CJSC Air Liquide Severstal

2008 - July 2012 Monitoring Report
Construction of a new Air Separation Plant by Air Liquide Severstal, Russia

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Construction of a new Air Separation Plant by Air Liquide Severstal, Russia

2012 MONITORING REPORT

Version 3, 27 September, 2012. Responsible for preparation and issuing - Bondarenko D.

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SECTION A General project activity information

A.1. Date and Version of Monitoring Report:

Project Title: "Construction of a new Air Separation Plant by Air Liquide Severstal, Russia"

This is version 3 of the Monitoring Report dated 27 September, 2012.

A.2. Key Documents:

Determination Report (Russia/0044-2/2010, v.2) by Bureau Veritas Certification issued on March 3, 2010.

Project Design Document, version 7, dated March 2, 2010

A.3. Short description of the project activity:

The company CJSC Air Liquide Severstal (ALS) commissioned, in December 2007, a state-of-the-art cryogenic air separation plant on the premises of the Severstal steel production complex in Cherepovets in the Vologda Region of Russia. The plant's purpose is to produce technical gases, especially high pressure oxygen and nitrogen, and deliver them to the steel plant. The facility has a maximum design capacity of 90,000 Sm^3/hr[1] of high pressure purified oxygen. It can also produce other gases, such as high-pressure nitrogen (30,000 Sm^3/hr), low-pressure nitrogen (30,000 Sm^3/hr) and argon (1,470 Sm^3/hr).

The key piece of equipment of the ALS facility is the cold box where the air separation takes place. The separated gases are liquefied, and the liquids are pumped to high pressure. Liquid oxygen and liquid nitrogen are pumped to a pressure of maximum 31 bar (30.6 atm), while Argon is pumped to a pressure of maximum 17 bar (16.8 atm). The project also includes the installation of three new air compressors, two of which are main air compressors that supplement the compressed air that ALS purchases, and one is a booster air compressor that recompresses the compressed air to a higher pressure.

A.4. Project approval by the parties:

The Decree of Ministry of Economic Development of the Russian Federation № 277 dtd. 16th May 2012 "About approving the list of projects, realizing in accordance with clause 6 of Kyoto Protocol to the United Nations Framework Convention on Climate Change"

Declaration of Approval of NL Agency Ministry of Economic Affairs, Agriculture and Innovation dtd 02 Feb 2012.

A.5. Monitoring period:

• Monitoring period starting date: January 1, 2008

1 All gas volumes are presented in Sm^3, i.e. under standard conditions of 20°C and 760 mmHg.

• Monitoring period closing date: July 31, 2012

A.6. Monitoring data:

Estimation of project emissions is provided with the next data:

- Project Design Document, version 7, dated March 2, 2010
- Monthly invoices for consumption of electricity, compressed air and steam sent by OAO Severstal and own monthly primary data on delivery of oxygen and nitrogen (Annex 3 of Monitoring Report)

2008 data was not finalized at the moment of PDD edition, 2008 monitoring data doesn't exceed the 2% materiality value of emission reductions in comparison with PDD data, hereinafter PDD 2008 annual values are used as more conservative.

A.7. Calibration of the measuring equipment:

Calibrations were provided by accredited organisation (ФБУ "Череповецкий ЦСМ"). Since 2012 there is a direct contract between ALS and ФБУ "Череповецкий ЦСМ", 2008-2011 was provided through an intermediary of STEK LLC.

SECTION B Key monitoring activities according to the monitoring plan

The Monitoring Plan detailed in section D of the PDD requires the measurement of six variables.

B.1. Electricity consumption by ALS plant ($EC_{ALS, y}$):

Electricity consumption (in MWh) is measured by the monthly invoices sent by OAO Severstal (Severstal). The invoices are based on the official electricity meter (manufacturer Energomera, model C6850, location GPP14), which is located on the Severstal premises.

For cross-checking purposes ALS has a meter (Model SEPAM, location RP113/RP114) on its premises. Monthly meter readings are taking by the subcontractor STEK and entered into an EXCEL spreadsheet, which is kept on the ALS server.

* 2008 annual value adjusted according to Section A.6. of Monitoring Report.

	$EC_{ALS, y}$, MWh				
Month	**2008**	**2009**	**2010**	**2011**	**2012**
January	33,493	21,760	33,309.6	22,599	32,496
February	31,608	26,886	30,694.4	28,782	30,914
March	33,86	30,194	33,357.2	31,531	31,295
April	29,111	29,618	30,420.4	31,252	26,807
May	33,964	20,967	33,458.8	32,190	26,533
June	32,127	29,067	31,045.1	31,828	30,469
July	33,354	32,190	28,808.6	32,781	32,601
August	31,71	33,416	32,840.4	30,313	-
September	29,864	32,322	31,886.4	30,031	-
October	32,579	33,748	32,094.2	32,977	-
November	27,262	31,628	31,754.8	30,475	-
December	23,615	33,187	33,409.6	33,065	-
Total	**372,655***	**354,982**	**383,080**	**367,822**	**211,115**

B.2. Consumption of compressed air by ALS plant ($Q_{AIR, ALS, y}$):

Compressed air consumption (in 1000 Sm^3) is measured by the monthly invoices sent by Severstal. The invoices are based on meter readings from a Deltafluid flow meter, which is located on ALS premises. It is an EMERSON-ROSEMOUNT Model3051 meter and wears the tag FI030. ALS Instrumentation Operators are preparing a monthly report on the meter readings. The reports are reviewed and signed by the Plant Manager.

* 2008 annual value adjusted according to Section A.6. of Monitoring Report.

	$Q_{AIR, ALS, y}$, 1000 Sm^3				
Month	**2008**	**2009**	**2010**	**2011**	**2012**
January	56,222	114,145	46,681	13,269	39,845
February	48,348	31,010	54,422	18,632	45,245
March	49,962	17,400	53,576	11,595	23,395
April	29,554	6,148	42,417	34,990	31,176
May	60,703	4,286	55,469	34,309	39,845
June	57,619	41,875	19,248	51,133	32,385
July	94,577	35,788	73,586	57,543	42,277
August	68,906	54,612	58,847	94,994	-
September	38,685	54,672	34,283	64,867	-
October	25,045	69,176	37,991	59,318	-
November	0,016	42,834	42,344	35,561	-
December	56,967	46,089	58,488	49,472	-
Total	**586,605***	**518,035**	**577,352**	**525,683**	**254,168**

B.3. Steam consumption by ALS plant ($Q_{ST, y}$):

Steam consumption (in Gcal) is measured by the monthly invoices sent by Severstal. The invoices are based on meter readings from the "Logika" heat meter, model CTP 961. The meter is located on Severstal premises. ALS may request a control of it at any moment if there is doubt about the accuracy of the measurement.

* 2008 annual value adjusted according to Section A.6. of Monitoring Report.

	$Q_{ST, y}$, Gcal				
Month	**2008**	**2009**	**2010**	**2011**	**2012**
January	1,549	959	1,502	1,152	1,104
February	1,161	692	1,687	1,034	0,746
March	1,286	1,070	1,757	0,831	0,768
April	0,97	735	1,719	0,991	0,743
May	1,493	2,242	1,748	1,027	0,787
June	1,308	755	739	1,588	0,750
July	1,465	1,016	2,139	1,479	-
August	1,601	1,100	1,156	1,097	-
September	1,144	1,311	1,204	1,043	-
October	1,144	1,993	1,225	1,374	-
November	0,907	1,227	1,117	0,898	-
December	2,348	1,194	1,959	1,072	-
Total	**16,376***	**14,294**	**17,952**	**13,584**	**4,899**

B.4. Delivery of high-pressure oxygen from ALS cold box ($P_{GOX, y}$):

Oxygen delivery from the ALS cold box (in 1000 Sm^3 O_2) is measured by the meter readings from a Deltafluid flow meter. The commercial counter is an EMERSON-ROSEMOUNT Model3051 meter and wears the tag FI001. In addition there is a process meter with the tag FI1510.

For cross-checking purposes, ALS Instrumentation Operators are preparing a monthly report on the meter readings. The reports are reviewed and signed by the Plant Manager.

* 2008 annual value adjusted according to Section A.6. of Monitoring Report.

	$P_{GOX, y}$, 1000 Sm^3 O_2				
Month	**2008**	**2009**	**2010**	**2011**	**2012**
January	60,707	46,872	62,530	31,286	59,902
February	57,544	48,970	58,656	48,538	58,963
March	63,32	48,681	62,039	53,207	55,599
April	52,771	48,082	53,926	57,332	47,381
May	64,068	28,527	61,646	57,565	46,658
June	57,459	51,817	50,956	58,698	53,949
July	64,823	58,185	51,211	60,615	59,294
August	56,678	62,983	58,981	60,739	-
September	50,27	61,078	54,899	57,094	-
October	53,805	65,258	55,438	63,895	-
November	35,613	56,898	58,070	54,546	-
December	37,715	61,788	63,150	63,144	-
Total	**650,566***	**639,137**	**691,502**	**666,658**	**381,745**

B.5. Delivery of high pressure oxygen from ALS liquid oxygen storage tank ($P_{LOX, y}$):

Oxygen delivery from the LOX storage tank (in 1000 Sm^3 O_2) is measured by the meter readings from a Deltafluid flow meter. It is an EMERSON-ROSEMOUNT Model3051 meter and wears the tag FI002.

For cross-checking purposes, ALS Instrumentation Operators are preparing a monthly report on the meter readings. The reports are reviewed and signed by the Plant Manager.

* 2008 annual value adjusted according to Section A.6. of Monitoring Report.

	$P_{LOX, y}$, 1000 Sm^3 O_2				
Month	**2008**	**2009**	**2010**	**2011**	**2012**
January	1,275	0,561	1,111	0,705	0,798
February	1,051	0,031	1,683	0,852	1,126
March	1,027	0,707	1,657	0,156	0,316
April	0,569	0,012	1,727	0,550	1,795
May	1,492	1,126	1,907	0,519	0,869

June	0,655	0,053	0,025	1,721	0,192
July	1,516	0,458	2,648	1,570	0,762
August	2,24	0,634	0,804	0,769	-
September	1,206	1,023	0,896	0,725	-
October	0,756	2,188	0,94	1,232	-
November	0,398	0,893	0,708	0,348	-
December	0,066	0,831	2,483	0,629	-
Total	**10,483***	**8,517**	**16,589**	**9,775**	**5,858**

B.6. Total delivery of high pressure gaseous nitrogen from ALS plant ($P_{GAN, y}$):

High-pressure Nitrogen delivery from the ALS cold box (in 1000 Sm^3 N_2) is measured by the meter readings from a Deltafluid flow meter. The commercial counter is an EMERSON-ROSEMOUNT Model3051 meter and wears the tag FI010. In addition there is a process meter with the tag FI1500.
For cross-checking purposes, ALS Instrumentation Operators are preparing a monthly report on the meter readings. The reports are reviewed and signed by the Plant Manager.

* 2008 annual value adjusted according to Section A.6. of Monitoring Report.

	$P_{GAN, y}$, 1000 Sm^3 N_2				
Month	**2008**	**2009**	**2010**	**2011**	**2012**
January	16,807	15,241	18,100	9,741	20,435
February	15,929	14,424	18,602	15,648	20,186
March	15,569	15,513	17,276	16,902	17,972
April	12,017	16,134	17,829	16,868	14,762
May	17,309	8,935	20,610	17,427	14,508
June	15,684	13,244	18,939	17,370	18,156
July	17,731	15,982	18,547	17,383	19,723
August	15,515	18,096	18,666	17,872	-
September	14,385	17,176	17,068	16,942	-
October	15,768	18,235	16,527	18,890	-
November	11,231	15,747	17,973	18,973	-
December	13,137	18,091	18,354	21,528	-
Total	**181,082***	**186,818**	**218,491**	**205,542**	**125,743**

B.7. Archiving of Monitoring Data

All of the above records are maintained both electronically and on paper. They will be archived until two years after the end of the crediting period.

(a) Electricity consumption by ALS plant ($EC_{ALS, y}$)
The ALS Accounting Department retains the original invoice. The Excel file that is maintained by the STEK employee and scanned copies of the invoices are retained electronically on the server.

(b) Consumption of compressed air by ALS plant ($Q_{AIR, ALS, y}$)

The ALS Accounting Department retains the original invoice and the reports signed by the ALS Plant Manager. The monthly reports prepared by the ALS Instrumentation Operator are retained electronically on the server.

(c) Steam consumption by ALS plant ($Q_{ST, y}$)
The ALS Accounting Department retains the original invoice.

(d) Delivery of high-pressure oxygen from ALS cold box ($P_{GOX, y}$)
The ALS Accounting Department retains the original invoice and the reports signed by the ALS Plant Manager. The reports prepared by ALS Instrumentation Operators are retained electronically on the server.

(e) Delivery of high pressure oxygen from ALS liquid oxygen storage tank ($P_{LOX, y}$)
The ALS Accounting Department retains the original invoice and the reports signed by the ALS Plant Manager. The reports prepared by ALS Instrumentation Operators are retained electronically on the server.

(f) Total delivery of high pressure gaseous nitrogen from ALS plant ($P_{GAN, y}$)
The ALS Accounting Department retains the original invoice and the reports signed by the ALS Plant Manager. The reports prepared by ALS Instrumentation Operators are retained electronically on the server.

B.8. Special event log

No special events affecting monitoring activities or monitored data occurred during 2008-July 2012.

SECTION C Quality assurance and quality control measures

Variable	QA/QC procedures
P1 $EC_{ALS, y}$	The meter is located on Severstal premises. Vologda Energo checks the meter once a year. ALS has a meter (Model SEPAM, location RP113/RP114) on its premises and is able to contest the power consumption figures if deviations are observed. Monthly meter readings are taking by the subcontractor STEK and entered into an EXCEL spreadsheet, which is kept on the server.
P3 $Q_{AIR, ALS, y}$	Calibration of the Deltafluid flow meter takes place at least every two years and was last done in May 2009. ALS Instrumentation Operators are preparing a monthly report on the meter readings. The calibration records are archived by the ALS Instrumentation Manager.
P5 $Q_{ST, y}$	The meter on which the invoice is based is located on Severstal premises. The Plant Manager is checking the steam volume for consistency before the invoice is paid.
B1 $P_{GOX, y}$	Calibration of the Deltafluid flow meter takes place at least every two years and was last done in May 2009. ALS Instrumentation Operators are preparing a monthly report on the meter readings. The calibration records are archived by the ALS Instrumentation Manager.
B2 $P_{LOX, y}$	Calibration of the Deltafluid flow meter takes place at least every two years and was last done in May 2009. ALS Instrumentation Operators are preparing a monthly report on the meter readings. The calibration records are archived by the ALS Instrumentation Manager.
B4 $P_{GAN, y}$	Calibration of the Deltafluid flow meter takes place at least every two years and was last done in May 2009. ALS Instrumentation Operators are preparing a monthly report on the meter readings. The calibration records are archived by the ALS Instrumentation Manager.

SECTION D

SECTION E

SECTION F Calculation of GHG emission reductions

F.1. Project emissions:

The Monitoring Plan in section D of the PDD contains six formulas to calculate the project emissions.

(1) $EF_{ELEC, y} = EF_{ELEC, GEN, y} / (1 - TL_{ELEC, y} / 100)$

Where

$EF_{ELEC, y}$ Carbon emission factor for consumption of grid-based electricity in year y
$EF_{ELEC, GEN, y}$ Carbon emission factor for generation of grid-based electricity in year y
$TL_{ELEC, y}$ Transmission losses for grid-based electricity in year y

Variable	Unit	2008	2009	2010	2011	2012	Source
$EF_{ELEC, GEN, y}$	t CO_2 / MWh	0,556	0,550	0,545	0,540	0,536	Section B.1 of PDD (B13)
$TL_{ELEC, y}$	%	9,400	8,793	8,308	7,823	7,338	Section B.1 of PDD (B14)
$EF_{ELEC, y}$	**t CO_2 / MWh**	**0,613**	**0,603**	**0,594**	**0,586**	**0,578**	**Calculated**

(2) $PE_{ELEC, y} = EC_{ALS,y} * EF_{ELEC, y}$

Where

$PE_{ELEC, y}$ Project emissions from electricity consumption by ALS plant in year y
$EC_{ALS,y}$ Electricity consumption by ALS plant in year y
$EF_{ELEC, y}$ Carbon emission factor for grid-based electricity in year y

Variable	Unit	2008	2009	2010	2011	2012	Source
$EF_{ELEC, y}$	t CO_2 / MWh	0,613	0,603	0,594	0,586	0,578	Equation (1)
$EC_{ALS,y}$	MWh	372,655	354,983	383,079	367,824	211,115	Section B.1 of this report
$PE_{ELEC, y}$	**t CO_2**	**228,488**	**213,999**	**227,730**	**215,616**	**122,024**	**Calculated**

(3) $EC_{AIR, y} = Q_{AIR, ALS, y} * SFC_{ELEC, AIR}$

Where

$EC_{AIR, y}$ Electricity consumption for compressed air consumed by ALS plant in year y
$Q_{AIR, ALS, y}$ Consumption of compressed air by ALS plant in year y
$SFC_{ELEC, AIR}$ Specific electricity consumption for compressed air

Variable	Unit	2008	2009	2010	2011	2012	Source
$Q_{AIR, ALS, y}$	1000 Sm^3	586,605	518,035	577,352	525,683	254,168	Section B.2 of this report
$SFC_{ELEC, AIR}$	MWh / 1000 Sm^3	0,1041	0,1041	0,1041	0,1041	0,1041	Section B.1 of the PDD (B7)
$EC_{AIR, y}$	**MWh**	**61,049**	**53,913**	**60,086**	**54,709**	**26,452**	**Calculated**

(4) $PE_{AIR, y} = EC_{AIR, y} * EF_{ELEC, y}$

Where

$PE_{AIR, y}$ Project emissions from consumption of compressed air by ALS plant in year y
$EC_{AIR, y}$ Electricity consumption for compressed air consumed by ALS plant in year y
$EF_{ELEC, y}$ Carbon emission factor for grid-based electricity in year y

Variable	Unit	2008	2009	2010	2011	2012	Source
$EC_{AIR, y}$	MWh	61,049	53,913	60,086	54,709	26,452	Equation (3)
$EF_{ELEC, y}$	t CO_2 / MWh	0,613	0,603	0,594	0,586	0,578	Equation (1)
$PE_{AIR, y}$	**t CO_2**	**37,431**	**32,501**	**35,720**	**32,070**	**15,289**	**Calculated**

(5) $PE_{ST, y} = Q_{ST, y} * EF_{GAS, ST}$

Where

$PE_{ST, y}$ Project emissions from consumption of steam by ALS plant in year y
$Q_{ST, y}$ Steam consumption by ALS plant in year y
$EF_{GAS, ST}$ Carbon emission factor for steam generated by natural gas combustion

Variable	Unit	2008	2009	2010	2011	2012	Source
$Q_{ST, y}$	Gcal	16,376	14,294	17,952	13,586	4,898	Section B.3 of this report
$EF_{GAS, ST}$	t CO_2 / Gcal	0,1243	0,1243	0,1243	0,1243	0,1243	Section B.1 of the PDD (B11)
$PE_{ST, y}$	t CO_2	**2,036**	**1,777**	**2,231**	**1,689**	**0,609**	**Calculated**

(6) $PE_y = PE_{ELEC, y} + PE_{AIR, y} + PE_{ST, y}$

Where

PE_y Total Project Emissions in year y
$PE_{ELEC, y}$ Project emissions from electricity consumption by ALS plant in year y
$PE_{AIR, y}$ Project emissions from consumption of compressed air by ALS plant in year y
$PE_{ST, y}$ Project emissions from consumption of steam by ALS plant in year y

Variable	Unit	2008	2009	2010	2011	2012	Source
$PE_{ELEC, y}$	t CO_2	228,488	213,999	227,730	215,616	122,024	Equation (2)
$PE_{AIR, y}$	t CO_2	37,431	32,501	35,720	32,070	15,289	Equation (4)
$PE_{ST, y}$	t CO_2	2,036	1,777	2,231	1,689	0,609	Equation (5)
PE_y	**t CO_2**	**267,955**	**248,277**	**265,681**	**249,374**	**137,922**	**Calculated**

F.2. Baseline emissions:

The Monitoring Plan in section D of the PDD contains eight formulas to calculate the baseline emissions.

(7) $EF_{ELEC, y} = EF_{ELEC, GEN, y} / (1 - TL_{ELEC, y} / 100)$

Where

$EF_{ELEC, y}$ Carbon emission factor for consumption of grid-based electricity in year y
$EF_{ELEC, GEN, y}$ Carbon emission factor for generation of grid-based electricity in year y
$TL_{ELEC, y}$ Transmission losses for grid-based electricity in year y

Variable	Unit	2008	2009	2010	2011	2012	Source
$EF_{ELEC, GEN, y}$	t CO_2 / MWh	0,556	0,550	0,545	0,540	0,536	Section B.1 of PDD (B13)
$TL_{ELEC, y}$	%	9,400	8,793	8,308	7,823	7,338	Section B.1 of PDD (B14)
$EF_{ELEC, y}$	**t CO_2 / MWh**	**0,613**	**0.603**	**0.594**	**0,586**	**0,578**	**Calculated**

(8) $P_{OX, y} = P_{GOX, y} + P_{LOX, y}$

Where

$P_{OX, y}$ Total delivery of high pressure oxygen from ALS plant in year y
$P_{GOX, y}$ Delivery of high-pressure oxygen from ALS cold box in year y
$P_{LOX, y}$ Delivery of high pressure oxygen from ALS liquid oxygen storage tank in year y

Variable	Unit	2008	2009	2010	2011	2012	Source
$P_{GOX, y}$	1000 Sm^3	650,564	639,139	691,502	666,659	381,746	Section B.4 of this report
$P_{LOX, y}$	1000 Sm^3	10,483	8,517	16,589	9,776	5,858	Section B.5 of this

							report
$P_{OX,y}$	**1000 Sm^3**	**661,047**	**647,656**	**708,091**	**676,435**	**387,604**	**Calculated**

(9) $BE_{ELEC,y} = P_{OX,y} * SFC_{ELEC} * EF_{ELEC,y}$

Where

$BE_{ELEC,y}$ Baseline emissions from electricity consumption in reference facility in year y
$P_{OX,y}$ Total delivery of high pressure oxygen from ALS plant in year y
SFC_{ELEC} Specific electricity consumption of the reference plant
$EF_{ELEC,y}$ Carbon emission factor for grid-based electricity in year y

Variable	Unit	2008	2009	2010	2011	2012	Source
$P_{OX,y}$	1000 Sm^3	661,047	647,656	708,091	676,435	387,604	Equation (8)
SFC_{ELEC}	MWh / 1000 Sm^3	0,0269	0,0269	0,0269	0,0269	0,0269	Section B.1 of the PDD (B8)
$EF_{ELEC,y}$	t CO_2 / MWh	0,613	0,603	0,594	0,586	0,578	Equation (1)
$BE_{ELEC,y}$	**t CO_2**	**10,903**	**10,503**	**11,323**	**10,666**	**6,027**	**Calculated**

(10) $BE_{AIR,y} = P_{OX,y} * SC_{AIR} * SFC_{ELEC,AIR} * EF_{ELEC,y}$

Where

$BE_{AIR,y}$ Baseline emissions from consumption of compressed air in reference facility in year y
$P_{OX,y}$ Total delivery of high pressure oxygen from ALS plant in year y
SC_{AIR} Specific compressed air consumption of the reference plant
$SFC_{ELEC,AIR}$ Specific electricity consumption for compressed air
$EF_{ELEC,y}$ Carbon emission factor for grid-based electricity in year y

Variable	Unit	2008	2009	2010	2011	2012	Source
$P_{OX,y}$	1000 Sm^3	661,047	647,656	708,091	676,435	387,604	Equation (8)
SC_{AIR}	1000 Sm^3 Air / 1000 Sm^3 O_2	6,3187	6,3187	6,3187	6,3187	6,3187	Section B.1 of the PDD
$SFC_{ELEC,AIR}$	MWh / 1000 Sm^3	0,1041	0,1041	0,1041	0,1041	0,1041	Section B.1 of the PDD

							(B7)
$EF_{ELEC, y}$	t CO_2 / MWh	0,613	0,603	0,594	0,586	0,578	Equation (1)
$BE_{AIR, y}$	**t CO_2**	**266,534**	**256,751**	**276,813**	**260,754**	**147,326**	**Calculated**

(11) $BE_{ST, y} = P_{OX, y} * SC_{ST} * EF_{GAS, ST}$

Where

$BE_{ST, y}$ Baseline emissions from steam consumption in reference facility year y
$P_{OX, y}$ Total delivery of high pressure oxygen from ALS plant in year y
SC_{ST} Specific steam consumption by reference plant
$EF_{GAS, ST}$ Carbon emission factor for steam generated by natural gas combustion

Variable	Unit	2008	2009	2010	2011	2012	Source
$P_{OX, y}$	1000 Sm^3	661,047	647,656	708,091	676,435	387,604	Equation (8)
SC_{ST}	Gcal / 1000 Sm3 O2	0,060	0,060	0,060	0,060	0,060	Section B.1 of the PDD (B5)
$EF_{GAS, ST}$	t CO_2 / Gcal	0,124	0,124	0,124	0,124	0,124	Section B.1 of the PDD (B11)
$BE_{ST, y}$	**t CO_2**	**4,930**	**4,830**	**5,281**	**5,045**	**2,891**	**Calculated**

(12) $BE_{HPGOX, y} = P_{OX, y} * SFC_{ELEC, HPGOX} * EF_{ELEC, y}$

Where

$BE_{HPGOX, y}$ Baseline emissions from electricity consumption by oxygen compressors in year y
$P_{OX, y}$ Total delivery of high pressure oxygen from ALS plant in year y
$SFC_{ELEC, HPGOX}$ Specific electricity consumption by oxygen compressors
$EF_{ELEC, y}$ Carbon emission factor for grid-based electricity in year y

Variable	Unit	2008	2009	2010	2011	2012	Source
$P_{OX, y}$	1000 Sm^3	661,047	647,654	708,091	676,433	387,603	Equation (8)
$SFC_{ELEC, HPGOX}$	MWh / 1000 Sm3 O2	0,1941	0,1941	0,1941	0,1941	0,1941	Section B.1 of the PDD (B10)
$EF_{ELEC, y}$	t CO_2 / MWh	0,613	0,603	0,594	0,586	0,578	Equation (1)
$BE_{HPGOX, y}$	**t CO_2**	**78,663**	**75,775**	**81,696**	**76,956**	**43,480**	**Calculated**

(13) $BE_{HPGAN, y} = P_{GAN, y} * SFC_{ELEC, HPGAN} * EF_{ELEC, y}$

Where

$BE_{HPGAN, y}$ Baseline emissions from electricity consumption by nitrogen compressors in year y
$P_{GAN, y}$ Total delivery of high pressure gaseous nitrogen from ALS plant in year y
$SFC_{ELEC, HPGAN}$ Specific electricity consumption by nitrogen compressors
$EF_{ELEC, y}$ Carbon emission factor for grid-based electricity in year y

Variable	Unit	2008	2009	2010	2011	2012	Source
$P_{GAN, y}$	1000 Sm^3	181,082	186,818	218,491	205,544	125,742	Section B.6 of this report
$SFC_{ELEC, HPGAN}$	MWh / 1000 Sm3 N2	0,1941	0,1941	0,1941	0,1941	0,1941	Section B.1 of the PDD (B10)
$EF_{ELEC, y}$	t CO_2 / MWh	0,613	0,603	0,594	0,586	0,578	Equation (1)
$BE_{HPGAN, y}$	**t CO_2**	**21,548**	**21,858**	**25,208**	**23,379**	**14,107**	**Calculated**

(14) $BE_y = BE_{ELEC, y} + BE_{AIR, y} + BE_{ST, y} + BE_{HPGOX, y} + BE_{HPGAN, y}$

Where

BE_y Total baseline emissions in year y
$BE_{ELEC, y}$ Baseline emissions from electricity consumption in reference facility in year y
$BE_{AIR, y}$ Baseline emissions from consumption of compressed air in reference facility in year y
$BE_{ST, y}$ Baseline emissions from steam consumption in reference facility year y
$BE_{HPGOX, y}$ Baseline emissions from electricity consumption by oxygen compressors in year y
$BE_{HPGAN, y}$ Baseline emissions from electricity consumption by nitrogen compressors in year y

Variable	Unit	2008	2009	2010	2011	2012	Source
$BE_{ELEC, y}$	t CO_2	10,903	10,503	11,323	10,666	6,027	Equation (9)
$BE_{AIR, y}$	t CO_2	266,534	256,751	276,813	260,754	147,326	Equation (10)
$BE_{ST, y}$	t CO_2	4,930	4,830	5,281	5,045	2,891	Equation (11)
$BE_{HPGOX, y}$	t CO_2	78,663	75,775	81,696	76,956	43,480	Equation (12)
$BE_{HPGAN, y}$	t CO_2	21,548	21,858	25,208	23,379	14,107	Equation (13)

BE_y	**t CO_2**	**382,578**	**369,717**	**400,321**	**376,800**	**213,831**	**Calculated**

F.3. Leakage:

No leakage has been identified within the project.

Variable	Unit	2008	2009	2010	2011	2012	Source
LE_y	t CO_2	0	0	0	0	0	Section D.1.3 of the PDD

F.4. Summary of the emissions reductions during the monitoring period:

(15) $ER_y = BE_y – PE_y – LE_y$

where

ER_y Emission reduction in year y

BE_y Total Baseline Emissions in year y

PE_y Total Project Emissions in year y

LE_y Leakage Emissions in year y, with $LE_y = 0$ for all years.

Variable	Unit	2008	2009	2010	2011	2012	Source
BE_y	t CO_2	382,578	369,717	400,321	376,800	213,831	Equation (14)
PE_y	t CO_2	267,955	248,277	265,681	249,374	137,922	Equation (6)
LE_y	t CO_2	0	0	0	0	0	Section D.1.3 of the PDD
ER_y	**t CO_2**	**114,623**	**121,440**	**134,640**	**127,426**	**75,909**	**Calculated**

Total values for the Verification period:

Baseline emissions (BE): 1743,247 t CO_2

Project emissions (PE): 1169,209 t CO_2

Emission reductions (ER): 574,038 t CO_2

F.5. Emissions reductions during the monitoring period by source:

Variable	Unit	2008	2009	2010	2011	2012
Baseline Emissions	t CO_2	**382,578**	**369,717**	**400,321**	**376,800**	**213,831**
Consumption of grid-based electricity for compressed air provided to the low-pressure air separation units (SB1)	t CO_2	266,534	256,751	276,813	260,754	147,326
Consumption of grid-based electricity by the low pressure air separation units (SB2)	t CO_2	10,903	10,503	11,323	10,666	6,027
Fuel combustion for the production of steam provided to the low-pressure air separation units (SB3)	t CO_2	4,930	4,830	5,281	5,045	2,891
Consumption of grid-based electricity by the oxygen compressors (SB4)	t CO_2	78,663	75,775	81,696	76,956	43,480
Consumption of grid-based electricity by the nitrogen compressors (SB5)	t CO_2	21,548	21,858	25,208	23,379	14,107
Project Emissions	t CO_2	**267,955**	**248,277**	**265,681**	**249,374**	**137,922**
Consumption of grid-based electricity by air compressors for compressed air provided to the ALS plant (SP1)	t CO_2	228,488	213,999	227,730	215,616	122,024
Consumption of grid-based electricity by ALS plant (SP2)	t CO_2	37,431	32,501	35,720	32,070	15,289
Fuel combustion by steam boiler for the production of steam provided to the ALS plant (SP3)	t CO_2	2,036	1,777	2,231	1,689	0,609
Leakage Emissions	t CO_2	**0**	**0**	**0**	**0**	**0**
Emission Reductions	t CO_2	**114,623**	**121,440**	**134,640**	**127,426**	**75,909**

SECTION G Overview Table

Variable	Description	Units	2008	2009	2010	2011	2012
$EC_{ALS, y}$	Total electricity consumption by ALS plant	MWh	372,655	354,983	383,079	367,824	211,115
$SFC_{ELEC, AIR}$	Specific electricity consumption for compressed air	MWh / 1000 Sm^3	0,1041	0,1041	0,1041	0,1041	0,1041
$Q_{AIR, ALS, y}$	Total consumption of compressed air by ALS plant	1000 Sm^3	586,605	518,035	577,352	525,683	254,168
$EC_{AIR, y}$	Total electricity consumption for compressed air consumed by ALS plant	MWh	61,049	53,913	60,086	54,709	26,452
$Q_{ST, y}$	Total steam consumption by ALS plant	Gcal	16,376	14,294	17,952	13,586	4,898
$EF_{GAS, ST}$	Carbon emission factor for steam generated by natural gas combustion	t CO_2 / Gcal	0,1243	0,1243	0,1243	0,1243	0,1243
$EF_{ELEC, y}$	Carbon emission factor for grid-based electricity	t CO_2 / MWh	0,613	0,603	0,594	0,586	0,578
$PE_{ST, y}$	CO2 emissions from consumption of steam by ALS plant	t CO_2	2,036	1,777	2,231	1,689	0,609
$PE_{AIR, y}$	CO2 emissions from consumption of	t CO_2	37,431	32,501	35,720	32,070	15,289

	compressed air by ALS plant						
$PE_{ELEC, y}$	CO2 emissions from electricity consumption by ALS plant	t CO_2	228,488	213,999	227,730	215,616	122,024
PE_y	**Total Project Emissions**	**t CO_2**	**267,955**	**248,277**	**265,681**	**249,374**	**137,922**
$P_{GOX, y}$	Total high-pressure gaseous oxygen delivery by ALS plant	1000 Sm^3	650,564	639,139	691,502	666,659	381,746
$P_{LOX, y}$	Total deliver of high pressure oxygen from ALS liquid oxygen storage tank	1000 Sm^3	10,483	8,517	16,589	9,776	5,858
$P_{OX, y}$	Total delivery of high pressure oxygen	1000 Sm^3	661,047	647,656	708,091	676,435	387,604
$P_{GAN, y}$	Total high-pressure nitrogen production by ALS plant	1000 Sm^3	181,082	186,818	218,491	205,544	125,742
SC_{ST}	Specific steam consumption by reference plant	Gcal / 1000 Sm^3 O_2	0,0600	0,0600	0,0600	0,0600	0,0600
SC_{AIR}	Specific compressed air consumption of the reference plant	1000 Sm^3 Air / 1000 Sm^3 O_2	6,3187	6,3187	6,3187	6,3187	6,3187
$SFC_{ELEC, AIR}$	Specific electricity consumption for compressed	MWh / 1000 Sm^3 Air	0,1041	0,1041	0,1041	0,1041	0,1041

	air						
SFC_{ELEC}	Specific electricity consumption of the cold box of the reference plant	MWh / 1000 Sm^3 O_2	0,0269	0,0269	0,0269	0,0269	0,0269
$SFC_{ELEC, HPGOX}$	Specific electricity consumption by oxygen compressors	MWh / 1000 Sm^3 O_2	0,1941	0,1941	0,1941	0,1941	0,1941
$SFC_{ELEC, HPGAN}$	Specific electricity consumption by nitrogen compressors	MWh / 1000 Sm^3 N_2	0,1941	0,1941	0,1941	0,1941	0,1941
$EF_{GAS, ST}$	Carbon emission factor for steam generated by natural gas combustion	t CO_2 / Gcal	0,1243	0,1243	0,1243	0,1243	0,1243
$EF_{ELEC, y}$	Carbon emission factor for the consumption of grid-based electricity	t CO_2 / MWh	0,613	0.603	0.594	0,586	0,578
$EF_{ELEC, GEN, y}$	Carbon emission factor for the generation of grid-based electricity	t CO_2 / MWh	0,556	0,550	0,545	0,540	0,536
$TL_{ELEC, y}$	Transmission losses for grid-based electricity	%	9,400	8,793	8,308	7,823	7,338
$BE_{ST, y}$	CO2 emissions from steam consumption by reference plant	t CO_2	4,930	4,830	5,281	5,045	2,891
$BE_{AIR, y}$	CO2 emissions from consumption of	t CO_2	266,534	256,751	276,813	260,754	147,326

	compressed air by reference plant						
$BE_{ELEC, y}$	CO2 emissions from electricity consumption by reference plant	t CO_2	10,903	10,503	11,323	10,666	6,027
$BE_{HPGOX, y}$	CO2 emissions from electricity consumption by oxygen compressors	t CO_2	78,663	75,775	81,696	76,956	43,480
$BE_{HPGAN, y}$	CO2 emissions from electricity consumption by nitrogen compressors	t CO_2	21,548	21,858	25,208	23,379	14,107
BE_y	**Total baseline emissions**	**t CO_2**	**382,578**	**369,717**	**400,321**	**376,800**	**213,831**
ER_y	**Emission Reductions**	**t CO_2**	**114,623**	**121,440**	**134,640**	**127,426**	**75,909**

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