

**JI MONITORING REPORT FORM  
ANNUAL REPORT**

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**“Rehabilitation of the District Heating System in Kharkiv City”**

**CONTENTS**

- A. General project activity and monitoring information
- B. Key monitoring activities
- C. Quality assurance and quality control measures
- D. Calculation of GHG emission reductions

**ANNEXES**

- Annex 1: Data
- Annex 2: CO<sub>2</sub> emissions reduction calculations at the ME "Kharkivski teplovi merezhi"
- Annex 3: Monitoring of gas flow meters and calibration
- Annex 4: CO<sub>2</sub> emissions reduction due to power saving at the ME "Kharkivski teplovi merezhi"
- Annex 5: Monitoring of electricity meters and calibration

**SECTION A. General Project activity and monitoring information****A.1 Title of the project activity:****"Rehabilitation of the District Heating System in Kharkiv City"****A.2. JI registration number:****UNFCCC JI Reference Number: 0150****ITL project ID - UA 100027****A.3. Short 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<sub>2</sub> and N<sub>2</sub>O). 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 "Pervomaiskieselmash" (Ukraine) - 3 gas engine-generator machines DvG1A-630, with total capacity 1890 kW<sub>e</sub>, 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<sup>3</sup> 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.

According to collected data the following amount of GHG emission reduction was achieved during the monitoring period:

Year	Baseline emissions, tCO <sub>2</sub> e	Project emissions, tCO <sub>2</sub> e	Emission Reduction. tCO <sub>2</sub> e
Emission Reduction, tCO <sub>2</sub> e	2148713,7	1852624,6	296089,1

*Table 1: Amount of GHG emission reduction during the monitoring period.*

**A.4. Monitoring period:**

- Monitoring period starting date: 1/01/2008
- Monitoring period closing date: 31/12/2008

**A.5. Methodology applied to the project activity (incl. version number):**

**A.5.1. Baseline methodology:**

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 “Rehabilitation of the District Heating System of Crimea” 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<sub>2</sub>) 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  $\epsilon_{project, i, y}$  and  $\epsilon_{baseline, i}$  for equipment. In the chapter "Baseline emissions" on the page 6 there is an explanation that:

Efficiencies for the project activity ( $\epsilon_{project, i, y}$ ) should be measured monthly throughout the crediting period, and annual averages should be used for emission calculations. Efficiencies for the baseline scenario ( $\epsilon_{baseline, i}$ ) 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  $\varepsilon_{\text{project},i,y}$ .

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  $SCPCSG_{i,y}$  (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” and “Rehabilitation of the District Heating System in Donetsk Region” 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.

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.

The second version of Baseline scenario was to make reconstruction works without JI mechanism. This alternative baseline scenario was not accepted as feasible because in this case the project is not attractive for investments.

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, etc., installation from the project. This makes project economically less attractive, with the longer pay back period.

Thus, the first version was chosen for Baseline scenario.

**A.5.2. Monitoring methodology:**

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<sub>2</sub>e:

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

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

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

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

where:

$E_{li}^b$  and  $E_{li}^r$  – CO<sub>2</sub> 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<sub>2</sub>e;

$E_{gen\ i}^b$  and  $E_{gen\ i}^r$  – CO<sub>2</sub> 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<sub>2</sub>e;

$E_{cons\ i}^b$  and  $E_{cons\ i}^r$  – CO<sub>2</sub> 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<sub>2</sub>e.

For each i boiler-house:

$$E_{li}^b = LHV_b * Cef_b * B_b$$

$$E_{li}^r = LHV_r * Cef_r * B_r$$

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

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

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

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

where:

## JI MONITORING REPORT FORM

**Monitoring Report #2 “Rehabilitation of the District Heating System in Kharkiv City”** page 7

LHV – lower heating value, MJ/m<sup>3</sup> (MJ/kg);

Cef – carbon emission factor, kt CO<sub>2</sub>/TJ;

B – amount of fuel consumed by a boiler-house, ths m<sup>3</sup> or tons;

W<sub>b</sub> – scheduled electric power production by the new CHP units at a boiler-house, MWh;

W<sub>r</sub> – electric power production by the installed new CHP units MWh;

CEF<sub>g</sub> – Carbon Emission factor for electricity generation in Ukraine, tCO<sub>2</sub>e/MWh;

P<sub>b</sub> – electric power consumption by a boiler-house where energy saving measures are scheduled to be implemented, MWh;

P<sub>r</sub> – electric power consumption by a boiler-house with energy saving measures implemented, MWh;

CEF<sub>c</sub> – Carbon Emission factors for reducing electricity consumption in Ukraine, tCO<sub>2</sub>e/MWh;

Q<sub>b</sub> – scheduled heat energy production by the new CHP units at a boiler-house, MWh;

Q<sub>r</sub> – heat energy production by the installed new CHP units at a boiler-house in reported year, MWh;

f<sub>b</sub> – specific natural gas consumption by a boiler-house, where CHP units are scheduled to be installed, m<sup>3</sup>/MW;

B<sub>g</sub> – amount of fuel (gas) consumed by the installed CHP units for heat and power generation, ths m<sup>3</sup>;

[<sub>b</sub>] index – related to the base year;

[<sub>r</sub>] 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<sub>1</sub><sup>b</sup> 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<sub>b</sub>) ≠ 0), the formulae for E<sub>1</sub><sup>b</sup> 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<sub>b</sub>) = 0), and in the reported year this service was provided (due to improvement of heat supply service quality for population), the formulae for E<sub>1</sub><sup>b</sup> 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<sup>3</sup> (MJ/kg);

Cef – carbon emission factor, kt CO<sub>2</sub>/TJ;

B – amount of fuel consumed by a boiler-house, ths m<sup>3</sup> or tons per year;

K<sub>1</sub>, K<sub>h</sub>, K<sub>w</sub>, K<sub>w0</sub> – adjustment factors;

a – portion of fuel (heat), consumed for heating purposes;

(1-a) – portion of fuel (heat), consumed for hot water supply services;

[<sub>b</sub>] index – related to the base year;

[<sub>r</sub>] 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”<sup>1</sup>, 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<sup>2</sup>;

$k_h$  – average heat transfer factor of buildings, (kW/m<sup>2</sup>\*K);

$T_{in}$  – average inside temperature for the heating period, K (or °C);

$T_{out}$  – average outside temperature for the heating period, K (or °C);

$N_h$  – 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):

<sup>1</sup> 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.

$$K_2 = (T_{inr} - T_{outr}) / (T_{inb} - T_{outb}).$$

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

$$K_3 = (F_{hr} * k_{hr}) / F_{hb} * k_{hb} = [(F_{hr} - F_{htr} - F_{hnr}) * k_{hb} + (F_{hnr} + F_{htr}) * k_{hn}] / F_{hb} * k_{hb},$$

where:

$F_{hb}$  – heating area of buildings in the base year,  $m^2$ ;

$F_{hr}$  – heating area of buildings in the reported year,  $m^2$ ;

$F_{hnr}$  – heating area of new buildings connected to DH system (assumed with the new (improved) thermal insulation) in the reported year,  $m^2$ ;

$F_{htr}$  – heating area of buildings (previously existed in the base year) in reported year with the renewed (improved) thermal insulation,  $m^2$ ;

$k_{hb}$  – average heat transfer factor of heated buildings in the base year,  $(W/m^2 * K)$ ;

$k_{hr}$  – average heat transfer factor of heated buildings in the reported year,  $(W/m^2 * K)$ ;

$k_{hn}$  – 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):

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

where:

$N_{hb}$  – duration of the heating period in the base year, hours;

$N_{hr}$  – 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,  $Q_w$ :

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

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:

$$Q_{wbr} = Q_{wb} * K_w = Q_{wr}$$

where:

$Q_{wbr}$  – required heat for hot water supply service for Dynamic Baseline, is assumed equal to  $Q_{wr}$  – required heat for hot water supply service in the reported year,

$Q_{wb}$  – 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:

$$K_w = Q_{wr} / Q_{wb}.$$

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:

$$K_w = n_{wr} * v_{wr} * N_{wr} / n_{wb} * v_{wb} * N_{wb}$$

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

$$K_5 = n_{wr} / n_{wb}$$

3.2.  $K_6$  (standard specific discharge of hot water per personal account change factor):

$$K_6 = v_{wr} / v_{wb}$$

At present the standard specific discharge of hot water is valid in Ukraine that was established by the KTM 204 Ukraine 244-94<sup>1</sup> 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):

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

where:

$N_{wb}$  – duration of the hot water supply period in the base year, hours;

$N_{wr}$  – 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, D.1.1.3** and **Monitoring plan**.

**JI MONITORING REPORT FORM**

**A.6. Status of implementation including time table for major project parts:**

The starting date of the project according to PDD is: 30/04/2004

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 20 years, and correspondingly December 31, 2024.

2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
1st Jan - 31st Dec	1st Jan - 31st Dec	1st Jan - 31st Dec	1st Jan - 31st Dec	1st Jan - 31st Dec	1st Jan - 31st Dec	1st Jan - 31st Dec	1st Jan - 31st Dec	1st Jan - 31st Dec	1st Jan - 31st Dec
Starting date of the project is: 11March 2004									
Base year									
	Boiler houses rehabilitation								
	Network rehabilitation								
					Heat exchangers replacement				
					Liquidation of HDS				
					Frequency controllers installation				
						CHP units installation			
					1 st Kyoto commitment period				
			1 st Monitoring Period		2 nd Monitoring Period				

*Table 2: Status of implementation (according to PDD)*

Implementation of boiler houses rehabilitation and network rehabilitation are realized according to project plan. In several cases replacement of different (from planned before) diameters of network pipes takes place. Installation of frequency controllers is not finished yet.

Table of implemented energy saving measures is presented below.

**JI MONITORING REPORT FORM**

Implemented energy saving measures	Volume of performed works (number of boilers, etc.) 2004-2007	Volume of performed works (number of boilers, etc.) 2008	Total	By PDD till 2008	Percentage of project implementation
Switch load to other boiler houses and CHP	25	10	35	72	49
Carrying out of boiler house from basement with gas furnace plant organizing	9	0	9	18	50
Furnace plant organizing	3	0	3	3	100
Liquidation or reconstruction of heating points	7	4	11	5	220
Replacement of boilers	76	14	90	53	170
Heat exchangers replacement	7	11	18	62	29
Frequency controllers installation	0	60	60	117	51
Additional energy saving measures					
Replacement of heating surface	76	2	78		
Switch boiler in hot -water mode	1	0	1		
Installation of automatic system of regulation on boilers	2	0	2		
Pre-insulated network replacement, m	75860	29000	104860	134860	78
Usual pipe network replacement, m	121600				
Restoration of pipes insulation, m	65864				

For detailed information about implemented measures see Annex 2.

**A.7. Intended deviations or revisions to the registered PDD:**

At first the PDD for this project - “Rehabilitation of the District Heating System in Kharkiv City”, - version 02 from July 15, 2008, was submitted to TUV SUD for determination. This version was published at the UNFCCC site for global stakeholder process - Reference number 0150 (Comment period 24 Jul 08 - 22 Aug 08).. During the determination, the Determination Protocol was received from TUV SUD with clarification requests and corrective action requests. After meeting of all requirements of determinator, in PDD Version 04, dated November 24, 2008, TUV SUD has issued the Final Determination Report # 1201751 from December 16, 2008.

The National Environmental Investment Agency of Ukraine has confirmed this JI project under Track 1 procedure by the Order No. 86 dated December 29, 2008.

**A.8. Intended deviations or revisions to the registered monitoring plan:**

There are no deviations or revisions to the registered monitoring plan.  
PDD with Monitoring plan for this project was determined by TUV SUD in the Final Determination Report # 1201751 from December 16, 2008.

**A.9. Changes since last verification:**

1 st Monitoring Report was prepared for period January 1, 2005- December 31, 2007 on December, 17 2008 (Version 01).  
Additional fuel and energy saving measures were realized at the ME "Kharkivski teplovi merezhi" within this project that led to additional GHG emissions reduction.

**A.10. Person(s) responsible for the preparation and submission of the monitoring report:**

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**SECTION B. Key monitoring activities**

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 caring out in volume units relate to standard conditions by means of automatic correction for temperature and pressure. The typical Gas distribution unit is shown at the fig. 1, typical Gas flow meter is shown at the fig. 2.



*Fig. 1. Gas distribution unit*



*Fig. 2. Gas flow meter*

The typical scheme of the Gas distributing system is shown at the fig. 3. Usually it consists of the following equipment:

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

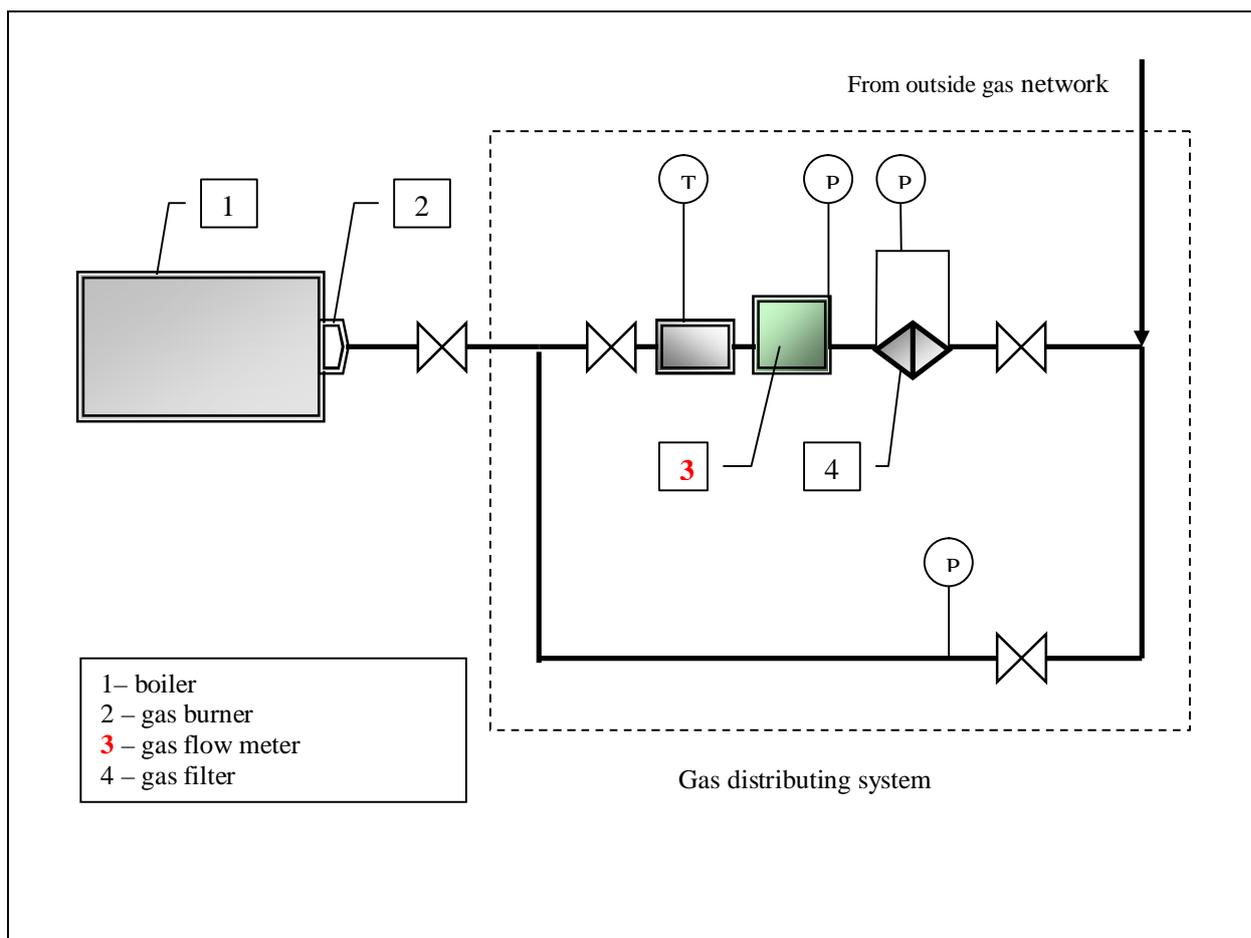


Fig. 3. Scheme of the Gas distribution system

Every hour operator of a boiler house read the values of outside air temperature, temperature of the natural gas and gas pressure at the entrance to the boiler-house. Natural gas consumption is measured by gas flow meters, installed at the every boiler-house. Every day operator of a boiler house make registration of daily gas consumption in the special paper journal.

T – outside air temperature and temperature of the natural gas;  
P - gas pressure at the entrance to the boiler-house.

**B.1. Monitoring equipment types:**

For gas consumption measurement the following Gas flow meters are used:

GMS-G-10 .... GMS-616-32	Produced by "Arsenal" plant Kiev city
BPCF-1	Produced by "Electroprylad" Kazan city
BK-011	Produced by "Energooblik" Kharkiv city
LG-K-80...200	Produced by Ivano-Frankivsk plant JSC "Promprylad"
RGK-100 ... 1000	Produced by Ivano-Frankivsk plant JSC "Promprylad"
RGK-40 ... 400	Produced by Ivano-Frankivsk plant JSC "Promprylad"
BK-610-T	Produced by Dnipropetrovsk city-Czechia

## JI MONITORING REPORT FORM

DELTA G-16	Produced in Slimburzhe city, France
Corrector КПЛГ-2.01	Produced by "Radmirteh" Kharkiv city
Corrector КПЛГ-1.02	Produced by "Radmirteh" Kharkiv city
Corrector METRIX-66	Produced in Czechia

### B.1.1. Table providing information on the equipment used:

See Annex 3 and Annex 5.

### B.1.2. Calibration procedures:

According to valid legislation, all measuring equipment in Ukraine should meet the specified requirements of corresponding standards and is subject to the periodical verifying.

Type of Gas flue meters	Calibration interval
GMS-G-10 .... GMS-616-32	2 years
BPCГ-1	2 years
BK-011	2 years
LG-K-80...200	2 years
RGK-100 ... 1000	2 years
RGK-40 ... 400	2 years
BK-610-T	2 years
DELTA G-16	2 years
Corrector КПЛГ-2.01	2 years
Corrector КПЛГ-1.02	2 years
Corrector METRIX-66	2 years
Electricity meters	4 years

According to the Monitoring Plan the volume of consumed natural gas and consumed power was corrected by measurement error using the principle of conservatism. Natural gas consumption and power consumption in the reported year that used for Project emissions calculations were increased on the level of accuracy of gas flue meters and electricity meters installed at the every boiler-house.

See Annex 2 and Annex 4.

### B.1.3. Involvement of Third Parties:

Measurement equipment calibration was carried out by DE "Kharkiv center of standardization, and metrology and calibration" for gas flow meters and for electricity meters. Electricity meters installation carried out by JSC "Kharkivoblenergo". Passports for again installed electricity meters are not given.

## JI MONITORING REPORT FORM

### B.2. Data collection (accumulated data for the whole monitoring period):

Data used for monitoring the emission reductions are presented in the table in Section B.2.1 (List of fixed default values, variables and attached values) and in Annex 1 (Data), Annex 2 (CO<sub>2</sub> emissions reduction calculations at the ME "Kharkivski teplovi merezhi") and Annex 4 (CO<sub>2</sub> emissions reduction due to power saving at the ME "Kharkivski teplovi merezhi") of this report. The table in Section B.2.1 contains all default values, variables and attached values that have been used in calculating emission reductions in this monitoring report.

#### B.2.1. List of fixed default values, variables and attached values:

	Symbol	Data variable	Data unit	Measured (m), calculated (c), estimated (e)
1	( <b>B<sub>b</sub></b> ) and ( <b>B<sub>r</sub></b> )	Fuel consumption at boiler houses		m
1.1		Natural Gas	m <sup>3</sup>	
1.2		Coal	ton	
2	( <b>LHV<sub>b</sub></b> ) and ( <b>LHV<sub>r</sub></b> )	Average annual Heating Value of a fuel calculated by Lower Heating Value		m, c
2.1		Natural Gas	MJ/m <sup>3</sup>	
2.2		Coal	MJ/kg	
3	( <b>T<sub>out b</sub></b> ) and ( <b>T<sub>out r</sub></b> )	Average outside temperature during the heating season	<sup>0</sup> C (K)	m, c
4	( <b>T<sub>in b</sub></b> ) and ( <b>T<sub>in r</sub></b> )	Average inside temperature during the heating season	<sup>0</sup> C (K)	m, c
5	( <b>n<sub>wb</sub></b> ) and ( <b>n<sub>wr</sub></b> )	Number of Customers		Statistics
6	( <b>F<sub>hb</sub></b> ) and ( <b>F<sub>hr</sub></b> )	Heating area (total)	m <sup>2</sup>	Statistics
7	( <b>k<sub>hb</sub></b> )	Average heat transfer factor of heated buildings in the base year	W/m <sup>2</sup> *K	c
8	( <b>F<sub>ht r</sub></b> )	Heating area of buildings (previously existed in the base year) with the renewed (improved) thermal insulation in the reported year	m <sup>2</sup>	Statistics
9	( <b>F<sub>hn r</sub></b> )	Heating area of newly connected buildings (assumed with the new (improved) thermal insulation) in the reported year	m <sup>2</sup>	Statistics
10	( <b>k<sub>hn</sub></b> )	Heat transfer factor of buildings with the new thermal insulation	W/m <sup>2</sup> *K	Normative documents
11	( <b>N<sub>hb</sub></b> ) and ( <b>N<sub>hr</sub></b> )	Duration of the heating period	Hours	m
12	( <b>N<sub>wb</sub></b> ) and ( <b>N<sub>wr</sub></b> )	Duration of the hot water supply period	Hours	m
13	( <b>L<sub>h<sup>b</sup></sub></b> ) and ( <b>L<sub>h<sup>r</sup></sub></b> )	Maximum connected load to the boiler-house, that is required for heating	MW	c

**JI MONITORING REPORT FORM**

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 <sub>2</sub> /TJ	
16.2		Coal	kt CO <sub>2</sub> /TJ	
17	<b>g</b>	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

**B.2.2. Data concerning GHG emissions by sources according to the project activity:**

See Annex 1, Annex 2 and Annex 4 of this monitoring report.

**B.2.3. Data concerning GHG emissions by sources according to the baseline:**

See Annex 1, Annex 2 and Annex 4 of this monitoring report.

**B.2.4. Data concerning leakage:**

There are no leakage effects associated with this project. Therefore monitoring of leakage is not required.

**B.2.5. Data concerning environmental and social impacts:**

Implementation of project “Rehabilitation of the District Heating System of Crimea” has a positive effect on environment. Following points give detailed information on environmental benefits.

1. Project implementation allowed to save over 166 million Nm<sup>3</sup> of natural gas, over 334 ton of coal and 17358 ths. kWh of power during 2008.
2. Due to fuel economy and new environmentally friendlier technologies of fuel combustion, project implementation reduced emissions of SO<sub>x</sub>, NO<sub>x</sub>, CO and particulate matter (co-products of combustion).

There are no negative social impacts associated with the project

**B.3. Data processing and archiving (including software used):**

Registration of Natural gas consumption at boiler houses of ME "Kharkivski teplovi merezhi" is carried out by the following scheme:

1. All boiler-houses are equipped with gas flow meters.
2. For automatic fuel control: gas flue commercial system, installed at gas distributing units of the boiler-houses, that consist of - gas flow meter and automatic corrector for temperature and pressure. Gas consumption registered automatically. 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.

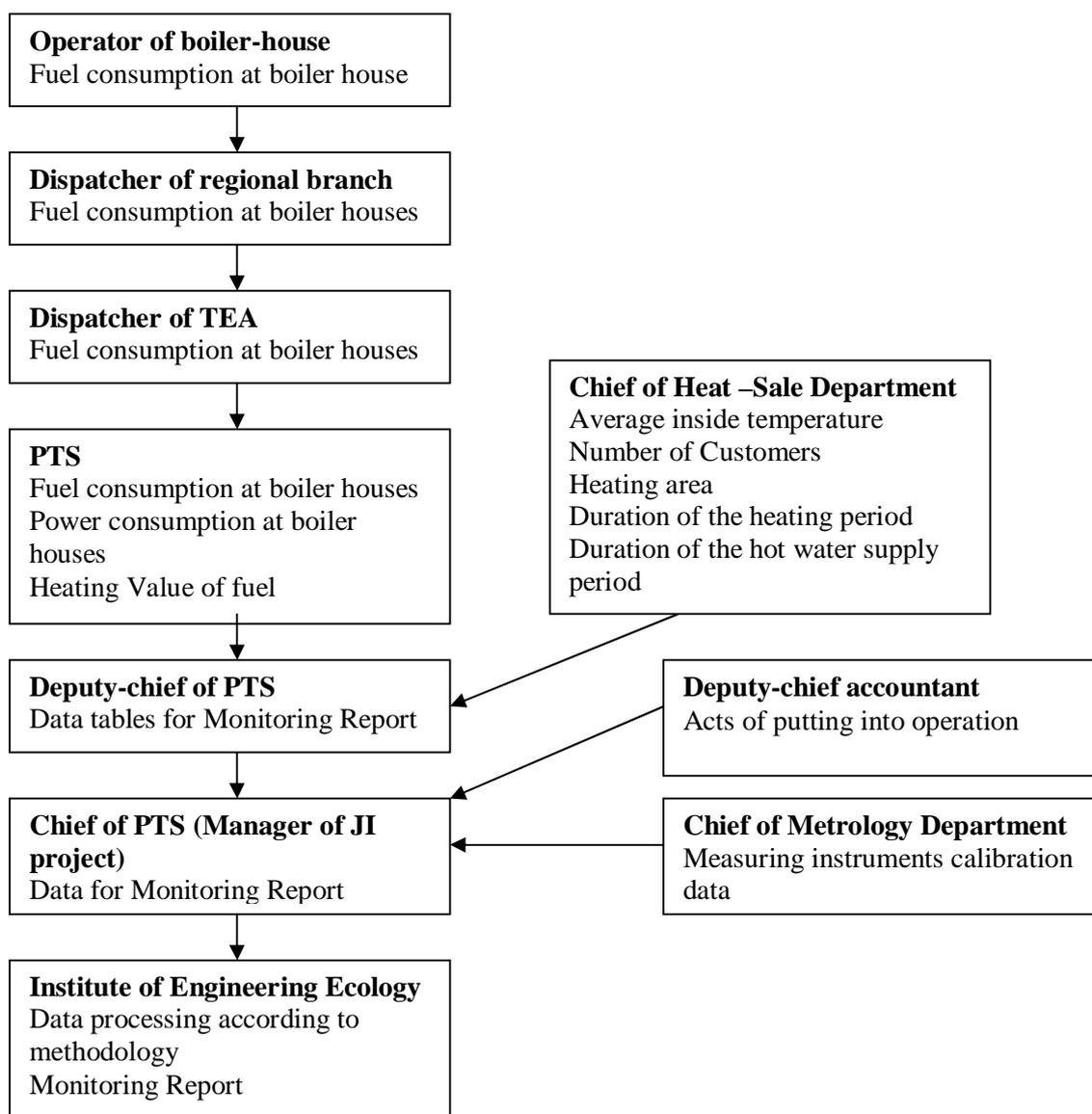
Scheme of data collection for Monitoring Report is shown at the Fig. 6.

Дата	Температура	Давление	Газ	Давление	Газ	Давление	Газ	Давление	Газ
8	4.5	3.8	3.6	4.2	3.4	3.4	3.8	4.0	1.4
9	4.5	3.9	3.5	4.2	3.4	3.6	3.8	4.0	1.4
10	4.8	3.8	3.5	4.2	3.4	3.8	4.0	4.0	1.5
11	4.8	3.8	3.5	4.2	3.4	3.6	3.8	4.0	1.5
12	4.8	3.8	3.5	4.2	3.4	3.8	4.0	4.0	1.5
13	4.8	3.8	3.5	4.2	3.4	3.8	4.0	4.0	1.5
14	4.8	3.8	3.5	4.2	3.4	3.8	4.0	4.0	1.5
15	4.8	3.8	3.5	4.2	3.4	3.8	4.0	4.0	1.5
16	4.8	3.8	3.5	4.2	3.4	3.8	4.0	4.0	1.5
17	4.8	3.8	3.5	4.2	3.4	3.8	4.0	4.0	1.5
18	4.8	3.8	3.5	4.2	3.4	3.8	4.0	4.0	1.5

Fig. 5 Paper journal for natural gas consumption registration

**B.4. Special event log:**

n.a.



*Fig.6. Scheme of data collection for Monitoring Report*

**SECTION C. Quality assurance and quality control measures****C.1. Documented procedures and management plan:****C.1.1. Roles and responsibilities:**

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.

**C.1.2. Trainings:**

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 implementation 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 "Pervomaiskieselmash" – the producer of cogeneration units – during all period of operation of engines-generators usually renders to purchasers 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 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 responsible stuff of the Production-Technical Service of ME "Kharkivski teplovi merezhi" is involved in this process.

**C.2. Involvement of Third Parties:**

There were no third parties involved.

**C.3. Internal audits and control measures:**

Measurement equipment calibration was carried out by DE "Kharkiv center of standardization, and metrology and calibration" for gas flow meters and for electricity meters.

**C.4. Troubleshooting procedures:**

Any problem occurring that concerns this project is to be reported immediately to the project manager, who takes the appropriate measures.

**SECTION D. Calculation of greenhouse gas emission reductions**

**D.1. Formulae used:**

In this section the formulae used for computing project emissions, baseline emissions and the total emission reduction are documented.

**Total emission reduction**

The total annual emission reduction is the difference between the baseline emissions (BE) and the project emissions (PE).

<b>Formula 1 – Total emission reduction (ERUs)</b>	
	$ERUs = \sum[E_i^b - E_i^r]; [t\ CO_2\text{-eq.}]$
	ERUs - Total annual emission reduction [t CO <sub>2</sub> -eq.] E <sub>i</sub> <sup>b</sup> - Baseline CO <sub>2</sub> emissions [t CO <sub>2</sub> -eq.] E <sub>i</sub> <sup>r</sup> - CO <sub>2</sub> emissions in the reported year [t CO <sub>2</sub> -eq.]
	The sum is taken over all boiler-houses (i) which are included into the project

**Project emissions**

<b>Formula 2 –Emissions in the reported year (E<sup>r</sup>)</b>	
	$E_i^r = E_{li}^r + E_{cons\ i}^r; [tCO_2\text{-eq.}]$
	E <sub>li</sub> <sup>r</sup> – CO <sub>2</sub> emissions due to fuel consumption for heating and hot water supply service for an i boiler-house in the reported year, t CO <sub>2</sub> e; E <sub>cons i</sub> <sup>r</sup> – CO <sub>2</sub> emissions due to electric power consumption from greed by the i boiler-house in the reported year, t CO <sub>2</sub> e.
	CO <sub>2</sub> emissions due to electric power generation associated to the project in the reported were not calculated follow the principle of conservatism

<b>Formula 3 – CO<sub>2</sub> emissions due to fuel consumption for heating and hot water supply service for an i boiler-house in the reported year, (E<sub>li</sub><sup>r</sup>)</b>	
	$E_{li}^r = LHV_r * Cef_r * B_{ri}, [tCO_2\text{-eq.}]$
	LHV <sub>ri</sub> – Average annual lower heating value, MJ/m <sup>3</sup> (MJ/kg) Average annual Heating Value is calculated for every town; Cef – carbon emission factor, ktCO <sub>2</sub> /TJ; B <sub>ri</sub> – amount of fuel consumed by a boiler-house in the reported year, ths m <sup>3</sup> or tons;

**JI MONITORING REPORT FORM**

<b>Formula 4</b> – CO <sub>2</sub> 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; $CEF_c$ – Carbon Emission factors for reducing electricity consumption in Ukraine, tCO <sub>2</sub> e/MWh;

**Baseline emissions**

<b>Formula 5</b> – Annual baseline emissions ( $E_b$ )	
$E_i^b = E_{li}^b + E_{cons\ i}^b$ ; [t CO <sub>2</sub> -eq.]	
	$E_{li}^b$ – baseline CO <sub>2</sub> emissions due to fuel consumption for heating and hot water supply service for an i boiler-house, t CO <sub>2</sub> e; $E_{cons\ i}^b$ – CO <sub>2</sub> emissions due to electric power consumption from greed by the i boiler-house in the base year, t CO <sub>2</sub> e.
	Baseline CO <sub>2</sub> emissions due to electric power generation associated to the project were not calculated follow the principle of conservatism

<b>Formula 6</b> – Baseline CO <sub>2</sub> emissions due to fuel consumption for heating and hot water supply service for an i boiler-house, ( $E_{li}^b$ )	
	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 $E_{li}^b$ is: $E_{li}^b = LHV_b * Cef_b * [B_b * a_b * K_1 * K_h + B_b * (1-a_b) * K_1 * K_w]$ , 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 $E_{li}^b$ is: $E_{li}^b = LHV_b * Cef_b * [B_b * a_b * K_1 * K_h + B_r * (1-a_r) * K_1 * K_{w0}]$ .
	$LHV_b$ – Average annual lower heating value in the base year, MJ/m <sup>3</sup> (MJ/kg); $Cef_b$ – carbon emission factor, KtCO <sub>2</sub> /TJ; $B_b$ – amount of fuel consumed by a boiler-house in the base year, ths m <sup>3</sup> 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.

**JI MONITORING REPORT FORM**

<b>Formula 7 – Portion of fuel (heat), consumed for heating purposes in the base year (<math>a_b</math>)</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; $L_w^b$ – connected load required for hot water supply service in the base year , MW; $g$ – recalculating factor for average load during heating period (usually 0,4-0,8); $N_h^b$ – duration of heating period in the base year , hours $N_w^b$ – duration of hot water supply service in the base year, hours.

<b>Formula 8 – Portion of fuel (heat), consumed for heating purposes in the reported year (<math>a_r</math>)</b>	
	$a_r = L_h^r * q * N_h^r / (L_h^r * g * N_h^r + L_w^r * N_w^r)$
	$L_h^r$ – maximum connected load required for heating in the reported year , MW; $L_w^r$ – 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.

<b>Formula 9 – Change in the lower heating value (<math>K_1</math>)</b>	
	$K_1 = LHV_b / LHV_r$
	$LHV_b$ – Average annual lower heating value in the base year, MJ/m <sup>3</sup> (MJ/kg); $LHV_r$ – Average annual lower heating value in the reported year, MJ/m <sup>3</sup> (MJ/kg)

<b>Formula 10 – Temperature change factor (<math>K_2</math>)</b>	
	$K_2 = (T_{in r} - T_{out r}) / (T_{in b} - T_{out b})$
	$T_{in r}$ – average inside temperature for the heating period in the reported year, K (or °C); $T_{in b}$ – average inside temperature for the heating period in the base year, K (or °C); $T_{out r}$ – average outside temperature for the heating period in the reported year , K (or °C); $T_{out b}$ – average outside temperature for the heating period in the reported year , K (or °C)

**JI MONITORING REPORT FORM**

<b>Formula 11 – Heating area and building thermal insulation change factor (<math>K_3</math>)</b>	
	$K_3 = [(F_{hr} - F_{htr} - F_{hnr}) * k_{hb} + (F_{hnr} + F_{htr}) * k_{hn}] / F_{hb} * k_{hb},$
	<p><math>F_{hb}</math> – heating area in the base year, <math>m^2</math>;  <math>F_{hr}</math> – heating area in the reported year, <math>m^2</math>;  <math>F_{hnr}</math> – heating area of new buildings connected to DH system (assumed with the new (improved) thermal insulation) in the reported year, <math>m^2</math>;  <math>F_{htr}</math> – heating area of buildings (previously existed in the base year) in reported year with the renewed (improved) thermal insulation, <math>m^2</math>;  <math>k_{hb}</math> – average heat transfer factor of heated buildings in the base year, <math>(W/m^2 * K)</math>;  <math>k_{hn}</math> – heat transfer factor of heated buildings with the new thermal insulation (new buildings or old ones with improved thermal insulation), <math>(W/m^2 * K)</math>.</p>

<b>Formula 12 – Heating period duration change factor (<math>K_4</math>)</b>	
	$K_4 = N_{hr} / N_{hb}$
	<p><math>N_{hb}</math> – duration of heating period in the base year, hours  <math>N_{hr}</math> – duration of heating period in the reported year, hours</p>

<b>Formula 13 – Number of customers change factor (<math>K_5</math>)</b>	
	$K_5 = n_{wr} / n_{wb}$
	<p><math>N_{wb}</math> – number of customers in base year;  <math>N_{wr}</math> – number of customers in the reported year</p>

<b>Formula 14 – Standard specific discharge of hot water per personal account change factor (<math>K_6</math>)</b>	
	$K_6 = v_{wr} / v_{wb}$
	<p><math>v_{wr}</math> – standard specific discharge of hot water per personal account in the reported year, (in heat units, kWh/h);  <math>v_{wb}</math> – standard specific discharge of hot water per personal account in the base year, (in heat units, kWh/h).</p>

**JI MONITORING REPORT FORM**

<b>Formula 15</b> – 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. $N_{wb}$ – duration of hot water supply service in the base year, hours.

<b>Formula 16</b> – CO <sub>2</sub> 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; $CEF_c$ – Carbon Emission factors for reducing electricity consumption in Ukraine, tCO <sub>2</sub> e/MWh;

**D.3. GHG emission reductions (referring to B.2 of this document):**

**D.3.1. Project emissions:**

Project emissions consist of CO<sub>2</sub> emissions due to fuel consumption for heating and hot water supply service at ME "Kharkivski teplovi merezhi" and of CO<sub>2</sub> emissions due to electric power consumption from the grid in the reported year.

<b>Project emissions, tCO<sub>2</sub>e</b>	2008
CO <sub>2</sub> emissions due to fuel consumption	1699722,0
CO <sub>2</sub> emissions due to electric power consumption	152902,6
Total	1852624,6

*Table 3: Project emissions*

**D.3.2. Baseline emissions:**

Baseline emissions consist of Baseline CO<sub>2</sub> emissions due to fuel consumption for heating and hot water supply service at ME "Kharkivski teplovi merezhi" and of CO<sub>2</sub> emissions due to electric power consumption from the grid.

<b>Baseline emissions, tCO<sub>2</sub>e</b>	2008
CO <sub>2</sub> emissions due to fuel consumption	1983256,3
CO <sub>2</sub> emissions due to electric power consumption	165457,4
Total	2148713,7

*Table 4: Baseline emissions*

**D.3.3. Leakage:**

There is no leakage associated with the project.

**D.3.4. Summary of the emissions reductions during the monitoring period:**

<b>Emission Reduction, tCO<sub>2</sub>e</b>	2008
CO <sub>2</sub> emissions reduction due to fuel saving	283534,3
CO <sub>2</sub> emissions due to electric power saving	12554,8
Total	296089,1

*Table 5: Total Emission Reductions*

**JI MONITORING REPORT FORM****Annex 1 – Data**

The data in this Annex are presented in accordance with Parameter 1-20 in the Monitoring plan.

<b>Parameter Number</b>	<b>Parameter Name</b>
1	Fuel consumption at boiler houses
1.1	Natural Gas
1.2	Coal
2	Average annual Heating Value of a fuel calculated by Lower Heating Value
2.1	Natural Gas
2.2	Coal
3	Daily outside temperature during the heating season
4	Average inside temperature during the heating season
5	Number of Customers
6	Heating area (total)
7	Heat transfer factor of buildings
8	Heating area of buildings (previously existed in the base year) with the renewed (improved) thermal insulation in the reported year
9	Heating area of newly connected buildings (assumed with the new (improved) thermal insulation) in the reported year
10	Heat transfer factor of new buildings and buildings with new thermal insulation
11	Heating period duration
12	Duration of the hot water supply period
13	Maximum connected load to the boiler-house, that is required for heating
14	Connected load to the boiler-house, that is required for hot water supply service
15	Standard specific discharge of hot water per personal account
16	Carbon emission factor
16.1	Natural Gas
16.2	Coal
17	Recalculating factor for average load during heating period
18	Scheduled electric power production ( was not take into consideration)
19	Scheduled heat energy production ( was not take into consideration)
20	Power consumption

**JI MONITORING REPORT FORM**

<b>Parameter number and name</b> (according to PDD monitoring plan)	<b>1.1 Natural gas consumption at boiler houses</b>
Description	Natural gas consumption at boiler houses
Value in monitoring period	2008 – 8666915,1 ths m <sup>3</sup>  The detailed data of natural gas consumption by every boiler-house are presented in Annex 2.
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.
Comment	According to the Monitoring Plan the volume of consumed natural gas was corrected by measurement error using the principle of conservatism. Natural gas consumption in the reported year that used for Project emissions calculations was increased on the level of accuracy of gas flue meters installed at the every boiler-house. See Annex 2 and Annex 3.

<b>Parameter number and name</b> (according to PDD monitoring plan)	<b>1.2 Coal consumption at boiler houses</b>
Description	Coal was consumed only at boiler houses Ak. Pavlova, 30/30-A, Feyerbaha sq.,12 in 2008.
Value in monitoring period	2008 – 89,3 ton
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. Invoices are filed in special journals.
Calculation method	n.a.
Comment	The detailed data of Coal consumption by every boiler-house are presented in Annex 2.

**JI MONITORING REPORT FORM**

<b>Parameter number and name</b> (according to PDD monitoring plan)	<b>2.1</b> Average annual Heating Value of Natural Gas
Description	Average annual Heating Value of Natural Gas calculated by Lower Heating Value
Value in monitoring period	Average annual Heating Value of Natural Gas was approximately 34,6 MJ/m <sup>3</sup> during 2008 year.
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 monthly
Background data	Registered in the paper journal
Calculation method	Weighted average value
Comment	

<b>Parameter number and name</b> (according to PDD monitoring plan)	<b>2.2</b> Average annual Heating Value of Coal
Description	Average annual Heating Value of Coal
Value in monitoring period	Average annual Heating Value of Coal was approximately 19 MJ/t during 2008 year.
Monitoring method	Accepted in accordance with quality certificate from heavy oil 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 heavy oil supplier for every consignment
Background data	Certificates are filed in special journals
Calculation method	Weighted average value

<b>Parameter number and name</b> (according to PDD monitoring plan)	<b>3.</b> Daily outside temperature during the heating season
Description	Average daily outside temperature during the heating season
Value in monitoring period	During the heating season 2008 - 0,85°C
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	Every day of heating season

## JI MONITORING REPORT FORM

Background data	Meteorological Centre sends the Report every month for every day of heating season. Reports are filed in special journals
Calculation method	Average value

<b>Parameter number and name</b> (according to PDD monitoring plan)	<b>4. Average inside temperature during the heating season</b>
Description	<p>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 °C) is not satisfied)</p> <p>Above 18 °C – is treated as 18 °C (according to the conservatism principle) and as meeting the normative. Below 18 °C – is treated as not meeting the normative, and is calculated as below.</p>
Value in monitoring period	The inside temperature at the consumer’s houses in Kharkiv was 18 °C during 2008 year.
Monitoring method	<p>The inside temperature was calculated from the sum of returned payments to population of Kharkiv city. According to “Rules of rendering of heat and hot water supply service to population” № 1497 from 30.12.1997, enterprise makes the return payment of:</p> <ul style="list-style-type: none"> <li>– 5% from payment for every degree from 18 to 12 °C;</li> <li>– 10% from payment for every degree from 12 to 5 °C;</li> <li>– when inside temperature is lower than 5 °C, the payment is to be returned completely.</li> </ul> <p>Therefore the inside temperature was calculated by formulae  <math>T_{in} = 18 - (R/5)</math>  R - % of return payment</p> <p>The total sum of charge for population of Kharkiv city in 2008 was 1014 mln hrn. The sum of returned payment was 0,8 mln hrn. Percentage of returned payment is 0.08 % that corresponds to inside temperature 18 °C.</p>
Recording frequency	Once per heating season
Background data	Sums of return payment
Calculation method	Principle of conservatism

**JI MONITORING REPORT FORM**

<b>Parameter number and name</b> (according to PDD monitoring plan)	<b>5. Number of Customers for hot water supply service</b>
Description	Number of Customers for hot water supply service for every boiler houses
Value in monitoring period	See Annex 2
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	

<b>Parameter number and name</b> (according to PDD monitoring plan)	<b>6. Heating area (Total)</b>
Description	Heating area for every boiler houses
Value in monitoring period	The detailed data of heating area for every boiler-house are presented in Annex 2. Heating areas connected to ME "Kharkivski teplovi merezhi" were 28206,5 ths m <sup>2</sup> in 2008.
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. 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
Comment	

<b>Parameter number and name</b> (according to PDD monitoring plan)	<b>7. Heat transfer factor of buildings</b>
Description	Heat transfer factor of buildings for every boiler-house
Value in monitoring period	The detailed data of Heat transfer factor of buildings for every boiler-house are presented in Annex 2
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.

**JI MONITORING REPORT FORM**

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.

<b>Parameter number and name</b> (according to PDD monitoring plan)	<b>8.</b> 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
Value in monitoring period	There were no reconstructed buildings with application of new insulations for walls in the operation area of boiler-houses ME "Kharkivski teplovi merezhi"
Monitoring method	Statistics ME "Kharkivski teplovi merezhi"
Recording frequency	Once per year
Background data	
Calculation method	

<b>Parameter number and name</b> (according to PDD monitoring plan)	<b>9.</b> 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
Value in monitoring period	There were no new buildings connected to boiler-houses of ME "Kharkivski teplovi merezhi"
Monitoring method	Statistics ME "Kharkivski teplovi merezhi"
Recording frequency	Once per year
Background data	
Calculation method	

<b>Parameter number and name</b> (according to PDD monitoring plan)	<b>10.</b> Heat transfer factor of new buildings and buildings with new thermal insulation
Description	Heat transfer factor of buildings with new thermal insulation
Value in monitoring period	Not higher than 0.36
Monitoring method	According to State Buildings Norms (B.2.6-31:2006)
Recording frequency	
Background data	
Calculation method	

**JI MONITORING REPORT FORM**

<b>Parameter number and name</b> (according to PDD monitoring plan)	<b>11. Heating period duration</b>
Description	Heating period duration in every town
Value in monitoring period	Heating period duration for every year was following: 2008 – 4440 hours.
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 °C or lower during 3 days, and finishes if average daily outside temperature is 8 °C or higher during 3 days. 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	

<b>Parameter number and name</b> (according to PDD monitoring plan)	<b>12. Duration of the hot water supply period</b>
Description	Duration of the period of hot water supply service for every boiler house.
Value in monitoring period	The detailed data on Duration of the period of hot water supply service for every boiler-house are presented in Annex 2.
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. In Kharkiv city Hot water supply service is usually 24 hours 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	

**JI MONITORING REPORT FORM**

<b>Parameter number and name</b> (according to PDD monitoring plan)	<b>13.</b> 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.
Value in monitoring period	The detailed data of maximum connected load to the boiler-house, that is required for heating for every boiler-house, are presented in Annex 2.
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 °C.
Calculation method	

<b>Parameter number and name</b> (according to PDD monitoring plan)	<b>14.</b> 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
Value in monitoring period	The detailed data of connected load, that is required for hot water supply service for every boiler-house are presented in Annex 2.
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	

<b>Parameter number and name</b> (according to PDD monitoring plan)	<b>15.</b> Standard specific discharge of hot water per personal account
Description	Standard specific discharge of hot water per personal account
Value in monitoring period	Standard specific discharges of hot water per personal account for different types of consumers are presented in “KTM 204 Ukraine 244-941”.
Monitoring method	Statistics
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	

**JI MONITORING REPORT FORM**

<b>Parameter number and name</b> (according to PDD monitoring plan)	<b>16. Carbon emission factor</b>
Description	Carbon emission factor for different fuels
Value in monitoring period	Cef (natural gas) = 0.0561 ktCO <sub>2</sub> /TJ; Cef (coal) = 0.0946 ktCO <sub>2</sub> /TJ; (taken as “Other bituminous coal”).
Monitoring method	Normative documents
Recording frequency	Once per year .
Background data	For all fuels we used CO <sub>2</sub> 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].
Calculation method	

<b>Parameter number and name</b> (according to PDD monitoring plan)	<b>17. Recalculating factor for average load during heating period</b>
Description	Recalculating factor for determination of the average load during heating period
Value in monitoring period	Recalculating factor is 0.5
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	$g = Q_{av}/Q_{max} = F_h * k_h * (T_{in} - T_{out av}) / F_h * k_h * (T_{in} - T_{out min})$ <p>where:</p> <p>g – recalculating factor for average load during heating period;  F<sub>h</sub> – heating area of buildings, m<sup>2</sup>;  k<sub>h</sub> – average heat transfer factor of heated buildings, (W/m<sup>2</sup>*K);  T<sub>in</sub> – average inside temperature for the heating period, K ;  T<sub>out av</sub> – average outside temperature for the heating period, K (or °C);  T<sub>out min</sub> – minimal outside temperature for the heating period, K (or °C).</p>

**JI MONITORING REPORT FORM**

<b>Parameter number and name</b>	<b>20. Electric power consumption</b>
Description	Electric power consumption by the boiler-houses where energy saving measures were implemented
Value in monitoring period	Electric power consumption in 2008 - 147304,1 ths.kWh
Monitoring method	Measurement by Electricity supply meters
Recording frequency	Every day
Background data	Electric power consumption was measured at the following objects: 1. Boiler houses and CHP, in the heating area of which reconstruction and liquidation of HDS will take place. 2. HDS that will be reconstructed and liquidated. 3. Boiler houses and HDS, where frequency controllers will be installed
Calculation method	According to the Monitoring Plan the volume of consumed electric power was corrected by measurement error using the principle of conservatism. Electric power consumption in the reported year that used for Project emissions calculations was increased on the level of accuracy of electricity meters installed at the every boiler-house. See Annex 4 and Annex 5.