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

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Annexes

SECTION A. General description of the project

A.1. Title of the project:

Reconstruction of Astrakhan TPP through construction of CCP-110, LLC "LUKOIL-Astrakhanenergo", Russian Federation

Sectoral scope[1]: (1) Energy industries (renewable/non-renewable sources)

Version: 1.2

Date: August 25, 2011

A.2. Description of the project:

Objective of the project

The project is aimed at reconstruction of Astrakhan TPP (ATPP) of LLC "LUKOIL-Astrakhanenergo" with a view to enhancing efficiency and increasing electricity generation, as well as reducing greenhouse gas (GHG) emissions through introduction of modern energy generation technologies based on a combined-cycle plant (CCP).

The project replaces a corresponding amount of electricity generated at the existing inefficient power generating capacities of ATPP and some electricity supplied by other grid power plants of the Integrated Energy System of the South of Russia (IES South). Besides the project also increases the proportion of heating cycle based electricity generation at the neighbouring Astrakhan CHPP-2 (ACHPP-2) also owned by LLC "LUKOIL-Astrakhanenergo".

Situation prior to the project

The first equipment at ATPP was put into operation in 1947. The existing equipment of ATPP has been in operation since 1962. Today the installed electrical capacity of Astrakhan TPP is 100MW, and the installed thermal capacity is 244 Gcal/h.

Most of electricity at ATPP is generated in condensation cycle, but the proportion of heating cycle based generation is also considerable, because ATPP supplies steam to industrial enterprises to cover their process needs and also ensures heat supply of the housing and utilities sector and industrial facilities.

Astrakhan CHPP-2 was commissioned in 1985. Its installed electrical capacity is 380 MW, the installed thermal capacity is 910 Gcal/h. The generating capacities of ACHPP-2 have a large thermal capacity margin.

The main fuel of ATPP and ACHPP-2 is natural gas, the backup fuel being heavy fuel oil (mazut).

Astrakhan Region has a deficit power system; there are considerable power flows from the neighboring regions.

Baseline scenario

The baseline scenario assumes that the existing steam-turbine based energy generation practice will be continued without any serious obstacles at least till late 2012.

Technical condition of ATPP's boilers and turbines makes it possible to keep their performance at the existing level for another number of years with the help of relatively inexpensive routine maintenance.

The project implies boosting electricity generation which would be unachievable under the baseline

[1] In accordance with the list of sectoral scopes adopted by the Joint Implementation Supervisory Committee. http://ji.unfccc.int/Ref/Documents/List_Sectoral_Scopes.pdf

scenario with the existing equipment. Therefore the lacking amount (compared with the project) of electricity would be provided by third parties. Energy generating companies within the IES South could increase electricity generation with the help of their existing capacities and through construction of new energy generating units.

Project scenario

ATPP is reconstructed by building a combined-cycle plant of CCP-110 type with the installed electrical capacity of 110 MW and with thermal capacity of heat extraction from steam turbine being 66 Gcal/h.

CCP-110 generating unit is a double-unit double-pressure combined-cycled gas turbine power plant designed for heat and electricity generation under base-mode operation.

Main equipment of CCP-110 features:

- two LM6000PF-Sprint gas-turbine units, 46.64 MW of nominal electrical capacity each, manufactured by General Electric, USA;
- two double-pressure heat recovery steam boilers of KGT-44/4.6-435-13/0.5-210 type, manufactured by CJSC "Belenergomash", Russia;
- one T-14/23-4.5/0.18 steam turbine manufactured by OJSC "Kaluzhsky Turbine Manufacturing Plant", Russia.

The main and backup fuel of the CCP is natural gas. The estimated electrical efficiency of the CCP when running in condensation mode is 55.1%. The project technologies comply with the up-to-date environmental standards.

After implementation of the project the old inefficient equipment of ATPP is planned to be decommissioned. However the thermal capacity of the CCP will not be sufficient to ensure the former level of heat supply from the plant. On the other hand, it is not feasible to install a higher capacity CCP because of the conditions of electrical output from ATPP (the electric network throughput is constrained).

Therefore the heat loads will be met with the help of a connecting heating main to be built between Astrakhan TPP and Astrakhan CHPP-2. Thus a full-fledged common heat circuit is created making it possible to cover all heat loads from Astrakhan CHPP-2 with additional loading of heat extraction turbines of ACHPP-2.

The expected results of the project are as follows:

- Re-equipment of the ATPP with installation of new and more efficient units which meet up-to-date environmental and technical requirements;
- Enhancement of electricity generation efficiency at ACHPP-2 due to additional loading of heating steam extraction turbines;
- Increased electricity generation in the power system of Astrakhan Region;
- Optimization of heat supply system of Astrakhan City;
- Mitigation of negative environmental impact, including reduction in greenhouse gas emission by 318 ktCO_2e per year.

Project history

RAO "UES of Russia" (Unified Energy Systems of Russia) had started gearing up for implementation of the Kyoto mechanisms long before the Protocol was ratified by the Russian Federation. To this end a Non-Commercial Investment and Environmental Organization "Energy Carbon Fund" was set up in

2000[2].

The main results of the Fund's operation are as follows:

- Together with RAO "UESR" it took a comprehensive survey of greenhouse gas emissions from energy sector covering the period from 1990 in accordance with the world standards, an emission inventory was created;
- A greenhouse gas emission monitoring system, including an accounting and reporting system, is up and running; emission inventories are developed;
- A number of joint implementation (JI) projects were prepared for approval by government authorities, some of these projects already have positive determination by international auditors; foreign investments were attracted for these projects;
- Together with regional energy generators, the Fund participated in international tenders for purchase of GHG emissions;
- "Greenhouse Gases", an information analysis system, was developed and introduced at a number of regional energy companies;
- Projections of emission reductions of the Unified Energy System of Russia have been made;
- Several regulatory and methodological guidelines were issued and are in effect in the energy sector, including the method for calculation of GHG emissions from thermal power plants.

In 2006-2007 the Fund evaluated several projects in terms of their potential for JI. The Astrakhan TPP reconstruction project was put on the list of the investment projects of S&A[3] of OJSC RAO "UES of Russia" that are implemented jointly in accordance with Article 6 of the Kyoto Protocol to the UNFCCC[4] as of 25.06.2007.

In 2007 a preliminary estimation of the GHG emission reduction potential of "Reconstruction of Astrakhan TPP through construction of CCP-110MW" Project was made and an inventory of GHG emissions originating from OJSC "SGC TGC-8" from 1990 through 2005 was taken [R6].

Open Joint Stock Company "Southern Generating Company – TGC-8" was established on March 22, 2005. The sole founder of the Company was OJSC RAO "UES of Russia". After completion of the restructuring of OJSC RAO "UES of Russia", LUKOIL Group consolidated the controlling interest in OJSC "SGC – TGC-8" and became the company's strategic investor. Since May 4, 2008 OJSC "SGC TGC-8" is a part of LUKOIL Group. LLC "LUKOIL-Astrakhanenergo" was established in 2009 in the course of restructuring of TGC-8.

On February 22, 2008 (considered to be the starting date of the project) the company management signed a turnkey contract with CJSC "Energokaskad" No.589 [R7] for works on "Reconstruction of Astrakhan TPP through construction of CCP-110MW".

Turning and start-up of the CCP with test generation of electricity started in May 2011. On June 16, 2011 Astrakhan City Administration issued an authorization for putting the CCP in operation [R11].

At the time of decision making the planned cost of the project implementation was estimated at RUR 4 212.61 million. The actual cost of construction totaled RUR 4 625.82 million.

As shown above, when taking the decision to implement the project, the company management from the very start considered a possibility to develop it as a carbon project in order to attract required financial resources and to ensure acceptable return on investments. The issues related to preparation of the JI

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[2] http://www.carbonfund.ru/about/general_information

[3] Subsidiaries and affiliates

[4] http://www.carbonfund.ru/projects/pso/

project documentation were discussed with many companies and eventually a contract was signed in 2011 with CCGS.

A.3. Project participants:

Party involved	Legal entity project participant (as applicable)	Please indicate if the Party involved wishes to be considered as project participant (Yes/No)
Russia (Host Party)	Limited Liability Company "LUKOIL-Astrakhanenergo"	No
One of the parties of Annex B to the Kyoto Protocol	To be determined within 12 months after approval of the project by the Russian Government	No

LLC "LUKOIL-Astrakhanenergo"

Within the framework of implementation of a strategic development programme at OJSC "LUKOIL" in 2008 a new business sector was created – "Electric Power Sector". The new sector incorporated all dimensions of energy business, starting with generation and ending with transportation and sale of heat and electricity.

The Electric Power Business Sector includes (apart from OJSC "SGC TGC-8" acquired in 2008, its own power plants at oilfields in Russia and generating companies in Bulgaria, Romania and Ukraine) Russian electricity and heat transportation and sale organizations.

In accordance with the target structure of the Electric Power Business Sector, 7 companies were set up (4 of them – LLC "LUKOIL-Astrakhanenergo", LLC "LUKOIL-Volgogradenergo", LLC "LUKOIL-Kubanenergo" and LLC "LUKOIL-Rostovenergo" – are generating companies) and started their operations in 2009. The power plants are located in Astrakhan, Volgograd and Rostov Regions, and in Krasnodar and Stavropol Krai, as well as in the Republic of Dagestan.

LLC "LUKOIL-Astrakhanenergo"[5] is 100% owned by OJSC "LUKOIL" and was established in 2009 in the course of restructuring of TGC-8. LLC "LUKOIL-Astrakhanenergo" produces thermal and electric energy. The company renders services to the left bank district of Astrakhan City and operates two largest power plants – Astrakhan CHPP-2 and Astrakhan TPP as well as 27 boiler houses.

The Company has an operative and constantly improved integrated environmental management system, occupational health and safety management system according to international standards ISO 14001, OHSAS 18001.

A.4. Technical description of the project:

A.4.1. Location of the project:

Location of the project: Russian Federation, Astrakhan Region, Astrakhan City, LLC "LUKOIL-Astrakhanenergo", territory of Astrakhan TPP (See Fig. A.4-1, A.4-2, A.4-3).

[5] http://www.lae.lukoil.ru/main/static.asp?art_id=2290

Fig. A.4-1. Location of Astrakhan Region and Astrakhan City on the map of Russia

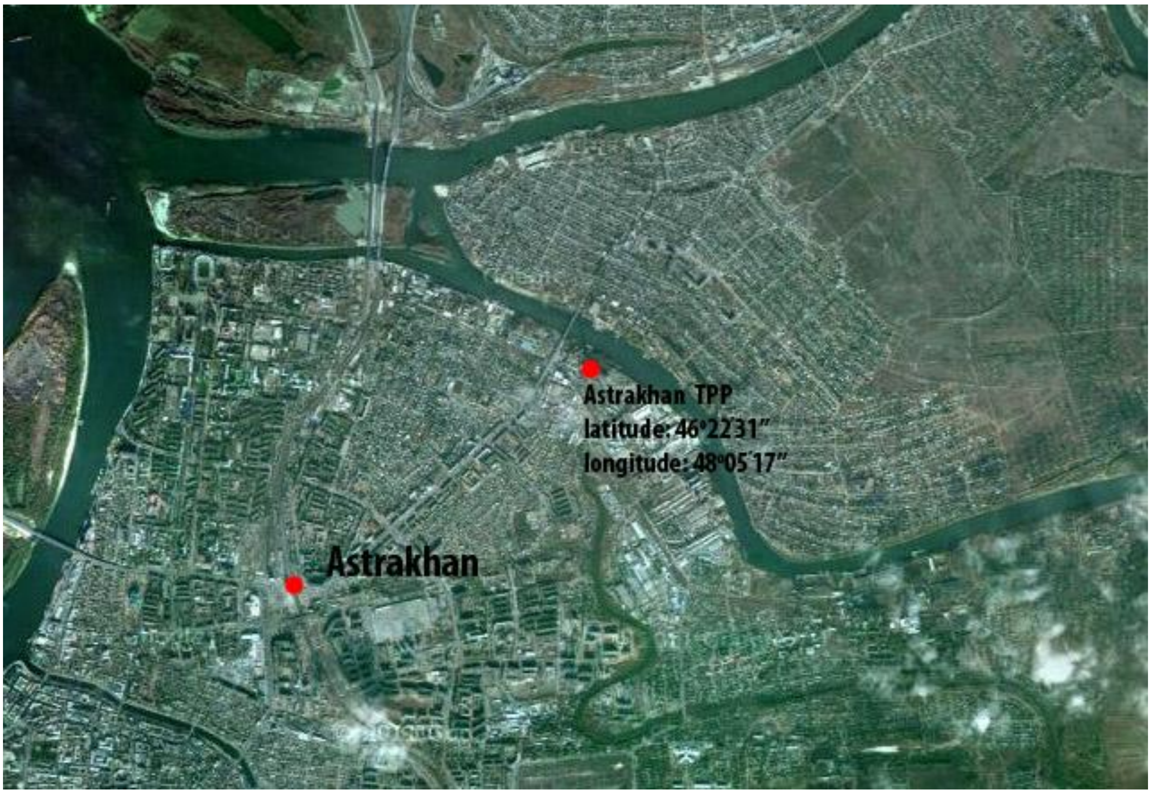

Fig. A.4-2. Google Earth map pinpointing the project activity

Fig. A.4-3. Astrakhan TPP of LLC "LUKOIL-Astrakhanenergo", general view of CCP-110

A.4.1.1. Host Party(ies):

Russian Federation

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

Astrakhan Region

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

Astrakhan City

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

Astrakhan Region is a constituent of the Russian Federation and is a part of the Southern Federal District. It borders Volgograd Region in the north, Kalmykia – in the west and Kazakhstan –in the east. The administrative center of the Region is Astrakhan City.

The climate is moderately continental, dry, and semiarid. The annual precipitation rate is 220 mm. Average annual temperature is +10 ^{0}C. Average annual air humidity is 70%. Average annual wind speed is 3 m/s.

Astrakhan Region covers the area of 49 thousand square km. The total population is 1.01 million.

Geographical coordinates of the project: latitude 46°22′N, longitude 48°05′E. Time zone GMT: +3:00.

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

Overview of the existing main equipment

Astrakhan TPP

Astrakhan TPP was put into operation in 1947. Its installed electrical capacity is 100MW and its installed thermal capacity is 244 Gcal/h.

The main fuel is natural gas, the backup fuel is heavy fuel oil (mazut).

The main equipment of the TPP is listed in Table A.4-1.

Table A.4-1. Main equipment of Astrakhan TPP

#	Name, type	Manufacturing plant	Year of commissioning	Capacity, MW steam output, t/h
3	Steam turbine VPT-25-4	TMZ	1962	25
4	Steam turbine VPT-25-4	TMZ	1960	25
5	Steam turbine VT-25-5	TMZ	1966	25
6	Steam turbine VT-25-5	TMZ	1965	25
4	Power boiler BKZ-160-100F	BKZ	1961	160
5	Power boiler BKZ-160-100F	BKZ	1962	160
6	Power boiler BKZ-160-100F	BKZ	1966	160
7	Power boiler BKZ-160-100F	BKZ	1968	160

Astrakhan CHPP-2

Astrakhan CHPP-2 was put into operation in 1985. Its installed electrical capacity is 380 MW and its installed thermal capacity is 910 Gcal/h.

The main fuel is natural gas, the backup fuel is heavy fuel oil (mazut).

The main equipment of the CHPP consists of:

- two TPE-430 boiler units No.No. 1,2;
- two TGME-464 boiler units No.No. 3,4;
- two KVGM-100 hot water boilers;
- two PT-80/100-130/13 turbines No.No. 1,2;
- two T-110/120-130 turbines No.No. 3,4.

Description of the project measures

The process technology introduced under the project is state-of-the-art. All technological parameters meet environmental standards and requirements.

The project measures caused significant reduction in GHG emissions due to enhancement of fossil fuel (natural gas) combustion efficiency and due to increase in heat and electricity generation efficiency.

The CHPP is planned to be reconstructed by building a combined-cycle plant of CCP-110 type with the installed electrical capacity of 110 MW, heat extraction from the steam turbine being 66 Gcal/h.

The existing steam boilers and turbines of ATPP are taken out of operation after commissioning of the CCP. The heat load covered by ATPP prior to the project will be partially covered by ACHPP-2 after commissioning of the CPP.

The CCP-110 generating unit is a double-unit double-pressure combined-cycle plant designed for generation of heat and power under base-load operation.

The main equipment of CCP-110 features:

- two LM6000PF-Sprint gas-turbine units (GTU), 46.64 MW each, manufactured by General Electric, USA;

- two steam double-pressure heat recovery boilers of KGT-44/4.6-435-13/0.5-210 type, manufactured by CJSC "Belenergomash", Russia;
- one T-14/23-4.5/0.18 steam turbine manufactured by OJSC "Kaluzhsky Turbine Manufacturing Plant", Russia.

The main and backup fuel of the CCP is natural gas.

The main technical and economic parameters of the CCP are given in Table A.4-2 below.

Table A.4-2. Main technical and economic performance parameters of the CCP

#	Parameter	Value
1.	Electrical capacity	110 MW
4.	Thermal capacity of heat extraction from steam turbine	66 Gcal/h
3.	Specific consumption of equivalent fuel per unit of electricity supply	222.9 g e.f./kWh
2.	Specific consumption of equivalent fuel per unit of heat supply	155.0 g e.f./Gcal
5.	(Gross) efficiency of the unit in condensation mode	55.1%

The double-unit scheme ensures higher operational reliability compared with the single-unit scheme.

Commissioning of CCP-110 at Astrakhan TPP accompanied by decommissioning of the old inefficient equipment helps to improve technical and economic performance of the TPP and enhance the system-wide reliability of the IES South. Besides the project has a positive effect upon operation modes of Astrakhan CHPP-2 permitting to increase the heating cycle based electricity generation.

Principles of combined-cycle plant operation

The classic version of a combined cycle plant operates as follows: it is based on combined operation of a gas turbine and a steam turbine. Atmospheric air is fed to the inlet of the GTU's air compressor, which is an axial-flow turbo-machine. The compressor rotor is driven by the gas turbine. The flow of pressurized air is fed to the combustion chamber which is also charged with fuel. The fuel of the gas turbine unit is natural gas. When fuel is fired, combustion gases with the temperature of over 1000 °C are produced. Working gas is supplied to the flow path of the gas turbine where it expands nearly to the atmospheric pressure, thus generating mechanical power. Most of this power is spent to drive the compressor, the remaining power being spent to drive the electric generator. This is the so-called first or gas-turbine cycle of the power plant operation, efficiency at this stage is 35-39%.

The high-temperature exhaust gases from the GTU are fed to a special heat recovery boiler, and at this point the steam-turbine plant comes into play. The exhaust gases heat the steam to the temperature of 500-600^{o}C, and then the steam passes to the steam turbine whose shaft is connected to the second electric generator. This enables the GTU to generate extra 20% of power. Thus the overall efficiency of a power plant based on the combined-cycle technology reaches almost 60%.

The same amount of fuel gives considerably higher power output when fired in a CCP compared with steam-turbine plants (STP). Thermodynamically this is explained by the fact that in a CCP the average inlet temperature of heat in the cycle is higher than in a STP, whereas the average outlet temperature of heat is practically the same.

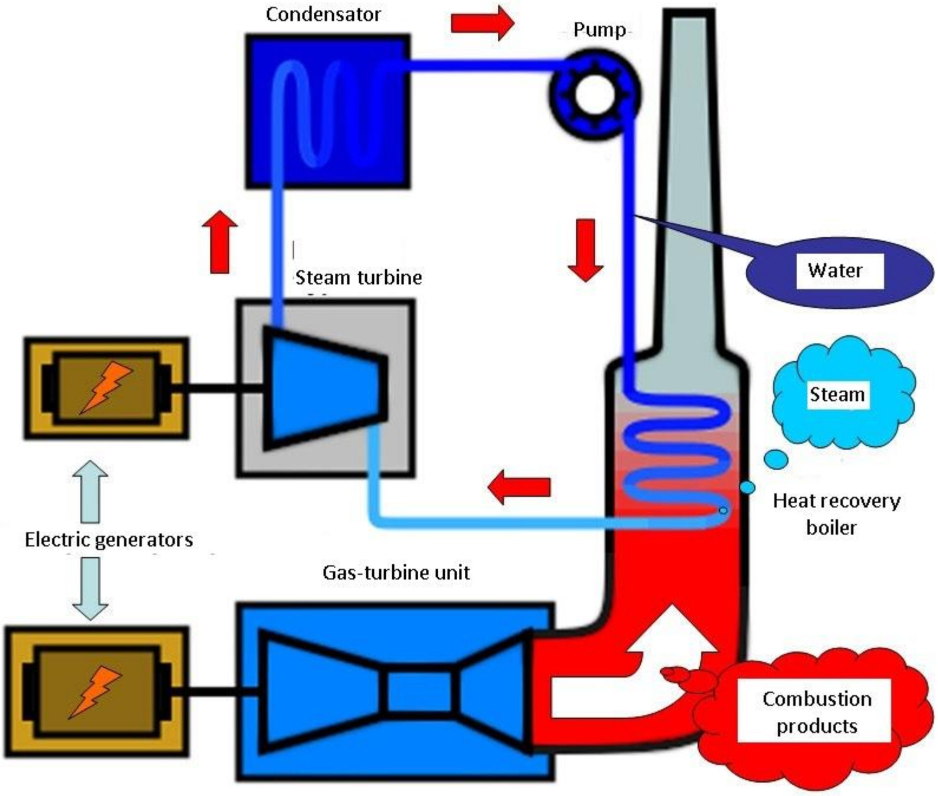

Fig. A.4-4. Principle of the combined-cycle plant operation

In a CCP heat input (fuel combustion) is generally provided only in the combustion chamber of the GTU, where high temperature of the working fluid is maintained. For steam production in the heat recovery boiler heat is hardly supplied from outside (parametric after burning of fuel is minimum or non-existent), and instead the heat of exhaust gases is used. Heat is removed in the CCP (similar to STP scheme) with the spent steam via extraction valves and steam turbine condenser.

The main advantages of CCP over STP are its high cost effectiveness, lower cooling water demand and low harmful emissions. Power plants based on the combined cycle process are not only very efficient but also meet the strictest environmental standards. For example, the level of NOx emissions from such plants is two to three times lower.

Description of the main equipment of the installed generating unit

Gas-turbine unit

The project involves installation of two GTUs of LM6000PF-Sprint type with ISO rated (GOST R 52200) output of 46.6 MW each with low-emission combustion chambers manufactured by General Electric, with 48.5 MW electric generators.

LM6000PF-Sprint gas turbine (GT) is a two-shaft gas turbine with the output rotary speed of 3600 rmp. The turbine is connected via a reducing gear box, which reduces rotation speed down to 3000 rmp, to BDAX 7-290ERJT electric generator 48.5 MW, 10.5 kV, 50 Hz.

The gas-turbine unit is fitted with SPRINT™ output boosting system that uses water injection to cool air in the compressor which significantly raises the mass air flow through the compressor. The system is based on extremely fine spraying of water through nozzles that are located in two places: one row of nozzles is placed between the low pressure and high pressure compressors, the other row – in the front frame. Fine dispersion of water is achieved due to the energy of pressurized air taken after the eighth stage of the high-pressure compressor. The water flow is determined by the engine control programme.

Water injection in the front frame and between the compressors when using the SPRINT ™ booster system is determined by the temperature of air at the inlet to the turbine.

The gas turbine unit is fitted with dry low emission (DLE) combustion chambers to minimize NOx when the turbine runs on natural gas which ensures high environmental performance of the GTU.

Table A.4-3 shows the rated characteristics and performance parameters of the GTU for the CCP operation in heat-extraction and condensation modes.

Table A.4-3. Rated characteristics of LM6000PF-Sprint gas turbine generators for heat-extraction and condensation modes of the CCP operation

Parameter	Unit	Value
Air flow	t/h	456.3
Fuel consumption	t/h	8.06
Electrical capacity	MW	46.64
Gas temperature after GTU	°C	451.6
Water supply for SPRINT system	t/h	8.6

General view of LM 6000 gas turbine is shown in Fig. A.4-4.

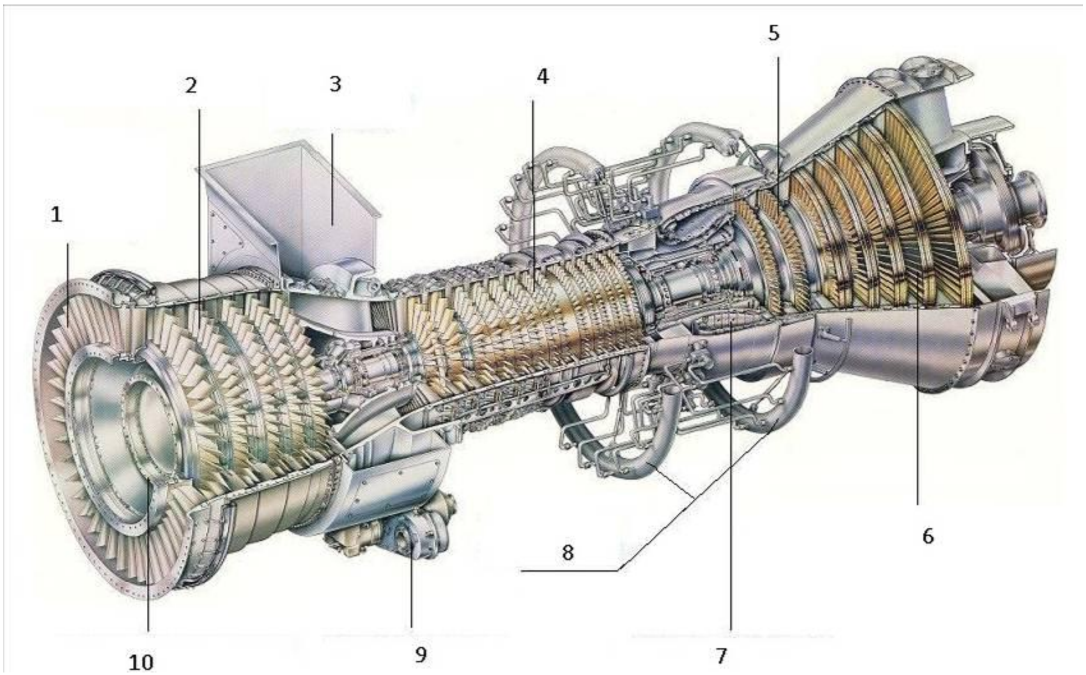

Fig. A.4.4 – General view of LM 6000 gas turbine

1 – inlet rotating guide vanes; 2 – 5-stage low-pressure compressor; 3 – bypass air duct; 4 – 14-stage high-pressure compressor; 5 – 2-stage high-pressure turbine; 6 – 5-stage low-pressure turbine; 7 – combustor; 8 – fuel inlets; 9 – accessory gear box assembly; 10 – drive flange.

<u>*Heat recovery boiler*</u>

The project includes installation of 2 double-pressure heat recovery boilers of KGT-44/4.6-435-13/0.5-210 type without additional combustion of natural gas in oxidizing medium after the GTU:

- HP circuit: steam output of 45 t/h, steam at 4.6 MPa, 435 °C;
- LP circuit: steam output of 13 t/h, steam at 0.5 MPa, 210°C.

The supplier and manufacture of the heat recovery boilers is CJSC "Belenergomash", Russia.

The heat recovery boiler (HRB) has a tower-type arrangement of heat transfer surfaces, two steam generating circuits with steam drums and with multiple forced circulation in high pressure and low pressure evaporation circuits. HRB is intended for operation as a part of the CCP, the heating medium being the products of natural gas (main fuel) combustion coming from LM-6000 gas turbine.

The HRB does not provide for steam pressure and temperature control within the working load range, the boiler is designed to operate under variable steam parameters determined by the temperature and flow of gases that are fed to the HRB from the GTU and also by the steam turbine operation mode.

The HRB is fitted with an automated control system which is a block level subsystem of ACS.

The main rated performance parameters of the HRB are given in Table A.4-4 below.

Table A.4-4. Main rated performance parameters of the HRB

Parameter	Value				
Ambient temperature, °C	-23	-6.7	-1.2	+15	+30
GTU load, %	100				
Inlet gas temperature, ^{0}C	436	445.7	448.5	455.2	464.9
Gas flow, t/h	139.9	138.5	137.3	131.7	121.1
High-pressure circuit					
Steam output, t/h	42.2	43.97	44.19	44.2	42.02
Superheated steam temperature, ^{0}C	419	427	429	435	435
Outlet steam pressure, MPa	4.6	4.6	4.6	4.6	4.6
Feed water temperature, ^{0}C	60	60	60	60	60
Low-pressure circuit					
Steam output, t/h	14.00	13.78	13.58	13.04	12.6
Outlet steam pressure, MPa	0.5	0.5	0.5	0.5	0.5
Superheated steam temperature, ^{0}C	215	214	214	213	213
Feed water temperature, ^{0}C	60	60	60	60	60
Outlet gas temperature, ^{0}C	101	100	99	95.4	95
Draught loss, Pa	3100	3100	3000	2900	2700

Steam turbine

The steam produced in the heat recovery boilers is fed to the steam turbine. The steam turbine has a heating steam extraction and a condensing unit. Steam from the heat extraction is fed to the water-steam heaters of delivery water. Delivery water is supplied to the city for heating and hot water supply. When the heat demand is low some electricity can be generated in condensation mode.

Plant's co-generation steam turbine of T-14/23-4.5/0.18 is designed for direct drive of the electric AC generator. The turbine is packaged with a 25 MW synchronous electric generator of TTK-25-2UZ type manufactured by OJSC "Privod", Russia, rated engine speed 50 s^{-1} (3000 rpm), air-cooled.

The turbine has a double-pressure scheme: high-pressure circuit (HPC) steam and intermediate input of steam from the low-pressure circuit (LPC) from the double-pressure heat recovery boiler.

The turbine is single-cylinder, its flow path has 17 stages. Its first stage is a control stage and velocity-compounded stage. The heat-extraction section separates the turbine into a high-pressure section (HPS) and low-pressure section (LPS). HPS section consists of 13 stages, LPS has 4 stages. The turbine construction allows for intermediate input of steam to the turbine (after stage 11) from the low-pressure collector.

The main parameters and characteristics for different modes are shown in Table A.4-5.

Table A.4-5. Main parameters and characteristics of steam turbine

Parameter		Warranted performance		Full power condition
Electrical capacity of turbine, MW		14.7	22.7	23.8
Steam from high-pressure circuit (HPC) of the HRB	Absolute pressure, MPa	4.5	4.5	4.5
	Temperature, °C	430	430	430
	Flow, t/h	88	88	92
Steam from low-pressure circuit (LPC) of the HRB	Absolute pressure, MPa	0.42	0.42	0.42
	Temperature, °C	208	208	208
	Flow, t/h	26	26	26
Heat extraction for delivery water heaters	Absolute pressure, MPa	0.18	-	-
	Temperature, °C	122	-	-
	Flow, t/h	103.3	-	-
Steam flow through LPS, t/h		10	113	117
Absolute steam pressure after the turbine, kPa		3.5	15	15.1
Cooling water consumption, m^3/h		4600	4600	4600
Cooling water temperature, °C		20	30	30
Steam consumption per unit of output, kg/kWh		6.0	-	-
Heat consumption per unit of output, kJ/kWh (kcal/kWh)		-	14834 (3543)	14697 (3510)

Power (at generator terminals):

- rated (in heat extraction mode) – 14.7 MW;
- maximum (in condensation mode at rated steam parameters of live steam) – 23.8 MW.

Heat is supplied from CCP-110 to the heat network at 130/70°C, this temperature chart will be fixed for the heat networks of Astrakhan after their reconstruction.

The heating network is in all modes replenished by Astrakhan CHPP-2 via a connecting pipeline (direct pipeline) together with water supply to open-circuit system. CCP-110 at ATPP takes water from the return pipeline of the heat network of ATPP's consumers in the volume that is necessary to ensure output of the available heat from the CCP at 130/70 °C.

The CCP-110 at ATPP shall not include a treatment facility for makeup water used for the distinct heating system (deaeration plant, tanks and pumps for makeup of the district heating system).

In order to boost natural gas pressure before the GTU there shall be installed modular booster compression stations of primary and backup gas supply. The stations are manufactured by ENERPROJECT SA.

Cooling of the CCP equipment there shall provided by a circulation water supply system featuring a six-section ventilation cooling tower consisting of six BVG 1000 Turbo sections manufactured by CJSC JV "BROTEP-EKO", Brovary, Ukraine.

Project implementation period

The general contractor for turnkey installation of the CCP at Astrakhan TPP was CJSC "Energokaskad" with which a contract was signed in February 2008 [R7]. However on 11.02.2011 an agreement was signed which provided for replacement of the Party under the contract with OJSC "Group E4".

According to [R5] the main construction period lasted from May 2008 till May 2011. Tuning and start up of the CCP with actual generation of electricity started in May 2011. On June 16, 2011 Astrakhan City Administration gave an authorization to put the CCP into operation [R11].

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

Fossil fuel combustion is a major source of GHG emissions. The main greenhouse gas from fossil fuel combustion is CO_2. Emissions of N_2O and CH_4 from combustion are negligible compared with CO_2 emissions.

The project GHG emission reductions will be mainly due to the enhanced efficiency of electricity generation at Astrakhan TPP achieved by using state-of-the-art combined-cycle electricity generation technology and respective substitution of output from the ATPP's existing generating equipment and grid electricity generated within the IES South mainly by using less efficient steam-turbine technology.

Besides, the project will also result in re-distribution of the volumes of heat supply to the city between ATPP and ACHPP-2. Astrakhan CHPP-2 is enabled to increase its heat supply and therefore to increase its electricity generation based on heating cycle. This leads to reduction in fuel consumption per unit of electricity output at ACHPP-2. (This being said, the CCP operation at ATPP will be efficient even if it completely switches to electricity generation in condensation mode, ceasing to produce heat). Hence the project emission reductions will be also due to enhancement of operating efficiency of ACHPP-2.

Without the project the said GHG emission reductions would not be achieved because then the required amount of electricity could be generated by using less efficient technologies at the existing ATPP equipment and other power plants within the IES South. The existing thermal capacities of ATPP are sufficient to maintain heat production at its former level.

It is unlikely that the project would be implemented in the absence of the joint implementation mechanism, considering the following circumstances:

- The project implementation requires serious investments whereas the return on investments without additional revenues from sale of emission reductions is not sufficiently high for this project;
- Technical condition of the existing generating equipment makes it possible to keep their performance at the existing level for another number of years with the help of relatively inexpensive routine maintenance.
- The project employs a fairly new CCP-based heat and electricity generation technology with which Astrakhan TPP has no previous experience;
- There are no caps on GHG emissions for companies in Russia;
- It is not expected that there will be any significant changes in Russian environmental legislations that might force the company to stop using the existing steam turbine technology of heat and electricity generation.

Without the project significant investment risks could be avoided. The investment risks can be such as, for instance, project investments being higher than the originally planned level. This could be due to mistakes in design, need to purchase additional equipment or undertake unscheduled works, rising prices for equipment, mounting and setup works, etc.

To mitigate the said risks and to increase the financial profitability of the project the company management has been looking to sell emission reduction units (ERUs) in the international market.

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

	Years
Length of the crediting period	1.58
Year	Estimate of annual emission reductions in tonnes of CO_2 equivalent
2011	185 451
2012	317 916
Total estimated emission reductions over the crediting period (tonnes of CO_2 equivalent)	**503 367**
Annual average of estimated emission reductions over the crediting period (tonnes of CO_2 equivalent)	317 916

A.5. Project approval by the Parties involved:

The letters of approval by the Parties will be received later.

SECTION B. Baseline

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

Choice of the baseline setting approach

When setting the baseline the developer applied a JI-specific approach based on paragraph 9 (a) of the “Guidance on criteria for baseline setting and monitoring” [R1].

The baseline was set in accordance with Appendix B to the JI Guidelines[6]. Justification of the baseline scenario was made in accordance with paragraphs 23-29 of the “Guidance on criteria for baseline setting and monitoring”.

The most likely baseline scenario was chosen on the basis of the analysis of several heat and electricity generation alternatives to the project. The baseline scenario was justified taking into account Annex 1 to the “Guidance on criteria for baseline setting and monitoring”.

All key data, factors and suppositions which affect GHG emission reductions are considered on a transparent and conservative basis.

Identification of the likely future scenarios and choice of the baseline scenario

The project CCP will generate electricity and produce heat in the form of hot water. The electricity supply system and heat supply system can be regarded as independent from each other and therefore for each of them an individual set of alternative scenarios is developed.

Groups of scenarios were considered separately for the following two types of the project activity:

- Generation of the required amount of electricity (such amount being equal to the amount of electricity supplied under the project);
- Production of the required amount of heat (such amount being equal to the amount of heat supplied under the project).

The following alternatives which allow generation of the required amount of electricity have been identified:

- Alternative E1. Generation of electricity by other existing power plants within the IES South;
- Alternative E2. Generation of electricity by other new energy generating units within the IES South;
- Alternative E3. Continuation of the existing electricity generation practice at ATPP;
- Alternative E4 Continuation of the existing electricity generation practice at ATPP and production of lacking amount of electricity (lacking, that is, compared with the project) by other existing power plants and new energy units within the IES South;
- Alternative E5. The project activity without the joint implementation mechanism.

The following alternatives which allow production of the required amount of heat have been identified:

- Alternative H1. Continuation of the existing heat production practice at ATPP;
- Alternative H2. The project activity without the joint implementation mechanism.

The analysis of each alternative is given further below.

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[6] Annex to Decision 9/CMP.1 (known as JI Guidelines) includes Appendix B which specifies criteria for baseline setting and monitoring.

Generation of the required amount of electricity

Alternative E1. Generation of electricity by other existing power plants within the IES South

This alternative assumes that electricity generation at ATPP is discontinued and the output gap is bridged by other existing power plants of the IES South.

Today the installed electrical capacity matches the demand in the electricity market. However there are many old energy generating units in operation in Russia. According to the assessment made by CJSC "Energy Forecasting Agency" in 2008, around 10GW of outdated capacities (whose design service life expired several years ago) should be taken out of operation by the year 2015, including – 3.9 GW to be decommissioned by the year 2010. At the same time these forecasts suggest that in 2012 the electricity demand will increase by 27.3 GW against the year 2009[7].

The expected electricity demand in the Southern Federal District will grow by 6.72 million MWh by 2012 compared with 2009, whereas the capacity deficit according to the forecast balance of electric sector development for 2009-2015 will be 452.2 MW in 2012[8].

It should be also noted that since Astrakhan has a deficit energy system, LLC "LUKOIL-Astrakhanenergo" would hardly ever choose to stop maintaining serviceability of the existing generating capacities and to decommission them in the absence of the project.

Thus, other existing power plants alone would not be able to satisfy future demand in the electricity market and *this alternative cannot be a likely future scenario.*

Alternative E2. Generation of electricity by other new energy generating units within the IES South

This alternative assumed that electricity generation at ATPP is discontinued and the output gap is bridged by other new generating units of the IES South.

The installed capacity of power plants within the IES South is 13.8 GW. The plant factor of the existing power plants of the IES South is between 0.47 and 0.75. Smart dispatching, modernization and improvement of operation of energy generating units (decreasing shutdown time, etc.) may improve performance parameters of the existing energy equipment which in turn will increase electricity generation at the existing power plants.

Reconstruction of the existing energy generating units may increase both the installed electrical capacity and the capacity utilization factor. According to the projections of CJSC "Energy Forecasting Agency" (see the above reference), the increment in the installed electrical capacity at the existing power plants (due to upgrade measures) may amount to around 2.3 GW by 2015.

The energy demand and consumption management in the electric power market is technically performed by OJSC "System Operator of the Unified Energy System" (OJSC "SO UES"). The System Operator ensures that the demand is satisfied in a most effective way both economically and technically. Since over 87% of the projected electricity demand will be met by the existing power plants, it is unlikely that the System Operator will be able to ensure that 0.1 GW (capacity of the project CCP) are constantly provided merely by commissioning of new energy generating units.

This means that electricity (the amount of which is equal to the project generation) will be also supplied to the grid by the existing power plants.

Besides, like it was mentioned above for Alternative E1, it is not likely that LLC "LUKOIL-Astrakhanenergo" would decommission the existing capacities of ATPP in the absence of the project.

Therefore *this alternative is not a likely future scenario.*

[7] http://www.e-apbe.ru/library/detail.php?ID=11106

[8] http://www.kwexpert.ru/files/porgnozniy_balanc_razwitiya_eletroenergetiki_09-15g_gg_2009g.pdf

Alternative E3. Continuation of the existing electricity generation practice at ATPP

This alternative assumes that the existing capacities of ATPP are continued to be operated. These capacities are in satisfactory condition and in general are able to ensure the former level of performance for another number of years provided that inexpensive routine maintenance is carried out. Besides, it is not foreseen that in the short term there will be any significant changes in Russia's environmental legislation that may compel the management of LLC "LUKOIL-Astrakhanenergo" to abandon steam-turbine technology based electricity generation.

The advantage of this alternative is that there are no additional and fairly risky investments related to introduction of a fairly new combined-cycle technology with which the company has no previous experience (See the Common Practice Analysis).

However the project implementation implies an increase in electricity generation which would be an unattainable task with the existing equipment. Therefore *this alterative cannot be a likely future scenario.*

Alternative E4. Continuation of the existing electricity generation practice at ATPP and production of lacking amount of electricity (lacking, that is, compared with the project) by other existing power plants and new energy units within the IES South.

This scenario is a combination of E1, E2 and E3. Alternative E4 implies further operation of the existing capacities of ATPP providing most of electricity output and production of the lacking (compared with the project) amount of electricity through combined operation of the existing power plants and new generating units of the IES South.

This alternative is quite realistic and can be viewed as the most likely scenario of electricity generation. Since Astrakhan Region is an energy deficient region it is crucial to use any available sources of generation and the additional demand in the electricity market, as shown above, can be covered only by combined operation of the existing power plants and new power units of the IES South.

Alternative E5. The project activity without the joint implementation mechanism

As shown in the "Power Sector Facilities Allocation Scheme up to 2020" [9] approved by the Russian Government (resolution dated February 22, 2008 No.215-r), modernization and construction of new thermal power plants running on natural gas should only be based on the projects involving gas-turbine technologies.

The project suggest that the existing power generating equipment of ATPP will be decommissioned because of the limited throughput of the electrical networks via which electricity is supplied from ATPP to the consumers. Once CCP-110 is commissioned it will completely take up all available capacity for power output to the grid without leaving any possibility of electricity generation by the existing steam turbines of ATPP.

The project also contributes to increase in the heating cycle based power generation at ACHPP-2, which additionally enhances power generation efficiency at power plants of LLC "LUKOIL-Astrakhanenergo".

The CCP construction project is technically feasible; there is sufficient amount of natural gas available for Astrakhan TPP. However without the joint implementation mechanism the economics of this project are not sufficiently attractive (See the Investment Analysis in Section B.2). Besides, construction and operation of CCPs is not yet a prevalent practice among Russian energy companies. Therefore *this alternative is not likely to be a plausible future scenario.*

[9] http://www.e-apbe.ru/scheme/

Production of the required amount of heat

Alternative H1. Continuation of the existing heat production practice at ATPP

This alternative does not presuppose any investments in installation of new heat production equipment at Astrakhan TPP or any additional operating costs to be incurred in connection with construction and installation of new equipment.

The existing thermal capacities of ATPP are in satisfactory condition and, in general, can keep up their performance at the same level for another number of years if routine maintenance which does not entail any significant costs is carried out. That said, thermal capacities are underloaded and would be able to meet the raising heat demand.

Besides, in the short run no significant changes are expected in the Russian law which may force the management of LLC "LUKOIL-Astrakhanenergo" to stop producing heat by using steam-turbine technology.

Considering the above circumstances, *this alternative is quite realistic and can be assumed as the most likely baseline scenario for heat production*.

Alternative H2. The project activity without the joint implementation mechanism

Commissioning of CCP-110 together with decommissioning of the existing boiler and turbine equipment of ATPP will result in reduction in overall capacity of ATPP in terms of heat supply.

However the lacking supply of heat from the ATPP to the city will be offset by increased heat supply from heat extraction turbines of ACHPP-2, which has a large thermal capacity reserve. Therefore CCP-110 operation coupled with ACHPP-2 operation would help to enhance efficiency and provide the desired heat production level.

However according to the argument given for Alternative E5, the economics of the CCP construction project at Astrakhan TPP without the joint implementation mechanism are not sufficiently attractive. Besides, CCP construction is not common practice in Russia. Therefore, *this alternative is not likely to be a plausible baseline scenario.*

Thus, on the basis of the above Analysis of Alternatives and taking into account the results of the Investment Analysis, we chose as the most likely baseline scenario the following combination of alternatives: Alternative E4 assuming electricity generation by the existing equipment of ATPP and supply of the lacking (compared with the project) amount of electricity to the grid by the existing power plants and new power generating units of the IES South, and Alternative H1 assuming heat production by the existing equipment of ATPP.

Justification and description of the GHG emission evaluation method

The following emission sources are considered further below.

For the baseline scenario:

- Electricity and heat generation at Astrakhan TPP, CO_2 emissions from natural gas combustion;
- Production of additional amount of electricity by power plants of the IES South, CO_2 emissions from combustion of fossil fuel.

For the project scenario:

- Electricity and heat generation at Astrakhan TPP, CO_2 emissions from natural gas combustion;
- Production of additional amount of electricity and heat by Astrakhan CHPP-2, CO_2 emissions from combustion of natural gas.

Leakages that may result from the project include:

– Fugitive emissions of CH_4 from production, processing, storage transportation and distribution of fossil fuel.

GHG emission reductions

In general case GHG emission reductions during the year *y* are calculated as follows, tCO_2e:

$$ER_y = BE_y - PE_y - LE_y, \quad \text{(B.1-1)}$$

where BE_y is the baseline GHG emissions during the year *y*, tCO_2e;

PE_y is the project GHG emissions during the year *y*, tCO_2e;

LE_y is the leakages due to the project activity during the year *y*, tCO_2e.

Baseline emissions

In accordance with the above list of emission sources, the baseline emissions of GHG during the year *y* are calculated by the following formula, tCO_2e:

$$BE_y = BE_{ATPP,y} + BE_{grid,y}, \quad \text{(B.1-2)}$$

where $BE_{ATPP,y}$ is the CO_2 emissions due to combustion[10] of natural gas[11] to produce (supply to the grid) electricity and heat at ATPP under the baseline scenario during the year *y*, tCO_2e;

$BE_{grid,y}$ is the CO_2 emissions due to combustion of fossil fuel to generate (supply to the grid) additional amount of electricity by power plants of the IES South under the baseline scenario during the year *y*, tCO_2e.

CO_2 emissions due to combustion of natural gas for production of electricity and heat at ATPP under the baseline scenario during the year *y* are calculated as follows, tCO_2e:

$$BE_{ATPP,y} = FC_{NG,ATTP,BL,y} \times EF_{CO2,NG}, \quad \text{(B.1-3)}$$

where $FC_{NG,ATTP,BL,y}$ is the consumption of natural gas for generation of electricity and heat at ATPP under the baseline scenario during the year *y*, GJ;

$EF_{CO2,NG}$ is the CO_2 emissions factor for natural gas, tCO_2/GJ.

The method of fuel consumption calculation is described further below.

CO_2 emissions due to combustion of fossil fuel for generation (supply to the grid) of additional amount of electricity by power plants of the IES South under the baseline scenario during the year *y* are calculated by the following formula, tCO_2e:

$$BE_{grid,y} = \Delta ES_{grid,y} \times EF_{CO2,grid}, \quad \text{(B.1-4)}$$

where $\Delta ES_{grid,y}$ is the supply of additional (lacking compared with the project) electricity to the grid by power plants of the IES South under the baseline scenario during the year *y*, MWh;

$EF_{CO2,grid}$ is the CO_2 emission factor for grid electricity, tCO_2/ MWh.

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[10] CH_4 and N_2O emissions produced from fuel combustion are considered to be negligible compared with CO_2 emissions and were not taken into account in the PDD

[11] The main fuel both at ATPP and ACHPP-2 is natural gas; consumption of heavy fuel oil is insignificant. Therefore it is assumed that only natural gas is fired at these plants. This assumption is conservative.

The CO_2 emission factor for natural gas is assumed in accordance with the IPCC Guidelines [R3] to be constant over years and numerically equal to $EF_{CO2,NG}$ = 0.0561 tCO_2/GJ.

The CO_2 emission factor for electricity supplied to the grid by the existing power plant and new power generating units of the IES South is assumed in accordance with the justification given in Annex 4 to be constant over years and numerically equal to $EF_{CO2,grid}$ = 0.6745 tCO_2/MWh.

Baseline electricity generation

The project implementation implies boosting of energy generation which would be unattainable under the baseline scenario with the existing equipment of ATPP. Therefore the lacking (compared with the project) amount of electricity would be supplied by the power plants of the IES South.

It is assumed that under the baseline scenario the consumers would be provided with the same amount of electricity as under the project, that is:

$$ES_{BL,y} = ES_{PJ,y}, \quad \text{(B.1-5)}$$

where $ES_{BL,y}$ is the overall baseline supply of electricity during the year *y*, MWh;

$ES_{PJ,y}$ is the overall supply of electricity under the project during the year *y*, MWh.

Taking into account formula (B.1-5), the additional amount of electricity which under the baseline scenario would be offset by the power plant of the IES South is calculated as follows:

$$\Delta ES_{grid,BL,y} = ES_{PJ,y} - ES_{ATPP,BL,y}, \quad \text{(B.1-6)}$$

where $ES_{ATPP,BL,y}$ is the baseline supply of electricity from Astrakhan TPP during the year *y*, MWh.

The baseline electricity supply from Astrakhan TPP during the year *y* is calculated by the following formula, MWh:

$$ES_{ATPP,BL,y} = EG_{ATPP,BL,y} \times \left(1 - \varepsilon_{el,ATPP}^{aux}\right), \quad \text{(B.1-7)}$$

where $\varepsilon_{el,ATPP}^{aux}$ is the specific consumption of electricity for auxiliary needs of ATPP;

$EG_{ATPP,BL,y}$ is the baseline electricity generation at ATPP during the year *y*, MWh.

The specific consumption of electricity for auxiliary needs of ATPP is assumed to be equal to the minimum average annual value recorded from 2008 to 2010 (See Annex2): $\varepsilon_{el,ATPP}^{aux}$ = 0.1 (2008).

Following the conservative approach, it is important not to overestimate the value of ATPP electricity generation under the baseline scenario till the end of the crediting period, because increase in this parameter will lead to increase in GHG emission reductions.

Annual electricity generation at ATPP over several years before 2008 (the year of the project start) was around 650 thousand MWh, and in some years exceeded 700 thousand MWh. However after the start of the project implementation and after it was decided to decommission the existing equipment after commissioning of the CCP (due to the existing constraints on the throughput of electric networks), the company management reduced the current expenses on repairs of old boiler and turbine equipment, paying special attention to the CCP construction project. Therefore from 2008 through 2010 annual electricity generation at ATPP had been gradually reducing from 574 to 429 thousand MWh (See Annex 2). However there is good reason to believe that in the absence of the project ATPP would continue to generate electricity in the amount approximately equal to the production level before the start of the project implementation.

It is a soundly conservative decision to set the baseline value of annual electricity generation by ATPP at the actual level recorded in 2008. Which means that the value of annual electricity generation at ATPP could have been assumed at the level of 650 thousand MWh, but was assumed at the level of 2008 (574 227 MWh), which is a more conservative decision.

The value for 2011 was adjusted in proportion to the number of full months of actual operation of the CPP in 2011. Considering that the actual operation of the CPP started in May 2011, it leaves 7 full months of operation till the end of 2011. Thus, for 2011:

$$EG_{ATPP,BL,2011} = \frac{7}{12} EG_{ATPP,2008}, \quad \text{(B.1-8)}$$

for 2012 (and subsequent years):

$$EG_{ATPP,BL,2012} = EG_{ATPP,2008}, \quad \text{(B.1-9)}$$

where $EG_{ATPP,2008}$ is the actual annual electricity generation at ATPP in 2008, MWh.

According to the report data $EG_{ATPP,2008}$ = 574 227 MWh.

Electricity at ATPP is generated both in heating and condensation cycles, that is:

$$EG_{ATPP,BL,y} = EG^{CC}_{ATPP,BL,y} + EG^{HC}_{ATPP,BL,y}, \quad \text{(B.1-10)}$$

where $EG^{CC}_{ATPP,BL,y}$ is the baseline electricity generation at ATPP based on condensation cycle during the year y, MWh;

$EG^{HC}_{ATPP,BL,y}$ is the baseline electricity generation at ATPP based on heating cycle during the year y, MWh.

It is reasonable and conservative to assume that for the purpose of fuel savings ATPP would attempt to generate as much electricity as possible based on heating cycle, and the remaining energy would be based on condensation cycle.

Annual electricity generation at ATPP based on heating cycle for the baseline scenario is assumed to be equal to the actual value in 2009 which is the maximum value over the last three years of operation of the plant (2008-2010). Then for 2011:

$$EG^{HC}_{ATPP,BL,2011} = \frac{7}{12} EG^{HC}_{ATPP,2009}, \quad \text{(B.1-11)}$$

for 2012 (and subsequent years):

$$EG^{HC}_{ATPP,BL,2012} = EG^{HC}_{ATPP,2009}, \quad \text{(B.1-12)}$$

where $EG^{HC}_{ATPP,2009}$ is the actual annual electricity generation at ATPP based on heating cycle in 2009, MWh.

According to the report data $EG^{HC}_{ATPP,2009}$ = 140 891 MWh.

Electricity generation at ATPP based on condensation cycle is determined by subtraction of the following values, MWh:

$$EG^{CC}_{ATPP,BL,y} = EG_{ATPP,BL,y} - EG^{HC}_{ATPP,BL,y}. \quad \text{(B.1-13)}$$

<u>Baseline heat production</u>

Under the baseline scenario the company would carry out routine overhaul and would maintain operation of the old boiler and turbine equipment of ATPP at the existing level. This would allow generation of the desired amount of heat:

$$HS_{BL,y} = HS_{ATTP,BL,y}, \quad \text{(B.1-14)}$$

where $HS_{BL,y}$ is the overall supply of heat under the baseline scenario during the year *y*, GJ;

$HS_{ATTP,BL,y}$ is the supply of heat from ATPP under the baseline scenario during the year *y*, GJ.

We assume that the entire heat supply from ATPP under the baseline scenario is based on heating cycle (which is almost consistent with reality and is conservative). Then the heat supply from ATPP during the year *y* can be determined by the following formula, GJ:

$$HS_{ATTP,BL,y} = \frac{EG^{HC}_{ATPP,BL,y}}{\chi_{ATPP}}, \quad \text{(B.1-15)}$$

where χ_{ATPP} is the specific electricity generation based on heat supply at ATPP, MWh/GJ.

The specific electricity generation based on heat supply at ATPP is assumed to be equal to the maximum average annual value recorded over 2008-2010 (See Annex 2): χ_{ATPP} = 0.0895 MWh/GJ (2009). In this case it follows from conservative considerations, because decrease in this parameter leads to increase in GHG emission reductions.

<u>Baseline consumption of natural gas</u>

Natural gas consumption for heat and electricity generation at ATPP under the baseline scenario during the year *y* can be calculated by the following formula, GJ:

$$FC_{NG,ATPP,BL,y} = \left(\frac{HS_{ATPP,BL,y}}{\varepsilon_{he}} + 3.6 \times \frac{EG^{HC}_{ATPP,BL,y}}{\eta_{em}} + 3.6 \times \frac{EG^{CC}_{ATPP,BL,y}}{\eta_{em} \times \eta^{r}_{i}} \right) \times \frac{1}{\varepsilon_{tr} \times \eta_{ATTP,boilers}}, \quad \text{(B.1-16)}$$

where ε_{he} is the factor of heat losses in heat exchangers;

η_{em} is the electromechanical efficiency;

ε_{tr} is the heat transportation (from boiler to turbine) factor;

$\eta_{ATTP,boilers}$ is the efficiency of gas-fired boilers at ATPP;

η^{r}_{i} is the absolute internal efficiency of turbine units at ATPP in condensation mode with allowance for regeneration;

3.6 is the MW to GJ conversion factor.

The efficiency of old gas-fired boilers of ATPP in accordance with recommendations [R4] is assumed at $\eta_{ATTP,boilers}$ = 0.87.

The absolute internal efficiency of turbine units at ATPP in condensation mode with allowance for regeneration is calculated using the methodology given in [R13], η^{r}_{i} = 0.32422.

The heat loss factor for heat exchangers in accordance with recommendations [R12] is assumed at ε_{he} = 0.99.

The electromechanical efficiency in accordance with recommendations [R12] is assumed at η_{em} = 0.98.

The heat transportation (from boiler to turbine) factor in accordance with recommendations [R12] is assumed at ε_{tr} = 0.98.

For the sake of simplicity, natural gas consumption values for the baseline and project scenarios are given in energy units (GJ) in the description of GHG emission calculation methodology.

Project GHG emissions

The project GHG emissions during the year *y* are calculated by the following formula, tCO_2e:

$$PE_y = PE_{ATPP,y} + PE_{ACHPP-2,y}, \qquad \text{(B.1-17)}$$

where $PE_{ATPP,y}$ is the CO_2 emissions due to combustion of natural gas for electricity and heat generation at ATPP under the project during the year *y*, tCO_2e;

$PE_{ACHPP-2,y}$ is the CO_2 emissions due to combustion of natural gas for production of additional amount of electricity and heat at ACHPP-2 as a result of the project during the year *y*, tCO_2e.

The emissions of CO_2 due to combustion of natural gas for electricity and heat generation at ATPP under the project during the year *y* are calculated by the following formula, tCO_2e:

$$PE_{ATPP,y} = \left(FC^{old}_{NG,ATPP,PJ,y} + FC^{CCP}_{NG,ATPP,PJ,y}\right) \times EF_{CO2,NG}, \qquad \text{(B.1-18)}$$

where $FC^{old}_{NG,ATPP,PJ,y}$ is the consumption of natural gas in the old section of ATPP for generation of electricity and heat under the project during the year *y*, GJ;

$FC^{CCP}_{NG,ATPP,PJ,y}$ is the consumption of natural gas in the CCP for generation of electricity and heat under the project during the year *y*, GJ.

The CO_2 emissions due to natural gas combustion for generation of additional amount of heat and electricity at ACHPP-2 as a result of the project during the year *y* are calculated by the following formula, tCO_2e:

$$PE_{ACHPP-2,y} = \Delta FC_{NG,ACHPP-2,PJ,y} \times EF_{CO2,NG}, \qquad \text{(B.1-19)}$$

where $\Delta FC_{NG,ACHPP-2,PJ,y}$ is the additional consumption of natural gas at ACHPP-2 under the project during the year *y*, GJ.

The method of fuel consumption calculation is described further below.

Heat and electricity generation under the project

In order to meet the consumer's demand under the project it is necessary to supply the same amount of heat as under the baseline scenario, therefore:

$$HS_{PJ,y} = HS_{BL,y}, \qquad \text{(B.1-20)}$$

where $HS_{PJ,y}$ is the overall heat supply under the project during the year *y*, GJ.

However the thermal capacity of the CCP will not be sufficient to ensure that, while the old equipment of ATPP is planned to be decommissioned. Therefore the heat loads will be covered with the help of a connecting heating main to be constructed between Astrakhan TPP and Astrakhan CHPP-2. Thus, a full-fledged single heating loop is created to cover all heat loads from Astrakhan CHPP-2 with additional loading of heat extraction turbines of ACHPP-2.

In general case heat supply from ATPP under the project during the year *y* is calculated by the following formula, GJ:

$$HS_{ATPP,PJ,y} = HS^{old}_{ATPP,PJ,y} + HS^{CCP}_{ATPP,PJ,y}, \quad (B.1\text{-}21)$$

where $HS^{old}_{ATPP,PJ,y}$ is the heat supply from the old section of ATPP under the project during the year y, GJ;

$HS^{CCP}_{ATPP,PJ,y}$ is the heat supply from the CCP under the project during the year y, GJ.

The additional heat supply from ACHPP-2 as a result of the project during the year y is calculated by the following formula, GJ:

$$\Delta HS_{ACHPP-2,PJ,y} = HS_{PJ,y} - HS_{ATPP,PJ,y}. \quad (B.1\text{-}22)$$

The project electricity supply during the year y, in general, is calculated by the following formula, MWh:

$$ES_{PJ,y} = ES_{ATPP,PJ,y} + \Delta ES_{ACHPP-2,PJ,y}, \quad (B.1\text{-}23)$$

where $ES_{ATPP,PJ,y}$ is the project electricity supply from ATPP during the year y, MWh;

$\Delta ES_{ACHPP-2,PJ,y}$ is the additional supply of electricity from ACHPP-2 as a result of the project during the year y, MWh.

The project electricity supply from ATPP during the year y is calculated as follows, MWh:

$$ES_{ATPP,PJ,y} = ES^{old}_{ATPP,PJ,y} + ES^{CCP}_{ATPP,PJ,y}, \quad (B.1\text{-}24)$$

where $ES^{old}_{ATPP,PJ,y}$ is the project electricity supply from the old section of ATPP during the year y, MWh;

$ES^{CCP}_{ATPP,PJ,y}$ is the project electricity supply from the CCP during the year y, MWh.

The additional supply of electricity from ACHPP-2 as a result of the project during the year y is calculated by the following formula, MWh:

$$\Delta ES_{ACHPP-2,PJ,y} = \left(1 - \varepsilon^{aux}_{el,ACHPP-2}\right) \times \Delta EG_{ACHPP-2,PJ,y}, \quad (B.1\text{-}25)$$

where $\varepsilon^{aux}_{el,ACHPP-2}$ is the specific consumption of electricity for auxiliary needs of ACHPP-2;

$\Delta EG_{ACHPP-2,PJ,y}$ is the additional electricity generation at ACHPP-2 as a result of the project during the year y, MWh.

$$\Delta EG_{ACHPP-2,PJ,y} = \Delta HS_{ACHPP-2,PJ,y} \times \chi_{ACHPP-2}, \quad (B.1\text{-}26)$$

where $\chi_{ACHPP-2}$ is the specific electricity generation based on heat supply at ACHPP-2, MWh/GJ.

In the projections for the year 2012 the value of annual electricity and heat supply from the CCP is assumed in accordance with the design documentation for CCP-110 [R8]: $HS^{CCP}_{ATPP,PJ,2012}$ = 882 620 GJ; $ES^{CCP}_{ATPP,PJ,2012}$ = 876 460 MWh. The energy generation forecast for 2011 was based on the estimates for the year 2012 and adjusted to the number of full months of actual operation of the CCP in 2011: $HS^{CCP}_{ATPP,PJ,2011}$ = 514 861 GJ; $ES^{CCP}_{ATPP,PJ,2011}$ = 511 268 MWh.

After installation of the CCP the equipment of the old section of ATPP is planned to be decommissioned, therefore in projections for the years 2011-2012 electricity and heat supply by such equipment is assumed to be zero: $HS^{old}_{ATPP,PJ,2011}$= 0 GJ; $HS^{old}_{ATPP,PJ,2012}$= 0 GJ; $ES^{old}_{ATPP,PJ,2011}$= 0 MWh; $ES^{old}_{ATPP,PJ,2012}$= 0 MWh.

The specific electricity consumption for auxiliary needs of ACHPP-2 according to the plant performance analysis for 2008-2010 (See Annex 2) is assumed to be equal to the specific electricity consumption of ATPP: $\varepsilon^{aux}_{el,ACHPP-2} = \varepsilon^{aux}_{el,ATPP} = \varepsilon^{aux}_{el}$ = 0.1.

The specific electricity generation based on heat supply at ACHPP-2 is assumed to be equal to the minimum average annual value recorded over 2008-2010 (See Annex 2): $\chi_{ACHPP-2}$ = 0.1366 MWh/GJ (2010). It follows from conservative considerations, because increase in this parameter will lead to increase in GHG emission reductions.

<u>Natural gas consumption under the project</u>

Natural gas consumption in the old section of ATPP is assumed to be zero in our estimations, because the equipment of the old section of the plant is planned to be decommissioned as soon as the CCP is put into operation. Thus: $FC^{old}_{NG,ATPP,PJ,2011}$= 0; $FC^{old}_{NG,ATPP,PJ,2012}$ = 0.

Natural gas consumption in the CCP under the project during the year *y* is calculated by the following formula, GJ:

$$FC^{CCP}_{NG,ATPP,PJ,y} = \left(ES^{CCP}_{ATPP,PJ,y} \times \delta_{ES} + HS^{CCP}_{ATPP,PJ,y} \times \delta_{HS} \right) \times \frac{29.31}{1000}, \qquad \text{(B.1-27)}$$

where δ_{ES} is the specific consumption of equivalent fuel per unit of electricity supply from the CCP, kg e.f./MWh;

δ_{HS} is the specific consumption of equivalent fuel per unit of heat supply from the CCP, kg e.f./GJ;

29.31 is the factor for conversion of tonnes of e.f. to GJ.

The additional consumption of natural gas at ACHPP-2 as a result of the project during the year *y* is calculated by the following formula, GJ:

$$\Delta FC_{NG,ACHPP-2,PJ,y} = \left(\frac{\Delta HS_{ACHPP-2,PJ,y}}{\varepsilon_{he}} + 3.6 \times \frac{\Delta EG_{ACHPP-2,PJ,y}}{\eta_{em}} \right) \times \frac{1}{\varepsilon_{tr} \times \eta_{ACHPP-2,boilers}}, \qquad \text{(B.1-28)}$$

where $\eta_{ACHPP-2,boilers}$ is the efficiency of gas-fired boilers of ACHPP-2.

In accordance with the recommendations of [R4] the efficiency of old gas-fired boilers of ACHPP-2 is assumed to be $\eta_{ACHPP-2\ boilers}$= 0.87, that is $\eta_{ACHPP-2,boilers} = \eta_{ATTP,boilers} = \eta_{old\ gas boilers}$.

In projections for the years 2011-2012 the values of specific consumption of equivalent fuel for heat and electricity supply are assumed in accordance with the design documentation for CCP-110 [R8] to be constant over years and equal to: δ_{HS} = 37.02 kg e.f./GJ and δ_{ES} = 222.9 kg e.f./MWh, respectively.

During monitoring the project consumption of natural gas will be determined by direct measurement of its volume consumed both in the CCP and in the old section of ATPP, which is then multiplied by the average calorific value of natural gas (See Section D).

Heat losses at the heating main between ACHPP-2 and ATPP were not taken into account. According to [R14] the coefficient of losses during heat transportation via heating networks that were built earlier than 1990, may be 0.9-0.95. Considering that the project connecting main is built much later than 1990 using up-to-date thermal insulation it is fair to assume that this coefficient will be 0.95. Considering that using this coefficient in calculations causes changes in GHG emission reductions of less than 1%, and considering that the heat losses in the connecting main are well offset by project-induced reduction in heat losses during supply of heat from ATPP in summer period, there is a good reason to neglect this parameter in our calculations.

Leakages

The leakages caused by the project include fugitive emissions of CH_4 from production, processing, storage, delivery and distribution of fossil fuel.

The main fuel for heat and electricity generation both under the project and the baseline scenario is natural gas.[12] The project will result in increase of the energy generation efficiency (due to operation of the CCP and additional loading of ACHPP-2 turbines), which will lead to reduction in natural gas consumption per unit of generated energy and, therefore, to reduction in fugitive emissions. For conservative reasons and for the sake of simplicity these leakages are excluded from consideration.

Application of the chosen approach

All necessary parameters for the baseline and the project scenarios were determined on the basis of the methodology described above. All key data and parameters are given in a tabular form below. See also Annex 2.

Data/Parameter	$EF_{CO2,NG}$
Data unit	tCO_2/GJ
Description	CO_2 emission factor for natural gas
Time of determination/monitoring	Determined once at the stage of the PDD development
Source of data (to be) used	2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2, Chapter 2, Table 2.2. [R3]
Value of data applied (for ex ante calculations/determinations)	0.0561
Justification of the choice of data or description of measurement methods and procedures (to be) applied	Default value
QA/QC procedures (to be) applied	Determined based on reference data
Any comment	Assumed as a constant both in estimations and for the monitoring period 2011-2012

Data/Parameter	$EF_{CO2,grid}$
Data unit	tCO_2/MWh
Description	CO_2 emission factor for grid electricity
Time of determination/monitoring	Determined once at the stage of the PDD development
Source of data (to be) used	Assumed in accordance with the justification given in Annex 4
Value of data applied (for ex ante calculations/determinations)	0.6745
Justification of the choice of	Calculated on the basis of actual performance data on the power

[12] According to [R2] the main type of fuel at power plants of the IES South is natural gas (in 2007 - 87% of the total fuel consumption). Practically all energy sources of Astrakhan are also fired with natural gas.

data or description of measurement methods and procedures (to be) applied	plants of the IES South. The emission factor takes into account the existing power plants and new energy generating units of the IES South, Russian Federation
QA/QC procedures (to be) applied	Determined based on reference data
Any comment	Assumed as a constant both in estimations and for the monitoring period 2011-2012

Data/Parameter	$\eta_{old\ gas boilers}$
Data unit	-
Description	Efficiency of old gas boilers (at ATPP and ACHPP-2)
Time of determination/monitoring	Determined once at the stage of the PDD development
Source of data (to be) used	Tool to determine the baseline efficiency of thermal or electric energy generation systems. Version 01. CDM Executive Board. p.7, Table 1. [R4]
Value of data applied (for ex ante calculations/determinations)	0.87
Justification of the choice of data or description of measurement methods and procedures (to be) applied	Recommended value for old gas boilers. The existing gas boilers at both Astrakhan TPP and ACHPP-2 have been in operation for over 10 years and in accordance with [R4] are regarded as old units. $\eta_{ACHPP-2,boilers} = \eta_{ATTP,boilers} = \eta_{old\ gas boilers}$
QA/QC procedures (to be) applied	Determined based on reference data
Any comment	Assumed as a constant both in estimations and for the monitoring period 2011-2012

Data/Parameter	δ_{ES}
Data unit	kg e.f./MWh
Description	Specific consumption of equivalent fuel per unit of electricity supply from the CCP
Time of determination/monitoring	Determined once at the stage of the PDD development
Source of data (to be) used	Design data for CCP-110 [R8]
Value of data applied (for ex ante calculations/determinations)	222.9
Justification of the choice of data or description of measurement methods and procedures (to be) applied	In projections for the years 2011-2012 per unit consumption of equivalent fuel for electricity supply from the CCP is assumed to be constant over years and equal to the value specified in the design for this CCP [R8].
QA/QC procedures (to be) applied	Determined based on the design data
Any comment	This value is used only for projection purposes and shall not affect the actual emission reduction value based on monitored data.

Data/Parameter	δ_{HS}
Data unit	kg e.f./GJ

Description	Specific consumption of equivalent fuel per unit of heat supply from the CCP
Time of determination/monitoring	Determined once at the stage of the PDD development
Source of data (to be) used	Design data for CCP-110 [R8]
Value of data applied (for ex ante calculations/determinations)	37.02
Justification of the choice of data or description of measurement methods and procedures (to be) applied	In projections for the years 2011-2012 per unit consumption of equivalent fuel for heat supply from the CCP is assumed to be constant over years and equal to the value specified in the design for this CCP [R8].
QA/QC procedures (to be) applied	Determined based on the design data
Any comment	This value is used only for projection purposes and shall not affect the actual emission reduction value based on monitored data.

Data/Parameter	ε_{el}^{aux}
Data unit	-
Description	Specific electricity consumption for auxiliary needs of power plants (ATPP and ACHPP-2)
Time of determination/monitoring	Determined once at the stage of the PDD development
Source of data (to be) used	Actual data on performance of ATPP and ACHPP-2 over 2008-2010. See Annex 2.
Value of data applied (for ex ante calculations/determinations)	0.1
Justification of the choice of data or description of measurement methods and procedures (to be) applied	In projections for the years 2011-2012 specific consumption of electricity for auxiliary needs of both power plants are assumed to be constant over years and equal to the minimum value for ATPP recorded over 2008-2010 (2008). $\varepsilon_{el,ACHPP-2}^{aux} = \varepsilon_{el,ATPP}^{aux} = \varepsilon_{el}^{aux}$
QA/QC procedures (to be) applied	Determined based on the actual data
Any comment	Assumed as a constant both in estimations and for monitoring over 2011-2012

Data/Parameter	χ_{ATPP}
Data unit	MWh/GJ
Description	Specific electricity generation based on heat supply at ATPP
Time of determination/monitoring	Determined once at the stage of the PDD development
Source of data (to be) used	Actual data on ATPP performance over 2008-2010. See Annex 2.
Value of data applied (for ex ante calculations/determinations)	0.0895
Justification of the choice of data or description of measurement methods and procedures (to be) applied	Assumed equal to the maximum average annual value of specific electricity generation based on heat supply at ATPP over 2008-2010, which corresponds to the year 2009: $\chi_{ATPP} = \frac{EG_{ATPP,2009}^{HC}}{HS_{ATPP,2009}^{ex.steam}}$,

	where $EG^{HC}_{ATPP,2009}$ is the electricity generation at ATPP based on heating cycle in 2009, MWh; $HS^{ex.steam}_{ATPP,2009}$ is the heat supply from ATPP with exhaust steam in 2009, GJ.
QA/QC procedures (to be) applied	Determined based on the actual data
Any comment	Assumed as a constant both in estimations and for monitoring over 2011-2012

Data/Parameter	$\chi_{ACHPP-2}$
Data unit	MWh/GJ
Description	Specific electricity generation based on heat supply at ACHPP-2
Time of determination/monitoring	Determined once at the stage of the PDD development
Source of data (to be) used	Actual data on ACHPP-2 performance over 2008-2010. See Annex 2.
Value of data applied (for ex ante calculations/determinations)	0.1366
Justification of the choice of data or description of measurement methods and procedures (to be) applied	Assumed equal to the minimum average annual value of specific electricity generation based on heat supply at ACHPP-2 over 2008-2010, which corresponds to the year 2010: $\chi_{ACHPP-2} = \frac{EG^{HC}_{ACHPP-2,2010}}{HS^{ex.steam}_{ACHPP-2,2010}}$, where $EG^{HC}_{ACHPP-2,2010}$ is the electricity generation at ACHPP-2 based on heating cycle in 2010, MWh; $HS^{ex.steam}_{ACHPP,2010}$ is the heat supply from ACHPP-2 with exhaust steam in 2010, GJ.
QA/QC procedures (to be) applied	Determined based on the actual data
Any comment	Assumed as a constant both in estimations and for monitoring over 2011-2012

Data/Parameter	$EG_{ATPP,BL,y}$
Data unit	MWh
Description	Baseline electricity generation at ATPP
Time of determination/monitoring	Determined once at the stage of the PDD development
Source of data (to be) used	Actual data on ATPP performance over 2008-2010. See Annex 2.
Value of data applied (for ex ante calculations/determinations)	2011: 334 966 2012: 574 227
Justification of the choice of data or description of measurement methods and procedures (to be) applied	Assume to be: in 2011 $EG_{ATPP,BL,2011} = \frac{7}{12} EG_{ATPP,2008}$, in 2012 $EG_{ATPP,BL,2012} = EG_{ATPP,2008}$,

	where $EG_{ATPP,2008}$ is the actual annual electricity generation at ATPP in 2008, MWh. According to the report data $EG_{ATPP,2008}$ = 574 227 MWh. The choice of 2008 value is soundly conservative considering that in the absence of the project the annual generation could be around 650 thousand MWh per year as it had been the case for several years prior to the project (2008). For 2011 the value was corrected in proportion to the number of full months of the CCP operation in 2011. Considering that the actual operation of the CCP started in May 2011, it leaves seven full months of operation before the end of 2011.
QA/QC procedures (to be) applied	Determined based on the actual data
Any comment	Assumed as constants both in estimations and for monitoring over 2011-2012

Data/Parameter	$EG^{HC}_{ATPP,BL,y}$
Data unit	MWh
Description	Electricity generation based on heating cycle at ATPP under the baseline scenario
Time of determination/monitoring	Determined once at the stage of the PDD development
Source of data (to be) used	Actual data on ATPP performance over 2008-2010. See Annex 2.
Value of data applied (for ex ante calculations/determinations)	2011: 82 186 2012: 140 891
Justification of the choice of data or description of measurement methods and procedures (to be) applied	Assume to be: in 2011 $EG^{HC}_{ATPP,BL,2011} = \frac{7}{12} EG^{HC}_{ATPP,2009}$, in 2012 $EG^{HC}_{ATPP,BL,2012} = EG^{HC}_{ATPP,2009}$, where $EG^{HC}_{ATPP,2009}$ is the actual annual electricity generation based on heating cycle at ATPP in 2009, MWh. According to the report data $EG^{HC}_{ATPP,2009}$ = 140 891 MWh. It is the maximum value over the period of ATPP operation from 2008 through 2010. For 2011 the value was corrected in proportion to the number of full months of the CCP operation in 2011. Considering that the actual operation of the CCP started in May 2011, it leaves seven full months of operation before the end of 2011.
QA/QC procedures (to be) applied	Determined based on the actual data
Any comment	Assumed as constants both in estimations and for monitoring over 2011-2012

Data/Parameter	η^{r}_{i}

Data unit	-
Description	Absolute internal efficiency of turbine units at ATPP in condensation mode with allowance for regeneration
Time of determination/monitoring	Determined once at the stage of the PDD development
Source of data (to be) used	Calculated in accordance with recommendations of [R13]: B.V. Sazanov, V.I. Sitas. Thermal Energy Systems of Industrial Facilities. - M.: Energoatomizdat, 1990.
Value of data applied (for ex ante calculations/determinations)	0.32422
Justification of the choice of data or description of measurement methods and procedures (to be) applied	Calculated in accordance with the methodology given in reference literature. The calculation is made using the nominal characteristics of the turbines installed in the old section of the ATPP.
QA/QC procedures (to be) applied	Determined based on the reference data
Any comment	Assumed as a constant both in estimations and for monitoring over 2011-2012

Data/Parameter	ε_{he}
Data unit	-
Description	Factor of heat losses in heat exchangers
Time of determination/monitoring	Determined once at the stage of the PDD development
Source of data (to be) used	V.Y.Ryzhkin. Thermal Power Plants. - M.: Energoatomizdat, 1987. [R12]
Value of data applied (for ex ante calculations/determinations)	0.99
Justification of the choice of data or description of measurement methods and procedures (to be) applied	Recommended default value
QA/QC procedures (to be) applied	Determined based on reference data
Any comment	Assumed as a constant both in estimations and for monitoring over 2011-2012

Data/Parameter	ε_{tr}
Data unit	-
Description	Heat transportation (from boiler to turbine) factor
Time of determination/monitoring	Determined once at the stage of the PDD development
Source of data (to be) used	V.Y.Ryzhkin. Thermal Power Plants. - M.: Energoatomizdat, 1987. [R12]
Value of data applied (for ex ante calculations/determinations)	0.98
Justification of the choice of data or description of measurement methods and	Recommended default value

procedures (to be) applied	
QA/QC procedures (to be) applied	Determined based on reference data
Any comment	Assumed as a constant both in estimations and for monitoring over 2011-2012

Data/Parameter	η_{em}
Data unit	-
Description	Electromechanical efficiency
Time of determination/monitoring	Determined once at the stage of the PDD development
Source of data (to be) used	V.Y.Ryzhkin. Thermal Power Plants. - M.: Energoatomizdat, 1987. [R12]
Value of data applied (for ex ante calculations/determinations)	0.98
Justification of the choice of data or description of measurement methods and procedures (to be) applied	Recommended default value
QA/QC procedures (to be) applied	Determined based on reference data
Any comment	Assumed as a constant both in estimations and for monitoring over 2011-2012

Data/Parameter	$HS^{CCP}_{ATPP,PJ,y}$
Data unit	GJ
Description	Project heat supply from the CCP
Time of determination/monitoring	Annually
Source of data (to be) used	Design data [R8]
Value of data applied (for ex ante calculations/determinations)	2011: 514 861 2012: 882 620
Justification of the choice of data or description of measurement methods and procedures (to be) applied	For projection purposes, annual heat supply from the CCP is assumed to be constant over years and equal to the value specified in the design for the CCP [R8]. For 2011 the value was corrected in proportion to the number of full months of the CCP operation in 2011. Considering that the actual operation of the CCP started in May 2011, it leaves seven full months of operation before the end of 2011. During monitoring this parameter will be determined based on heat meter readings.
QA/QC procedures (to be) applied	In projections it is determined on the basis of design data. During monitoring all heat meters will be regularly checked and verified.
Any comment	-

Data/Parameter	$ES^{CCP}_{ATPP,PJ,y}$
Data unit	MWh

Description	Project electricity supply from the CCP
Time of determination/monitoring	Annually
Source of data (to be) used	Design data [R8]
Value of data applied (for ex ante calculations/determinations)	2011: 511 268 2012: 876 460
Justification of the choice of data or description of measurement methods and procedures (to be) applied	For projection purposes, annual electricity supply from the CCP is assumed to be constant over years and equal to the value specified in the design for the CCP [R8]. For 2011 the value was corrected in proportion to the number of full months of the CCP operation in 2011. Considering that the actual operation of the CCP started in May 2011, it leaves seven full months of operation before the end of 2011. During monitoring this parameter will be determined based on electric meter readings.
QA/QC procedures (to be) applied	In projections it is determined on the basis of design data. During monitoring all electric meters will be regularly checked and verified.
Any comment	-

Data/Parameter	$HS_{ATPP,PJ,y}^{old}$
Data unit	GJ
Description	Heat supply from the old section of ATPP under the project
Time of determination/monitoring	Annually
Source of data (to be) used	Design data [R8]
Value of data applied (for ex ante calculations/determinations)	2011: 0 2012: 0
Justification of the choice of data or description of measurement methods and procedures (to be) applied	After installation of the CCP the equipment of the old section of ATPP is planned to be decommissioned, therefore in projections for 2011-2012 heat supply from the old section is assumed to be zero. During monitoring this parameter will be determined based on heat meter readings.
QA/QC procedures (to be) applied	In projections it is determined on the basis of design data. During monitoring all heat meters will be regularly checked and verified.
Any comment	-

Data/Parameter	$ES_{ATPP,PJ,y}^{old}$
Data unit	MWh
Description	Electricity supply from the old section of ATPP under the project
Time of determination/monitoring	Annually
Source of data (to be) used	Design data [R8]
Value of data applied (for ex ante calculations/determinations)	2011: 0 2012: 0
Justification of the choice of data or description of	The equipment of the old section of ATPP is planned to be decommissioned after installation of the CCP, therefore in

measurement methods and procedures (to be) applied	projections for 2011-2012 electricity supply from the old section is assumed to be zero. During monitoring this parameter will be determined based on electric meter readings.
QA/QC procedures (to be) applied	In projections it is determined on the basis of design data. During monitoring all electric meters will be regularly checked and verified.
Any comment	-

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

The approach described in paragraph 2 (a) of Annex 1 to the "Guidance on criteria for baseline setting and monitoring" [R1] was chosen to demonstrate that the project-induced reduction in GHG emissions from sources are additional to those that might have otherwise occurred in the absence of the project.

Within the framework of the chosen approach the additionality of the project was proven using the project alternatives analysis, investment analysis and common practice analysis.

Analysis of the project alternatives

The alternatives for electricity generation and heat production have been identified and looked at separately. Description of the alternatives and their analysis can be found in Section B.1.

Based on the analysis of the project alternatives it was concluded that the most likely baseline scenario should be the scenario which assumes that most of electricity and all heat will be supplied by the existing equipment of ATPP whereas the lacking amount (compared with the project) of electricity will be supplied by the existing power plants and new energy generating units of the IES South.

This analysis refers to the below investment analysis which demonstrates that the project activity without the joint implementation mechanism is not a viable baseline scenario.

Investment analysis

The following main economic parameters of the project option without selling ERUs were calculated: internal rate of return (IRR) and net present value (NPV).

The investment analysis was developed using data and assumptions relevant as of the starting date of the project (February 2008).

The overall capital investment in the project was estimated at RUR 4 212.613 million.

The time horizon of the analysis is limited to the year 2030.

The calculations were made using the general inflation rate, rate of growth of heat and electricity tariffs and rate of increase in natural gas prices for the IES South. The said macroeconomic parameters were assumed in accordance with the "Development Scenarios for the Russian Electric Power Sector for the years 2009-2020" developed by the Energy Forecasting Agency in 2008.

The source of revenues from the project implementation is sale of heat and electricity. The expenses consist of fuel costs and other process costs (salary, maintenance and repair costs, payments for permissible emissions and for use of water bodies, water treatment costs).

The discount rate was determined using the "Guidelines on estimation of investment projects efficiency …"[13]. According to this methodology, the discount rate in calculations of efficiency may include an allowance for risk.

[13] Guidelines on estimation of investment projects efficiency. Approved by the Russian Ministry of Economics, the Russian Ministry of Finance and the Russian Gosstroi dated 21 June 1999 N BK 477

The inflation-free or real discount rate p_{real} used for estimation of commercial efficiency of the project on the whole can be set in accordance with the requirements to the minimum permissible future inflation-free return on investments, in practice – 4-6%. We shall assume the average value of real risk-free rate of 5%.

With the help of the Fisher equation $1 + p_{nom} = (1 + p_{real}) \cdot (1 + i)$ we get an equation to determine the sought nominal risk-free discount rate with allowance for inflation:

$$p_{nom} = (1 + p_{real}) \cdot (1 + i) - 1, \qquad \text{(B.2-1)}$$

where p_{nom} is the nominal risk-free discount rate with allowance for inflation, %;

p_{real} is the inflation-free or real risk-free discount rate;

i is the level of inflation.

The projected average level of inflation over the considered planning period was calculated using the above-mentioned "Development Scenarios for the Russian Electric Power Sector…" and amounted to around i = 4.5%.

Thus, the nominal risk-free discount rate is:

$$p_{nom} = (1+0.05) \cdot (1+0.045) - 1 = 9.7\%.$$

The risk of failure to generate revenues envisaged by the project is estimated not be below average (in accordance with Table 11.1 from the "Guidelines on estimation of investment projects efficiency…"). The recommended premium for this risk is between 8 and 10%. Other risks were decided to be neglected.

The final discount rate was assumed at the level of 18%.

The results of calculation of the project's net present value (NPV) and internal rate of return (IRR) are given in Table B.2-1.

It is apparent that the project implementation without selling GHG emission reductions has a negative NPV and its IRR is less than 18%.

Table B.2-1. Comparison of NPV and IRR

Parameter	Unit	Project without sale of GHG emission reductions
NPV	Million RUR	-792
IRR	%	14.36%

Further below is the analysis of the project sensitivity to changes in main parameters (See Table B.2-2) within the range of ±10%. In all considered cases the NPV is negative and the IRR is below 18%. Thus the project implementation under usual commercial practice remains unprofitable.

Table B.2-2. Sensitivity analysis

Parameter	Unit	Project without sale of GHG emission reductions
An increase of 10% in the investment costs		
NPV	Million RUR	-1 181
IRR	%	12.98%
A reduction of 10% in the investment costs		
NPV	Million RUR	-402
IRR	%	15.98%
An increase of 10% in the revenues from sale of heat		
NPV	Million RUR	-733

IRR	%	14.65%
A reduction of 10% in the revenues from sale of heat		
NPV	Million RUR	-851
IRR	%	14.07%
An increase of 10% in the revenues from sale of electricity		
NPV	Million RUR	-154
IRR	%	17.32%
A reduction of 10% in the revenues from sale of electricity		
NPV	Million RUR	-1 429
IRR	%	11.10%
An increase of 10% in the planned fuel costs		
NPV	Million RUR	-1 037
IRR	%	13.12%
A reduction of 10% in the planned fuel costs		
NPV	Million RUR	-546
IRR	%	15.54%

Common practice analysis

The Russian electric power sector is characterized by a high proportion of natural gas (around 70%) consumption at CHPPs. Nonetheless, the combined-cycle technology has not spread widely. All combined-cycle plants account for around 2% of the total installed capacity of all thermal power plants in Russia. Nearly all thermal power plants are using the Rankine cycle (boilers running on fossil fuel and steam turbines).

It should also be noted that almost all projects of this kind in Russia have been deemed to implement[14] and are implemented with the involvement of the Joint Implementation mechanism.

Thus the considered project is not common practice.

Proceeding from the above, GHG emission reductions resulting from the project are additional to those that might have otherwise occurred.

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

Fig. B.3-1 and B.3-2 show main GHG emission sources, energy and fuel flows for the baseline and project scenarios, respectively. Table B.3-1 shows emission sources included in and excluded from the project boundary.

[14] http://www.carbonfund.ru/projects/pso/

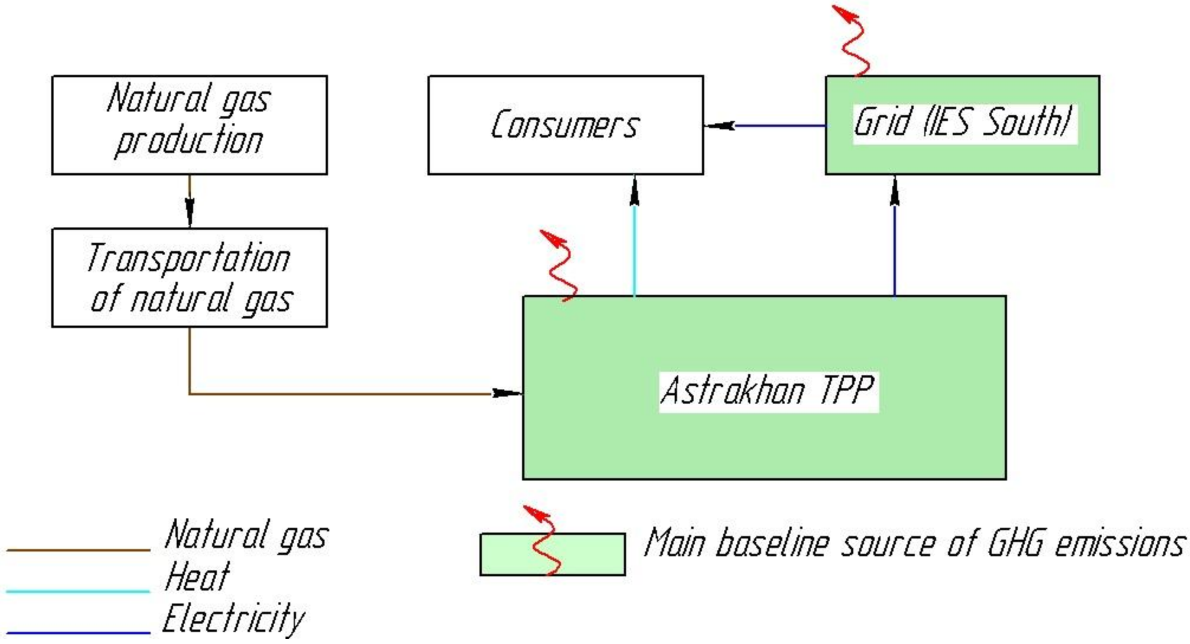

Fig. B.3-1. Main emission sources and flows for the baseline scenario

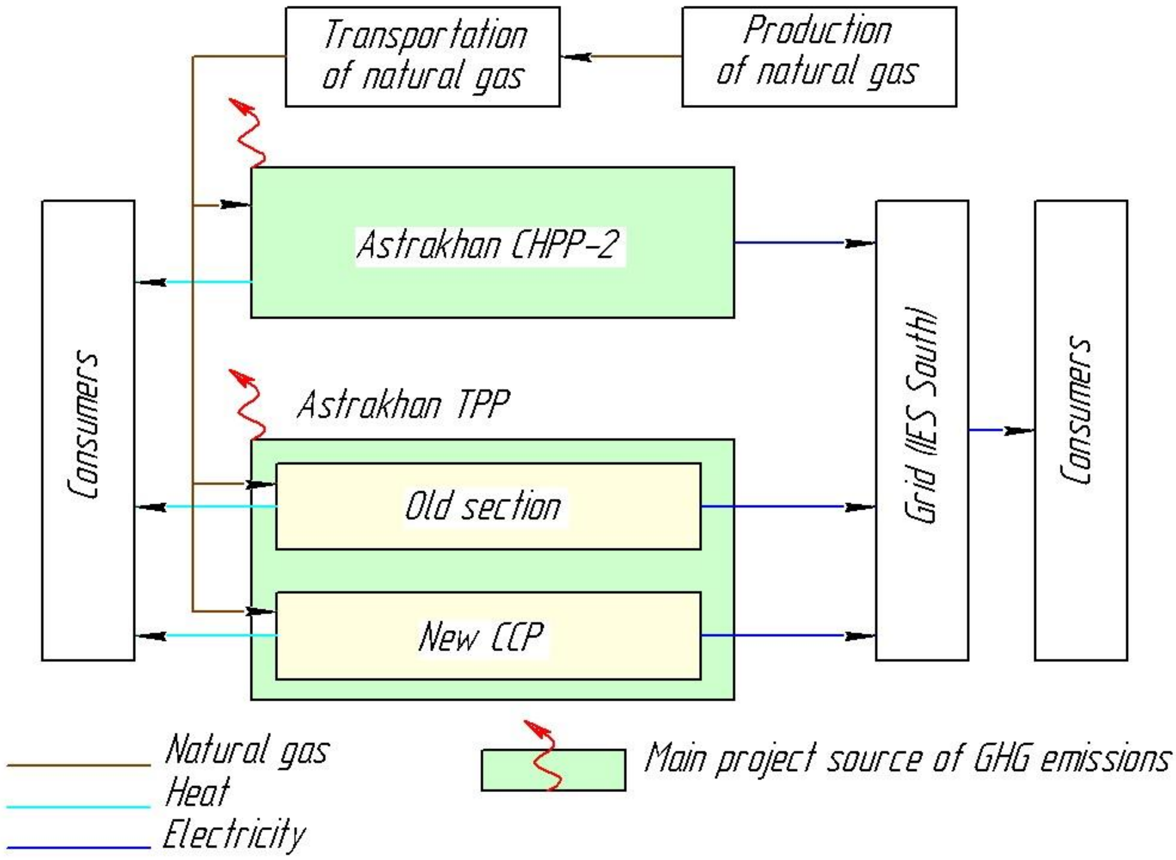

Fig. B.3-2. Main emission sources and flows for the project scenario

Table B.3-1. Emission sources included in and excluded from the project boundary

	Source	Gas	Incl./Excl.	Justification / Explanation
Baseline	ATPP, Combustion of natural gas	**CO_2**	**Incl.**	**Main emission source**
		CH_4	Excl.	Negligible. This is conservative.
		N_2O	Excl.	Negligible. This is conservative.
	Power plant of the IES South, Combustion of fossil fuel	**CO_2**	**Incl.**	**Main emission source**
		CH_4	Excl.	Negligible. This is conservative.
		N_2O	Excl.	Negligible. This is conservative.
Project	CCP, Combustion of natural gas	**CO_2**	**Incl.**	**Main emission source**
		CH_4	Excl.	Negligible
		N_2O	Excl.	Negligible
	Equipment of the old section of ATPP, Combustion of natural gas	**CO_2**	**Incl.**	**Main emission source**
		CH_4	Excl.	Negligible
		N_2O	Excl.	Negligible
	ACHPP-2, Combustion of natural gas	**CO_2**	**Incl.**	**Main emission source**
		CH_4	Excl.	Negligible
		N_2O	Excl.	Negligible
Leakages	Production, processing, storage, transportation and distribution of fossil fuel, fugitive emissions	CO_2	Excl.	Negligible
		CH_4	Excl.	Excluded from consideration because fossil fuel consumption is reduced due to the project. This is conservative.
		N_2O	Excl.	Negligible

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

The date of baseline setting: 13/07/2011

The baseline was developed by CCGS LLC (CCGS LLC is not a project participant and is not listed in Annex 1 of this PDD).

Contact person: Dmitry Potashev

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SECTION C. Duration of the project / crediting period

C.1. Starting date of the project:

February 22, 2008 (signing of the contract with CJSC "Energokaskad" for works on "Reconstruction of Astrakhan TPP through construction of CCP-110")

C.2. Expected operational lifetime of the project:

20 years / 240 months (life expectancy of the main equipment)

C.3. Length of the crediting period:

1.58 years / 19 months (from June 1, 2011 till December 31, 2012)

SECTION D. Monitoring plan

D.1. Description of monitoring plan chosen:

For development of the monitoring plan a JI-specific approach was applied on the basis of paragraph 9 (a) of the "Guidance on criteria for baseline setting and monitoring" [R1].

Data required for calculation of GHG emission reductions are to be collected at Astrakhan TPP in any case and the data collection process complies with the best sectoral standards and practices of fuel and energy accounting and environmental impact assessment.

All data required for monitoring shall be kept in the company's archive in electronic and hard copy for at least two years after the end of the crediting period or the last transfer of ERUs.

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

D.1.1.1. Data to be collected in order to monitor emissions from the project, and how these data will be archived:

ID number *(Please use numbers to ease cross-referencing to D.2.)*	Data variable	Source of data	Data unit	Measured (m), calculated (c), estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment
1. $FC^{old,\upsilon}_{NG,ATPP,PJ,y}$	Volumetric consumption of natural gas in the old section of ATPP under the project	Readings of flow meters measuring gas supply to the old section of ATPP	Thousand m^3	m, c	Continuously	100%	Electronic and paper	Gas consumption is adjusted to standard conditions 20°C and 0.1013 MPa
2. $FC^{CCP,\upsilon}_{NG,ATPP,PJ,y}$	Volumetric consumption of natural gas in the CCP under the project	Readings of flow meters measuring gas supply to the CCP	Thousand m^3	m, c	Continuously	100%	Electronic and paper	Gas consumption is adjusted to standard conditions 20°C and 0.1013 MPa
3. $NCV_{NG,y}$	Average net calorific value of natural gas	Certificates of fuel suppliers, readings of the	GJ/thousand m^3	m, c	Monthly (certificates), Continuously	100%	Electronic and paper	Calorific value of natural gas is adjusted to

	consumed in ATPP	calorimeter at ATPP			(calorimeter)			standard conditions 20°C and 0.1013 MPa
4. $HS^{old}_{ATPP,PJ,y}$	Heat supply from the old section of ATPP	Heat meter readings	GJ	m, c	Continuously	100%	Electronic and paper	Heat supply is calculated on the basis of measured values of flow, temperature and pressure of heat medium
5. $HS^{CCP}_{ATPP,PJ,y}$	Heat supply from the CCP	Heat meter readings	GJ	m, c	Continuously	100%	Electronic and paper	Heat supply is calculated on the basis of measured values of flow, temperature and pressure of heat medium

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

The project emissions of GHG are due to combustion of fossil fuel (natural gas) at ATPP and ACHPP-2 for generation and supply of heat and electricity during the year *y*, tCO_2e:

$$PE_y = PE_{ATPP,y} + PE_{ACHPP-2,y}, \quad \text{(D.1-1)}$$

where $PE_{ATPP,y}$ is the emissions of CO_2 due to combustion of natural gas for generation of electricity and heat at ATPP under the project during the year *y*, tCO_2e;

$PE_{ACHPP-2,y}$ is the emissions of CO_2 due to combustion of natural gas for generation of additional quantity of electricity and heat at ACHPP-2 as a result of the project during the year *y*, tCO_2e.

$$PE_{ATPP,y} = \left(FC^{old}_{NG,ATPP,PJ,y} + FC^{CCP}_{NG,ATPP,PJ,y}\right) \times EF_{CO2,NG}, \quad \text{(D.1-2)}$$

where $FC^{old}_{NG,ATPP,PJ,y}$ is the consumption of natural gas in the old section of ATPP under the project during the year *y*, GJ;

$FC^{CCP}_{NG,ATPP,PJ,y}$ is the consumption of natural gas in the CCP under the project during the year *y*, GJ;

$EF_{CO2,NG}$ is the CO_2 emission factor for natural gas, tCO_2/GJ. In accordance with the IPCC Guidelines [R3] $EF_{CO2,NG}$ = 0.0561 tCO_2/ GJ.

$$FC^{old}_{NG,ATPP,PJ,y} = FC^{old,\upsilon}_{NG,ATPP,PJ,y} \times NCV_{NG,y}, \tag{D.1-3}$$

where $FC^{old,\upsilon}_{NG,ATPP,PJ,y}$ is the volumetric consumption of natural gas in the old section of ATPP under the project during the year *y* (<u>this value is to be monitored</u>), thousand m^3. Data over the period from June 01, 2011 through December 31, 2011 are used for the year 2011[15];

$NCV_{NG,y}$ is the average net calorific value of natural gas combusted in ATPP during the year *y* (<u>this value is to be monitored</u>), GJ/thousand m^3. Data over the period from June 01, 2011 through December 31, 2011 are used for the year 2011.

$$FC^{CCP}_{NG,ATPP,PJ,y} = FC^{CCP,\upsilon}_{NG,ATPP,PJ,y} \times NCV_{NG,y}, \tag{D.1-4}$$

where $FC^{CCP,\upsilon}_{NG,ATPP,PJ,y}$ is the volumetric consumption of natural gas in the CCP under the project during the year *y* (<u>this value is to be monitored</u>), thousand m^3. Data over the period from June 01, 2011 through December 31, 2011 are used for the year 2011.

$$PE_{ACHPP-2,y} = \Delta FC_{NG,ACHPP-2,PJ,y} \times EF_{CO2,NG}, \tag{D.1-5}$$

where $\Delta FC_{NG,ACHPP-2,PJ,y}$ is the additional consumption of natural gas at ACHPP-2 under the project during the year *y*, GJ.

$$\Delta FC_{NG,ACHPP-2,PJ,y} = \left(\frac{\Delta HS_{ACHPP-2,PJ,y}}{\varepsilon_{he}} + 3.6 \times \frac{\Delta EG_{ACHPP-2,PJ,y}}{\eta_{em}} \right) \times \frac{1}{\varepsilon_{tr} \times \eta_{old\,gas\,boilers}}, \tag{D.1-6}$$

where $\eta_{old\,gas\,boilers}$ is the efficiency of old gas-fired boilers (at ATPP and ACHPP-2). In accordance with the recommendations [R4] the efficiency of old gas-fired boilers (over 10 years in service) is $\eta_{old\,gas\,boilers}$ = 0.87;

[15] That is data for seven full months of 2011 from the start of actual operation of CCP-110.

η_{em} is the electromechanical efficiency. In accordance with the recommendations [R12] η_{em} = 0.98;

ε_{tr} is the heat transportation (from boiler to turbine) factor. In accordance with the recommendations [R12] ε_{tr} = 0.98;

ε_{he} is the factor of heat losses in heat exchangers. In accordance with the recommendations [R12] ε_{he} = 0.99;

3.6 is the MW to GJ conversion factor.

$\Delta EG_{ACHPP-2,PJ,y}$ is the additional generation of electricity at ACHPP-2 as a result of the project during the year y, MWh.

$\Delta HS_{ACHPP-2,PJ,y}$ is the additional heat supply from ACHPP-2 as a result of the project during the year y, GJ;

$$\Delta EG_{ACHPP-2,PJ,y} = \Delta HS_{ACHPP-2,PJ,y} \times \chi_{ACHPP-2}, \quad \text{(D.1-7)}$$

where $\chi_{ACHPP-2}$ is the specific electricity generation based on heat supply at ACHPP-2, MWh/GJ. According to Section B.1 $\chi_{ACHPP-2}$ = 0.1366 MWh/GJ.

$$\Delta HS_{ACHPP-2,PJ,y} = HS_{PJ,y} - HS_{ATPP,PJ,y}, \quad \text{(D.1-8)}$$

where $HS_{PJ,y}$ is the total supply of heat under the project during the year y, GJ;

$HS_{ATPP,PJ,y}$ is the supply of heat from ATPP under the project during the year y, GJ.

$$HS_{ATPP,PJ,y} = HS^{old}_{ATPP,PJ,y} + HS^{CCP}_{ATPP,PJ,y}, \quad \text{(D.1-9)}$$

where $HS^{old}_{ATPP,PJ,y}$ is the supply of heat from the old section of ATPP under the project during the year y (this value is to be monitored), GJ. Data over the period from June 01, 2011 through December 31, 2011 are used for the year 2011;

$HS^{CCP}_{ATPP,PJ,y}$ is the supply of heat from the CCP under the project during the year y (this value is to be monitored), GJ. Data over the period from June 01, 2011 through December 31, 2011 are used for the year 2011.

$$HS_{PJ,y} = HS_{BL,y}, \quad \text{(D.1-10)}$$

where $HS_{BL,y}$ is the total heat supply under the baseline scenario during the year *y*, GJ.

$$HS_{BL,y} = HS_{ATTP,BL,y}, \quad \text{(D.1-11)}$$

where $HS_{ATTP,BL,y}$ is the supply of heat from ATPP under the baseline scenario during the year *y*, GJ.

$$HS_{ATTP,BL,y} = \frac{EG^{HC}_{ATPP,BL,y}}{\chi_{ATPP}}, \quad \text{(D.1-12)}$$

where χ_{ATPP} is the specific electricity generation based on heat supply at ATPP, MWh/GJ. According to Section B.1 χ_{ATPP} = 0.0895 MWh/GJ;

$EG^{HC}_{ATPP,BL,y}$ is the electricity generation at ATPP based on heating cycle under the baseline scenario during the year *y*, MWh.

For 2011:

$$EG^{HC}_{ATPP,BL,2011} = \frac{7}{12} EG^{HC}_{ATPP,2009}, \quad \text{(D.1-13)}$$

where $EG^{HC}_{ATPP,2009}$ is the actual annual electricity generation based on heating cycle in 2009, MWh. According to Section B.1 $EG^{HC}_{ATPP,2009}$ = 140 891 MWh;

7 is the number of full months of operation in 2011 from the start of actual operation of CCP-110;

12 is the total number of months in a year.

For 2012 (and subsequent years):

$$EG^{HC}_{ATPP,BL,2012} = EG^{HC}_{ATPP,2009}. \quad \text{(D.1-14)}$$

D.1.1.3. Relevant data necessary for determining the baseline of anthropogenic emissions of greenhouse gases by sources within the project boundary, and how such data will be collected and archived:								
ID number *(Please use numbers to ease cross-referencing to D.2.)*	Data variable	Source of data	Data unit	Measured (m), calculated (c), estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment
6. $ES^{old}_{ATPP,PJ,y}$	Supply of electricity from the old section of ATPP	Electric meter readings	MWh	m	Continuously	100%	Electronic and paper	-
7. $ES^{CCP}_{ATPP,PJ,y}$	Supply of electricity from the CCP	Electric meter readings	MWh	m	Continuously	100%	Electronic and paper	-

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

The baseline GHG emissions are determined by adding up emissions from fossil fuel (natural gas) combustion at ATPP for heat and electricity generation and CO_2 emissions due to combustion of fossil fuel for generation and supply to the grid of lacking (compared with the project) amount of electricity by the existing power plants and new power generating units of the IES South during the year *y*, tCO_2e:

$$BE_y = BE_{ATPP,y} + BE_{grid,y}, \tag{D.1-15}$$

where $BE_{ATPP,y}$ is the baseline emissions of CO_2 due to combustion of natural gas for generation (supply to the grid) of electricity and heat at ATPP during the year *y*, tCO_2e;

$BE_{grid,y}$ is the baseline emissions of CO_2 due to combustion of fossil fuel for generation (supply to the grid) of additional amount of electricity by power plants of the IES South during the year *y*, tCO_2e.

$$BE_{ATPP,y} = FC_{NG,ATTP,BL,y} \times EF_{CO2,NG}, \tag{D.1-16}$$

where $FC_{NG,ATTP,BL,y}$ is the baseline consumption of natural gas at ATPP during the year *y*, GJ.

$$FC_{NG,ATPP,BL,y} = \left(\frac{HS_{ATPP,BL,y}}{\varepsilon_{he}} + 3.6 \times \frac{EG^{HC}_{ATPP,BL,y}}{\eta_{em}} + 3.6 \times \frac{EG^{CC}_{ATPP,BL,y}}{\eta_{em} \times \eta_i^r} \right) \times \frac{1}{\varepsilon_{tr} \times \eta_{old\,gas boilers}}, \quad \text{(D.1-17)}$$

where η_i^r is the absolute internal efficiency of turbine units at ATPP in condensation mode with allowance for regeneration. According to the methodology given in [R13], η_i^r = 0.32422;

$EG^{CC}_{ATPP,BL,y}$ is the baseline electricity generation at ATPP in condensation cycle during the year *y*, MWh.

$$EG^{CC}_{ATPP,BL,y} = EG_{ATPP,BL,y} - EG^{HC}_{ATPP,BL,y}, \quad \text{(D.1-18)}$$

where $EG_{ATPP,BL,y}$ is the electricity generation at ATPP under the baseline scenario during the year *y*, MWh.

For the year 2011:

$$EG_{ATPP,BL,2011} = \frac{7}{12} EG_{ATPP,2008}, \quad \text{(D.1-19)}$$

where $EG_{ATPP,2008}$ is the actual annual generation of electricity at ATPP in 2008, MWh. According to Section B.1 $EG_{ATPP,2008}$ = 574 227 MWh.

For the year 2012 (and subsequent years):

$$EG_{ATPP,BL,2012} = EG_{ATPP,2008}. \quad \text{(D.1-20)}$$

$$BE_{grid,y} = \Delta ES_{grid,y} \times EF_{CO2,grid}, \quad \text{(D.1-21)}$$

where $\Delta ES_{grid,y}$ is the supply of additional (lacking compared with the project) amount of electricity to the grid by power plants of the IES South under the baseline scenario during the year *y*, MWh;

$EF_{CO2,grid}$ is the CO_2 emission factor for grid electricity, tCO_2/MWh. In accordance with the justification given in Annex 4 it is assumed to be constant over years and numerically equal to $EF_{CO2,grid,y}$ = 0.6745 tCO_2/MWh.

$$\Delta ES_{grid,BL,y} = ES_{PJ,y} - ES_{ATPP,BL,y}, \quad \text{(D.1-22)}$$

where $ES_{ATPP,BL,y}$ is the baseline supply of electricity from ATPP during the year y, MWh;

$ES_{PJ,y}$ is the total project supply of electricity during the year y, MWh.

$$ES_{ATPP,BL,y} = EG_{ATPP,BL,y} \times \left(1 - \varepsilon_{el}^{aux}\right), \quad \text{(D.1-23)}$$

where ε_{el}^{aux} is the specific consumption of electricity for auxiliary needs of the power plant (ATPP and ACHPP-2). According to Section B.1 ε_{el}^{aux} = 0.1.

$$ES_{PJ,y} = ES_{ATPP,PJ,y} + \Delta ES_{ACHPP-2,PJ,y}, \quad \text{(D.1-24)}$$

where $ES_{ATPP,PJ,y}$ is the project supply of electricity from ATPP during the year y, MWh;

$\Delta ES_{ACHPP-2,PJ,y}$ is the additional supply of electricity from ACHPP-2 as a result of the project during the year y, MWh.

$$ES_{ATPP,PJ,y} = ES_{ATPP,PJ,y}^{old} + ES_{ATPP,PJ,y}^{CCP}, \quad \text{(D.1-25)}$$

where $ES_{ATPP,PJ,y}^{old}$ is the project supply of electricity from the old section of ATPP during the year y (this value is to be monitored), MWh. Data over the period from June 01, 2011 through December 31, 2011 are used for the year 2011;

$ES_{ATPP,PJ,y}^{CCP}$ is the project supply of electricity from the CCP during the year y (this value is to be monitored), MWh. Data over the period from June 01, 2011 through December 31, 2011 are used for the year 2011.

$$\Delta ES_{ACHPP-2,PJ,y} = \left(1 - \varepsilon_{el}^{aux}\right) \times \Delta EG_{ACHPP-2,PJ,y}. \quad \text{(D.1-26)}$$

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

This option is not applicable

D.1.2.1. Data to be collected in order to monitor emission reductions from the project, and how these data will be archived:								
ID number *(Please use numbers to ease cross-referencing to D.2.)*	Data variable	Source of data	Data unit	Measured (m), calculated (c), estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment

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

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

As shown in Section B.1 leakages are considered to be zero.

D.1.3.1. If applicable, please describe the data and information that will be collected in order to monitor leakage effects of the project:								
ID number *(Please use numbers to ease cross-referencing to D.2.)*	Data variable	Source of data	Data unit	Measured (m), calculated (c), estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment

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

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

The GHG emission reductions during the year *y* are determined by subtracting project emissions from baseline emissions, tCO_2e:

$$ER_y = BE_y - PE_y, \quad \text{(D.1-27)}$$

where BE_y is the baseline emissions during the year y, tCO_2e;

PE_y is the project emissions during the year y, tCO_2e.

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

Industrial environmental control within LLC "LUKOIL-Astrakhanenergo" is carried out by the Industrial Safety, Health and Environment Department (ISH&ED), in subdivisions environmental control is performed by ISH&E Group.

The programme of industrial environmental monitoring currently implemented by Astrakhan TPP will not undergo any significantly changes after the project implementation and will be fulfilled according to the scheme and schedule approved by the interested authorities of Astrakhan Region.

Similarly to the way it is now, the monitoring will be performed by the ISH&E Group.

- Analytical control of compliance with the prescribed pollutant emission standards in accordance with the laboratory control charts;
- Monitoring of the impact of waste disposal sites on underground and surface waters, atmospheric air and soil;
- Control of pollution content in the atmospheric air on the border of the sanitary protection zone, etc.

The enterprise has the following reporting obligations as per official annual statistic forms:

- 2-tp (air) "Data on Atmospheric Air" containing information on the quantities of trapped and destroyed air pollutants, detailed emissions of specific pollutants, number of emission sources, emission reduction actions and emissions from separate groups of pollutant sources;
- 2-tp (water) "Data on Water Use", containing information on water consumption from natural sources, discharges of effluents and their pollutant content, capacity of wastewater treatment facilities, etc.;
- 2-tp (wastes) "Data on generation, utilization, destruction, transportation and disposal of production and consumption residues", containing an annual balance of wastes flows by their types and hazard classes.

In compliance with the Russian law, the company annually develops and implements environment protection measures.

Environment, occupational health and safety management systems that comply with international standards ISO 14001, OHSAS 18001 have been implemented and are constantly improved at the company.

D.2. Quality control (QC) and quality assurance (QA) procedures undertaken for data monitored:		
Data *(Indicate table and ID number)*	Uncertainty level of data (high/medium/low)	Explain QA/QC procedures planned for these data, or why such procedures are not necessary.
Table D.1.1.1 ID 1,2	Low	Volumetric consumption of natural gas is measured continuously by flow meters. Flow meters are checked regularly in compliance with the instrumentation and control verification schedule and procedure adopted by the company.
Table D.1.1.1 ID 3	Low	Calorific value of natural gas is determined by the fuel supplier's certified laboratories, the fuel certificates are submitted to the TPP on a monthly basis. At the end of the year an average value is calculated. Besides, a cross-check with the help of a calorimeter installed at the TPP is carried out. This calorimeter calculates the calorific value of gas on a real-time basis by measuring its composition.
Table D.1.1.3 ID 4,5	Low	Heat medium flow meters, temperature and pressure gauges are used for monitoring of heat supply from the CCP and the old section of TPP. Measuring devices are checked regularly in compliance with the instrumentation and control verification schedule and procedure adopted by the company. All current signals from the measuring devices are transmitted to the automatic control system where the heat supply is automatically calculated.
Table D.1.1.3 ID 6,7	Low	Electricity supply from the CCP and from the old section of TPP is measured continuously by electric meters. Electric meters are checked regularly in compliance with the instrumentation and control verification schedule and procedure adopted by the company.

Actions undertaken during calibration of measuring devices

The measuring devices are calibrated during the periods of scheduled shutdown of the equipment. If necessary the removed measuring device is replaced with a backup calibrated instrument. Operation of the equipment without instrumentation and control equipment is not allowed.

Monitoring procedure in case of emergency

In case of an emergency arising at the company and affecting the project monitoring system (breakdown of equipment, failure of measuring devices, etc.), the specialists of LLC "LUKOIL-Astrakhanenergo" and CCGS LLC shall analyze the situation, develop alternative monitoring and measuring procedures for the duration of such circumstances and suggest corrective actions for the equipment and/or monitoring plan.

Cross-check

The input data are reviewed by cross-checking various sources where such data are recorded.

The project monitoring reports are checked by the specialists of both LLC "LUKOIL-Astrakhanenergo" and CCGS LLC.

The primary review of monitoring reports is made by the Director of Energy and GHG Emissions Management Department of CCGS LLC or, on his instructions, by a specialist of the same Department who is not directly involved in preparation of this report.

Additional cross-check is made by the Director of the Project Development Department of CCGS LLC or, on his instructions, by another specialist of this Department.

As soon as all comments made by the Project Development Department are closed, the monitoring report is submitted for internal check out to the company that implements the project.

Internal check

Internal check by the company includes checking primary data provided to CCGS LLC during information collection period as well as checking the project monitoring reports.

Test verifications

Regularly, but not less than once per year, specialists of CCGS LLC shall carry out test verifications with a view to verifying the observance of the monitoring plan.

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

Information transfer

The initial request for input GHG emission reduction monitoring data is made by the Director of Energy and GHG Emissions Management Department of CCGS LLC to the Deputy Chief Engineer for Operations at LLC "LUKOIL-Astrakhanenergo", the latter in turn gives instructions to collect the requested data to the Head of Planning and Technical Department (PTD) of LLC "LUKOIL-Astrakhanenergo". The company has a working group responsible for collection, checkout and transfer of monitoring data. The responsibility of these persons is stipulated in corresponding orders.

The information collected at the enterprise is transferred to the Deputy Chief Engineer for Operations at LLC “LUKOIL-Astrakhanenergo”, the latter in turn transfers it further to the Director of Energy and GHG Emissions Management Department of CCGS LLC. All information is transferred via email.

Based on the received data, the Energy and GHG Emissions Management Department of CCGS LLC prepares a project monitoring report and submits it for additional cross-check to the Project Development Department of CCGS LLC. As soon as all comments made by the Project Development Department have been accommodated, the project monitoring report is transferred to the company where the project is implemented.

At CCGS LLC the procedures for checking the project monitoring reports are laid out in the “CCGS LLC’s internal regulation on the procedure for quality control of the project documentation and monitoring reports developed for GHG emission reduction projects”.

After checking and making required corrections to the report, the Director of Energy and GHG Emissions Management Department at CCGS LLC shall inform the Deputy Chief Engineer for Operations of LLC “LUKOIL-Astrakhanenergo” about the preliminary results of monitoring and if there are no objections on his part, the Director General of CCGS LLC shall make a final decision to submit the project monitoring report for verification by an accredited independent entity.

Registration and collection of monitoring data

The information required for calculation of GHG emission reductions is collected in accordance with the procedures for resources monitoring and accounting adopted at the company.

Location of monitoring points is shown in Fig. D.3-1.

The procedure for collection and transfer of information that is required by the monitoring plan is shown in Fig.3-2

The procedures for input data registration and storage, as well as persons responsible for monitoring are specified in Table D.3-1.

GHG emission reductions are calculated in the end of each reporting period by the specialists of CCGS LLC.

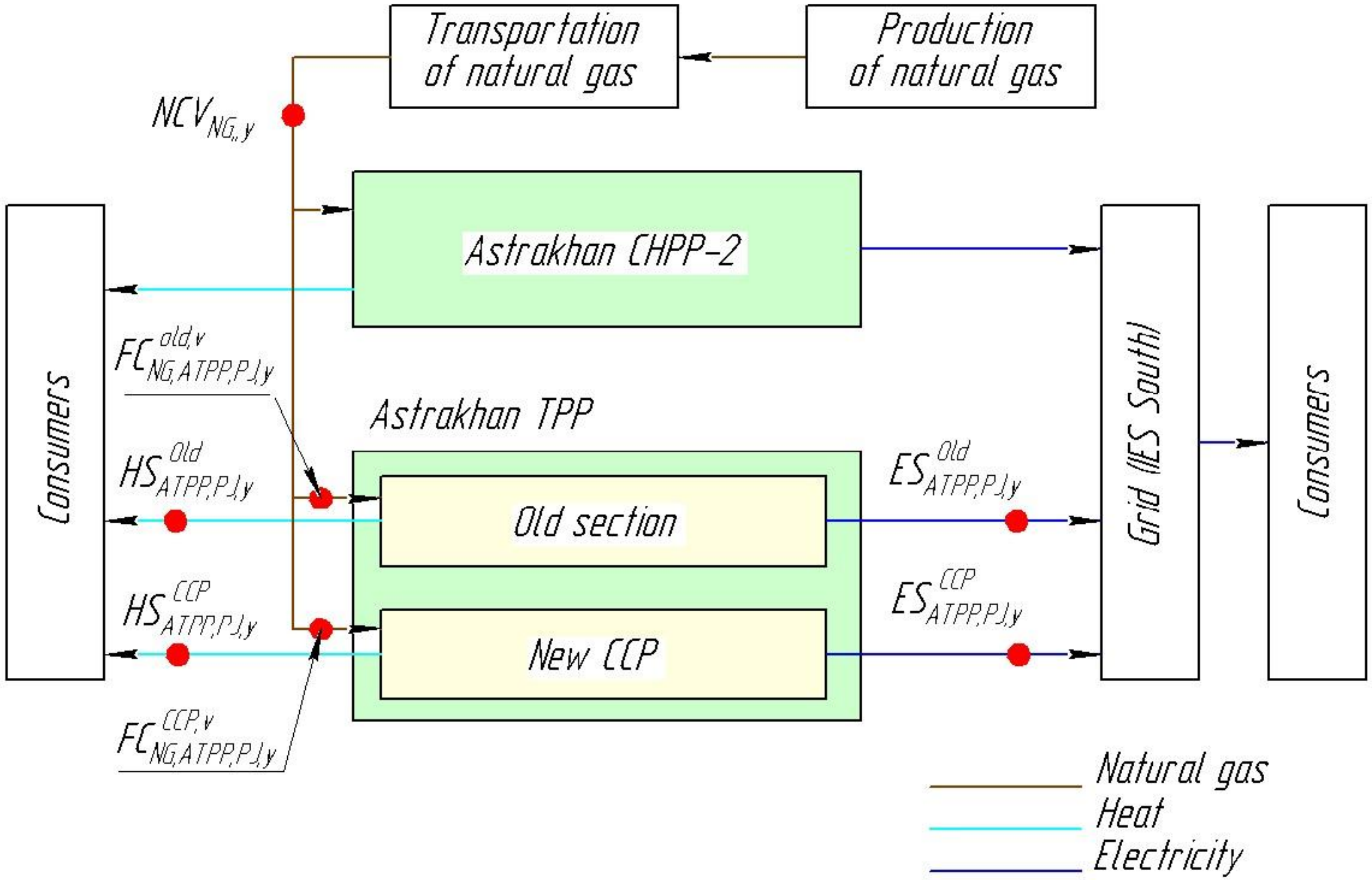

Fig. D.3-1. Location of monitoring points

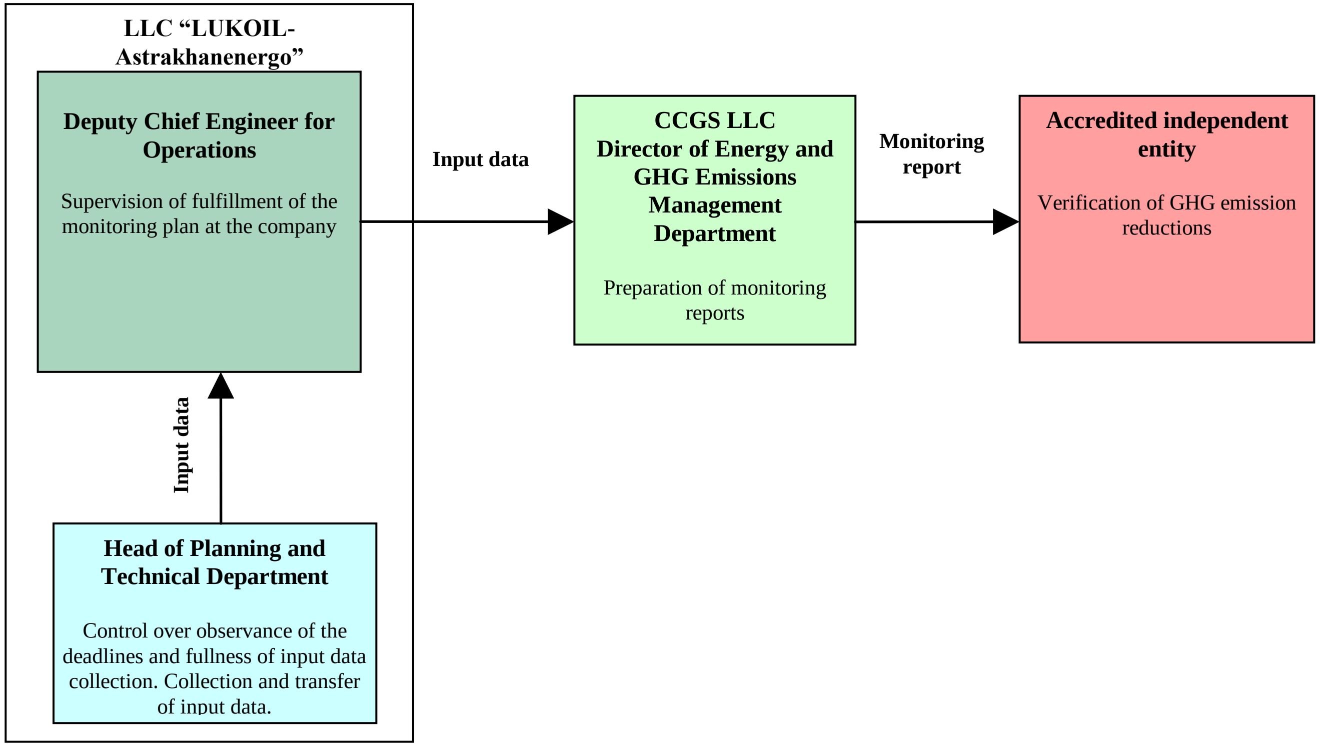

Fig. D.3-2. Monitoring information collection and transfer structure

Table D.3-1. Monitoring procedure

Monitored parameter	Procedures for registration, monitoring, accounting/record and storage of data (including everyday monitoring)	Person responsible for monitoring
Heat supply from the CCP and the old section of ATPP	1. Sensors and transmitters that continuously measure flow, temperature and pressure of heat medium are used for monitoring of heat supply. 2. Readings of the measuring devices are recorded in the automatic control system and are displayed on all computers which have relevant software. Data are printed on paper and are stored in the computer memory. 3. Data are recorded by the operators on a daily basis in daily records and logs and are then summarized in monthly and annual reports. 4. Heat supply data shall be archived at the TPP electronically and in hard copy and shall be kept for at least 2 years after the end of the crediting period or the last issue of ERUs.	Head of PTD
Electricity supply from the CCP and the old section of ATPP	1. The amount of electricity supplied from the CCP and the old section of ATPP is measured continuously by electric meters. 2. Readings of the measuring devices are recorded in the automatic control system and are displayed on all computers which have relevant software. Data are printed on paper and are stored in the computer memory. 3. Data are recorded by the operators on a daily basis in daily records and logs and are then summarized in monthly and annual reports. 4. Electricity supply data shall be archived at the TPP electronically and in hard copy and shall be kept for at least 2 years after the end of the crediting period or the last issue of ERUs.	Head of PTD
Volumetric consumption of natural gas at the CCP and in the old section of ATPP	1. Sensors and transmitters that continuously measure flow, temperature and pressure are used for monitoring of natural gas consumption volume. 2. Readings of the measuring devices are recorded in the automatic control system and are displayed on all computers which have relevant software. Data are printed on paper and are stored in the computer memory. 3. Data are recorded by the operators on a daily basis in daily records and logs and are then summarized in monthly and annual reports.	Head of PTD

	4. Natural gas consumption data shall be archived at the TPP electronically and in hard copy and shall be kept for at least 2 years after the end of the crediting period or the last issue of ERUs.	
Average net calorific value of natural gas combusted at ATPP	1. Natural gas calorific value is determined by certified laboratories of fuel suppliers, the fuel certificates are submitted to the TPP by gas suppliers on a monthly basis. Besides, a cross-check is made with the help of a calorimeter installed at the TPP. The calorimeter calculates calorific value of natural gas on a real-time basis by measuring its componential composition. 2. Calorific value data are recorded in logs and are entered into the electronic data base. In the end of each year an average calorific value is calculated. 3. Calorific value data shall be archived at the TPP electronically and in hard copy and shall be kept for at least 2 years after the end of the crediting period or the last issue of ERUs.	Head of PTD

The monitoring system complies with the requirements of the following state laws and rules:

- Federal Law No.102-FZ “On measurements uniformity assurance” dated 26.06.2008;

-“Rules for electricity metering” dated September 26, 1996;

- RD 34.09.102 “Rules for heat metering” dated 31.08.1995.

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

The monitoring plan was developed by CCGS LLC (CCGS LLC is not a project participant and is not listed in Annex 1 of this PDD).

Contact person: Dmitry Potashev

E-mail: d.potashev@ccgs.ru

SECTION E. Estimation of greenhouse gas emission reductions

Emission reductions were estimated using the formulae in accordance with the methodology described in detail in Section B.1. In the same section and also in Annex 2 all necessary input data are given in a tabular form. Below are the results of the emissions estimation for both scenarios with a breakdown by sources covering the period from 2008 to 2012.

E.1. Estimated project emissions:

Table E.1-1. Project emissions, tCO_2e

Parameter	2011	2012	2008-2012
GHG emissions, total	**258 859**	**443 758**	**702 617**
CO_2 from natural gas combustion for heat and electricity generation at ATPP	218 726	374 959	593 685
CO_2 from natural gas combustion for additional generation of heat and electricity at ACHPP-2	40 133	68 799	108 932

E.2. Estimated leakage:

Leakages are assumed to be zero

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

Since leakages are zero then: E.1 + E.2 = E.1.

E.4. Estimated baseline emissions:

Table E.4-1. Baseline emissions, tCO_2e

Parameter	2011	2012	2008-2012
GHG emissions, total	**444 310**	**761 674**	**1 205 984**
CO_2 from natural gas combustion for heat and electricity generation at ATPP	269 348	461 739	731 086
CO_2 from fossil fuel combustion for generation (supply to the grid) of additional power by power plants of the IES South	174 963	299 936	474 898

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

Table E.5-1. Emission reductions, tCO_2e

Parameter	2011	2012	2008-2012
Emission reductions, total	**185 451**	**317 916**	**503 367**

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

Year	Estimated project emissions (tonnes of CO_2 equivalent)	Estimated leakage (tonnes of CO_2 equivalent)	Estimated baseline emissions (tonnes of CO_2 equivalent)	Estimated emission reductions (tonnes of CO_2 equivalent)
2011	258 859	0	444 310	185 451
2012	443 758	0	761 674	317 916
Total (tonnes of CO_2e)	**702 617**	**0**	**1 205 984**	**503 367**

SECTION F. Environmental impacts

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

Enhancement of efficiency and increase in the amount of heat and electricity generated due to construction of the CCP at Astrakhan TPP leads to displacement of the respective amount of electricity generated at less efficient power generating capacities of ATPP and at thermal power plants of the Integrated Energy System of the South (IES South), and therefore, on the regional level, all of this causes reduction in pollutant and greenhouse gas emissions.

The environmental impact of the CCP was assessed in accordance with the requirements of the Russian legislation and is laid out in the design documentation [R9].

Impact upon atmospheric air

The main sources of pollutant emissions during operation will be combustors of the two gas-turbine units of the CCP where the following harmful pollutants are produced: nitrogen oxides (NO, NO_2) carbon oxide (CO) and sulphur oxide (SO_2). The sources of pollutant emissions are two individual flue stacks of heat recovery boilers of gas turbine units.

Besides, pollutants from auxiliary facilities will be also released into the atmosphere. Additional sources of pollution are: a start-up boiler house, gas supply network, oil system (consisting of an oil facility for handling, treatment and dehydration and feeding of oil to the storage tank and to the CCP, an outdoor storage of oil in cylindrical metallic horizontal reservoirs and tanks for oil-contaminated discharge).

Pollutants are removed from the oil facility via individual airlines to the atmosphere. The sources of pollutant emission from the outdoor oil storage are the oil reservoir tubes. The sources of pollutant emissions from the gas supply networks are gas line pipes.

The expected gross pollutant emissions from the main equipment during operation of the CCP are shown in Table F.1-1.

Table F.1-1. Expected gross pollutant emissions from main equipment during operation of the CCP

Pollutant	**Gross emission, t/y**		**Maximum emission, g/s**	
	From one GTU	From two GTUs	From one GTU	From two GTUs
Sulfurous anhydride	4.145	8.290	0.131	0.263
Carbon oxide	257.576	515.152	8.174	16.348
Nitrogen dioxide	152.306	304.612	4.833	9.667
Nitrogen oxide	24.750	49.499	0.785	1.571
Total:	438.777	877.554	13.925	27.849

The emission dispersion modeling shows that the estimated maximum ground-level concentration of nitrogen dioxide is 0.09 MPC (maximum permissible concentration) which does not exceed 0.1 MPC set for residential area and is reached at a distance of 260 m from the boundary of the enterprise’s site. Maximum concentration of NO_2 with allowance for background concentration at the boundary of the enterprise’s sanitary protection zone will amount to 0.759 MPC for residential areas. The maximum ground level concentrations caused by emissions from the designed facility meet the sanitary and health standards of air quality both for industrial areas and residential areas.

Reconstruction of Astrakhan TPP through installation of CCP-110 will lead to reduction in gross pollutant emissions by 1.7. Emissions of nitrogen dioxide into atmosphere will decrease by 1.75.

Besides, one particular pollutant - mazut ash - will not be emitted into the atmosphere, because as soon as the CCP is commissioned, liquid fuel (heavy fuel oil) will be no longer used.

From what has been said it follows that the technical solutions applied for the ATPP reconstruction project help to improve the environment at the construction site due to reduction of pollutant emissions.

Impact upon surface and ground waters

Upon commissioning of CCP-110, the existing generating equipment of Astrakhan TPP shall be decommissioned. Therefore effluents are displaced. The quality and quantity of effluents generated due to construction of the CCP are comparable with the displaced (existing) effluents.

As a result of the project solutions no sewerage is discharged to surface water bodies.

The quantity and composition of effluents generated as a result of the CCP-110 operation are specified below:

- storm water runoff - around 1600 m^3/year;
- domestic sewerage - 8.12 m^3/h (20.23 m^3/day);
- oil-contaminated discharge - not more than 2 t/year;
- saline discharge, total - 59.2 m^3/h.

Environmental monitoring

Pollution control (air, water resources) shall be continued to be performed by the company in accordance with the schedule approved by the Chief Engineer and agreed with the supervising authorities.

Environmental consequences of the project implementation

The most significant environmental effect of the project implementation is the improvement of the environment in Astrakhan due to pollutant emission reduction (compared with the baseline scenario).

No less important is the reduction in fossil fuel consumption and the corresponding reduction in greenhouse gas emissions to the atmosphere, which will contribute to the fulfillment by the Russian Federation of its commitments to enhance energy efficiency and cut greenhouse gas (CO_2) emissions. GHG emission reductions due to the project are estimated at around 318 thousand tCO_2e per year.

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

The project meets the environmental requirements set by the Russian law and does not have any significant impact upon the environment. The design documentation for “Reconstruction of Astrakhan TPP through construction of CCP-110MW” project complies with the requirements of the regulatory technical documents, the compliance is confirmed by the positive review of the state expert committee:

- Opinion on the project “Reconstruction of Astrakhan TPP through construction of CCP-110MW”. The Main Department of the State Expert Committee FSI “GLAVGOSEKSPERTIZA ROSSIYI”, No. 00-1-4-4990-09 dated 18.12.2009.

Besides, on the regional level the project leads to reduction in pollutant emissions, fossil fuel consumption and greenhouse gas emissions.

SECTION G. Stakeholders' comments

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

Comments on the project were received, basically, from the local and federal government authorities in the form of positive reviews of state expert committee and project implementation permits. These documents confirm that the project meets the requirements of technical regulations, industrial safety standards, environmental and health requirements.

The public hearings were not held since it was not necessary within the framework of this project.

The project measures were widely covered by the mass media. Only positive feedback was received.

Annex 1

CONTACT INFORMATION ON PROJECT PARTICIPANTS

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Annex 2

BASELINE INFORMATION

Parameter	Unit	Value
Heat transportation (from boiler to turbine) factor	-	0,98
Factor of heat losses in heat exchangers		0,99
Electromechanical efficiency	-	0,98
Efficiency of boiler units	-	0,87
Specific generation of electricity based on heat supply at ATPP	MWh/GJ	0,0895
Specific generation of electricity based on heat supply at ACHPP-2	MWh/GJ	0,1366
Specific electricity consumption for auxiliary needs	-	0,1
Internal absolute efficiency of turbine units at ATPP in condensation mode with allowance for regeneration	-	0,32422
CO2 emission factor for natural gas	kgCO2/GJ	56,1
CO2 emission factor for grid electricity	tCO2/MWh	0,6745

Parameter	Unit	Value over the period		
		2011	2012	2011-2012
Project scenario				
Supply of electricity generated at the CCP	MWh	511 268	876 460	1 387 728
Supply of electricity generated in the old section of ATPP	MWh	0	0	0
Electricity supply from ATPP	MWh	511 268	876 460	1 387 728
Additional electricity generation at ACHPP-2	MWh	55 108	94 470	149 578
Additional electricity supply from ACHPP-2	MWh	49 597	85 023	134 620
Total electricity supply	**MWh**	**560 865**	**961 483**	**1 522 348**
Supply of heat produced at the CCP	GJ	514 861	882 620	1 397 481
Supply of heat produced in the old section of ATPP	GJ	0	0	0
Heat supply from ATPP	GJ	514 861	882 620	1 397 481
Additional heat supply from ACHP-2	GJ	403 423	691 582	1 095 004
Total heat supply	**GJ**	**918 284**	**1 574 201**	**2 492 485**
Specific consumption of equivalent fuel for electricity supply from the CCP	g e.f./kWh	222,9	222,9	222,9
Specific consumption of equivalent fuel for heat supply from the CCP	kg e.f./GJ	37,02	37,02	37,02
Consumption of natural gas in the CCP	GJ	3 898 861	6 683 763	10 582 624
Consumption of natural gas in the old section of ATPP	GJ	0	0	0
Consumption of natural gas at ATPP	GJ	3 898 861	6 683 763	10 582 624
Additional consumption of natural gas at ACHPP-2	GJ	715 380	1 226 366	1 941 747
Total consumption of natural gas	**GJ**	**4 614 242**	**7 910 129**	**12 524 371**
Emissions of CO_2 from ATPP	tCO_2	218 726	374 959	593 685
Emissions of CO_2 from ACHPP-2, related to additional generation of electricity and heat	tCO_2	40 133	68 799	108 932
Total emissions of CO_2	**tCO_2**	**258 859**	**443 758**	**702 617**
Baseline scenario				
Condensation cycle based electricity generation at ATPP	MWh	252 779	433 336	686 115
Heating cycle based electricity generation at ATPP	MWh	82 186	140 891	223 077
Total electricity generation at ATPP	**MWh**	**334 966**	**574 227**	**909 193**
Supply of electricity from ATPP	MWh	301 469	516 804	818 273
Additional supply of electricity to the grid from other power plants	MWh	259 396	444 679	704 075
Total supply of electricity	**MWh**	**560 865**	**961 483**	**1 522 348**
Supply of heat from ATPP	GJ	918 284	1 574 201	2 492 485
Total supply of heat	**GJ**	**918 284**	**1 574 201**	**2 492 485**
Consumption of natural gas at ATPP	GJ	4 801 203	8 230 634	13 031 838
Total consumption of natural gas	**GJ**	**4 801 203**	**8 230 634**	**13 031 838**
Emissions of CO_2 from ATPP	tCO_2	269 348	461 739	731 086
Emissions of CO_2, related to additional electricity supply to the grid from other power plants	tCO_2	174 963	299 936	474 898
Total emissions of CO_2	**tCO_2**	**444 310**	**761 674**	**1 205 984**
GHG emission reductions	**tCO_2**	**185 451**	**317 916**	**503 367**

Astrakhan TPP Performance Data for 2008-2010

Parameter	Units	Years		
		2008	2009	2010
Electricity generation	MWh	**574 227**	452 057	429 188
including:				
based on heating cycle	MWh	119 193	**140 891**	119 434
based on condensation cycle	MWh	455 034	311 166	309 754
Electricity consumption for auxiliary needs	MWh	57 348	51 122	49 170
Electricity supply	MWh	516 879	400 935	380 018
Heat supply	Gcal	436 262	401 650	357 232
including exhaust steam	Gcal	408 087	376 016	336 828
Fuel consumption	t e.f.	290 448	244 528	231 623
including:				
natural gas	t e.f.	289 299	244 251	231 590
heavy fuel oil	t e.f.	1 149	277	33
Proportion of electricity consumption for auxiliary needs of the plant	%	**10,0**	11,3	11,5
Specific electricity generation based on heat supply	MWh/GJ	0,0698	**0,0895**	0,0847

Astrakhan CHPP-2 Performance Data for 2008-2010

Parameter	Units	Years		
		2008	2009	2010
Electricity generation	MWh	2 363 783	2 098 115	2 135 135
including:				
heating cycle	MWh	859 083	830 673	703 476
condensation cycle	MWh	1 504 700	1 267 442	1 431 659
Electricity consumption for auxiliary needs	MWh	230 751	210 600	214 993
Electricity supply	MWh	2 133 032	1 887 515	1 920 142
Heat supply	Гкал	1 461 457	1 428 404	1 230 729
including exhaust steam	Gcal	1 461 457	1 428 404	1 230 325
Fuel consumption	t e.f.	969 424	871 210	887 256
including:				
natural gas	t e.f.	969 424	866 867	887 256
heavy fuel oil	t e.f.	0	4 343	0
Proportion of electricity consumption for auxiliary needs of the plant	%	9,8	10,0	10,1
Specific electricity generation based on heat supply	MWh/GJ	0,1404	0,1389	**0,1366**

Annex 3

MONITORING PLAN

See Section D

Annex 4

Calculation of emission factor for the IES South

See calculation in Excel file "EF_{grid} of the IES South".

Annex 5

LIST OF REFERENCES

[R1] Guidance on criteria for baseline setting and monitoring, Version 02, The Joint Implementation Supervisory Committee

(http://ji.unfccc.int/Ref/Documents/Baseline_setting_and_monitoring.pdf)

[R2] Projected balance of electric power sector development for the period 2009-2015 and for 2020. Energy Forecasting Agency. Moscow, 2009.

[R3] 2006 IPCC Guidelines on National Greenhouse Gas Inventories. Volume 2, Energy. (http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol2.htm)

[R4] Methodological tool to determine the baseline efficiency of thermal or electric energy generation systems. Version 01. CDM Executive Board

(http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-09-v1.pdf)

[R5] Certificate of compliance for the constructed site. Construction and Housing Supervision Service of Astrakhan Region. Approved by the resolution of the Head of the Service, No. 46/11-R dated June 10, 2011.

[R6] Report "Inventory of GHG emissions in 1990-2005 from OJSC "SGC TGC-8". Energy Carbon Fund. Moscow 2007.

[R7] Turnkey contract for works on the project "Reconstruction of Astrakhan TPP with installation of CCP-110MW", No.589 dated February 22, 2008.

[R8] Design documentation. "Reconstruction of Astrakhan TPP through construction of CCP-110MW". Section 1. Executive Summary. Volume 1. CJSC "Energokaskad", Moscow 2008.

[R9] Design documentation. "Reconstruction of Astrakhan TPP through construction of CCP-110MW". Section 8. List of Environment Protection Actions. Volume 3. CJSC "Energokaskad", Moscow 2008.

[R10] Positive review on the project "Reconstruction of Astrakhan TPP through construction of CCP-110MW". The Main Department of the State Expert Committee FSI "GLAVGOSEKSPERTIZA ROSSIYI", No. 00-1-4-4990-09 dated 18.12.2009.

[R11] Commissioning Permit for the CCP issued by Astrakhan City Administration, No. RU3030100-27 dated June 16, 2011.

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