indices and indicators are identified to serve as parameters to define energy poverty.	The Company
12.	Develop and maintain the data basis of vulnerable consumers.	The Company
13.	Develop a database of measures related to vulnerable consumer protection and energy poverty.	The City and the Company
14.	The social welfare system is used to identify the recipients of support.	The Company and the City
15.	Financial mechanisms from social welfare payments, or direct payments to specific groups (e.g. elderly or retired people), and social tariffs to ensure that vulnerable consumers can access the most affordable energy are implemented.	The City

No.	Activity	Responsible
16.	Customers are educated on how to use energy and how behaviour change can influence energy use.	The Company
17.	A long-term policy indirectly subsidizing low-income consumers by applying subsidies to investments like installation of heat metering, heat substations, automatic controls units, some basic building insulation or other innovative means is developed.	Energy regulator and the City
18.	Define subsidising principles applied for the vulnerable and most sensitive consumer group with low income and/or high-energy consumption due to a poor building passive and active energy systems efficiency	Energy regulator and the City
19.	Encourage end users to implement energy metering of flat level	The City and the Company
20.	Develop guidelines for engineering technology producers for technical engineering upgrades within buildings in order to raise investment	The Company
21.	Define the technical and metrological requirements for the heat energy and hot water meters	The Company
22.	Define requirements for the installation of heat energy and hot water meters	The Company
23.	Define requirements for the periodic heat energy and hot water meters maintenance and metrological tests	The Company

5. Annexes

Annex 1. About the Project

The District Energy Systems Initiative ("the Initiative") is a multi-stakeholder partnership coordinated by UN Environment that assists developing countries and cities to accelerate their transition to lower-carbon and climate resilient societies through promoting modern district energy. District energy is a proven energy solution that has been deployed for many years in a growing number of cities worldwide. The ability of district energy systems to combine energy efficiency improvements with renewable energy integration has brought new relevance to these technologies. The Initiative is an accelerator of the Sustainable Energy for All Energy Efficiency Accelerator Platform and aims to double the rate of energy efficiency improvements for heating and cooling in buildings by 2030 and quantify the corresponding decrease in greenhouse gas emissions. The Initiative has a network of partners ("the Partners") including manufacturers, operators, academia, NGOs, international organizations and finance institutions that have committed to provide international expertise to the Initiative's work in pilot countries. Furthermore, the Initiative is one of the initiating organizations of the Global Alliance for Buildings and Construction and had a strong presence on the Lima Paris Action Agenda (LPAA) of both Buildings Day and Energy Day at COP21 in Paris. The global programme of the Initiative is financed by the Government of Denmark and the Global Environment Facility (GEF).

As district energy is a local technology application, new tools, methodologies and best practice must be demonstrated at the city level within countries and then scaled-up nationally and regionally. As such, the Initiative will provide 'deep-dive' support to pilot cities in different countries using the ten district energy action modules defined in the UN Environment publication 'District Energy in Cities: Unlocking the Potential of Energy Efficiency and Renewables'. The objective of this 'deep-dive' support is to demonstrate the costs and benefits of applying a modern district energy approach in each city and to ground-truth and adapt policy best practice to the country/regional context.

Serbia has been selected by the Initiative's Secretariat as one of the four pilot countries of the global GEF project "Increasing Investments in District Energy Systems in Cities – a SE4All Energy Efficiency Accelerator". A National Project Steering Committee (NPSC) including representatives of ministries, the City of Belgrade ("the City"), professional associations, associations of local self-governments and the UN Environment is in the process of establishment. Local coordination multi-stakeholder group consisting of the representatives of the stakeholders entrusted to provide technical inputs has been nominated. The multi-stakeholder group aims to support and scrutinize the long-term development of district energy in Belgrade, ensuring multi-sector integration to deliver improved environmental standards, cost-effective district energy expansion and modernization and the accounting of diverse viewpoints in strategy and plan development. It also has an advisory role and will accompany and provide strategic and knowledge support to the City and the district energy utility company ("the Company").

In 2016, a detailed Development Strategy of the District Heating Company ("the DH Strategy") was developed for the period 2015-2025 and has now been approved by the City. The analysis undertaken through the activities below will, in part, build upon the data and analysis contained within this DH Strategy as well as provide an Action Plan to address the priorities of the DH Strategy.

The Initiative will also support the collection of good practices from the City of Belgrade to be replicated throughout Serbia and the region and will collect feedback from the activities in Belgrade and prepare for feeding into the national policy making processes of relevance for the expansion of modern and energy efficient DH in Serbia. The main objective of the overall activities in Serbia is to provide analysis, training and support to the City and the Company to rehabilitate, modernise and expand district energy in Belgrade.

The overall activities to be implemented by the Initiative in Belgrade include the following:

- Support the establishment of a multi-stakeholder coordination group in Belgrade to provide input to assessments, policy design and strategy and to receive training;
- Develop a Rapid Assessment (RA) of district energy in the City that will identify high-level options for rehabilitation, expansion and fuel switching which will then be prioritized in the deep-assessment and developed into a DES city-wide plan of policies and investments that is aligned with the city's strategy and priorities;

- In partnership with the Company, develop a detailed plan for the updated thermographic imaging of the City's existing DH network and identify priority network renovations to inform the priority investment plan of the deep assessment;
- Undertake a Deep Assessment of district energy in the City, including: a techno-economic assessment of the existing network; evaluation of the benefits and potential for modernization, rehabilitation and expansion; analysis of policy, regulatory, financial and institutional barriers; development of a priority investment plan including network rehabilitation; identification and pre-feasibility analysis of two high priority projects;
- Support the City to prepare a Procurement Plan for the demonstration project dependent on the chosen business model for the project;
- Building upon the existing DH Strategy and findings of the Deep Assessment, develop, in partnership with the City and the Company, a 10 to 20-year District Energy Action Plan of actions, policies and investments to deliver Belgrade's full potential for modern and energy efficient district energy. Work with the City and the Company through tailored policy dialogues to ensure the adoption of the District Energy Action Plan and its integration into City planning processes;
- Provide technical support to tailor a Monitoring, Reporting and Verification (MRV) framework designed by the Initiative to Belgrade and provide input to a training workshop to deliver its implementation;
- Prepare synthesis reports with targeted policy and regulatory recommendations for the City, provincial and national officials that will address barriers documented in the Deep Assessment while also referencing similar barriers in other countries in the region;
- Develop 'train the trainer' modules which will build capacity in the relevant institutions in Serbia on specific training topics. Train relevant institution(s) on the modules so that these institution(s) could then deliver training independently.

In Belgrade, a heat metering assessment has been undertaken to provide the following:

- Evaluation of existing policies on metering of heating/cooling consumption and any plans to implement a meter installation programme;
- Analysis of the technical, legal and regulatory requirements for installation and monitoring of meters to establish the heat/cool demands of potential anchor loads, specific building archetypes and sources of high- and low-temperature waste heat.

Based on the assessment, a metering strategy for heat energy generation sources, buildings and end users is developed to be recommended to the City for adoption (including information on technical requirements for meters, locations for meters, meter types, advice on meters installation and monitoring and the use of data) and to be implemented jointly by the City and the Company. Strategies and policies for metering of individual buildings as part of network renovation and improvement will be developed in the District Energy Action Plan.

Annex 2. Assessment of the current state in City of Belgrade

Legal and regulatory framework in Belgrade and Serbia

In Serbia the legislation for electricity and gas sectors is developed slightly deeper than for the DH sector. Currently, there are no obligations to use individual end user (or "flat level") heat energy meters for customers.

On November 7, 2007 Serbia initiated a Stabilisation and Association Agreement (SAA) with the EU and it officially applied for the EU membership on 22 December 2009. Serbia is in the negotiations process and while still not being officially one of the EU member countries, it takes into consideration certain EU directives for development of strategies or other documents. By adopting the Energy Community Treaty from 2015, Serbia made legally binding the commitments to adopt core EU energy legislation, the so-called "*acquis communautaire*". The Treaty acquis evolve constantly to incorporate new sectors, but also to update or replace older acts. To keep on track with the evolution of the EU laws, Treaty allows the adaptation of the acquis and implementation of possible amendments to ensure that Serbia keeps pace with EU developments and continuously align its regulatory frameworks in energy and related sectors. For that matter, not all EU directives are "*de jure*" obligatory for Serbia but this certainly is a positive facilitator. After the adoption of the Energy Community Treaty Serbia has considered implementation of the 2012/27/EU Energy Efficiency Directive and the implementation deadline for individual metering is foreseen to be November 30, 2019. Article 7 of the 2012/27/EU Energy Efficiency Directive is a key energy saving measure and contributes to the EU energy efficiency target. The savings reported by European Commission in 2017 assessment of the progress made by Member States towards the national energy efficiency targets for 2020 and towards the implementation of the Energy Efficiency Directive (Brussels, 23.11.2017) for 2015 (28.5 Mtoe in cumulative terms) indicate good progress in the implementation of Article 7 across the EU countries. However, this progress varies at national level. Some countries have put in place ambitious energy efficiency measures that deliver significant savings over the first few years of the obligation period, while a number of Member States will need to increase their efforts if they want to meet their savings requirements due by the end of 2020.

Serbia's local legislation, when connecting buildings to the DH systems distributors obliges to install metering device enabling metering that accurately reflects the end user's actual energy consumption on building's level and provides information on actual time of use. The device has to be installed before the inner installations of the building and control of the conformity of equipment already installed has to be done.

For buildings already connected to DH network and with installed heat substations heat energy distributor is obliged to install heat meters before the inner installations of the building with the following requirements:

1. To install heat metering device measuring energy quantity and the time it was consumed
2. To install the device for automatic regulation of the delivered heat to the building
3. To perform regular control of the installed equipment

For buildings already connected to the DH network, based on the request of the building owner or owners of building parts, when building is a single metering point, the distributor is obliged to provide offer to owners if it is technically possible and economically feasible, to equip the internal heating systems installation with the equipment for metering that accurately reflect the actual energy consumption and that provide information on actual time of use for every part of the building, as well as with the equipment for regulation of heat on every single heating body, or perform technical review and acceptance of such equipment installed buy the third party.

DH energy distributors are obliged to apply the heat energy tariff system within the time frame prescribed by the local self-governments but not later than 18 months after the entry into force of the Serbia's law on efficient use of energy from 2013. Local self-government is obliged to include metered and delivered consumption as one of the elements of the tariff systems for district heating.

Investors of the newly constructed buildings are obliged to supply every new building with the:

1) Supplied energy control and regulation and heat metering devices for building
2) Heat metering devices for every part of the building
3) Supplied energy control and regulation devices for every heat energy source

Minister of Energy of Serbia prescribes the conditions under which installation of the metering equipment would be deemed technically or economically non-feasible taking into account the long term projected savings and the type of the building for which legal obligations are applicable.

- *Overview of the requirements and regulations in other countries*

The need to decrease primary energy consumption and GHG emissions has been recognized by many countries. The metering strategy should take into consideration and should be based on how different countries have implemented a range of legislative measures, do they have specific energy metering and controls requirements or if they are in any other way indirectly encouraging end users (building owners and users) for wider application of metering in buildings.

Most of the legislation in Europe has been introduced in response to the EU Directives. One of them is the Directive 2010/31/EU of the European Parliament and the Council made on 19 May 2010 on the Energy Performance of Buildings, introducing building energy labelling and specific requirements for metering and controls. Second one is the Directive 2012/27/EU of the European Parliament and the Council made on 25 October 2012 on Energy Efficiency (amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC) that besides including specific requirements for metering and controls also requires the provision of smart meters to all end users and the creation of energy audit programs for enterprises.

In the United Kingdom (UK) the buildings energy labelling is covered by the Energy Performance of Buildings (Certificates and Inspections) (England and Wales) Regulations 2007 No. 991. The private sector enterprises in UK have been obliged to conduct energy audits on a sample of their buildings by December 5, 2015 and once every four years after. The sub-metering and control requirements for customers are covered in the Building Regulations, Part L. Also, UK government in 2010 has introduced the Carbon Reduction Commitment energy efficiency scheme to be independent of any EU directives.

In Lithuania the Heat Economy Law describes the responsibility of heat suppliers to provide heat medium of specified technical parameters, defines the metering point and where heat meters have to be installed in a building, and that the payment to the district energy company should be based on the heat meter readings data. All responsibility on technical and metrological maintenance belong to the district energy company and these costs are included in the energy price tariff. All heat meters are in ownership of the State Metrological Inspectorate. Heat energy and heat metering regulations define what a heat meter is and what its parts are.

Taking into consideration legislation worldwide, it should be noted that in the US metering requirements for federal buildings were introduced in the Energy Policy Act 2005 and the Energy Independence and Security Act from 2007. The International Code Council's International Energy Conservation Code (IECC) has been created in 2000 and accepted and implemented in most of the US states and municipal governments as their basis for building energy regulations and have also introduced enhanced requirements.

To encourage sub-metering, the Building Energy Efficiency Disclosures Act in Australia allows commercial landlords to exclude tenant energy use if it was separately metered in order to produce a "Base Building" energy rating. This improved energy rating works as a marketing tool, as it encourages sub-metering of tenant energy consumption.

Australian building regulations, as well as regulations in US and UK have very strict and specific requirements for sub-metering and controls.

In Japan, legislations and regulations on building energy use are less mandatory and prescriptive and only rely on a voluntary compliance for sub-metering and controls.

Table 1. Energy sector legislation in different countries

No.	Country	Legislation	Type of the Building/Action	Requirements and Facilitators for the Metering	Requirements and Facilitators for the Control
1	EU	EPBD 2002/91/EC (2002)	Applicable to all new and refurbished buildings/action	The installation of smart meters and sub-meters is encouraged with support of Energy Certification	None

No.	Country	Legislation	Type of the Building/Action	Requirements and Facilitators for the Metering	Requirements and Facilitators for the Control
2	EU	EPBD 2010/31/EU (2010)	Applicable to all buildings	Encourage the use of metering systems for new or renovated buildings	Encourage installation of active control systems (such as automation, control and monitoring) to decrease energy consumption
3	EU	Energy Efficiency Directive 2012/27/EU (2012)	General energy efficiency for various buildings	Access to real-time and historical energy consumption data through individual metering for every building and end user. Obligations for energy auditing of big enterprises.	• Annually save 1.5% of end use energy • Until a defined deadline renovate 3% of central government buildings, procure energy efficient buildings, products and services
4	UK	The Companies Act (2006)	Reduction of GHG emissions	Data collection requirements encourage installation of smart meters in buildings	None
5	UK	The Energy Performance of Buildings (Certificates and Inspections) Regulations (2007)	Applicable to all buildings with some exceptions	Data collection requirements for display energy certificates (DEC) encourage installation of energy meters in buildings. In some buildings sub-metering may be required to accurately calculate DEC rating	Controls will improve energy performance (EPC) asset rating and in-use DEC rating
6	UK	Carbon Reduction Commitment (2007)	Applicable to all electricity and gas supplies	Reporting requirements plus 10% uplift on use of estimated data encourage installation of smart meters to ensure timely and accurate data collection	Control measures that reduce energy use can influence reduction of carbon allowance purchase costs
7	UK	Building Regulations Part L2A and L2B (2010)	Applicable to all buildings	Commit end-use categories (heating, lighting, small power, etc.) to 90% of building energy use. Monitor the output of any renewable energy systems. Install automatic meter reading and data collection capability in buildings over 1,000 m2	• Establish separate zone control for areas with different solar exposure, occupancy or use type • Prevent simultaneous heating and cooling • Demand side energy management and control of central district heating plant
8	UK	Energy Saving Opportunities Scheme (2013)	Applicable to private organizations	No regulatory requirement established but the need for reporting encourages the installation of smart meters to ensure timely and accurate data collection	Audit reports tend to include controls recommendations
9	UK	UK Smart Metering Implementation Plan (2014)	Applicable to small non-domestic and domestic buildings	Installation of smart meters on smaller non-domestic and domestic electricity supplies by 2020 including wireless communications ability and real-time data collection and visualization	None
10	USA	Energy Policy Act (2005)	Applicable to all federal buildings	Measure electricity consumption where it is possible and practical, hourly interval data collected daily from 1 October 2012	None
11	USA	Energy Independence and Security Act (2007)	Applicable to all federal buildings	Provide equivalent metering for natural gas and steam as Environmental Protection Agency from 2005	None
12	USA	International Energy Conservation Code (2009)	Applicable to all buildings (adopted in 46 US States, District of	None	• Thermostatic control of HVAC systems including different zone control, minimum 7-day time control, automatic shut-

No.	Country	Legislation	Type of the Building/Action	Requirements and Facilitators for the Metering	Requirements and Facilitators for the Control
			Columbia, NYC, Puerto Rico and US Virgin Islands)		off of supply, and exhaust dampers when premises are not used • Demand control ventilation of spaces bigger than 50 m^2
13	USA	Seattle Energy Code (2009)	Applicable to a new and refurbished buildings (excluding single family homes)	For buildings larger than 1,858 m^2 end-use metering of HVAC systems, lighting, plug and miscellaneous loads. Automatic daily data acquisition and 36 months data storage. Energy displays for building managers.	• Humidistat control for each humidity control system • Optimum start control for systems with design air capacities exceeding 2000 CFM • Speed Control of supply fans for AHUs with cooling capacity
14	AUS	Building Energy Efficiency Disclosure Act (2014)	Applicable to all commercial buildings	No specific requirements, but sub-metering enable exclusion of tenant energy use from Base Building energy rating on Building Energy Efficiency Certificate that is required when office space is leased	No specific requirements, but reductions in energy use from good controls can improve the Base Building energy rating
15	AUS	National Construction Code vol. 1 (2014)	Applicable to all commercial and multi-flat buildings	Individual gas and electricity metering for all buildings with a floor area exceeding 500 m^2 (includes campus sites). Sub-metering of main energy end-uses in buildings over 2,500 m^2	• Timer control of main HVAC plant • Independent thermostatic control of zones with differing thermal characteristics and occupancy requirements • Occupancy linked control of room/space conditioners • Provision of an outdoor air economy cycle in air conditioning systems • Use of variable speed fans when variable air supply rates are required
16	JP	CCREUB (1999)	Applicable to all commercial buildings	None	Requires proper controls for HVAC, lighting, hot water and lifts
17	JP	Energy Conservation Law (2009)	Applicable to all buildings	No specific metering and/or control required, but buildings larger than 2,000 m^2 must submit an energy conservation report to the local authority before any new construction or major alteration, to demonstrate compliance with law and to implement recommended improvements. Local governments offer such incentives as relaxed height and size restrictions for energy efficient buildings to encourage implication of greater energy efficiency measures.	
18	SR	No obligatory legal documents as the member of EU but after the adoption of the Energy Community Treaty, voluntary following EU Directives as EPBD 2010/31/EU (2010), Energy Efficiency Directive 2012/27/EU (2012) and International organizations	Applicable to all buildings	When connecting building to the DH systems distributor is obliged to install metering device and enable metering that accurately reflects the end user's actual energy consumption and that provide information on actual time of use. For buildings already connected to the DH network and with installed heat substations to install heat meters before the inner installations of the building, the distributor is to measure energy quantity and the time it was consumed, to install the device for automatic regulation of the delivered heat to the building. For buildings already connected to district heating network and to provide offer to owners if it is technically possible and if economically feasible, the distributor is to equip the internal heating systems installation with the equipment for metering that accurately reflect the actual energy consumption and that provide information on actual time of use for every part of the building, as well as with the equipment for regulation of heat. Local self-government is obliged to include metered and delivered consumption as one of the elements of the tariff systems for DH.	

No.	Country	Legislation	Type of the Building/Action	Requirements and Facilitators for the Metering	Requirements and Facilitators for the Control
				Investors for the newly constructed buildings are obliged to supply every new building with the energy control and regulation, as well as heat metering devices for the building.	

District heating system in Belgrade

- *Condition of the network and current metering approach*

Belgrade's DH system is one of the largest in Europe with:

- Installed power 2,850 MW
- Length of the DH Network 1,460 (730+730) km
- Number of Heat Substations 8,700
- The total heated area of consumers 22 million m2

The Company operates with 61 heat sources (14 power plants and 47 boiler houses) with a total installed thermal capacity of 2,819 MW. The economizers give an additional 34 MW of thermal capacity. Belgrade's DH system is not uniform, it is distributed in separate districts. The annual consumption of heat energy is 3,500 GWh. The sanitary hot water production is ensured from 10 different power generation sources with 70 MW installed capacity. 89% of heat energy produced in the Company is from natural gas. Heavy oil is a secondary fuel with a tendency to be eliminated. RES makes 0.38% of produced energy. During the 2014/2015 heating season RSD 14.1 billion (USD 0.14 billion) was expensed for fuel.

The total heating area covered by the Company in February 2016 was 21,882,862 m2, with 81% occupied by the residential area (305,000 consumers) and 19% by the commercial area (15,500 consumers). The DH supplied area is growing.

The main Company's activities include:

1) Production and distribution of heat energy for the heating needs of its consumers
2) Delivery of Sanitary Hot Water ("SHW")
3) Distribution of electric energy
4) Natural gas distribution
5) Development and maintenance of heat and gas facilities, and
6) Technical testing and analysis

On the territory of City of Belgrade, besides the DH system in the City's central municipalities which is managed by the Company (including the Mladenovac municipality), there are DH systems in municipalities of Lazarevac, Obrenovac and Grocka (which do not belong to the Company), while Surcin and Sopot municipalities do not have such systems nor appropriate utility with this activity. According to the views of the Secretariat of energy representatives it is in the City's and Company's interest that the DH system is expanded to these municipalities as well. The expansion on these municipalities is planned by 2025. The secretariat is considering the possibilities of one joint company on the City level which would have as its activity district heating on the entire City's territory.

The development of the Company's DH system in a new area of the City starts with permits for urbanistic or planning document for the given part of the City to the Company. In this process other public authorities for management of infrastructure objects and pipelines also take part. The secretariats which directly take part in the development of a relevant urbanistic-planning act are the Secretariat for urbanism, Secretariat for environmental protection, and the Secretariat for energy with jurisdiction of rational energy resource management in the City. Although the expansion of the DH system would take place in the current municipalities and the above states suburban municipalities, there is no plan that DH system is a mandatory heat source in any of the City's parts.

Currently on the DH system approximately 305,000 households are connected, that is about 50% of all households in Belgrade, which provides sufficient possibility for DH system consumption expansion. By 2025 the goal is to have at least 360,000 households connected to SDH, which represents a compound annual growth rate ("CAGR") of 1.7%. In the previous 20 years the CAGR of households connected was 2.5%. Also, with the construction of a large number of new residential and office objects an increase in the expected potential consumption is expected.

Heat energy is not produced in one location in Belgrade - there are a lot of heat production power plants with rating from low to average efficiency. The reconstruction of old power plants has a positive trend. Fuel diversification should be done in the following years and the share of biomass and renewables should be increased. The location of different fuel sources should be distributed in the City uniformly.

The DH network in Belgrade can be described as a closed-loop network. Total length of the network is 1,460 km (both ways). The hot water production using electricity inside individual flats/households is common, so the DH network mainly covers only heat load. The main facilitator for domestic hot water production is a low electricity prices.

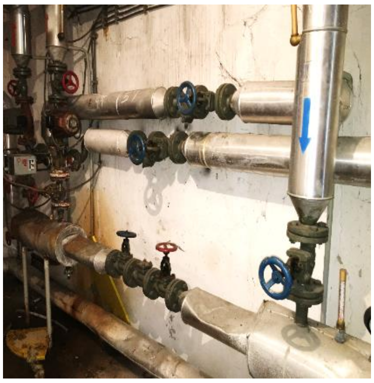
Figure 8. DH network pipes have water leakages and poor thermal insulation

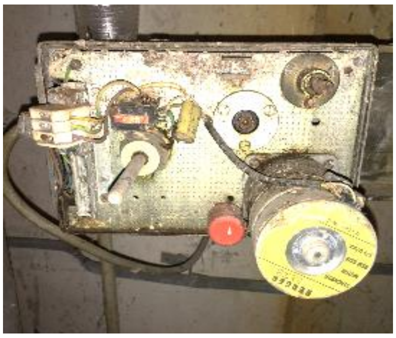
Heat production in new reconstructed power plants are managed and operated with the assistance of installed computer software. The operator monitors automatic heat production processes in the computers screens to increase energy production efficiency.

The energy production is based on the qualitative energy supply principles proportionally increasing the DH network supplied temperature then the outside air temperature drops. There is a possibility to manage amount of supplied heat keeping the same supplied temperature but changing water flow volume in the DH network, decreasing overall pipe network heat losses.

The heat from the DH network is supplied to the building with the help of heat substations. In old buildings, regulators have been installed to regulate the temperature supplied to the building's internal heating system according to outside air temperature but today most of regulators are not working, so the main temperature regulation comes from the power plant. That leads to lack of precision in supplied temperature, and the premises can be overheated. As the main billing for heat energy for residential sector is not consumption based but square-meter based, overheating does not influence directly the final bill of buildings.

To increase energy efficiency demand side management should be applied, the square-meter based billing should be switched to actual consumption-based billing. Heat meters should be installed in all buildings and existing non-working equipment should be repaired, non-reconstructed heat substations should be reconstructed to closed system with heat exchangers.





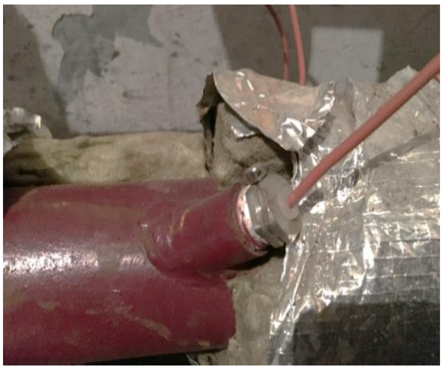


Figure 9. Heat substation and old equipment, heat meters in a substation

Heat substations in new constructed buildings are designed well and are in good operation shape.

Figure 10. Heat substations in new buildings

After implementation of demand side management in every building, it should be upgraded to the level of individual customer consumption and if not possible, by installing heat costs allocators for every final customer/apartment. Demand side management will increase overall efficiency of the DH system by proper load management by shifting heat load control to flat as much as possible.

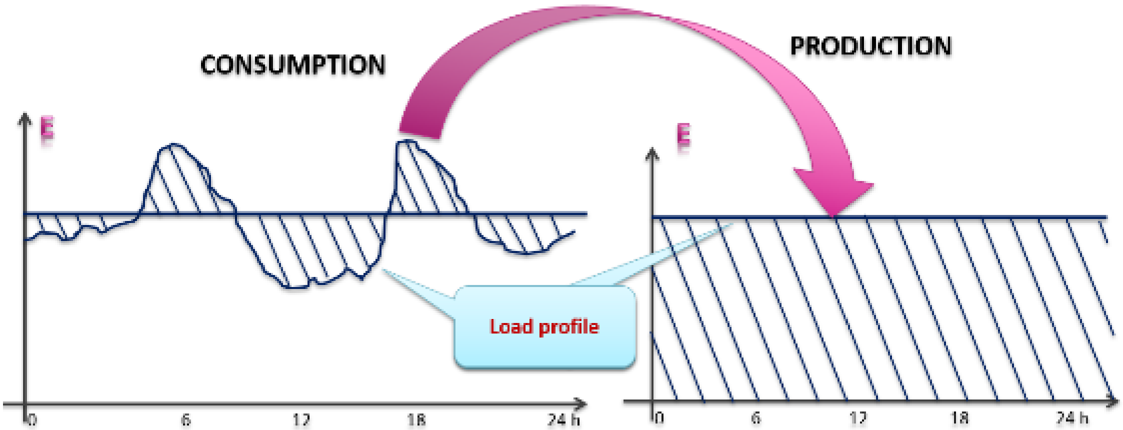


Figure 11. Demand side management

Belgrade's DH system needs investments in energy production, transmission and consumption aspects, which is foreseen in the DH Strategy. All these investments will facilitate the increase of reliability, increase fuel diversification and energy efficiency in the entire DH chain. The increased energy efficiency will affect energy demand and amount of consumed fuel leading to decrease of the Company's revenue. The increase of energy efficiency in consumer side as building efficiency means or heat metering may also leads to a lower energy demand, so the percentage of heat losses in the total utility energy balance may proportionally increase, but will remain the same value in numbers. The rehabilitation of the DH network transferring to low temperature DH network may give a positive result on heat losses decrement in DH. Heat metering enables the DH company to locate heat losses and focus investments there where the losses are high. The decreased Company revenue due to increased energy efficiency should not decrease the Company's profit level and EBITDA[3]. For that matter the heat energy price methodology should be based not on the revenue, but on the "cost and profit" principles.

- *Tariffs and billing system in Belgrade*

The Directive of the Government of Serbia defines the methodology for determination of the heat energy price for the end users. According to the Law, utility is using the methodology, calculates the tariff elements and sends it to the competent authority of the City of Belgrade for approval. Later the City of Belgrade has to approve the heat energy price by the decision of the Mayor published in the Official Journal of the City of Belgrade. Serbia has an independent regulatory body the Energy Agency set by the Parliament since 2005, which is a member of ERRA (a voluntary organization comprising of independent energy regulatory bodies primarily from Europe, Asia, Africa, Middle East, South and North America), but its activity does not have competencies over the DH sector.

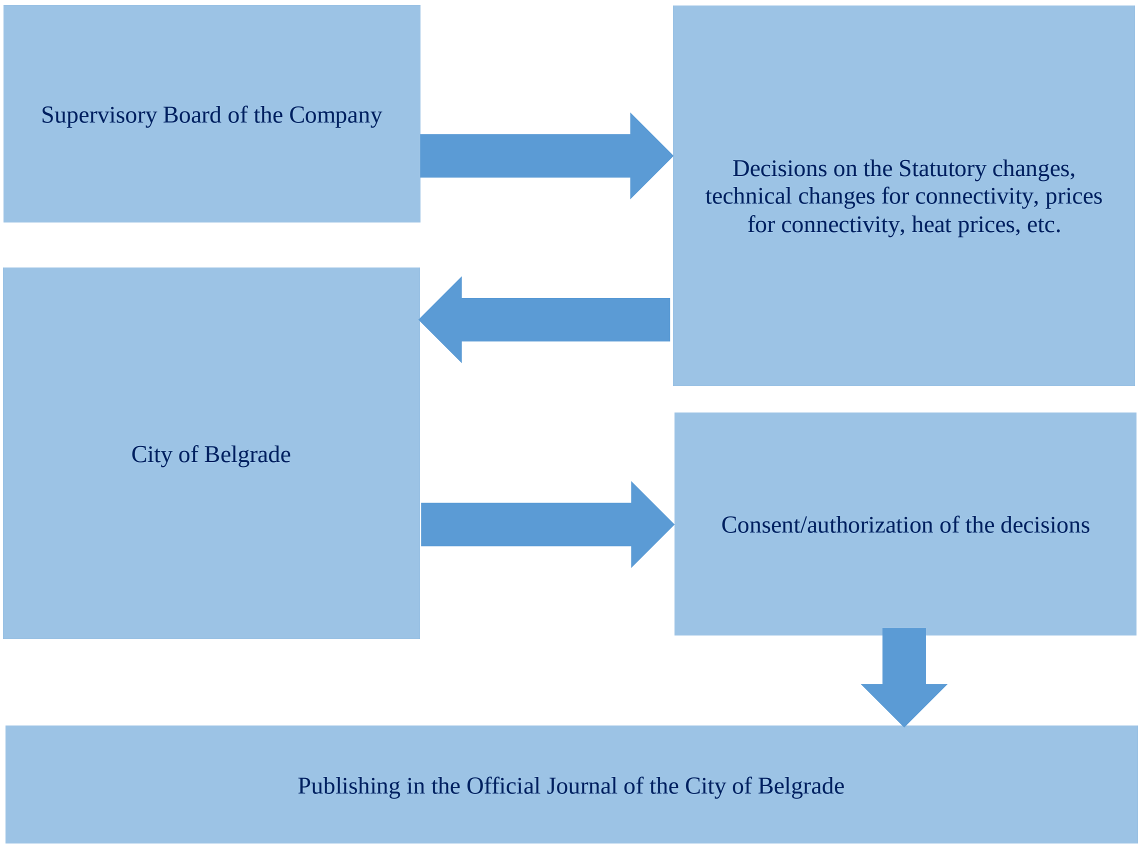


Figure 12. The structure and mechanisms of the heat energy price calculation in Belgrade

The heat energy price can be regulated in 4 main ways: 1) political-economical; 2) competitive market; 3) state-economical; 4) combined. The participation of the City contributes with political influence on the heat energy tariff.

The heat energy price in Belgrade includes mechanisms to compensate fixed and variable costs of heat production and achieves a return on the fixed part of the costs. The heat price is recalculated annually. If the revenue of the Company was higher than the defined top level (for example the heating season was shorter, the outside air temperature was higher than usually, the fuel price has decreased, etc.), the Company may get additional earnings. These earnings above prescribed level will be compensated for the customers recalculating the heat energy price for the next following heating season. The situation should be avoided then the heat price methodology does not encourage the Company to make investments to increase energy efficiency in heat generation, transition and consumption chains as increased energy efficiency may lead to decreased revenue and decreased heat energy price in the following heating season and lack of proper investment funds may lead to decrease of technological level of the Company. In addition, there should be an interest for a cheaper fuel or renewable energy resources

[3] Earnings before interest, taxes, depreciation, and amortization

integration. For that matter, the heat energy price methodology in Belgrade should encourage all necessary investments and the profit should keep positive trend in relation to processed investments.

Table 2. Profit and loss statement of the Company

No.	Indices	FY[4]10	FY11	FY12	FY13	FY14	FY15
1.	Revenue, Eur	15.9	19.5	23.2	27.0	26.7	28.4
2.	Heating area, m^2	16,155	14,456	16,672	16,965	17,230	17,439
3.	EBITDA	2.0	1.1	4.5	8.1	8.1	5.0
4.	Profit after taxes, Eur	0.0	1.3	0.8	0.6	4.7	3.1
5.	Average annual heat price, Eur/kWh	811	1,004	1,017	1,113	1,290	1,366
6.	Sales growth, %	7.7%	22.6%	19.2%	16.3%	1.1%	6.4%

The collection of payments and invoicing of residential customers is made by the local company "Infostan technologije" founded by the Belgrade city municipality. The commercial and public customers are invoiced directly by the Company. The collection rate is about 90% of total invoiced bills (in 2016 collection rate was 88.0%, in 2017 was 89.1%). The heat price tariff methodology allows that up to 10% of total to customers invoiced sum to be withdrawn, further accepting these expenses as fixed operational cost. In other words that means that these non-paid bills are “socialized” and included in the regulated revenue. The total gross amount of insolvency (including interest rates) of the Company exceeds EUR 100 million.

The Company gets approximately 70% of revenue by providing heating services to households. The largest part of operating costs are the natural gas costs (approximately 95% of fuel costs is for gas 80% and fuel oil 15%). The City provides subsidies for socially sensitive customers.

Today an average customer in Belgrade consumes 140 kWh/m^2 annually. The Company invoices customers in two ways: 1) flat rate; 2) consumption based.

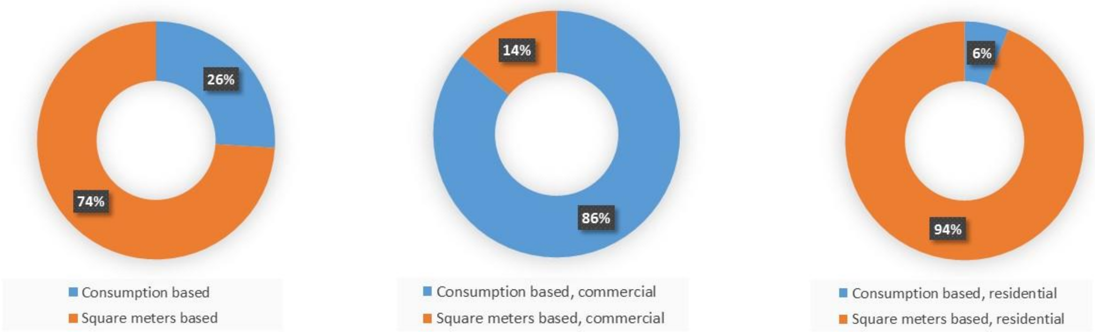


Figure 13. The share of consumption-based billing, in commercial sector and residential sector

For the flat rate customers pay depending on the heating area they occupy the same amount every month throughout the year. For the consumption-based billing the customers pay one part as flat rate depending on the installed heat capacity and heated area throughout the year and a second part based on the actual consumption just during October-April heating season. The consumption-based billing is more common for the commercial customers, where 86% of which are invoiced by the actual consumption and only 5-6% of residential customers are invoiced by the actual consumption. In total, 26% of customers are invoiced by actual consumption.

Current heat tariffing in Belgrade is presented in the table below.

Table 3. Overview of heat tariffs in Belgrade

Unmetered household tariff	Unmetered commercial tariff	Metered household tariff	Metered commercial tariff	Notes

[4] Fiscal year

1.00 Eur/m^2 per month + 27.80 Eur/kW per year	N/A	60.87 Eur/MWh + 0.36 Eur/m^2 per month	74.47 Eur/MWh	Included 10% VAT

Support mechanisms influence the DH market, so the support policy plays a very important role. Financial and fiscal support mechanisms include feed-in tariffs for electricity from renewables and cogeneration. The new energy law foresees similar incentives for heat production (Article 62). Financial support mechanisms have feed-in tariffs for the CHP electricity that is exported to the grid but have not implemented specific feed-in tariffs for heat production from cogeneration or RES. Regulatory mechanisms are applied for privileged electricity producers (access to feed-in tariffs and not paying balancing service) and the new energy law foresees similar incentives for heat (Articles 57–58 and 365–366). Interconnection policies foresees preferential access for the privileged producers. Overview of feed-in tariffs for renewable energy is presented in the table below.

Table 4. Overview of feed-in tariffs EUR cents/kWh for renewable energy

CHP (coal)	CHP (gas)	Biomass	Geothermal	Hydro	Solar PV	Wind	Waste	Duration of feed-in tariffs, years
8.7	9.6	14.0-17.3	7.5-10.4	8.0-13.3	17.5-22.2	9.9	9.21	12

Consumption-based invoicing

The measurement of supplied heat and management of the delivered heat in a building is mandatory according to Energy Law from 2015. Since 2010, all newly built residential and commercial buildings are invoiced by actual consumption.

The transition to consumption-based billing can be made in 2 ways:

1. To facilitate consumption-based billing the heat price methodology should be updated in such a way that existing customers with low energy efficient buildings would pay per year the same or less amount after consumption-based billing was introduced, keeping the same optimal inside premises comfort level. As today the temperature inside premises may be very different in different buildings, the City should decide the lowest temperature limit inside premises to be considered as optimal and normal. The optimal temperature limit has indicate that this bottom temperature limit is valid only in cases where the building partitions correspond to technical requirements, i.e. no broken windows, and the technical conditions of windows, walls and ceiling correspond to defined technical requirements. Otherwise, the customers may be asked to ensure the defined temperature level for premises that do not satisfy the technical requirements. If the customer has paid more compared to the square meter based billing, the reimbursement from the following payment should be made. All the reimbursements for all customers have to be included in the Company’s heat tariff. After few years the actual consumption heating tariff will be calibrated to correspond to square meter based billing. These steps can be taken only for the transitional period as the customers may abuse the billing system by increasing inside temperature, meaning the proper management of heat substations should be performed and buildings should not be overheated. The heat substation premises have to be locked to avoid customers to enter and adjust heating parameters. After the transitional period the reimbursements have to be eliminated. The customers with very low building energy efficiency will be stipulated to invest in increase of building energy efficiency.

2. The second consumption-based transition mechanism can be implemented slowly by increasing the share of actual consumption part in the invoice. For the first year it can be set that consumption-based part makes only 10% of the bill, so there are no risks that the bills for heating increase dramatically after consumption-based billing is introduced. If the customers pay a little bit more comparing to square meter based billing, the Company will profit, and these extra earnings should be reimbursed to customers by decreasing the heat price for the following year. During the following years, the share of actual consumption systematically should transfer from 10% to 100%.

Historical and forecasted heat tariffs

Historical data shows that the heat energy prices constantly increase for residential and other type customers. The prices for customers invoiced by square meters and by installed power increase as well.

Figure 14. Historical heating energy prices for residential and other type customers in the Company[5]

[5] PUC “Beogradske elektrane“ Development Strategy for the period by 2025 with Projections by 2035

Table 5. Historical heat energy tariffs by different billing methods according to heated area and installed capacity for residential and other customers in the Company[6]

		Date												
Billing method	Charge	2005	2006	2007	2008	2009	2010	2011	2012	2013	1.2014.	9.2014.	1.2015.	10.2015
Heating area based	**Residential** RSD/m2	29,22	35,06	43,82	47,33	64,37	83,68	89,95	106,60	111,93	114,00	114,00	119,36	119,39
	Other consumption per capacity charge only in RSD	4236,46	5083,75	5083,75	5490,45	6588,54	7944,48	8540,32	10120,27	10423,88	10616,91	13969,63	14626,19	12146,27
Consumption based	**Oher**, capacity charge, RSD per KW annually	1287,71	1545,25	1545,25	1668,87	2002,64	2403,17	2583,41	3061,35	3061,35	3118,04	4102,68	4295,51	3564,74
	Other, energy charge RSD per KWh	3,51	4,21	4,21	4,55	5,45	6,15	6,61	7,85	8,19	8,34	8,34	8,73	9,23
	Residential, capacity charge, RSD per KW annually	675,08	810,10	1012,62	1630,66	2217,69	2403,17	2583,41	3061,35	3061,35	3118,04	4102,68	4295,51	3564,74
	Residential, energy charge RSD per KWh	1,02	1,22	1,52	2,45	3,34	4,89	5,26	6,23	6,70	6,82	6,82	7,14	7,57

[6] PUC “Beogradske elektrane“ Development Strategy for the period by 2025 with Projections by 2035

Due to inflation, investment and fixed assets of the heat energy price in Belgrade according to the Directive for heat prices calculation has had a noticeable growth tendency. This growth tendency is based on the operating revenue keeping profit growth and EBITDA at much lower rates. After consumption-based billing is implemented EBITDA may remain at the same level, but as the revenue will constantly grow, it will have proportionally lower percentage (20% for period 2030-2035).

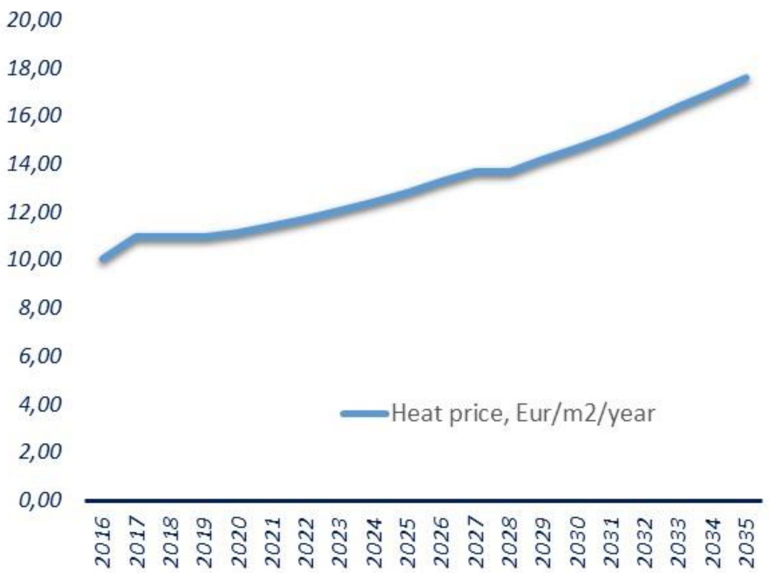


Figure 15. Heat price forecast for Belgrade customers, Eur/m^2/year[7]

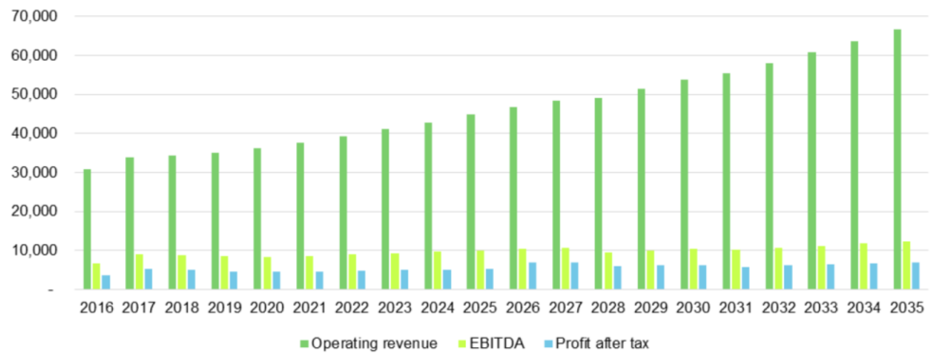


Figure 16. Forecasted operating revenue, EBITDA and profit in Belgrade[8]

- Cost assessment of metering for different building types

The heat metering systems (building level and further on individual final consumption flat level) should be installed by the Company. All investments, regular maintenance (CAPEX, OPEX), regular metrological inspection, data reading and transferring to billing system or directly transferring to billing system by wireless technologies should be included in the heat pricing methodology and distributed evenly for all customers. As the buildings have different heating area and heat losses, different meters for different building types should be used. For smaller buildings (for example 4 flats building) the heat meters will be of smaller capacity and cheaper. The customers of different buildings cannot be invoiced for the heat metering installation in the same way, as these costs for smaller buildings will be disproportionally high and for big multi-flat buildings disproportionally small, which can decrease the attractiveness of the metering installation. The solidarity principle should be kept

[7] PUC “Beogradske elektrane“ Development Strategy for the period by 2025 with Projections by 2035
[8] PUC “Beogradske elektrane“ Development Strategy for the period by 2025 with Projections by 2035

distributing all these costs proportionally in the heat price. The operational costs, as well as the repair of the meters cannot be invoiced directly to the customers. The costumer demographics do not play a role, as all metering related costs should be included in the energy price. The subsidies for low income or vulnerable customers should be based on the total heat energy spent.

<u>Belgrade's Utility outlook</u>

The Belgrade DH utility company provides a list of strategic goals for the DH system and network. One of them is the increase of energy efficiency in the following segments:

- Heat sources
- Distribution network and
- Heating substations

According to the Energy Law from 2015 measuring and regulating delivered heat is mandatory for each building. Since 2010 payment by consumption (PBC) has been introduced in all newly developed residential and commercial objects in Belgrade as well as existing objects at the owners' request. Approximately 18,000 flats are currently under PBC.

In the long term, the DH Strategy states that the introduction of PBC for the remaining users of the DH system is possible and this strategic goal can be implemented by 2025. The DH Strategy indicates PBC should comply with the current advance payment system in order to mitigate seasonality in the monthly bills, which may have effect on the Company's cash flows.

Advanced payment for PCB would be implemented in the following way: yearly average heat consumption for each heat meter is calculated for three previous years. This way of calculating heat consumption provides an estimate potential of energy to be used and according to that the billing is undertaken. At the end of the heating season a correction is made based on the paid and delivered heat, based on which the monthly bills for the following period are adjusted. Alternatively, in the first following months additional payment can be asked if more energy has been consumed then envisioned through the advanced payment, or a reduction in case heat consumption is smaller than envisioned. Before the introduction of PBC an additional analysis of all aspects of PBC is necessary both from the users' perspective and the Company's perspective, states the DH Strategy.

Introduction of PBC for remaining DH system users would affect the turnover, net earnings, and cash flow for the Company. According to the estimation of the Company, the revenue would be reduced by approximately RSD 3 billion (USD 29.36 million) if all users of the DH system would be using PBC. On the other hand, projections made show that the transfer of all users to PBC until 2025 would result in net earnings reduction by RSD 0.5-1 billion (USD 5-10 million) annually in the period 2026-2035 compared to the scenario of current ratio of PBC and "flat rate" billing. Although measurement of energy consumption is legally mandatory, and the technical conditions in the Company are present, a consent from the City is needed as well as the Company management in order to transfer all users to PBC.

<u>Building stock in Belgrade</u>

Available data on the structure, composition and performance of both the national Serbian building stock and the Belgrade building stock is only limited. It is estimated that the housing sector accounts for 38% of total energy consumption in Serbia, and almost nine out of ten buildings were built before 1991 (as shown below).

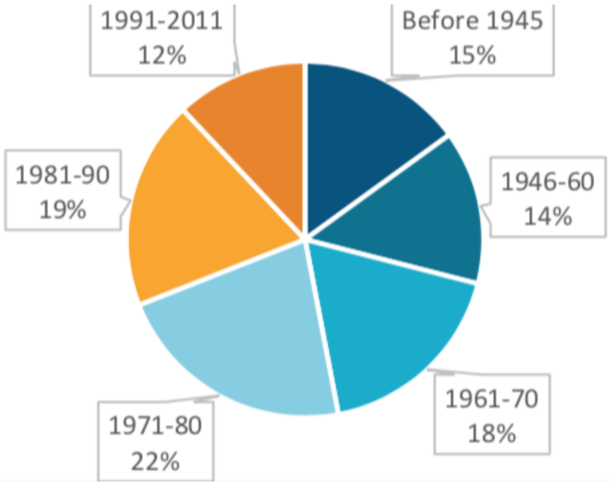


Figure 17. Share of residential buildings in Serbia by construction period

Energy for heating has the largest share of total energy demand in households. This puts a considerable strain on the income of many Serbian households. Eurostat estimates that more than 41% of the overall population in Serbia cannot pay their bills on time, while 26% live in very low-quality dwellings with serious defects, such as leaking roofs, damp walls and rotting floors. Consequently, one family in six is not able to keep their home adequately warm and experiences higher incidences of poor health and damp-induced illnesses and diseases. These energy poverty indicators are among the worst in Europe and provide a further dimension to the need to improve the energy performance and quality of the building stock in Belgrade.

In addition to the generally poor quality of the building stock, poor air quality is a serious problem in many parts of the city and pollution levels are rising every year. Measures to reduce energy demand will also have a positive impact on the air quality. Gas dependency is a concern for Serbia, with 71% of gas used imported. Buildings are one of the biggest consumers of energy, particularly for heating and cooling, and in Serbia district heating is, to a large extent, supplied by gas. Therefore, renovation of buildings to reduce the demand for gas is crucial for energy security.

The common building typologies vary across different districts. The Belgrade city center has a combination of multi-family houses (i.e. flats) and single-family houses, while there are mainly single-family houses in Banovo Brdo and New Belgrade that are characterised as multi-family houses.

Annex 3. Billing and tariff setting

The heating sector is commercialized and the heat price system is supposed to be based on full cost recovery of justified costs. A fair profit margin is based on asset values with tariffs specific for each heat supply company. Price cap regime and base line tariffs are valid for a period of three to five years and prices are adjusted automatically to provide better incentives for achieving efficiency gains.

The tariffs for residential and non-residential customers should be set the same, with an exception that different heat energy tariffs can be set for residential and non-residential customers with a different taxation (for example different VAT taxes for the residential and non-residential sector) to set a higher profit rate from the non-residential customers.

Consumers are responsible to pay bills according to actual heat consumption, but switching from square meters billing to consumption-based billing would decrease the income of the Company during non-heating season or these financial flows can become even equal to zero if the Company produces only heat without hot water. During non-heating season the heat supplier still operates all energy utilities, maintaining the DH pipe network, preparing boilers for the next heating season, buying biofuel, etc., so it still needs a financial flow to be able operate. The possible solutions in this case can be the following:

1. Get a short-term loan from the banks and include interest rates in the heat energy price tariff. Consequently, the consumers will pay for the interest rates
2. Make heat energy pricing methodology which will collect necessary flows during heating season, so in certain way the customers paying according to actual energy consumption will pay in advance to cover non-heating season expenses
3. Make a two part heat energy tariff (the fixed/normative part and the variable part)

Sometimes consumers are billed inconsistently in the way the information they receive from their heat suppliers and in the way they are able to access help, advice or even file a complaint. Heat suppliers should ensure that customers are billed in a clear and transparent way to ensure they understand how their bills are calculated and to know what period their bills cover. Payment options as pre-payment (Top-up card, over phone, text message, on-line), direct debit and credit billing should be taken into consideration.

The heat suppliers have to set minimum efficiency standards and a regular maintenance and inspection (under state metrological inspection supervision) regime in place including checking of all heat meters every two years to make sure users are being billed for the right amount of heat.

The heat suppliers should develop and constantly maintain a list of vulnerable customers (e.g. Priority Services Register) and ensure these customers are treated as a priority during periods of system downtime and maintenance, and provided with assistance in controlling their heating and billing.

At a higher level there is a lack of information regarding the number and location of DH schemes in many countries. Without a central database it is very difficult to obtain further detail on schemes to get a coherent picture of the DH systems that exist, the service they provide and the costs to consumers to understand where better practice and greater costumer protection might be required. This data collection should be delegated to the responsible institution, the details on the number and location of heat networks across country should be published and this should be a publically available information.

Annex 4. Energy poverty

Serbia is on the list to become one of EU Member countries, and following EU Directives sets a good example for Serbia. Energy Efficiency Directive 2012/27/EU article 7(7) (a) states that Member States shall set up an energy efficiency obligation scheme including requirements with a social aim in the saving obligations they impose, including requiring a share of energy efficiency measures to be implemented as a priority in households affected by energy poverty or in social housing, however without a precise definition of energy poverty, this is difficult to implement.

The main EU Directives regarding vulnerable consumers are the Directives concerning common rules for the internal market in natural gas (2009/73/EC) and electricity sector (2009/72/EC), but the same principles can be applied for district energy sector as well. Main principles from the electricity sector (2009/72/EC) can be transferred to the DH sector by adopting article 3 (7 and 8).

Point 7 can be adapted to the district energy sector as follows: “Country shall take appropriate measures to protect end users, and shall, in particular, ensure that there are adequate safeguards to protect vulnerable customers. In this context country shall define the concept of vulnerable customers which may refer to energy poverty and, inter alia, to the prohibition of disconnection of electricity to such customers in critical times. Country shall ensure that rights and obligations linked to vulnerable customers are applied. In particular, they shall take measures to protect end users in remote areas” (EU Directives 2009/73/EC and 2009/72/EC).

Point 8 can be adapted to the district energy sector as follows: “Country shall take appropriate measures, such as formulating national energy action plans, providing benefits in social security systems to ensure the necessary energy supply to vulnerable customers, or providing for support for energy efficiency improvements to address energy poverty where identified, including in the broader context of poverty. The country should focus on longer term solutions (e.g. building passive and active systems retrofit, metering technologies, etc.), and not only short term relief (e.g. bill support)” (EU Directives 2009/73/EC and 2009/72/EC).

Energy Community Ministerial Council endorsed a proposal for a regional definition of vulnerable customers in the electricity sector that should also be adapted to the district energy sector as follows:

“Vulnerable energy consumers:

- Uses energy for supplying his/her permanent housing.
- Does not exceed the maximum energy consumption per building area.
- Belongs to a category of citizens with lowest income: for the definition of low income, beside the income of all available assets shall be taken into account” (EU Directives 2009/73/EC and 2009/72/EC).

A good practice should be taken from the European Consumer Consultative Group, a European Commission forum for consumer organizations, targeting that the country should implement strategies that reflect the different needs among different groups of consumers in order to make it easier for all consumers to make energy-efficient choices. The policy should focus on the most long term and sustainable solution to fuel poverty, namely radical improvement to the energy efficiency standards of housing, particularly one occupied by low income and vulnerable households.

All regulations protecting vulnerable consumers should not influence negatively non-vulnerable consumers, so the regulations on the indoor temperature, comfort level and other regulations, hygiene norms, and etc. should define the technical and regulatory (for example heat distribution inside building with individual heat metering methodologies) means to protect the vulnerable consumers trying to decrease bills for energy as much as possible after individual heat metering in every flat will switch off at all heating in their flat of multi-flat buildings. In this case the temperature inside flat will decrease, the heat losses through the neighbours partitions will increase and the non-vulnerable consumers will pay more. The technical regulations to install thermostatic valves with no possibility to decrease a temperature less than for example +18ºC should be applied. Heat distribution inside buildings with individual heat metering methodologies also solve these problems and protects non-vulnerable consumers.

Heating companies should not be the source of subsidy funds for vulnerable customers. This contradict to a more commercial behaviour of heating companies. DH companies should offer more flexible and customer-tailored payment terms to improve affordability and collection rates, especially from low-income customers. Also it is important to maintain simplicity, so the payment and subsidies systems would not become too complicated, non-transparent and difficult to administer.

The subsidies for the low-income consumers can be done in two ways:

1. Directly subsidizing bills for energy (applying smaller VAT, giving discounts or other means) (short-term policy)
2. Indirectly subsidizing low-income consumers by applying subsidies to such investments as installation of heat metering, heat substations, automatic controls units, some basic building insulation or other innovative means (long-term policy)

The main difference between first and second solution is that in the first case the vulnerable low-income customers will forever stay vulnerable and in second case they will jump to a typical customer group. By calculating, for example, how much subsidies will be paid in the period of 30-50 years, the second example is much more attractive. But it should be kept in mind that the second option, indirect subsidizing, can be applied only to one family buildings or to a whole multi-flat building if the majority of customers are low-income as indirect subsidizing would not work if in the multi-flat building only one customer is vulnerable and low-income. The hybrid model for subsidies can be applied.

Annex 5. Heat metering systems: components, processes and types

The following components take part of the energy metering process:

1. Energy generation source to produce heat energy (power plant or other energy source)
2. DH network to transfer generated energy from the generation source to the buildings
3. Building connection with DH network described as heat substation located inside the building
4. Heat energy meters to measure total supplied heat to the building from the DH network
5. Building heating pipe network inside building to transfer heat from building heat substation to every heating device in the building
6. Heating devices (radiators, convectors, forced convectors, heated floor, etc.) inside the building to transfer heat from the devise to the premises
7. Heat energy meters or heat cost allocators to measure or allocate consumed heat for every customer
8. Building hot water pipe network inside the building to transfer hot water from building heat substation to every customer consumption point
9. Hot water meters to measure consumed amount of hot water for every customer
10. Data collection system to collect data from all energy consumption measuring devices and hot water meters

Building level heat meters, flat level heat meters (for one floor or collector type internal heating systems) and heat cost allocators are used for heat energy measurement. Hot water meters are used for metering the consumption of hot water. Heat meters should be accurate and should be properly maintained and periodically checked.

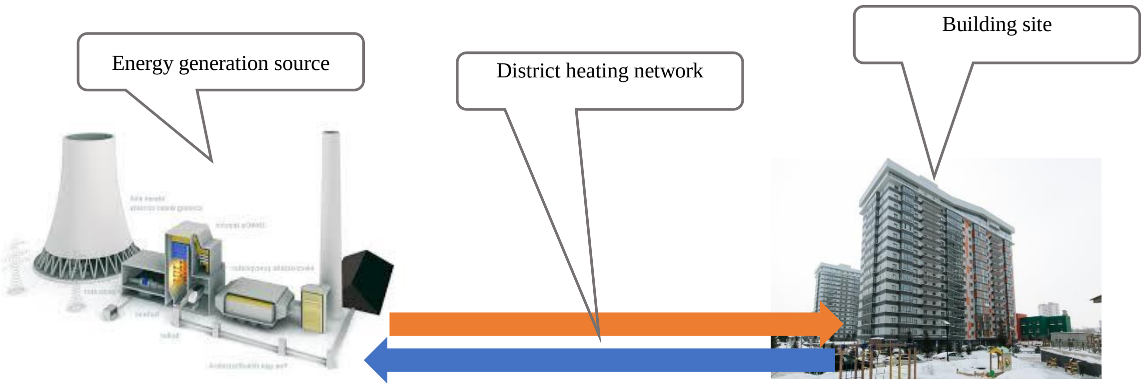


Figure 18. Visualization of energy generation source, district heating network and building connection

Figure 19. Visualization of energy supply from district heating network to the building level heat substation and energy transition to the heating device

Figure 20. Visualization of individual heat substation and heat meter for every flat

Figure 21. Visualization of heating system collector and individual heat meter for the flat (collector or one floor heating system)

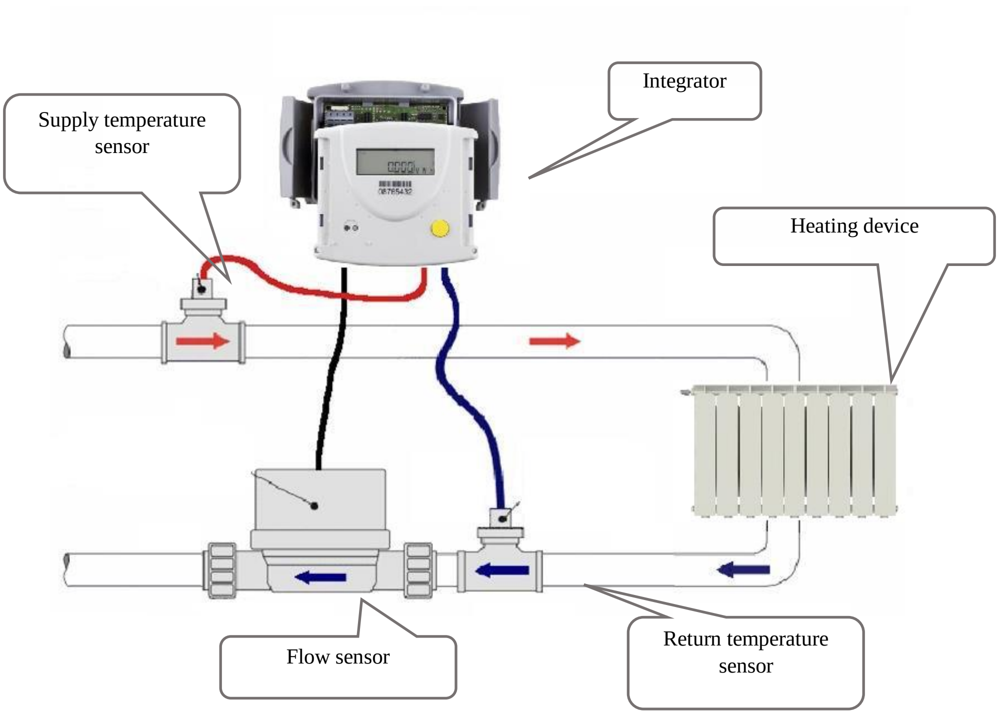


Figure 22. Visualization of heat metering process by heat meter

It is technically not feasible to install individual heat meters in single-pipe and two-pipe heating systems without reconstructing them, because the same heat transfer agent flows vertically through the storages from one flat to the remaining flats. It is technically feasible to reconstruct single-pipe and two-pipe heating systems making them collector-type heating systems, but it is not economically viable. This is confirmed by the experience of restructuring of heating systems - reconstruction of the single-pipe heating system of the analogous multi-flat building making it a collector-type system increases labour costs by 5 times (excluding costs of major repair of the flat), while savings may be expected only after almost 8 years.

Table 6. Description of different types of heat meters

No.	Types of flow sensors	Operating method	Water quality	Pressure drop and operation temperature	Flow rate issues	Costs
1.	Single jet turbine flow sensor: impeller, multi-jet impeller and Woltman sensors	Inline turbine	Dirty water or solid parts in the water can influence the rotating parts, the jamming can affect accuracy	Higher pressure drop in the flow sensor, may have a maximal operating temperature	Flow sensor is not so accurate with low or variable flow rates	Low
2.	Electromagnetic flow sensor operating in magnetic inductive or mag meter principle	No moving parts in water, very fast instantaneous response to flow measurement. Danger of signal interference can be observed	Flow sensor is not sensitive to the water quality or cavitation process	Low pressure drop in the flow meter	Flow sensor can manage flow rate variation well	High
3.	Ultrasonic flow sensor: transit-time or Doppler-shift	No moving parts in the water, some flow meters (with transmitter and receiver at opposite ends of measurement pipe) can cope well with poor flow patterns	Flow sensor can be sensitive to air bubbles and cavitation	Low pressure drop in the flow meter, to operate needs a minimum system pressure	Flow sensor can manage flow rate variation well, may not require straight pipes for the installation	High

Distribution of the amount of heat among flats is done with individual heat cost allocators. These are used both in newly built buildings with collector-type heating system and in old-style buildings with single-pipe or two-pipe heating systems which have been reconstructed by tailoring each heating appliance to individual regulation and heat metering needs.

There are two types of heat cost allocators: capillary ampoule type and electronic. Capillary heat cost allocators have been used for determining heating costs already since 1926. Their operating principle is simple – the main part of the instrument is a calibrated ampoule and a heat conductive metal plate for mounting. Graduations are drawn on the ampoule for the purpose of measuring the quantity of evaporated liquid. The ampoule is filled with non-hazardous liquid which evaporates more intensively the higher the temperature. The number of graduations that the liquid subsided and other factors may suggest the share of the heat consumed attributable to the specific heating appliance. There were many stages in the development of capillary heat cost allocators and as of 1983 the German Institute for Standardization (DIN) standard has been applied, according to which methyl benzoate, under the norms of that period, was regarded as the least toxic and having the most appropriate evaporation characteristics.

Figure 23. Capillary heat cost allocator

The main advantage of capillary heat cost allocators is a relatively low price. The main drawback of is that in order to measure the amount of heat consumed by each heating appliance it is necessary to enter each flat and to visit each resident. In a large building or a multi-flat building it is complicated to do this simultaneously, on the same day and in the same hour; therefore it is difficult and practically impossible to record the individual heat consumption each month. When readings of each capillary heat cost allocator are recorded manually, it is necessary to calculate again manually the amount attributable to each particular flat. As a result, readings of capillary heat cost allocators are most often recorded only at the beginning and at the end of the heating season and such rarely performed data capturing does not motivate final heat consumers to save thermal energy. After the liquid has evaporated, the capillary heat cost allocator needs to be replaced.

Electronic heat cost allocators are fairly accurate and have several logic functions allowing measuring to begin and stop according to the pre-programmed date. When the temperature of the radiator is higher than programmed and the difference between the radiator surface temperature and the indoor air temperature is sufficient the measuring stops. Electronic heat cost allocators can have two temperature sensors which separately record the temperature of indoor air and of the heating appliance. This increases the accuracy of measurement even more. Electronic heat cost allocators are more expensive than the capillary, however, they provide the possibility to read the data in a centralised wireless way at a chosen frequency. Most often the method of meter reading is to take the last hour of the last day of the month. After the readings of each electronic heat cost allocator are recorded in a centralised wireless way, these readings are automatically processed in a programmatic manner and it is calculated how much heat shall be attributed to each flat.

Figure 24. Visualization of metering process by electronic heat cost allocator

Table 7. Pros and Cons of heat meters versus heat cost allocators

	Heat meters	Heat cost allocators
Pros	• Heat is measured accurately	• Cheaper • Technically can be installed in more instances
Cons	• More expensive • Not in every situation can be installed technically	• No direct energy measurement, energy is distributed according to allocated data • More likely to be damaged

Hot water metering

Heating and hot water consumers who are supplied hot water in a centralised way have individual hot water meters in their flats. Their number in a flat is determined by the type of the hot water supply system and most often there are one or two hot water meters in a flat.

One hot water meter is mostly installed in newly-built buildings or buildings having separate hot water supply through one pipe to each flat and later hot water is distributed to the bathroom and the kitchen. In such a case, one common hot water meter is installed in the flat for the bathroom and the kitchen. Two separate hot water meters for the bathroom and kitchen are mostly installed in mass construction Soviet buildings having separate hot water circulation risers for the bathroom and the kitchen, and hot water is supplied to the flat from these risers.

Hot water metering in flats plays a key role. If the annual balance of thermal energy in a typical building was measured, it would be evident that energy demand for pre-heated hot water and annual circulation represents about half of the amount of thermal energy consumed by the whole building. In countries with developed metering systems and approved metering methodologies heat is allocated to each flat in proportion to the floor area occupied. In this case, the amount of heat for hot water circulation and the amount of heat for pre-heated hot water are subtracted from the amount of heat recorded by the inlet heat metering device of the building and the remaining sum is divided proportionally among the flats according to the floor area occupied. The amount of heat for pre-heating hot water is measured according to the quantity of hot water declared by residents.

Residents may sometimes influence the readings of hot water meters in different ways; often magnets are put on old-type hot water meters, which stop rotation of the meter; therefore hot water meters in flats must be replaced with meters complying with modern technical requirements, which most often have plastic internal parts and are immune to magnetic tampering. Besides, meters complying with modern technical requirements offer the option of recording their readings in a simultaneous centralised wireless way. It offers the solution to the problem of untimely declaration of hot water readings.

Figure 25. Magnets on water meters

<u>Data collection systems</u>

Smart/intelligent system is a system which measures consumption of electricity, gas, water and heat, may perform communication function in real time by transmitting reference data, may analyse the consumption of energy (also of gas, water, electricity). It differs from the usual old-type metering in the way that the smart/intelligent metering system not only has the automated meter reading functionality, but also all devices are connected into a common system which may perform automated meter reading (AMR), monitoring of the system devices and other functions typical of the common system. Until the end of 2008, there were more than 39 million smart metering devices in Europe, whereas in 2012 the market of smart metering devices accounted for about 7 billion pieces. Smart metering devices are part of the smart/intelligent metering system, however, individual smart metering devices cannot constitute the smart/intelligent metering system.

The purpose of the smart/intelligent metering system in relation to final consumers is to help them expeditiously receive energy consumption data, monitor and control energy consumption. It improves energy efficiency, reduces consumption of primary energy and CO_2 emissions.

Figure 26. Example of Finnish smart metering system

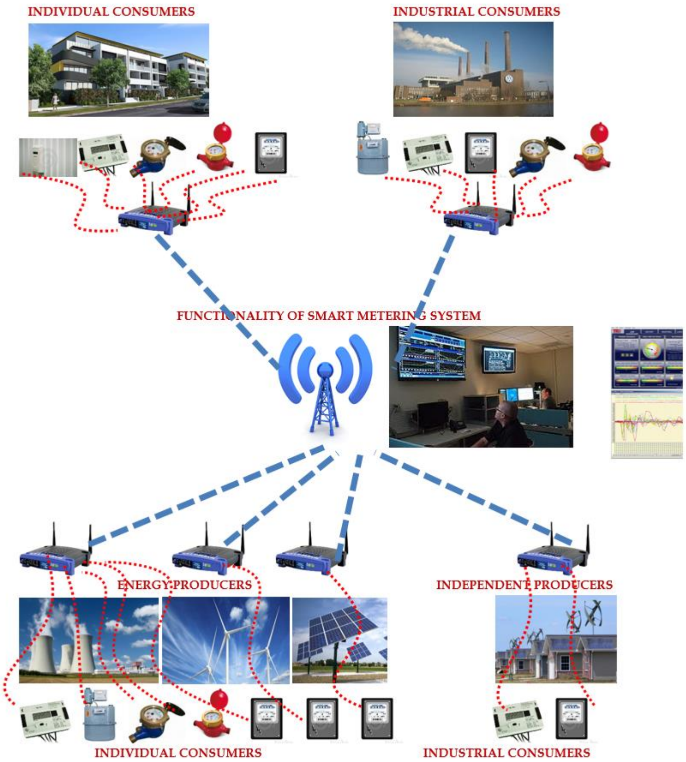


Figure 27. Remote smart metering, data transmission and monitoring system operation scheme

The implementation of metering in existing buildings has already been made in many buildings and technologies for communication and data protocols are well known. In principle, the data communication technologies are divided into wired and wireless technologies and are used for data transmission between meters and providers of energy services, customers, indoor premises monitoring sensors, smart appliances, etc. Described technologies have many advantages and disadvantages. Wireless technologies are usually low-cost with low CAPEX and OPEX costs, wired technologies are more reliable and have a more secure way of data transfer. Most widely used communication and network technologies for metering in the buildings are:

1. WiFi,
2. Ethernet,

3. M-Bus,
4. GPRS and GSM,
5. ZigBee,
6. Power line carriers,
7. ModBus,
8. BACnet.

Some of the widely used communication and network technologies and their advantages and disadvantages are presented in the table below.

Table 8. Data collection methods advantages and disadvantages

No.	Method	Description	Advantages	Disadvantages
1.	Visual direct reading of meter	Meter reader gains access to each dwelling and visually inspects the meter	No additional infrastructure required, hence no additional capital investment	• Labour intensive and hence costly • Access not always available which necessitates estimation of reading
2.	(GPRS) Radio – General Packet Radio Service	Meter is fitted with a radio module and the data is collected by either a meter reader on a 'walk by' to the dwellings or relayed to aerials on site for re-transmission	• Does not require access • Meter can be read on an external walk by with a hand held data collection device	• Less labour intensive than visual direct reading but still requires labour and hence is costly • There can be issues regarding communication software between data collection device and meter
3.	M-BUS	Meter is fitted with an MBUS module and is cabled to a data collection point forming a local area network	• Does not require access • Direct wired connection with each meter	• Requires capital investment in data cabling to each dwelling • Risk of cabling damage during construction or during any building work on property
4.	Radio/M-BUS Hybrid	Meter is fitted with a radio module and transmits data to a fixed M-BUS node (in a plant room or building core), which is then collected	• Does not require access • No cable required to each dwelling – reduced capital cost	Requires capital investment in M-BUS nodes and cabling to central data collection

During the last years, the technological progress was very fast regarding the metering. The metering has become more advanced in data storage, accuracy, ability to connect using multiple communication protocols, miniaturisation, integration with building management systems and the Cloud. The selection of metering and sensing solutions is related to accuracy, easy deployment, communication protocol, granularity, costs and availability.

Annex 6. Comparative analysis of benefits of heat metering

By taking into consideration the undertaken analysis, heat metering has the following benefits:

- Heat meters are better than heat cost allocators as they measure actual consumed heat energy data and are less likely to get damaged in the long run; there is no evidence that their much higher costs are compensated by higher benefits, so an "one size fits all" approach in heat metering should be avoided.
- Least-cost solutions for heat energy metering should be identified for all building types - energy efficient and other buildings and the solutions will not necessarily be the same for all types of buildings, so different technologies can be applied depending on the case.
- Not everywhere there is a technical possibility to install heat meters for every end user due to different internal heating system types, and in those cases heat cost allocators should be used instead.
- Out of all heat energy meters the meters with ultrasonic flow sensors are generally more reliable in the long run than impeller meters. Nevertheless, ultrasonic heat meters are more expensive than impeller meters and heat cost allocators taking into consideration all pros and cons of ultrasonic heat meters.
- Heat energy metering should be initiated in all buildings with or without heat substations in the buildings. This will provide direct incentives for heating companies to improve the efficiency of heat production and distribution, and will provide incentives to undertake energy savings on the consumption side.
- The second step is to install flat level heat energy metering to undertake the potential end-use energy savings, which is essential for motivating customers for the heating energy conservation.
- From a public policy point of view, the main objective of heat metering is the creation of a market incentive for end-use energy conservation and this incentive to have cost savings will directly result in increased energy savings. Billing based on the actual amount of consumed heat energy will encourage consumers to purchase more energy efficient flats that are supplied by more efficient heating systems and have smaller heat losses. It will also positively influence the newly constructed or refurbished buildings in the future, so besides direct savings from more efficient use of heating systems, the additional energy savings will be due to the improvement of building insulation. The cases in Poland show that after building insulation and individual heat metering in flats the total energy consumption in multi-flat buildings has decreased by about 50%, in Lithuania has decreased about 50-60%. The overall impact of a package of heat price reform and improved building energy efficiency with a growing building stock is several times larger than that of consumption-based billing in isolation.
- Heat suppliers will ultimately benefit from actual heat metering. In short term heat consumption may go down, leading to reduced sales and revenues but in the mid- to long-term heat suppliers will generate profits again by modernizing investments thus improving efficiency and reducing costs of heat supply and by connecting new customers to the DH network grid.

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