1. Estimate of CO2 emissions in Generation of Electricity for National Energy System

As a result of any CDM project activities, "measureable" reduction of the greenhouse gas emissions should be achieved. Emission reductions will be assessed against so called baseline level. Baseline is the scenario of GHG, which would occur in the absence of proposed CDM project activities.

In the projects related to electricity generation or consumption, energy baseline is assessed as electricity produced/consumed (kWh) in certain timeframe (as a rule, a year).

Baseline emissions are estimated by multiplying baseline energy by appropriate coefficient of emissions (gCO_2/kWh).

GHG emission reductions as a result of **CDM project activities** in electricity production or consumption is the volume of electricity per annum, i.e.:

Emission reductions = baseline emissions – project emissions

For instance, in the CDM projects for power generation via renewable energy sources, as a result of project activities, power generated at thermal power plants and CHPP by using fossil fuels is replaced by electricity generated by utilizing renewable energy sources, i.e. reduction of emissions equals to the amount of electricity generated and multiplied by the coefficient of emissions (gCO_2/kWh * kWh per annum)

In the CDM projects related to greater energy efficiency and reduced consumption of electricity as a result of project activities, reduction of emissions equals the difference between consumption without CDM project (baseline) and project consumption multiplied by the coefficient of emissions (gCO_2/kWh * kWh per annum).

Coefficient of emissions may be estimated based on accessible statistical data of the national energy system for certain year and approved by the Authorized National Body for subsequent use in the estimates of baseline and project lines in development of CDM project applications.

3.1 Methodology of Estimates

According to the *Tool to calculate the emission factor for an electricity system* approved by the CDM Executive Board, [3] in assessment of the coefficient of emissions for on-grid power, coefficient of emissions are estimated as the average weighted operating range and introduced range (0.5 + 0.5).

Operating margin and build margin is the percentage of CO2 emissions (coefficient of emissions) emitted in generating 1KWh in the energy system.

In case of **operating margin**, output and percentage emissions for entire energy system is determined except of renewable and low-cost sources of energy.

In determination of **build margin**, percentage of CO2 for any 5 power plants commissioned last and contributing at least 20% of total power output are estimated.

As of mid-August 2008, CDM Executive Council approved 15 methodologies including 4 consolidated methodologies, which can be used for development of baseline in the energy-related projects (Table 9).

Table 9: List of Approved Methodologies by Category 1 – Power generation (Traditional/RES)

Number of Methodology	Title
Consolidated Methodologies	
ACM0002	Consolidated methodology for power generation from renewable sources
ACM0004	Consolidated methodology for power generation from exhaust gas and/or heat
ACM0006	Consolidated methodology for power generation from biomass
ACM0007	Consolidated methodology for power generation in transition from single cycle to combined cycle
Methodology for Full-Scale Projects	
AM0007	Analysis of the least costly options of fuel for seasonal plants for biomass-based cogeneration
AM0010	Projects for trapping waste gas and generating electricity where trapping waste gases is not mandated by law
AM0014	Cogeneration based on comprehensive utilization of natural gas
AM0019	Renewable energy projects substituting the part of electricity generated at one of single stations operating on fossil fuel off-grid or on-grid, except for biomass projects
AM0024	Methodology to reduce greenhouse gases by trapping exhaust heat and utilizing it to generate electricity at cement factories
AM0026	Methodology for generating on-grid electricity with zero-emissions from renewable sources in Chile or countries with grounded qualified procedures in the dispatcher network
AM0029	Power stations operating on natural gas and generating on-grid electricity
AM0045	Connecting isolated power systems to the grid
AM0048	New cogeneration installations to supply electricity and/or steam to various consumers and substituting power and steam generation by more carbon-intensive fuel
AM0049	Power generation methodology utilizing natural gas in the industrial sector
AM0052	Increase power generation at existing hydropower plants by optimizing Decision-making Support System

In this report on assessment of the coefficient of emissions for CDM projects for generation of electricity, coefficient of CO2 emissions in generation of 1kWh were estimated at the following level (gCO_2/kWh):

1. All energy systems, i.e. thermal power plants of Uzbekenergo SJSC except for hydraulic stations.

2. At the level of individual thermal power plants: New Angren, Syrdarya, and Talimarjan (Annex 2);

Detailed outcomes of estimated CO2 emissions in generating 1kWh electricity (gCO2/kWh) based on approved methodology (3) from 2005 to 2007 are presented in Annex 1.

Official data obtained from Uzbekenergo SJSC were used to estimate CO2 emissions at thermal power plants by calorific value and natural spending of various types of fuel to generate electricity were used to estimate CO2 emissions at thermal power plants.

3.1.1 Calculating the Operating Margin Emission Factor

Coefficient of emissions – operating margin EF_OM (simplified) is determined as average weighted emissions (in gCO_2/kWh) in producing the unit of energy from all generating sources connected to the grid. According to the approved methodologies, energy generation from renewable energy sources was excluded in assessment of the coefficient. In case of Uzbekistan – this is energy generated at hydropower plants.

In assessment of the operating range, statistical data on operation of thermal power plants of Uzbekenergo SJSC in 2004-2007 were taken into account. Meanwhile, it was acknowledged that various forms of fuel are on the fuel balance of certain power plants, and heat energy is produced (Table 11).

Table 11: Main Features of Thermal Power Plants of Uzbekistan and Ratio of Different Fuels (2007)

Power Station	Technology	Fuel	Electricity Output (mln.kWh)	Useful Heat Output (thou. gCal)	Ratio of Fuel spent, electricity/ heat	Year Commissioned
Syrdarya TPP (rehabilitation of Unit 7 and 8)	□○	◆⦿	13502.4	330.6	97.20%	1972 **2002**
Tashkent TPP	□○	◆⦿	6355.9	209.6	96.30%	1963
New Angren TPP	□○	◆⦿■	5703.3	82.2	98.35%	1985
Navoi TPP	□○	◆	6711.8	2861.7	66.90%	1961
Talimarjon TPP	□○	◆	5647.9	27.3	99.40%	**2004**
Takhiatash TPP	□○	◆⦿	2649.6	3.6	99.80%	1961
Angren TPP	□○	◈⦿■	569.4	412.6	54.30%	1957
Muborak CHPP	□○	◆	433.9	1,934.7	16.20%	1985
Tashkent CHPP	□○	◆	191.8	1,805.8	8.40%	1939
Ferghana CHPP	□○	◆⦿	594.2	2,105.6	19.50%	1956

□ - power output
○ - useful heat produced (in excess of 500,000 gCal)
○ - useful heat produced (less than 500,000 gCal)
◆- natural gas, ⦿ - black oil, ■ - coal, ◈ - underground gas

Operating range was estimated based on the following formula:

$$EF_{grid,OMsimple,y} = \frac{\sum_{i,m} FC_{i,m,y} \cdot NCV_{i,y} \cdot EF_{CO2,i,y}}{\sum_{m} EG_{m,y}} \quad \textbf{(1) [3]}$$

Whereas:

$FC_{i,m,y}$ = amount of i type fossil fuel consumed by power generating unit m in year *y* (in bulk or volume units)

$NCV_{i,y}$ = Lowest calorific value (energy component) of fossil fuel type *i* in year *y* (gJ / in bulk or volume units)

$EF_{CO2,I,y}$ = Coeffient of CO_2 emissions for certain type of fuel *i* in year *y* (tCO_2/gJ)

$EG_{m,y}$ = New electricity generated and transmitted by the station/unit *m* in year *y* (MWh)

m = all power plants/power generating units in year y except for low cost power plants and power generating units (hydropower plants)

i = all types of fossil fuels burnt by the power station/power generating unit *m* in year - *y*

In 2007 the working range for the national energy system of Uzbekistan (TPP and CHPP of Uzbekenergo SJSC) was **586.8 g CO_2/kWh** (Table 12).

According to the guidelines approved by UNFCCC, the coefficient of emissions of operational range is estimated as the average value of power generated and accompanying emissions based on the available statistical data of the last 3 years. Average operating range was **617.7 g CO_2/kWh** (Table 13) in 2005-2007.

Table 12: Operating Margin for National Energy System of Uzbekistan (Uzbekenergo SJSC), 2007

Title	Total	Black oil, thousand tons	Gas, mln. m^3	Coal, thou.tons	GHG, mln. m^3
Power output, GWh	42 360				
Net imports, GWh	988.4				
TOTAL power, GWh	43 348				

Title	Total	Black oil, thousand tons	Gas, mln. m^3	Coal, thou.tons	GHG, mln. m^3
Natural fuel spending		478.2	11289.7	2379.36	164.1
Fuel calorific value, tJ/unit		40.07	34.16	10.04	3.58
CO_2 emissions, Gg	25 435	1 483.10	21 635.31	2 259.88	56.44
Emissions, gCO_2/kWh	**586,8**				

Table 13: Operating Margin for TPP and CHPP in 2005 - 2007

Uzbekenergo SJSC (only TPP and CHPP)	Power Output (GWh per annum)	Emissions of all types of fuel (CO_2 thou. tons)
2005	40 173.53	25,939.74
2006	42 889.62	26,708.95
2007	43 347.97 *	25,435.02
Average value gCO_2/kWh	**617.7**	

** - Approved methodology (3) required that net imports of electricity generated by the national energy grid in the aforementioned year should be taken into account. In 2007 output of TPP and CHPP amounted to 42,360.3 GWh per annum, while net import of electricity amounted to 988.4 GWh per annum.*

3.1.2 Estimating the Coefficient of Emissions of Build Margin

Coefficient of emissions – build margin of $EF_{grid,BM,y}$ is determined as the average weighted emissions (in gCO_2/kWh) from the capacity fed into the energy system in recent times. According to the approved methodology, last five are determined in assessment of capacity, while total depreciation of the last five stations should be at least 20% of total.

Total output of electricity generated in the national energy system in 2007 amounted to **49,033,000** mln. kWh. At the first stage of estimates of introduced range, Talimarjan TPP, which reached its designed capacity in 2006 and 2 minor hydropower plants in Urgut and Tupalang commissioned in 2004 and 2006.

Total electricity output of these stations amounted to 5,712,300 mln. kWh, which constitutes 11.6% of total output of national energy system.

As indicated in the Table 11 above, 2 power generating units were rehabilitated at Syrdarya TPP in 2002 (power generating units 7 and 8) with total capacity of 600 MW. Another modern condensation station of Uzbekenergo with elaborate fuel balance is New Angren TPP commissioned in 1985, which utilizes natural gas, black fuel, and coal as fuel.

Today New Angren TPP, Syrdarya TPP (power generating units 7 and 8) commissioned in 2004 and Talimarjan TPP (1 unit – 800 MW) are one of the best condensation type stations in the national energy system of Uzbekistan.

Thus, New Angren TPP and Syrdarya TPP (power generating units 7 and 8 only) were added in the second stage of estimates to the representative sample of stations and total output of these 5 plants amounted to 14,791,800 mln. kWh, which equaled 30% of total domestic power output.

Table 14: Baseline Data for Calculation of Build Margin Emission Factor

Power station/power generating untis	Year commissioned	Power output (mln. kWh)	Black oil	Gas	Coal
			thousand tons	Mln. cu.m.	thousand tons
Syrdarya (Power generating units 7 and 8)	2002	3376.2	33.94	915.718	
New Angren	1985	5703.3	17.86	1226.7	2047.8
Talimarjan	2004	5647.9		1511.4	
Urgut	2005	2.6			
Tupalang	2006	61.8			
Total		**14 791.8**	**51.8**	**3653.82**	**2047.8**

Build margin was estimated based on the following formula:

$$EF_{grid,BM,y} = \frac{\sum_{m} EG_{m,y} \times EF_{EL,m,y}}{\sum_{m} EG_{m,y}} \quad \textbf{(2) [3]}$$

where

$EG_{m,y}$ = net electricity generated and transmitted to the grid by power station/power generating unit *m* in a year *y* (MWh)

$EF_{EL,m,y}$ = coefficient of CO2 emissions for the power station - m in a year - y (tCO_2/MWh)

m = power stations included in the introduced range

y = latest available power output data

Table 15: Build margin for National Energy System of Uzbekistan, 2007

Title	Total	Black oil (thou. tons)	Gas,mln. m^3	Coal, thou. tons
Power output (total), GWh	49 032,9			
Power output TPP+HPP (sample)	14 791,8			
Natural fuel spending		51.80	3653.82	2047.80
Calorific value of fuel, tJ/unit		40.07	34.16	10.04
CO_2 emissions, Gg	9 108	160.65	7002.09	1 944.97
Emissions per unit, gCO_2/kWh	**615,7**			

Build margin amounted to **615.7 g. CO_2/kWh** in 2007.

3.1.3 Calculation of the Combined Margin Emissions Factor

Methodologies approved by the CDM Executive Board, in determination of the coefficient of emissions in power generation, it is proposed to use average weighted value estimated as the amount of operating (average) and introduced range divided by two. This combined approach was used in assessment of the coefficient of emissions for the energy system of Uzbekistan.

$$\mathbf{EF_{grid,\,CM,\,y} = w_{OM} * EF_{grid,\,OM,\,y} + w_{BM} * EF_{grid,\,BM,\,y}} \quad \mathbf{(3)\ [2]}$$

with appropriate weighted coefficients of w_{OM} and w_{BM}(where $w_{OM} + w_{BM} = 1$), and on default weighted equal ($w_{OM} = w_{BM} = 0.5$).

$$\mathbf{EF_{grid,\,CM,\,y} = 0{,}5 * 617{,}7 + 0{,}5 * 615{,}7 = 617\ г.\ CO_2/kWh.}$$

Thus, **combined margin emissions factor** for energy system of Uzbekistan was 617 gCO_2/kWh in 2007.