**JOINT IMPLEMENTATION PROJECT DESIGN DOCUMENT FORM**
**Version 01 - in effect as of: 15 June 2006**

**"Rehabilitation of the District Heating System in Kharkiv City"**

**CONTENTS**

## SECTION A. General description of the project

### A.1. Title of the project:

**"Rehabilitation of the District Heating System in Kharkiv City"**
PDD Version: 04, dated November 24, 2008

### A.2. Description of the project:

The project main goal is fuel consumption reduction, in particular reduction of natural gas (which is imported to Ukraine) and coal consumption, by means of district heating system rehabilitation in Kharkiv City, including boiler and distribution network equipment replacement and rehabilitation, installation of combined heat and power production plants and frequency controllers. Such reduction of fuel consumption will result in decrease of greenhouse gas emissions ($CO_2$ and $N_2O$). The purpose of the project is sustainable development of the region through implementation of energy saving technologies.

Municipal Enterprise (ME) "Kharkivski teplovi merezhi" is one of the main enterprises in field of production and distribution of the heat energy in Kharkiv City. It sells heat energy in forms of heat, hot water and steam, to local consumers, namely households, municipal consumers and state-owned organizations. Besides ME "Kharkivski teplovi merezhi", heat energy is produced by CHP-5 and CHP-3 stations, which have no their own distribution network, but have consumers, with which they have signed contracts for heat energy supply. Therefore they forced to have contractual relations with ME "Kharkivski teplovi merezhi" concerning to heat energy distribution to their consumers. Surplus of produced heat energy is sale to ME "Kharkivski teplovi merezhi". Heat supply market in the region is stable for years.

The project was initiated in 2004 to rehabilitate Kharkiv City's district heating system, including boiler and distribution network equipment replacement and rehabilitation, and installation of combined heat and power production plants (CHP) as well as frequency controllers. Project includes 277 boiler-houses with 610 boilers, CHP-4 station and 1411,5 km of heat distributing networks, that are managed by ME "Kharkivski teplovi merezhi".

Project provides installation of cogeneration units at boiler houses of Salkivskiy Living Area (KSZHM). At that time there are two companies considered as potential candidates for installation their cogeneration units – JSC "Pervomaiskdieselmash" (Ukraine) - 3 gas engine-generator machines DvG1A-630, with total capacity 1890 $kW_e$, or „Caterpillar" (USA) - 2 engine-generator machines G3516 of 1060 kW each..

CHP-4 does not produce electricity in present. The electricity production ended in 1983, and there are no scheduled measures for plant reconstruction except frequency controllers installation. Only networks that distribute heat from CHP-4 are scheduled to be replaced within the project, and load from several boiler-houses will be switched to it. The frequency controller has been installed in 2008.

The project employs the increase in fuel consumption efficiency to reduce greenhouse gas emissions relative to current practice. Over 157.3 million $Nm^3$ of natural gas and 354 ton of coal will be saved annually starting from 2012. Such reduction of fuel consumption is based on increase of the boiler efficiencies, reduction of heat losses in networks and CHP and frequency controllers installation. The following activities will ensure fuel saving:

- Replacement of old boilers by the new highly efficient boilers;
- Switching of load from boiler-houses with obsolete equipment to modern equipped boiler houses and CHP plants and units.
- Switching of boiler-houses from coal to natural gas;
- Improving of the network organization;
- Application of the pre-insulated pipes;
- Installation of combined heat and power production units;
- Installation of frequency controllers at electric drives of draught-blowing equipment and hot water pumps motors.

Estimated project annual reductions of GHG emissions, in particular $CO_2$, are from 4.1 thousand tons to 12.6 thousand tons in 2005 – 2007, from 61.3 thousand tons to 187.1 thousand tons in 2008 – 2010, and over 300 thousand tons per year starting from 2011 comparing to business-as-usual or baseline scenario.

Implementation of the project will provide substantial economic, environmental, and social benefits to the Kharkiv city. Social impact of the project is positive since after project implementation the heat supply service will be improved.
Environmental impact of the project is expected to be very positive as emission of the exhaust gases such as $CO_2$, $NO_x$, and CO will be reduced. Also due to better after-implementation service, some part of population will cease to use electric heaters thus reducing electricity consumption, which is related to power plants emissions of $CO_2$, $SO_x$, $NO_x$, CO and particulate matter.

ME "Kharkivski teplovi merezhi" fulfils annual minimal repairing of the DH system to keep it working. Particularly it executes repairing of network's parts and boilers that might cause accidents. More economically feasible and realistic scenario without carbon credits sales is a baseline scenario with very slow reconstruction activity than to make a major overhaul of the heating system. Minimal annual repairing doesn't lead to drooping of baseline emissions because of degradation of the whole system with efficiency droop at other objects, the overall actual emissions of Supplier would stay on the approximately same level. This scenario is less environmentally favorable for the near future (including first commitment period 2008-2012), since GHGs emissions of Supplier will continue to be kept at the same level or even higher, but economically such scenario is more attractive.

Estimated project risks are limited and minimized. Ukraine has claimed district heating and municipal energy sector as a priority of the national energy-saving development.

## A.3. Project participants:

| Party involved | Legal entity project participant (as applicable) | Please indicate if the Party involved wishes to be considered as project participant (Yes/No) |
|---|---|---|
| Ukraine (Host Party) | ME "Kharkivski teplovi merezhi"; | No |
| The Netherlands | "E – energy B.V." | No |

The project is initiated by three partners that distribute their functions in the project as follows:

- ***ME "Kharkivski teplovi merezhi":*** is a project implementation agency (**Supplier**). It operates equipment for heat production and distribution, and renders the heat supply services. As far as this organization purchases all the necessary inputs, including fuel, electricity, water, etc., it has the primary interest in the reduction of specific fuel consumption that can be achieved by the implementation of the project. Besides, this enterprise has all licenses and permissions, required under Ukrainian legislation, to perform designing and rehabilitating of the equipment. It is responsible for designing, engineering and installation works execution by its own personnel or with the aid of subcontractors. It finances this project and receives profits.

Historical details:

At the beginning of 1930 the chief engineer's management of section of communal economy of the Kharkiv city council together with scientific-technical enterprise "Heat and power" have developed the project for heating supply of Kharkiv City. In this project the engineering solution on the future centralized district heating supply of Kharkiv City was founded.

In 1932 Kharkiv celebrated the event that gave the start for development of the largest district heating system in USSR. Startup of exploitation of the first heating pipe-line in Ukraine, which length was only 5,5 km, was celebrated as a outstanding achievement in developing of municipal engineering.

In 1934-1935 the enterprise "Teplomerezha" built the hot-water and steam pipelines from CHP-3 to industrial enterprises.
To the end of 1937 the total length of main lines was 42 km and their heat load – 185 Gkal per hour.

In post-war period the half-destroyed stations and heat networks were not only renewed, but development of heating supply system of the city had been continuing.

In 1960 the intensive development of residential community in the area of Selektsiyna station was started. For its heat supplying in October, 1960, building of the new pipeline with diameter 600 mm was started.

The intensive development of residential communities required the further development of heat sources. The necessity for building of regional boiler-houses in the places of advanced development such as: Selektsiyniy region, Pavlovo Pole and Saltivskiy region, was adopted by city council.

At the end of 70-th and at the beginning of 80-th the development of new building had been continuing in Kharkiv City.

Through building of the new huge industrial enterprises the existing facilities didn't cover needs of city, there was necessity in increasing of heat and electric power production. For compensation of deficit of heat power and covering heat loads of Kharkiv City, building of CHP-5 as well as of two heat pipelines was provided..

We can see the general dynamic of development of pipelines and distribution heat networks:

- 1932 – the length of main and distribution heat networks was 5.5 km, maximum load – 25 Gkal per hour;
- 1935 – accordingly, - 12.5 km and 35 Gkal per hour;
- 1940 – 42 km, 226 Gkal per hour;
- 1950 – 54 km, 295 Gkal per hour;
- At the end of 50-th, at the beginning of intensive development of residential area, there was started the intensive application of heat supply shemes with Central Heating Points that were connected to main heat networks and from which heat was distributed by branched network to the houses in the middle of the residential areas.
- 1967 – the length of heat networks was 780 km and heat load was 1201.2 Gkal per hour;
- 1975 – 1052 km;
- 1980 – 1231 km;
- 1993 – 1556 km, and head load reached 5390.3 Gkal per hour.

But at the beginning of 90-th the disastrous reduction of load happened, which was caused by stoppage of many industrial enterprises and plants.

After reorganization at the end of 90-th - beginning of 2000-th, heat supply in Kharkiv city is implemented by Municipal Enterprise (ME) "Kharkivski teplovi merezhi", OJSC "Kharkivska CHP-5", CJSC "CHP-3" and departmental boiler-houses.

Today ME "Kharkivski teplovi merezhi" is the heat engineering enterprise which produce, transport and distribute heat to the all groups of consumers in Kharkiv City.

ME "Kharkivski teplovi merezhi" is one of the most powerful enterprises of municipal heat engineering of Ukraine. About 5800 qualified specialists operate 1533 km of pipelines, 208 heat distributional stations (HDS), 11 transfer pumping stations, 284 boiler-houses and combined heat and power station CHP-4.

About 95 % of Kharkiv's population use services of this enterprise. For providing effective and rational use of energy resources, ME "Kharkivski teplovi merezhi" implements complex of measures on reconstruction and technical retooling of thermal energy sources, networks and detached units.

ME "Kharkivski teplovi merezhi" successfully uses programme-technical complex for automation and dispatching, that leads to increasing of operating efficiency of Kharkiv's district heating system. Automatic system of supervisory control includes three CHP, all existing region and partly quarter boiler-houses, main networks with all pumping stations and the most important main chambers, and also detached distribution points.

Also, the specialists of the enterprise develop new energy saving competitive equipment and automatic systems. For example, electronic water counter SV-4T; system for remote measurement of data from consumer's water counters, temperature universal regulator “TUR-M”; regulation and indication block of temperature “BRIT-2”, etc.

Described above measures improve service quality of ME "Kharkivski teplovi merezhi" to population with reducing of fuel consumption level.

Enterprise characteristics:

| | 01.01.2003 | 01.01.2007 |
|---|---|---|
| Total amount of the boiler-houses | 284 | 272 |
| Length of the heat supply networks in the 2-pipe calculation, km | 1523.4 | 1604.6 |
| Total enterprise capacity, Gkal per hour | 3408.6 | 3052.5 |
| Connected heat load, Gkal per hour | 4373.3 | 4079.8 |
| Heating area, 1000*$m^2$ | 29285.1 | 28900.8 |
| Heating area (living), 1000*$m^2$ | 23366.3 | 22836.8 |
| Amount of personal accounts | 472776 | 487543 |

*Table 1. Enterprise characteristics*

ME "Kharkivski teplovi merezhi" owned 284 boiler-houses in the base year 2003. 277 of them were included in the project baseline, See **Appendix 1**. Load from some of them were switched to CHP or other boiler-houses within the project during 2004-2007. Therefore the total number of boiler houses to the date 01.01.2007 was 272.

The heating area for the population makes 79.8 % of the total heating area, for the legal entities – 20.2%.

- ***E-Energy B.V.:*** is a purchaser of the project. It is a company registered in the Netherlands, is one of subsidiaries belonging E energija group.

Having started its activity in 1994, E energija group has expanded from its first established company Energijos taupymo centras (Energy saving center).

The rising work range and economical-social conditions caused the creation of vertically integrated company's structure, with the separation of group's operation fields. For this purpose, the company E energija UAB, which now is the management company of the whole E energija group, was established.

E energija, UAB is an energy planning and management company, which implements turnkey projects from conceptual development and owns companies generating and supplying energy for industries and residents of the cities.

One of key aims of E energija specialists is to prepare energy plans to meet energy needs for subsistence and development of alternate energy sources and the increase of energy efficiency at least cost to the economy and environment.

Since 2005 E energija group, one of the first companies in the Baltic countries has been involved in the project development under Kyoto Protocol flexible mechanisms and started trading activities with EU allowances as specified by EU Emission Trading Scheme.

E-Energy B.V. is a company responsible for E energija group carbon credit procurement for its own purposes and all business related with carbon credit trade. E-Energy B.V. is active investor in the market of Eastern European countries in a number of JI projects.

## A.4. Technical description of the project:

### A.4.1. Location of the project:

The Project is located in Kharkiv City in the North-East part of Ukraine (**Fig.1**).


*Fig. 1. The map of Ukraine with neighboring countries*

#### A.4.1.1. Host Party(ies):

Ukraine is an Eastern European country that ratified the Kyoto Protocol to UN FCCC on February 4th, 2004, enters into the list of the countries of the Appendix 1 and is eligible for the Joint Implementation projects.

#### A.4.1.2. Region/State/Province etc.:

Kharkiv region is located in the North-East part of Ukraine. Its territory is 31400 km$^2$. The region is bordered with Dnipropetrovsk, Donetsk, Luhansk, Poltava and Sumy regions. In the North of Kharkiv region the national boundary with Russian Federation is passed. The administrative center of Kharkiv region is the city of Kharkiv.

The Kharkiv's region climate is mostly mild-continental. The average temperatures are: +21°C in summer, -7°C in winter, with average annual rainfall of 540 mm.

Thus the heating period is usually 189 days. The average outside temperature over the heating period is -2.1 $^0$C (by SNIP), and – 0.9 $^0$C by statistical data (included in the tariff).

**A.4.1.3. City/Town/Community etc.:**

Kharkiv City

The territory of Kharkiv City is 30604 hectares.
The population of the Kharkiv City is more than 1470.9 thousand inhabitants.

**A.4.1.4. Detail of physical location, including information allowing the unique identification of the project (maximum one page):**

The city territory is divided into 9 administrative districts*:* Dzerzhinskiy, Kyivskiy, Kominternivskiy, Leninskiy, Moskovskiy, Zhovtneviy, Ordzhonikidzivskiy, Frunzenskiy, Chervonozavodskiy. ME "Kharkivski teplovi merezhi" is divided into 9 applicable branches, respectively. It should be noted that the district heating systems from all territorial districts of the Kharkiv city are involved in the project (**Fig. 2**).

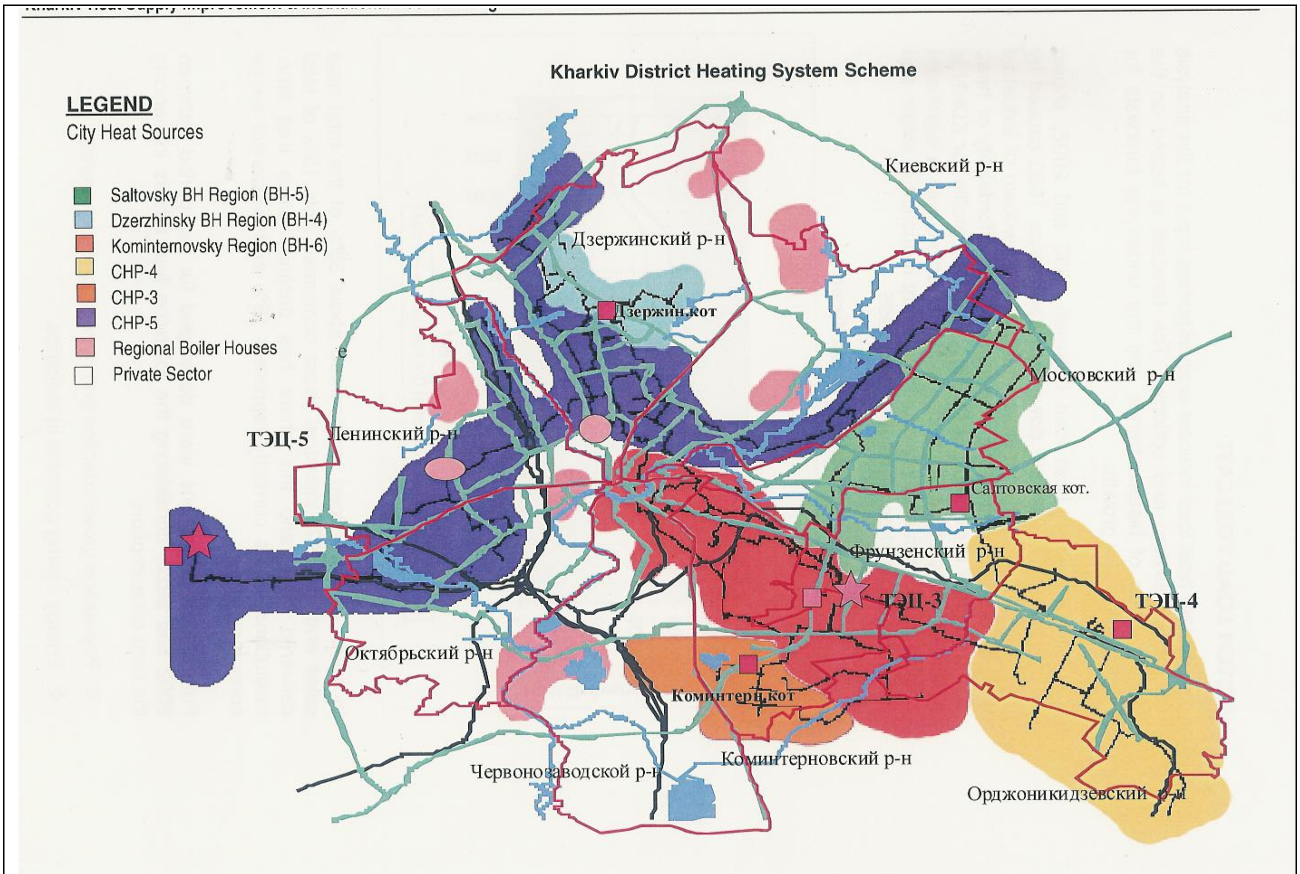


*Fig. 2. The map of the Kharkiv city with District Heating System scheme.*

**A.4.2. Technology(ies) to be employed, or measures, operations or actions to be implemented by the project:**

Sectoral scope related to approved CDM methodologies and DOEs (version 18 Jan 08) are:

- Energy industries (renewable - / non-renewable sources);
- Energy distribution;
- Energy demand.

Measures that will be used to improve the efficiency of ME "Kharkivski teplovi merezhi" utility are as follows:

- Old operating boilers with low efficiency will be replaced by the new highly efficient ones that will result in efficiency increase from 65-85% up to 90-93%. Technical characteristic of new boilers scheduled to be installed are presented at the producer's websites that are listed in table below.

| Type of boiler | Website of boiler producer |
|---|---|
| VK-21 | www.tekom.com.ua/kotel/vk.html |
| AOGV-20 | www.majak.com.ua/products/majak12ks.html |
| AOGV-50 | www.majak.com.ua/products/majak12ks.html |
| AOGV-100 | www.majak.com.ua/products/majak12ks.html |
| RTQ 100 | www.riello.su/products/info-riello.aspx?id=6&pid=9 |
| RTQ 130 | www.riello.su/products/info-riello.aspx?id=6&pid=9 |
| RTQ 165 | www.riello.su/products/info-riello.aspx?id=6&pid=9 |
| RTQ 200 | www.riello.su/products/info-riello.aspx?id=6&pid=9 |
| RTQ 250 | www.riello.su/products/info-riello.aspx?id=6&pid=9 |
| RTQ 300 | www.riello.su/products/info-riello.aspx?id=6&pid=9 |
| RTQ 350 | www.riello.su/products/info-riello.aspx?id=6&pid=9 |
| RTQ 400 | www.riello.su/products/info-riello.aspx?id=6&pid=9 |
| RTQ 450 | www.riello.su/products/info-riello.aspx?id=6&pid=9 |
| RTQ 500 | www.riello.su/products/info-riello.aspx?id=6&pid=9 |
| RTQ 600 | www.riello.su/products/info-riello.aspx?id=6&pid=9 |
| RTQ 700 | www.riello.su/products/info-riello.aspx?id=6&pid=9 |
| Ferroli | www.ferroli.kiev.ua |
| Kolvitherm | www.kolvi.com/index.php?option=com_content&task=blogcategory&id=11&Itemid=105 |
| KS-G-100 | http://permgazkomplekt.ru/product_info.php?products_id=179 |
| KGB-100 | http://3106.ukrindustrial.com/ |

*Table 2.Boilers producer's web sites*

*Fig. 3. Boiler AOGV-100 with efficiency 92%.*

- Switching load from the boiler houses with obsolete equipment to the boiler houses with highly effective equipment and CHP plants.

  71 boiler-house will be switched during the project to the following boiler- houses: Ilicha, 118, Gertsena, 17, Kotlova, 29, Volodarskogo, 57 b, Krasnooktyabrska, 7, Slavianska, 8, Volodarskogo, 88, boiler-house of Plant Hartron, KSZHM and CHP-3, CHP-4, CHP-5. This boiler-houses have reserve capacity, that is enough to accept load from boiler-houses, that will be closed. Total heat output will be the same.

  There is only one boiler-house among all boiler-houses with installed steam boilers, where connected load will be switched. It is boiler-house Proskury str., 12 with 1 boiler DKVR-6,5/13. It is planed to swith it to boiler-house of Plant Hartron. But there was no connected steam load at boiler-house Proskury str., 12. Steam boilers provided only heat load in 2003 year.

  Boiler-houses where steam load was connected in 2003 have special marks “steam” in the column E -Boiler's type of Appendix 1. They are: K. Marksa, 17 (1 steam boiler NIISTU-5); Zhovtnevoyi Revolutsiyi, 59 (2 steam boilers NIISTU-5); Pushkinska,104 (2 steam boilers DKVR 2,5/13); Pomerky, 70 (3 steam boilers DKVR- 4/13); Valeryanivska, 113 (3 steam boilers Lankashir); K. Marksa, 17 (1 steam boiler NIISTU-5); Tynyakova, 7 (1 steam boiler E-1/9); Klochkovska, 366 (1 steam boilers E-1/9). But there is no switching of load planed at these boiler-houses. Thus the total heat output will be the same and measure of switching heat load from one boiler-house to another will not have influence to the baseline. Besides this, changes in connected load (heating area, number of consumers, etc.) in the reported years will be compensated due to adjustment factors, that are described in detail in monitoring methodology. See Annex 3 Monitoring plan.

  There is no replacement of boilers at boiler houses from those the load will be re-distributed to the other DHS project sites.

- Obsolete coal-fired boilers will be mostly replaced by the new gas-fired boilers.

- The reconstruction of heat distribution networks system will help to reduce heat losses down to 1-2 % per km by replacing of the main and distribution networks pipes with diameter 38 mm -1120 mm by the pre-insulated ones. ME "Kharkivski teplovi merezhi" uses pipes previously heat and hydro insulated with foamed polyurethane produced by JSC “Transprogress” (http://www.transprogress.com.ua/products.htm).

*Fig.4. Pipes produced by JSC "Transprogress".*

- Improvement of the heat networks system organization will be provided by liquidation of Heat Distribution Stations (HDS) - replacing 4-pipe lines by 2-pipe ones with simultaneous installation of heat exchangers directly at the consumers (Individual Heating Point – IHP), or reconstruction of HDS with modern lower capacity heat exchangers (reduction of necessary power will be realizable due to switching of part of power to IHP). It will enable to liquidate 46 km of pipes with different diameters, to reduce heat losses and to reduce power consumption for power supply of circulation pumps. Technical characteristic of new heat exchangers (see fig. 5) are presented on the producer's website http://teploenergo.com.ua.

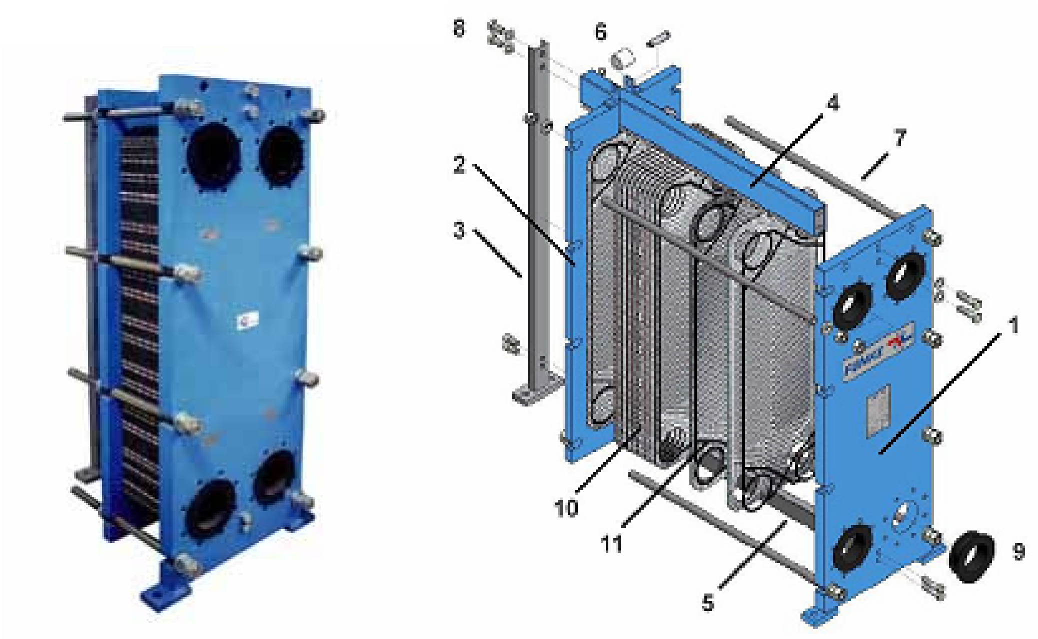


*Fig.5.Heat exchangers produced by "Ukrteploenergo" corporation.*

- Installation of cogeneration units will result in increasing the fuel consumption efficiency, decreasing of dependence on the grid power supply, improvement of operational stability and reliability, decreasing of power consumption from power stations, decreasing of power transfer losses, and decreasing of environmental pollution.

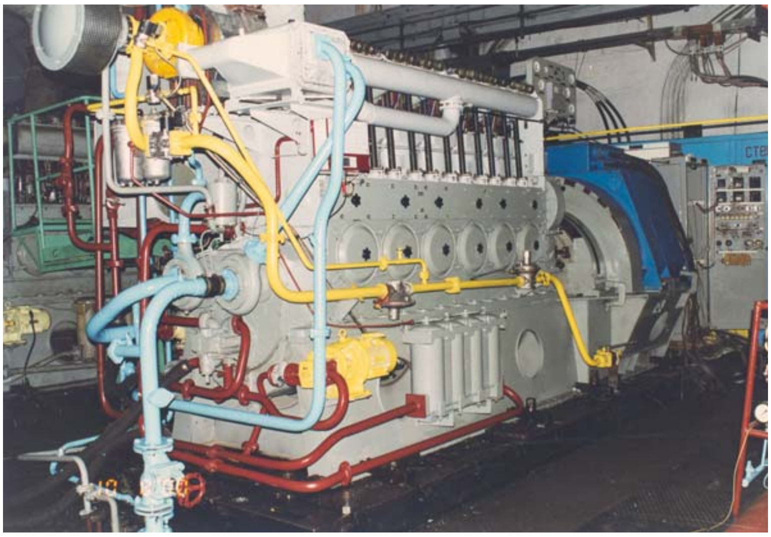

*Fig.6. Cogeneration unit produced by JSC "Pervomaiskdieselmash".*

Technical characteristic of cogeneration units produced by JSC "Pervomaiskdieselmash" (see fig. 6) are presented on the producer's website http://www.dieselmash.com.ua.

- Installation of frequency controllers at hot water pumps' motors will result in energy saving. Those regulators make it possible to change actual capacity of the motors depending on connected load, both as during a day when water consumption is changes, and during a year when in summer motors work only for hot water supply.

- Installation of frequency controllers at smoke exhausters' electric drives will result in considerably energy saving.
  Technical characteristic of frequency controllers "Strum ST2" are presented on the website of "Kranovyj elektropryvod", Ltd.: http://www.kep.kh.ua.

The measures from this list will be implemented at boiler houses subject to rehabilitation.

The generalised schedule of their implementation will be the following:

- boiler houses rehabilitation – 2004 – 2010;
- network rehabilitation – 2004 – 2011;
- installation of CHP units – since 2009;
- installation of frequency controllers – since 2008;
- heat exchangers replacement – 2007 – 2010;
- reconstruction and liquidation of HDS – 2007 – 2010.

Achieved results of employing of these technologies and measures are listed in the **Appendixes 1 – 7.**

These technologies are already approved but some of them are not widespread. Therefore, there might be some bottlenecks, which are typical when implementing the new technologies and equipment.

**A.4.3. Brief explanation of how the anthropogenic emissions of greenhouse gases by sources are to be reduced by the proposed JI project, including why the emission reductions would not occur in the absence of the proposed project, taking into account national and/or sectoral policies and circumstances:**

The project activities including rehabilitation of boilers, heat distribution networks and installation of combined heat and power production units will increase energy efficiency of Kharkiv City DH system, thus enabling it to produce the same amount of heat energy with less fuel consumption. Additionally it will produce electric power with less specific fuel consumption. Reduced fuel consumption will lead to reduction of $CO_2$ emissions.

In the absence of the proposed project, all equipment, including the old low efficient one but still workable for a long life period, will operate in as-usual mode, and any emission reductions will not occur.

Ukraine has claimed district heating and municipal energy sector as a priority of the national energy-saving development. This is pointed out in the State Program for Reformation and Development of municipal economy for 2004-2010 (Law of Ukraine from 24.06.2004 № 1869-IV), The Law of Ukraine from 01.07. 1994 № 74/94-VR "On energy saving" and The Law of Ukraine from 22.12.2005 №3260- IV "On changes in The Law of Ukraine "On energy saving". The law of Ukraine "On heat energy supply" (№ 2633-IV from 02.06.2005) regulates all relations in the heat supply market. It does not considerably change the previously existing practices in the market, but stimulates the more rigid energy saving and implementation of energy-efficient technologies.

### A.4.3.1. Estimated amount of emission reductions over the crediting period:

In course of project implementation, the following emission reductions will be achieved, at the stages of project implementation:

| Length of the crediting period | Years |
|---|---|
| 2005-2024 | 20 |
| **Year** | **Estimate of annual emission reduction in tones of $CO_2$ equivalent** |
| 2005 | 4116.9 |
| 2006 | 7513.3 |
| 2007 | 12549.7 |
| **Subtotal 2005 - 2007** | **24179.9** |
| 2008 | 61289.5 |
| 2009 | 122328.4 |
| 2010 | 187125.3 |
| 2011 | 302096.0 |
| 2012 | 328503.1 |
| **Subtotal 2008 - 2012** | **1001342.3** |
| 2013 | 328503.1 |
| 2014 | 328503.1 |
| 2015 | 328503.1 |
| 2016 | 328503.1 |
| 2017 | 328503.1 |
| 2018 | 328503.1 |
| 2019 | 328503.1 |
| 2020 | 328503.1 |
| 2021 | 328503.1 |
| 2022 | 328503.1 |
| 2023 | 328503.1 |
| 2024 | 328503.1 |
| **Subtotal 2013 - 2024** | **3942037.2** |
| **Total estimated emission reduction over the crediting period (tones of $CO_2$ equivalent** | **4967559.4** |
| **Annual average of estimated emission reduction over the crediting period (tones $CO_2$ equivalent)** | **248378.0** |

*Table 3.Estimated amount of $CO_2$e Emission Reductions*

Thus the estimated amount of emission reductions over the commitment period (2008-2012) is **1001342.3** tons of $CO_2$e, over the crediting period - is **4967559.4** tons of $CO_2$e.

For more detailed information see **Appendixes 1 – 7**.

Average annual amount of ERUs will be the following:

During commitment period 2008-2012 years – 200268.5 t $CO_2e$;
After commitment period 2013-2024 years – 328503.1 t $CO_2e$.

Description of formulae used to estimate emission reductions is represented in paragraph D.1.4.

## A.5. Project approval by the Parties involved:

The project is already approved by local authorities, namely Executive committee of Kharkiv City Council, and Ukrainian government representatives, namely Ministry for Environmental Protection of Ukraine (at that time the Local focal point for Kyoto Protocol in Ukraine) has issued the Letter of Endorsement in October, 2007. Therefore, organizational risk for this project is minimized.

The project was initiated in 2004.

The main milestones of the project history and approval:

January, 2004 - Institute of Engineering Ecology suggested ME "Kharkivski teplovi merezhi" to develop the Joint Implementation Project on Green House Gas Emissions Reduction.

March, 2004 – Technical Council meeting of ME "Kharkivski teplovi merezhi" on question " About realization of international agreements on Kyoto Protocol at ME "Kharkivski teplovi merezhi" (Protocol from 11.03,2004)

September, 2004 – Agreement was signed between the ME "Kharkivski teplovi merezhi" and the Institute of Engineering Ecology (№524/221866 from 24.09.2004) on development of the Joint Implementation Project on Green House Gases Emissions Reduction due to fuel saving through rehabilitation of the district heating system of Kharkiv city.

December, 2005 – Agreement was signed between the ME "Kharkivski teplovi merezhi" and "European Institute for safety, security, insurance and environmental technics" (SVT e.V.) (Germany), to fulfill the preparation of the project proposal for the JI project for submission to potential buyer (№ 43 from 26.12.2005).

September, 2007 – Agreement was signed between the ME "Kharkivski teplovi merezhi" and the company "E – energy B.V." (The Netherlands), potential purchaser of the ERUs to be generated from this project (№ 221347 from 21.09.2007).

October, 2007 - Ministry for Environmental Protection of Ukraine has issued the Letter of Endorsement for this JI project (№ 11552/11/10-07 from 23.10.2007).

## SECTION B. Baseline

### B.1. Description and justification of the baseline chosen:

At the time when this Project was developed, no approved CDM methodology for such project activity existed. Our own-developed methodology is partly similar to later appeared "Baseline and monitoring methodology AM0044". But the AM0044 was not used because the project "Rehabilitation of the District Heating System in Kharkiv City" has some differences from applicability conditions of this methodology.

The main cause of impossibility of methodology AM0044 using for baseline calculation is no data for thermal energy output, because of thermal energy meters absence on the majority of boiler houses included in the project. That's why the European Institute for safety, security, insurance and environmental technics - "SVT e.V." (Germany) and Institute of Engineering Ecology (Ukraine) invented the special methodology, that takes into account all measures involved in the project and it's peculiarities. This methodology is presented in section D (monitoring plan). It was already approved by IAE for the similar JI Projects for Chernihiv region, Donetsk Region and Republic of Crimea.

The main complication for implementation of the JI projects on district heating in Ukraine is the practical absence of monitoring devices for heat and heat-carrier expenditure in the municipal boiler-houses. Only the fuel consumption is registered on a regular basis. It makes practically impossible the application of AM0044 methodology which basic moment is monitoring of the value $EG_{PJ,\ i,\ y}$ (thermal energy output of project boiler i in year y) - page 9 of Methodology AM0044, which should be measured every month by flow-meters (the expenditure of heat-carrier) and thermal sensors (temperatures at the input and output of the boiler, etc.).

This also concerns the definition of the average historical value of heat power generation per year $EG_{BL,\ his,\ i}$ (average historic thermal energy output from the baseline boiler "i").

Besides, in section "Scope of Application" it is mentioned, that the scope of application of the Methodology AM0044 is limited only to the increase of boilers' efficiency by means of their replacement or modernization, and it does not apply to the fuel type switch. At the same time our project includes also such kind of modernization as well as some others such as the replacement of burner equipment, installation of cogeneration units, etc.

The developed "Methodology" is based on the basis of permanent monitoring of fuel consumption and of the account of various other factors, such as connection or disconnection of the consumers, change of fuel heating value, weather change, ratio of the heat consumption for heating and for hot water supply, etc.

The developed "Methodology" has two important advantages in comparison with the methodology AM0044 (at least for Ukrainian conditions):

- It takes into account the quality of heat supply (heating and hot water supply). Almost annually for the various reasons (receiving of less amount and high price of the fuel, in particular natural gas which is nearly 95 % of fuel type used in Ukraine for the needs of the municipal heat supply), the consumers receive less than necessary amount of heat, in the result of which the temperature inside the buildings is much lower than normative one, and hot water supply is insufficient or absent. As the purpose of JI projects, including the current project, is the GHG ($CO_2$) emission reduction under the conditions of not worsening in any circumstances of the social conditions of population, the issue of approaching of the heat supply quality to the normative one is extremely important. Therefore, the amount of the fuel consumption for the after project implementation period is calculated for the conditions of providing the normative parameters of heat supply and at least partially of hot water supply, and in accordance with the monitoring plan, the implementation of continuous control (monitoring) of its quality (measurement of internal temperature in the specific buildings as well as registration of residents' complaints for the poor-quality heat supply) is foreseen. This increases the control for the qualitative heat supply for the consumers and excludes deliberate reduction of heat consumption, and, in such a way, of fuel consumption with the purpose of increasing of generation of GHG emissions reduction units (ERUs) at the project verification.

- Definition of the fuel consumption in base year (baseline) in view of the fact that in Ukraine at the majority of the municipal heat supply enterprises the natural gas is used as a fuel, which consumption is measured constantly by the counters with the high measurement accuracy, seems to be more exact, than definition of the fuel consumption with use of heat power, boiler efficiency and heat value of the fuel. This especially concerns the efficiency, which changes greatly depending on load of boilers, which also changes essentially, and often not automatically but manually, in the heat supply systems within a day and within a year. Averaging of such values without having of the heat account system is fraught with serious discrepancies. Definition of the fuel consumption in the presence of counters requires only data collection and implementation of arithmetic actions.

Approved Consolidated Methodology ACM0009 "Consolidated baseline methodology for fuel switching from coal or petroleum fuel to natural gas" proposes the dependences for baseline and reporting year emissions quantity definition (see pages 4 and 5), that contain determination of Energy efficiency $\varepsilon_{project,i,y}$ and $\varepsilon_{baseline,i}$ for equipment. In the chapter "Baseline emissions" on the page 6 there is an explanation that: Efficiencies for the project activity ($\varepsilon_{project,i,y}$) should be measured monthly throughout the crediting period, and annual averages should be used for emission calculations. Efficiencies for the baseline scenario ($\varepsilon_{baseline,i}$) should be measured monthly during 6 months before project implementation, and the 6 months average should be used for emission calculations. These requirements are confirmed by tables for monitoring on the pages 13-15.

However, as it was mentioned before in this PDD, the majority of boiler-houses in Ukraine are not equipped with devices for heat-carrier expenditure definition or heat meters. There is only one parameter, that is regularly and with high precision defined in the boiler houses – fuel consumption.

For this reason, the own project specific methodology was developed, that is based on the permanent measuring of the fuel consumption and amendments for possible parameters changes in baseline in comparison with reporting year. The variable parameters may be the changes in lower heating value of fuels, quality of heating service, weather changes, changes in customers' number, etc. Taking into account only equipment efficiency does not eliminate the possibilities of undersupply of heat to customers (deterioration of heat supply service), and possible weather warming in reported year, change in fuel quality, disconnection of some consumers, and other factors, and could lead to artificial overestimation of ERUs amount.

In additional, the proposition in ACM0009 to take (by conservatism principle) the baseline efficiency of equipment equal to 100 % is unacceptable in "District Heating" type projects, because not only fuel switch, but mainly namely increasing of equipment (boilers) efficiency are implemented in these projects. Accepting of such calculated baseline would lead to essential underestimation of results of implemented measures. And, anyway, as it was shown before, this would not solve the problem with impossibility of monthly measurements for getting energy efficiency $\varepsilon_{project,i,y.}$

Approved Methodology AM0048 "New cogeneration facilities supplying electricity and/or steam to multiple customers and displacing grid/off-grid steam and electricity generation with more carbon-intensive fuels" already in its title shows the scope of applicability, that is different from the scope of the "District Heating" projects. In our projects, the cogeneration facilities produce hot water and not steam. Beside this, in according to AM0048 (page 22) and its monitoring plan (pages 23-30), it is necessary to realize, among other measurements, monthly measurement of $SC_{PCSG,i,y}$ (Total steam self-generated by project customer 'i' during year 'y' of the crediting period, TJ), measured by the steam meter at the customer 'i' (page 25). Thus Methodology AM0048 couldn't be implemented in original. In principle, it could be modified for conditions of hot water production for heating and hot water supply systems, but this will require modification of monitoring plan with introduction of other parameters that it is necessary to measure and register. But it would be the another methodology, that would require to measure such parameters as heat output, or hot water output with its temperature (in analogy with requirements of Methodology AM0048 to measure steam output, its pressure and temperature.

As it was already mentioned before, the majority of the heat supply enterprises and heat customers in Ukraine are not equipped with heat meters or devices for heat-carrier output (hot water for heating and hot water service) determination. Just for this reason, the methodology was developed that is based on the permanent measuring of the fuel consumption and corrections for possible changes of parameters in reporting year comparing to the baseline. The changeable parameters may be the lower heating value of fuels, quality of heating service (providing of normative temperature value inside apartments), weather features, number of customers, etc. As it was mentioned before, this approach eliminates any possibility of reduction of fuel consumption and correspondingly GHG emission due to incomplete delivery of heat to consumers.

In view of the above mentioned, in contrast to the methodologies AM0044, ACM0009 and AM0048, our Methodology, developed for “District Heating” projects in Ukrainian conditions and used in JI Projects “Rehabilitation of the District Heating System in Donetsk Region”, “Rehabilitation of the District Heating System in Chernihiv Region”, “Rehabilitation of the District Heating System in Crimea” and others, is the most appropriate, precise, corresponding to the principle of conservatism, and the most closely reflects the aims, goals and spirit of Kyoto Protocol.

The baseline study will be fulfilled every year of the emission reduction purchasing, to correct adjustment factors which have an influence at the baseline. For more detailed information see **paragraph D.1.**

There were three different versions of Baseline scenario that were discussed before starting this project.

The first version of Baseline scenario was a business-as-usual scenario with minimum reconstruction works balanced by overall degradation of DH system. For this Baseline scenario there are no barriers (no investment barrier since this scenario doesn't require the attraction of additional investments, and no technological barrier since the equipment is operated by existing skilled personnel, and additional re-training is not required), and represent the common practice in Ukraine.

The second version of Baseline scenario was to make reconstruction works without JI mechanism. In this case there exist both investment barrier since this scenario requires the attraction of large additional investments, and due to very large payback time and high risks it is not attractive for investments, and as well the technological barrier since operation of the new modern equipment will require additional re-training of personnel. Rehabilitation of heat supply equipment in order to improve its efficiency is not a common practice in Ukraine.

The third version of Baseline scenario was the shortened project activity, without any of the non-key type of activity, for example elimination of frequency controllers installation, etc., from the project. This makes project economically less attractive, with the longer pay back period.

Thus, the first version was chosen for Baseline scenario.

ME "Kharkivski teplovi merezhi" fulfils annual minimal repairing of the DH system to keep it working. Particularly it executes repairing of network’s parts and boilers that might cause accidents. The most economically feasible and realistic scenario without carbon credits sales is a baseline scenario with very slow reconstruction activity, making a major overhaul of the heating system is not economically attractive and is not required according to valid regulations. Old boilers could remain in operation for the whole period when they pass the regular tests, with minimal repairing if necessary, without lifetime limitation; and at least during the crediting period. Switching of load from boiler-houses with obsolete equipment to modern equipped requires building of the new parts of network, that is the most expensive measure. Minimal annual repairing doesn’t lead to drooping of baseline emissions because of degradation of the whole system with efficiency droop at other objects, the overall actual emissions of Supplier would stay on the approximately same level. This scenario is less environmentally favorable for the near future (including first commitment period 2008-2012), since GHGs emissions of Supplier will continue to be kept at the same level or even higher, but economically such scenario is more attractive.

**Status and adequacy of the current delivery system**

Current supply of Kharkiv city DH systems is primarily based on Ukrainian and Russian made gas and coal fired boilers including PTVM-50, PTVM-100, DKVR-10/13, DKVR-6.5/13, DKVR-4/13, DE-10/14, DE-25/14, KVGM-20, KVG-6,5, KVG-4, KGB-50, KGB-100, Lankashir, Nadtochiya, Universal, TVG-1,5, TVG-4, TGV-8, NIKA-1.25, NIISTU-5, Energija, E-1/9G, KSVa-1.25 and few other types. Detailed information is presented in **Appendix 1 (Boilers).** Current efficiencies of these boilers are in the range of 65 - 85%.

Current distribution networks are characterized by heat losses from 20 to 31%. Detailed information is presented in **Appendix 2 (Networks).**

**Construction of the Baseline Scenario**

Current operation of the Kharkiv city district heating system results in continuous deterioration of the heat-generating and distribution equipment, followed by continuous slight efficiency droop. However, at the same time operative maintenance increases efficiency, which pretty much compensates deterioration, and makes annual total emissions level (the Baseline) about the same for years.

Project also provides electric power production on the new cogeneration units. This power will replace consumption from the national power system, that's why we take into account national standard of power system emissions for Baseline definition.

**Calculation of Baseline Carbon Emission Factors**

For all fuels we used $CO_2$ emission factors from the data table provided in Annex C of the Operational Guidelines for Project Design Documents of Joint Implementation Projects (Volume 1: General guidelines; Version 2.2).

Cef (natural gas) = 0.0561 $KtCO_2/TJ$;
Cef (coal) = 0.0946 $KtCO_2/TJ$ (was taken as "Other bituminous coal").

We assume that $CO_2$ emission factors for the fuels will be the same for period 2003-2012. For our calculations we assume that the Lower Heating Value of a fuel (LHV) doesn't change during that time, however in the Monitoring Plan the LHV factor will be taken into account for the baseline correction for any year until 2012.

LHV of fuels used by ME "Kharkivski teplovi merezhi" changes insignificantly from year to year. Table 4 gives average Lower Heating Values for fuels that are used by the Applicant in 2003:

| Type of fuel | Average lower heating value of fuel | |
|---|---|---|
| | kcal | MJ/m$^3$ (MJ/kg) |
| Natural gas | 8258 | 34.6 |
| Coal | 4535 | 19.0 |

*Table 4. Lower heating value for fuels used by the Applicant*

**Calculation of $CO_2$ Conversion Factor (CF)**

CF (Conversion Factor) = LHV (Lower Heating Value)* Cef (Carbon Emission Factor)

1000 m$^3$ of natural gas input = 34.6 [MJ/m$^3$]*0.0561 [Kt$CO_2$/TJ] = 1.941 t$CO_2$

1t of coal input = 19.0 [MJ/kg]*0.0946 [Kt$CO_2$/TJ] = 1.797 t$CO_2$

**.Calculation of Activity Level**

Activity level is represented by annual fuel consumption. For calculation of Baseline emissions, the 2003 was taken as the Base year. This year is one of the typical years concerning the outside temperature in heating period, as well as concerning the conditions of production and consumption of the heat.

| | Baseline Natural Gas Consumption, ths Nm$^3$/yr | Baseline coal Consumption, t/yr |
|---|---|---|
| ME "Kharkivski teplovi merezhi" (277 boiler houses, which are included in project + CHP -4 ) | 563662.8 | 422.9 |
| CHP -3, in purpose of production of the heat energy, which it sales to ME "Kharkivski teplovi merezhi" | 228353.0 | 0 |
| CHP -5, in purpose of production of the heat energy, which it sales to ME "Kharkivski teplovi merezhi" | 240998.0 | 0 |
| **Total** | **1033013.8** | **422.9** |

*Table 5. Baseline fuel consumption*

Detailed information is presented in **Appendix 1 (Boilers).**

| ME "Kharkivski teplovi merezhi" | Baseline electricity consumption, ths kWh |
|---|---|
| Boiler houses and CHP, where reconstruction or liquidation of HDS will take place, and boiler houses where frequency controllers will be set. | 171604.6 |

| | |
|---|---|
| | |
| HDS, which will be liquidated, where reconstruction will take place and where frequency controllers will be set. | 22978.1 |
| **Total** | **194582.7** |

*Table 6. Baseline electricity consumption*

Detailed information is presented in **Appendix -1, and Appendixes 3– 5.**

**Calculation of Baseline Carbon Emissions**

There are 4 types of GHG emissions involved in the baseline scenario:

1) $CO_2$ emissions from boilers operated by ME "Kharkivski teplovi merezhi". Baseline calculations were based on the assumption that baseline emissions during any report year (2008-2012) remain the same as in the base year 2003.
2) $CO_2$ emissions due to electricity production to the grid in amount that is consumed by boiler houses and CHP, in operation area of which the reconstruction and liquidation of HDS will take place, and also by the boiler houses, where frequency controllers will be set.
3) $CO_2$ emissions due to electricity production to the grid in amount that is consumed by HDS, which will be liquidate and where reconstruction and installation of frequency controllers will take place.
4) $CO_2$ emissions due to electricity consumption from the grid in amount, which will be replaced after CHP units installation.

Ukraine has united state power grid, therefore the averaged values for Carbon Emission factors (CEF) for electricity production should be used.

Carbon Emission factors (CEF) for 2008-2012 are taken from Table B1 "Baseline carbon emission factors for JI projects generating electricity" and Table B2 "Baseline carbon emission factors for JI projects reducing electricity consumption" of operational Guidelines for PDD's of JI projects (ERUPT 4, Senter, the Netherlands) (Tables 7, 8).

| Year | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|
| $CEF_g$ $tCO_2e/MWh$ | 0.77 | 0.755 | 0.74 | 0.725 | 0.71 | 0.695 | 0.68 | 0.66 | 0.651 | 0.636 |

*Table 7. Carbon Emission factors (CEF) for electricity generation in Ukraine*

| Year | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|
| $CEF_c$ $tCO_2e/MWh$ | 0.94 | 0.92 | 0.90 | 0.88 | 0.856 | 0.836 | 0.816 | 0.796 | 0.776 | 0.756 |

*Table 8. Carbon Emission factors (CEF) for reducing electricity consumption in Ukraine*

It is possible to use the new Carbon Emission factors (CEF) for 2006-2012, taken from Table 8 "Emission Factors for the Ukrainian grid 2006-2012" of Annex 2 "Standardized Emission Factors for the Ukrainian Electricity Grid" to "Ukraine - Assessment of new calculation of CEF", verified by TUV SUD Industrie Service GmbH 17.08.2007 (Table 9).

| **Type of project** | **Parameter** | **EF (tCO2/MWh)** |
|---|---|---|
| JI project producing electricity | $EF_{grid,produced,y}$ | 0.807 |
| JI projects reducing electricity | $EF_{grid,reduced,y}$ | 0.896 |

*Table 9. New Carbon Emission factors (CEF) for electricity generation and consumption in Ukraine*

Using of the last values of CEF will enable to obtain the higher calculated forecasted amounts of Emission reductions. However for this project emission reductions associated with electricity make up only a small part of total project emission reductions, and the difference due to such calculations will be about 1 %. Thus according to conservatism principle we use the ERUPT values for CEF.

In course of development of the Monitoring reports for this project, the valid values for corresponding period will be used.

Calculation of resulting annual Baseline Carbon Emissions, that would take place during typical heating season if Kharkiv systems remains unchanged, see in **Appendix 8 (Baseline)**. They consist of an exact amount of total $CO_2$ emissions that took place during the base (2003) year, and additionally of emissions due to electricity consumption for own needs from the grid in amount that will be replaced after installation of CHP units by the own-produced one, and electricity which will be saved after frequency controllers installation.

**B.2. Description of how the anthropogenic emissions of greenhouse gases by sources are reduced below those that would have occurred in the absence of the JI project:**

The anthropogenic emissions of GHG will be reduced due to complex modernization of heat generating and distributing equipment with application of the technologies proposed in the project activities and described above, which include replacement of old obsolete boilers by new ones with higher efficiency, replacement of obsolete coal-fired boilers by the modern gas-fired ones, frequency controllers installation, reconstruction and liquidation of HDS, installation of cogeneration units at the boiler house KSZHM, renovation of degraded heat distribution networks with using of the pre-insulated pipes.

The more obvious description of how the anthropogenic emissions of GHG are reduced below those that would have occurred in the absence of the JI project, may be represented by dynamic baseline, which is the function of the stage of project implementation (see **Fig. 5**).

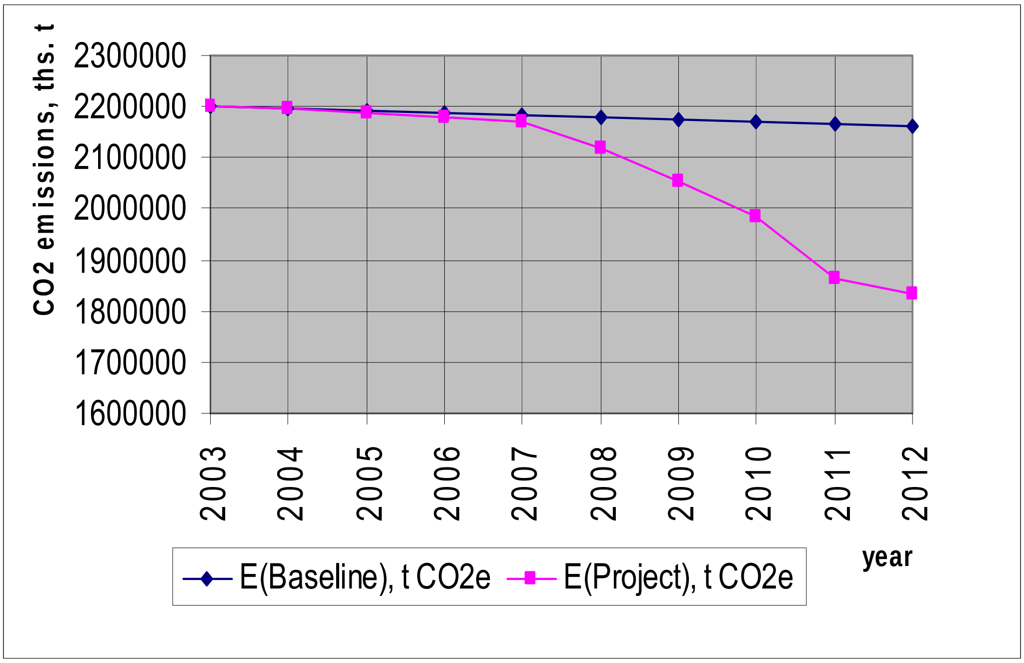


*Fig. 5. Dynamic baseline and project emissions of GHG*

**Additionality of the project**

The additionality of the project activity is demonstrated and assessed below with using the "Tool for the demonstration and assessment of additionality" (Version 5.2) (see **Fig. 6**). This tool was originally developed for CDM projects but may be applied to JI projects as well. This tool is used for the project in accordance with the guidance on its use provided in the partly similar "Baseline and monitoring methodology AM0044".

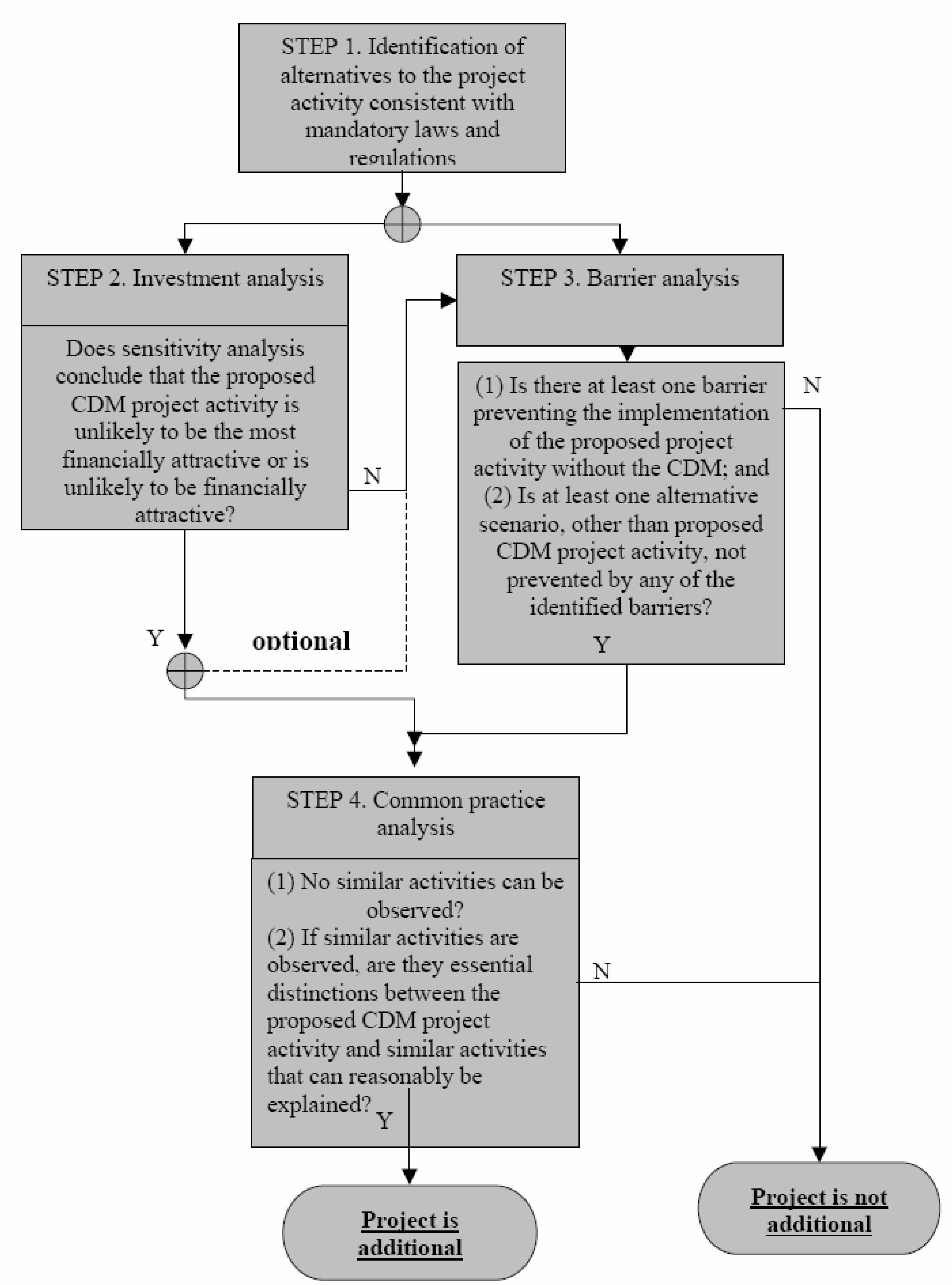


*Fig. 6. Steps for demonstration of additionality*

**Step 1. Identification of alternatives to the project activity consistent with current laws and regulations**

**Sub-step 1a. Define alternatives to the project activity:**

There are three alternatives to this project (as was already discussed in section B1).
1. The first alternative is continuation of the current situation (no project activity or other alternatives undertaken), i.e. business-as-usual scenario with minimum reconstruction works, approximately balanced by overall degradation of the DH system.
It should be noted that there is no local legislation regarding the time of boilers replacement and maximum lifetime permitted for boilers. It is common practice to exploit boilers which was installed in 70 th. and even 50-60 th. and earlier in Ukraine, if they pass the technical examination pass by the authorized body ("Derzhnagliadohoronpratsi").

2. The second alternative is to make reconstruction works (the proposed project activity) without JI mechanism.

3. The third alternative is the shortened project activity, without any of the non-key type of activity, for example elimination of frequency controllers installation, etc., from the project.

**Outcome of Step 1a:** Three realistic and credible alternative scenarios to the project activity are identified.

**Sub-step 1b. Consistency with mandatory laws and regulations:**

According to The Laws of Ukraine "On licensing of the separate types of activity" (№ 1775-III, from June 01, 2000) and "On heat energy supply" (№ 2633-IV from 02.06.2005); Ukrainian Government Regulation "On introduction of changes to the Government Regulations №1698 from 14.11.2000 and №756 from 04.07.2001" №549 from 19.04.2006 and "On approval of the list of licensing bodies" №1698 from 14.11.2000, execution of economic activity in fields of heat energy production, distribution and supply require a license that is issued by Ministry of Housing and Municipal Economy of Ukraine.

ME "Kharkivski teplovi merezhi" has such licenses.

The Project "District Heating System Rehabilitation in Kharkiv City" has been prepared according to The Law of Ukraine from 01.07.1994 №74/94-VR "On energy saving" and The Law of Ukraine from 22.12.2005 №3260-IV "On changes in The Law of Ukraine "On energy saving".

**Outcome of Step 1b:** The alternatives, which are: to continue business-as-usual scenario, to make reconstruction works without JI mechanism and to implement shortened project activity, without any of the non-key type of project activity, are in compliance with the mandatory laws and regulations.

Hence, the Step 1 is satisfied.

According to the "Tool for the demonstration and assessment of additionality" (Version 5.2), for further additionality analysis it is possible to follow the Step 2 or Step 3 (or both).

We shall follow the Step 3.

**Step 3: Barrier analysis**

**Sub-step 3a: Identification of barriers that would prevent the implementation of the proposed project activity**

**Investment barriers**

All project activities require substantial investment – about 177.5 million EUR (The prices for the new equipment, that is planned to be installed in the project, are represented on the sheets "Parameters" in the **Appendixes 1 - 6** in Excel format, based on the averaged prices of the manufacturers. These prices are used for calculations of investment costs, and should be corrected in future according to actual manufacturer's prices (changed due to inflation, etc.). The final table with necessary investments for each year is available in the **Appendix 7 (Total)**. Operational and maintenance costs are not included in the project because it is assumed that they will remain at the previous level or even decreased due to less such costs for the new equipment).

The financial indicators Net Present Value (NPV) and Internal Rate of Return (IRR) were calculated for two cases of project implementation – with and without the JI mechanism (see **Appendix 9**). Calculations were made with the help of Microsoft office Excel financial functions.

The simple pay back period without JI mechanism will be 13.7 years, with JI mechanism – 13.5 years.

In both cases the project is not attractive for investment, since the IRR values (0.6 % and 1.1 % respectively) are very much lower than typical values of deposit interest rate in Ukrainian banks (from 9 % to 12 % in Euro/USD and up to 18 % in Ukrainian hryvnas, see for example information of KreditPromBank [www.kreditprombank.com], UkrGasBank [www.ukrgasbank.com] and deposit market review [http://news.finance.ua/ru/orgtrg/~/3/1/114/130266], etc.). Using of JI mechanism enables to slightly improve project attractiveness.

The general situation in District Heating sector in Ukraine may be characterized as quite insufficient, and is analyzed and described in several available reviews and reports. Some citations, especially describing technical and financial situation, are given below.

"The existing district heating systems suffer from the same, well-known problems as those in other Central and European Countries. Old-fashioned Russian technology, oversized equipment, neglected maintenance and repairs, have resulted in increasing inefficiency. Typically, the overall efficiency of the DH systems (from fuel consumption in boilers to heat supplied to the building entrance) is about 50%. Including the losses within the buildings, it is estimated that only one third of the energy of the fuel is useful heat for the final consumers.

The bad technical state of the DH systems has its counterpart in the bad financial state. Non cost-covering tariffs can not meet the revenue requirements and subsidy payments are too small to cover all costs and are often delayed. In addition, collection rates are going in line with increasing tariffs" [Report: Market Potential for District Heating Projects in the Ukraine and their Modernization with Austrian Technology, Vienna, 2004, p.3. http://www.energyagency.at/(publ)/themen/elektrizitaet_index.htm].

"The current regulatory framework and tariff policy makes it difficult to attract private investors to district heating. Yet the main stakeholders, *e.g.* municipalities and residents, in most cases lack the necessary financing capacity. (P. 324).
District heating in Ukraine suffers from inefficiency and urgently needs investment in refurbishment and modernisation. … Yet, the current policy framework does not make district heating attractive for investment, which undermines its sustainability. Barriers to investment and efficiency improvements include (but are not limited to): the current pricing policy; lack of metering; the focus on heat production, not consumption; unclear ownership and management of buildings; and difficult access to financing for interested parties. It is vital to create adequate policy and regulatory conditions for attracting private

investments in the sector. (P. 328). [UKRAINE ENERGY POLICY REVIEW 2006, OECD/IEA, 2006. http://www.iea.org/Textbase/ publications/free_new_Desc.asp?PUBS_ID=1819].

“District heating suffers from inefficiency and low level of investment. The major impediments for investment include the unclear pricing policy, unregulated management and ownership conditions, the accumulated debt of heat producers” [Overview of Heating Sector in Ukraine, CASE, 2007. www.case-ukraine.com.ua].

The energy efficiency projects in the district heating sector in Ukraine could not be implemented at the expense of tariffs for heat energy, since the innovative constituent in tariffs is usually absent, and even “In some regions of Ukraine heat tariffs are below the cost coverage level, which results in debt accumulation of heat producers to the creditors (fuel supply companies, staff etc.)” [Overview of Heating Sector in Ukraine, CASE, 2007. www.case-ukraine.com.ua].

For example, the following documents from the price inspection, etc. that confirm fixed low tariff for heat energy are available at ME "Kharkivski teplovi merezhi":

- Law of Ukraine from 24.06.06. №1875-IV “Municipal-housing service”;
- State inspection of price control in Kharkiv Region 10.06.2008 “Conclusions #567, #570, #571, #572, #575, #576 on calculations of economical justified planed costs for municipal-housing service”;
- Kharkiv State City Council Decision from 04.10.06 #804 “About tariffs establishment for production transportation and distribution of heat energy and district heating service and water supply service, that rendered by ME "Kharkivski teplovi merezhi" for all consumers in Kharkiv city.

As to loans, the Ukrainian DH heat supply companies practically couldn’t get loans from Ukrainian banks, where the annual interest rates due to high risks, etc. are usually up to 20 % and even more [http://news.finance.ua/ru/~/3/20/all/2008/07/14/131967]. Moreover, no bank gives credits without the proper guarantees. ME "Kharkivski teplovi merezhi" is a communal ownership enterprise, and all its main funds belong to territorial population. For this reason the property of enterprise can not be a credit mortgage. Thus, the DH system rehabilitation without additional external investments (grants, subsidy, subvention, etc.) practically isn’t possible, and in current situation practically only municipal or state financing might be used for this purposes. But Ukrainian government does not have enough funds for this, and insufficiency and delay of the budget financing of activity in this sector is the main its problem.

Moreover, the real budget financing is usually significantly lower than scheduled (see diagram below, [UKRAINE ENERGY POLICY REVIEW 2006, OECD/IEA, 2006].

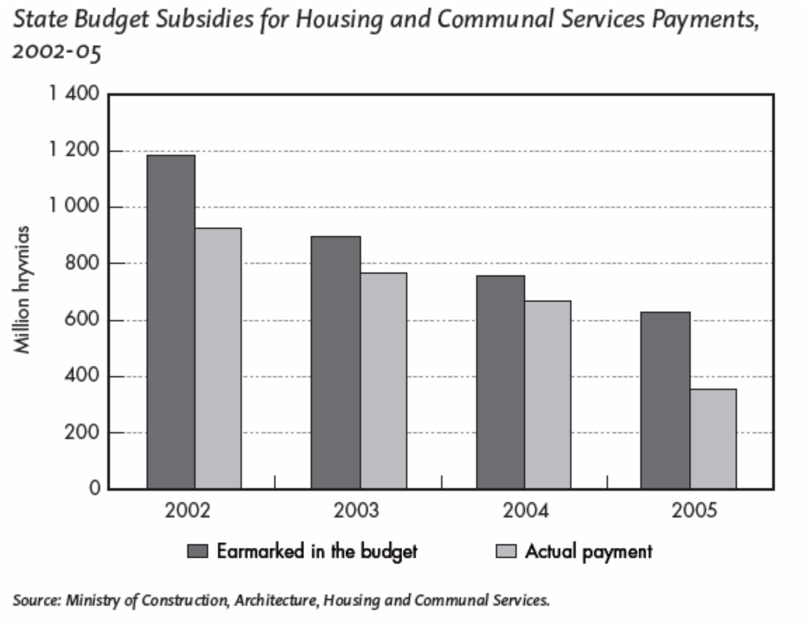


*Fig. 7. Diagram of the real State budget subsidies for Housing and communal services payments*

Also, as discussed earlier, "district heating tariffs do not cover costs and the difference must be covered by direct subsidies to heat providers, which come from local or state budgets". But even these payments are often delayed or even not paid: "Budget payments, however, are often delayed, which results in significant accumulated debt to district heating companies" [UKRAINE ENERGY POLICY REVIEW 2006, OECD/IEA, 2006].

From the other side, the additional financing of the project activity from JI mechanism is not only important for project financing, but the fact of signing of the external economic contract between Supplier and Purchaser itself is a very positive factor that even can enable to shift the priorities of budget financing in favor of the project, thus decreasing the investment barrier. The evidence for this, in particular for the very similar JI project on rehabilitation of the heat supply system of Chernihiv region, is available in the letter from the local authority – the Chernihiv Regional State Administration #01.04-05/1554 from 03.06.2008.

For this project, also the fact of signing of the external economic contract between ME "Kharkivski teplovi merezhi" and the purchaser of the Emissions reduction units provides the priority for distribution of funds from the state and local budgets to the rehabilitation of the city district heating system, thus to provide fulfillment of international liabilities on the joint implementation project. This is evidenced by the real situation with budget financing for ME "Kharkivski teplovi merezhi": after the decision on development of the Joint Implementation Project on Green House Gas Emissions Reduction (2004) the abrupt increasing of financing from the city budget took place. See **Table 10** below (Sums are in Ukrainian hryvnas).

| Financing source | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|
| The city budget - actions on energy saving and social and economic development | 0 | 1708 | 0 | 5377 | 5278 | 10310 | 6372 |
| ME «Kharkivski teplovi merezhi»` | 13250 | 10966 | 10813 | 21114 | 29304 | 36100 | 68300 |
| Total | 13250 | 12674 | 10813 | 26491 | 34582 | 46410 | 74672 |

*Table 10. Financing obtained by ME "Kharkivski teplovi merezhi"*

As the Project has not passed determination and registration yet, the state target (for energy saving) financing is not present. After Project registration and acquisition of JI status, possibility for target financing will appear.

**Technological barriers**

1. Not all proposed technologies are widely approved already. Qualification of operational personal for implementation of the new technologies may be not sufficient to provide proper activity implementation in time.

2. Efficiency of installed equipment could be lower than was claimed by producers or equipment may have substantial defects.

3. Available amount of natural gas. Last years Ukraine faced with incomplete delivery of natural gas from Russian Federation. Ukrainian Government realized attempts to decrease dependence from Russian natural gas delivery. Unfortunately it could lead to impossibility of boiler houses fuel switch from coal to natural gas.

**Organizational barriers**

The management experience in implementation of JI projects is absent, including international collaboration, determination, verification, registration, monitoring of similar projects and so on.

**Outcome of Step 3a:** Identified barriers would prevent the implementation of the proposed project activity as well as of the other alternatives - to make reconstruction works without JI mechanism and to shortened project activity, without any of the non-key type of project activity.

**Sub-step 3b: Explanation that the identified barriers would not prevent the implementation of at least one of the alternatives (except the proposed project activity)**

One of the alternatives is to continue business-as-usual scenario. Therefore, as the barriers mentioned above are directly related to investing into upgrading of the Kharkiv City district heating system, there is no impediment for ME "Kharkivski teplovi merezhi" to maintain the district heating system at its present level.

**Outcome of Step 3b:** The identified barriers would not prevent the implementation of at least one of the alternatives – the business-as-usual scenario.

Hence, the Step 3 is satisfied.

**Step 4: Common practice analysis**

**Sub-step 4a. Analysis of other activities similar to the proposed project activity.**

It should be noted that the district heating systems of almost all territorial districts of the Kharkiv City are involved in the project. ME "Kharkivski teplovi merezhi" is the main heat supply service enterprise in the City of Kharkiv. Besides ME "Kharkivski teplovi merezhi", heat energy in the Kharkiv City is produced by JSC "Kharkiv CHPP-5" (CHP-5) and CJSC "Teploelektrotsentral-3" (CHP-3), which have no their own distribution network, but have consumers, with which they have signed contracts for heat energy supply. Therefore they are forced to have contractual relations with ME "Kharkivski teplovi merezhi" concerning heat energy distribution to their consumers. Surplus of produced heat energy is saled to ME "Kharkivski teplovi merezhi". The heat supply service in Kharkiv Region is provided by Inter-branch Regional Corporation "Teploenergiya". But there are no similar intensive rehabilitation activity observed in the Kharkiv region.

At present there are at least 4 District Heating Rehabilitation Projects with JI mechanism in Ukraine at advansed stages beside this project: for DH systems in Chernihiv region, Donetsk region, AR Crimea and Lugansk city. But other CDM (JI) project activities are not to be included in Common practice analysis. The common practice for district heating enterprises in Ukraine without JI is only a necessary repairment of the old equipment, mainly in emergensy cases, and not the renewal. With the JI component it is possible to obtain the additional funds for real rehabilitation of the district heating system.

**Outcome of Step 4a:** Since the similar projects are not observed in the region, there is no basis for analysis of similar activities.

**Conclusion:**

The results of the above discussed analysis lead to the conclusion that the project activity is additional.

**B.3. Description of how the definition of the project boundary is applied to the project:**

Greenhouse Gas Sources and Project Boundaries:

Project boundaries for Baseline scenario are represented by dotted line on the graphical picture on the **Fig. 8.**

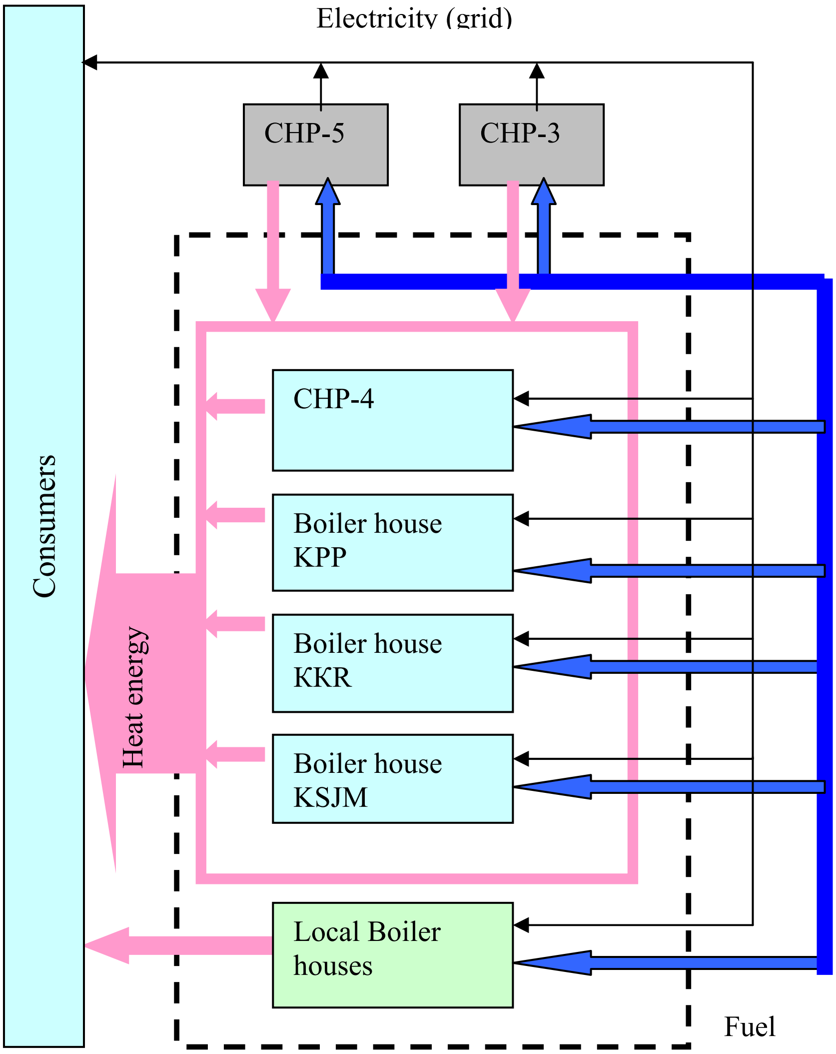


*Fig.8. Flowchart of Project boundaries for Baseline scenario*

As we can see from the picture, under the current heating system three boiler houses KPP, KKR, KSJM and three CHPs have united heating system that belongs to ME "Kharkivski teplovi merezhi". In addition, there are local boiler houses that mostly have separate heating systems. Project boundaries include $CO_2$ emissions from boiler houses that belong to ME "Kharkivski teplovi merezhi", and CHP-4 (operating at present only in heat generation mode, see page 2). Into project boundaries there are also included $CO_2$ emissions, associated with consumption of fuel at CHP–5 and CHP–3, that is used for heat energy generation, which is provided by these CHP to the general heat supply system.

Project boundaries also include $CO_2$ emissions due to electricity consumption from the grid that boiler houses, CHP and HDS consume for heat and hot water supply service providing.

$CO_2$ emissions associated with electricity production at CHP are not included in project boundaries. Emissions due to production and transportation of fuel are not included in project boundaries as well.

Project boundaries for Project scenario will remain without changes (Flowchart of project boundaries for the Project scenario is the same as for Baseline scenario, see Fig. 8), but load from some local boiler houses will be switched to CHP-5, CHP-3, CHP-4, boiler houses KPP, KKR, KSZHM, Hartron's boiler house and some other boiler houses (see **Appendix 1**).

Also, at the boiler house of Saltivsk residential area (KSZHM) the CHP units will be installed, that will supply residential community with hot water, and partly cover the own needs of this boiler house in electric energy.

**Direct and Indirect Emissions**

*Direct on-site emissions:* $CO_2$ from natural gas combustion in boilers (in some cases coal is used as a fuel), $NO_x$ and CO emission from combustion in the existing boilers/ burners, $CO_2$ emissions from fuel combustion in gas engines at the new CHP units, additional $CO_2$ emissions from fuel combustion in boilers at the boiler houses due to the too large heat losses in the distribution networks.

*Direct off-site emissions:* $CO_2$ emissions from power stations due to electricity production to the grid, consumption of which will be replaced after CHP units installation.
$CO_2$ emissions from power stations due to electricity production to the grid, that consumed by boiler houses and CHP plants, in area of which the reconstruction and liquidation of HDS will take place, and also that consumed by boiler houses and HDS, where frequency controllers will be set.
$CO_2$ emissions from power stations due to electricity consumption used for heating of Kharkiv city customers. It takes place due to inefficiencies of heat supply service quality for many consumers in the current situation. Exploitation of electric heaters is quite typical and widespread.
$CO_2$ emissions from conventional power station(s) due to electricity consumption for network's work providing. It is not efficient due to water leakages, and extended networks' distance.

*Indirect on-site emissions:* none.

*Indirect off-site emissions:* $CO_2$ emissions from fuel extraction and transportation.

| On-site emissions | | | |
|---|---|---|---|
| Current situation | Project | Direct or indirect | Include or exclude |
| $CO_2$ emissions from fuel combustion in boilers | Reduced $CO_2$ emissions from fuel combustion in boilers due to increased efficiency and fuel saving.<br>Additional $CO_2$ emissions at the boiler houses where the new CHP units will be installed due to additional fuel consumption by CHP | Direct | Include |
| $NO_x$ and CO emission from | Reduced $NO_x$ and CO | Direct | Exclude. $NO_x$ and CO |

| | | | |
|---|---|---|---|
| combustion in existing boilers/ burners | emissions from fuel combustion after boiler / burners' replacement | | are not GHGs. |
| $CO_2$ emissions from fuel combustion in boilers at the boiler houses due to the too large heat losses in the networks | Reduced $CO_2$ emissions from boiler houses due to decreasing of heat losses in the network pipes, due to replacement pipes with the pre-insulated ones, reconstruction of HDS, and reduction of networks' length | Direct | Include |
| Off-site emissions | | | |
| Current situation | Project | Direct or indirect | Include or exclude |
| $CO_2$ emissions from power plant(s) due to electricity production to the grid, which will be replaced after installation of CHP units | Reduced $CO_2$ emissions from power plant(s) | Direct | Include |
| $CO_2$ emissions from power plant(s) due to electricity production to the grid, that is consumed by boiler houses and CHP plants, in area of which the reconstruction and liquidation of HDS will take place, and also by the boiler houses, where frequency controllers will be installed. | Reduced $CO_2$ emissions from power plant(s) due to reduction of electricity consumption by boiler houses and CHP plants. | Direct | Include |
| $CO_2$ emissions from power plant(s) due to electricity production to the grid, that is consumed by HDS, where reconstruction and liquidation will take place and where frequency controllers will be installed. | Reduced $CO_2$ emissions from power plant(s) due to reduction of electricity consumption by HDS. | Direct | Include |
| $CO_2$ emissions from power plant(s) due to power consumption used for heating by Kharkiv city customers. It takes place due to inefficiencies of heat supply service quality for many consumers in the current situation. Exploitation of power heaters is quite typical and widespread. | Reduced $CO_2$ emissions from power plant(s) due to reduction of power consumption for heating by Kharkiv city customers. This will take place after project implementation when heat supply service will become more efficient. Exploitation of electric heaters will be decreased substantially. | Direct | Exclude, not under control of project developer |

| | | | |
|---|---|---|---|
| $CO_2$ emissions from fuel extraction and transportation. | Reduced $CO_2$ emissions from fuel extraction and transportation due to fuel saving. | Indirect | Exclude, not under control of project developer |

*Table 11. Project boundaries and sources of emissions*

**B.4. Further baseline information, including the date of baseline setting and the name(s) of the person(s)/entity(ies) setting the baseline:**

Date of baseline setting: 15/11/2004

The baseline is determined by the Institute of Engineering Ecology (IEE), project developer and project partner, in collaboration with European Institute for safety, security, insurance and environmental techniques (SVT e.V.), the project consultant, and ME "Kharkivski teplovi merezhi", the project supplier.

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## SECTION C. Duration of the project / crediting period

### C.1. Starting date of the project:

The starting date of the project is: 11/03/2004

### C.2. Expected operational lifetime of the project:

Minimum - 20 years (the nominal lifetime of the new boiler and network equipment). The real average lifetime of the new boiler and network equipment is estimated to be up to 30 – 40 years. Thus the expected operational lifetime of the project may be about 30 years. According to conservatism principle, for further calculations we assume lifetime and corresponding crediting period for the project equal to 20 years (2005 – 2024).

### C.3. Length of the crediting period:

Earning of the ERUs corresponds to the first commitment period of 5 years (January, 1, 2008 – December, 31, 2012).

The starting date of the crediting period is set to the date where the first emission reduction units are expected to be generated from the project that is January 1, 2005. The end of the crediting period is the end of the lifetime of the main equipment that is minimal December 31, 2024. Thus the length of the crediting period is 20 years (240 months).

If the past first commitment period under the Kyoto Protocol will be applicable, the crediting period may be expanded up to the end of the expected operational lifetime of the project (20 years, 2005-2024).

## SECTION D. Monitoring plan

### D.1. Description of monitoring plan chosen:

#### D.1.1. Option 1 – Monitoring of the emissions in the project scenario and the baseline scenario:

**Indicator of project performance**

The most objective and cumulative factor that will give a clear picture of whether emission reductions really took place – is *fuel saving*. It can be identified as a difference between baseline fuel consumption and fuel consumption after project implementation. If boilers consume fuel at the projected level, than all other relevant indicators such as efficiencies of new boilers and burners, specific gas consumption of CHP units, as well as heat losses in pre-insulated pipes are adequate.

**Verification of project performance indicators**

ME "Kharkivski teplovi merezhi" collects data on fuel purchasing for heating in form of fuel bills. Information on saved fuel will be attached to verification reports on a yearly basis (before April 1st for all years of project implementation) with all relevant documentation and historical information on fuel purchasing transactions made by Supplier.

**Verification of Emission Reduction Units and Baseline Scenario**

The monitoring methodology developed for "District Heating" projects in Ukrainian conditions consists in the following:

For any project year, the baseline scenario may be different due to the influence of external factors such as weather conditions, possible changes of the lower heating value of fuel(s), number of customers, heating area, etc. The Baseline and the amount of ERUs for each project year should be corrected with taking into account these and some other factors.

The following methodology is proposed to be used.

Amount of the Emission Reduction Units (ERUs), t $CO_2$e:

ERUs = $\sum[E_i^b - E_i^r]$

The sum is taken over all boiler-houses (i) which are included into the project.

$E_i^b = E_{1i}^b + E_{gen\ i}^b + E_{cons\ i}^b$,
$E_i^r = E_{1i}^r + E_{gen\ i}^r + E_{cons\ i}^r$,

where:
$E_{1i}^b$ and $E_{1i}^r$ – $CO_2$ emissions due to fuel consumption for heating and hot water supply service for an i boiler-house in the base year and in the reported year, respectively, t $CO_2$e;
$E_{gen\ i}^b$ and $E_{gen\ i}^r$ – $CO_2$ emissions due to electric power generation associated to the project for an i boiler-house in the base year (consumed from greed, amount to be substituted in the reported year), and generated by included into the project objects in the reported year, respectively, t $CO_2$e;
$E_{cons\ i}^b$ and $E_{cons\ i}^r$ – $CO_2$ emissions due to electric power consumption from greed by the i boiler-house in the base year and in the reported year, respectively, t $CO_2$e.

For each i boiler-house:

$E_1^b = LHV_b*Cef_b*B_b$

$E_1^r = LHV_r* Cef_r*B_r$

$E_{gen}^b = W_b*CEF_g+ Q_b*f_b/1000* LHV_r* Cef$

$E_{gen}^r = (W_b - W_r)*CEF_g+ [(Q_b-Q_r)*f_b/1000+ B_g]* LHV_r* Cef$

$E_{cons}^b = P_b*CEF_c$

$E_{cons}^r = P_r*CEF_c$

where:

LHV – lower heating value, MJ/$m^3$ (MJ/kg);
Cef – carbon emission factor, kt $CO_2$/TJ;
B – amount of fuel consumed by a boiler-house, ths $m^3$ or tons;
$W_b$ – scheduled electric power production by the new CHP units at a boiler-house, MWh;
$W_r$ – electric power production by the installed new CHP units, MWh;

$CEF_g$ – Carbon Emission factor for electricity generation in Ukraine, $tCO_2e/MWh$;
$P_b$ – electric power consumption by a boiler-house where energy saving measures are scheduled to be implemented, MWh;
$P_r$ – electric power consumption by a boiler-house with energy saving measures implemented, MWh;
$CEF_c$ – Carbon Emission factors for reducing electricity consumption in Ukraine, $tCO_2e/MWh$;

$Q_b$ – scheduled heat energy production by the new CHP units at a boiler-house, MWh;
$Q_r$ – heat energy production by the installed new CHP units at a boiler-house in reported year, MWh;
$f_b$ – specific natural gas consumption by a boiler-house, where CHP units are scheduled to be installed, $m^3/MW$;
$B_g$ – amount of fuel (gas) consumed by the installed CHP units for heat and power generation, ths $m^3$;
[$_b$] index – related to the base year;
[$_r$] index – related to the reported year.

If any boiler-house consumes more than one type of fuel, the calculations of E are to be made for each type of fuel separately, and results are to be summed.

According to the Dynamic Baseline assumption, the efficient value of $E_1^b$ may be defined as follows:
$E_{1i}^b = E_{hi}^b, + E_{wi}^b$;
where the first term describes emissions from fuel consumption for heating, and the second one – from fuel consumption for hot water supply.

For the case when in the base year the hot water supply service was provided (independent of this service duration, $(1-a_b) \neq 0$), the formulae for $E_1^b$ is:
$E_1^b = LHV_b * Cef_b * [B_b * a_b * K_1 * K_h + B_b * (1-a_b) * K_1 * K_w]$,
where the first term in brackets describes fuel consumption for heating, and the second one – fuel consumption for hot water supply.

For the case when in the base year the hot water supply service was absent at all $((1-a_b) = 0)$, and in the reported year this service was provided (due to improvement of heat supply service quality for population), the formulae for $E_1^b$ is:
$E_1^b = LHV_b * Cef_b * [B_b * a_b * K_1 * K_h + B_r * (1-a_r) * K_1 * K_{w0}]$

$E_1^r = LHV_r * Cef_r * B_r$

where:
LHV – lower heating value, $MJ/m^3$ (MJ/kg);
Cef – carbon emission factor, kt $CO_2/TJ$;
B – amount of fuel consumed by a boiler-house, ths $m^3$ or tons per year;
$K_1$, $K_h$, $K_w$, $K_{w0}$ – adjustment factors;

a – portion of fuel (heat), consumed for heating purposes;
(1-a) – portion of fuel (heat), consumed for hot water supply services;
[$_b$] index – related to the base year;
[$_r$] index – related to the reporting year.

$a_b = L_h^b * g * N_h^b / (L_h^b * g * N_h^b + L_w^b * N_w^b)$;
$a_r = L_h^r * g * N_h^r / (L_h^r * g * N_h^r + L_w^r * N_w^r)$,

where:
$L_h$, $L_w$ – maximum connected load to the boiler-house, that is required for heating and for hot water supply service, MW;
g – recalculating factor for average load during heating period (is determined for each boiler-house on historical base, usually is in the range 0,4 – 0,8);
$N_h$, $N_w$ – duration of heating period and period of hot water supply service per year, hours.

Adjustment factors:

1. $K_1$ (change in the lower heating value of fuel):

$K_1 = LHV_b / LHV_r$

2. Adjustment factors for heating should be used for creation the Dynamic Baseline which takes into account changes of the external factors such as weather conditions, heating area, etc.

Fuel consumption for heating is proportional to the required amount of heat during heating period, $Q_h$:

$B_h = B*a = Q_h / LHV*\eta$,

where $\eta$ is overall heating system efficiency.

According to the assumption of the Dynamic Baseline, the required amount of heat in the base year for correct comparison should be reduced to real conditions (external to the project) in the reported year:

$Q_{h\,br} = Q_{h\,b} * K_h = Q_{h\,r}$

where:

$Q_{h\,br}$ – required heat for Dynamic Baseline, is assumed equal to $Q_r$ – required heat in the reported year,
$Q_{h\,b}$ – required heat in the base year,
$K_h$ – averaged adjustment factor for heating.

From this equation it is possible to determine the averaged adjustment factor:
$K_h = Q_{h\,r} / Q_{h\,b.}$

Required amount of heat for heating of buildings during a year, according to the "Codes and regulations on rationing of fuel and heat energy for heating of residential and public buildings, as well as for communal and domestic requirements in Ukraine. KTM 204 Ukraine 244-94"[5], is determined by [ibid, equation 2.17]:

$Q_h = F_h*k_h*(T_{in} - T_{out})*N_h$,

where:
$Q_h$ – required amount of heat for heating, kWh;
$F_h$ – heating area of buildings, $m^2$;
$K_h$ – average heat transfer factor of buildings, $kW/m^2*K$;
$T_{in}$ – average inside temperature for the heating period, K (or $^0C$);
$T_{out}$ – average outside temperature for the heating period, K (or $^0C$);
$N_h$ – duration of the heating period per year, hours.

Then:
$K_h = (F_{h\,r} *k_{h\,r})*(T_{in\,r} - T_{out\,r})*N_{h\,r} / F_{h\,b}*k_{h\,b}*(T_{in\,b} - T_{out\,b})*N_{h\,b}$
2.1. $K_2$ (temperature change factor):

$K_2 = (T_{in\,r} - T_{out\,r}) / (T_{in\,b} - T_{out\,b})$.

2.2. $K_3$ (heating area and building thermal insulation change factor):

[5] Codes and regulations on rationing of fuel and heat energy for heating of residential and public buildings, as well as for communal and domestic requirements in Ukraine. KTM 204 Ukraine 244-94. Kyiv, 2001, 376 p.

$K_3 = (F_{h\,r} * k_{h\,r}) / F_{h\,b} * k_{h\,b} = [(F_{h\,r} – F_{h\,t\,r} – F_{h\,n\,r}) * k_{h\,b} + (F_{h\,n\,r} + F_{h\,t\,r}) * k_{h\,n}] / F_{h\,b} * k_{h\,b}$,

where:
$F_{h\,b}$ – heating area of buildings in the base year, $m^2$;
$F_{h\,r}$ – heating area of buildings in the reported year, $m^2$;
$F_{h\,n\,r}$ – heating area of new buildings connected to DH system (assumed with the new (improved) thermal insulation) in the reported year, $m^2$;
$F_{h\,t\,r}$ – heating area of buildings (previously existed in the base year) in reported year with the renewed (improved) thermal insulation, $m^2$;
$k_{h\,b}$ – average heat transfer factor of heated buildings in the base year, $W/m^2*K$;
$k_{h\,r}$ – average heat transfer factor of heated buildings in the reported year, $W/m^2*K$;
$k_{h\,n}$ – heat transfer factor of heated buildings with the new thermal insulation (new buildings or old ones with improved thermal insulation), $W/m^2*K$.

2.4. $K_4$ (heating period duration change factor):

$K_4 = N_{h\,r} / N_{h\,b}$

where:
$N_{h\,b}$ – duration of the heating period in the base year, hours;
$N_{h\,r}$ – duration of the heating period in the reported year, hours.

Thus,

$K_h = K_2 * K_3 * K_4$

3. Adjustment factors for hot water supply service should be used for creation the Dynamic Baseline which takes into account changes of the external factors such as weather conditions, number of customers, etc.:

Fuel consumption for hot water supply service is proportional to the required amount of heat during the service rendered period, $Q_w$:

$B_w = B*(1\text{-}a) = Q_w / LHV*\eta$,

where $\eta$ is overall hot water supply system efficiency.

According to the assumption of the Dynamic Baseline, the required amount of heat for hot water supply service in the base year for correct comparison should be reduced to real conditions (external to the project) in the reported year:

$Q_{w\,br} = Q_{w\,b} * K_w = Q_{w\,r}$

where:
$Q_{w\ br}$ – required heat for hot water supply service for Dynamic Baseline, is assumed equal to $Q_{w\ r}$ – required heat for hot water supply service in the reported year,
$Q_{w\ b}$ – required heat for hot water supply service in the base year,
$K_w$ – averaged adjustment factor for hot water supply service.

From this equation it is possible to determine the averaged adjustment factor:
$K_w = Q_{w\ r} / Q_{w\ b.}$

The components of $K_w$ may be illustrated by correlation of heat used for hot water supply service in the base and reported years:

$Q_w = n_w * v_w * N_w$,

where:
$Q_w$ – required amount of heat for hot water supply service, kWh;
$n_w$ – average number of service's customers, personal accounts;
$v_w$ – standard specific discharge of hot water per personal account (in heat units, kWh/h);
$N_w$ – duration of the service period per year, hours.

Then:
$K_w = n_{w\ r} * v_{w\ r} * N_{w\ r} / n_{w\ b} * v_{w\ b} * N_{w\ b}$

3.1. $K_5$ (number of customers change factor):

$K_5 = n_{w\ r} / n_{w\ b}$

3.2. $K_6$ (standard specific discharge of hot water per personal account change factor):
$K_6 = v_{w\ r} / v_{w\ b}$

At present the standard specific discharge of hot water is valid in Ukraine that was established by the KTM 204 Ukraine 244-94[1] in 1993. and no information is available on any propositions to change it, thus $K_6 = 1$ and does not require special monitoring.

3.3. $K_7$ (hot water supply period duration change factor):

$K_7 = N_{w\ r} / N_{w\ b}$

where:
$N_{w\,b}$ – duration of the hot water supply period in the base year, hours;
$N_{w\,r}$ – duration of the hot water supply period in the reported year, hours.

Thus,

$K_w = K_5 * K_6 * K_7$.

3.4. Adjustment factors for hot water supply service in case when there was no hot water supply service in base year, and in the reported year this service was provided:

Since in case when there was no hot water supply service in base year, number of customers, standard specific discharge of hot water per personal account and duration of hot water supply period in the base year are assumed to be equal to these values in the reported year,

$K_5 = K_6 = K_7 = 1$.

Thus

$K_{w0} = 1$.

The table of parameters included in the process of monitoring and verification for ERUs calculation, is represented in the Section **D.1.1.1** and **D.1.1.3.** Every year the table with foregoing factors will be updated with account for possible change of these factors, and the dynamic baseline will be developed as well as the amount of ERUs will be calculated**.**

| D.1.1.1. Data to be collected in order to monitor emissions from the project, and how these data will be archived: | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ID number *(Please use numbers to ease cross-referencing to D.2.)* | Data variable | Source of data | Data unit | Measured (m), calculated (c), estimated (e) | Recording frequency | Proportion of data to be monitored | How will the data be archived? (electronic/ paper) | Comment |
| **1** | Fuel consumption at boiler houses: (**$B_r$**) | Every Boiler house | | m | Every day | 100% | Registered in the journal (paper and/or electronic) | Fuel consumption at boiler houses is the main data which allows to calculate GHG emissions in the reported year |
| **1.1** | Natural Gas | | $m^3$ | | | | | |
| **1.2** | Coal | | ton | | | | | |
| **2** | Average annual Heating Value of a fuel calculated by Lower Heating Value (**$LHV_r$**) | Fuel Supplier's Report or Chem. Lab Analysis Report | | m, c | Once per month | 100% | Registered in the journal (paper and/or electronic) | |
| **2.1** | Natural Gas | | $MJ/m^3$ | | | | | |
| **2.2** | Coal | | MJ/kg | | | | | |
| **3** | Power consumption (**$P_r$**) | 1. Boiler houses and CHP, in the heating area of which reconstruction | MWh | m | Every month | 100% | Registered in the journal (paper and/or electronic) | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | and liquidation of HDS will take place.<br>2. HDS that will be reconstructed and liquidated.<br>3. Boiler houses and HDS, where frequency controllers will be installed | | | | | | |
| **4** | Power production (**$W_{gr}$**) | New CHP units | MWh | m | Every day | 100% | Registered in the journal (paper and/or electronic) | |
| **5** | Heat energy production (**$Q_{gr}$**) | New CHP units | MWh | m | Every day | 100% | Registered in the journal (paper and/or electronic) | |
| **6** | Fuel consumption at the CHP units: (**$B_g$**) | Every CHP units | 1000 $m^3$ | m | Every day | 100% | Registered in the journal (paper and/or electronic) | |

According to valid legislation, all measuring equipment in Ukraine should meet the specified requirements of corresponding standards and is subject to the periodical verifying and calibration (usually once per year, for some equipment once per two and three years).

For example, the gas flow meters of the SG type should meet the requirements of the standard TU 4213-001-07513518-02, in particular the measurement error should be not more than ± 2% in the flow range from Qmin to 0,2Qmax; ± 1% - in the range from 0,2Qmax to Qmax.

In case of failure of measurement equipment, it should be replaced or repaired as soon as possible. Such cases should be noted in monitoring reports.

**D.1.1.2. Description of formulae used to estimate project emissions (for each gas, source etc.; emissions in units of $CO_2$ equivalent):**

$E_i^r = E_{1i}^r + E_{gen\ i}^r + E_{cons\ i}^r$;

where:
$E_{1i}^r$ – $CO_2$ emissions due to fuel consumption for heating and hot water supply service for an i boiler-house in the reported year, t $CO_2$e;
$E_{gen\ i}^r$ – $CO_2$ emissions due to electric power generated by included into the project objects in the reported year, t $CO_2$e;
$E_{cons\ i}^r$ – $CO_2$ emissions due to electric power consumption from greed by the i boiler-house in the reported year, t $CO_2$e.

$E_{1i}^r = LHV_r * Cef_r * B_{ri}$ ,

where:
$LHV_{ri}$ – Average annual lower heating value, MJ/$m^3$ (MJ/kg)
Average annual Heating Value is calculated for every town;
Cef – carbon emission factor, kt$CO_2$/TJ;
$B_{ri}$ – amount of fuel consumed by a boiler-house in the reported year, ths $m^3$ or tons;

$E_{gen}^r = (W_b - W_r)*CEF_g + [(Q_b - Q_r)*f_b/1000 + B_g]* LHV_r * Cef$

where:
$W_b$ – scheduled electric power production by the all new CHP units, MWh;
$W_r$ – electric power production by the installed new CHP units in reported year, MWh;
$CEF_g$ – Carbon Emission factor for electricity generation in Ukraine, t$CO_2$e/MWh;
$Q_b$ – scheduled heat energy production by the all new CHP units, MWh;
$Q_r$ – heat energy production by the installed new CHP units, MWh;
$f_b$ – specific natural gas consumption by the boiler-house, where CHP units are scheduled to be installed, $m^3$/MW;
$B_g$ – amount of fuel (gas) consumed by the installed CHP units for generation, ths $m^3$;

$E_{cons\ i}^r = P_r * CEF_c$;

where:

$P_r$ – electric power consumption by the boiler-houses with energy saving measures implemented (Power consumption of the boiler houses and CHP, in the heating area of which reconstruction and liquidation of HDS will take place, HDS that will be reconstructed and also of boiler houses and HDS, where frequency controllers will be installed), MWh;

$CEF_c$ – Carbon Emission factors for reducing electricity consumption in Ukraine, $tCO_2e/MWh$;

$[_r]$ index – related to the reporting year

| **D.1.1.3. Relevant data necessary for determining the baseline of anthropogenic emissions of greenhouse gases by sources within the project boundary, and how such data will be collected and archived:** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ID number *(Please use numbers to ease cross-referencing to D.2.)* | Data variable | Source of data | Data unit | Measured (m), calculated (c), estimated (e) | Recording frequency | Proportion of data to be monitored | How will the data be archived? (electronic/ paper) | Comment |
| 1 | Fuel consumption at boiler houses (**$B_b$**) | Every Boiler-house | | m | Every day | 100% | Registered in the journal (paper and/or electronic) | Fuel consumption at boiler houses is the main data which allows to calculate GHG emissions in the base year |
| 1.1 | Natural Gas | | $m^3$ | | | | | |
| 1.2 | Coal | | ton | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 2 | Average annual Heating Value of a fuel calculated by Lower Heating Value (**$LHV_b$**) | Fuel Supplier's Report or Chem. Lab Analysis Report | | m, c | Once per month | 100% | Registered in the journal (paper and/or electronic) | Data which allows to calculate GHG emissions in the base year |
| 2.1 | Natural Gas | | MJ/m3 | | | | | |
| 2.2 | Coal | | MJ/kg | | | | | |
| 3 | Average outside temperature during the heating season (**$T_{out\ b}$** and **$T_{out\ r}$**) | ME "Kharkivski teplovi merezhi", Meteorological Service | $^{0}$C (K) | m, c | Once per heating season. Daily temperatur e is registered every day | 100% | Registered in the journal (paper and/or electronic) | Auxiliary data which allows correcting of the dynamic baseline |
| 4 | Average inside temperature during the heating season (**$T_{in\ b}$** and **$T_{in\ r}$**) | ME "Kharkivski teplovi merezhi" The average inside temperature will be calculated from the sum of returned payments caused by insufficient heating (in case of normative level is not satisfied) | $^{0}$C (K) | m, c | Once per heating season | 100% | Registered in the journal (paper and/or electronic) | Auxiliary data which allows correcting of the dynamic baseline |
| 5 | Number of Customers (**$n_{wb}$** and **$n_{wr}$**) | ME "Kharkivski teplovi merezhi" | | Statistics | Once per year | 100% | Special Reports (paper and/or electronic) | Auxiliary data which allows correcting the dynamic baseline |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 6 | Heating area (total) (**$F_{hb}$** and **$F_{hr}$**) | ME "Kharkivski teplovi merezhi" | $m^2$ | Statistics | Once per year | 100% | Special Reports (paper and/or electronic) | Auxiliary data which allows correcting the dynamic baseline |
| 7 | Average heat transfer factor of heated buildings in the base year (**$k_{hb}$**) | ME "Kharkivski teplovi merezhi" | $W/m^2*K$ | Statistics | Once per year | 100% | Special Reports (paper and/or electronic) | Auxiliary data which allows correcting the dynamic baseline |
| 8 | Heating area of buildings (previously existed in the base year) with the renewed (improved) thermal insulation in the reported year (**$F_{htr}$**) | ME "Kharkivski teplovi merezhi" | $m^2$ | Statistics | Once per year | 100% | Special Reports (paper and/or electronic) | Auxiliary data which allows correcting the dynamic baseline |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 9 | Heating area of newly connected buildings (assumed with the new (improved) thermal insulation) in the reported year (**$F_{h\,n\,r}$**) | ME "Kharkivski teplovi merezhi" | $m^2$ | Statistics | Once per year | 100% | Special Reports (paper and/or electronic) | Auxiliary data which allows correcting the dynamic baseline |
| 10 | Heat transfer factor of buildings with new thermal insulation (**$k_{h\,n}$**) | ME "Kharkivski teplovi merezhi",<br>State Buildings Norms (B.2.6-31:2006) | $W/m^2*K$ | Normative documents | Once per year | 100% | Special Reports (paper and/or electronic) | Auxiliary data which allows correcting the dynamic baseline |
| 11 | Heating period duration (**$N_{h\,b}$** and **$N_{h\,r}$**) | ME "Kharkivski teplovi merezhi" | Hours | m | Once per year | 100% | Special Reports (paper and/or electronic) | Auxiliary data which allows correcting the dynamic baseline |
| 12 | Duration of period of hot water supply service (**$N_{w\,b}$** and **$N_{w\,r}$**) | ME "Kharkivski teplovi merezhi" | Hours | m | Once per year | 100% | Special Reports (paper and/or electronic) | Auxiliary data which allows correcting the dynamic baseline |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 13 | Maximum connected load to the boiler-house, that is required for heating (**$L_h^b$** and **$L_h^r$**) | ME "Kharkivski teplovi merezhi" | MW | c | Once per year | 100% | Special Reports (paper and/or electronic) | Auxiliary data which allows correcting the dynamic baseline |
| 14 | Connected load to the boiler-house, that is required for hot water supply service (**$L_w^b$** and **$L_w^r$**) | ME "Kharkivski teplovi merezhi" | MW | c | Once per year | 100% | Special Reports (paper and/or electronic) | Auxiliary data which allows correcting the dynamic baseline |
| 15 | Standard specific discharge of hot water per personal account (**$v_{w\ r}$** and **$v_{w\ b}$**) | ME "Kharkivski teplovi merezhi" | kWh/h | Normative documents | Once per year | 100% | Special Reports (paper and/or electronic) | Auxiliary data which allows correcting the dynamic baseline |
| 16 | Carbon emission factor (**$Cef_b$** and **$Cef_r$**) | IPCC | | Normative documents | Once per year | 100% | Special Reports (paper and/or electronic) | Auxiliary data which allows correcting the dynamic baseline |
| 16.1 | Natural Gas | | kt $CO_2$/TJ | | | | | |
| 16.2 | Coal | | kt $CO_2$/TJ | | | | | |
| 17 | Recalculating factor for average load during heating period (**g**) | ME "Kharkivski teplovi merezhi" | | Statistics | Once per year | 100% | Special Reports (paper and/or electronic) | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 18 | Scheduled electric power production (**$W_{gb}$**) | ME "Kharkivski teplovi merezhi" | MWh | c | Once | 100% | Special Reports (paper and/or electronic) | Data which allows to calculate GHG emissions due to power consumption from the grid in the baseline scenario |
| 19 | Scheduled heat energy production (**$Q_{gb}$**) | ME "Kharkivski teplovi merezhi" | MWh | c | Once | 100% | Special Reports (paper and/or electronic) | Data which allows to calculate GHG emissions in the baseline scenario |
| 20 | Power consumption (**$P_b$**) | Boiler houses and CHP plants, in the heating area of which reconstruction and liquidation of HDS will take place; HDS that will be reconstructed and liquidated and also boiler houses and HDS where frequency controllers will be installed | MWh | m | Every month | 100% | Data journal, (paper and electronic file) | Data which allows to calculate GHG emissions due to power consumption from the grid in the baseline scenario |

See Annex 3 for more detailes.

**D.1.1.4. Description of formulae used to estimate baseline emissions (for each gas, source etc.; emissions in units of $CO_2$ equivalent):**

$E_i^b = E_{1i}^b + E_{gen\ i}^b + E_{cons\ i}^b$;

where:
$E_i^b$ – baseline emissions, t $CO_2$
$E_{1i}^b$ – $CO_2$ emissions due to fuel consumption for heating and hot water supply service for an i boiler-house in the base year, t $CO_2$e;
$E_{gen\ i}^b$ – $CO_2$ emissions due to electric power generation associated to the project for an i boiler-house in the base year, t $CO_2$e;
$E_{cons\ i}^b$ – $CO_2$ emissions due to electric power consumption for an i boiler-house in the base year, t $CO_2$e.

For the case when in the base year the hot water supply service was provided (independent of this service duration, $(1-a_b) \neq 0$), the formulae for $E_1^b$ is:
$E_1^b = LHV_b*Cef_b*[B_b*a_b*K_1*K_h + B_b*(1-a_b)*K_1*K_w]$,
where the first term in brackets describes fuel consumption for heating, and the second one – fuel consumption for hot water supply.

For the case when in the base year the hot water supply service was absent at all ($(1-a_b) = 0$), and in the reported year this service was provided (due to improvement of heat supply service quality for population), the formulae for $E_1^b$ is:
$E_1^b = LHV_b*Cef_b*[B_b*a_b*K_1*K_h + B_r*(1-a_r)*K_1*K_{w0}]$.

where:
$LHV_b$ – Average annual lower heating value in the base year, MJ/$m^3$ (MJ/kg);
Cef – carbon emission factor, $KtCO_2$/TJ;
$B_b$ – amount of fuel consumed by a boiler-house in the base year, ths $m^3$ or tons;
$K_1$, $K_h = K_2* K_3* K_4$; $K_w = K_5 * K_6 * K_7$ – adjustment factors;
$a_b$ – portion of fuel (heat), consumed for heating purposes in the base year;
$(1-a_b)$ – portion of fuel (heat), consumed for hot water supply services in the base year;
$a_r$ – portion of fuel (heat), consumed for heating purposes in the reported year.

$a_b = L_h^b*q*N_h^b / (L_h^b*g*N_h^b + L_w^b*N_w^b)$;

where:
$L_h^b$ – maximum connected load required for heating in the base year, MW;
$L_w^b$ – connected load required for hot water supply service in the base year, MW;

g – recalculating factor for average load during heating period (usually 0,5-0,8);
$N_h^b$ – duration of heating period in the base year , hours
$N_w^b$ – duration of hot water supply service in the base year, hours

$a_r = L_h^r * q * N_h^r / (L_h^r * g * N_h^r + L_w^r * N_w^r)$

where:
$L_h^r$ – maximum connected load required for heating in the reported year, MW;
$L_w^r$ – connected load required for hot water supply service in the reported year, MW;
g – recalculating factor for average load during heating period (usually 0,5-0,8);
$N_h^r$ – duration of heating period in the reported year, hours,
$N_w^r$ – duration of hot water supply service in the reported year, hours.

$K_1 = LHV_b / LHV_r$;

where:
$LHV_b$ – Average annual lower heating value in the base year, MJ/$m^3$ (MJ/kg);
$LHV_r$ – Average annual lower heating value in the reported year, MJ/$m^3$ (MJ/kg)

$K_2 = (T_{in\,r} - T_{out\,r}) / (T_{in\,b} - T_{out\,b})$;

where:
$T_{in\,r}$ – average inside temperature for the heating period in the reported year, K (or $^0$C);
$T_{in\,b}$ – average inside temperature for the heating period in the base year, K (or $^0$C);
$T_{out\,r}$ – average outside temperature for the heating period in the reported year , K (or $^0$C);
$T_{out\,b}$ – average outside temperature for the heating period in the reported year , K (or $^0$C)

$K_3 = [(F_{h\,r} - F_{h\,t\,r} - F_{h\,n\,r})*k_{h\,b} + (F_{h\,n\,r} + F_{h\,t\,r})*k_{h\,n}] / F_{h\,b}*k_{h\,b}$;

where:
$F_{h\,b}$ – heating area in the base year, $m^2$;
$F_{h\,r}$ – heating area in the reported year, $m^2$;

$F_{h\,n\,r}$ – heating area of new buildings connected to DH system (assumed with the new (improved) thermal insulation) in the reported year, $m^2$;
$F_{h\,t\,r}$ – heating area of buildings (previously existed in the base year) in reported year with the renewed (improved) thermal insulation, $m^2$;
$k_{h\,b}$ – average heat transfer factor of heated buildings in the base year, $W/m^2*K$;
$k_{h\,n}$ – heat transfer factor of heated buildings with the new thermal insulation (new buildings or old ones with improved thermal insulation), $W/m^2*K$.

$K_4=N_{hr}/N_{hb}$;

where:
$N_{hb}$,– duration of heating period in the base year, hours
$N_{hr}$ – duration of heating period in the reported year, hours

$K_5 = n_{wr} / n_{wb;}$
where:
$N_{wb}$,– number of customers in the base year;
$N_{wr}$ – number of customers in the reported year

$K_6 = v_{w\,r} / v_{w\,b}$ ;

where:
$v_{w\,r}$ – standard specific discharge of hot water per personal account in the reported year, (in heat units, kWh/h);
$v_{w\,b}$ – standard specific discharge of hot water per personal account in the base year, (in heat units, kWh/h).

$K_7 = N_{wr}/ N_{wb}$;

where:
$N_{wr}$– duration of hot water supply service in the reported year, hours.
$N_{wb}$ – duration of hot water supply service in the base year, hours.

$E_{gen}^{b} = W_b*CEF_g + Q_b*f_b/1000* LHV_r* Cef$ ;

where:
$W_b$ – scheduled electric power production by the all new CHP units, MWh;
$CEF_g$ – Carbon Emission factor for electricity generation in Ukraine, $tCO_2e/MWh$;

$Q_b$ – scheduled heat energy production by the all new CHP units, MWh;
$f_b$ – specific natural gas consumption by the boiler-house, where CHP units are scheduled to be installed, $m^3$/MW;
$LHV_r$ – Average annual lower heating value in reported year, MJ/$m^3$ (MJ/kg)
Cef – carbon emission factor, Kt$CO_2$/TJ;

$E_{cons}^{b} = P_b * CEF_c$;

where:
$P_b$ – electric power consumption by the boiler-houses where energy saving measures are scheduled to be implemented ( power consumption of the boiler houses and CHP, in the heating area of which reconstruction and liquidation of HDS will take place; HDS that will be reconstructed and liquidated; and also of boiler houses and HDS, where frequency controllers will be installed), MWh;
$CEF_c$ – Carbon Emission factors for reducing electricity consumption in Ukraine, t$CO_2$e/MWh;
[$_b$] index – related to the base year;
[$_r$] index – related to the reporting year.

The Methodology for "District Heating" projects in Ukrainian conditions was developed for application in different Regions of Ukraine. In some Regions the consumers receive less than necessary amount of heat, in result of which the temperature inside the buildings is much lower than normative one (18 $^0$C), and hot water supply is insufficient or absent. Therefore this Methodology allows to take into account improving of the heat supply quality for the consumers and excludes deliberate reduction of heat delivery, and, in such a way, of fuel consumption with the purpose of increasing of generation of GHG emissions reduction units (ERUs) at the project activity.

Delivery of the less than necessary amount of heat and hot water really took place previously in cities and regions of Ukraine (and takes place even now in some cities and regions where situation business-as-usual is continued), and is reflected for example in JI Projects "Rehabilitation of the District Heating System in Donetsk Region", "Rehabilitation of the District Heating System of Chernihiv Region", etc.
According to "Rules of rendering of heat and hot water supply service to population" № 1497 from 30.12.1997, the heat supply enterprises must make the return payments to population for delivery less than necessary for providing normative heating level amount of heat. The normative inside temperature should be not lower than 18 $^o$C.
Amount of such return payment is the following:
– 5% from normative payment for every degree from 18 to 12 $^o$C;
– 10% from normative payment for every degree from 12 to 5 $^o$C;
– when inside temperature is lower than 5 $^o$C the payment is to be returned completely.

Average inside temperature during the heating season is calculated from the sum of returned payments caused by insufficient heating (in case of normative level (18 $^0$C) is not satisfied).
Above 18 $^0$C – is treated as 18 $^0$C (according to the conservatism principle) and as meeting the normative.
Below 18 $^0$C – is treated as not meeting the normative, and is calculated as below.

The average inside temperature is calculated by formulae:

If R = 0 (according to conservatism principle for the baseline assume R < 0.05):
$\mathbf{T_{in\ b}}$ = 18 $^o$C.

If 0.05 < R ≤ 0.3 NP:
$\mathbf{T_{in\ b}}$ = 18 – (R/5) [$^o$C]

If 0.3 NP < R < NP:
$\mathbf{T_{in\ b}}$ = 12 – [(R – 0.3 NP)/10] [$^o$C]

where:
R - % of return payment from NP;
NP – amount of normative payment.

Thus if the inside temperature will be 18 $^o$C or higher we will accept it as 18 $^o$C according to conservatism principle, if it will be lower than 18 $^o$C it will be calculated from return payments by the methodology presented before.

ME "Kharkivski teplovi merezhi" made return payments to consumers for underheating in 2003 base year. The sum was 1,7 mln. UAH, that is less then 3% from normative payment for heat energy. Thus inside temperature in 2003 base year according to conservatism principle is considered to be not lower than 18 $^o$C.

**D. 1.2. Option 2 – Direct monitoring of emission reductions from the project (values should be consistent with those in section E.):**

**D.1.2.1. Data to be collected in order to monitor emission reductions from the project, and how these data will be archived:**

| ID number *(Please use numbers to ease cross-referencing to D.2.)* | Data variable | Source of data | Data unit | Measured (m), calculated (c), estimated (e) | Recording frequency | Proportion of data to be monitored | How will the data be archived? (electronic/ paper) | Comment |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| | | | | | | | | |

There are no data to be collected in order to monitor emission reductions from the project, because emission reductions will be calculated by means of formulae presented in paragraph **D.1.2.2.**

**D.1.2.2. Description of formulae used to calculate emission reductions from the project (for each gas, source etc.; emissions/emission reductions in units of $CO_2$ equivalent):**

Amount of the Emission Reduction Units (ERUs), t $CO_2$e:
ERUs = $\sum[E_i^b - E_i^r]$;

The sum is taken over all boiler-houses which are included into the project.
$E_i^b = E_{1i}^b + E_{gen\ i}^b + E_{cons\ i}^b$,
$E_i^r = E_{1i}^r + E_{gen\ i}^r + E_{cons\ i}^r$,

where:
$E_{1i}^b$ and $E_{1i}^r$ – $CO_2$ emissions due to fuel consumption for heating and hot water supply service for an i boiler-house in the base year and reported year, t $CO_2$e;
$E_{gen\ i}^b$ and $E_{gen\ i}^r$ – $CO_2$ emissions due to electric power generation associated to the project for an i boiler-house in the base year (grid, amount to be substituted in the reported year) and reported year, t $CO_2$e;
$E_{cons\ i}^b$ and $E_{cons\ i}^r$ – $CO_2$ emissions due to electric power consumption for an i boiler-house in the base year and reported year, t $CO_2$e.

**D.1.3. Treatment of leakage in the monitoring plan:**

No leakage is expected. Dynamic baseline (based on collected monitoring data) will exclude all possible leakages.

**D.1.3.1. If applicable, please describe the data and information that will be collected in order to monitor leakage effects of the project:**

| ID number *(Please use numbers to ease cross-referencing to D.2.)* | Data variable | Source of data | Data unit | Measured (m), calculated (c), estimated (e) | Recording frequency | Proportion of data to be monitored | How will the data be archived? (electronic/ paper) | Comment |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| | | | | | | | | |

Any occasional leakage emissions (for example, caused by pipes' leakages, etc.) should be eliminated as soon as possible.

**D.1.3.2. Description of formulae used to estimate leakage (for each gas, source etc.; emissions in units of $CO_2$ equivalent):**

No leakages are expected.

**D.1.4. Description of formulae used to estimate emission reductions for the project (for each gas, source etc.; emissions/emission reductions in units of $CO_2$ equivalent):**

Formulae presented in D.1.1. - D.1.3. will be used for monitoring of the emissions in the project scenario and the baseline scenario. They will be used in Monitoring report. The baseline is dynamic and depends on conditions of every reporting year. Therefore we can't use these formulae in PDD to estimate emission reductions because we have no data (whether conditions, low heating value of fuels, etc.) for any reporting year yet.

Formulae presented in D.1.4. are used to estimate emission reductions in PDD. Results of the corresponding calculations made with using of these formulae are listed in **Appendices 1 - 6**. These calculations are based on equipment efficiency increasing. Parameters' names corresponding to these formulae are pointed out in **Appendices 1 - 6**.

Every Appendix contains calculations of GHG emissions reduction that corresponds to specified technologies used in the JI project.

**Appendix 1** - replacement of boilers.

Replacement of old operating boilers with low efficiency by the new highly efficient ones, replacement of obsolete coal-fired boilers by the new gas-fired boilers, switching load from the boiler houses with obsolete equipment to the boiler houses with highly effective equipment and CHP plants.

**Appendix 2** - replacement of network pipes.

Replacement of the main and distribution networks pipes with diameter 38 mm - 1120 mm by the pre-insulated ones.

**Appendix 3** - replacement of heat exchangers,

Replacement of old heat exchangers by the new highly efficient ones.

**Appendix 4** - liquidation of HDS with network shortening,

Improvement of the heat networks system organization by liquidation of Heat Distribution Stations (HDS) and building of Individual Heating Points (IHP) with replacing of the 4-pipe lines by 2-pipe ones. (It is common situation in Kharkiv city when main pipeline stretches near heated buildings several kilometers to HDS and then 4- pipe lines stretch back to heated buildings. In such situations ME "Kharkivski teplovi merezhi" installes the Individual Heating Points near the heated buildings (usually in basements) and lays short pipelines from main pipeline to ITP. This will enable to liquidate in total 46 km of pipes with different diameters). Calculations of heat energy saving were made in accordance with valid «Methodical instructions by definition of heat losses in hot water and steam heat networks» МУ 34-70-080-84.

**Appendix 5** - frequency controllers installation.

Installation of frequency controllers at hot water pumps' motors and electric drives of draught-blowing equipment.

**Appendix 6** - cogeneration units installation.

Installation of combined heat and power production units.

**Appendix 7** contains total sums of emission reductions for every year for each technology;

**Appendix 8** contains calculations of baseline emissions and project emissions as well as GHG emissions reduction for every project year, based on formulae presented in D.1.4.

**Appendix 7** and **Appendix 8** contain links with all **Appendices 1 - 6**.

GHG emission reductions from the project are estimated by means of the following formulae:

$ERUs = E_b – E_r$.

where:
ERUs – emission reduction units, t $CO_2e$;
$E_r$ – project emissions, t $CO_2e$
$E_b$ – baseline emissions, t $CO_2e$

**Baseline emissions**

The main cause of impossibility of methodology AM0044 using for baseline calculation is no data for thermal energy output, because of thermal energy meters absence on the majority of boiler houses included in the project.
According to AM0044 methodology the following steps shall be used to estimate the baseline emissions:
Step 1 – Determine the thermal efficiency of each baseline boiler
The baseline thermal efficiency for each boiler included in the project boundary shall be determined using the following formula:

$$\eta_{BL,m,i} = EG_{BL,his,i} / FC_{BL,his,i} \qquad (1)$$

Where:
$\eta_{BL,m,I}$ - Average baseline thermal efficiency of boiler 'i'
$EG_{BL,his,I}$ - Average historic thermal energy output from the baseline boiler 'i' (MJ/yr).
$FC_{BL,his,i}$ - Average historic fossil fuel consumption from the baseline boiler 'i' (MJ/yr).

Where possible, the above calculation shall be based on historical data for the project activity site for the most recent 3 years before the implementation of the project activity. The average thermal output and fuel consumption value for the 3 years will be used in the equation. This data shall be reported in the CDM PDD.

**Total thermal output for each baseline boiler** will be determined from **actual measured baseline data for steam flow**, pressure and temperature, using acceptable standard methods as outlined in ASME PTC 4- 19987 or BS8458 or other recognized national or international standard.

Thus, without heat meters at each boiler (as in case of this project) it is impossible to use the AM0044 methodology.

Baseline emissions consist of four types of GHG emissions:

1) $CO_2$e emissions from boilers operated by the Supplier.
2) $CO_2$e emissions due to electricity production to the grid, that consumed by boiler houses and CHP plants, in the heating area of which reconstruction and liquidation of HDS will take place and also boiler houses and HDS where frequency controllers will be installed.
3) $CO_2$e emissions due to electricity production to the grid, that consumed by HDS, which will be liquidated and where reconstruction will take place and where frequency controllers will be installed.
4) $CO_2$e emissions due to electricity production to the grid, that will be replaced after CHP units installation.

$$E_b = E1_b + E2_b + E3_b + E4_b$$

Where:
$E1_b$ – emissions from boilers operated by the Supplier, t $CO_2$e;
$E2_b$ – emissions due to electricity production to the grid, that consumed by boiler houses and CHP plants, in the area of which reconstruction and liquidation of HDS will take place, and also where frequency controllers will be installed, t $CO_2$e;
$E3_b$ – emissions due to electricity production to the grid, that consumed by HDS where liquidation and reconstruction will take place and where frequency controllers will be installed, t $CO_2$e.
$E4_b$ –emissions due to electricity production to the grid, that will be replaced after CHP units installation, t $CO_2$e;

1) Emissions from heat generating sources operated by the Supplier:

$$E1_b = \sum (B_{b(i)} * LHV_{b(i)} * Cef_i),$$

where:
$B_{b(i)}$ – fuel consumption in the baseline scenario (for each fuel), 1000 $m^3$ (t);
$LHV_{b(i)}$ – Lower Heating Value for each fuel, MJ/$m^3$ (MJ/kg);
$Cef_{i}$- – Carbon Emission Factors for each fuel, Kt $CO_2$/TJ.

For more detailed information see **Appendix 1.**

2) $CO_2e$ emissions due to electricity production to the grid, that consumed by boiler houses and CHP plants, in the area of which reconstruction and liquidation of HDS will take place, and also where frequency controllers will be installed.

$E2_b = P_2 * CEF_c$,

where:
$P_2$ – annual power consumption of boiler houses and CHPplants in the area of which reconstruction and liquidation of HDS will take place, and also where frequency controllers will be installed, MWh;
$CEF_c$ – Carbon Emission factor for reducing electricity consumption, $tCO_2e$/MWh., see **Table 8**.

For more detailed information see **Appendix 1.**

3) $CO_2e$ emissions due to electricity production to the grid, that consumed by HDS, which will be liquidated and where reconstruction will take place and where frequency controllers will be installed.

$E3_b = P_3 * CEF_c$,

where:
$P_3$ – annual power consumption of HDS where liquidation and reconstruction will take place and where frequency controllers will be installed, MWh;
$CEF_c$ – Carbon Emission factors for reducing electricity consumption, $tCO_2e$/MWh, see **Table 8**.

For more detailed information see **Appendixes 3 – 5.**

4) Baseline $CO_2e$ emissions due to electricity production to the grid, that will be replaced after CHP units installation.

$E4_b = W * CEF_g$,
where:
W - annual power production of new CHP units, which will be installed by Supplier, MWh;
$CEF_g$ - Carbon Emission factors for electricity production, $tCO_2e$/MWh, see **Table 7**.

Heat, that will be produced from this CHP units, will be used for the hot water supply service. For more detailed information see **Appendix 6.**

**Project emissions**

Project emissions consist of four types of GHG emissions:

$E_r = E1_r + E2_r + E3_r + E4_r$

Where:
$E1_r$ – emissions from boilers operated by the Supplier, t $CO_2$e;
$E2_r$ – emissions due to electricity production to the grid, that consumed by boiler houses and CHP plants, in the area of which reconstruction and liquidation of HDS will take place, and also where frequency controllers will be installed, t $CO_2$e;
$E3_r$ – emissions due to electricity production to the grid, that consumed by HDS where liquidation and reconstruction will take place and where frequency controllers will be installed, t $CO_2$e.
$E4_r$ – emissions from new CHP units, t $CO_2$e.

Project scenario emissions from boiler-houses are a sum of actual fuel amounts to be used in any report year (starting from 2008) multiplied by corresponding conversion factors. Actual – means with subtracted fuel saving due to improving of the network efficiency, HDS liquidation and reconstruction:

$$E1_r = \sum ([B_{r(i)} - V_{(i)} - Q1_{(i)} - Q2_{(i)}] * LHV_{(i)} * Cef_i) ;$$

where:
$E1_r$ – project emissions from boiler-houses in any reported year, t $CO_2$e
$B_{r(i)}$ – fuel consumption by boiler-houses in the project scenario (for each fuel), 1000 $m^3$ (t);
$V_{(i)}$ –fuel saving due to network rehabilitation for each fuel, 1000 $m^3$ (t);
$Q1_{(i}$ - fuel saving due to reconstruction of HDS for each fuel, 1000 $m^3$ (t);
$Q2_{(i}$ - fuel saving due to liquidation of HDS for each fuel, 1000 $m^3$ (t);
$LHV_{(i)}$ – Lower Heating Value for each fuel, MJ/$m^3$ (MJ/kg);
$Cef_{i-}$ – Carbon Emission Factors for each fuel, kt $CO_2$/TJ.

$$B_{r(i)} = [B_{b(i)} * LHV_{b(i)} * BBE_i] / [LHV_{r(i)} * PBE_i],$$

where:
$BBE_i$ - Baseline Boilers Efficiency, %;
$PBE_i$ - Project Boilers Efficiency, %.

Parameter **BBEi** - Baseline Boilers Efficiency was taken from operation sheets of each boiler.

Operation sheets established experimentally during the adjustment works are kept at the front of boilers at every boiler-house.

$V_{(i)} = B_{b(i)} - B_{b(i)} * (100-L_b)/(100-L_r)$,

where:
$B_{b(i)}$ – fuel consumption in the baseline scenario (for each fuel), 1000 $m^3$ (t);
$L_b$ – heat losses in the network in the baseline scenario, %;
$L_r$ – heat losses in the network in the project scenario, %.

$E2_r + E3_r = (P_2+P_3 – P1_r – P2_r – P3_r )* CEF_c$,

where:
$P_2$ – annual power consumption of boiler houses and CHP in the area of which reconstruction and liquidation of HDS will take place, and also where frequency controllers will be installed, MWh;
$P_3$ – annual power consumption of HDS where liquidation and reconstruction will take place and where frequency controllers will be installed, MWh;
$CEF_c$ – Carbon Emission factors for reducing electricity consumption, $tCO_2e/MWh$;
$P1_r$ – calculated power saving due to reconstruction of HDS, MWh;
$P2_r$ – calculated power saving due to liquidation of HDS, MWh;
$P3_r$ – calculated power saving due to frequency controllers installation, MWh;
$CEF_c$ – Carbon Emission factors for reducing electricity consumption, $tCO_2e/MWh$.

$E4_r = B_g$ *LHV *Cef – $Q_b$*$f_b$/1000* LHV* Cef,

where:
$B_g$ – calculated amount of fuel (gas) consumed by the installed CHP units for generation, ths $m^3$;
$Q_b$ – scheduled heat energy production by the all new CHP units, MWh;
$f_b$ – specific natural gas consumption by the boiler-house, where CHP units are scheduled to be installed, $m^3$/MW.

For more detailed information see **Appendices 1 – 6 and 8.**

**D.1.5. Where applicable, in accordance with procedures as required by the host Party, information on the collection and archiving of information on the environmental impacts of the project:**

According to the common Ukrainian practice for such type projects, the environmental impact of the project will be estimated by fuel consumption and combustion.

| **D.2. Quality control (QC) and quality assurance (QA) procedures undertaken for data monitored:** | | |
|---|---|---|
| Data *(Indicate table and ID number)* | Uncertainty level of data (high/medium/low) | Explain QA/QC procedures planned for these data, or why such procedures are not necessary. |
| Amount of natural gas consumed by boiler houses.<br>Amount of coal consumed by boiler houses. | Low for gas.<br>Medium for coal | Measuring instruments must be calibrated according to national regulations |
| Outside temperature. | Low | Measuring instruments must be calibrated according to national regulations |
| Fuel quality (Lower Heating Values). | Low | Measuring instruments must be calibrated according to national regulations |
| Number of customers (heating area). | Low | Statistic data. No quality assurance is needed. |

**D.3. Please describe the operational and management structure that the project operator will apply in implementing the monitoring plan:**

The operational structure will include operation departments (adjustment and alignment, etc.) of Supplier (ME "Kharkivski teplovi merezhi") and boiler house operation personnel.
The management structure will include management departments of Supplier and specialists of project developer (Institute of Engineering Ecology).

**D.4. Name of person(s)/entity(ies) establishing the monitoring plan:**

The monitoring plan is determined by the Institute of Engineering Ecology (IEE), project developer and project partner, in collaboration with European Institute for safety, security, insurance and environmental techniques (SVT e.V.), project consultant, and ME "Kharkivski teplovi merezhi", project supplier.

IEE:

Institute of Engineering Ecology

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## SECTION E. Estimation of greenhouse gas emission reductions

### E.1. Estimated project emissions:

Project Carbon Emission Factors are assumed equal to the Baseline Carbon Emission Factors.

**Calculation of Project Activity Level**

Project's activity level, estimated by fuel and power consumption, will be reduced comparing to the baseline activity level due to fuel saving.

| Types of project activity | Energy resources consumption |
|---|---|
| Gas consumption by boiler houses, CHP units, CHP-4; also by CHP-3 and CHP-5 for heat production, that is sold to ME "Kharkivski teplovi merezhi", ths $m^3$ | 875748.9 |
| Coal consumption, t | 68.5 |
| Power consumption by CHP, boiler houses and HDS, where reconstruction will take place, ths kWh | 177678.9 |

*Table 12. Project Energy resources consumption*

Detailed information is presented in **Appendices 1 - 6.**

**Estimation of Direct Project Emissions**

Project emissions consist of four types of GHG emissions:

$E1_r$ – emissions from boilers operated by the Supplier, t $CO_2$e;
$E2_r$ – emissions due to electricity production to the grid, that consumed by boiler houses and CHP, in the area of which reconstruction and liquidation of HDS will take place, and also where frequency controllers will be installed, t $CO_2$e;
$E3_r$ – emissions due to electricity production to the grid, that consumed by HDS where liquidation and reconstruction will take place and where frequency controllers will be installed, t $CO_2$e.
$E4_r$ – emissions from new CHP units, t $CO_2$e.

Project Emissions of $CO_2$e after project implementation are shown in Table 13.

| Project emissions by the types of project activity | Project emissions, t $CO_2$ |
|---|---|
| $E1_r$ | 1695847.8 |
| $E2_r + E3_r$ | 134325.2 |
| $E4_r$ | 4156.4 |
| **Total** | **1834329.5** |

*Table 13. Project Emissions of $CO_2$e after project implementation*

See **Appendix 8**.

Project emissions are ~ **1 834 329.5** t $CO_2$

## E.2. Estimated leakage:

We assume that possible leakage is negligible that is less than 1% of the total direct emissions. These indirect emissions are not under control of project developer so we do not include them in calculations.

## E.3. The sum of E.1. and E.2.:

Project Emissions + Leakages = 1 834 329.5 + 0 = **1 834 329.5** t $CO_2$.

## E.4. Estimated baseline emissions:

Baseline emissions consist of four types of GHG emissions:

1) $CO_2$e emissions from boilers operated by the Supplier.
2) $CO_2$e emissions due to electricity production to the grid, that consumed by boiler houses and CHP, in the operation area of which reconstruction and liquidation of HDS will take place, and also boiler houses and HDS where frequency controllers will be installed.
3) $CO_2$e emissions due to electricity production to the grid, that consumed by HDS, which will be liquidated and where reconstruction will take place and where frequency controllers will be installed.
4) $CO_2$e emissions due to electricity production to the grid, that will be replaced after CHP units installation.

| Baseline emissions by the types of project activity | Baseline emissions, t $CO_2$ |
|---|---|
| $E1_b$ | 2005901.9 |
| $E2_b$ | 129733.1 |
| $E3_b$ | 17371.5 |
| $E4_b$ | 9826.2 |
| **Total** | **2162832.6** |

*Table 14. Baseline Emissions of $CO_2$*

Baseline emissions ~ **2 162 832.6** t $CO_2$.

The total (Dynamic!) Baseline emissions are different for any reported years. In the table 14 the total Baseline emissions are presented for 2012 year and are 2162832.6 that is corresponds to Baseline emissions from Appendix 8 Baseline (see 2012 year). Value – 2199928 – relates to Baseline emissions in 2003 Base year.
Baseline for this project is Dynamic. It's mean that it depends on different factors. Dynamic Baseline show what emission would happen in any reported year if District Heating system remains without changes.
Baseline emissions for any reported year consist of the following factors:
- fuel consumption in Base year and adjustment factors - whether conditions, heating area, etc. in reported year. (Adjustment factors will be taken into consideration during monitoring);
- power consumption in the Base year:
-power production to the grid that will be replaced by power from new CHP units.
For estimation of Baseline emissions fuel consumption, power consumption and power production to the grid in any reported year is constant and equal to 2003 year.
But Carbon Emission factors (CEF) for electricity generation and electricity consumption in Ukraine used for Baseline emissions calculations are different for years 2003-2012. Baseline emissions are decreased from 2003 to 2012. See Fig. 5. Dynamic baseline and project emissions of GHG.

More detailed calculation of resulting annual Baseline Carbon Emissions, that would take place during typical heating season if ME "Kharkivski teplovi merezhi" DH system remains unchanged, see in **section B** and **Appendix 8 (Baseline)**.

**E.5. Difference between E.4. and E.3. representing the emission reductions of the project:**

Project Emission Reduction = Baseline emission - (Project emission +Estimated leakage) =

**2 162 832.6 - 1 834 329.5 = 328 503.1 t $CO_2$ / year**

In course of the project implementation, the different emission reduction will be achieved at the different stages of project implementation. The amounts of emission reduction are represented in the **Table 3,** Paragraph **A.4.3.1.**

| Year | Emissions reduction, t $CO_2$e | | | | | | |
|---|---|---|---|---|---|---|---|
| | Due to boiler houses reconstruction | Due to network system reconstruction | Due to heat exchangers installation | Due to HDS liquidation and reconstruction | Due to frequency controllers implementation | Due to cogeneration implementation | Total |
| 2004 | | | | | | | 0.0 |
| 2005 | 2157.9 | 1959.0 | | | | | 4116.9 |
| 2006 | 3279.2 | 4234.1 | | | | | 7513.3 |
| 2007 | 3744.9 | 8804.8 | | | | | 12549.7 |
| 2008 | 6477.3 | 31439.6 | 12454.0 | 10918.6 | | | 61289.5 |
| 2009 | 7134.4 | 55346.5 | 29935.2 | 24229.4 | 5683.0 | | 122328.4 |
| 2010 | 7546.6 | 80396.2 | 50013.5 | 37584.6 | 5543.8 | 6040.6 | 187125.3 |
| 2011 | 8038.4 | 106354.4 | 127773.7 | 48623.5 | 5404.5 | 5901.6 | 302096.1 |
| 2012 | 8038.4 | 133331.3 | 127656.1 | 48542.4 | 5265.1 | 5669.8 | 328503.2 |
| **Total** | **46417.1** | **421865.8** | **347832.5** | **169898.5** | **21896.4** | **17612.0** | **1025522.4** |

*Table 15.Estimated $CO_2$e Emission Reductions*

**E.6. Table providing values obtained when applying formulae above:**

| Year | Estimated project emissions (t $CO_2$ equivalent) | Estimated leakage (t $CO_2$ equivalent) | Estimated baseline emissions (t $CO_2$ equivalent) | Estimated emissions reduction (t $CO_2$ equivalent) |
|---|---|---|---|---|
| 2005 | 2187564.1 | 0 | 2191681.0 | 4116.9 |
| 2006 | 2180044.3 | 0 | 2187557.6 | 7513.3 |
| 2007 | 2170884.5 | 0 | 2183434.2 | 12549.7 |
| **Subtotal 2005 - 2007** | **6538492,9** | **0** | **6562672.7** | **24179.9** |
| 2008 | 2118021,3 | 0 | 2179310.8 | 61289.5 |
| 2009 | 2052859,0 | 0 | 2175187.4 | 122328.4 |
| 2010 | 1983861,4 | 0 | 2170986.7 | 187125.3 |
| 2011 | 1864860,0 | 0 | 2166956.0 | 302096.0 |
| 2012 | 1834329.5 | 0 | 2162832.6 | 328503.1 |
| **Subtotal 2008 - 2012** | **9853931.1** | **0** | **10855273.5** | **1001342.3** |
| 2013 | 1834329.5 | 0 | 2162832.6 | 328503.1 |
| 2014 | 1834329.5 | 0 | 2162832.6 | 328503.1 |
| 2015 | 1834329.5 | 0 | 2162832.6 | 328503.1 |
| 2016 | 1834329.5 | 0 | 2162832.6 | 328503.1 |
| 2017 | 1834329.5 | 0 | 2162832.6 | 328503.1 |
| 2018 | 1834329.5 | 0 | 2162832.6 | 328503.1 |
| 2019 | 1834329.5 | 0 | 2162832.6 | 328503.1 |
| 2020 | 1834329.5 | 0 | 2162832.6 | 328503.1 |
| 2021 | 1834329.5 | 0 | 2162832.6 | 328503.1 |
| 2022 | 1834329.5 | 0 | 2162832.6 | 328503.1 |
| 2023 | 1834329.5 | 0 | 2162832.6 | 328503.1 |
| 2024 | 1834329.5 | 0 | 2162832.6 | 328503.1 |
| **Subtotal 2013 - 2024** | **22011954.0** | **0** | **25953991.2** | **3942037.2** |
| **Subtotal (t $CO_2$ equivalent)** | **38404378.0** | **0** | **43371937.4** | **4967559.4** |

*Table 16.Estimated $CO_2$e Emissions*

## SECTION F. Environmental impacts

### F.1. Documentation on the analysis of the environmental impacts of the project, including transboundary impacts, in accordance with procedures as determined by the host Party:

According to the Ukrainian rules, the design documentation for the new building, reconstruction and technical re-equipment of industrial and civil objects must include the environmental impact assessment, the main requirements for which are listed in the State Building Norms of Ukraine A.2.2-1-2003.

ME "Kharkivski teplovi merezhi" has the necessary Environmental Impact Assessment for its activity according to Ukrainian legislation.

Overall, the project “Rehabilitation of the District Heating System in Kharkiv City” will have a positive effect on environment. Following points will give detailed information on environmental benefits.

1. Project implementation will allow saving over 157.3 million $Nm^3$ of natural gas and over 354 ton of coal per year starting from 2012. Natural gas and coal are non-renewable resources and their saving is important.

2. Project implementation will reduce $CO_2$ emissions in Kharkiv city by 328 thousand tons per year starting from 2012 due to increased boilers efficiencies, achieved through installation of up-to-date boiler equipment, particularly new boilers, CHP units, heat exchangers, reconstruction and liquidation of HDS and installation of pre-insulated network pipes instead of existing regular network pipes.

3. Due to fuel saving and the new environmentally friendlier technologies of fuel combustion, project implementation will reduce emissions of $SO_x$, $NO_x$, CO and particulate matter (co-products of combustion).

4. It is expected that due to a better DH service population of Kharkiv city will reduce electricity consumption from electric heaters thus reducing power plants emissions of $CO_2$, $SO_x$, $NO_x$, CO and particulate matter.

### F.2. If environmental impacts are considered significant by the project participants or the host Party, please provide conclusions and all references to supporting documentation of an environmental impact assessment undertaken in accordance with the procedures as required by the host Party:

**Impact on the water medium**

Impact on the water medium is present. Impact on water resources is will be the same as in baseline scenario. The existing technology of heat energy production exploited at the objects of ME "Kharkivski teplovi merezhi" foresees discharging of waste water to the sewage network with obligatory chemical control in accordance to Water Code of Ukraine, GOST 28.74-82 “Hygienic regulations and quality control”, SNiP 4630-92 on determining maximum concentration limits for internal water bodies. Discharge of wastewater to the open water bodies will not take place.

Project implementation will have positive environmental effect. It will allow to decrease the water consumption and as a result – to decrease the amount of waste water.

**Effects on the ambient air**

The project implementation will have positive effect on ambient air:

1) Reduction of $NO_x$, $SO_x$, CO and PM due to application of cleaner technologies at boiler houses;
2) Reduction of electricity consumption results in lower emissions of the same air pollutants;
3) Heat stress on the atmosphere (due to lower temperatures of flue gases);
4) Lower emissions per unit of fuel at the same load on boiler house.

**Effects on land use**

Impact on the land medium is not present.

Relevant regulation is the sphere of land use is presented by the Land Code of Ukraine. National technological practice / standard: GOST 17.4.1.02.-83 “Protection of Nature, Soils. Classification of chemical substances for pollution control”.

**Effects on biodiversity**

Impact on biodiversity is not present.

**Waste generation, treatment and disposal**

Waste generation, treatment and disposal are present. In the process of project implementation the generation of waste will occur after disassembling of physically and morally obsolete equipment, burners, pipes, etc. Also there will occur some construction waste due to destruction of boiler settling, boiler house foundations, etc.

Possible recycling of the old equipment will by definition have a positive effect on the environment.

## SECTION G. Stakeholders' comments

### G.1. Information on stakeholders' comments on the project, as appropriate:

As project activity won't provide negative influence on environment and negative social effect, special public discussion was not hold. The authorities of Kharkiv city have expressed the support for the project.

Project "Rehabilitation of the District Heating System in Kharkiv City" was presented at the XVII (Yalta, June 5-9, 2007) and XVIII (Yalta, June 10-14, 2008) International Conferences "Problems of Ecology and Exploitation of Energy Objects", where it was comprehensively discussed with representatives of governmental and district heating organizations.

Annex 1

**CONTACT INFORMATION ON PROJECT PARTICIPANTS**

**Supplier:**

| | |
|---|---|
| Organisation: | ME "Kharkivski teplovi merezhi" |
| Street/P.O.Box: | Dobrokhotova str. |
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| Represented by: | |
| Title: | Director |
| Salutation: | Mr. |
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**Partner - Purchaser:**

| | |
|---|---|
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| Street/P.O.Box: | Strawinskylaan |
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| City: | Amsterdam |
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| Postal code: | 1077XX |
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| Represented by: | |
| Title: | Head of Climate Change department |
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Annex 2

**BASELINE INFORMATION**

See Section B for the Baseline information

Annex 3

**MONITORING PLAN**

1. REHABILITATION OF THE DISTRICT HEATING SYSTEM IN KHARKIV CITY

This monitoring plan describes the methodology that will be used to calculate the ongoing amount of greenhouse gas emission reduction units (ERUs) resulting from installation and commissioning of the JI project in Kharkiv City. Upgrades to the district heating system are expected to result in improved system performance. Each component of the JI project is expected to result in a reduction in greenhouse gas emissions. The reduction in greenhouse gas emissions will be quantified using the methodology presented in this Monitoring Plan.

2. PROJECT DESCRIPTION

Project includes 277 boiler-houses with 610 boilers, CHP-4 station and 1411.5 km of heat distributing networks, that are managed by ME "Kharkivski teplovi merezhi", and may be slightly expanded by including the other DH objects in the city.

Measures that will be used to improve the efficiency of ME "Kharkivski teplovi merezhi" utility are as follows:

- Old operating boilers with low efficiency will be replaced by the new highly efficient ones that will result in efficiency increase from 65-85% up to 90-93%.
- Switching load from the boiler houses with obsolete equipment to the boiler houses with highly effective equipment and CHP.
- Obsolete coal-fired boilers will be mostly replaced by the new gas-fired boilers.
- The reconstruction of heat distribution networks system will help to reduce heat losses down to 1-2 % per km by replacing of the main and distribution networks pipes with diameter 38 mm - 1120 mm by the pre-insulated ones.
- Improvement of the heat networks system organization will be provided by liquidation of Heat Distribution Stations (HDS) - replacing 4-pipe lines by 2-pipe ones with simultaneous installation of heat exchangers directly at the consumers (Individual Heating Point – IHP), or reconstruction of HDS with modern lower capacity heat exchangers (reduction of necessary power will be realizable due to switching of part of power to IHP. It will allow to liquidate 46 km of pipes with different diameters, to reduce heat losses and to reduce power consumption for power supply of circulation pumps.
- Installation of cogeneration units will result in increasing the fuel consumption efficiency, decreasing of dependence on the power supply and improvement of operational stability and reliability, decreasing of power consumption from power stations, decreasing of power transfer losses, and decreasing of environmental pollution.
- Installation of frequency controllers at hot water pumps' engines will result in energy saving. Those regulators make it possible to change actual capacity of engines depending on connected load, both as during a day when water consumption is changes, and during a year when in summer engines work only for hot water supply.

- Implementation of frequency controllers for smoke exhausters electric drives will result in considerable energy saving.

3. MONITORING METHODOLOGY

Relevant monitoring methodologies

In course of development of the project **"Rehabilitation of the District Heating System in Kharkiv City"**, the **own-developed methodology** was used that is partly similar to "Baseline and monitoring methodology AM0044". The project "Rehabilitation of the District Heating System in Kharkiv city" has some differences from applicability conditions of this methodology.
The main cause of impossibility of using the methodology AM0044 for baseline calculation is absence of data for heat energy output, because of heat energy meters absence at the majority of boiler houses included in the project. That's why "SVT e.V." (Germany) and Institute of Engineering Ecology (Ukraine) have developed the project specific methodology, which takes into account all activity involved in the project and its peculiarities.

The main complication for implementation of the JI projects on district heating in Ukraine is the practical absence of direct monitoring devices for heat and heat-carrier expenditure in the municipal boiler-houses. Only such main characteristic as fuel consumption is registered on a regular basis. It makes practically impossible the application of AM0044 methodology, which basic moment is monitoring of the value $EG_{PJ, i, y}$ – the thermal energy output of project boiler i in year y (pages 9, 13 of Methodology AM0044), that should be measured every month by flow-meters (the expenditure of heat-carrier) and thermal sensors (temperatures at the input and output of the boiler, etc.).

This also concerns the definition of the average historical value of heat power generation per year $EG_{BL, his, i}$ (average historic thermal energy output from the baseline boiler "i").

Besides, in section "Scope of Application" it is mentioned, that the scope of application of the Methodology AM0044 is limited only to the increase of boilers' efficiency by means of their replacement or modernization, and it does not apply to the fuel type switch. At the same time our project includes also such kind of modernization as well as some others such as the replacement of burner equipment, installation of cogeneration units, etc.

The developed project specific "Methodology" is based on the permanent monitoring of fuel consumption and on the account of various other factors, such as connection or disconnection of the consumers, change of fuel heating value, weather conditions change, ratio of the heat consumption for heating and for hot water supply, consumption for own needs, etc.

The developed "Methodology" has two important advantages in comparison with the methodology AM0044 (at least for Ukrainian conditions):

- It takes into account the quality of heat supply (heating and hot water supply). Almost annually for the various reasons (receiving of less amount and high price of the fuel, in particular natural gas which is nearly 95 % of fuel type used in Ukraine for the needs of the municipal heat supply), the consumers receive less than necessary amount of heat, in the result of which the temperature inside the buildings is much lower than normative one, and hot water supply is insufficient or absent. As the purpose of JI projects, including the current project, is the GHG ($CO_2$) emission reduction under the conditions of not worsening in any circumstances of the social conditions of population, the issue of approaching of the heat supply quality to the normative one is extremely important. Therefore, the amount of the fuel consumption for the after project implementation period is calculated for the conditions of providing the normative parameters of heat supply and at least partially of hot water supply, and in accordance with the monitoring plan, the implementation of continuous control (monitoring) of its quality (measurement of internal temperature in the specific buildings as well as registration of residents' complaints for the poor-quality heat supply) is foreseen. This increases the control for the qualitative heat supply for the consumers and excludes deliberate reduction of heat consumption, and, in such a way, of fuel consumption with the purpose of increasing of generation of GHG emissions reduction units (ERUs) at the project verification.

- Definition of the fuel consumption in base year (baseline) in view of the fact that in Ukraine at the majority of the municipal heat supply enterprises the natural gas is used as a fuel, which consumption is measured constantly by the counters with the high measurement accuracy, seems to be more exact, than definition of the fuel consumption with use of heat power, boiler efficiency and heat value of the fuel. This especially concerns the efficiency, which changes greatly depending on load of boilers, which also changes essentially, and often not automatically but manually, in the heat supply systems within a day and within a year. Averaging of such values without having of the heat account system is fraught with serious discrepancies. Definition of the fuel consumption in the presence of counters requires only data collection and implementation of arithmetic actions.

Approved Consolidated Methodology ACM0009 "Consolidated baseline methodology for fuel switching from coal or petroleum fuel to natural gas" proposes the dependences for baseline and reporting year emissions quantity definition (see pages 4 and 5), that contain determination of Energy efficiency $\varepsilon_{project,i,y}$ and $\varepsilon_{baseline,i}$ for equipment. In the chapter "Baseline emissions" on the page 6 there is an explanation that:

Efficiencies for the project activity ($\varepsilon_{project,i,y}$) should be measured monthly throughout the crediting period, and annual averages should be used for emission calculations. Efficiencies for the baseline scenario ($\varepsilon_{baseline,i}$) should be measured monthly during 6 months before project implementation, and the 6 months average should be used for emission calculations. These requirements are confirmed by tables for monitoring on the pages 13-15.

However, as it was mentioned before in this report, the majority of boiler-houses in Ukraine are not equipped with devices for heat-carrier expenditure definition or heat meters. There is only one parameter, that is regularly and with high precision defined in the boiler houses – fuel consumption.

For this reason, the own project specific methodology was developed, that is based on the permanent measuring of the fuel consumption and amendments for possible parameters changes in baseline in comparison with reporting year. The variable parameters may be the changes in lower heating value of fuels, quality of heating service, weather changes, changes in customers number, etc. Taking into account only equipment efficiency does not eliminate the possibilities of undersupply of heat to customers (deterioration of heat supply service), and possible weather warming in reported year, change in fuel quality, disconnection of some consumers, and other factors, and could lead to artificial overestimation of ERUs amount.

In additional, the proposition in ACM0009 to take (by conservatism principle) the baseline efficiency of equipment equal to 100 % is unacceptable in "District Heating" type projects, because not only fuel switch, but mainly namely increasing of equipment (boilers) efficiency are implemented in these projects. Accepting of such calculated baseline would lead to essential underestimation of results of implemented measures. And, anyway, as it was shown before, this would not solve the problem with impossibility of monthly measurements for getting energy efficiency $\varepsilon_{project,i,y.}$

Approved Methodology AM0048 "New cogeneration facilities supplying electricity and/or steam to multiple customers and displacing grid/off-grid steam and electricity generation with more carbon-intensive fuels" already in its title shows the scope of applicability, that is different from the scope of the

"District Heating" projects. In our projects, the cogeneration facilities produce hot water and not steam. Beside this, in according to AM0048 (page 22) and its monitoring plan (pages 23-30), it is necessary to realize, among other measurements, monthly measurement of $SC_{PCSG,i,y}$ (Total steam self-generated by project customer 'i' during year 'y' of the crediting period, TJ), measured by the steam meter at the customer 'i' (page 25). Thus Methodology AM0048 couldn't be implemented in original. In principle, it could be modified for conditions of hot water production for heating and hot water supply systems, but this will require modification of monitoring plan with introduction of other parameters that it is necessary to measure and register. But it would be the another methodology, that would require to measure such parameters as heat output, or hot water output with its temperature (in analogy with requirements of Methodology AM0048 to measure steam output, its pressure and temperature.

As it was already mentioned before, the majority of the heat supply enterprises and heat customers in Ukraine are not equipped with heat meters or devices for heat-carrier output (hot water for heating and hot water service) determination. Just for this reason, the methodology was developed that is based on the permanent measuring of the fuel consumption and corrections for possible changes of parameters in reporting year comparing to the baseline. The changeable parameters may be the lower heating value of fuels, quality of heating service (providing of normative temperature value inside apartments), weather features, number of customers, etc. As it was mentioned before, this approach eliminates any possibility of reduction of fuel consumption and correspondingly GHG emission due to incomplete delivery of heat to consumers.

In view of the above mentioned, in contrast to the methodologies AM0044, ACM0009 and AM0048, our Methodology, developed for "District Heating" projects in Ukrainian conditions and used in JI Projects "District Heating System Rehabilitation of Chernihiv Region", "Rehabilitation of the District Heating System in Donetsk Region", "Rehabilitation of the District Heating System in Crimea" and others, is the most appropriate, precise, corresponding to the principle of conservatism, and in the most closely manner reflects the aims, goals and spirit of Kyoto Protocol.

The baseline study will be fulfilled every year of the emission reduction selling, to correct adjustment factors which have an influence at the baseline.

Monitoring methodology developed for "District Heating" projects in Ukrainian conditions

Monitoring methodology developed for "District Heating" projects in Ukrainian conditions is presented in section D.1.1. of this PDD (Option 1 – Monitoring of the emissions in the project scenario and the baseline scenario).

Formulae for monitoring

Formulae used for computing project emissions, baseline emissions and the total emission reduction are presented in the tables below.

**Total emission reduction**

The total annual emission reduction is the difference between the baseline emissions and the project emissions.

| **Formula 1 –** Total emission reduction (ERUs) | |
|---|---|
| | $ERUs = \sum[E_i^b - E_i^r]$; [t $CO_2$e] |
| | ERUs - Total annual emission reduction [t $CO_2$e]<br>$E^b{}_i$ - Baseline $CO_2$ emissions [t $CO_2$e]<br>$E^r{}_i$ - $CO_2$ emissions in the reported year [t $CO_2$e] |
| | The sum is taken over all boiler-houses (i) which are included into the project |

**Project emissions**

| **Formula 2 –**Emissions in the reported year **($E^r$)** | |
|---|---|
| | $E_i^r = E_{1i}^r + E_{gen\ i}^r + E_{cons\ i}^r$; [t $CO_2$e] |
| | $E_{1i}^r$ – $CO_2$ emissions due to fuel consumption for heating and hot water supply service for an i boiler-house in the reported year, t $CO_2$e;<br>$E_{gen\ i}^r$ – $CO_2$ emissions due to electric power generated by included into the project objects in the reported year, t $CO_2$e;<br>$E_{cons\ i}^r$ – $CO_2$ emissions due to electric power consumption from greed by the i boiler-house in the reported year, t $CO_2$e. |
| | |

| **Formula 3 –** $CO_2$ emissions due to fuel consumption for heating and hot water supply service for an i boiler-house in the reported year, ($E_{1i}^r$) | |
|---|---|
| | $E_{1i}^r = LHV_r * Cef_r * B_{ri}$ , [tCO2-eq.] |
| | $LHV_{ri}$ – Average annual lower heating value, MJ/$m^3$ (MJ/kg)<br>Average annual Heating Value is calculated for every town;<br>Cef – carbon emission factor, kt$CO_2$/TJ;<br>$B_{ri}$ – amount of fuel consumed by a boiler-house in the reported year, ths $m^3$ or tons; |
| | |

| **Formula 4 –** $CO_2$ emissions due to electric power generated by included into the project objects in the reported year ($E_{gen\ i}^r$) | |
|---|---|
| | $E_{gen}^r = (W_b - W_r) * CEF_g + [(Q_b - Q_r) * f_b / 1000 + B_g] * LHV_r * Cef$ |
| | $W_b$ – scheduled electric power production by the all new CHP units, MWh;<br>$W_r$ – electric power production by the installed new CHP units in reported year, MWh;<br>$CEF_g$ – Carbon Emission factor for electricity generation in Ukraine, t $CO_2$e/MWh;<br>$Q_b$ – scheduled heat energy production by the all new CHP units, MWh;<br>$Q_r$ – heat energy production by the installed new CHP units, MWh;<br>$f_b$ – specific natural gas consumption by the boiler-house, where CHP units are scheduled to be installed, $m^3$/MW;<br>$B_g$ – amount of fuel (gas) consumed by the installed CHP units for generation, ths $m^3$; |
| | |

| **Formula 5 –** $CO_2$ emissions due to electric power consumption from greed by the i boiler-house in the reported year ( $E_{cons\ i}^{r}$) | |
|---|---|
| | $E_{cons\ i}^{r} = P_r*CEF_c$ |
| | $P_r$ – electric power consumption by the boiler-houses with energy saving measures implemented, MWh;<br>$CEF_c$ – Carbon Emission factors for reducing electricity consumption in Ukraine, $tCO_2e/MWh$; |
| | |

**Baseline emissions**

| **Formula 6 –** Annual baseline emissions ($E_b$) | |
|---|---|
| | $E_i^b = E_{1i}^b + E_{gen\ i}^b + E_{cons\ i}^b$; [t $CO_2e$] |
| | $E_{1i}^b$ – baseline $CO_2$ emissions due to fuel consumption for heating and hot water supply service for an i boiler-house , t $CO_2e$;<br>$E_{gen\ i}^b$– $CO_2$ emissions due to electric power generation associated to the project for an i boiler-house in the base year (consumed from greed, amount to be substituted in the reported year), t $CO_2e$;<br>$E_{cons\ i}^b$ – $CO_2$ emissions due to electric power consumption from greed by the i boiler-house in the base year, t $CO_2e$. |
| | |

| **Formula 7 –** Baseline $CO_2$ emissions due to fuel consumption for heating and hot water supply service for an i boiler-house, ($E_{1i}^b$) | |
|---|---|
| | For the case when in the base year the hot water supply service was provided (independent of this service duration, $(1-a_b) \neq 0$), the formulae for $E_1^b$ is:<br>$E_1^b = LHV_b*Cef_b*[B_b*a_b*K_1*K_h + B_b*(1-a_b)*K_1*K_w]$,<br>where the first term in brackets describes fuel consumption for heating, and the second one – fuel consumption for hot water supply.<br><br>For the case when in the base year the hot water supply service was absent at all ($(1-a_b) = 0$), and in the reported year this service was provided (due to improvement of heat supply service quality for population), the formulae for $E_1^b$ is:<br>$E_1^b = LHV_b*Cef_b*[B_b*a_b*K_1*K_h + B_r*(1-a_r)*K_1*K_{w0}]$. |
| | $LHV_b$ – Average annual lower heating value in the base year, $MJ/m^3$ (MJ/kg);<br>Cef – carbon emission factor, $KtCO_2/TJ$;<br>$B_b$ – amount of fuel consumed by a boiler-house in the base year, ths $m^3$ or tons;<br>$K_1$, $K_h = K_2* K_3* K_4$; $K_w = K_5 * K_6 * K_7$ – adjustment factors;<br>$a_b$ – portion of fuel (heat), consumed for heating purposes in the base year;<br>$(1-a_b)$ – portion of fuel (heat), consumed for hot water supply services in the base year;<br>$a_r$ – portion of fuel (heat), consumed for heating purposes in the reported year. |
| | |

| **Formula 8 –** Portion of fuel (heat), consumed for heating purposes in the base year ($a_b$) |
|---|

| | |
|---|---|
| | $a_b = L_h^b * q * N_h^b / (L_h^b * g * N_h^b + L_w^b * N_w^b)$; |
| | $L_h^b$ – maximum connected load required for heating in the base year, MW;<br>$L_w^b$ – connected load required for hot water supply service in the base year, MW;<br>g – recalculating factor for average load during heating period (usually 0.4-0.8);<br>$N_h^b$ – duration of heating period in the base year , hours;<br>$N_w^b$ – duration of hot water supply service in the base year, hours. |
| | |

| **Formula 9 –** Portion of fuel (heat), consumed for heating purposes in the reported year ($a_r$) | |
|---|---|
| | $a_r = L_h^r * q * N_h^r / (L_h^r * g * N_h^r + L_w^r * N_w^r)$ |
| | $L_h^r$ – maximum connected load required for heating in the reported year, MW;<br>$L_w^r$ – connected load required for hot water supply service in the reported year, MW;<br>g – recalculating factor for average load during heating period (usually 0.4-0.8);<br>$N_h^r$ – duration of heating period in the reported year, hours;<br>$N_w^r$ – duration of hot water supply service in the reported year, hours. |
| | |

| **Formula 10 –** Change in the lower heating value ($K_1$) | |
|---|---|
| | $K_1 = LHV_b / LHV_r$ |
| | $LHV_b$ – Average annual lower heating value in the base year, $MJ/m^3$ (MJ/kg);<br>$LHV_r$ – Average annual lower heating value in the reported year, $MJ/m^3$ (MJ/kg) |
| | |

| **Formula 11 –** Temperature change factor ($K_2$) | |
|---|---|
| | $K_2 = (T_{in\ r} - T_{out\ r}) / (T_{in\ b} - T_{out\ b})$ |
| | $T_{in\ r}$ – average inside temperature for the heating period in the reported year, K (or $^0C$);<br>$T_{in\ b}$ – average inside temperature for the heating period in the base year, K (or $^0C$);<br>$T_{out\ r}$ – average outside temperature for the heating period in the reported year , K (or $^0C$);<br>$T_{out\ b}$ – average outside temperature for the heating period in the reported year , K (or $^0C$) |
| | |

| **Formula 12 –** Heating area and building thermal insulation change factor ($K_3$) | |
|---|---|
| | $K_3 = [(F_{h\,r} – F_{h\,t\,r} – F_{h\,n\,r})*k_{h\,b} + (F_{h\,n\,r} + F_{h\,t\,r})*k_{h\,n}] / F_{h\,b}*k_{h\,b}$, |
| | $F_{h\,b}$ – heating area in the base year, $m^2$;<br>$F_{h\,r}$ – heating area in the reported year, $m^2$;<br>$F_{h\,n\,r}$ – heating area of new buildings connected to DH system (assumed with the new (improved) thermal insulation) in the reported year, $m^2$;<br>$F_{h\,t\,r}$ – heating area of buildings (previously existed in the base year) in reported year with the renewed (improved) thermal insulation, $m^2$;<br>$k_{h\,b}$ – average heat transfer factor of heated buildings in the base year, $(W/m^2*K)$;<br>$k_{h\,n}$ – heat transfer factor of heated buildings with the new thermal insulation (new buildings or old ones with improved thermal insulation), $(W/m^2*K)$. |
| | |

| **Formula 13 –** Heating period duration change factor ($K_4$) | |
|---|---|
| | $K_4=N_{hr}/N_{hb}$ |
| | $N_{hb}$,– duration of heating period in the base year, hours<br>$N_{hr}$ – duration of heating period in the reported year, hours |
| | |

| **Formula 14 –** Number of customers change factor ($K_5$) | |
|---|---|
| | $K_5 =n_{wr} / n_{wb}$ |
| | $N_{wb}$,– number of customers in base year;<br>$N_{wr}$ – number of customers in the reported year |
| | |

| **Formula 15 –** Standard specific discharge of hot water per personal account change factor ($K_6$) | |
|---|---|
| | $K_6 = v_{w\,r} / v_{w\,b}$ |
| | $v_{w\,r}$ – standard specific discharge of hot water per personal account in the reported year, (in heat units, kWh/h);<br>$v_{w\,b}$ – standard specific discharge of hot water per personal account in the base year, (in heat units, kWh/h). |
| | |

| **Formula 16 –** Hot water supply period duration change factor ($K_6$) | |
|---|---|
| | $K_7 = N_{wr} / N_{wb}$ |
| | $N_{wr}$– duration of hot water supply service in the reported year, hours.<br>$N_{wb}$ – duration of hot water supply service in the base year, hours. |
| | |

| **Formula 17 –** $CO_2$ emissions due to electric power generation associated to the project for an i boiler-house in the base year ($E_{gen\ i}^{b}$) | |
|---|---|
| | $E_{gen}^{b} = W_b$*$CEF_g + Q_b$*$f_b/1000$* $LHV_r$* Cef |
| | $W_b$ – scheduled electric power production by the all new CHP units, MWh;<br>$CEF_g$ – Carbon Emission factor for electricity generation in Ukraine, $tCO_2e/MWh$;<br>$Q_b$ – scheduled heat energy production by the all new CHP units, MWh;<br>$f_b$ – specific natural gas consumption by the boiler-house, where CHP units are scheduled to be installed, $m^3/MW$;<br>$LHV_r$ – Average annual lower heating value in reported year, $MJ/m^3$ (MJ/kg)<br>Cef – carbon emission factor, $ktCO_2/TJ$; |
| | |

| **Formula 18 –** $CO_2$ emissions due to electric power consumption for an i boiler-house in the base year ($E_{cons\ i}^{b}$) | |
|---|---|
| | $E_{cons}^{b} = P_b$*$CEF_c$ |
| | $P_b$ – electric power consumption by the boiler-houses where energy saving measures are scheduled to be implemented in the base year, MWh;<br>$CEF_c$ – Carbon Emission factors for reducing electricity consumption in Ukraine, $tCO_2e/MWh$; |
| | |

4. MONITORING OF BASELINE AND PROJECT EMISSIONS

Parameters to be monitored

Monitoring methodology identifies and takes into account the parameters that are need to be measured or monitored at regular intervals. These parameters will then be input into a project Tracking Database, which will be an Excel based spreadsheet that will track GHG emission reductions annually.
List of parameters to be monitored are in the table below.

| | **Symbol** | Data variable | Data unit | Measured (m), calculated (c), estimated (e) |
|---|---|---|---|---|
| 1 | ($B_b$) and ($B_r$) | Fuel consumption at boiler houses | | m |
| 1.1 | | Natural Gas | $m^3$ | |
| 1.2 | | Coal | ton | |
| 2 | ($LHV_b$) and ($LHV_r$) | Average annual Heating Value of a fuel calculated by Lower Heating Value | | m, c |
| 2.1 | | Natural Gas | $MJ/m^3$ | |
| 2.2 | | Coal | MJ/kg | |
| 3 | ($T_{out\ b}$) and ($T_{out\ r}$) | Average outside temperature during the heating season | $^0C$ (K) | m, c |
| 4 | ($T_{in\ b}$) and ($T_{in\ r}$) | Average inside temperature during the heating season | $^0C$ (K) | m, c |
| 5 | ($n_{wb}$ and ($n_{wr}$) | Number of Customers | | Statistics |
| 6 | ($F_{h\ b}$ and ($F_{h\ r}$) | Heating area (total) | $m^2$ | Statistics |
| 7 | ($k_{hb}$) | Average heat transfer factor of heated buildings in the base year | $W/m^2*K$ | c |
| 8 | ($F_{h\ t\ r}$) | Heating area of buildings (previously existed in the base year) with the renewed (improved) thermal insulation in the reported year | $m^2$ | Statistics |
| 9 | ($F_{h\ n\ r}$) | Heating area of newly connected buildings (assumed with the new (improved) thermal insulation) in the reported year | $m^2$ | Statistics |
| 10 | ($k_{h\ n}$) | Heat transfer factor of buildings with the new thermal insulation | $W/m^2*K$ | Normative documents |
| 11 | ($N_{h\ b}$ ) and ($N_{h\ r}$) | Duration of the heating period | Hours | m |
| 12 | ($N_{w\ b}$) and ($N_{w\ r}$) | Duration of the hot water supply period | Hours | m |
| 13 | ($L_h^b$ ) and ($L_h^r$) | Maximum connected load to the boiler-house, that is required for heating | MW | c |

| | | | | |
|---|---|---|---|---|
| 14 | **($L_w^b$)** and **($L_w^r$)** | Connected load to the boiler-house, that is required for hot water supply service | MW | c |
| 15 | **($v_{w\,r}$)** and **($v_{w\,b}$)** | Standard specific discharge of hot water per personal account | kWh/h | Normative documents |
| 16 | **($Cef_r$)** and **($Cef_b$)** | Carbon emission factor | | Normative documents |
| 16.1 | | Natural Gas | kt $CO_2$/TJ | |
| 16.2 | | Coal | kt $CO_2$/TJ | |
| 17 | **g** | Recalculating factor for average load during heating period | | Statistics |
| 18 | **($W_b$)** and **($W_r$)** | Scheduled electric power production by the all new CHP units and electric power generation by the installed new CHP units in reported year, MWh | MWh | c/m |
| 19 | **($Q_b$)** and **($Q_r$)** | Scheduled heat power production by the all new CHP units and heat power generation by the installed new CHP units in reported year, MWh | MWh | c/m |
| 20 | **($P_b$)** and **($P_r$)** | Electric power consumption by the boiler-houses where energy saving measures are scheduled to be implemented | MWh | m |

Data to be monitored

| **Parameter number and name** | **1.1** Natural gas consumption at boiler houses |
|---|---|
| Description | Natural gas consumption at boiler houses.<br>Consumption of fuel is the main parameter affecting greenhouse gas emissions. The most objective and accurate indicator of project performance will therefore be the changes in fuel consumption. Changes in fuel consumption in result of the project implementation, when compared to baseline fuel consumption, will integrate all other relevant indicators such as improvement of boiler efficiency, reduction of network losses, etc. |
| Monitoring method | Gas flow meters |
| Recording frequency | Every day |
| Background data | Instrument readings are registered in the paper journals at every boiler-house. |
| Calculation method | n.a. |

| Parameter number and name | **1.2** Coal consumption at boiler houses |
|---|---|
| Description | Coal consumption at boiler houses |
| Monitoring method | Purchasing of coal is realized in accordance with invoices. Consumption of coal is measured by wheelbarrows and pails then recalculated to weight |
| Recording frequency | Every day |
| Background data | Coal consumption is registered in the paper journals at every boiler-house.<br>Invoices are filed in special journals. |
| Calculation method | n.a. |

| Parameter number and name | **2.1** Average annual Heating Value of Natural Gas |
|---|---|
| Description | Average annual Heating Value of Natural Gas calculated by Lower Heating Value for every town |
| Monitoring method | Accepted in accordance with reference or telephone message from natural gas supplier or independent chemical lab analysis report. Independent chemical lab analysis is used in questionable cases. It is used rarely. |
| Recording frequency | Data is provided by natural gas suppliers usually 3 times per month |
| Background data | Registered in the paper journal |
| Calculation method | Weighted average value |

| Parameter number and name | **2.2** Average annual Heating Value of Coal |
|---|---|
| Description | Average annual Heating Value of Coal calculated by Lower Heating Value for every town |
| Monitoring method | Accepted in accordance with quality certificate from coal supplier's or independent chemical lab analysis report. Independent chemical lab analysis is used in contentious cases. It is used rarely. |
| Recording frequency | Quality certificate is given by coal supplier's for every consignment |
| Background data | Certificates are filed in special journals |
| Calculation method | Weighted average value |

| **Parameter number and name** | **3.** Average outside temperature during the heating season |
|---|---|
| Description | Average outside temperature during the heating season |
| Monitoring method | Average outside temperature during the heating season is calculated by ME "Kharkivski teplovi merezhi" from the daily outside temperature values taken by dispatcher of ME "Kharkivski teplovi merezhi" from Kharkiv Meteorological Centre from 10 to 11 a.m. every day of heating season. |
| Recording frequency | Once per heating season.<br>Daily temperature is registered every day of heating season |
| Background data | Meteorological Centre sends the Report every decade or month for every day of heating season. Reports are filed in special journals |
| Calculation method | Average value |

| **Parameter number and name** | **4.** Average inside temperature during the heating season |
|---|---|
| Description | Average inside temperature during the heating season is calculated from the sum of returned payments caused by insufficient heating (in case of normative level (18 $^0$C) is not satisfied)<br><br>Above 18 $^0$C – is treated as 18 $^0$C (according to the conservatism principle) and as meeting the normative.<br>Below 18 $^0$C – is treated as not meeting the normative, and is calculated as below. |
| Monitoring method | Sum of returned payments |
| Recording frequency | Once per heating season |
| Background data | Sums of return payment |
| Calculation method | According to “Rules of rendering of heat and hot water supply service to population” № 1497 from 30.12.1997, the enterprises must make the return payments to population for delivery less than necessary amount of heat. The normative inside temperature should be not lower than 18 $^o$C.<br>Amount of the return payment is:<br>– 5% from normative payment for every degree from 18 to 12 $^o$C;<br>– 10% from normative payment for every degree from 12 to 5 $^o$C;<br>– when inside temperature is lower than 5 $^o$C the payment is to be returned completely.<br><br>Therefore the inside temperature will be calculated by formulae:<br>If R = 0 (according to conservatism principle for the baseline assume R < 0.05):<br>$\mathbf{T_{in\ b}}$ = 18 $^o$C.<br>If 0.05 < R ≤ 0.3 NP:<br>$\mathbf{T_{in\ b}}$ = 18 – (R/5) [$^o$C]<br>If 0.3 NP < R < NP:<br>$\mathbf{T_{in\ b}}$ = 12 – [(R – 0.3 NP)/10] [$^o$C] |

| | |
|---|---|
| | where:<br>R - % of return payment from NP;<br>NP – amount of normative payment.<br><br>Thus if the inside temperature will be 18 $^{o}$C or higher we will accept it as 18 $^{o}$C according to conservatism principle, if it will be lower than 18 $^{o}$C it will be calculated from return payments by the methodology presented before. |

| **Parameter number and name** | **5.** Number of Customers for hot water supply service |
|---|---|
| Description | Number of Customers for hot water supply service for every boiler houses |
| Monitoring method | Statistics of ME "Kharkivski teplovi merezhi" |
| Recording frequency | Contracts with population, organizations and legal entities are concludes directly with ME "Kharkivski teplovi merezhi". They are updated once per year. |
| Background data | The information is collected in special electronic journals “Registration of income from population” (for inhabitants). For organizations and legal entities such information is taken from contracts concluded with them |
| Calculation method | |

| **Parameter number and name** | **6.** Heating area (Total) |
|---|---|
| Description | Heating area for every boiler houses |
| Monitoring method | Statistics of ME "Kharkivski teplovi merezhi" |
| Recording frequency | The revise is made in case of new contracts with Customers or in case of contracts break. |
| Background data | The information is collected at the sale departments of ME "Kharkivski teplovi merezhi" by the certificates of owners in accordance with technical passport of building.<br>Total area with balconies and stairs and Heating area are displayed in the special journal |
| Calculation method | The data is taken for January, 01 for every year |

| **Parameter number and name** | **7.** Heat transfer factor of buildings |
|---|---|
| Description | Heat transfer factor of buildings for every boiler-house |
| Monitoring method | Statistics ME "Kharkivski teplovi merezhi" |
| Recording frequency | Heat transfer factor is recorded ones per year at recording of connection or disconnection of any heating area to boiler-houses included in project. |
| Background data | |
| Calculation method | For calculation of Heat transfer factor of buildings for every boiler-house, the method of Weighted average value was used, |

| | |
|---|---|
| | that depends on heating area of existing buildings and heating area of the new buildings. Values of the heat transfer factor for existing buildings were taken from SNiP 2-3-79 (1998) - not higher than 0.63. Values of the heat transfer factor of new buildings were taken according to State Buildings Norms (B.2.6-31:2006) - not higher than 0.36. |

| **Parameter number and name** | **8.** Heating area of buildings (previously existed in the base year) with the renewed (improved) thermal insulation in the reported year |
|---|---|
| Description | Heating area of reconstructed buildings with application of new insulations for walls |
| Monitoring method | Statistics of ME "Kharkivski teplovi merezhi" |
| Recording frequency | Once per year |
| Background data | |
| Calculation method | |

| **Parameter number and name** | **9.** Heating area of newly connected buildings (assumed with the new (improved) thermal insulation) in the reported year |
|---|---|
| Description | Heating area of newly connected buildings with application of the new insulation for walls |
| Monitoring method | Statistics of ME "Kharkivski teplovi merezhi" |
| Recording frequency | Once per year |
| Background data | |
| Calculation method | |

| **Parameter number and name**) | **10.** Heat transfer factor of new buildings and buildings with new thermal insulation |
|---|---|
| Description | Heat transfer factor of buildings with new thermal insulation |
| Monitoring method | According to State Buildings Norms (B.2.6-31:2006) |
| Recording frequency | |
| Background data | |
| Calculation method | |

| **Parameter number and name** | **11.** Heating period duration |
|---|---|
| Description | Heating period duration in every town |
| Monitoring method | Measured by ME "Kharkivski teplovi merezhi" |
| Recording frequency | Once per year |
| Background data | The duration of the Heating period is accepted in accordance with item 7.9.4 of “Rules of technical exploitation of heating equipment and networks. 2007”. Beginning and ending of the heating period are determined in every town separately. The heating period begins if the average daily outside temperature is 8 $^{o}$C or lower during 3 days, and finishes if average daily outside |

| | |
|---|---|
| | temperature is 8 $^{o}$C or higher during 3 days.<br>According to SNiP 2.01.01-84 (Climatology in heating engineering) the duration of heating period for project development is to be taken as 183 days, and usually it is from October,15, till April 15. |
| Calculation method | |

| **Parameter number and name** | **12.** Duration of the hot water supply period |
|---|---|
| Description | Duration of the period of hot water supply service for every boiler house. |
| Monitoring method | Measured by ME "Kharkivski teplovi merezhi" |
| Recording frequency | Once per day |
| Background data | Hot water supply service is realized by hot water delivery schedule for every town.<br>In Kharkiv city Hot water supply service is usually 24 houers per day throughout the year at the boiler-houses where the load for Hot water supply service is foreseen. There is a plan of disconnection of load for Hot water supply service for maintenance and preventive measures for every boiler-house. |
| Calculation method | |

| **Parameter number and name** | **13.** Maximum connected load to the boiler-house, that is required for heating |
|---|---|
| Description | Maximum connected load to the boiler-house, that is required for heating. |
| Monitoring method | Calculated by ME "Kharkivski teplovi merezhi" |
| Recording frequency | Once per year |
| Background data | Maximum connected load to the boiler-house, that is required for heating, is calculated by ME "Kharkivski teplovi merezhi" for every heating season. It is calculated according to heat demand at outside temperature -23 $^{o}$C. |
| Calculation method | |

| **Parameter number and name** | **14.** Connected load to the boiler-house, that is required for hot water supply service |
|---|---|
| Description | Connected load to the boiler-house, that is required for providing the hot water supply service |
| Monitoring method | Calculated by ME "Kharkivski teplovi merezhi" |
| Recording frequency | Once per year |
| Background data | Connected load to the boiler-house, that is required for hot water supply service, is calculated by ME "Kharkivski teplovi merezhi" every year according to contracts with consumers. |
| Calculation method | |

| **Parameter number and name** | **15.** Standard specific discharge of hot water per personal account |
|---|---|
| Description | Standard specific discharge of hot water per personal account |
| Monitoring method | Normative documents |
| Recording frequency | Once per year |
| Background data | At present the standard specific discharge of hot water is valid in Ukraine that was established by the “KTM 204 Ukraine 244-94” in 1993, and no information is available on any propositions to change it. |
| Calculation method | |

| **Parameter number and name** | **16.** Carbon emission factor |
|---|---|
| Description | Carbon emission factor for different fuels |
| Monitoring method | Normative documents |
| Recording frequency | Once per year |
| Background data | For all fuels we used $CO_2$ emission factors from the data table provided in Annex C of the Operational Guidelines for Project Design Documents of Joint Implementation Projects [Volume 1: General guidelines; Version 2.2].<br>Cef (natural gas) = 0.0561 $ktCO_2/TJ$;<br>Cef (coal) = 0.0946 $ktCO_2/TJ$; (taken as “Other bituminous coal”). |
| Calculation method | |

| **Parameter number and name** | **17.** Recalculating factor for average load during heating period |
|---|---|
| Description | Recalculating factor for determination of the average load during heating period |
| Monitoring method | Statistics of ME "Kharkivski teplovi merezhi" |
| Recording frequency | Once per year |
| Background data | Recalculating factor for average load during heating period is determined for each boiler-house on historical base, usually it is in the range (0,4 – 0,8) |
| Calculation method | $g = Q_{av}/Q_{max} = F_h*k_h*(T_{in} - T_{out\ av})/F_h*k_h*(T_{in} - T_{out\ min})$<br>where:<br>g – recalculating factor for average load during heating period;<br>$F_h$ – heating area of buildings, $m^2$;<br>$k_h$ – average heat transfer factor of heated buildings,($W/m^2*K$);<br>$T_{in}$ – average inside temperature for the heating period, K ;<br>$T_{out\ av}$ – average outside temperature for the heating period, K (or $^0C$);<br>$T_{out\ min}$ – minimal outside temperature for the heating period, K (or $^0C$). |

| **Parameter number and name** | **18.** Electric power generation |
|---|---|
| Description | Electric power generation by the installed new CHP units |
| Monitoring method | Measurement of generated electricity by power meter |
| Recording frequency | Every day |
| Background data | |
| Calculation method | |

| **Parameter number and name** | **19.** Heat power generation |
|---|---|
| Description | Heat power generation by the installed new CHP units |
| Monitoring method | Measurement of generated eheat energy by Heat flow meter |
| Recording frequency | Every day |
| Background data | |
| Calculation method | |

| **Parameter number and name** | **20.** Electric power consumption |
|---|---|
| Description | Electric power consumption by the boiler-houses where energy saving measures are scheduled to be implemented |
| Monitoring method | Measurement by Electricity supply meters |
| Recording frequency | Every day |
| Background data | Electric power consumption should be measured at the following objects:<br>1. Boiler houses and CHP, in the heating area of which reconstruction and liquidation of HDS will take place.<br>2. HDS that will be reconstructed and liquidated.<br>3. Boiler houses and HDS, where frequency controllers will be installed |
| Calculation method | |

Scheme of monitoring system

The control and monitoring system comes to fuel consumption measurement. Other parameters are defined by calculations or taken from statistic data. Fuel consumption measurement is realized at the Gas distributing units of the boiler-houses. Gas registration is carring out in volume units reduced to standard conditions by means of automatic correction for temperature and pressure. The scheme of typical Gas distribution unit is shown at the Fig. 1.

The typical Gas distributing system usually consists of the following equipment:

- Gas filter;
- Control and measuring devices for gas operation pressure measurement and control of pressure difference at the gas filter;
- Gas flow meter;
- stop valve;
- bypass facility.

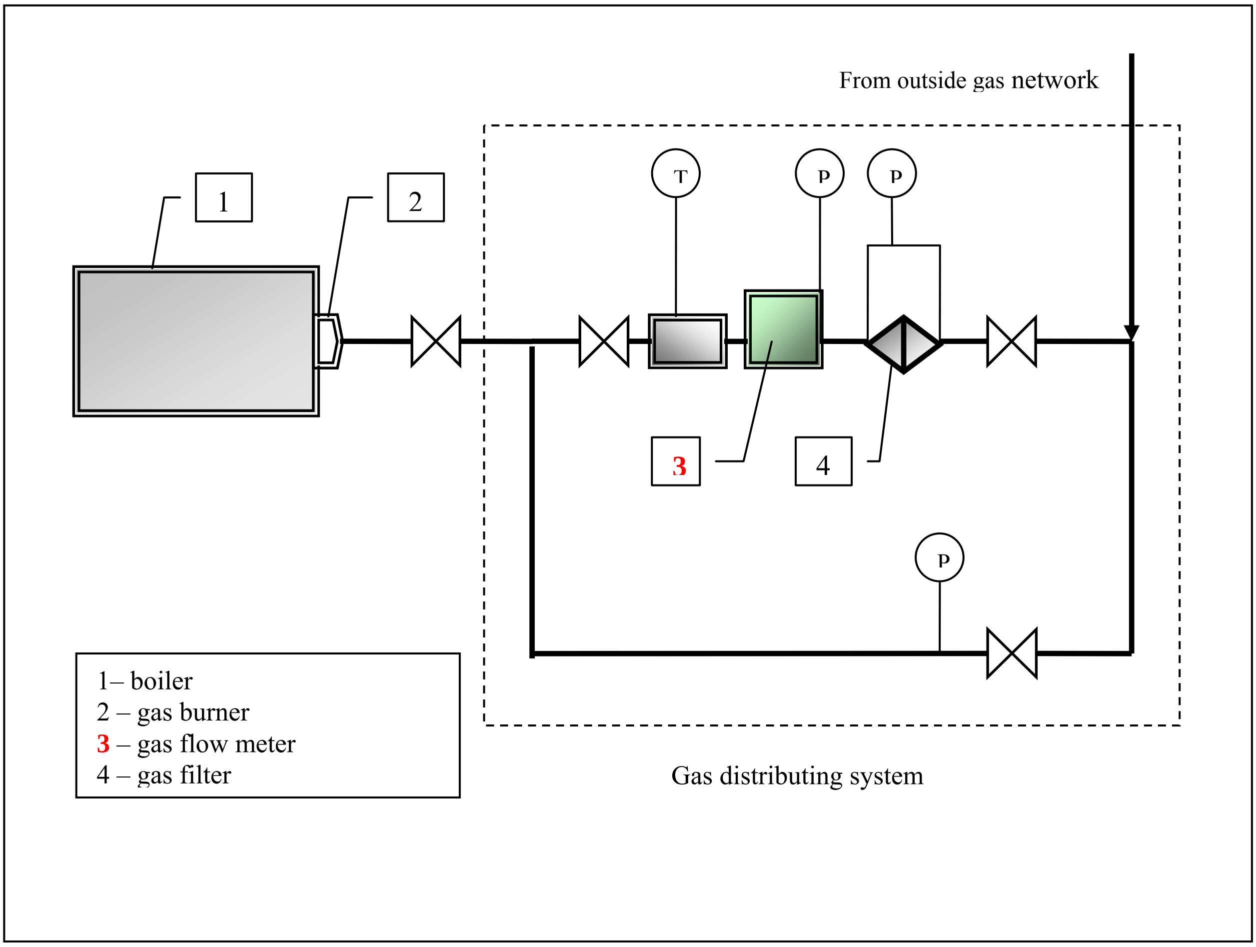


*Fig. 1. Scheme of the Gas distribution system*

The typical scheme of monitoring system for boiler-house where the CHP units will be installed is shown at the Fig. 2. Usually it consists of the following equipment:

GFM – gas flow meter;
HFM – heat flow meter with sensors;
GEM - generated electricity meter;
CP - control panel of gas engine-generator machine

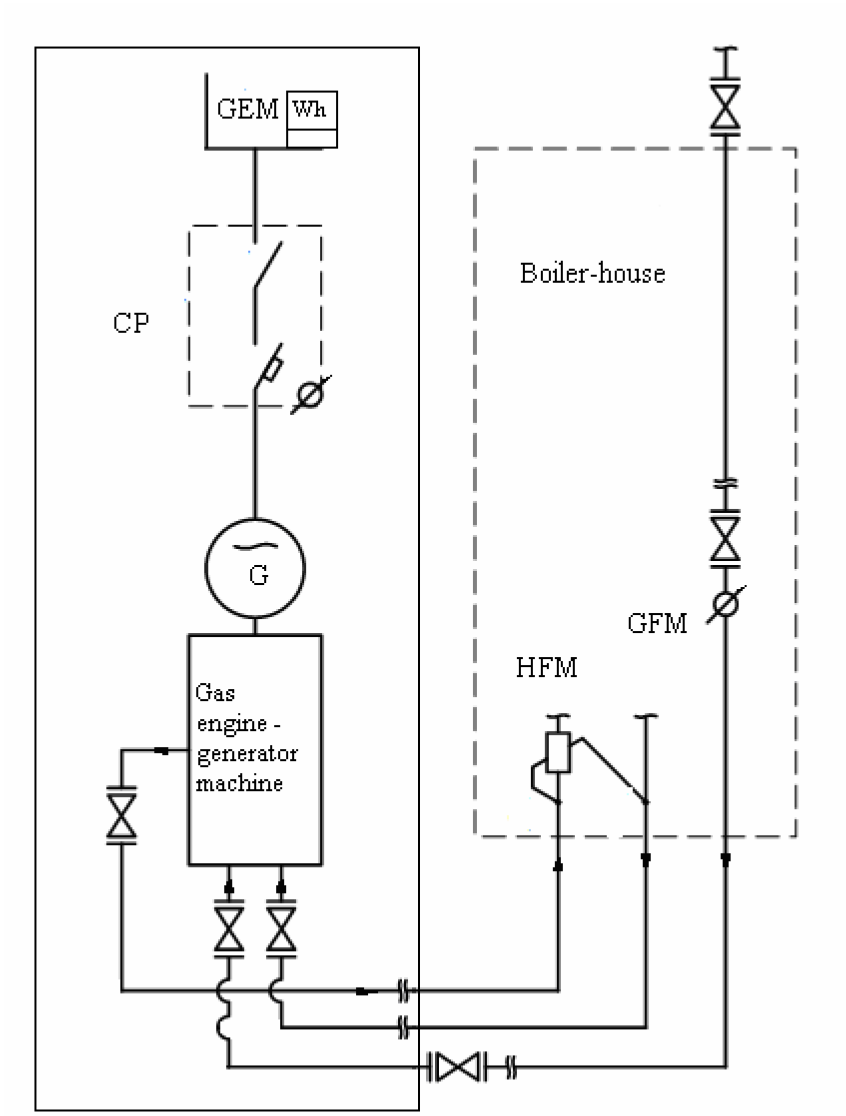


*Fig. 2. Scheme of monitoring system for boiler-house where the CHP units will be installed*

Monitoring equipment

The equipment to be used by the project executor for monitoring of the relevant parameters are summarized in Table 1. The table also provides information on equipment type, calibration and procedures to follow in case of equipment failure.

| ID number and data variable | Equipment | Accuracy | Calibration | Frequency | Procedure in case of failure |
|---|---|---|---|---|---|
| 1.1 Natural Gas consumption | Gas flow meters | +/-(0.5…2)%<br><br>Usually 1% | JSC "Kharkiv State center of standardization, metrology and certification" | Once per from 1 to 5 years, usually two years | Failure should be firstly reported to the Project manager or Chief Engineer. If failure is not removed within 48 hrs, the equipment supplier should be ordered for repair. If repair is not possible, equipment should be replaced by equivalent item. Failure events will be recorded in the site events log book. |
| 17. Power consumption | Electricity supply meters | +/-(0.2…0.5)%<br><br>Usually 0.2% | JSC "Kharkiv State center of standardization, metrology and certification" | Once per from 1 to 5 years, usually two years | Failure should be firstly reported to the Project manager or Chief Engineer. If failure is not removed within 48 hrs, the equipment supplier should be ordered for repair. If repair is not possible, equipment should be replaced by equivalent item. Failure events will be recorded in the site events log book. |
| 18. Power production by the new CHP unit | Generated electricity meter | +/-(0.2…0.5)%<br><br>Usually 0.2% | JSC "Kharkiv State center of standardization, metrology and certification" | Once per from 1 to 5 years, usually two years | Failure should be firstly reported to the Project manager or Chief Engineer. If failure is not removed within 48 hrs, the equipment supplier should be ordered for repair. If repair is not possible, equipment should be replaced by equivalent item. Failure events will be recorded in the site events log book. |
| 19. Heat production by the new CHP unit | Heat flow meter | +/-2.0% | JSC "Kharkiv State center of standardization, metrology and certification" | Once per from 1 to 5 years, usually two years | Failure should be firstly reported to the Project manager or Chief Engineer. If failure is not removed within 48 hrs, the equipment supplier should be ordered for repair. If repair is not possible, equipment should be replaced by equivalent item. Failure events will be recorded in the site events log book. |

*Table 1. Monitoring equipment*

Level of uncertainty and errors

Possible uncertainty and errors for such type project may arise from two main reasins: measurement and stipulation. Measurement error is due to metering equipment inaccuracies. Stipulation occurs when some values are required to complete calculations, but these values cannot be measured directly. In these cases estimates are used in place of actual measurements, and therefore error may be introduced. The stipulation error itself may be estimated based on the expected accuracy of the stipulated values.

The project error can be calculated from the two error components described above. The total project error (Standard Error, SE) can be calculated by taking the square root of the sum of the squares of the individual error components, as below:

$SE = \sqrt{[(\text{measurement error})^2 + (\text{stipulation error})^2]}$

The monitoring plan developed for this project does not rely on any estimates and is therefore free of any stipulation errors.

Thus, $SE = \sqrt{[(\text{measurement error})^2 + (0)^2]} = (\text{measurement error})$

Although the project has 20 monitoring points, only four of these (quantity of natural gas consumption, power consumption, power production on the new CHP and heat production on the new CHP unit) are measured directly. The remaining monitoring points used in calculation of the baseline and project line emissions are taken as statistic data. Furthermore, they are used for adjustment factors calculation. Calculations of adjustment factors are based on reported and base year parameters ratio. For example, temperature change factor is calculated as ratio of inside and outside temperature differences in reported and base years: $K_2 = (T_{in\ r} - T_{out\ r}) / (T_{in\ b} - T_{out\ b})$. Therefore any error in statistic data will be cancelled.

The four measurement errors (maximal values) which impact on the Standard Error and their level of accuracy are presented in Table 2.

| ID number and data variable | Measurement error (maximal) | Comment |
|---|---|---|
| 1.1 Natural Gas consumption | ± 2.0% | Accuracy of data is high due to necessity of information for commercial account purposes. |
| 18. Power production by the new CHP unit | ±0.5% | Accuracy of data is high due to necessity of information for account purposes. |
| 19. Heat production by the new CHP unit | ±1.0% | Accuracy of data is high due to necessity of information for account purposes. |
| 20. Power consumption | ± 0.5% | Accuracy of data is high due to necessity of information for commercial account purposes. |

*Table 2: Measurement errors (accuracy) for standard error*

5. MONITORING OF ENVIRONMENTAL IMPACTS

As the project involves rehabilitation of an existing district heating network leading to an improvement of energy efficiency and therefore better environmental performance of the system, and is not a new build project, no negative environmental impacts are expected, and therefore no formal environmental impact assessment is required by the relevant Ukrainian authorities.
There is therefore no need to monitor specified environmental impact indicators during implementation and operation of the project activities.

6. PROJECT MANAGEMENT PLANNING

The overall responsibility for the project management and implementation is carried out by the director of ME "Kharkivski teplovi merezhi", Mr. Sergiy Andreev, and appointed responsible persons leaded by Mr. Andriy Repin, Chief of the Production-Technical Service (PTS) of ME "Kharkivski teplovi merezhi". The stuff of PTS is responsible for project activity.

Compliance of the project activity with the operational requirements is constantly controlled by responsible stuff of a boiler-house, and according to their reports – by PTS.
Possible bottlenecks and mistakes in project implementation should be identified and solved by responsible stuff of PTS.

Responsibilities for data collection

The director of ME "Kharkivski teplovi merezhi", Mr. Sergiy Andreev, appointed the responsible person, Mr. Andriy Repin, for the implementation and management of the monitoring process at the ME "Kharkivski teplovi merezhi". Mr. Andriy Repin is responsible for supervising of data collection, measurements, calibration, data recording and storage.
Dr. Vladimir Gomon, Managing Engineer of European Institute for safety, security, insurance and environmental techniques, is responsible for baseline and monitoring methodology development.
Dr. Dmitri Paderno, vice director of Institute of Engineering Ecology, is responsible for baseline and monitoring methodology development.
Ms. Tetiana Grechko, senior engineer of Institute of Engineering Ecology, is responsible for baseline and monitoring methodology development and data processing.

Data collection for fuel consumption is providing in the following way:

1. All boiler-houses are equipped with gas flow meters.

2. Operators of all boiler-houses register the instrument readings in the paper journals “Journal of registration of boiler-house’s operation parameters” every day.

3. At the boiler-houses that are not equipped with gas volume correctors (at present about 10 % of the total number of boiler-houses), operators register parameters of gas: temperature and pressure in these journals every 2 hours. These parameters are used to bring gas consumption to normal conditions.

4. Every day operators transfer values of gas consumption to dispatcher of the regional branch of ME "Kharkivski teplovi merezhi" by phone. Monthly they transfer the paper report.

5. Regional branches transfer data to Techno-Economic Activities Department (TEA) of Production-Technical Service (PTS) of ME "Kharkivski teplovi merezhi" where they are storing and used for payments with gas suppliers.

Scheme of data collection for Monitoring Report is shown at the Fig. 3.

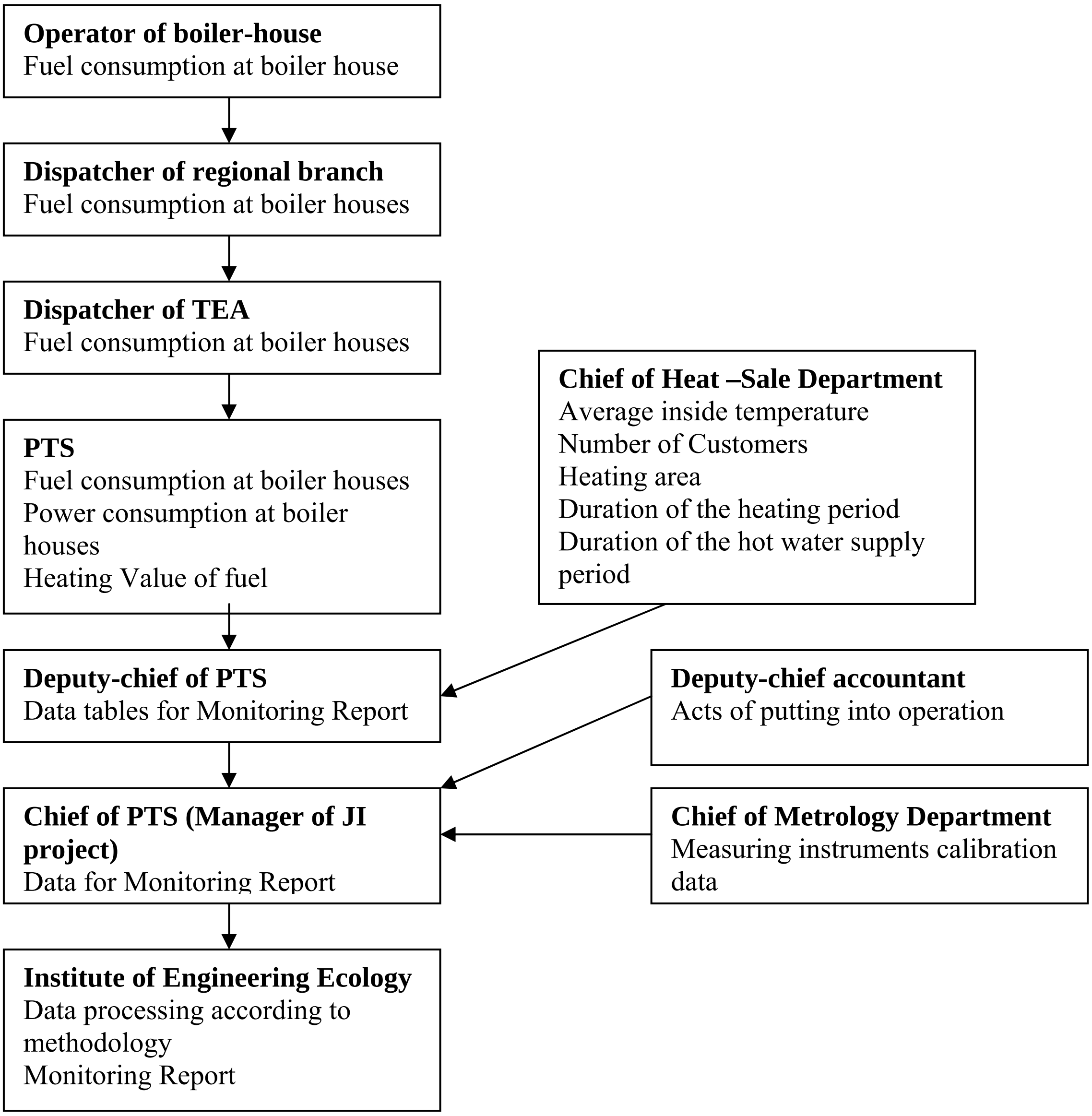


*Fig.3. Scheme of data collection for Monitoring Report*

<u>Trainings</u>

As far as the main activity of ME "Kharkivski teplovi merezhi" will not change in course of the JI project implementation, the special technical trainings for personnel are not necessary. The technical personnel of the enterprise has sufficient knowledge and experience for implmentation of the project activity and maintenance of the usual equipment.

In cases of the new (never used at this enterprise before, for example: cogeneration units, foreign produced boilers, etc.) equipment installation, the company - producer of this equipment should provide trainings for personnel.

For example, JSC "Pervomaiskdieselmash" – the producer of cogeneration units – during all period of operation of engines-generators usually renders to purchaisers of their equipment all kinds of service:

- Performance mounting, starting-up and adjustment works, commissioning;
- Training of the attendants on service regulations at object of the customer or at industrial base of a factory;
- Guarantee and after guarantee service;
- Performance on place of operation maintenance service;
- Performance on place of operation current, average and major overhauls, including on vessels without their conclusion from operation.

ME "Kharkivski teplovi merezhi" provides personnel retraining according to protection of labour norms. The enterprise has the Labour protection department, which is responsible for raising the level of personnel skills and trainings.

In course of the JI project development (starting from 2004), specialists of Institute of Engineering Ecology and then also of the European Institute for safety, security, insurance and environmental technics carried out a comprehensive consultations and trainings for involved representatives of ME "Kharkivski teplovi merezhi" on the necessary data collection according to Monitoring plan for the project.
The special training is scheduled to be held before the development of the Monitoring report, in January, 2009.

The special group was organized consisted of representatives of ME "Kharkivski teplovi merezhi" and Institute of Engineering Ecology, in particular:
Sergiy Andreev - ME "Kharkivski teplovi merezhi", Director;
Andriy Repin - ME "Kharkivski teplovi merezhi", Chief of Production-Technical Service;
Roman Zinchenko - ME "Kharkivski teplovi merezhi", Deputy chief of Production-Technical Service;
Tetiana Grechko - Institute of Engineering Ecology, senior engineer;
Dmitri Paderno - Institute of Engineering Ecology, vice director.

The responcible stuff of the Production-Technical Service of ME "Kharkivski teplovi merezhi" is involved in this process.

Responsibilities for data management

All collected data will be transferred to Andriy Repin, who will be responsible for data storage and archiving, entry of the data into the monitoring spreadsheets. Tetiana Grechko will be responsible for the data processing according to methodology and for development of Monitoring Report. Support in co-ordination of verification process will be undertaken by Dmitry Paderno. Responsibilities for data management are presented in Table 3.

| Activity | Responsible person | |
|---|---|---|
| | Name | Position and department |
| Data storage and archiving | Ludmila Tonitsoy | Head of Techno-Economic Activities Department of ME "Kharkivski teplovi merezhi" |
| Data storage and archiving | Galina Kuznetsova | Chief of Heat –Sale Department of ME "Kharkivski teplovi merezhi" |
| Data storage and archiving, filling up the spreadsheets for Monitoring Report | Roman Zinchenko | Deputy chief of PTS of ME "Kharkivski teplovi merezhi" |
| Data monitoring and reporting, coordination of verification process | Andriy Repin | Chief of PTS of ME "Kharkivski teplovi merezhi" |

| | | |
|---|---|---|
| Data processing according to methodology, development of Monitoring Report | Tetiana Grechko | Senior engineer of Institute of Engineering Ecology, Ltd |
| Monitoring methodology assessment | Vladimir Gomon | Managing Engineer of European Institute for safety, security, insurance and environmental techniques |
| Support in coordination of verification process | Dmitri Paderno | Vice Director of Institute of Engineering Ecology, Ltd |

*Table 3: Responsibilities for data management*