JI MONITORING REPORT

MR 002 VERSION 4.0 DATED 26 APRIL 2011

CONTENTS

<u>Annexes</u>

SECTION A. General project activity information

A.1 Title of the project activity:

Usage of alternative raw materials at Kryvyi Rih Cement, Ukraine.

A.2. JI registration number: JI0194

A.3. Short description of the project activity:

The project is aimed at significant decrease of the emissions originating from calcination of raw materials in the clinker kiln at PJSC Heidelbergcement Ukraine (formerly Kryvyi Rih Cement plant). Emissions from calcination can be decreased by addition of alternative raw materials[1] (AMC) which do not contain carbonates. Such alternative materials are metallurgical slag of different types, ashes generated at power plants that use coal fuel.

Kryvyi Rih cement is the major cement producers in Central Ukraine. The plant is owned by HeidelbergCement, one of the world's leading producers of building materials. Kryvyi Rih Cement was built in 1952 and fully modernized in 1983. Since the modernization the plant uses dry production process – one rotary kiln with calciner and multistage cyclone system capable to produce approximately 1.0 to 1.1mln ton of clinker annually.

It was planned to increase step by step over 2 to 3 years the share of AMC in the raw material mix to approximately 20% by mass from the level of about 4% which was achieved before the project start in 2004. This level is taken for the baseline. To adopt such high proportion of AMC the composition of raw materials had been adjusted by increasing the number of components to keep the clinker chemical composition and quality within the required limits.

Conventional raw materials for clinker manufacturing are limestone and clay with addition of small amounts of correcting additives (ferrous oxide).

As stated in the plan, from 2004 blast furnace slag was being added into raw material mix, thus partially replacing the natural raw materials. The actual annual amount of slag added since the beginning of the project is presented in Table 1. The slag is being added into the raw mix, prior to raw mills, and mixed/milled together with other raw materials (limestone, clay, additives) prior to entering the clinker kiln. The slag being originated from blast furnace process had already passed the treatment at high temperature and does not contain calcium and magnesium carbonates. Therefore, during thermal processing in clinker kiln at high temperature it does not decarbonizes with emission of CO_2 like natural raw materials do. The more slag in the raw meal, the less CO_2 is emitted during burning of materials in the kiln (emission from calcinations).

A.4. Monitoring period:

- Monitoring period starting date: 01.01.2010 at 00:00;
- Monitoring period closing date:31.12.2010 at 24:00

[1] AMC is defined as de-carbonated materials, see ACM0015/version02

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

A.5.1. Baseline methodology: The “Guidance on criteria for baseline setting and monitoring”, issued by the Joint Implementation Supervisory Committee allows using approved methodologies of the CDM. The PDD, determined by an AIE, uses a JI project specific approach to establish baseline scenario

A.5.2. Monitoring methodology: A JI-specific monitoring approach was developed for this project in line with the “Guidance on criteria for baseline setting and monitoring”. The resulting Monitoring Plan was determined as part of the determination process.

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

The project implementation started within planned time schedule. The actually achieved proportion of slag addition is presented in a table below:

Year	Slag addition percentage achieved
2004	11.51
2005	18.03
2006	20.62
2007	16.67
2008	18.4
2009	20.4
2010	**21.7**

Table 1: Status of project implementation during 2004 -2010

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

Monitored amount of emission reduction differs from the one expected in PDD for the respective period stated in A.4. as shown in a table 2 below:

Year	2010
ERs in MR002 in tons of CO_2 equiv.	77 515
ERs in determined PDD in tons of CO_2 equiv.	123 199

Table 1: Monitored amount of ER and expected in PDD for 2010

The difference can be explained by i) increase of calculation accuracy by using of more accurate (e.g. weighted average instead of annual average) initial data collected for MR versus those at PDD stage and taking into account small emissions sources which at the stage of PDD calculations preparation were neglected as minor or not material ones; ii) changes in clinker production volume: actual ones versus estimates in PDD; iii) changes in the share of slags used in raw meal.
There are no other deviations to the determined PDD

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

There are no deviations to the determined MP.

A.9. Changes since last verification:

As the kiln was equipped with coal dust heating system, the dosing, supplying and measuring of coal had to be maintained. New supplying, dosing and weighting devices were put into operation:

1) Weigh feeder Pfister DRW 4.10/1,6 Serial №: 77068.20
2) Weigh feeder Pfister DRW 4.12/2 Serial №: 77068.30

This upgrade took place in December 2009. Therefore, coal dust supplied for the plant's purposes after the upgrade was used for clinker production needs. In the previous MR formulae on BE_{FC} and PE_{FC} from PDD were simplified as only NG was used as a fuel. Since coal equipment has been put into operation, the former formulae become not applicable. Baseline and project emissions after the upgrade will be calculated using the following approach proved to include all data needed:

Monitoring activities according to the previous monitoring report			Deviations to the previous monitoring report		
Variable	**Units**	**Method of monitoring**	**Variable**	**Units**	**Method of monitoring**
BE_{FC}	tCO2	Calculated by formula: $BE_{FC} = KE_{BSL} \times \frac{\sum_i (FC_{i,y} \times NCV_{NG} \times EF_{CO_2,NG})}{\sum_i (FC_{i,y} \times NCV_{NG})} \times CLNK_y$ Where: BE_{FC} is the baseline emissions due to kiln fuel combustion (tCO_2) KE_{BSL} is the specific baseline kiln calorific consumption (kiln efficiency) (GJ/t clnk) $FC_{i,y}$ is the kiln fuel of type i consumption during the year y (thousand normalized m^3) $EF_{CO2,NG}$ is the carbon emission factor of fuel of type i (tCO_2/GJ) NCV_{NG} is the net (lower) calorific value of fuel of type I (GJ/ton or thousand normalized m^3) $CLNK_y$ is the annual clinker production in year y (tons)	BE_{FC}	tCO2	Calculated by formula: $BE_{FC} = KE_{BSL} \times \frac{\sum_i (FC_{i,y} \times NCV_i \times EF_{CO_2,i})}{\sum_i (FC_{i,y} \times NCV_i)} \times CLNK_y$ Where: BE_{FC} is the baseline emissions due to kiln fuel combustion (tCO_2) KE_{BSL} is the specific baseline kiln calorific consumption (kiln efficiency) (GJ/t clnk) $FC_{i,y}$ is the kiln fuel of type i consumption during the year y (thousand normalized m^3) $EF_{CO2,i}$ is the carbon emission factor of fuel of type i (tCO_2/GJ) NCV_i is the net (lower) calorific value of fuel of type I (GJ/ton or thousand normalized m^3) $CLNK_y$ is the annual clinker production in year y (tons)
$PE_{kiln,y}$	tCO2	Calculated by formula: $PE_{kiln,y} = FC_{NG,kiln\,y} \times NCV_{NG,y} \times EF_{CO2,NG,y}$ Where: $PE_{kiln,y}$ is project emission from combustion of kiln fuels in year y (tCO2); $FC_{NG,\,kiln,y}$ is the fuel of type i consumed by the kiln during the year y (thousands normalized m^3);	PE_{FC}	tCO2	Calculated by formula: $PE_{FC} = SKC_y \times \frac{\sum_i (FC_{i,y} \times NCV_i \times EF_{CO_2,i})}{\sum_i (FC_{i,y} \times NCVi)} \times CLNK_y$ Where: PE_{FC} is the project emissions due to kiln fuel combustion (tCO_2); SKC_y is the specific kiln calorific consumption (kiln efficiency) (GJ/t clnk); $FC_{i,y}$ is the kiln fuel of type i

		$NCV_{NG,y}$ is the net calorific value of natural gas used in year y(GJ/thousand normalized m^3); $EF_{CO2,NG,y}$ is Carbon Emission Factor of NG (tCO2/GJ).			consumption during the year y (ton or thousand normalized m^3); $EF_{CO2,i}$ is the carbon emission factor of fuel of type i (tCO_2/GJ); NCV_i is the net (lower) calorific value of fuel of type i (GJ/ton or thousand normalized m^3); $CLNK_y$ is the annual clinker production in year y (tons).

Table 3: Deviations to the previous monitoring plan

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

PJSC Heidelbergcement

- Yevgeniya Shamatulska, Chief engineer for environment;
- Lyudmila Rudneva, Chief specialist for safety and environment.

Global Carbon B.V.

- Denis Rzhanov, Team Leader JI Consultants;
- Iurii Petruk, Junior JI Consultant.

SECTION B. Key monitoring activities according to the monitoring plan for the monitoring period stated in A.4.

Key monitoring activities for each subproject could be described as follows.

The emission sources in the project are:

- Emission due to fuel combustion (in the kiln and auxiliary combustion for material drying);
- Emissions from calcinations of raw materials at high temperatures in the kiln;
- Indirect emissions due to consumption of grid electricity.

The following parameters are monitored in order to calculate the emissions:

Monitoring of kiln fuel consumption.
Cement plant has 1 kiln, which is in operation for the whole year except for overhaul/maintenance shutdowns. The fuels during monitoring period stated in A.4. were natural gas (NG) and coal dust. Gas consumption is constantly monitored by the two gas flow meters – one for the kiln burner and the second one for calciner of the kiln. Coal dust consumption is constantly monitored by the two weigh feeders Pfister.

Monitoring of fuel consumption for pre-drying of raw materials and components
Some of the materials added into the kiln require drying prior to be mixed and put into the kiln. Such materials are slags used to partially substituted the natural raw materials. The drying of them is conducted in drying drums using NG as fuel. Gas consumption for drums is measured by gas meters.

Monitoring of the calorific values of fuels used
The fuels during monitoring period stated in A.4. were natural gas and coal dust. The NCV of NG and coal dust has been monitored by the fuel certificates issued by the suppliers which have been regularly requested by cement plant.

Monitoring of electricity consumption for raw materials preparation and handling to kiln, for kiln operation and for fuel preparation and handling. This consumption is measured by the group of electrical meters.

Monitoring of CaO and MgO content in the clinker produced
Monitoring of oxides content in clinker is made by conducting regular chemical analysis in the plant laboratory.

Monitoring of non-carbonated CaO and MgO content in raw meal
Monitoring of non-carbonated content of these oxides in the raw meal is made by performing the chemical analysis of CaO and MgO content in alternative raw materials (AMC) added into raw meal, quantity of AMC added and further calculation to obtain the proportion of non-carbonated content of these oxides in the raw meal.

Monitoring of quantity of raw meal (RM) consumed by the kiln
The weight meters are used for monitoring of the RM quantity supplied to the kiln

Monitoring of quantity of clinker produced by the kiln
Clinker production is calculated based on constant metering of raw meal volume and chemical composition of RM (moisture and chemical composition measured my on-line x-ray spectrometer).

Quantity of clinker is obtained by multiplying special transition coefficient by weigh of raw meal supplied to the decarbonizer and the kiln.

B.1. Monitoring equipment:

The monitoring equipment can be divided into four groups: electrical meters, gas flow meters, weight meters and laboratory chemical test equipment.

Gas meters

There are six gas meters used to measure the gas consumption as shown in Fig 1 below, the GM1 and GM2 are measuring the kiln fuel consumption, which includes also the calciner of the kiln, and the four meters GM3 to GM6 measure the consumption for raw materials drying.

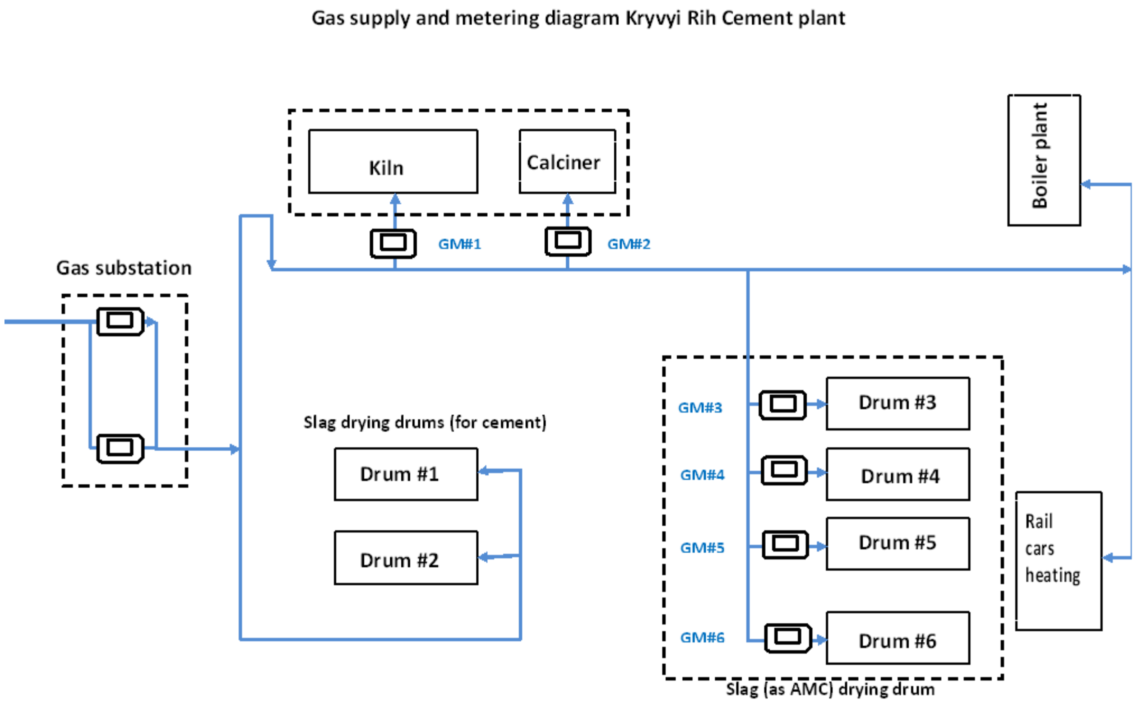


Figure 1: Gas supply and metering diagram

Meters are connected to the PC allowing for monitoring and storage of data.
Gas meters GM3 to GM6 outputs (flow rate, pressure and temperature of the gas) are processed in electronic processors “UNIVERSAL” which converts the actual gas flow rate into normalized m^3. The processors are connected to the PC allowing for monitoring and storage of data. The PC to which the data are logged and stored is installed in the department of chief power engineer.
During the period 2004-2006 the flows were recorded using paper circular diagrams which were processed daily and consumption recorded in a logbook. From 2007 until 2009 local electronic loggers were used instead of diagrams, data were processed daily and recorded in a logbook.
Since December 2009 the outputs of GM 1 and GM2, including gas flow rate, pressure and temperature are logged in the server of kiln automation system where the normalization of gas flow rate in normalized m^3 is performed and data are stored. The daily consumption data is transferred to the department of chief power engineer.

Coal dust weights

The weight of coal dust combusted in the kiln is measured by weigh feeder Pfister DRW 4.10/1,6 and weigh feeder Pfister DRW 4.12/2 that are installed at the line of coal dust dosing and supply to the kiln and the decarbonizer.

Power meters

To measure the total power consumption of raw material preparation chain (which includes mixing, milling grinding and handling to the kiln); kiln consumption and fuel preparation (if coal is used) 26 meters are used installed at switch rooms #6, 7 and 8.

Weight meters

To monitor the consumption of raw meal fed into the kiln the weight feeders are used as shown in the Figure 2 below. Each of weight feeders consist of dosing device DCC-130, meter Multistream G-400 D and feeding unit P7-M.

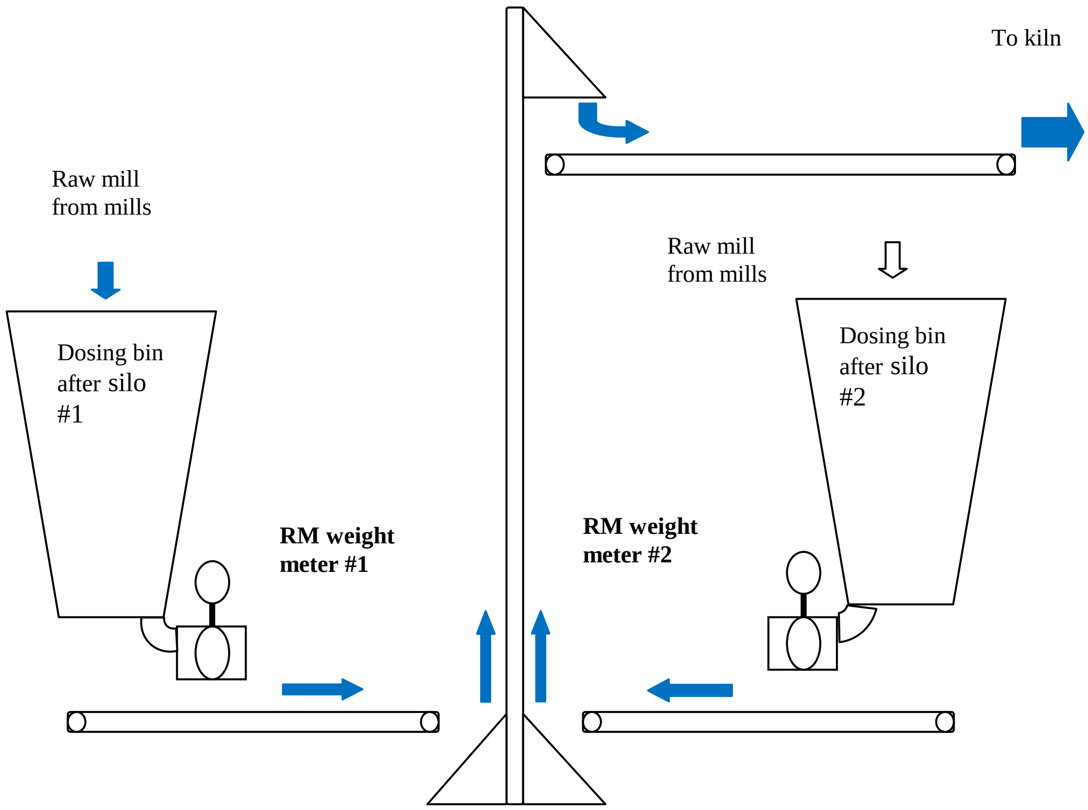


Figure 2: RM flow and measurement devices.

B.1.2. Table providing information on the equipment used (incl. manufacturer, type, serial number, date of installation, date of last calibration, information to specific uncertainty, need for changes and replacements):

Gas meters

Equipment	Variable	Unit	Producer/type	Serial number	Installation date	Last calibration	Next calibration	Accuracy	Comments
Gas meter #1	$FC_{NG,y}$	normalized m^3	Yokogava	91K616641	02/2011	02/02/2011	02/02/2013	± 0.1 %	Rotary kiln fuel consumption
Gas meter #2			Yokogava	91K616640	02/2011	02/02/2011	02/02/2013	± 0.1 %	Calciner of the kiln fuel consumption
Gas meter #3	$FC_{drums,y}$	normalized m^3	ABB 2600	6404031065	12/2009	01/02/2011	01/02/2013	± 0.1 %	NG consumption drum#1
Gas meter #4			ABB 2600	6404031066	12/2009	01/02/2011	01/02/2013	± 0.1 %	NG consumption drum#2
Gas meter #5			ABB 2600	6404031063	12/2009	01/02/2011	01/02/2013	± 0.1 %	NG consumption drum#3
Gas meter #6			ABB 2600	6404031068	12/2009	01/02/2011	01/02/2013	± 0.1 %	NG consumption drum#4

Table 4: Gas meters

Coal dust weight feeders

Equipment	Variable	Unit	Producer/type	Serial number	Installation date	Calibration frequency	Accuracy	Comments
Coal dust weigh feeder #1	$FC_{coal\ dust,y}$	t	Pfister DRW 4.10/1,6	77068.20	12/2009	On manufacture necessity	± 2 %	Decarbonizer coal dust supply
Coal dust weigh feeder #2			Pfister DRW 4.12/2	77068.30	12/2009		± 2 %	Rotary kiln coal dust supply

Table 5: Coal dust weights

Power meters

($EL_{RM, kiln, y}$)

Equipment	Location/ meter abbreviation	Manufacturer/ type	Serial number	Unit	Installation date	Accuracy	Last calibration	Next calibration	Comments
Power consumption for drying of raw materials in drying drums									
Consumption of draft fan №1, 6kV	SR8, cubicle14/ **EM1**	Elster-Metronica EA05RL-B-4	1090938	kWh	April 2011	± 0.5 %	11/04/2011	11/04/2017	Replacement report from 12/04/2011
Consumption of draft fan №2, 6kV	SR8 cubicle15/ **EM2**	Elster-Metronica EA05RL-B-4	1090930	kWh	April 2011	± 0.5 %	11/04/2011	11/04/2017	Replacement report from 12/04/2011
Consumption of draft fan №3, 6kV	SR8 cubicle16/ **EM3**	Elster-Metronica EA05RL-B-4	1090923	kWh	April 2011	± 0.5 %	11/04/2011	11/04/2017	Replacement report from 12/04/2011
Consumption of draft fan №4, 6kV	SR8 cubicle17/ **EM4**	Elster-Metronica EA05RL-B-4	1090965	kWh	April 2011	± 0.5 %	11/04/2011	11/04/2017	Replacement report from 12/04/2011
Consumption of 0.4 kV dryer drums auxiliaries TS17 TR#1	SR8 cubicle27/ **EM5**	Elster-Metronica EA05RL-B-4	1090963	kWh	April 2011	± 0.5 %	11/04/2011	11/04/2017	Replacement report from 12/04/2011
Consumption of 0.4 kV dryer drums auxiliaries TS16TR#2	SR8 cubicle20/ **EM6**	Elster-Metronica EA05RL-B-4	1090974	kWh	April 2011	± 0.5 %	04/04/2011	04/04/2017	Replacement report from 08/04/2011
Consumption for raw materials milling									
Consumption of raw mill #1 at 6 kV	SR7 cubicle15/ **EM7**	Elster-Metronica EA05RL-B-4	1090968	kWh	December 2010	± 0.5 %	18/02/2010	18/02/2016	Replacement report from 07/12/2010
6 kV fan of raw mill #1consumption	SR7 cubicle17/ **EM8**	Elster-Metronica EA05RL-B-4	1090900	kWh	December 2010	± 0.5 %	18/02/2010	18/02/2016	Replacement report from 07/12/2010

Consumption of raw mill #2 at 6 kV	SR7 cubicle16/ **EM9**	Elster-Metronica EA05RL-B-4	1090931	kWh	December 2010	± 0.5 %	18/02/2010	18/02/2016	Replacement report from 08/12/2010
Consumption of 6 kV fan of raw mill #2	SR7 cubicle20/ **EM10**	Elster-Metronica EA05RL-B-4	1090957	kWh	December 2010	± 0.5 %	18/02/2010	18/02/2016	Replacement report from 08/12/2010
Consumption of 0.4 kV auxiliaries of raw mills at TS13/TR#1	SR7 cubicle23/ **EM11**	Elster-Metronica EA05RL-B-4	1090925	kWh	April 2011	± 0.5 %	04/04/2011	04/04/2017	Replacement report from 07/04/2010
Consumption of 0.4 kV auxiliaries of raw mills at TS13/TR#2	SR7 cubicle26/ **EM12**	Elster-Metronica EA05RL-B-4	1090950	kWh	April 2011	± 0.5 %	04/04/2011	04/04/2017	Replacement report from 07/04/2010
Kiln power consumption									
Consumption of kiln main drive #1	SR6 cubicle14/ **EM13**	Elster-Metronica EA05RL-B-4	1090929	kWh	December 2010	± 0.5 %	18/02/2010	18/02/2016	Replacement report from 16/12/2010
Consumption of kiln main drive #2	SR6 cubicle5/ **EM14**	Elster-Metronica EA05RL-B-4	1090952	kWh	December 2010	± 0.5 %	18/02/2010	18/02/2016	Replacement report from 16/12/2010
Consumption of kiln end draft fan	SR7 cubicle27/ **EM15**	Elster-Metronica EA05RL-B-4	1090932	kWh	December 2010	± 0.5 %	18/02/2010	18/02/2016	Replacement report from 16/12/2010
Consumption of aspiration fan #1	SR6 cubicle15/ **EM16**	Elster-Metronica EA05RL-B-4	1090912	kWh	December 2010	± 0.5 %	18/02/2010	18/02/2016	Replacement report from 16/12/2010
Consumption of aspiration fan #2	SR6 cubicle24/ **EM17**	Elster-Metronica EA05RL-B-4	1090934	kWh	December 2010	± 0.5 %	18/02/2010	18/02/2016	Replacement report from 16/12/2010
6 kV consumption of after kiln fan	SR9 cubicle7/ **EM18**	Elster-Metronica EA05RL-B-4	1090933	kWh	April 2011	± 0.5 %	04/04/2011	04/04/2017	Replacement report from 08/04/2011

0.4 kV consumption of after kiln fan	SR9 cubicle2/ **EM19**	Elster-Metronica EA05RL-B-4	1090947	kWh	April 2011	± 0.5 %	04/04/2011	04/04/2017	Replacement report from 08/04/2011
0.4 kV consumption of kiln auxiliaries from TS11/TR#1	SR6 cubicle7/ **EM20**	Elster-Metronica EA05RL-B-4	1090906	kWh	April 2011	± 0.5 %	04/04/2011	04/04/2017	Replacement report from 08/04/2011
0.4 kV consumption of kiln auxiliaries from TS11/TR#2	SR6 cubicle12/ **EM21**	Elster-Metronica EA05RL-B-4	1090896	kWh	April 2011	± 0.5 %	04/04/2011	04/04/2017	Replacement report from 08/04/2011
0.4 kV consumption of kiln auxiliaries from TS14/TR#1	SR7 cubicle25/ **EM22**	Elster-Metronica EA05RL-B-4	1090954	kWh	April 2011	± 0.5 %	04/04/2011	04/04/2017	Replacement report from 07/04/2011
0.4 kV consumption of kiln auxiliaries from TS14/TR#2	SR7 cubicle28/ **EM23**	Elster-Metronica EA05RL-B-4	1090917	kWh	April 2011	± 0.5 %	04/04/2011	04/04/2017	Replacement report from 07/04/2011
Coal mill consumption									
Consumption of the coal mill	SR8 cubicle32/ **EM24**	Elster-Metronica EARALX-P4B-4	1150424	kWh	2009	± 0.5 %	09/02/2007	09/02/2013	
Consumption of the coal mill fan	SR8 cubicle30/ **EM25**	Elster-Metronica EA05RAL-B-4	1140832	kWh	2009	± 0.5 %	07/07/2006	07/07/2012	
Consumption of the coal mill fan	SR8 cubicle22/ **EM26**	Elster-Metronica EA05RL-B-4	1090905	kWh	April 2011	± 0.5 %	18/02/2010	18/02/2016	Replacement report from 19/04/2011

Table 6: Power meters

Weight meters for raw meal

Equipment	**Variable**	**Unit**	**Producer/type**	**Serial number**	**Installation date**	**Calibration frequency**	**Accuracy**	**Comments**
RM weight	RM_y	t	Schenck	HWFK/01038/1	11/02/2003	On	± 1 %	Calibration is performed by

meter #1			Process, DCC-130-1 Multistream G400			manufacture necessity		plant personnel in accordance with the calibration instruction issued by the manufacturer once per shift (12 hours)
RM weight meter #2				HWFK/01038/2	20/05/2003			

Table 7: Raw meal weight meters

B.1.3. Calibration procedures:

For Natural Gas Meters

QA/QC procedures	Body responsible for calibration and certification
Calibration interval of such meters is 2 years.	Ukrainian Centre for Standardization and Metrology

For coal dust weigh feeders and raw meal weigh feeders

QA/QC procedures	Body responsible for calibration and certification
Calibration interval of such meters is not specified and is performed on technical demand.	Plant internal services

For power meters

QA/QC procedures	Body responsible for calibration and certification
Calibration interval of such meters is 6 years.	Ukrainian Centre for Standardization and Metrology

B.1.4. Involvement of Third Parties:

Ukrainian Centre for Standardization and Metrology
Gas distribution company "GazUkraina"
Coal distribution company "HC Fuels Ltd."
Coal distribution company "Westlink Group Ltd."
Coal distribution company "Loretta Holding Inc."

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

B.2.1. List of fixed default values:

Data variable	Source of data	Data unit	Comment
EF_{NG} emission factor of the NG combustion process	IPCC 2006	tCO2/GJ	IPCC 2006 default value = 0.0561 tCO2/GJ[2]
$EF_{Coal\ dust}$ emission factor of the coal dust combustion process	IPCC 2006	tCO2/GJ	IPCC 2006 default value = 0.101 tCO2/GJ[2]
$EF_{el,y}$, Standardized emission factor of the Ukrainian grid for reducing project	See Annex 2	tCO2/MWh	= 0.896 tCO2/MWh

Table 8: Project fixed default values

Data variable	Source of data	Data unit	Comment
EF_{NG} emission factor of the NG combustion process	IPCC 2006	tCO2/GJ	IPCC 2006 default value = 0.0561 tCO2/GJ
$EF_{Coal\ dust}$ emission factor of the coal dust combustion process	IPCC 2006	tCO2/GJ	IPCC 2006 default value = 0.101 tCO2/GJ.
$EF_{el,y}$, emission factor of the Ukrainian grid for reducing project	See Annex 2	tCO2/MWh	= 0.896 tCO2/MWh

[2] http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_2_Ch2_Stationary_Combustion.pdf

Table 9: Baseline fixed default values

Data variable	**Source of data**	**Data unit**	**Comment**
$CLNK_{Bsl}$ the baseline ex-ante annual clinker production volume	Baseline information	tons	See PDD, Annex 2. = 738 567 tons
RM_{Bsl} the baseline ex ante annual consumption of raw meal for clinker production	Baseline information	tons	See PDD, Annex 2. = 1163977 tons
CaO_{RM_Bsl} baseline ex ante contents of non-carbonated CaO in the raw meal	Baseline information	Tons non-carbonated CaO in ton of raw meal	See PDD, table 25 Annex 2. = 1.61% or 0.016 tons of non-carbonated CaO/ton of raw meal
MgO_{RM_Bsl} baseline ex ante contents of non-carbonated MgO in the raw meal	Baseline information	Tons non-carbonated MgO in ton of raw meal	See PDD, table 25 Annex 2. = 0.212% or 0.00212 tons of non-carbonated MgO/ton of raw meal
CaO_{CLNK_Bsl} baseline ex ante contents of CaO in the clinker	Baseline information	Tons of CaO in ton of clinker	See PDD, table 25 Annex 2. = 65.67% or 0.6567 tons of CaO/ton of clinker
MgO_{CLNK_Bsl} baseline ex ante contents of MgO in the clinker	Baseline information	Tons of MgO in ton of clinker	See PDD, table 25 Annex 2. = 1.8% or 0.018 tons of MgO/ton of clinker
KE_{BSL} baseline ex-ante kiln efficiency(specific fuel consumption)	Baseline information	GJ/ton of clinker	See PDD, table 24 of Annex 2. = 3.67 GJ/ton of clinker
$EL_{RM,\ kiln,\ BSl}$ baseline ex ante specific power consumption for clinker production including raw meal	Baseline information	kWh/ton of clinker	See PDD, table 27 of Annex 2. =101.06 kWh/ton of clinker

preparation and fuel preparation			
$FC_{dry, Bsl}$ baseline consumption of fuel for raw materials drying and kiln fuel preparation	Baseline information	GJ	See PDD, table 26 of Annex 2. =169084
CKD_{Bsl} annual amount of cement kiln dust left the kiln system	Baseline information	tons	See SD3 Dust emissions estimate. = 657 tons
D_{Bsl} cement kiln dust calcination rate		fraction	0.5

Table 10: Baseline ex-ante factors

B.2.2. List of variables:

Data variable	Data unit	Method of calculation	Meters used for calculation
$CLNK_y$ the annual clinker production volume for the monitoring period stated in the A.5	tons	Sum of daily kiln production reports	
RM_y the annual RM consumption over the monitoring period stated in A.5	tons	Sum of daily RM production reports	Sum of RM1 + RM2 (see. Table 7)
$CaO_{CLNK,y}$ average annual contents of CaO in the clinker	Fraction -tons CaO in ton of clinker	Weighted average made on monthly basis laboratory measurements	Chemical analysis made at plant chemical lab according to DSTU B V.2.7-202:2009
$MgO_{CLNK, y}$ annual average contents of MgO in the clinker	Tons MgO in ton of clinker	Weighted average made on monthly basis laboratory measurements	Chemical analysis made at plant chemical lab according to DSTU B V.2.7-202:2009
$CaO_{RM, y}$ annual average contents of CaO in the raw meal	Tons CaO in ton of RM	Weighted average made on monthly basis laboratory measurements	Chemical analysis made at plant chemical lab according to DSTU B V.2.7-202:2009
$MgO_{RM, y}$ annual average contents of MgO in the raw meal	Tons MgO in ton of RM	Weighted average made on monthly basis laboratory measurements	Chemical analysis made at plant chemical lab according to DSTU B V.2.7-202:2009
$FC_{i, y}$ kiln fuel consumption of type i	Tons or	Measuring by gas meters and coal weigh	$FC_{NG, y}$ = GM1+GM2 (see Table 4)

in year y.	Thousands normalized m^3	feeders	$FC_{coal\ dust,\ y}$ = WF1+WF2 (see Table 5)
$FC_{drums,y}$ Fuel consumption for drying of RM and kiln fuel in year y	Thousands normalized m^3	Measuring by gas meters	$FC_{drums,y}$ =GM3+GM4+GM5+GM6 (see Table 4)
$NCV_{i,\ y}$ net calorific values of fuels used in year y (annual average) [2]	Gas and coal dust suppliers monthly certificate	GJ/1000 normalized m^3 and GJ/ton. NCV given in the certificates in kcal/1000 normalized m^3 and kcal/ton is further converted into GJ/1000 normalized $m^3$and GJ/ton using multiplication factor of 4.187[3]	Gas supplier provides the NCV certificated on monthly basis Coal supplier provides the NCV certificated on each shipment
SKC_y	GJ/ton of clinker	Calculated as ratio of sum of $FC_{i,\ y}$, $NCV_{i\ y}$ and clinker produced $CLNK_y$	
$EL_{RM,\ kiln,\ y}$ is the annual power consumption for clinker production including raw meal preparation and fuel preparation	kWh	Measurement by power meters	$EL_{RM,\ kiln,\ y}$= ∑(EM1........EM25), see Table 6
CKD_y is the annual amount of cement kiln dust leaving kiln system (discarded CKD)	tons	Periodical testing of kiln flue gases after deducting units	Plant reporting according to state form 2-TP "Air pollutions" based on periodical flue gas sampling for dust content
d_y is the CKD calcinations rate	fraction		Default data

Table 11: Project monitored variables

B.2.3. Data concerning GHG emissions by sources of the project activity (referring to paragraph 53(a)):

Variable	Description	Unit	Value
	Period: year 2010		
$CLNK_{2010}$	Clinker production 2010	tons	898400
RM_{2010}	Consumption of raw meal in 2010	tons	1365568
$CaO_{CLNK,2010}$	Average annual contents of CaO in the clinker	tons CaO in ton of clinker	0.6583
$MgO_{CLNK,2010}$	Average annual contents of MgO in the clinker	tons MgO in ton of clinker	0.0195

[3] http://www.unitconversion.org/unit_converter/energy.html

$CaO_{RM,2010}$	Annual average contents of non-carbonated CaO in the raw meal	tons CaO in ton of RM	0.0664
MgO_{RM2010}	Annual average contents of non-carbonated MgO in the raw meal	tons MgO in ton of RM	0.0080
$FC_{NG,\ 2010}$	Kiln NG consumption in 2010	Thousands normalized m^3	12989.676
$FC_{coal\ dust,\ 2010}$	Kiln coal dust consumption in 2010	t	102032.2
$FC_{drums,2010}$	Consumption of NG for RM drying in 2010	Thousands normalized m^3	5987.634
$EL_{RM,\ kiln,\ 2010}$	Power consumption for clinker production including raw meal preparation and fuel preparation in 2010	kWh	90021231
CKD_{2010}	Annual volume of cement kiln dust left the kiln system	tons	53.015
d_{2010}	CKD calcinations rate	fraction	0.5
$NCV_{NG\ 2010}$	Average net calorific value of natural gas in 2010	GCal/1000 normalized m^3	8.1519
$NCV_{coal\ 2010}$	Average net calorific value of coal dust in 2010	GCal/t	6.26910

Table 12: Data used in the project scenario

B.2.4. Data concerning GHG emissions by sources of the baseline (referring to paragraph 53(b)):

Variable	Description	Unit	Value
$CLNK_{Bsl}$	Clinker production in the baseline	tons	738 567
RM_{Bsl}	Consumption of raw meal in the baseline	tons	1163977
$CaO_{CLNK,Bsl}$	Average annual contents of CaO in the clinker	tons CaO in ton of clinker	0.6567
$MgO_{CLNK,Bsl}$	Average annual contents of MgO in the clinker	tons MgO in ton of clinker	0.018
$CaO_{RM,Bsl}$	Annual average contents of non-carbonated CaO in the raw meal	tons CaO in ton of RM	0.016
$MgO_{RM,Bsl}$	Annual average contents of non-carbonated MgO in the raw meal	tons MgO in ton of RM	0.00212
$FC_{drums,Bsl}$	Consumption of fuel for RM drying in the baseline	GJ	169084
$EL_{RM,\ kiln,\ Bsl}$	Specific power consumption for clinker production including raw meal preparation and fuel preparation in the baseline	kWh/ton clinker	101.06
CKD_{Bsl}	Annual volume of cement kiln dust left the kiln system	tons	657
d_{Bsl}	CKD calcinations rate in the baseline	fraction	0.5

Table 13: Data used in the baseline scenario

B.2.5. Data concerning leakage (referring to paragraph 53(c)):

No leakage has been identified in the PDD; therefore this section is not applicable.

B.2.6. Data concerning environmental impacts (referring to paragraph 53(d)):

The project foresees usage of different types of metallurgical slag being in most cases a waste product for metallurgy. Usage of such AMC does not directly influence the plant pollutions.

Starting slag addition required fulfilling the separate assessment of environmental impact (EIA in Ukrainian abbreviation).

Such assessment was performed in 2005 by the Special Design & Engineering Bureau "Cement" (Kharkiv, Ukraine). This EIA has received positive decision of the State Authority on Environmental Protection in Dnipropetrovs'k Region (# 168, 12 July 2006) and of the Dnipropetrovs'k Regional Sanitary Epidemic Station (# 140, 14 March 2006).

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

Fuel consumption

Kiln fuel consumption is measured by use of two gas meters measuring the NG consumption of the kiln main burner and two coal dust weigh feeders for measuring of the coal dust consumption of the kiln main burner and the calciner burner as shown at Figure 1 and Table 4 and Table 5.

Fuel consumption for drying of raw materials and AMC is measured by four identical gas meters.

All the data collected, transferred to the monitoring system and stored. Responsible for data collection and storage is within the energy department.

Power consumption

Metering of power consumed for raw meal preparation and handling, operation of the kiln, including the auxiliaries is organized by 26 power meters (See table 6). All the data metered are transferred to the monitoring system and stored. Responsible for data collection and storage is within the energy department.

CaO and MgO contents

CaO and MgO contents in clinker are being periodically (daily) measured by chemical test at plant laboratory as a part of quality assurance procedure. Data are stored and archived.

Non-carbonated CaO and MgO contents in raw meal are calculated at chemical laboratory on monthly basis using the result of chemical tests of all AMC added during the period and amounts of each types of AMC.

Raw meal consumption

RM consumption is measured constantly by weight meters (see Fig. 2 and Table 7) and daily sum data are collected and stored by kiln department in daily reports. Based on daily data, monthly and annual reports are produced and stored.

Clinker production

Clinker production is calculated based on constant metering of raw meal volume and chemical composition of RM (moisture and chemical composition measured my on-line x-ray spectrometer). Quantity of clinker is obtained by multiplying special transition coefficient by weigh of raw meal supplied to the decarbonizer and the kiln. Daily sum of clinker produced volumes are included in kiln department daily reports. Based on daily data, monthly and annual reports are produced.

CKD volume

The annual volume of CKD leaving the kiln system is obtained by regular testing (4 times a year) of dust contents in kiln exhaust gases after the filters. The data are collected and included in the state reporting form 2-TP “Air pollution”.

B.4. Special event log:

SECTION C. Quality assurance and quality control measures

C.1. Documented procedures and management plan:

C.1.1. Roles and responsibilities:

The general management of the monitoring team is implemented by the Chief Engineer for safety and environment through coordinating activities. On-site day-to-day (operational) management is implemented by the heads of corresponding units.

The data on fuel consumption by kiln and by RM drying drums, as well as the electricity consumption of RM and kiln are collected in the department of chief energy engineer and then transferred to the department of Deputy technical director for safety and environment.

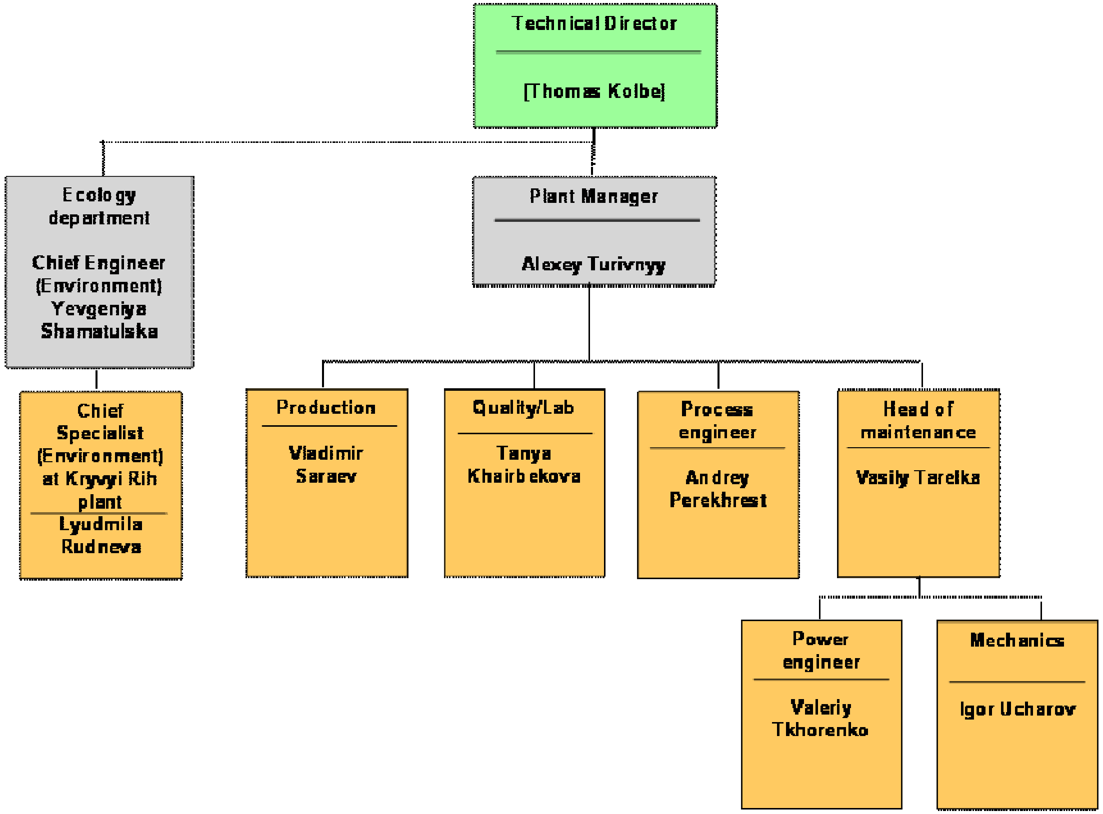
The data of contents of CaO and MgO in clinker, AMC are collected in the plant laboratory that is certified for making analysis and supplied to the department of chief technologist. The data on raw meal consumption, clinker production, are collected in the department of chief technologist and together with the data from plant laboratory are supplied to the department of Chief Engineer for safety and environment.

Reporting procedures in place are approved by plant instructions which include, among others, daily collection and reporting of RM consumption, clinker and cement production, slag usage as raw material, fuels and power usage. Based on this a regular daily report is produced which includes, besides abovementioned, the calculated specific kiln fuel consumption, specific power consumption per ton of cement, chemical composition of RM, clinker and cement.

All data necessary for the CO_2 emission reductions calculation is collected in the department of Chief Engineer for environment. The calculation of emission reduction is made on a regular basis by Global-Carbon.

For this monitoring period the names of the personnel involved is as follows:

- Technical Director of the plant: Thomas Kolbe;
- Plant manager of Kryvyi Rih Cement: Olexiy Turyvnyi;
- Chief engineer for environment: Yevgeniya Shamatulska;
- Chief specialist for safety and environment: Lyudmila Rudneva;
- Chief Process engineer; Andriy Perekhrest;
- Chief energy officer: Valery Thorenko;
- Head of laboratory: Tatyana Khairbekova;
- Production manager: Vladimir Saraev;
- Head of maintenance: Vasily Tarelka;
- Head of mechanics: Igor Ucharov.



C.1.2. Trainings:

All the equipment supplied foresaw personnel training as a separate contract clause. Training is providing by manufacturers. Technical and scientific support is being regularly provided to Kryvyi Rih plant by Heidelberg Technical Centre, a research unit responsible for new technologies/projects implementation support within the Heidelbergcement group worldwide.

C.2. Involvement of Third Parties:

The Ukrainian state body - Centre for Standardization and Metrology is a Third Party involved.

C.3. Internal audits and control measures:

The flows of materials (raw meal consumption, clinker production, cement production, slag consumption and other) are additionally audited by conducting of monthly inventory reports. This would allow for regular cross checking of values. All energy flows (electricity, coal dust and NG) are logged on the server at Energy department.

For the purpose of monitoring of emission reductions in a JI project JI0194 a calculations are made in accordance with the Monitoring plan in PDD by Global-Carbon.

C.4. Troubleshooting procedures:

In accordance with standard cement producer practice the department of chief technologist prepares a daily report which includes: cement production, clinker production, RM consumption, consumption of kiln and auxiliary fuels, consumption of electricity, specific consumption of fuel per ton of clinker (Kiln Efficiency), specific consumption of electricity per ton of cement produced, CaO and MgO contents and other data.

In case of a failure of any meter, the latter is being replaced by an operational one. The consumption during meter failure period will be calculated using cross checking method. Operating hours, capacity, working load of equipment, data from other meters will be analyzed and used for estimations.

SECTION D. Calculation of GHG emission reductions

D.1. Table providing the formulae used:

See section D.3 for description of formulae used for calculation of baseline, project emissions and resulting emission reduction for the monitoring period stated in A.4.1.

D.2. Description and consideration of measurement uncertainties and error propagation:

The uncertainties related to activity data (RM consumption, clinker production, consumption of energy and fuel) as well as the chemical composition of materials can be considered low as described in IPCC Volume 3, Chapter 2 (mineral industry emissions), 2.2.2 Uncertainty assessment.
The higher uncertainty associated with the calcination rate of discarded CKD, however does not present material influence on the resulting emissions due to very low volume of CKD discarded.

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

D.3.1. Project emissions:

The project emissions are calculated according to the equation 1 described below:

$$PE_y = PE_{calc,y} + PE_{FC,y} + PE_{dust,y} + PE_{dry,y} + PE_{EL\_grid,y} \quad \textbf{(1)}$$

Where:

PE_y	Project emission in year y, (tCO_2)
$PE_{calc,y}$	Project emission due to raw meal calcination in year y (tCO_2)
$PE_{FC,y}$	Project emission from combustion of kiln fuels in year y (tCO_2)
$PE_{dust,y}$	Project emission due to discarded dust from kiln bypass and dedusting units in year y (tCO_2)
$PE_{dry,y}$	Project emission due to fuel consumption for raw meal drying and fuel preparation in year y (tCO_2)
$PE_{EL\_grid, y}$	Project emission due consumption of grid electricity for clinker production y (tCO_2)

Calcination
Emissions from calcination are defined as follows:

$$PE_{calc,y} = 0.785(CaO_{CLNK,y} \times CLNK_y - CaO_{RM,y} \times RM_y) + 1.092(MgO_{CLNK,y} \times CLNK_y - MgO_{RM,y} \times RM_y) \quad \textbf{(2)}$$

Where:

$PE_{calc, y}$ is the project emission due to calcination of calcium carbonate and magnesium carbonate contained in the raw meal during pyroporocessing in clinker kiln in year y (tCO_2)
0.785 is the stoichiometric emission factor for CaO (tCO2/tCaO)
1.092 is the stoichiometric emission factor for MgO (tCO2/tMgO)
$CaO_{CLNK,y}$ is the non-carbonate CaO content in clinker in year y (tons of CaO/ton of clinker)
$CaO_{RM,y}$ is the non-carbonate CaO content in raw meal in year y (tons of CaO/ton of raw meal)
$MgO_{CLNK,y}$ is the non-carbonate MgO content in clinker in year y (tons of MgO/ton of clinker)
$MgO_{RM\_PR,y}$ is the non-carbonate MgO content in raw meal in year y (tons of MgO/ ton of raw meal)
$CLNK_y$ is the annual production of clinker y (tons)
RM_y is the annual consumption of raw meal in year y (tons)

Combustion of fuels in the kiln

In order to obtain the baseline value of emissions due to combustion of fuel(-s) in the kiln, the historical specific kiln energy consumption values were used

$$PE_{FC} = SKC_y \times \frac{\sum_i \left(FC_{i,y} \times NCV_i \times EF_{CO_2,i}\right)}{\sum_i \left(FC_{i,y} \times NCVi\right)} \times CLNK_y \qquad \textbf{(3)}$$

Where:

PE_{FC} is the project emissions due to kiln fuel combustion (tCO_2)
SKC_y is the specific kiln calorific consumption (kiln efficiency) (GJ/t clnk)
$FC_{i, y}$ is the kiln fuel of type i consumption during the year y (ton or thousands normalized m^3)
$EF_{CO2,i}$ is the carbon emission factor of fuel of type i (tCO_2/GJ)
NCV_i is the net (lower) calorific value of fuel of type i (GJ/ton or thousand normalized m^3)
$CLNK_y$ is the annual clinker production in year y (tons)

Bypass dust

If there is a discarded bypass dust from kiln bypasses and dedusting units (CDK), the project emissions due to discarded dust shall be determined as follows:

$$PE_{dust,y} = PE_{calc\,y} \times ByPass_y + \frac{PE_{calc\,y} \times d_y}{\left[PE_{calc,y}(1-d_y)+1\right]} \times CKD_y \qquad \textbf{(3)}$$

Where:

$PE_{dust,y}$ is the annual emission due to discarded dust from bypass and deducting unit (tCO_2)
$PE_{calc,y}$ is the project emissions from calcination of the raw meal in the year y (tCO_2)

$ByPass_y$ is the annual production of bypass dust living kiln system (tons)
CKD_y is the annual production of CKD dust leaving kiln systems (tons)
d_y is the CKD calcinations rate % (released CO_2 expressed as a fraction of the total carbonates CO_2 in the raw meal)
The dry kiln system of Kryvyi Rih Cement plant has no bypass duct, therefore By Pass = 0 and only CKD will be taken into account

Project emission from combustion of fuel for drying of raw meal and fuel
In addition to fuel consumption by the clinker kiln and calciner, fuel is also consumed by raw meal drying drums and dryer of coal meal.

$$PE_{dry,y} = FC_{drums,y} \times NCV_{fd,y} \times EF_{CO2,i} \qquad \textbf{(4)}$$

Where:
$PE_{dry,y}$ Project emission from combustion of fuels for drying drums in year y (tCO_2)
$FC_{drums,y}$ is the fuel of type *i* consumed by the drying drums during the year y (tons of thousands normalized m^3)
$EF_{CO2,i}$ fuel of type *i* Emission Factor (tCO_2/GJ)
$NCV_{fd,y}$ is the net (lower) calorific value of fuel of type i in the year y(GJ/ton or thousand normalized m^3)

Project emission from grid electricity consumption for clinker manufacture
Within the frames of the project electricity is consumed for clinker kiln and its auxiliary systems operation, for preparation (handling, drying, grinding) of raw meal and for fuel preparation and feeding in the kiln system

$$PE_{El\_grid,y} = EL_{RM,kiln,y} \div 1000 \times EF_{el,y} \qquad \textbf{(5)}$$

Where:
$PE_{El\_grid, y}$ is the project emission due to electricity consumption for preparation of raw meal, for clinker kiln system operation and for fuel feeding y (tCO_2)
$EF_{el, y}$ is the carbon emission factor of electricity grid of Ukraine in year y (tCO_2/MWh)
$EL_{RM, kiln,y}$ is the grid electricity consumption for clinker production, including consumption of electricity for raw meal preparation, kiln electricity consumption, fuel preparation and feeding in year y (kWh).

Project emissions PE $_y$	**2010**
Calcination PE_{calc}	400338
Kiln fuel PE_{FC}	295372

PE_{dust}	53
From fuel for drying PE_{dry}	11465
From grid power $PE_{EL\ RM,\ Kiln}$	80659
Total for the monitoring period 2010	**787888**

Table 14: Project emissions

D.3.2. Baseline emissions:

Baseline emissions are calculated as follows:
Where:

$$BE_y = BE_{Calcin} + BE_{FC} + BE_{Dust} + BE_{dry} + BE_{EL\_grid} \quad \textbf{(6)}$$

Where:

BE_y is the baseline emissions for the year y (tCO_2)

BE_{Calcin} is the baseline CO_2 emissions from calcinations of calcium carbonate and magnesium carbonate contained in the raw materials during burning in the clinker kiln (tCO_2)

BE_{FC} is the baseline emissions due to kiln fuel combustion (tCO_2)

BE_{Dust} is the baseline emissions due to discarded dust from kiln bypass and kiln exhaust de-dusting system (tCO_2)

BE_{dry} is the baseline emissions due to additional fuel consumption for raw materials or fuel preparation, (tCO_2)

BE_{EL_grid} is the baseline emissions due to grid electricity consumption (tCO_2)

Baseline emission from calcinations

$$BE_{Calcin} = \frac{CLNK_y}{CLNK_{Bsl}} \times \left(0.785 \times \left(CaO_{CLNK\_Bsl} \times CLNK_{Bsl} - CaO_{RM\_Bsl} \times RM_{Bsl}\right) + 1.092 \times \left(MgO_{CLNK\_Bsl} \times CLNK_{Bsl} - MgO_{RM\_Bsa} \times RM_{Bsl}\right)\right) \quad \textbf{(7)}$$

Where:

BE_{Calcin} is the baseline CO_2 emission from calcinations of calcium carbonate and magnesium carbonate (tCO2)

0.785 is the stoichiometric emission factor for CaO (tCO2/tCaO)

1.092 is the stoichiometric emission factor for MgO (tCO2/tMgO)

CaO_{CLNK_Bsl} is the non-carbonate CaO content in clinker in baseline (tons of CaO/ton of clinker)

CaO_{RM_Bsl} is the non-carbonate CaO content in raw meal in baseline (tons of CaO/ton of raw meal)

MgO_{CLNK_Bsl} is the non-carbonate MgO content in clinker in baseline (tons of MgO/ton of clinker)

MgO_{RM_Bsl} is the non-carbonate MgO content in raw meal in baseline (tons of MgO/ ton of raw meal)

$CLNK_{Bsl}$	is the annual production of clinker in the baseline (tons)
$ClNK_y$	is the actual annual production of clinker in the project year y (tons)
RM_{Bsl}	is the annual consumption of raw meal in the baseline (tons)

Baseline emissions from combustion of fuels in the kiln

In order to obtain the baseline value of emissions due to combustion of fuel(-s) in the kiln, the historical specific kiln energy consumption values were used

$$BE_{FC} = KE_{BSL} \times \frac{\sum_i \left(FC_{i,y} \times NCV_i \times EF_{CO_2,i}\right)}{\sum_i \left(FC_{i,y} \times NCVi\right)} \times CLNK_y \quad \textbf{(8)}$$

Where:

BE_{FC}	is the baseline emissions due to kiln fuel combustion (tCO_2)
KE_{BSL}	is the specific baseline kiln calorific consumption (kiln efficiency) (GJ/t clnk)
$FC_{i, y}$	is the kiln fuel of type i consumption during the year y (tons or thousands normalized m^3)
$EF_{CO2,i}$	is the carbon emission factor of fuel of type i (tCO_2/GJ)
NCV_i	is the net (lower) calorific value of fuel of type I (GJ/ton or thousand normalized m^3)
$CLNK_y$	is the annual clinker production in year y (tons)

Baseline emissions due to discarded dust from kiln exhaust gases de-dusting units

$$BE_{dust} = \left(BE_{calc} \times ByPass + \frac{BE_{calc} \times d}{\left[BE_{calc}(1-d)+1\right]} \times CKD_{Bsl} \right) \times \frac{CLNK_y}{CLNK_{Bsl}} \quad \textbf{(9)}$$

Where:

BE_{dust}	is the annual baseline emission due to discarded dust from bypass and deducting unit (tCO_2)
BE_{calc}	is the baseline emissions from calcination of the raw meal (tCO_2)
$ByPass_y$	is the annual production of bypass dust living kiln system (tons)
CKD_{Bsl}	is the baseline production of CKD dust leaving kiln systems (tons)
d	is the CKD calcinations rate % (released CO_2 expressed as a fraction of the total carbonates CO_2 in the raw meal)
$CLNK_y$	is the annual clinker production in year y (tons)
$CLNK_{Bsl}$	is the annual clinker production in baseline (tons)

Existing dry kiln at Kryvyi Rih Cement is not equipped with kiln gases by-pass; therefore discarded dust can occur only from cement kiln de-dusting units and only CKD will be taken into account.

Baseline emissions from fuel consumption for drying of raw meal or fuel preparation

Additional (to the kiln consumption) fuel can be consumed to pre-dry the raw materials and to dry the fuel (consumption of fuel by dryer of coal mill). Emissions due to additional fuel consumption are defined as follows:

$$BE_{dry} = \sum_i \left(FC_{dry,Bsl} \times EF_{CO2,i}\right) \times \frac{CLNK_y}{CLNK_{Bsl}} \quad \textbf{(10)}$$

Where:

BE_{dry} is the baseline emissions due to additional fuel consumption for raw materials or fuel preparation, (tCO_2)

FC_{dry_Bsl} is the baseline consumption of fuel of type i for raw meal drying and kiln fuel preparation (GJ)

$EF_{CO2,i}$ is the carbon emission factor of fuel of type i (tCO_2/GJ)

$CLNK_y$ is the annual clinker production in year y (tons)

$CLNK_{Bsl}$ is the annual clinker production in baseline (tons)

Baseline emission from grid electricity consumption for clinker production

Grid electricity is consumed in the baseline for kiln operation, raw meal preparation and for fuel preparation and feeding. Emissions from grid electricity consumption for these purposes are defined as follows:

$$BE_{El\_grid} = EL_{RM,kiln,Bsl} \div 1000 \times EF_{el,y} \times CLNK_y \quad \textbf{(11)}$$

Where:

$BE_{el,y}$ is the baseline emissions due to grid electricity consumption (tCO_2)

$EF_{el,\ y}$ is the carbon emission factor of electricity grid of Ukraine in year y (tCO_2/MWh)

$EL_{RM,\ kiln,Bsl}$ is the specific grid electricity consumption for clinker production, including consumption of electricity for raw meal preparation, kiln electricity consumption, fuel preparation and feeding in the baseline (kWh/ton clinker).

Baseline emissions BE $_y$	**2010**
Calcination BE_{calc}	459732
Kiln fuel BE_{kiln}	311983
BE $_{dust}$	799
From fuel for drying BE_{dry}	11538
From grid power BE $_{EL\ RM,\ Kiln}$	81350
Total for the monitoring period 2010	**865403**

Table 15: Baseline emissions

D.3.3. Leakage:

No leakage occurs. Not applicable.

D.3.4. Summary for the emission reductions during the monitoring period:

Emission reduction	**2010**
ER y, tCO2	77515

Table 16: Emission reduction for MR002

Annex 1

Standardized emission factors for the Ukrainian electricity grid

Introduction

Many Joint Implementation (JI) projects have an impact on the CO_2 emissions of the regional or national electricity grid. Given the fact that in most Economies in Transition (IET) an integrated electricity grid exists, a standardized baseline can be used to estimate the amount of CO_2 emission reductions on the national grid in case of:

a) Additional electricity production and supply to the grid as a result of a JI project (=producing projects);
b) Reduction of electricity consumption due to the JI project resulting in less electricity generation in the grid (= reducing projects);
c) Efficient on-site electricity generation with on-site consumption. Such a JI project can either be a), b), or a combination of both (e.g. on-site cogeneration with partial on-site consumption and partial delivery to the grid).

So far most JI projects in EIT, including Ukraine, have used the standardized Emission Factors (EFs) of the ERUPT program. In the ERUPT program for each EIT a baseline for producing projects and reducing projects was developed. The ERUPT approach is generic and does not take into account specific local circumstances. Therefore in recent years new standardized baselines were developed for countries like Romania, Bulgaria, and Estonia. In Ukraine a similar need exist to develop a new standardized electricity baseline to take the specific circumstances of Ukraine into account. The following baseline study establishes a new electricity grid baseline for Ukraine for both producing JI projects and reducing JI projects.

This new baseline has been based on the following guidance and approaches:

- The "Guidance on criteria for baseline setting and monitoring" for JI projects, issued by the Joint Implementation Supervisory Committee[4];
- The "Operational Guidelines for the Project Design Document", further referred to as ERUPT approach or baseline [5];
- The approved CDM methodology ACM0002 "Consolidated baseline methodology for grid-connected electricity generation from renewable sources" [6];
- Specific circumstances for Ukraine as described below.

ERUPT

The ERUPT baseline was based on the following main principles:

- Based mainly on indirect data sources for electricity grids (i.e. IEA/OECD reports);
- Inclusion of grid losses for reducing JI projects;
- An assumption that all fossil fuel power plants are operating on the margin and in the period of 2000-2030 all fossil fuel power plants will gradually switch to natural gas.

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[4] Guidance on criteria for baseline setting and monitoring, version 01, Joint Implementation Supervisory Committee, ji.unfccc.int

[5] Operational Guidelines for Project Design Documents of Joint Implementation Projects. Ministry of Economic Affairs of the Netherlands, May 2004

[6] Consolidated baseline methodology for grid-connected electricity generation from renewable sources, version 06, 19 May 2006, cdm.unfccc.int

The weak point of this approach is the fact that the date sources are not specific. For example, the Net Calorific Value (NCV) of coals was not determined on installation level but was taken from IPCC default values. Furthermore the IEA data included electricity data until 2002 only. ERUPT assumes that Ukraine would switch all its fossil-fuel plant from coal to natural gas. In Ukraine such an assumption is unrealistic as the tendency is currently in the opposite direction.

ACM0002

The ACM0002 methodology was developed in the context of CDM projects. The methodology takes a combination of the Operating Margin (OM) and the Build Margin (BM) to estimate the emissions in absence of the CDM project activity. To calculate the OM four different methodologies can be used. The BM in the methodology assumes that recent built power plants are indicative for future additions to the grid in the baseline scenario and as a result of the CDM project activity construction of new power plants is avoided. This approach is valid in electricity grids in which the installed generating capacity is increasing, which is mostly the case in developing countries. However, the Ukrainian grid has a significant overcapacity and many power plants are either operating below capacity or have been moth-balled.

Nuclear is providing the base load in Ukraine

In Ukraine nuclear power plants are providing the base load of the electricity in Ukraine. To reduce the dependence on imported fuel the nuclear power plants are running at maximum capacity where possible. In the past five years nuclear power plants provide almost 50% of the total electricity:

Year	2001	2002	2003	2004	2005
Share of AES	44%	45%	45%	48%	48%

Table 2: Share of nuclear power plant in the annual electricity generation

All other power stations are operating on the margin. This includes hydro power plants which is show in the table below.

	Minimum; 03:00	Maximum; 19:00
Consumption, MW	21,287	27,126
Generation, MW	22,464	28,354
Thermal power plants	*10,049*	*13,506*
Hydro power plants	*527*	*3,971*
Nuclear power plants	*11,888*	*10,877*
Balance imports/export, MW	-1,177	-1,228

Table 3: Electricity demand in Ukraine on 31 March 2005[7]

Development of the Ukrainian electricity sector

The National Energy Strategy[8] sets the approach for the overall energy complex of Ukraine and the electricity sector in particular. The main priority of Ukraine is to reduce the dependence of imported fossil fuels. The strategy sets the following priorities[9]:

- increased use of local coal as a fuel;
- construction of the new nuclear power plants;

[7] Ukrenergo, http://www.ukrenergo.energy.gov.ua/ukrenergo/control/uk/publish/article?art_id=39047&cat_id=35061

[8] http://mpe.kmu.gov.ua/fuel/control/uk/doccatalog/list?currDir=50505

[9] Energy Strategy of Ukraine for the Period until 2030, section 16.1, page 127.

- energy efficiency and energy saving.

Due to the sharp increase of imported natural gas prices a gradual switch from natural gas to coal at the power plants is planned in the nearest future. Ukraine possesses a large overcapacity of the fossil-powered plants of which many are mothballed. These moth-balled plants might be connected to the grid in case of growing demand.

In the table below the installed capacity and load factor is given in Ukraine. As one can see the average load factor of thermal power plant is very low.

	Installed capacity (GW)	Average load factor, %
Thermal power plants	33.6	28.0
Hydro power plants	4.8	81.4
Nuclear power plants	13.8	26.0
Total	**52.2**	**39.0**

Table 4: Installed capacity in Ukraine in 2004[10]

According to IEA's estimations, about 25% of thermal units might not be able to operate (though there is no official statistics). This means that still at least 45% of the installed thermal power capacity could be utilized, but is currently not used. In accordance with the IEA report the 'current capacity will be sufficient to meet the demand in the next decade'[11].

In the table below the peak load of the years 2001- 2005 are given which is approximately 50% of the installed capacity.

	2001	2002	2003	2004	2005
Peak load (GW)	28.3	29.3	26.4	27.9	28.7

Table 5: Peak load in Ukraine in 2001 - 2005[12]

New nuclear power plants will take significant time to be constructed will not get on-line before the end of the second commitment period in 2012. There is no nuclear reactor construction site at such an advanced stage remaining in Ukraine, it is unlikely that Ukraine will have enough resources to commission any new nuclear units in the foreseeable future (before 2012)[13].

Latest nuclear additions (since 1991):
- Zaporizhzhya NPP unit 6, capacity 1 GW, commissioned in 1995;
- Rivne NPP unit 4, capacity 1 GW, commissioned in 2004;
- Khmelnitsky NPP unit 2, capacity 1 GW, commissioned in 2004.

Nuclear power plants under planning or at early stage of construction:
- South Ukraine NPP one additional unit, capacity 1 GW;
- Khmelnitsky NPP two additional units, capacity 1 GW each.

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[10] Source: Ukraine Energy Policy Review. OECD/IEA, Paris 2006. p. 272, table 8.1

[11] Source: Ukraine Energy Policy Review. OECD/IEA, Paris 2006. p. 269

[12] Ministry of Energy, letter dated 11 January 2007

[13] http://www.xaec.org.ua/index-ua.html

Approach chosen

In the selected approach of the new Ukrainian baseline the BM is not a valid parameter. Strictly applying BM in accordance with ACM0002 would result in a BM of zero as the latest additions to the Ukrainian grid were nuclear power plants. Therefore applying BM taking past additions to the Ukrainian grid would result in an unrealistic and distorted picture of the emission factor of the Ukrainian grid. Therefore the Operating Margin only will be used to develop the baseline in Ukraine.

The following assumptions from ACM0002 will be applied:

1) The grid must constitute of all the power plants connected to the grid. This assumption has been met as all power plants have been considered;
2) There should be no significant electricity imports. This assumption has been met in Ukraine as Ukraine is a net exporting country as shown in the table below;
3) Electricity exports are not accounted separately and are not excluded from the calculations.

	2001	2002	2003
Electricity produced, GWh	175,109	179,195	187,595
Exports, GWh	5,196	8,576	12,175
Imports, GWh	2,137	5,461	7,235

Table 6: Imports and exports balance in Ukraine[14]

ACM0002 offers several choices for calculating the OM. Dispatch data analysis cannot be applied, since the grid data is not available[15]. Simple adjusted OM approach is not applicable for the same reason. The average OM calculation would not present a realistic picture and distort the results, since nuclear power plants always work in the base load due to the technical limitations (and therefore cannot be displaced) and constitute up to 48% of the overall electricity generation during the past 5 years.

Therefore, the simple OM approach is used to calculate the grid emission factor. In Ukraine the low-cost must-run power plants are nuclear power stations. Their total contribution to the electricity production is below 50% of the total electricity production. The remaining power plants, all being the fossil-fuel plants and hydro power plants, are used to calculate the Simple OM.

%	2001	2002	2003	2004	2005
Nuclear power plants	44.23	45.08	45.32	47.99	47.92
Thermal power plants	38.81	38.32	37.24	32.50	33.22
Combined heat and power	9.92	11.02	12.28	13.04	12.21
Hydro power plants	7.04	5.58	5.15	6.47	6.65

Table 7: Share of power plants in the annual electricity generation of Ukraine[16]

[14] Source: State Committee of Statistics of Ukraine. Fuel and energy resources of Ukraine 2001-2003. Kyiv, 2004

[15] Ministry of Energy, letter dated 11 January 2007

[16] “Overview of data on electrical power plants in Ukraine 2001 - 2005“, Ministry of Fuel and Energy of Ukraine, 31 October 2006 and 16 November 2006.

The simple OM is calculated using the following formula:

$$EF_{OM,y} = \frac{\sum_{i,j} F_{i,j,y} \cdot COEF_{i,j}}{\sum GEN_{j,y}}$$ **(Equation 12)**

Where:

$F_{i,j,y}$ is the amount of fuel *i* (in a mass or volume unit) consumed by relevant power sources *j* in year(s) *y* (2001-2005);

j refers to the power sources delivering electricity to the grid, not including low-operating cost and must-run power plants, and including imports to the grid;

$COEF_{i,j,y}$ is the CO2 emission coefficient of fuel *I* (tCO2 / mass or volume unit of the fuel), taking into account the carbon content of the fuels used by relevant power sources *j* and the percent oxidation of the fuel in year(s) *y*;

$GEN_{j,y}$ is the electricity (MWh) delivered to the grid by source *j*.

The CO2 emission coefficient $COEF_i$ is obtained as:

$$COEF_i = NCV_i \cdot EF_{CO2,i} \cdot OXID_i$$ **(Equation 13)**

Where:

NCV_i is the net calorific value (energy content) per mass or volume unit of a fuel *i*;

$OXID_i$ is the oxidation factor of the fuel;

$EF_{CO2,i}$ is the CO2 emission factor per unit of energy of the fuel *i*.

Individual data for power generation and fuel properties was obtained from the individual power plants[17]. The majority of the electricity (up to 95%) is generated centrally and therefore the data is comprehensive[18].

The Net Calorific Value (NCV) of fossil fuel can change considerably, in particular when using coal. Therefore the local NCV values of individual power plants for natural gas and coal were used. For heavy fuel oil, the IPCC[19] default NCV was used. Local CO_2 emission factors for all types of fuels were taken for the purposes of the calculations and Ukrainian oxidation factors were used. In the case of small-scale power plants some data regarding the fuel NCV is missing in the reports. For the purpose of simplicity, the NCV of similar fuel from a power plant from the same region of Ukraine was used.

Reducing JI projects

The Simple OM is applicable for additional electricity production delivered to the grid as a result of the project (producing JI projects). However, reducing JI projects also reduce grid losses. For example a JI

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[17] “Overview of data on electrical power plants in Ukraine 2001 - 2005“, Ministry of Fuel and Energy of Ukraine, 31 October 2006 and 16 November 2006.

[18] The data for small units (usually categorized in the Ukrainian statistics as ‘CHPs and others’) is scattered and was not always available. As it was rather unrealistic to collect the comprehensive data from each small-scale power plant, an average CO2 emission factor was calculated for the small-scale plants that provided the data. For the purpose of simplicity it was considered that all the electricity generated by the small power plants has the same average emission factor obtained.

[19] IPCC 1996. Revised guidelines for national greenhouse gas inventories.

project reduces on-site electricity *consumption* with 100,000 MWh and the losses in the grid are 10%. This means that the actual reduction in electricity *production* is 111,111 MWh. Therefore a reduction of these grid losses should be taken into account for reducing JI projects to calculate the actual emission reductions.

The losses in the Ukrainian grid are given in the table below and are based on the data obtained directly from the Ukrainian power plants through the Ministry of Energy.

Year	Technical losses %	Non-technical losses %	Total %
2001	14,2	7	21,2
2002	14,6	6,5	21,1
2003	14,2	5,4	19,6
2004	13,4	3,2	16,6
2005	13,1	1,6	14,7

Table 8: Grid losses in Ukraine[20]

As one can see grid losses are divided into technical losses and non-technical losses. For the purpose of estimating the EF only technical losses[21] are taken into account. As can been seen in the table the technical grid losses are decreasing. The average decrease of grid losses in this period was 0.275% per annum. Extrapolating these decreasing losses to 2012 results in technical grid losses of 12% by 2012. However, in order to be conservative the grid losses *over the full period 2006-2012* have been taken as 10%.

Further considerations

The "Guidance on criteria for baseline setting and monitoring" for JI projects requires baselines to be conservative. The following measures have been taken to adhere to this guidance and to be conservative:

- The grid emission factor is actually expected to grow due to the current tendency to switch from gas to coal;
- Hydro power plants have been included in the OM. This is conservative;
- With the growing electricity demand, out-dated mothballed fossil fired power plants are likely to come on-line as existing nuclear power plants are working on full load and new nuclear power plants are unlikely to come on-line before 2012. The emission factor of those moth-balled power plants is higher as all of them are coal of heavy fuel oil fired[22];
- The technical grid losses in Ukraine are high, though decreasing. With the current pace the grid losses in Ukraine will be around 12% in 2012. To be conservative the losses have been taken 10%;
- The emissions of methane and nitrous oxide have not taken into consideration, which is in line with ACM0002. This is conservative.

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[20] "Overview of data on electrical power plants in Ukraine 2001 - 2005", Ministry of Fuel and Energy of Ukraine, 31 October 2006 and 16 November 2006.

[21] Ukrainian electricity statistics gives two types of losses – the so-called 'technical' and 'non-technical'. 'Non-technical' losses describe the non-payments and other losses of unknown origin.

[22] "Overview of data on electrical power plants in Ukraine 2001 - 2005", Ministry of Fuel and Energy of Ukraine, 31 October 2006 and 16 November 2006.

Conclusion

An average CO_2 emission factor was calculated based on the years 2003-2005. The proposed baseline factors is based on the average constituting a fixed emission factor of the Ukrainian grid for the period of 2006-2012. Both baseline factors are calculated using the formulae below:

$$EF_{grid,produced,y} = EF_{OM,y} \quad \textbf{(Equation 14)}$$

and

$$EF_{grid,reduced,y} = \frac{EF_{grid,produced,y}}{1 - loss_{grid}} \quad \textbf{(Equation 15)}$$

Where:

$EF_{grid,produced,y}$ is the emission factor for JI projects supplying additional electricity to the grid (tCO2/MWh);

$EF_{grid,reduced,y}$ is the emission factor for JI projects reducing electricity consumption from the grid (tCO2/MWh);

$EF_{OM,y}$ is the simple OM of the Ukrainian grid (tCO2/MWh);

$loss_{grid}$ is the technical losses in the grid (%).

The following result was obtained:

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

Table 9: Emission Factors for the Ukrainian grid 2006 - 2012

Monitoring

This baseline requires the monitoring of the following parameters:

- Electricity produced by the project and delivered to the grid in year y (in MWh);
- Electricity consumption reduced by the project in year (in MWh);
- Electricity produced by the project and consumed on-site in year y (in MWh);

The baseline emissions are calculated as follows:

$$BE_y = EF_{grid,produced,y} x EL_{produced,y} + EF_{grid,reduced,y} x \left(EL_{reduced,y} + EL_{consumed,y}\right) \quad \textbf{(Equation 16)}$$

Where:

BE_y are the baseline emissions in year y (tCO2);

$EF_{grid,produced,y}$ is the emission factor of producing projects (tCO2/MWh);

$EL_{produced,y}$ is electricity produced and delivered to the grid by the project in year y (MWh);

$EF_{grid,reduced,y}$ is the emission factor of reducing projects (tCO2/MWh);

$EL_{produced,y}$ is electricity consumption reduced by the project in year y(MWh);

$EL_{consumed,y}$ is electricity produced by the project and consumed on-site in year y (MWh).

This baseline can be used as ex-ante (fixed for the period 2006 – 2012) or ex-post. In case an ex-post baseline is chosen the data of the Ukrainian grid have to be obtained of the year in which the emission reductions are being claimed. Monitoring will have to be done in accordance with the monitoring plan of ACM0002 with the following exceptions:

- the Monitoring Plan should also include monitoring of the grid losses in year y;

- power plants at which JI projects take place should be excluded. Such a JI project should have been approved by Ukraine and have been determined by an Accredited Independent Entity.

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