# JI PROJECT MONITORING REPORT

**# UA1000027 / 5**

**Version 02**

**March 15, 2012**

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

**CONTENTS**



**ANNEXES**



* Annexes 2-5 are provided on electronic data medium.

## 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:

ITL project ID - UA 1000027

### 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 ($CO_2$ 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 (in the 2-pipe calculation), that are managed by ME "Kharkivski teplovi merezhi".

Project provides installation of cogeneration units of JSC "Pervomaiskdieselmash" (Ukraine) - 3 gas engine-generator machines DvG1A-630, with total capacity 1890 kW at boiler houses of Saltivskiy Living Area (KSZHM).

The following activities will ensure fuel saving:

- Replacement of old boilers by the new highly efficient boilers;
- Switch load from boiler-houses with obsolete equipment to modern equipped boiler houses and CHP plants and units.
- Switch 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.

The PDD for this project Version 04 dated November 24, 2008 was determined by TUV SUD (the Determination Report # 1201751 dated December 16, 2008).

Letter of Approval from the Party of buyer - The Netherlands # 2008JI10 was issued on 19.12.2008[1].

The National Environmental Investment Agency of Ukraine has issued the Letter of Approval for this project #1144/23/7 dated 24.12.2008[2].

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.

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

| Year | Baseline emissions, $tCO_2e$ | Project emissions, $tCO_2e$ | Emission reduction, $tCO_2e$ |
|---|---|---|---|
| 2011 | 2402653 | 2009996 | 392657 |

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

### A.4. Monitoring period:

- Monitoring period starting date: 01/01/2011
- Monitoring period closing date: 31/12/2011

### A.5. Methodology applied to the project activity:

#### A.5.1. Baseline methodology:

According to the "Guidelines for users of the JI PDD form" version 04[3], the baseline shall be established on a project-specific basis, or where applicable, project participants may opt to apply approved clean development mechanism (CDM) baseline and monitoring methodologies.

In course of development of this JI project **"Rehabilitation of the District Heating System in Kharkiv City"**, in accordance with paragraph 9(a) of the "Guidance on criteria for baseline setting and monitoring", the project specific approach was used, developed in accordance with appendix B "Criteria for baseline setting and monitoring" of the JI guidelines.

This project specific approach is partly similar to the Baseline and monitoring methodology AM0044 "Energy efficiency improvement projects: boiler rehabilitation or replacement in industrial and district heating sectors" (version 1)[4],, however the AM0044 can not be used for the JI project "Rehabilitation of the District Heating System in Kharkiv City" since this project has some differences from applicability conditions of this methodology.

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

[1] *http://neia.gov.ua/nature/doccatalog/document?id=116758*
[2] *http://neia.gov.ua/nature/doccatalog/document?id=116759*
[3] *http://ji.unfccc.int/Ref/Documents/Guidelines.pdf*
[4] *http://cdm.unfccc.int/UserManagement/FileStorage/CDMWF_AM_L4AQZSBA770KNI0BUSG1JVIWCXIFU5*

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, 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 production per year $EG_{BL, his, i}$ (average historic thermal energy output from the baseline boiler "i"), etc.

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 this project includes also such kind of modernization as well as some others such as the replacement of burner equipment, installation of cogeneration units, etc.

Approved Consolidated Methodology ACM0009 "Consolidated baseline methodology for fuel switching from coal or petroleum fuel to natural gas" (version 03.2)[5] proposes the dependences for baseline and reported year emissions quantity definition, 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.

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.

In additional, the proposition in ACM0009 to take (by conservatism approach) 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" (version 03)[6] 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 and its monitoring plan, 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'. 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.

In view of above mentioned, the specialists of the European Institute for safety, security, insurance and environmental technics "SVT e.V." (Germany) and of the Institute of Engineering Ecology (Ukraine) have developed the project specific approach, which takes into account all activities involved in and the peculiarities of the JI projects on rehabilitation of the district heating systems in Ukraine.

This project specific approach is based on the permanent measuring of the fuel consumption and on

[5] *http://cdm.unfccc.int/UserManagement/FileStorage/K4P3YG4TNQ5ECFNA8MBK2QSMR6HTEM*
[6] *http://cdm.unfccc.int/methodologies/DB/Z4R6FBTQ5FMWU76ISIM5M5GJPN4F6Y*

amendment of the baseline for possible changes of parameters in a reported year. The changeable parameters may be the Net Calorific Value of fuels, quality of heating service, weather conditions, number of customers, etc. Taking into account only equipment efficiency change does not eliminate the possibilities of undersupply of heat to customers (worsening of heat supply service), and possible weather warming in reported year, change in fuel quality, disconnection of some consumers and other factors could lead to artificial overestimation of ERUs amount. The developed project specific approach eliminates any possibility to depreciate fuel consumption and correspondingly to underestimate GHG emissions due to underdelivery of heat to consumers.

This developed project specific approach has two important advantages (at least for Ukrainian conditions):

- It takes into account the quality of heat supply (heating and hot water supply). Almost every year 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 excess reduction of heat consumption, and, in such a way, of fuel consumption with the purpose of excess increasing of generation of emission 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.

Thus, in contrast to the methodologies AM0044, ACM0009 and AM0048, this project specific approach, 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 of Chernihiv Region", "Rehabilitation of the District Heating System of Crimea" and "Rehabilitation of the District Heating System in Luhansk city", etc., as well, is the most appropriate, precise, corresponding to the conservative approach, and in the most closely manner reflects the aims, goals and spirit of Kyoto Protocol.

This project specific approach is presented in section **A.5.2** (**Monitoring methodology**).

### A.5.2. Monitoring methodology:

The monitoring JI project specific approach developed for "District Heating system rehabilitation" projects in Ukrainian conditions consists in the following:

For any project year, the baseline is different due to the influence of external factors such as weather conditions, possible changes of the Net Calorific Value of fuel(s), number of customers, heated area, etc. The Baseline and the amount of ERUs for each project year (period) should be corrected with taking into account these and some other factors (the Dynamic Baseline).

The following project specific approach is used.

Total amount of emission reduction units (ERUs), t $CO_2e$:

$$ERUs = \Sigma[E_{(i)}^{b} - E_{(i)}^{r}]; \quad (1)$$

where:
$E_{(i)}^{b}$ and $E_{(i)}^{r}$ - baseline and project emissions for an (i) boiler-house in the reported year, t $CO_2e$.

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

For each boiler-house:

**Baseline emissions:**

$$E^{b} = E_1^{b} + E_{gen}^{b} + E_{cons}^{b}; \quad (2)$$

where:
$E_1^{b}$ – emissions due to fuel consumption for heating and hot water supply service by a boiler-house that would be in the base year in terms of the reported year, t $CO_2e$;
$E_{gen}^{b}$ – emissions due to electricity generation associated to the project for a boiler-house in the base year (consumed from grid, amount that is substituted in the reported year), t $CO_2e$;
$E_{cons}^{b}$ – emissions due to electricity consumption by a boiler-house that would be in the base year in terms of the reported year, t $CO_2e$.

For this monitoring report $E_{gen}^{b} = 0$, since no electricity generation associated to the project was in 2011 (CHP units have not been implemented yet). Thus formulae 2 becomes:

$$E^{b} = E_1^{b} + E_{cons}^{b}. \quad (2')$$

For the case when in the base year the hot water supply service was provided (irrespective of this service duration, $(1-a^{b}) \neq 0$), the formulae for $E_1^{b}$ is:

$$E_1^{b} = NCV^{b} * Cef^{r} * [B^{b} * a^{b} * K_1 * K_h + B^{b} * (1-a^{b}) * K_1 * K_w]; \quad (3)$$

where the first term in brackets describes fuel consumption for heating, and the second one – fuel consumption for hot water supply service.

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:

$$E_1^{b} = NCV^{b} * Cef^{r} * [B^{b} * a^{b} * K_1 * K_h + B^{r} * (1-a^{r}) * K_1 * K_{w0}]; \quad (4)$$

where:
$NCV^{b}$ – average calorific value of a fuel in the base year, GJ/ ths $m^3$ (GJ/t);
$Cef^{r}$ – carbon emission factor for a fuel, $tCO_2/GJ$;
$B^{b}$ – fuel consumption by a boiler-house in the base year, ths $m^3$ or tons;
$B^{r}$ – fuel consumption by a boiler-house in the reported year, ths $m^3$ (t);
$K_1$; $K_h = K_2 * K_3 * K_4$; $K_w = K_5 * K_6 * K_7$, $K_{w0}$ – 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 service in the base year;
$a^{r}$ – portion of fuel (heat), consumed for heating purposes in the reported year;
$(1- a^{r})$ – portion of fuel (heat), consumed for hot water supply service purposes in the reported year.

$$a^b = L_h^b * g^b * N_h^b / (L_h^b * g^b * N_h^b + L_w^b * N_w^b); \quad (5)$$

where:
$L_h^b$ – maximum connected load to a boiler-house, that is required for heating in the base year, MW;
$L_w^b$ – connected load to a boiler-house, that is required for hot water supply service in the base year, MW;
$g^b$ – recalculation factor for average heat load during heating period in the base year;
$N_h^b$ – heating period duration in the base year, hours;
$N_w^b$ – duration of period of hot water supply service in the base year, hours.

$$a^r = L_h^r * g^r * N_h^r / (L_h^r * g^r * N_h^r + L_w^r * N_w^r); \quad (6)$$

where:
$L_h^r$ – maximum connected load to a boiler-house, that is required for heating in the reported year, MW;
$L_w^r$ – connected load to a boiler-house, that is required for hot water supply service in the reported year, MW;
$g^r$ – recalculation factor for average heat load during heating period in the reported year;
$N_h^r$ – heating period duration in the reported year, hours;
$N_w^r$ – duration of period of hot water supply service in the reported year, hours.

$$g^{b,r} = F_h^{b,r} * k_h^b * (T_{in}^{b,r} - T_{out}^{b,r}) / F_h^{b,r} * k_h^b * (T_{in}^{b,r} - T_{out\,min}^{b,r}) = (T_{in}^{b,r} - T_{out}^{b,r}) / (T_{in}^{b,r} - T_{out\,min}^{b,r}); \quad (7)$$

where:
$F_h^{b,r}$ – heated area, $m^2$;
$k_h^b$ – averaged heat transfer factor of heated buildings in the base year, $kW/(m^2*K)$;
$T_{in}^{b,r}$ – average inside temperature during the heating period, K (or $^0C$);
$T_{out}^{b,r}$ – average outside temperature during the heating period, K (or $^0C$);
$T_{out\,min}^{b,r}$ – minimal outside temperature during the heating period, K (or $^0C$).

$$K_1 = NCV^b / NCV^r; \quad (8)$$

where:
$K_1$ –calorific value of a fuel change factor;
$NCV^b$ – average calorific value of a fuel in the base year, GJ/ ths $m^3$ (GJ/t);
$NCV^r$ – average calorific value of a fuel in the reported year, GJ/ ths $m^3$ (GJ/t).

$$K_2 = (T_{in}^r - T_{out}^r) / (T_{in}^b - T_{out}^b); \quad (9)$$

where:
$K_2$ – temperature change factor;
$T_{in}^r$ – average inside temperature during the heating period in the reported year, K (or $^0C$);
$T_{in}^b$ – average inside temperature during the heating period in the base year, K (or $^0C$);
$T_{out}^r$ – average outside temperature during the heating period in the reported year, K (or $^0C$);
$T_{out}^b$ – average outside temperature during the heating period in the base year, K (or $^0C$).

$$K_3 = [(F_h^r - F_{h\,t}^r - F_{h\,n}^r) * k_h^b + (F_{h\,n}^r + F_{h\,t}^r) * k_{h\,n}] / F_h^b * k_h^b; \quad (10)$$

where:
$K_3$ – heated area and building heat insulation change factor;
$F_h^r$ – heated area in the reported year, $m^2$;
$F_h^b$ – heated area in the base year, $m^2$;
$F_{h\,n}^r$ – heated area of newly connected buildings (assumed with the new (improved) heat insulation) in the reported year, $m^2$;
$F_{h\,t}^r$ – heated area of buildings (previously existed in the base year) with the renewed (improved) heat insulation in the reported year, $m^2$;
$k_h^b$ – averaged heat transfer factor of heated buildings in the base year, $kW/(m^2*K)$;
$k_{h\,n}$ – heat transfer factor of buildings with new heat insulation, $kW/(m^2*K)$.

$$K_4 = N_h^r / N_h^b; \quad (11)$$

where:
$K_4$ – heating period duration change factor;
$N_h^r$ – heating period duration in the reported year, hours;

$N_h^b$ – heating period duration in the base year, hours.

$K_5 = n_w^r / n_w^b$; (12)

where:
$K_5$ – number of customers of hot water supply service change factor;
$n_w^r$ – number of customers of hot water supply service in the reported year;
$n_w^b$ – number of customers of hot water supply service in the base year.

$K_6 = v_w^r / v_w^b$; (13)

where:
$K_6$ – standard specific discharge of hot water per personal account change factor;
$v_w^r$ – standard specific discharge of hot water per personal account in the reported year, (heat units, kWh/h);
$v_w^b$ – standard specific discharge of hot water per personal account in the base year, (heat units, kWh/h).

$K_7 = N_w^r / N_w^b$; (14)

where:
$K_7$ – duration of period of hot water supply service change factor;
$N_w^r$ – duration of period of hot water supply service in the reported year, hours;
$N_w^b$ – duration of period of hot water supply service in the base year, hours.

For the case when in the base year the hot water supply service was absent at all, and in the reported year this service was provided (due to improvement of heat supply service quality for population), number of customers, standard specific discharge of hot water per personal account and duration of period of hot water supply service for baseline are assumed equal to these values in the reported year, and then:

$K_5 = K_6 = K_7 = 1$.

Thus

$K_{w0} = 1$.

$E_{cons}^b = P^b * CEF_c^r$; (15)

where:
$P^b$ – electricity consumption by a boiler-house in the base year, MWh;
$CEF_c^r$ – carbon emission factor for electricity consumption in Ukraine, $tCO_2e/MWh$.

**Project emissions:**

$E^r = E_1^r + E_{gen}^r + E_{cons}^r$; (16)

where:
$E_1^r$ – emissions due to fuel consumption for heating and hot water supply service by a boiler-house in the reported year, t $CO_2e$;
$E_{gen}^r$ – emissions due to electricity generation by cogeneration units (due to fuel consumption) at a boiler-house in the reported year, t $CO_2e$;
$E_{cons}^r$ – emissions due to electricity consumption by a boiler-house in the reported year, t $CO_2e$.

For this monitoring report $E_{gen}^r = 0$, since no electricity generation associated to the project was in 2011 (CHP units have not been implemented yet). Thus formulae 16 becomes:

$E^r = E_1^r + E_{cons}^r$; (16')

$E_1^r = B^r * NCV^r * Cef^r$; (17)

where:
$B^r$ – fuel consumption by a boiler-house in the reported year, ths $m^3$ (t);
$NCV^r$ – average calorific value of a fuel, GJ/ ths $m^3$ (GJ/t);
$Cef^r$ – carbon emission factor for a fuel, $tCO_2/GJ$.

$E_{cons}^r = P^r * CEF_c^r$; (18)

where:
$P^r$ – electricity consumption by a boiler-house in the reported year, MWh;
$CEF_c^r$ – carbon emission factor for electricity consumption in Ukraine, $tCO_2e/MWh$.

[$^b$] – index related to the base year;
[$^r$] – index related to the reported year.

The table of parameters included in the process of monitoring and verification for ERUs calculation is represented in the Section **B.2.1** and **Annex 1.**

**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 when the first emission reduction units were generated from the project, 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 | 3 rd Monitoring Period | 4 th Monitoring Period | 5 th Monitoring Period | |

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

Implementation of boiler houses rehabilitation and network rehabilitation are realized according to project plan with some deviations (delay) from time-table. In several cases replacement of different (from planed before) diameters of network pipes takes place. Installation of frequency controllers and cogeneration units are not finished yet.

Table of implemented energy saving measures is presented bellow.

| Implemented energy saving measures | Volume of performed works (number of boilers, etc.) 2004-2010 | Volume of performed works (number of boilers, etc.) 2011 | Total |
|---|---|---|---|
| Switch load to other boiler houses and CHP | 60 | 8 | **68** |
| Improving of the network organization with liquidation or reconstruction of heat supply stations (HSS) | 51 | 7 | **58** |
| Replacement of boilers | 125 | 10 | **135** |
| Heat exchangers replacement | 53 | 40 | **93** |
| Frequency controllers installation | 73 | 22 | **95** |
| Reconstruction of boilers | 89 | 14 | **103** |
| Installation of automatic system of regulation on boilers | 2 | | **2** |
| Application of the pre-insulated pipes, m | 188349 | 29262 | **217611** |
| Usual pipe network replacement, m | 121600 | | **121600** |
| Restoration of pipes insulation, m | 65864 | | **65864** |

For detailed information about implemented measures see Annex 2.

*Fig. 1. New boilers OVK-100 LWE installed at boiler-house Pyatysotnitska, 19 (# 212)*

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

There were no intended deviations or revisions to the registered PDD.

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

In order to improve the accuracy and applicability of data and calculations, in accordance to the "Guidance on criteria for baseline setting and monitoring" (version 03)[7], the following revisions were made to the registered monitoring plan:

The newly developed officially approved valid country-specific values of parameter 16 "Carbon emission factor" were used for calculations:

For all types of fuels – according to the "National inventory report of Ukraine for 1990 – 2009"[8], instead of the data from table provided in Annex C of the Operational Guidelines for Project Design Documents of Joint Implementation Projects [Volume 1: General guidelines; Version 2.2, The Netherlands, 2003];

For electricity generation and consumption in Ukraine – the values according to the Order of the National Environmental Investment Agency of Ukraine #75 dated 12.05.2011[9]., instead of using the ex-ante data 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. Volume 1: General guidelines Version 2.3. Ministry of Economic Affairs of the Netherlands, 2004 (ERUPT 4, Senter, the Netherlands)[10], with adding these parameters $CEF_c$ (16.3) and $CEF_g$ (16.4) to the Monitoring plan.

### 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).
2 nd Monitoring Report was made for period January 1, 2008 – December 31, 2008 (Version 02 from March 25, 2009).
3 rd Monitoring Report was made for period January 1, 2009 – December 31, 2009 (Version 02 from February 01, 2010).
4 th Monitoring Report was made for period January 1, 2010 – December 31, 2010 (Version 02 dated April 4, 2011).

The further implementation of fuel and energy saving measures at the ME "Kharkivski teplovi merezhi" within this project has leaded to additional GHG emissions reduction.

[7] *http://ji.unfccc.int/Ref/Documents/Baseline_setting_and_monitoring.pdf*
[8] *http://unfccc.int/files/national_reports/annex_i_ghg_inventories/national_inventories_submissions/application/zip/ukr-2011-nir-08jun.zip*
[9] *http://www.neia.gov.ua/nature/doccatalog/document?id=127498*
[10] *http://ji.unfccc.int/CallForInputs/BaselineSettingMonitoring/ERUPT/index.html*

In the Monitoring Report # 5, the code and/ or address of the boiler-house was corrected (see the table bellow):

| # in the project | In the previous Monitoring Reports | | In the Monitoring Report # 5 | |
|---|---|---|---|---|
| | Code of boiler-house | Address of boiler house | Code of boiler-house | Address of boiler house |
| 129 | 507 | Gostinna, 16 | 5579 | Gostinna, 16 |
| 122 | 384 | Gagarina av., 199/1 | 384 | Gagarina av., 199/2 |

Code of the boiler-house #129 was changed by ME "KhTM", this is caused by the internal organization of the enterprise. Address of the boiler house #122 was changed according to Order of Kominternivsky district Council in Kharkiv city.

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

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## SECTION B. Key monitoring activities

### B.1. Data measurement

#### B.1.1. Measurement scheme

The control and monitoring system comes to fuel consumption measurements. Other parameters are defined by calculations or taken from statistic data. Fuel (natural gas) consumption measurements are realized at the gas distribution units of the boiler-houses. Gas consumption registration is carried out in volume units reduced to standard conditions by means of automatic correction for temperature and pressure. The typical gas distribution unit is shown at the Fig. 2, typical gas flow meter is shown at the Fig. 3.

*Fig. 2. Gas distribution unit*

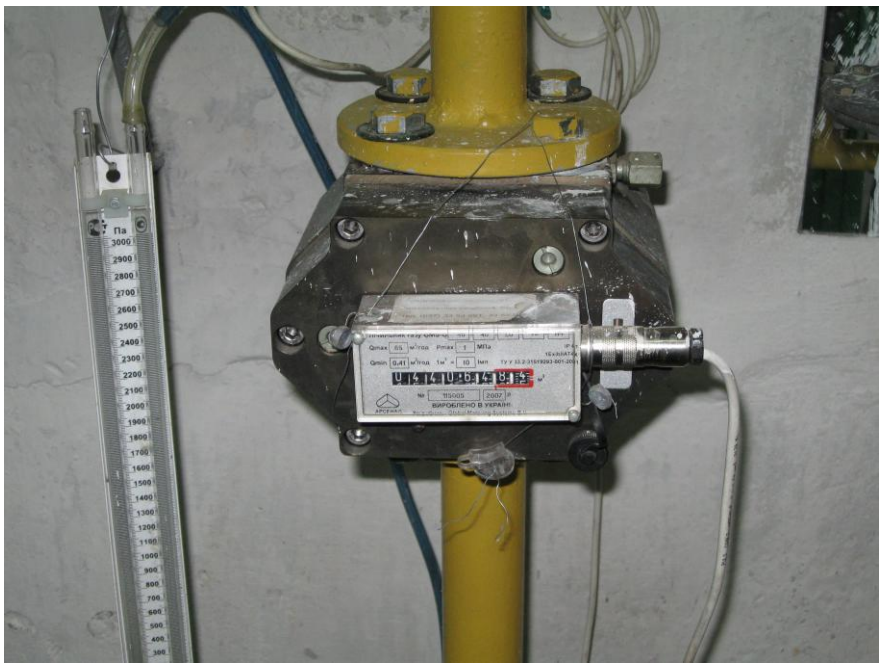
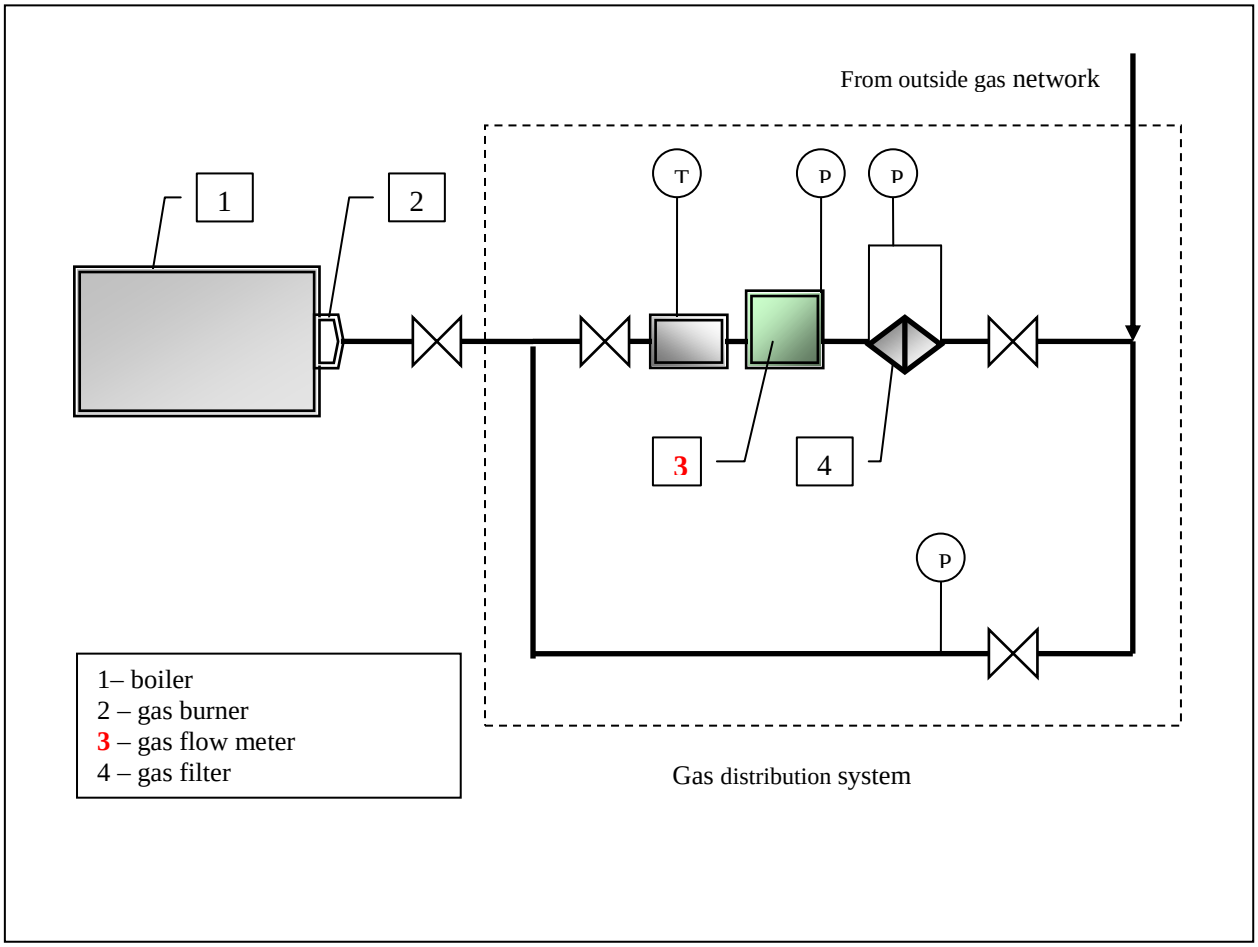


*Fig. 3. Gas flow meter*

The typical scheme of the Gas distribution system is shown at the Fig. 4. 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 flow meter;
- stop valve;
- bypass facility.




T –temperature of the natural gas;
P - natural gas pressure at a boiler-house gas-input.

*Fig. 4. Scheme of the gas distribution system*

**B.1.2. Monitoring equipment types:**

For gas consumption measurements the following equipment types are used:

| Type of gas flow meter | Manufacturer |
|---|---|
| GMS-G-10 | SE "Arsenal plant", Kyiv |
| GMS-G-16 | |
| GMS-G-25 | |
| GMS-G-40 | |
| GMS-G-65 | |
| GMS-G-100 | |
| GMS-G-160 | |
| GMS-G-250 | |
| VRSG-1-50 | SPE "Irvis", Ltd., Russia, Kazan |
| VRSG -1-80 | |
| VK-011 | JSC "Energooblik", Kharkiv |
| LG-K-80 | OJSC "Ivano-Frankivsk plant "Promprylad"", Ivano-Frankivsk |
| LG-K -100 | |
| LG-K -150 | |
| LG-K -200 | |
| G-6-RL | OJSC "Ivano-Frankivsk plant "Promprylad"", Ivano-Frankivsk |
| G-10-RL | |
| G-10-RGA | OJSC "Ivano-Frankivsk plant "Promprylad"", Ivano-Frankivsk |
| G-16-RGA | |
| G-25-RGK | OJSC "Ivano-Frankivsk plant "Promprylad"", Ivano-Frankivsk |
| G-40-RGK | |
| G-100-RGK | |
| G-250-RGK | |
| G-400-RGK | |
| VK-G10-T | "Premgas", Slovakia |
| PREMAGAS G6 | |
| DELTA G-16 | Itron (Actaris ), France |
| METRIX-6 | Apator Metrix, Czechia |
| **Type of corrector** | |
| KPLG-1.01 | "Radmirteh", Ltd., Kharkiv |
| KPLG-1.02 | |
| KPLG-2.01 | |
| Vega-1 (KPLG-1.02) | |
| Vega-2 (KPLG-2.01P) | |
| Gamma-Flow | PSPE "Softservis", Kharkiv |

See Annex 3.

The following electricity meters are used for electricity consumption measurement:

| Type of electricity meter | Manufacturer |
|---|---|
| EMS-134 | "Elgama Elektronika", Lithuania |
| EMS135 | |
| EMT133.10.6 | |
| SL761C071 | Itron (Actaris ), France |
| ZMD410CR44 | "Intercomenergo" Ltd., Kharkiv |
| Delta 8010 | PJSC "Mitel", Dnipropetrovsk |
| Mercuriy 230A | Incotex, Ltd., Russia |
| SA3U-I670 | OJSC "LEMZ", Russia |
| SA3U-I670M | |
| SA4-I672M | |
| SA4-I678 | |
| SA4U-672M | |
| SA4U-I672M | |
| SA4U-I678 | |
| SA4U-I681 | |
| SR4U-I673M | |
| SA4-195 | SE "Kharkivskyi zavod elektroaparatury", Kharkiv |
| SA4-196 | |
| SA4U-196 | |
| SA4-198 | |
| SA4-199 | |
| SO-193 | |
| SA4-5001 | CJSC "Rostok Company", Kyiv |
| SO-2M | Vilnius State Factory of electricity measuring equipment, Lithuania |
| SO-I446M | |
| ST-EA01 | SSPE "Ob'ednannia Komunar", Kharkiv |
| ST-EA05 | |
| ST-EA05Д1 | |
| ST-EA08Д5 | |
| STK3 | OJSC "Telekart-Prylad", Odesa |
| CE 6803 V | OJSC "Koncern Energomira", Russia |

See Annex 5.

### B.1.3. Calibration procedures:

According to the requirements of the State Standard of Ukraine № 2708:2006 "Metrology. Calibration of measuring equipment. The organization and procedure"[11], all measuring equipment in Ukraine should meet the specified requirements and is to be inspected (calibrated) periodically.

Information on calibration of the used measuring equipment is provided in Annex 3 and Annex 5.

[11] *http://oscill.com/files/27082006.pdf*

### B.1.4. Involvement of Third Parties:

Gas consumption measurement equipment calibration was carried out by DE "Kharkiv center of standardization, metrology and calibration".

Electricity measurement equipment calibration was carried out by OJSC "Kharkivoblenergo".

### 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 (GHG emission reductions due to fuel saving) and Annex 4 (GHG emission reductions due to electricity saving) 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 | ($\mathbf{B^b}$) and ($\mathbf{B^r}$) | Fuel consumption by a boiler-house: | | m |
| 1.1 | | - Natural Gas | ths. $m^3$ | |
| 1.2 | | - Coal | ton | |
| 2 | ($\mathbf{NCV^b}$) and ($\mathbf{NCV^r}$) | Average calorific value of a fuel: | | m, c |
| 2.1 | | - Natural Gas | $MJ/m^3$ | |
| 2.2 | | - Coal | MJ/kg | |
| 3 | ($\mathbf{T_{out}^b}$) and ($\mathbf{T_{out}^r}$) | Average outside temperature during the heating period | $^0C$ (K) | m, c |
| 4 | ($\mathbf{T_{in}^b}$) and ($\mathbf{T_{in}^r}$) | Average inside temperature during the heating period | $^0C$ (K) | m, c |
| 5 | ($\mathbf{n_w^b}$) and ($\mathbf{n_w^r}$) | Number of customers of hot water supply service | | c |
| 6 | ($\mathbf{F_h^b}$) and ($\mathbf{F_h^r}$) | Heated area (total) | ths. $m^2$ | c |
| 7 | ($\mathbf{k_h^b}$) | Averaged heat transfer factor of heated buildings in the base year | ths. $m^2$ | Statistics |
| 8 | ($\mathbf{F_{h\,t}^r}$) | Heated area of buildings (previously existed in the base year) with the renewed (improved) heat insulation in the reported year | $W/(m^2*K)$ | c |
| 9 | ($\mathbf{F_{h\,n}^r}$) | Heated area of newly connected buildings (assumed with the new (improved) heat insulation) in the reported year | ths. $m^2$ | c |
| 10 | ($\mathbf{k_{h\,n}}$) | Heat transfer factor of buildings with new heat insulation | ths. $m^2$ | Normative documents |

| | | | | |
|---|---|---|---|---|
| 11 | ($\mathbf{N_h^b}$) and ($\mathbf{N_h^r}$) | Heating period duration | hours | m |
| 12 | ($\mathbf{N_w^b}$) and ($\mathbf{N_w^r}$) | Duration of period of hot water supply service | hours | m |
| 13 | ($\mathbf{L_h^b}$) and ($\mathbf{L_h^r}$) | Maximum connected load to a boiler-house, that is required for heating | Gcal/hour | c |
| 14 | ($\mathbf{L_w^b}$) and ($\mathbf{L_w^r}$) | Connected load to a boiler-house, that is required for hot water supply service | Gcal/hour | c |
| 15 | ($\mathbf{v_w^r}$) and ($\mathbf{v_w^b}$) | Standard specific discharge of hot water per personal account | kWh/h | Normative documents |
| 16 | | Carbon emission factor for: | | Normative documents |
| 16.1 | ($\mathbf{Cef^r}$) | - Natural Gas | kt $CO_2$/TJ | |
| 16.2 | ($\mathbf{Cef^r}$) | - Coal | kt $CO_2$/TJ | |
| 16.3 | ($\mathbf{CEF_c^r}$) | - Electricity consumption in Ukraine | t $CO_2$/ MWh | |
| 16.4 | ($\mathbf{CEF_g^r}$) | - Electricity generation in Ukraine | t $CO_2$e/ MWh | |
| 17 | ($\mathbf{P^b}$) and ($\mathbf{P^r}$) | Electricity consumption by a boiler-house | MWh | m |

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

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

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

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

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

There were no leakage effects associated with this project.

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

Implementation of project "Rehabilitation of the District Heating System in Kharkiv City " has a positive effect on environment. Following points give detailed information on environmental benefits.

1. Project implementation allowed saving over 81 million $m^3$ of natural gas, over 292 tones of coal and 51330.5 MWh of power during 2011.

2. Due to fuel and electricity saving and implementation of new environmentally friendlier technologies of fuel combustion, project activity has reduced emissions of $SO_x$, $NO_x$, CO and particulate matter (co-products of combustion).

There are no negative social impacts associated with the project

**B.3. Data processing and archiving:**

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

1. Natural gas consumption is measured by gas flow meter, installed at a boiler-house. All boiler-houses are equipped with gas flow meters.

2. The majority of boiler-houses are equipped with automatic correctors for gas temperature and pressure. Gas consumption is registered automatically. Every day operator of a boiler house makes registration of daily gas consumption in the special paper journal "Journal of registration of boiler-house's operation parameters", see Fig. 5.

3. At the boiler-houses that are not equipped with gas volume correctors, operator of a boiler house every 2 hours registers parameters of natural gas (temperature and pressure) in the paper journal "Journal of registration of boiler-house's operation parameters". These parameters are used to bring gas consumption to standard conditions.

4. Every day operators report values of gas consumption by phone to dispatcher of the regional branch of ME "Kharkivski teplovi merezhi". Regional branches transfer data to Techno-Economic Activities Department (TEAD) of Production-Technical Service (PTS) of ME "Kharkivski teplovi merezhi", where they are stored and used for payments to gas suppliers.

5. Every month the account centers transfer data to gas suppliers.

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

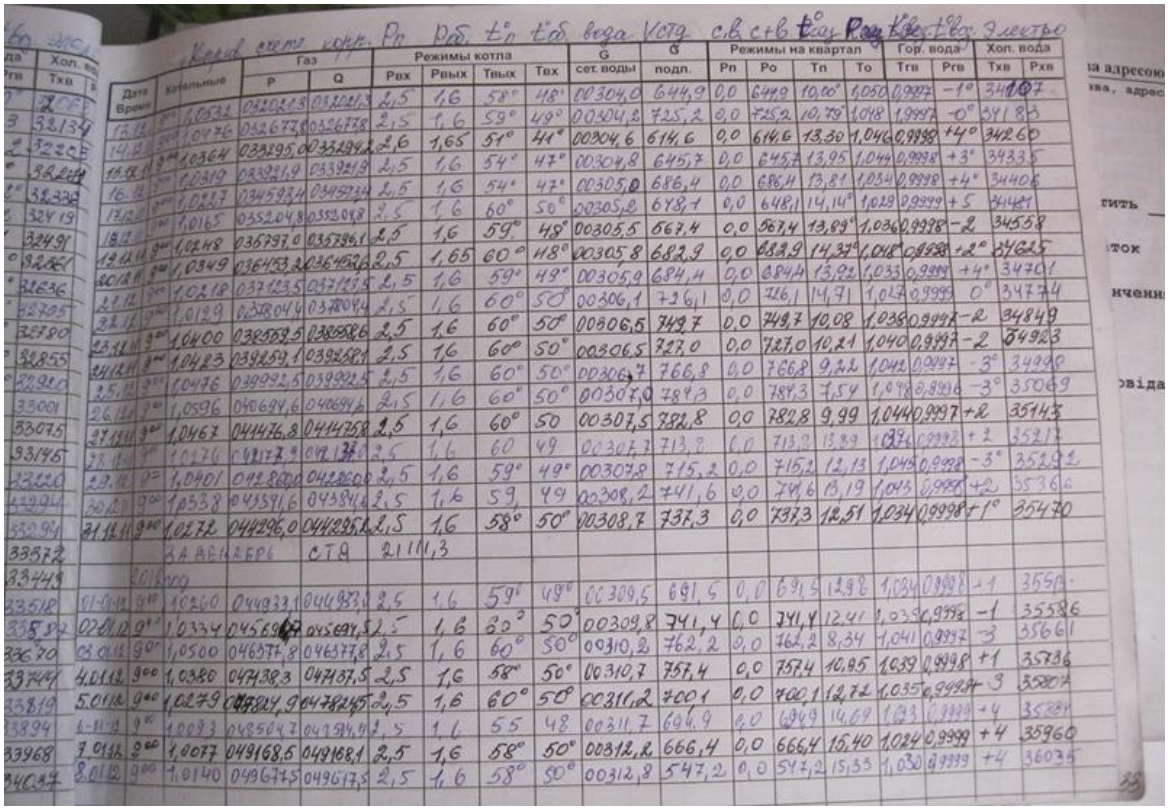


*Fig. 5. Journal of registration of boiler-house's operation parameters*

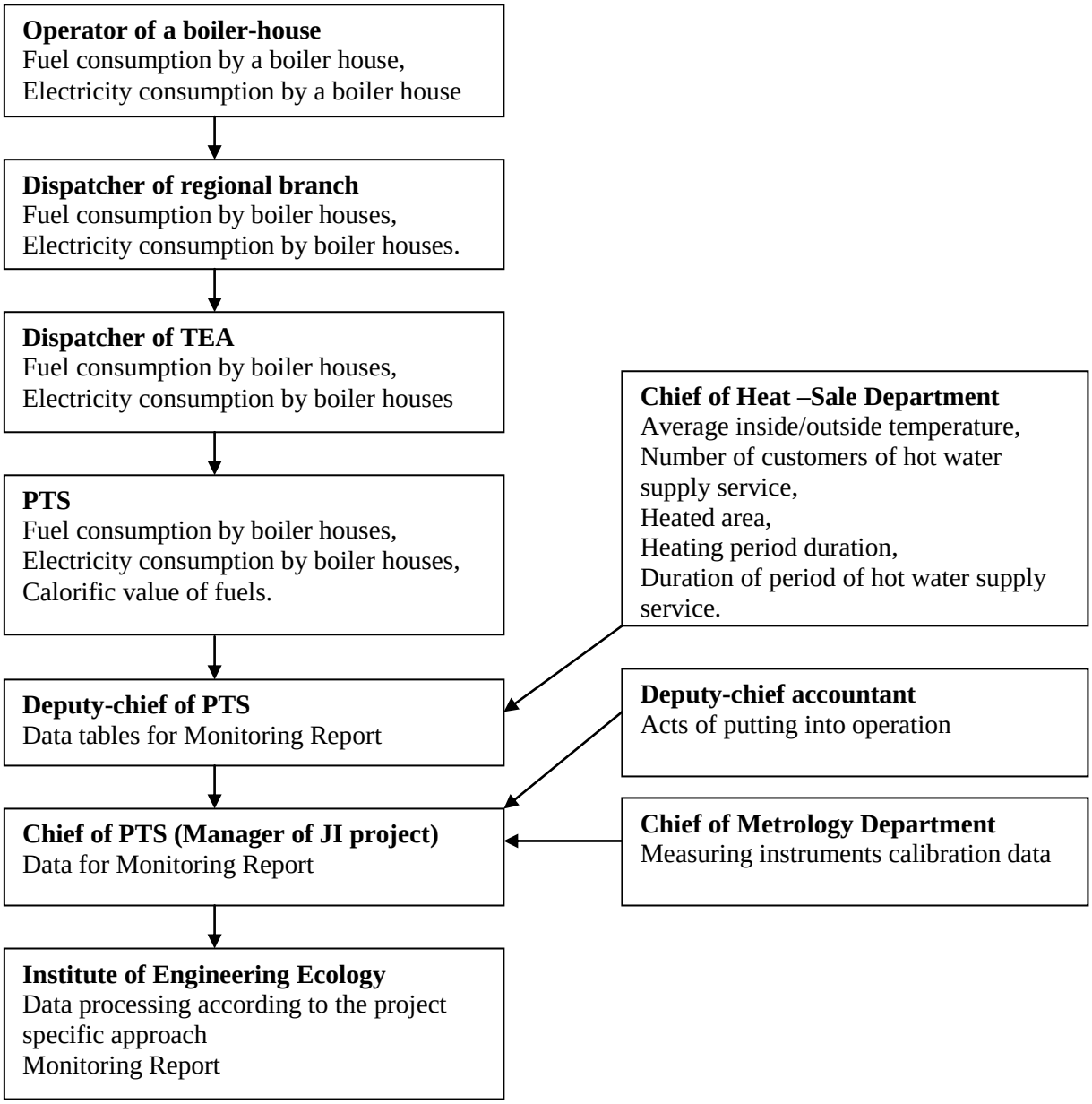



*Fig.6. Scheme of data collection for Monitoring Report*

Collected data are to be submitted for development of Monitoring reports and verification, and are to be stored during two years after the end of the crediting period, according to the Order #159 dated 31.03.2011, on appointment of the responsible person and storage term of documents.

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

n.a.

## SECTION C. Quality assurance and quality control measures

### C.1. Documented procedures and management plan:

#### C.1.1. Roles and responsibilities:

The Director General of ME "Kharkivski teplovi merezhi", Mr. Sergiy Andreev, appointed the responsible person, Mr. Andriy Repin, Chief of Production-Technical Service (PTS), for the implementation and management of the monitoring process at the ME "Kharkivski teplovi merezhi". Mr. Andriy Repin is responsible for data measurement, collection, recording and storage.

Dr. Vladimir Gomon, Managing Engineer of the European Institute for safety, security, insurance and environmental technics, is responsible for baseline and monitoring JI project specific approach development.

Dr. Dmytro Paderno, deputy director of the Institute of Engineering Ecology, is responsible for baseline and monitoring JI project specific approach development.

Ms. Kateryna Korinchuk, scientific researcher of the Institute of Engineering Ecology, is responsible for data processing.

#### C.1.2. Trainings:

Since the main activity of ME "Kharkivski teplovi merezhi" was not changed in course of the JI project implementation, the special technical training for personnel was not needed. The technical staff of the enterprise has adequate knowledge and experience to implement the project and repair conventional equipment.

In cases of the new (never used at this enterprise before) equipment installation, the company - producer of this equipment should provide trainings for personnel.

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 the Institute of Engineering Ecology and later 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 was hold in January 2009.

The special group was organized consisted of representatives of ME "Kharkivski teplovi merezhi" and the 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 - the Institute of Engineering Ecology, senior engineer;
Dmitri Paderno - the Institute of Engineering Ecology, deputy 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 for quality assurance and quality control measures.

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

Manager of the JI project, the Chief of PTS of ME "Kharkivski teplovi merezhi", Mr. Andriy Repin controls and checks up the adequacy of the data collection mechanism and the reliability of parameters of the Monitoring plan as well as of other information on project implementation.

### C.4. Troubleshooting procedures:

Any occurring problem 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 (dynamic) emissions and the project emissions.

| **Formula 1 –** Total emission reduction (ERUs) | |
|---|---|
| | $ERUs = \sum[E_{(i)}^{b} - E_{(i)}^{r}]$ |
| | $E_{(i)}^{b}$ – baseline emissions for an (i) boiler-house in the reported year, t $CO_2e$;<br>$E_{(i)}^{r}$ – project emissions for an (i) boiler-house in the reported year, t $CO_2e$. |
| | The sum is taken over all boiler-houses (i) which are included into the project |

### Project emissions

| **Formula 2 –** Project emissions in the reported year ($E^r$) | |
|---|---|
| | $E^r = E_1^r + E_{cons}^r$ |
| | $E_1^r$ – emissions due to fuel consumption for heating and hot water supply service by a boiler-house in the reported year, t $CO_2e$;<br>$E_{cons}^r$ – emissions due to electricity consumption by a boiler-house in the reported year, t $CO_2e$. |
| | |

| **Formula 3 –**Emissions due to fuel consumption for heating and hot water supply service by a boiler-house in the reported year ($E_1^r$) | |
|---|---|
| | $E_1^r = B^r * NCV^r * Cef^r$ |
| | $B^r$ –fuel consumption by a boiler-house in the reported year, ths $m^3$ (t);<br>$NCV^r$ – average calorific value of a fuel in the reported year, GJ/ ths $m^3$ (GJ/t);<br>$Cef^r$ – carbon emission factor for a fuel, $tCO_2/GJ$. |
| | |

| **Formula 4 –** Emissions due to electricity consumption by a boiler-house in the reported year ($E_{cons}^r$) | |
|---|---|
| | $E_{cons}^r = P^r * CEF_c^r$ |
| | $P^r$ – electricity consumption by a boiler-house in the reported year, MWh;<br>$CEF_c^r$ – carbon emission factor for electricity consumption in Ukraine, $tCO_2e/MWh$. |
| | |

**Baseline emissions**

| **Formula 5 –** Baseline emissions in the reported year ($E_b$) | |
|---|---|
| | $E^b = E_1^b + E_{cons}^b$ |
| | $E_1^b$ – emissions due to fuel consumption for heating and hot water supply service by a boiler-house that would be in the base year in terms of the reported year, t $CO_2e$;<br>$E_{cons}^b$ –emissions due to electricity consumption by a boiler-house that would be in the base year in terms of the reported year, t $CO_2e$. |
| | |

| **Formula 6 –** Emissions due to fuel consumption for heating and hot water supply service by a boiler-house that would be in the base year in terms of the reported year ($E_1^b$) | |
|---|---|
| | For the case when in the base year the hot water supply service was provided ($(1-a^b) \neq 0$):<br>$E_1^b = NCV^b * Cef^r * [B^b * a^b * K_1 * K_h + B^b * (1-a^b) * K_1 * K_w]$<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):<br>$E_1^b = NCV^b * Cef^r * [B^b * a^b * K_1 * K_h + B^r * (1-a^r) * K_1 * 1]$. |
| | $NCV^b$ – average calorific value of a fuel in the base year, GJ/ ths $m^3$ (GJ/t);<br>$Cef^r$ – carbon emission factor for a fuel, $tCO_2/GJ$;<br>$B^b$ –fuel consumption by a boiler-house in the base year, ths $m^3$ or tons;<br>$B^r$ –fuel consumption by a boiler-house in the reported year, ths $m^3$ (t);<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 service in the base year;<br>$a^r$ – portion of fuel (heat), consumed for heating purposes in the reported year;<br>$(1-a^r)$ – portion of fuel (heat), consumed for hot water supply service in the reported year. |
| | |

| **Formula 7 –** Portion of fuel (heat), consumed for heating purposes in the base year ($a^b$) | |
|---|---|
| | $a^b = L_h^b * g^b * N_h^b / (L_h^b * g^b * N_h^b + L_w^b * N_w^b)$ |
| | $L_h^b$ – maximum connected load to a boiler-house, that is required for heating in the base year, MW;<br>$L_w^b$ – connected load to a boiler-house, that is required for hot water supply service in the base year, MW;<br>$g^b$ – recalculation factor for average heat load during heating period in the base year;<br>$N_h^b$ – heating period duration in the base year, hours;<br>$N_w^b$ – duration of period of hot water supply service in the base year, hours. |
| | |

| **Formula 8 –** Portion of fuel (heat), consumed for heating purposes in the reported year ($a^r$) | |
|---|---|
| | $a^r = L_h^r * g^r * N_h^r / (L_h^r * g^r * N_h^r + L_w^r * N_w^r)$ |
| | $L_h^r$ – maximum connected load to a boiler-house, that is required for heating in the reported year, MW;<br>$L_w^r$ – connected load to a boiler-house, that is required for hot water supply service in the reported year, MW;<br>$g^r$ – recalculation factor for average heat load during heating period in the reported year;<br>$N_h^r$ – heating period duration in the reported year, hours;<br>$N_w^r$ – duration of period of hot water supply service in the reported year, hours. |
| | |

| **Formula 9 –** Recalculation factor for average heat load during heating period ($g^{b,r}$) | |
|---|---|
| | $g^{b,r} = (T_{in}^{b,r} - T_{out}^{b,r}) / (T_{in}^{b,r} - T_{out\ min}^{b,r})$ |
| | $T_{in}^{b,r}$ – average inside temperature for the heating period, $^0$C ;<br>$T_{out}^{b,r}$ – average outside temperature for the heating period, $^0$C;<br>$T_{out\ min}^{b,r}$ – minimal outside temperature for the heating period, $^0$C. |
| | |

| **Formula 10 –** Calorific value of a fuel change factor ($K_1$) | |
|---|---|
| | $K_1 = NCV^b / NCV^r$ |
| | $NCV^b$ – average calorific value of a fuel in the base year, GJ/ ths $m^3$ (GJ/t);<br>$NCV^r$ – average calorific value of a fuel in the reported year, GJ/ ths $m^3$ (GJ/t). |
| | |

| **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 during the heating period in the reported year, $^0$C;<br>$T_{in}^b$ – average inside temperature during the heating period in the base year, $^0$C;<br>$T_{out}^r$ – average outside temperature during the heating period in the reported year, $^0$C;<br>$T_{out}^b$ – average outside temperature during the heating period in the base year, $^0$C. |
| | |

| **Formula 12 –** Heated area and building heat insulation change factor ($K_3$) | |
|---|---|
| | $K_3 = [(F_h^r - F_{ht}^r - F_{hn}^r) * k_h^b + (F_{hn}^r + F_{ht}^r) * k_{hn}] / F_h^b * k_h^b$ |
| | $F_h^r$ – heated area in the reported year, $m^2$;<br>$F_h^b$ – heated area in the base year, $m^2$;<br>$F_{hn}^r$ – heated area of newly connected buildings (assumed with the new (improved) heat insulation) in the reported year, $m^2$;<br>$F_{ht}^r$ – heated area of buildings (previously existed in the base year) with the renewed (improved) heat insulation in the reported year, $m^2$;<br>$k_h^b$ – averaged heat transfer factor of heated buildings in the base year, kW/($m^2$*K);<br>$k_{hn}$ – heat transfer factor of buildings with new heat insulation, kW/($m^2$*K). |
| | |

| **Formula 13 –** Heating period duration change factor ($K_4$) | |
|---|---|
| | $K_4=N_h^r/N_h^b$ |
| | $N_h^r$ – heating period duration in the reported year, hours;<br>$N_h^b$ – heating period duration in the base year, hours. |
| | |

| **Formula 14 –** Number of customers of hot water supply service change factor ($K_5$) | |
|---|---|
| | $K_5 = n_w^r / n_w^b$ |
| | $n_w^r$ – number of customers of hot water supply service in the reported year;<br>$n_w^b$ – number of customers of hot water supply service in the base 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, (heat units, kWh/h);<br>$v_w^b$ – standard specific discharge of hot water per personal account in the base year, (heat units, kWh/h) |
| | |

| **Formula 16 –** Duration of period of hot water supply service change factor ($K_7$) | |
|---|---|
| | $K_7 = N_w^r / N_w^b$ |
| | $N_w^r$ – duration of period of hot water supply service in the reported year, hours;<br>$N_w^b$ – duration of period of hot water supply service in the base year, hours. |
| | |

| **Formula 17 –**Emissions due to electricity consumption by a boiler-house that would be in the base year in terms of the reported year ($E_{cons}^b$) | |
|---|---|
| | $E_{cons}^b = P^b * CEF_c^r$ |
| | $P^b$ – electricity consumption by a boiler-house in the base year, MWh;<br>$CEF_c^r$ – carbon emission factor for electricity consumption in Ukraine, $tCO_2e/MWh$. |
| | |

**D.2. GHG emission reductions:**

**D.2.1. Project emissions:**

Project emissions consist of emissions due to fuel consumption for heating and hot water supply service at ME "Kharkivski teplovi merezhi" and of emissions due to electricity consumption from the greed in the reported year.

| **Project emissions,** t $CO_2e$ | **2011** |
|---|---|
| Emissions due to fuel consumption | 1849960 |
| Emissions due to electricity consumption | 160036 |
| Total | **2009996** |

*Table 3. Project emissions*

**D.2.2. Baseline emissions:**

Baseline emissions consist of emissions due to fuel consumption for heating and hot water supply service at ME "Kharkivski teplovi merezhi" and of emissions due to electricity consumption from the greed, adjusted according to the actual conditions in the reported year (the dynamic baseline).

| **Baseline emissions,** t $CO_2e$ | **2011** |
|---|---|
| Emissions due to fuel consumption | 2179804 |
| Emissions due to electricity consumption | 222849 |
| Total | **2402653** |

*Table 4. Baseline emissions*

**D.3.3. Leakage:**

There is no leakage associated with this project.

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

| **Emission Reduction,** t $CO_2e$ | **2011** |
|---|---|
| Emissions reduction due to fuel saving | 329844 |
| Emissions reduction due to electricity saving | 62813 |
| Total | **392657** |

*Table 5. Total Emission Reductions*

See Annex 2, Annex 4.

**D.3. Deviation of the actual emissions reductions from estimated in the registered PDD, if any:**

According to the results of the Monitoring Report for the project **"Rehabilitation of the District Heating System in Kharkiv City"** for 2011, the actual achieved GHG emission reductions (392657 t $CO_2$e) are larger than it was indicated as prognostic estimation in the PDD (302096 t $CO_2$e).

The main reasons of the difference between the prognostic estimation of emission reductions in the PDD and the actual emission reductions in the Monitoring Report are:

1) Application of the principally different approaches and methods for prognostic estimation of GHG emission reductions in the PDD and for calculation of the actually achieved GHG emission reductions in the Monitoring Report (both approaches are described in details in the PDD), in particular impossibility of taking into account in the PDD of the actual conditions in reported period, etc.

2) Application of the strictly conservative approach for estimation of emission reductions in the PDD: the minimum assured (on the basis of the known results of similar measures) effect from implementation of all energy saving measures was accepted, and in some cases, when it was impossible to define it quantitatively was not taken into account in the calculations in the PDD, although it obviously must be positive.

3) Application in course of calculations in the Monitoring Report of the value of the carbon emission factor for electricity consumption in Ukraine according to the valid Order of the National Environmental Investment Agency of Ukraine, which is substantially higher than value used in the PDD according to the normative documents valid before.

In connection with participation in the JI project, in course of the project realization the system of responsibility of every employee from an operator to the technical director for optimal consumption of fuel and energy resources at the enterprise was established, as a result of which the off-schedule monitoring of all key parameters of operation of the system as a whole is carried out at the objects of the included enterprises, in particular the gas-air ratio during fuel combustion, compliance of temperature conditions of the heat carrier, optimization of partition of load for boilers at boiler-houses, etc., as well as additional and concomitant measures for emission reduction are implemented.

Thus, the actually achieved GHG emission reductions, under compliance with all proper conditions of the heat supply services, necessarily should be larger than the prognostic estimations.

# Annex 1 – Data

The data in this Annex are presented in accordance with Parameter 1 - 17 in the Monitoring plan.

| Parameter Number | Parameter Name |
|---|---|
| 1 | Fuel consumption by a boiler-house: |
| 1.1 | - Natural Gas |
| 1.2 | - Coal |
| 2 | Average calorific value of a fuel: |
| 2.1 | - Natural Gas |
| 2.2 | - Coal |
| 3 | Average outside temperature during the heating period |
| 4 | Average inside temperature during the heating period |
| 5 | Number of customers of hot water supply service |
| 6 | Heating area (total) |
| 7 | Averaged heat transfer factor of heated buildings in the base year |
| 8 | Heated area of buildings (previously existed in the base year) with the renewed (improved) heat insulation in the reported year |
| 9 | Heated area of newly connected buildings (assumed with the new (improved) heat insulation) in the reported year |
| 10 | Heat transfer factor of buildings with new heat insulation |
| 11 | Heating period duration |
| 12 | Duration of period of hot water supply service |
| 13 | Maximum connected load to a boiler-house, that is required for heating |
| 14 | Connected load to a boiler-house, that is required for hot water supply service |
| 15 | Standard specific discharge of hot water per personal account |
| 16 | Carbon emission factor for: |
| 16.1 | - Natural Gas |
| 16.2 | - Coal |
| 16.3 | - Electricity consumption in Ukraine |
| 16.4 | - Electricity generation in Ukraine |
| 17 | Electricity consumption by a boiler-house |

| **Parameter number and name** | **1.1.** Fuel consumption by a boiler house. Natural Gas |
|---|---|
| Description | Natural gas consumption by boiler houses |
| Value in monitoring period | 952010.32 ths $m^3$<br>The detailed data of natural gas consumption by every boiler-house are presented in Annex 2. |
| Monitoring method | Gas flow meters |
| Recording frequency | Registered every day and calculated once per year |
| Background data | Instrument readings are registered in the paper journals at every boiler-house. |
| Calculation method | n.a. |
| Comment | According to the conservative approach, the volume of consumed natural gas was corrected by measurement error. Amount of natural gas consumption in the reported year was used for Project emissions calculations was increased proportionally to the level of accuracy of gas flow meters installed at a boiler-house.<br>See Annex 2 and Annex 3. |

| **Parameter number and name** | **1.2.** Fuel consumption by a boiler house. Coal |
|---|---|
| Description | Coal consumption by boiler houses |
| Value in monitoring period | 130.40 tones |
| Monitoring method | Registration of coal purchasing was realized in accordance with invoices. |
| Recording frequency | Registered every day and calculated once per year |
| Background data | Coal consumption is registered in the paper journals at a boiler-house.<br>Invoices are filed in special journals. |
| Calculation method | n.a. |
| Comment | Coal was consumed only at boiler house Ak. Pavlova, 30/30-A in 2011. |

| **Parameter number and name** | **2.1.** Average calorific value of a fuel. Natural Gas |
|---|---|
| Description | Average Calorific Value of Natural Gas calculated by Net Calorific Value |
| Value in monitoring period | 34.66 MJ/$m^3$ |
| 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 contentious cases. It is used rarely |
| Recording frequency | Data is provided by natural gas suppliers monthly.<br>Registered every month and calculated once per year. |
| Background data | Registered in the paper journal |
| Calculation method | Weighted average value |
| Comment | n.a. |

| **Parameter number and name** | **2.2.** Average calorific value of a fuel. Coal |
|---|---|
| Description | Average Calorific Value of Coal calculated by Net Calorific Value |
| Value in monitoring period | 21.84 MJ/kg |
| 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 |
| Comment | n.a. |

| **Parameter number and name** | **3.** Average outside temperature during the heating period |
|---|---|
| Description | Average outside temperature during the heating period |
| Value in monitoring period | -1.56$^{o}$C |
| Monitoring method | Average outside temperature during the heating period is calculated by ME "Kharkivski teplovi merezhi" from the values of daily outside temperature taken by dispatcher of ME "Kharkivski teplovi merezhi" from Kharkiv Meteorological Centre at 10 to 11 a.m. every day of heating period. |
| Recording frequency | Average outside temperature is calculated once per year. Daily outside temperature is recorded every day of heating period |
| Background data | Meteorological Centre sends the Report every month for every day of heating period. Reports are filed in special journals |
| Calculation method | Average value |
| Comment | n.a. |

| **Parameter number and name** | **4.** Average inside temperature during the heating period |
|---|---|
| Description | Average inside temperature in the heated buildings during the heating period. |
| Value in monitoring period | 18 $^{o}$C |
| Monitoring method | Sum of returned payments |
| Recording frequency | Once per heating period |
| Background data | Accounting documents |
| Calculation method | According to item 5 of the "Order for recalculation of payment for rendering the centralized heating, cold and hot water supply services in cases of their non- rendering or non-full rendering, quality decrease" confirmed by the Order of Cabinet of Ministries of Ukraine No. 151 dated 17.02.2010[12], valid since 17.02.2010, enterprise makes the return payment of:<br>– 5% from payment for every degree from 18 to 12 $^{o}$C;<br>– when inside temperature is lower than 12 $^{o}$C, the payment is to be returned completely. |

[12] *http://zakon2.rada.gov.ua/laws/show/151-2010-%D0%BF*

| | |
|---|---|
| | Therefore the inside temperature is calculated by formulae:<br>If R = 0 (according to conservative approach, R < 0.05 is assumed for the baseline):<br>$\mathbf{T_{in\,b}}$ = 18 $^{o}$C.<br>If 0.05 < R ≤ 0.3:<br>$\mathbf{T_{in\,b}}$ = 18 – (R/0.05) [$^{o}$C];<br>If 0.3 < R < 1:<br>$\mathbf{T_{in\,b}}$ = 12 $^{o}$C is accepted.<br><br>where:<br>R - part of returned payment of NP;<br>NP – amount of normative payment.<br><br>The total sum of charge for population of Kharkiv city in 2011 was 1544.605 mln hrn. The sum of returned payment was 2.217 mln hrn. Percentage of returned payment is 0.14 % that corresponds to inside temperature 18$^{o}$ C. |
| Comment | n.a. |

| **Parameter number and name** | **5.** Number of customers of hot water supply service |
|---|---|
| Description | Number of customers of hot water supply service for every boiler house |
| Value in monitoring period | See Annex 2 |
| Monitoring method | Statistics of ME "Kharkivski teplovi merezhi" |
| Recording frequency | Customers update the contracts for hot water supply service with balance-owners (ZhEK) once per year. ZhEKs give to ME "Kharkivski teplovi merezhi" personal accounts of customers once per year. Contracts with organizations and legal entities are concluded directly with ME "Kharkivski teplovi merezhi". |
| 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 | n.a. |
| Comment | The data is taken for January, 01 of the next to reported year |

| **Parameter number and name** | **6.** Heating area (Total) |
|---|---|
| Description | Heating area for every boiler house |
| Value in monitoring period | 30919.22 ths m$^2$<br>The detailed data of heating area for every boiler-house are presented in Annex 2. |
| 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 sales departments of district heating productive unit of ME "Kharkivski teplovi merezhi" by the certificates of owners or balance-owners (ZhEK) in accordance with technical passports of buildings.<br>Total area with balconies and stairs and heated area are displayed in the special journal. |
| Calculation method | n.a. |
| Comment | The data is taken for January, 01 of the next to reported year |

| **Parameter number and name** | **7.** Averaged heat transfer factor of heated buildings in the base year |
|---|---|
| Description | Averaged heat transfer factor of buildings existed in the base year |
| Value in monitoring period | Assumed 0.63 W/($m^2$*K) |
| Monitoring method | Normative documents |
| Recording frequency | Once after the end of the base year |
| Background data | SNiP 2-3-79 (1998)[13], table 1a |
| Calculation method | n.a. |
| Comment | n.a. |

| **Parameter number and name** | **8.** Heated area of buildings (previously existed in the base year) with the renewed (improved) heat insulation in the reported year |
|---|---|
| Description | Heated area of reconstructed buildings with application of new heat insulation |
| Value in monitoring period | There were no reconstructed buildings with application of new improved heat insulation in the operation area of boiler-houses of ME "Kharkivski teplovi merezhi" |
| Monitoring method | Statistics of ME "Kharkivski teplovi merezhi" |
| Recording frequency | Once per year |
| Background data | Documents of ME "Kharkivski teplovi merezhi" |
| Calculation method | n.a. |
| Comment | n.a. |

| **Parameter number and name** | **9.** Heated area of newly connected buildings (assumed with the new (improved) heat insulation) in the reported year |
|---|---|
| Description | Heated area of newly connected buildings with application of the new heat insulation |
| Value in monitoring period | There were no new buildings connected to boiler-houses of ME "Kharkivski teplovi merezhi" |
| Monitoring method | Statistics of ME "Kharkivski teplovi merezhi" |
| Recording frequency | Once per year |
| Background data | Documents of ME "Kharkivski teplovi merezhi" |
| Calculation method | n.a. |
| Comment | n.a. |

| **Parameter number and name** | **10.** Heat transfer factor of new buildings and buildings with new heat insulation |
|---|---|
| Description | Heat transfer factor of buildings with new heat insulation |
| Value in monitoring period | Assumed 0.36 W/($m^2$*K) |
| Monitoring method | Normative documents |
| Recording frequency | Once per year |
| Background data | State Buildings Norms B.2.6-31:2006[14], Table 1 |
| Calculation method | n.a. |
| Comment | n.a. |

[13] *http://www.snip-info.ru/Snip_ii-3-79_%281998%29.htm*
[14] *http://dbn.at.ua/load/1-1-0-13*

| **Parameter number and name** | **11.** Heating period duration |
|---|---|
| Description | Heating period duration for every boiler-house |
| Value in monitoring period | 4464 hours |
| Monitoring method | Statistics of ME "Kharkivski teplovi merezhi" |
| Recording frequency | Once per year |
| Background data | The duration (beginning and ending) of the heating period is defined in accordance with item 7.9.4 of "Rules of technical exploitation of heating equipment and networks. 2007"[15]. 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>The actual duration of the heating period is taken from statistics of ME "Kharkivski teplovi merezhi". |
| Calculation method | Sum of durations from the beginning of the calendar year till data of ending of the heating season, and from data of beginning of the new heating season till ending of this calendar year |
| Comment | n.a. |

| **Parameter number and name** | **12.** Duration of period of hot water supply service |
|---|---|
| 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 | Statistics of ME "Kharkivski teplovi merezhi" |
| Recording frequency | Once per day |
| Background data | Documents of ME "Kharkivski teplovi merezhi" |
| Calculation method | Total duration of the hot water supply time per the calendar year |
| Comment | 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. |

| **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. |
| 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 | Statistics of ME "Kharkivski teplovi merezhi" |
| Recording frequency | Once per year |
| Background data | Documents of ME "Kharkivski teplovi merezhi" |
| Calculation method | Maximum connected load to the boiler-house, that is required for heating, is calculated by ME "Kharkivski teplovi merezhi" for every heating period. It is calculated according to heat demand at |

[15] *http://zakon.rada.gov.ua/cgi-bin/laws/main.cgi?page=6&nreg=z0197-07*

| | |
|---|---|
| | outside minimal temperature -23 $^{o}$C set in KTM 204 Ukraine 244-94[16], Annex 1. |
| Comment | n.a. |

| **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 |
| 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 | Statistics of ME "Kharkivski teplovi merezhi" |
| Recording frequency | Once per year. |
| Background data | Documents of ME "Kharkivski teplovi merezhi" |
| Calculation method | 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 and standard specific discharge of hot water per personal account. |
| Comment | n.a. |

| **Parameter number and name** | **15.** 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 Table 2.10 of "KTM 204 Ukraine 244-94". |
| Monitoring method | Normative documents |
| Recording frequency | Once per year. |
| Background data | Table 2.10 of "KTM 204 Ukraine 244-94" |
| Calculation method | n.a. |
| Comment | At present the standard specific discharge of hot water is valid in Ukraine that was established by the "KTM 204 Ukraine 244-94", and no information is available on any propositions to change it. |

| **Parameter number and name** | **16.** Carbon emission factor |
|---|---|
| Description | Carbon emission factor for different fuels, for electricity generation and consumption in Ukraine. |
| Value in monitoring period | Cef (natural gas) = 0.0554 kt$CO_2$/TJ<br>Cef (coal) = 0.0928 kt$CO_2$/TJ<br>$CEF_g$ = 1.063 t $CO_2$e/ MWh<br>$CEF_c$ (for 1 class customers) = 1.090 t $CO_2$e/ MWh<br>$CEF_c$ (for 2 class customers) = 1.227 t $CO_2$e/ MWh |
| Monitoring method | Normative documents |
| Recording frequency | Once per year |
| Background data | For all fuels the data from the "National inventory report of Ukraine for 1990 – 2009"[17] (determined for 2009) were used. For natural gas the data from the Table P2.6, for coal - from the Table P2.12. |

[16] http://www.twirpx.com/file/153194/
[17] http://unfccc.int/files/national_reports/annex_i_ghg_inventories/national_inventories_submissions/application/zip/ukr-2011-nir-08jun.zip

| | |
|---|---|
| | The values of the carbon emission factors for electricity generation and consumption in Ukraine was taken according to the Order of the National Environmental Investment Agency of Ukraine #75 dated 12.05.2011[18]. |
| Calculation method | Carbon emission factors for all fuels (kt $CO_2$/TJ) were calculated by carbon content of fuels (t C/TJ) multiplied by the ratio of molar masses of carbon dioxide ($CO_2$) to carbon (C). |
| Comment | The national data for carbon emission factors calculated for Ukraine and confirmed by Ukrainian DFP were used in this Monitoring report. |

| **Parameter number and name** | **17.** Electricity consumption by a boiler-house |
|---|---|
| Description | Electricity consumption by the boiler-houses (CHPs) and heat supply stations related to them. |
| Value in monitoring period | 131229.19 MWh<br>The detailed data of electricity consumption by every boiler-house are presented in Annex 4. |
| Monitoring method | Registered every day and calculated once per year |
| Recording frequency | Every day |
| Background data | Instrument readings are registered in the paper journals at boiler-house. |
| Calculation method | Total electricity consumption is calculated separately for 1 and 2 class customers. The boiler-house KKR (#161 in the project) and CHP-4 (#278 in the project) are the 1 class customers, and all other objects that are included to ERUs calculations due to electricity saving are the 2 class customers. |
| Comment | According to the conservative approach, the volume of consumed electricity was corrected by measurement error. Electricity consumption in the reported year that used for Project emissions calculations was increased proportionally to the level of accuracy of electricity meters installed at a boiler-house.<br>See Annex 4 and Annex 5. |

[18] *http://www.neia.gov.ua/nature/doccatalog/document?id=127498*