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:

Evaporation System Modernization at OJSC "Ilim Group" Branch in Koryazhma

Sectoral Scope: Manufacturing industries (4)

Version: 1.2

Date: 13 May 2009

A.2. Description of the project:

The project is implemented on the site of OJSC "Ilim Group" Branch in Koryazhma (the former OJSC "Kotlas Pulp and Paper Mill"), Arkhangelsk Region, Russia.

The project is aimed at modernization of the Mill's evaporation system, which is intended to reduce power consumption of the pulp production process, stabilize operation of the process equipment, mitigate negative environmental impacts and reduce greenhouse gases (GHG) emissions.

The pulp cooking process produces large quantities of spent liquor which contains wood dissolution products. Liquor is fed to the evaporator plant designed to remove excess water from spent liquor and to bring its concentration to at least 50% of dry matter, so that minerals could be further recovered and useful energy could be generated by firing liquor in liquor recovery boilers. Liquor evaporation process has very high requirements of steam, electricity and water and yields large quantities of contaminated condensate and malodorous gases.

Before the project implementation liquor had been evaporated by six evaporator plants characterized by low efficiency and lack of operation consistency. Average specific steam consumption was high; condensate and warm water were discharged into the sewerage system without recycling; harmful gases were emitted into the atmosphere. Significant proportion of liquors had to be evaporated at the plants which were not fitted with concentrators (designed to increase dry matter content up to 65%). Therefore liquor recovery boilers had high losses caused by water evaporation from the liquor during combustion. Deficient operation of the evaporation system resulted in lower level of liquor separation in the pulp washing process; thus a significant part of liquor solids was irretrievably lost. Another negative side effect was the high demand of chemicals for pulping.

However the old evaporation equipment, provided that relatively inexpensive routine maintenance was carried out in good time, could have continued its operation at the previous production level without violating any Russian standards at least up until 2012.

This project envisages construction of a new high-technology evaporator plant manufactured by "Andritz" with the evaporating capacity of 600 tonnes per hour and decommissioning of the two old "Ramen" evaporator plants with the design capacity of 140 tonnes per hour, each.

The new evaporator unit, for the first time in Russia, uses a process flow scheme which provides for separation of condensates into relatively clean and highly contaminated streams and has an in-built stripping column for treatment of highly contaminated condensates. The scheme also envisages a system for collection and efficient utilization of sulfur-containing malodorous vapour gas emissions and methanol fraction in a special utilizing boiler with further desulfurization of gaseous emissions. Cooling water is not contaminated in the plant's process flow scheme.

The implementation of the project resulted in:

- Reduction of energy intensity of production and stable operation of technological equipment of all evaporator plants and other technological units aligned with it (washing installations, recovery boilers);
- Increase of the rate of liquor separation at pulp washing;

- Increase of heat and electricity supply from the Mill's energy technological heat and power station (ETHPS) through combustion of more liquor in the liquor recovery boilers and through increase of liquor calorific value;
- Utilization of methanol fraction and malodorous gases (which have been earlier released into the atmosphere) ensuring additional production of heat;
- Re-use of warm water, relatively clean and treated condensate streams from the new evaporator plant in the process flows, which leads to reduction of fresh water consumption for process needs and to reduction of heat consumption for water heating;
- Reduction of fossil fuel consumption (natural gas) at the Mill's CHPP-1;
- Reduction of chemicals consumption for pulp production;
- Mitigation of adverse environmental impacts; and
- Average reduction of GHG emissions by 175 988 tonnes of CO_2e/year over the period 2008-2012.

The path from the project idea to its actual implementation was a long and uphill one for the enterprise. Prior to the project start its value had been estimated at USD 21.6 million. Without soft crediting the project would not be viable in terms of financial resources availability. And without extra revenues from sale of GHG emission reductions the project could not be efficient enough in terms of financial return. Therefore from the start the company's management had undertaken measures to mobilize funds from these sources.

On October 24, 2002 Kotlas Pulp and Paper Mill submitted an application for a Subloan to the Executive Directorate of the National Pollution Abatement Facility (NPAF) for financing of the investment project "Pollution Abatement at OJSC "Kotlas Pulp and Paper Mill" through Replacement of Evaporator Plant". On January 15, 2003 the project was approved by the NPAF Supervisory Board. It is important to note that in terms of global environmental effects the planned complex of technical measures was categorized as a project aimed at reduction of GHG emissions and complying with the objective of the developed countries and countries with transition economy to meet their commitments as to reducing their GHG emissions in compliance with the Kyoto Protocol to the UN Framework Convention on Climate Change. On April 23, 2003 the International Bank of Reconstruction and Development (IBRD) granted its "no objections" visa.

The loan in the amount of USD 11 million did not become available until a notification thereof was received from the Russian Ministry of Finance on April 23, 2004. The contract for procurement of evaporator plant was concluded on January 11, 2005 (this date is considered to be the actual project starting date), construction and installation works began in March 2005. The equipment was mounted in full and put into test operation on 20.12.2007. Eventually, the actual project investments turned out to be almost twice as much as the estimated amount totaling to USD 40.6 million (of which the company's internal resources account for 72.9%).

In 2003, in parallel with the execution of documents for obtaining the soft credit, Kotlas PPM sent a tender bid under the Emission Reduction Unit Procurement Tender (ERUPT) programme implemented by SENTER Agency of the Netherlands Ministry of Economic Affairs. The project documentation was developed by OJSC "Krzizhanovsky Power Engineering Institute" (KPEI) and the ED of NPAF. The project qualified, but since there was no official approval by the Russian Government of Russia's participation in the ERUPT programme, the project had to be excluded from further consideration.

However, later on, after the Kyoto Protocol was ratified by the Russian Federation and entered into force, OJSC "Ilim Group" (Kotlas PPM has been a part of the Group since 2007) made a decision to develop the Evaporator System Modernization Project as a JI project seeking to sell future GHG emission reductions in the world carbon market. To this end in 2008 the company began cooperation with CCGS

Ltd., which acts as a consultant and a commercial agent of OJSC "Ilim Group". CCGS Ltd. is not a project participant.

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)
Party A: Russian Federation (Host Party)	Legal entity A1: Open Joint Stock Company "Ilim Group"	No
Party B: EC	Legal entity B1: To be determined within 12 months upon approval of the project by the Russian Government	No

OJSC "Ilim Group"

OJSC "Ilim Group" was incorporated on September 27, 2006 in Saint-Petersburg. In 2007 OJSC "Kotlas PPM", OJSC "Pulp and Paperboard Mill", OJSC "Bratskcomplexholding" and OJSC "Ust-Ilim Timber Industry Production Association" joined the Group through single share issue.

The strategic partner of OJSC "Ilim Group" is International Paper, a pulp and paper company.

The company is managed by an international Board of Directors.

The company's plant assets located in the Leningrad, Arkhangelsk and Irkutsk Regions are the largest enterprises of the Russian timber processing complex and account for 65% of Russia's overall market pulp production and for over 25% of cardboard production. The total annual production of pulp and paper by the company is over 2.5 million tonnes.

Koryazhma Branch

The Branch of OJSC "Ilim Group" in Koryazhma is the former OJSC "Kotlas Pulp and Paper Mill", located in the town of Koryazhma. The Mill is one of the largest wood chemical producers in Europe.

The first stage of the Mill was commissioned in 1961, the second – in 1965 and the third – in 1972. Currently the aggregate design capacity of Koryazhma Branch amounts to 938 000 tonnes of cooked pulp and 255 000 tonnes of cardboard per year. Due to the undertaken modernization, the enterprise's annual volume of pulping has been over 1 million tonnes since 2005.

The enterprise produces hardwood sulfate bleached pulp, viscose pulp, cardboard for flat layers of corrugated board (kraft liner), corrugating paper (fluting), offset paper for printing, products of wood chemical and biochemical processing. The Branch accounts for around 14% of Russia's commercial pulp production, for over 10% of all types of cardboard production and for over 6% of paper production. Over 35% of the enterprise's products are sold in the domestic market; the remaining amount is exported to Europe, Near East and Northern America.

The PPM consists of 6 production lines, 22 independent workshops and three power stations. Being the principal employer in Koryazhma, the Mill also supplies the town with electricity, heat, cold and hot water, as well as renders wastewater collection and treatment services.

Quality, environment and industrial safety management systems at Koryazhma Branch meet the international standards of ISO 9001, ISO 14001 and OHSAS 18001. The enterprise manufactures products certified to be in compliance with the requirements of the Forest Stewardship Council (FSC).

Fig. A.3-1. OJSC "Ilim Group" Branch in Koryazhma

A.4. Technical description of the project:

A.4.1. Location of the project:

A.4.1.1. Host Party(ies):

The Russian Federation

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

The Arkhangelsk Region

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

The Town of Koryazhma

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

The project was implemented on the site of OJSC "Ilim Group" Branch in Koryazhma, Arkhangelsk Region, Russia. The Mill is located on the bank of the Vychegda River within the city limits and covers the territory of 995.8 ha. The enterprise is connected to the Russian transport network by railway and motor roads. The distance from Koryazhma to Kotlas along the railway is 32 km, and to Arkhangelsk - 830 km.

Latitude: 61°18'. Longitude: 47°10'. Time zone GMT: +3:00

The Arkhangelsk Region is located in the north of the European part of Russia and is a constituent of the North-Western Federal District of the Russian Federation. The administrative center of the region is the city of Arkhangelsk.

Fig. A.4-1. The Arkhangelsk Region and the town of Koryazhma on the map of Russia

Fig. A.4-2. The town of Koryazhma on the map of the Arkhangelsk Region

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

General principles of pulp cooking and liquor recovery

Pulp cooking is the key process of pulp and paper production. Sorted pulp chips are fed for cooking to digesters along with the so-called "white liquor", a mixture of sodium hydroxide and sodium sulfide, which when heated causes wood lignin to degrade and unbleached pulp is produced. The chips are steamed and mixed with white liquor and then flow to the upper section of the digester. Cooking and diffusion washing of brown stock takes place when chips are moving downwards. From the lower section of the digester the pulp is fed for separation because it contains various impurities such as knurs and undercooked fiber. The separated liquid is called black liquor, it contains dissolved organic wood matter and mineral matter, such as different salts of sodium and sulfur. Black liquor is fed to the recovery system. The produced pulp is quite brown, therefore to achieve the required whiteness it is bleached.

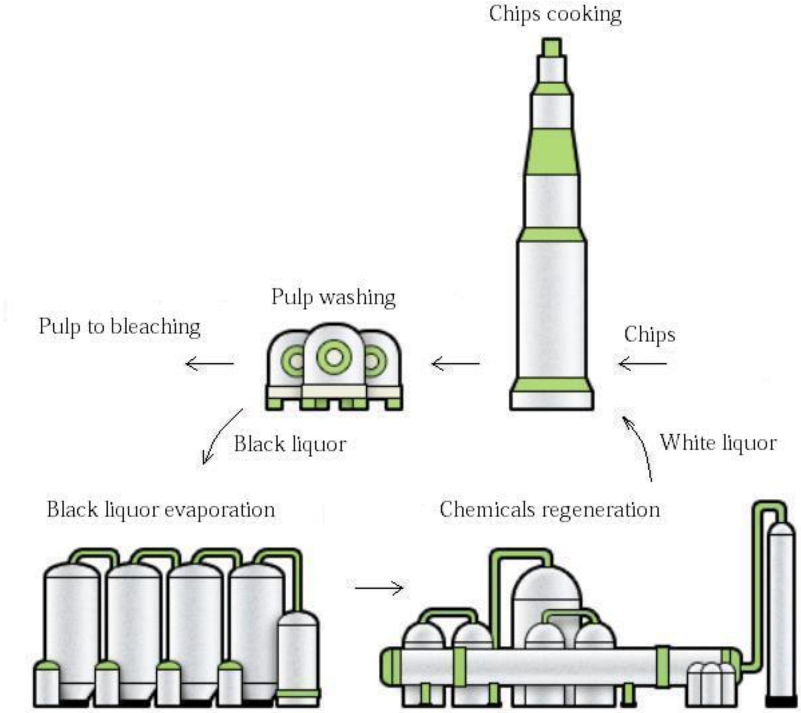

Fig. A.4-3. Key process stages

In order to make black liquor combustion possible it is necessary to remove excess water from the liquor. Therefore black liquor is fed to evaporators where excess water is evaporated. Evaporated black liquor is burnt in liquor recovery boilers, where its organic content burns up and its mineral content is reduced to sodium carbonate and sodium sulfide, the solution of which is known as green liquor. This liquor is fed to causticization room where it is mixed with slacked lime (calcium hydrate) and becomes white liquor. Calcium hydrate is produced in lime slackers by dissolving unslacked lime (calcium oxide) in water. The spent lime after causticization is recovered by burning it in rotating kilns. Lime losses are offset by means of limestone (calcium carbonate) being fed to the kiln.

Overview of the Mill's energy system

Heat and electricity needs of the Mill are met by its own combined heat and power plant (CHPP-1) and integrated energy technological heat and power station (ETHPS). The Mill is connected to the external power grid and supplies heat to consumers in Koryazhma.

The installed electric capacity of CHPP-1 amounts to 305 MW and its thermal capacity – to 984 MW. CHPP-1 is fitted with 12 steam boilers (boiler No.1 of TP-21 TKZ type, boilers No.No. 2 to 5 of BKZ-160-100F type and boilers No.No. 6 to 12 of BKZ-210-140 type). The principle fuel of CHPP-1 is natural gas. Only some boilers are running on coal in winter time. Seven turbine units are operated to generate electricity (No.No. 1 to 3 of VTP-25-4 type, No.4 of PT-60-90/13 type, No.No. 5 and 6 of PT-60-130/13 type and No.7 of R-50-130/13).

ETHPS consists of CHP-2, CHP-3 and a bark-fired boiler house connected by common steam lines. The installed electric capacity of ETHPS is 48 MW, its thermal capacity is 468 MW. ETHPS runs the total of 5 black liquor recovery boilers (three black liquor recovery boilers manufactured by "Tampella" and two by "Parsons&Whittemore") and 5 bark-fired boilers (two "Tampella-Carlson" bark-fired boilers and tree boilers of KM-75 BKZ type). Evaporated liquors and wood and bark wastes are the principle fuel used. The backup fuel for black liquor recovery boiler is heavy fuel oil and for bark-fired boilers – natural gas. Six turbine units are installed to generate electricity (No.1 of R-6-35/5 type, No.No.2 and 3 of R-12-35/5 type and No.No.4 to 6 of PR-6-35/15/5 type).

The existing fixed assets (buildings, facilities, main equipment) are in rather good technical condition.

Background for the project implementation

The pulp is cooked in the four pulp cooking workshops of the Mill at three production departments:

- CPP – cardboard and paper production which is responsible for cooking of softwood sulfate pulp (SAS-1 pulp cooking workshop) and neutral sulfite semi-chemical pulp (NSSP cooking workshop);
- SBPP – production of hardwood sulfate bleached pulp (SAS-2 cooking workshop);
- VPP – production of sulfite viscose pulp (SIS-1 pulp cooking workshop).

Before the project implementation the Mill had operated 6 evaporator plants:

Two "Ramen" evaporator plants, related to CHP-2 with the design evaporating capacity of 140 t/h each, are designed for evaporation of liquors from CPP: black liquor from softwood sulfate pulp cooking and red liquor from neutral sulfite semi-chemical pulp cooking are evaporated to 60% concentration (design). Each evaporator plant consists of six evaporating units. The evaporator plants were put into operation in 1964.

Operation of "Ramen" plants was characterized by high specific steam consumption. Condensate of moisture evaporated from liquors was not treated. The barometric condenser, in which condensate was mixed with cooling water, and also leaks in the heat exchangers caused water contamination. For this reason condensate and warm water from the evaporator plants were discharged into the Mill's production sewer system and further to the Mill's biological wastewater treatment plant.

Furthermore, due to rapid clogging of the evaporator plants the actual concentration of evaporated liquor stood at around 50%, and the evaporating capacity of the evaporator plants was as low as 100 t/h each. In 1995-1997 in order to increase liquor density CHP-2 was fitted with concentrators manufactured by "Ahlstrom" which made it possible to achieve liquor evaporation concentration of up to 65%.

However the insufficient actual output of "Ramen" plants remained a bottleneck. Therefore there was a problem with evaporation of standard volumes of liquor-containing waters from sulfate pulp washing, which resulted in high losses of black liquor solids. And red liquor had to be fed for evaporation to one of the evaporator plants of the sulfite production line, which impaired the stability of operation of all plants and associated equipment (washing installations, recovery boilers, etc.).

The schematic flow diagram of CHP-2 evaporator plants and associated equipment prior to the project implementation is shown in Annex 2.1.

"Parsons&Whittemore" evaporator plant, related to CHP-3 with the design evaporating capacity of 230 t/h, is designed for evaporation of black liquor from SBPP to 50-52% concentration. The plant consists of 7 evaporating units operating as per a six-stage scheme. The evaporator plant was put into operation in 1975 (upgraded in 2000). In the 1980-s in order to increase the black liquor density CHP-3 was fitted with a "Rosenlew" concentrator which allowed to achieve liquor evaporation concentration of up to 65%.

Two "UkrNIIHimMash" and one "Rosenblad" evaporator plants are designed for evaporation of sulfite liquors from VPP, as well as products of alcohol-yeast production. Because of insufficient capacity of the evaporator plants of CHP-2 and CHP-3, "UkrNIIHimMash" plant No.2 had to be operated to evaporate red liquor. Specific steam consumption of the plant is high, and with no concentrators the density of the red liquor at the outlet from the plant was low – around 50%.

Prior to the project implementation the evaporating system had, in general, low efficiency and insufficient stability, which had a negative impact upon energy, technological and environmental performance of the production on the whole:

- Average specific steam consumption for evaporation was high;
- Condensate and warm water from the evaporator plants were discharged into the sewer system without recycling, which increased the Mill's fresh water demand and heat requirements for fresh

water heating and, moreover, caused overload and lower operation efficiency of the biological wastewater treatment facility;

– Harmful substances from evaporation, including malodorous gases, were released into the atmosphere;
– Significant amount of liquors had a low concentration of dry matter after evaporation, which means that more heat was needed in black liquor recovery boilers to evaporate moisture from the liquors;
– Deficient operation of the evaporation system resulted in lower rate of liquor separation at pulp washing, therefore a significant quantity of liquor solids was irretrievably lost;
– Pulp cooking required higher amounts of chemicals.

These and other factors forced the enterprise to seek ways of modernizing its evaporation system.

The liquor streams flow chart prior to the project implementation is given in Fig. A.4-4. It is safe to consider that the project does not affect sulfite cooking and sulfite liquor recovery system, therefore only black and red liquor streams from SAS-1, SAS-2 and NSSP are regarded.

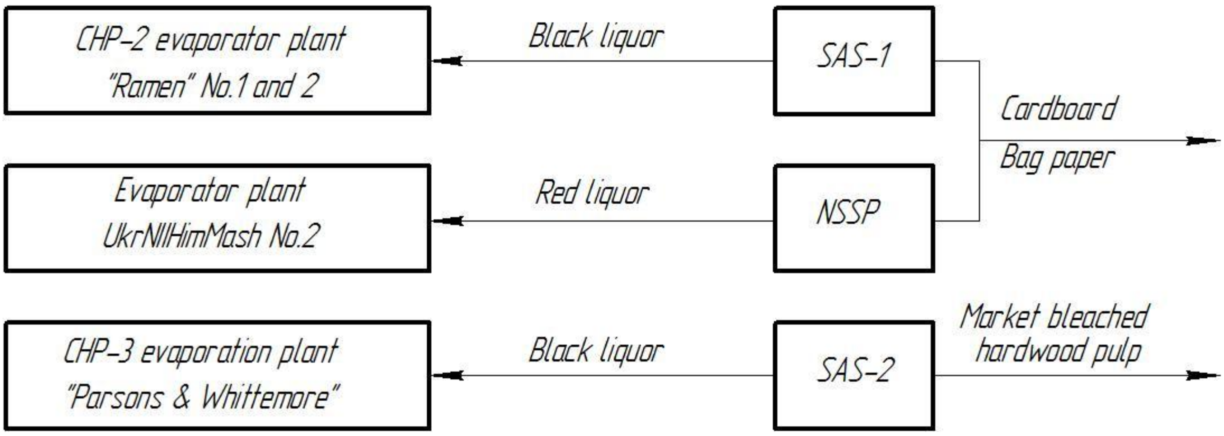

Fig. A.4-4. The liquor streams flow chart prior to the project implementation

<u>Description of the principle project solutions</u>

The principle solution for modernization of the evaporation system was to build a new high-technology evaporator plant manufactured by “Andritz” (Finland) with the evaporating capacity of 600 t/h, to install other auxiliary equipment and to decommission the two inefficient “Ramen” evaporator plants.

The process flows introduced under the project measure up to the world’s state-of-the-art level of technology development in this sector. All technological parameters meet environmental standards and requirements.

The contract for procurement of primary equipment was concluded in January 2005. Construction and assembly works began in March 2005. The equipment was mounted in full and put into test operation on 20.12.2007.

With the project implementation it became possible to reduce energy intensity of the production, redistribute liquor streams between the evaporator plants, stabilize operation of the technological equipment, increase black liquors separation level and to reduce fossil fuel consumption and GHG emissions.

The liquor streams flow chart after the project implementation is given in Fig. A.4-5. Now, the new evaporator plant of CHP-2 handles not only the entire quantity of black and red liquors from CPP, but also some proportion of black liquors from SBPP. Redistribution of the streams allowed to reduce the load on CHP-3 evaporator plant and to discontinue evaporation of red liquor in the evaporator plant of sulfite production.

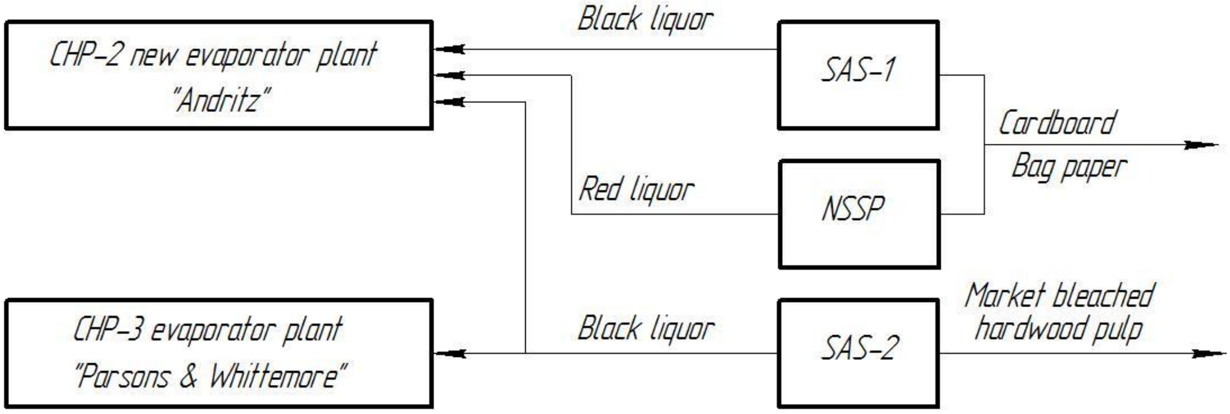

Fig. A.4-5. The liquor streams flow chart after the project implementation

The schematic diagram of the new evaporator plant and associated equipment after the project implementation is given in Annex 2.2.

The new evaporator plant is a single-line six-stage plant consisting of seven evaporating units operating as per a six-stage scheme and on the principle of falling film formed across heat exchange surfaces manufactured from "lamellar" packages. There is no barometric condenser. Highly contaminated condensates are treated in a stripping column. Design concentration of dry residue after the evaporator plant is 53%, further evaporation to 65% is achieved in the existing "Ahlstrom" concentrators. Evaporating capacity of the evaporator plant is 600t/h and it can be freely regulated within the range of 20÷100%. Quick start and shutdown of the units is ensured by presence of small quantities of liquor in the units.

Liquor stream (see Fig.A.4-6). Weak black liquor is fed to unit 4 where evaporation starts, then to units 5 and 6 after which it enters heat exchangers and then it is fed to a newly installed semi-dense liquor tank for settlement of sulfate soap. Separated from sulfate soap, black liquor goes successively to units 3, 2 and 1. Having passed the expansion tank, liquor is fed to the existing concentrators operating on the falling film principle. Strong liquor evaporated to concentration of 65% is pumped from the concentrator to the strong liquor accumulator and further for combustion to recovery boilers.

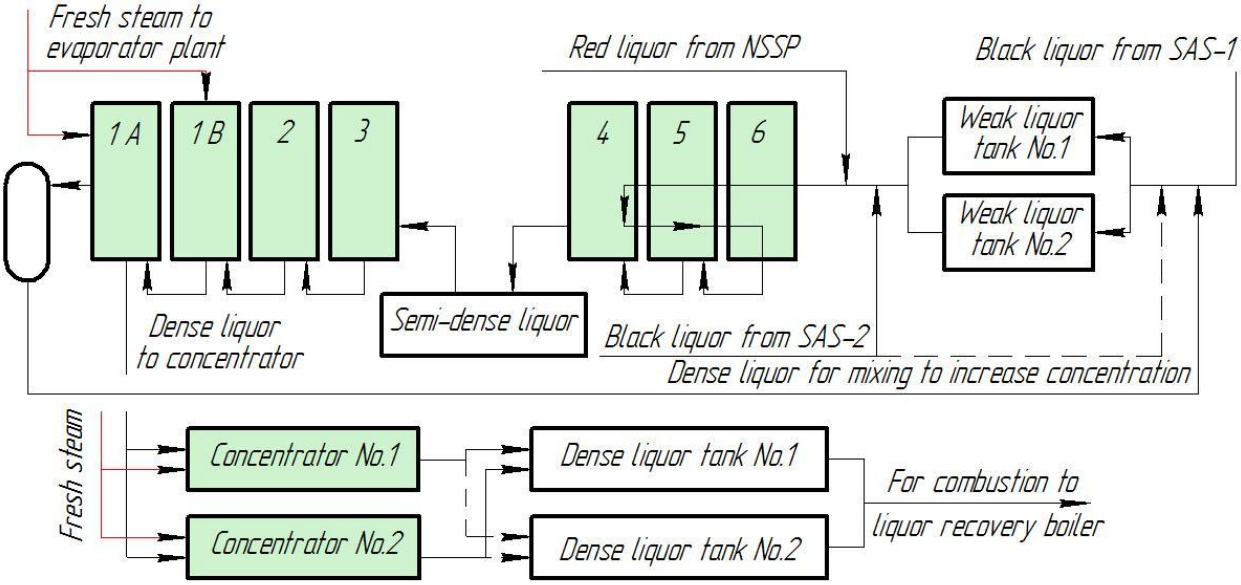

Fig A.4-6. Liquor flow through the units of the new evaporator plant

Steam streams. Primary steam (p = 0.3 МПа, t = 143 ^{0}C) is fed to evaporator unit 1 and to the existing concentrators. The produced secondary steam from the concentrators and unit 1 are fed to unit 2 and further to evaporating units 3, 5 and 6. Non-condensable steam gases from the surface condensers are fed to the vacuum pump and further to the vapour gas treatment unit for treatment.

Condensate streams. Primary condensate from the shell side of evaporating unit 1 flows to the condensate expansion tank, where it cools down to 100 ^{0}C, and then it is pumped to the condensate collection unit. Vapours are fed to evaporating unit 3 and condensate is fed to the expansion tank of unit 3 and mixed with secondary condensate of evaporating unit 3.

Secondary condensate is pumped from units 1, 2, 3 and 4 and from the first stage of unit 5 to the secondary treated condensate tank where it is mixed with condensate treated in the stripping column, and at around 50 ^{0}C is used for process needs (for sludge washing in the liquor recovery cycle and for pulp washing in the bleaching section).

Relatively clean secondary condensate from stage I of unit 6 together with condensate from the surface condenser of stage I is fed at around 70 ^{0}C for pulp washing to “Chemi-Washer” unit.

Second stages of evaporating units 5 and 6 are equipped with an internal methanol stripping system. Steam is fed to the lower section of the heat exchanger and goes upward against the condensate flow. The heat exchanger functions like an internal stripping column. It is the counterflow scheme and a good contact of steam and liquid that ensure maximum treatment efficiency. Methanol-contaminated condensate is removed from a separate section in the upper part of the heat exchanger and is fed to the contaminated condensate tank.

Treatment of contaminated condensates. The stripping column handles contaminated condensates from the second stages of evaporating units 5 and 6 and from surface condenser of stage II. Secondary steam from evaporating unit 2 is used for condensate treatment. In order to reduce steam consumption the contaminated condensate, which is fed for stripping, is heated by means of treated condensate. Treated condensate after the stripping column is fed to the secondary treated condensate tank for further use. The scheme of collection, treatment and utilization of condensates is given in Fig. A.4-7.

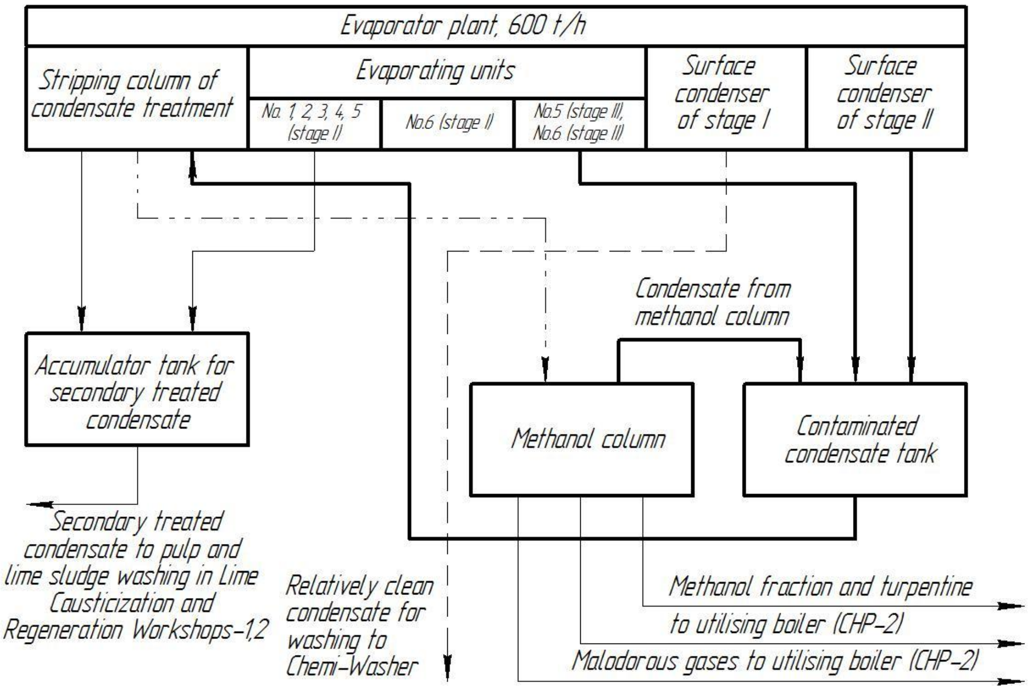

Fig. A.4-7. Scheme of collection, treatment and utilization of condensates from the new evaporator plant

Methanol fraction enrichment. The unit for enrichment of methanol fraction to 80% methanol content is located in a separate room adjacent to the evaporator plant. The enriched methanol fraction and non-condensable gases are fed for combustion to the utilizing boiler. Condensate from the stripping column after cooling and turpentine settlement is fed to the contaminated condensate tank.

Malodorous gases produced in the evaporator plant are collected from individual sources via hydraulic gates to avoid gas leaks from one source to another, and are then transported for combustion with the help of ejector. Gas ducts are fitted with the required explosion protection devices, flame arrestors and drop catchers.

In order to recuperate heat from combustion of methanol and malodorous gases it is envisaged to install a VAPOR TTK-175 gas-tight steam boiler. The boiler is fire-tube, three-pass, with one reversal chamber and two gas passes through smoke tubes. The boiler can run on liquid and gaseous fuel with maximum capacity of 4.7 MW and produces steam at 2 MPa and 215 ^oC.

Malodorous gases are burnt in the boiler via a special burner. Liquid methanol from the methanol distilling unit of the evaporator plant is used as a secondary fuel, and natural gas is used as a backup fuel.

In case of a short-term shutdown of the fire-tube boiler, vapor gas emissions and methanol fraction shall be flared through a special burner, natural gas being the backup fuel.

Flue gases are removed from the boiler by an induced draft fan. From the ID fan the flue gases are fed to a scrubber where 95% of SO_2 are removed with the help of white liquor. Purified flue gases are released into the atmosphere via the existing 100m high chimney of CHP-2.

Cooling water. Large quantities of cooling water are required for the process needs of the evaporating plant. Since there is no barometric condenser and no leaks in the heat exchangers, the water is not contaminated and in addition to that it is filtered. Warm filtered water after the evaporator plant's heat exchangers is fed to the warm water tank holding 200 m^3 and at around 45 ^0C is pumped to be reused in pulp washing and also in bleaching workshops.

Enlargement of the tank holding capacity. Whereas the output of the evaporator plant has increased, the holding capacity of tanks at CHP-2 has been significantly enlarged: weak liquor – 730 m^3/h, holding capacity of the tanks – 10 800 m^3; semi-evaporated liquor – 560 m^3/h, holding capacity of the tanks – 2720 m^3; and strong liquor – 120 m^3/h, holding capacity of the tanks – 500 m^3.

The building and laying of pipelines. A new 1120 m^2 building was added to the existing workshop, which earlier housed "Ramen" evaporator plants No.1 and No.2, in order to accommodate the new evaporator plant. Inter-workshop pipes were laid along the existing overhead bridges, which were reinforced for this purpose, and partly inside the Mill's operating workshops. The following was carried out at the construction sites: removal of underground and overground pipes from the development zone, vertical planning, motor roads and pavement construction and laying of engineering services.

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:

Combustion of fossil fuel generates significant GHG emissions. The principle greenhouse gas from fossil fuel combustion is CO_2. Emissions of N_2O and CH_4 from combustion are neglected, because they are negligibly small compared to emissions of CO_2. CO_2 emissions from biomass combustion are climatically neutral and are therefore assumed equal to zero.

Due to the implemented project the energy intensity of the production is reduced and additional heat and power are generated by means of non-fossil fuel combustion. Energy intensity decreases due to reduction of steam consumption for liquor evaporation and fresh water heating. Additional energy is generated by ETHPS due to more black liquor being fed to the liquor recovery boilers and due to increase of net calorific value of red liquor, as well as through combustion of methanol fraction and malodorous gases in the utilizing steam boiler.

As a result, combustion of fossil fuel (natural gas) at CHPP-1 is reduced accompanied by respective reduction of CO_2 emissions. The project emissions are insignificant and attributed to additional consumption of natural gas in the utilizing boiler and in the flare (flaring takes place only in the event of shutdown of the utilizing boiler). Leakages outside the project boundaries are substantial and are entailed by reduction of heat consumption based electricity generation at CHPP-1, therefore the shortfall of electricity in the general case has to be made up for from the grid.

In the absence of the project GHG emission reductions would not be generated, because it would be impossible to achieve the above mentioned effects operating the old “Ramen” evaporator plants. However the PPM could have continued its operation without facing any obstacles to operating the same liquor evaporating equipment in the previous mode at least until 2012, taking into account national and sectoral circumstances:

- Given the technical condition of the old “Ramen” evaporating plants No.1 and No.2, in principle, it was possible to continue their operation in the previous mode keeping the same production levels for another number of years provided routine maintenance was carried out;
- It is not foreseen that there should be any major changes to the Russian environmental regulation which could have forced the enterprise to stop using the equipment operated prior to the project;
- There are no limits on GHG emissions set for the Russian enterprises, and such are not expected at least until 2012[1];
- In the absence of the project it would have been possible to avoid large financial investments of internal resources and credits with a high risk of not paying them back within reasonable time (as shown below, the project is economically attractive only as long as there is a soft loan and revenues from selling GHG emission reductions);
- In the absence of the project it could have been possible to avoid risks associated with the new technology with which Kotlas PPM has no experience.

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

	Years
Length of the crediting period	5
Year	Estimate of annual emission reductions in tonnes of CO_2e
2008	157 152
2009	172 955
2010	175 871
2011	173 179
2012	200 782
Total estimated emission reductions over the crediting period (tonnes of CO_2 equivalent)	**879 939**
Annual average of estimated emission reductions over the crediting period (tonnes of CO_2 equivalent)	175 988

A.5. Project approval by the Parties involved:

The Letters of Approval from the Parties will be received later.

[1] http://www.economy.gov.ru/wps/wcm/connect/economylib/mert/welcome/economy/kiorealize/doc1143621403750

SECTION B. Baseline

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

For the baseline setting and GHG emission reductions calculation the PDD developer proposes his own approach without having to agree it with any CDM methodologies, but he certainly makes his approach consistent with the requirement of *Decision 9/CMP.1, Appendix B* [R1].

The baseline was chosen on the basis of critical analysis of several alternatives (See Section B.2).

The baseline scenario assumes that without JI mechanism and without sale of GHG emission reductions the Mill would have continued to operate its existing evaporator plants that could, in principle, ensure satisfactory liquor evaporation at the same target level of pulp cooking. Basically, technical condition of the old "Ramen" evaporator plants No.1 and No.2 made it possible to keep their performance at the same level for a number of years provided that relatively cheap routine maintenance was carried out.

Further below, we consider the main factors, which have influence upon GHG emission estimations both under the baseline and the project scenarios:

- Pulp cooking and liquors supply for evaporation;
- Heat and electricity consumption for liquor evaporation;
- Increase in heat and electricity supply from ETHPS;
- Heat savings due to reuse of warm water and condensates;
- Heat supply from the utilizing boiler running on methanol fraction and malodorous gases;
- Reduction of heat production by CHPP-1 boilers as a result of the project;
- Reduction of electricity supply to the grid as a result of the project; and
- Fuel savings within the project boundaries.

Considering that the new evaporator plant began to operate in the late 2007, the enterprise's reporting data for the first three quarters of 2008, available as of the date of calculation model development, were used for the projections of the main factors under the project scenario. And, essentially, the reporting data for the first three quarters of 2007 are used for the baseline scenario. The projections of some parameters for both scenarios also use 2006 data. Actual data for the fourth quarter of 2007 are not used in the projections, because this quarter is considered transitional.

Each factor is further analyzed in detail.

Pulp cooking and liquors supply for evaporation

The main gross indicator of PPM performance is its pulp cooking volume. Pulp cooking volumes are directly related to liquor generation volumes. The project affects neither the volumes nor the structure of pulp cooking, although it has an impact upon liquor recovery processes. It is safe to consider that the project does not affect sulfite liquors, which agrees with the conservative approach[2]. Therefore sulfite cooking and sulfite liquors were excluded from consideration.

Three cooking streams and respective liquor streams are considered, these are as follows:

- Cooking of sulfate softwood pulp (in SAS-1 cooking workshop) and produced black liquor from Cardboard and Paper Production (BL CPP);

[2] It appears that the project has some positive effect upon sulfite liquor evaporation, because less capacity of the sulfite production's evaporator plants is employed due to the project (due to shifting of red liquor streams to the new plant). It is supposed that the most inefficient evaporating units of sulfite production will be freed up in the first place. However this effect can be considered insignificant and is therefore excluded from analysis.

– Cooking of sulfate hardwood bleached pulp (in SAS-2 cooking workshop) and produced black liquor (BL SBPP);
– Cooking of neutral sulfite semi-chemical pulp (in NSSP cooking workshop) and produced red liquor.

The project scenario

The total pulp cooking volume under the project is determined as a sum of pulp cooking volumes per streams:

$$P_{PJ,y} = P_{1,y} + P_{2,y} + P_{3,y}, \quad (B.1\text{-}1)$$

where $P_{PJ,y}$ is the total sulfate pulp cooking under the project during the year y, t a.d.p. [3];

$P_{1,y}$ is the quantity of pulp produced in SAS-1 cooking workshop during the year y, t a.d.p.;

$P_{2,y}$ is the quantity of pulp produced in SAS-2 cooking workshop during the year y, t a.d.p.;

$P_{3,y}$ is the quantity of pulp produced in NSSP cooking workshop during the year y, t a.d.p.

Actual and projected quarterly volumes of pulp cooking in 2008 with a breakdown by streams according to information provided by OJSC “Ilim Group” Branch in Koryazhma are presented in Table B.1-1.[4]

Table B.1-1. Pulp cooking volumes in 2008

Streams	Units	2008				
		1st quarter	2nd quarter	3rd quarter	4th quarter	Year
SAS-1	t a.d.p.	97 095	96 016	93 585	94 258	**380 954**
SAS-2	t a.d.p.	98 796	101 328	95 494	100 842	**396 460**
NSSP	t a.d.p.	38 954	39 651	41 385	42 952	**162 942**
TOTAL	t a.d.p.	234 845	236 995	230 464	238 052	**940 356**

Grey cells show actual data.

Quarterly data on liquor supply to evaporator plants in 2008 are given in Table B.1-2. Actual data for the first three quarters were provided by the enterprise, the projections are based on the calculation using target values of specific liquor yield per tonne of pulp (see below).

Table B.1-2. Liquors supply for evaporation in 2008

Streams	Units	2008				
		1st quarter	2nd quarter	3rd quarter	4th quarter	Year
BL CPP	t a.d.m.	118 165	116 851	121 660	122 535	**479 211**
BL SBPP	t a.d.m.	134 856	138 312	130 351	137 650	**541 169**
Red liquor	t a.d.m.	6 908	6 217	6 796	7 135	**27 056**
TOTAL	t a.d.m.	259 929	261 380	258 807	267 319	**1 047 435**

Grey cells show actual data.

The total quantity of liquors fed for evaporation:

$$LG_{PJ,y} = LG_{RL,PJ,y} + LG_{BL\ CPP,PJ,y} + LG_{BL\ SBPP,PJ,y}, \quad (B.1\text{-}2)$$

Where $LG_{PJ,y}$ is the total quantity of liquors fed for evaporation under the project during the year y, t a.d.m.[5];

[3] a.d.p. – air-dry pulp

[4] Projected pulp cooking data with a breakdown by streams were provided by the enterprise for the period until the end of 2012 (See Table B.1-7).

$LG_{RL,PJ,y}$ is the quantity of red liquor fed for evaporation under the project during the year *y*, t a.d.m.;

$LG_{BL\ CPP,PJ,y}$ is the quantity of BL CPP fed for evaporation under the project during the year *y*, t a.d.m.;

$LG_{BL\ SBPP,PJ,y}$ is the quantity of BL SBPP fed for evaporation under the project during the year *y*, t a.d.m.

Specific yield of liquor per tonne of cooked pulp by streams is determined as:

$$\alpha_{RL,PJ} = \frac{LG_{RL,PJ,y}}{P_{3,y}}, \quad \text{(B.1-3)}$$

where $\alpha_{RL,PJ}$ is the specific yield of red liquor under the project, t a.d.m./t a.d.p.;

$$\alpha_{BL\ CPP,PJ} = \frac{LG_{BL\ CPP,PJ,y}}{P_{1,y}}, \quad \text{(B.1-4)}$$

where $\alpha_{BL\ CPP,PJ}$ is the specific yield of BL CPP under the project, t a.d.m./t a.d.p.;

$$\alpha_{BL\ SBPP,PJ} = \frac{LG_{SBPP,PJ,y}}{P_{2,y}}, \quad \text{(B.1-5)}$$

where $\alpha_{BL\ SBPP,PJ}$ is the specific yield of BL SBPP under the project, t a.d.m./t a.d.p.

Quarterly values of specific liquor yield in 2006-2008 are given in Table B.1-3.

Table B.1-3. Specific liquor yield data for 2006-2008

Streams	Units	2006	2007	2008				
				1st quarter	2nd quarter	3rd quarter	4th quarter	Year
BL CPP	t a.d.m./t a.d.p.	1.201	1.204	1.217	1.217	1.300	1.300	1.258
BL SBPP	t a.d.m./t a.d.p.	1.370	1.365	1.365	1.365	1.365	1.365	1.365
Red liquor	t a.d.m./t a.d.p.	0.167	0.170	0.177	0.157	0.164	0.166	0.166

Grey cells show actual data.

The analysis of the actual data from Table B.1-3 shows a significant increase in specific yield of BL CPP in the 3rd quarter 2008. This is explained by the fact that by the beginning of the 3rd quarter of 2008 a new evaporator plant and the associated equipment were up and running in stable operation mode (in the first two quarters of 2008 some increase can be also seen in BL CPP yield compared to 2007 but it is not that sizable), so it became possible to increase the rate of liquor separation during pulp washing, and this also reduced liquor losses in SAS-1.

From the 4th quarter of 2008 till the end of 2012 the values of quarterly average specific yield of red liquor and BL SBPP were assumed constant and equal to the average of the three quarters of 2008, and the same for BL CPP stream was assumed constant and equal to the specific yield of liquor in the 3rd quarter of 2008, that is: $\alpha_{RL,PJ} = 0.166$; $\alpha_{BL\ CPP,PJ} = 1.300$; $\alpha_{BL\ SBPP,PJ} = 1.365$ t a.d.m./t a.d.p.

Projected volumes of liquor supply are calculated as follows:

$$LG_{RL,PJ,y} = \alpha_{RL,PJ} \times P_{3,y} \quad \text{(B.1-6)}$$

$$LG_{BL\ CPP,PJ,y} = \alpha_{BL\ CPP,PJ} \times P_{1,y} \quad \text{(B.1-7)}$$

$$LG_{BL\ SBPP,PJ,y} = \alpha_{BL\ SBPP,PJ} \times P_{2,y} \quad \text{(B.1-8)}$$

[5] a.d.m. – absolutely dry matter

The baseline scenario

In the baseline scenario the overall pulp cooking volumes and pulp cooking volumes by streams are assumed equal to their respective project values, that is:

$$P_{BL,y} = P_{1,y} + P_{2,y} + P_{3,y}, \quad \text{(B.1-9)}$$

where $P_{BL,y}$ is the total volume of pulp cooking under the baseline during the year *y*, t a.d.p.

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

$$P_{BL,2,y} = P_{PJ,2,y} = P_{2,y} \quad \text{(B.1-11)}$$

$$P_{BL,3,y} = P_{PJ,3,y} = P_{3,y} \quad \text{(B.1-12)}$$

$$P_{BL,y} = P_{PJ,y} \quad \text{(B.1-13)}$$

Pulp cooking volumes by streams in 2006 and 2007 are given in Table B.1-4.

Table B.1-4. Pulp cooking volumes in 2006 and 2007

Streams	Unit	2006	2007				
			1st quarter	2nd quarter	3rd quarter	4th quarter	Year
SAS-1	t a.d.p.	**350 195**	88 407	89 019	78 890	78 116	**334 432**
SAS-2	t a.d.p.	**369 576**	97 053	95 003	92 354	94 851	**379 261**
NSPP	t a.d.p.	**156 978**	38 179	39 708	36 224	41 488	**155 599**
ВСЕГО	t a.d.p.	**876 749**	223 639	223 730	207 468	214 455	**869 292**

Grey cells show actual data.

Data on supply of liquors to evaporator plants in 2006 and 2007 are presented in Table B.1-5. Actual data was provided by the enterprise. Projections for the baseline scenario were based on calculations using target values of specific yield of liquor per tonne of pulp (see below).

Table B.1-5. Liquor supply for evaporation in 2006 and 2007

Streams	Unit	2006	2007				
			1st quarter	2nd quarter	3rd quarter	4th quarter	Year
BL CPP	t a.d.m.	**420 648**	106 088	106 823	95 242	94 308[6]	**402 461**
BL SBPP	t a.d.m.	**506 319**	132 477	129 679	126 063	129 472	**517 691**
Red liquor	t a.d.m.	**26 156**	6 859	6 661	6 413	6 461	**26 394**
TOTAL	t a.d.m.	**953 123**	245 424	243 163	227 718	230 241	**946 546**

Grey cells show actual data.

The total quantity of liquors fed for evaporation:

$$LG_{BL,y} = LG_{RL,BL,y} + LG_{BL\ CPP,BL,y} + LG_{BL\ SBPP,BL,y}, \quad \text{(B.1-14)}$$

where $LG_{BL,y}$ is the total quantity of liquors fed for evaporation under the baseline during the year *y*, t a.d.m.;

$LG_{RL,BL,y}$ is the quantity of red liquor fed for evaporation under the baseline during the year *y*, t a.d.m.;

[6] Actual supply of BL CPP was somewhat higher way back in the 4th quarter of 2007 and stood at 94 530 t a.d.m., which is due to commissioning of the new evaporator plant.

$LG_{BL\ CPP,BL,y}$ is the quantity of BL CPP fed for evaporation under the baseline during the year y, t a.d.m.;
$LG_{BL\ SBPP,BL,y}$ is the quantity of BL SBPP fed for evaporation under the baseline during the year y, t a.d.m.

Specific yield of liquors per tonne of cooked pulp by streams:

$$\alpha_{RL,BL} = \frac{LG_{RL,BL,y}}{P_{3,y}}, \quad (B.1\text{-}15)$$

where $\alpha_{RL,BL}$ is the specific yield of red liquor under the baseline, t a.d.m./t a.d.p.;

$$\alpha_{BL\ CPP,BL} = \frac{LG_{BL\ CPP,BL,y}}{P_{1,y}}, \quad (B.1\text{-}16)$$

where $\alpha_{BL\ CPP,BL}$ is the specific yield of BL CPP under the baseline, t a.d.m./t a.d.p.;

$$\alpha_{BL\ SBPP,BL} = \frac{LG_{SBPP,BL,y}}{P_{2,y}}, \quad (B.1\text{-}17)$$

where $\alpha_{BL\ SBPP,BL}$ is the specific yield of BL SBPP under the baseline, t a.d.m./t a.d.p.

Specific yield of liquor per tonne of cooked pulp (t a.d.m./t a.d.p.) in 2006 and 2007 is presented in Table B.1-6.

Since the project does not affect the specific yield of red liquor and BL SBPP, such values for these streams are assumed equal to their respective project values (i.e. to average values over three quarters of 2008, See Table B.1-3); and for BL CPP stream – to a constant value equal to an average specific liquor yield in 2006-2007, the value of specific yield in the 4th quarter of 2007 was assumed equal to the maximum value over the first three quarters. That is the following is assumed for the baseline scenario for the period 2008-2012: $\alpha_{RL,BL} = \alpha_{RL,PJ} = 0.166$; $\alpha_{BL\ CPP,BL} = 1.202$; $\alpha_{BL\ SBPP,BL} = \alpha_{BL\ SBPP,PJ} = 1.365$, t a.d.m./t a.d.p.

Table B.1-6. Specific yield of liquor in 2006 and 2007

Streams	Units	2006	2007				
			1st quarter	2nd quarter	3rd quarter	4th quarter	Year
BL CPP	t a.d.m./t a.d.p.	1.201	1.200	1.200	1.207	1.207	1.203
BL SBPP	t a.d.m./t a.d.p.	1.370	1.365	1.365	1.365	1.365	1.365
Red liquor	t a.d.m./t a.d.p.	0.167	0.180	0.168	0.177	0.156	0.170

Grey cells show actual data.

Liquor supply for evaporation under the baseline is calculated as follows:

$$LG_{RL,BL,y} = \alpha_{RL,BL} \times P_{3,y} \quad (B.1\text{-}18)$$

$$LG_{BL\ CPP,BL,y} = \alpha_{BL\ CPP,BL} \times P_{1,y} \quad (B.1\text{-}19)$$

$$LG_{BL\ SBPP,BL,y} = \alpha_{BL\ SBPP,BL} \times P_{2,y} \quad (B.1\text{-}20)$$

The projections of pulp cooking and liquor generation for the period 2008-2012 for both scenarios are given in Table B.1-7. The only difference in the data is that under the project more BL CPP will be supplied for evaporation than under the baseline.

Table B.1-7. Projections of pulp cooking and liquor supply for evaporation for the period 2008-2012

Streams	Units	Years					
		2008	2009	2010	2011	2012	2008-2012
Project							
Pulp cooking volume							
SAS-1	t a.d.p.	380 954	339 924	334 381	283 421	348 512	1 687 192
SAS-2	t a.d.p.	396 460	402 395	402 272	391 396	387 081	1 979 604
NSSP	t a.d.p.	162 942	224 440	244 563	355 668	355 989	1 343 602
TOTAL	t a.d.p.	940 356	966 759	981 216	1 030 485	1 091 582	5 010 398
Specific yield of liquor							
BL CPP	t a.d.m./ t a.d.p.	1.258	1.300	1.300	1.300	1.300	1.290
BL SBPP	t a.d.m./ t a.d.p.	1.365	1.365	1.365	1.365	1.365	1.365
Red liquor	t a.d.m./ t a.d.p.	0.166	0.166	0.166	0.166	0.166	0.166
Liquor supply for evaporation							
BL CPP	t a.d.m.	479 211	441 899	434 694	368 446	453 064	2 177 313
BL SBPP	t a.d.m.	541 169	549 270	549 102	534 256	528 366	2 702 162
Red liquor	t a.d.m.	27 056	37 267	40 609	59 057	59 111	223 101
TOTAL	t a.d.m.	1 047 435	1 028 437	1 024 404	961 759	1 040 541	5 102 576
Baseline							
Pulp cooking volume							
SAS-1	t a.d.p.	380 954	339 924	334 381	283 421	348 512	1 687 192
SAS-2	t a.d.p.	396 460	402 395	402 272	391 396	387 081	1 979 604
NSSP	t a.d.p.	162 942	224 440	244 563	355 668	355 989	1 343 602
TOTAL	t a.d.p.	940 356	966 759	981 216	1 030 485	1 091 582	5 010 398
Specific yield of liquor							
BL CPP	t a.d.m./ t a.d.p.	1.202	1.202	1.202	1.202	1.202	1.202
BL SBPP	t a.d.m./ t a.d.p.	1.365	1.365	1.365	1.365	1.365	1.365
Red liquor	t a.d.m./ t a.d.p.	0.166	0.166	0.166	0.166	0.166	0.166
Liquor supply for evaporation							
BL CPP	t a.d.m.	458 021	408 690	402 026	340 757	419 016	2 028 509
BL SBPP	t a.d.m.	541 169	549 270	549 102	534 256	528 366	2 702 162
Red liquor	t a.d.m.	27 056	37 267	40 609	59 057	59 111	223 101
TOTAL	t a.d.m.	1 026 245	995 227	991 737	934 070	1 006 492	4 953 772

Heat and electricity consumption for liquor evaporation

Below is the analysis of heat and electricity consumption by all evaporator plants responsible for evaporation of black and red liquors.

The project scenario

The project scenario envisages redistribution of liquor streams between evaporator plants. Black liquor from SAS-1 pulp cooking workshop (BL CPP) and partially from SAS-2 (BL SBPP), as well as red liquor from NSSP are fed for evaporation to the new plant of CHP-2. Larger proportion of the produced BL SBPP is fed to "Parsons&Whittemore" evaporator plant of CHP-3. The project liquor flow scheme is shown in Fig.A.4-5.

Tables B.1-8 and 9 below show actual data on evaporated liquors quantities and heat and electricity consumption by evaporator plants of CHP-2 and CHP-3 in the first three quarters of 2008 and also estimated data for the 4th quarter of 2008.

Table B.1-8. Performance of the new evaporator plant of CHP-2 in 2008

Parameter	Unit	2008				
		1st quarter	2nd quarter	3rd quarter	4th quarter	Year
BL CPP	t a.d.m.	118 165	116 851	121 660	122 535	479 211
BL SBPP	t a.d.m.	26 972	27 663	26 071	30 045	110 751
Red liquor	t a.d.m.	6 908	6 217	6 796	7 135	27 056
Heat consumption	GJ	696 001	804 653	704 379	770 584	2 975 617
Electricity consumption	MWh	5 879	5 316	5 531	5 842	22 567
Specific heat consumption	GJ/ t a.d.m.	4.578	5.338	4.558	4.825	4.823
Specific electricity consumption	MWh/ t a.d.m.	0.0387	0.0353	0.0358	0.0366	0.0366

Grey cells show actual data.

Table B.1-9. Performance of CHP-3 evaporator plant in 2008

Parameter	Unit	2008				
		1st quarter	2nd quarter	3rd quarter	4th quarter	Year
BL SBPP	t a.d.m.	107 884	110 649	104 280	107 604	430 417
Heat consumption	GJ	405 599	427 451	401 600	411 546	1 646 196
Electricity consumption	MWh	2 103	2 173	2 044	2 107	8 427
Specific heat consumption	GJ/ t a.d.m.	3.760	3.863	3.851	3.825	3.825
Specific electricity consumption	MWh/ t a.d.m.	0.0195	0.0196	0.0196	0.0196	0.0196

Grey cells show actual data.

The total quantity of liquors fed to CHP-2 evaporator plant under the project:

$$LE_{CHP-2,PJ,y} = LE_{CHP-2,BL\ CPP,PJ,y} + LE_{CHP-2,RL,PJ,y} + LE_{CHP-2,BL\ SBPP,PJ,y}, \quad \text{(B.1-21)}$$

where $LE_{CHP-2,PJ,y}$ is the total quantity of liquors fed to the evaporator plant of CHP-2 under the project during the year y, t a.d.m;

$LE_{CHP-2,BL\ CPP,PJ,y}$ is the quantity of BL CPP fed to the evaporator plant of CHP-2 under the project during the year y, t a.d.m.;

$LE_{CHP-2,RL,PJ,y}$ is the quantity of red liquor fed to the evaporator plant of CHP-2 under the project during the year y, t a.d.m.;

$LE_{CHP-2,BL\ SBPP,PJ,y}$ is the quantity of BL SBPP fed to the evaporator plant of CHP-2 under the project during the year *y*, t a.d.m.

Since all BL CPP and red liquor are fed for evaporation to CHP-2:

$$LE_{CHP-2,BL\ CPP,PJ,y} = LG_{BL\ CPP,PJ,y}, \quad \text{(B.1-22)}$$

$$LE_{CHP-2,RL,PJ,y} = LG_{RL,PJ,y}. \quad \text{(B.1-23)}$$

BL SBPP stream is fed to both CHP-2 and CHP-3 for evaporation, therefore:

$$LE_{CHP-2,BL\ SBPP,PJ,y} = LG_{BL\ SBPP,PJ,y} - LE_{CHP-3,BL\ SBPP,PJ,y}, \quad \text{(B.1-24)}$$

where $LE_{CHP-3,BL\ SBPP,PJ,y}$ is the quantity of BL SBPP fed to the evaporator plant of CHP-3 under the project during the year *y*, t a.d.m.

The total quantity of liquor fed to the evaporator plant of CHP-3 under the project:

$$LE_{CHP-3,PJ,y} = LE_{CHP-3,BL\ SBPP,PJ,y}, \quad \text{(B.1-25)}$$

where $LE_{CHP-3,PJ,y}$ is the total quantity of liquors fed to the evaporator plant of CHP-3 under the project during the year *y*, t a.d.m.

The quantity of BL SBPP fed to the evaporator plant of CHP-3, for the purpose of estimations for the years 2009-2012, was assumed constant over the years and numerically equal to the respective quantity in 2008. The missing data for the 4th quarter of 2008 were assumed equal to the respective average values in the first three quarters of 2008.

Heat consumption by evaporator plants

Heat consumption for liquor evaporation under the project during the year *y* is calculated as follows:

$$HC_{CHP,PJ,y} = HC_{CHP-3,PJ,y} + HC_{CHP-2,PJ,y}, \quad \text{(B.1-26)}$$

where $HC_{CHP,PJ,y}$ is the total heat consumption for liquor evaporation under the project during the year *y*, GJ;

$HC_{CHP-3,PJ,y}$ is the heat consumption by the evaporator plant of CHP-3 under the project during the year *y*, GJ;

$HC_{CHP-2,PJ,y}$ is the heat consumption by the evaporator plant of CHP-2 under the project during the year *y*, GJ.

For projection calculations for the period until 2012, heat consumption by plants was determined using specific values of heat consumption by evaporator plants:

$$\beta_{HC,CHP-2,PJ} = \frac{HC_{CHP-2,PJ,y}}{LE_{CHP-2,PJ,y}}, \quad \text{(B.1-27)}$$

$$\beta_{HC,CHP-3,PJ} = \frac{HC_{CHP-3,PJ,y}}{LE_{CHP-3,PJ,y}}, \quad \text{(B.1-28)}$$

where $\beta_{HC,CHP-2,PJ}$ is the specific heat consumption by the evaporator plant of CHP-2 under the project, GJ/t a.d.m.;

$\beta_{HC,CHP-3,PJ}$ is the specific heat consumption by the evaporator plant of CHP-3 under the project, GJ/t a.d.m.

Specific heat consumption values for the 4th quarter of 2008 were determined as an average of the first three quarters of 2008 (See Tables B.1-8 and 9). For the purpose of estimations for the years 2009-2012, the specific heat consumption by the evaporator plants of CHP-2 and CHP-3 under the project is assumed constant over the years and equal to their respective values in 2008: $\beta_{HC,CHP-2,PJ} = 4.823$GJ/t a.d.m., $\beta_{HC,CHP-3,PJ} = 3.825$ GJ/t a.d.m. These figures will be updated in the course monitoring.

Heat consumption by the evaporator plants of CHP-2 and CHP-3 will be determined as:

$$HC_{CHP-2,PJ,y} = \beta_{HC,CHP-2,PJ} \times LE_{CHP-2,PJ,y}, \quad \text{(B.1-29)}$$

$$HC_{CHP-3,PJ,y} = \beta_{HC,CHP-3,PJ} \times LE_{CHP-3,PJ,y}. \quad \text{(B.1-30)}$$

Electricity consumption by evaporator plants

The total electricity consumption for liquor evaporation under the project during the year *y* is calculated as follows:

$$EC_{CHP,PJ,y} = EC_{CHP-2,PJ,y} + EC_{CHP-3,PJ,y}, \quad \text{(B.1-31)}$$

where $EC_{CHP,PJ,y}$ is the total electricity consumption for liquor evaporation under the project during the year *y*, MWh;

$EC_{CHP-2,PJ,y}$ is the electricity consumption by the evaporator plant of CHP-2 under the project during the year *y*, MWh;

$EC_{CHP-3,PJ,y}$ is the electricity consumption by the evaporator plant of CHP-3 under the project during the year *y*, MWh;

Electricity consumption by the plants up until 2012 was determined using specific electricity consumption values of the evaporator plants:

$$\beta_{EC,CHP-2,PJ} = \frac{EC_{CHP-2,PJ,y}}{LE_{CHP-2,PJ,y}}, \quad \text{(B.1-32)}$$

$$\beta_{EC,CHP-3,PJ} = \frac{EC_{CHP-3,PJ,y}}{LE_{CHP-3,PJ,y}}, \quad \text{(B.1-33)}$$

where $\beta_{EC,CHP-2,PJ}$ is the specific electricity consumption by the evaporator plant of CHP-2 under the project, MWh/t a.d.m.;

$\beta_{EC,CHP-3,PJ}$ is the specific electricity consumption by the evaporator plant of CHP-3 under the project, MWh/t a.d.m.

Specific electricity consumption values for the 4th quarter of 2008 were determined as an average of the first three quarters of 2008 (See Table B.1-8 and 9). For estimation purposes the specific electricity consumption by CHP-2 and CHP-3 for the period 2009-2012 was assumed constant over the years and equal to the plants' respective consumption in 2008: $\beta_{EC,CHP-2,PJ} = 0.0366$ MWh/t a.d.m., $\beta_{EC,CHP-3,PJ} = 0.0196$ MWh/t a.d.m. These figures will be updated in the course of monitoring.

Electricity consumption at CHP-2 and CHP-3 will be determined as:

$$EC_{CHP-2,PJ,y} = \beta_{EC,CHP-2,PJ} \times LE_{CHP-2,PJ,y}, \quad \text{(B.1-34)}$$

$$EC_{CHP-3,PJ,y} = \beta_{EC,CHP-3,PJ} \times LE_{CHP-3,PJ,y}. \quad \text{(B.1-35)}$$

The baseline scenario

The baseline scenario assumes that BL CPP is fed to the old "Ramen" evaporator plants of CHP-2, BL SBPP is fed to "Parsons & Whittemore" evaporator plant of CHP-3 and red liquor – to "UkrNIIHimMash" evaporator plant of sulfite production. The project liquor flow scheme is given in Fig.A.4-4.

Tables B.1-10 and 11 below show actual data on liquor evaporation and heat and electricity consumption by the evaporator plants of CHP-2 and CHP-3 in 2006 and in the first three quarters of 2007, and estimates for the 4th quarter of 2007. Table B.1-12 gives annual actual data for 2006 and 2007 for "UkrNIIHimMash" evaporator plant.

Table B.1-10. Performance of the old evaporator plants of CHP-2 in 2006 and 2007

Parameter	Unit	2006	2007				
			1st quarter	2nd quarter	3rd quarter	4th quarter	Year
BL CPP	t a.d.m.	420 648	106 088	106 823	95 242	94 308	402 461
Heat consumption	GJ	2 856 484	748 146	746 655	630 403	624 218	2 749 422
Electricity consumption	MWh	4 155	1 039	1 088	1 233	924	4 283
Specific heat consumption	GJ/t a.d.m.	6.791	7.052	6.990	6.619	6.619	6.832
Specific electricity consumption	MWh/ t a.d.m.	0.0099	0.0098	0.0102	0.0129	0.0098	0.0106

Grey cells show actual data.

Table B.1-11. Performance of the evaporator plant of CHP-3 in 2006 and 2007

Parameter	Unit	2006	2007				
			1st quarter	2nd quarter	3rd quarter	4th quarter	Year
BL SBPP	t a.d.m.	506 319	132 477	129 679	126 063	129 472	517 691
Heat consumption	GJ	1 643 812	419 110	435 712	414 098	409 604	1 678 524
Electricity consumption	MWh	9 659	2 584	2 486	2 612	2 482	10 164
Specific heat consumption	GJ/ t a.d.m.	3.247	3.164	3.360	3.285	3.164	3.242
Specific electricity consumption	MWh/ t a.d.m.	0.0191	0.0195	0.0192	0.0207	0.0192	0.0196

Grey cells show actual data.

Table B.1-12. Performance of "UkrNIIHimMash" evaporator plant in 2006 and 2007

Parameter	Unit	2006	2007
Red liquor	t a.d.m.	26 156	24 318
Heat consumption	GJ	507234	416 506
Electricity consumption	MWh	5 717	5 156
Specific heat consumption	GJ/ t a.d.m.	19.39	17.13
Specific electricity consumption	MWh/ t a.d.m.	0.2186	0.2120

Grey cells show actual data.

The total quantity of liquor fed to the evaporator plants of CHP-2 under the baseline:

$$LE_{CHP-2,BL,y} = LE_{CHP-2,BL\ CPP,BL,y}, \quad \text{(B.1-36)}$$

where $LE_{CHP-2,BL,y}$ is the total quantity of liquors fed to the evaporator plants of CHP-2 under the baseline during the year *y*, t a.d.m.;

$LE_{CHP-2,BL\ CPP,BL,y}$ is the quantity of BL CPP fed to the evaporator plants of CHP-2 under the baseline during the year *y*, t a.d.m.

All BL CPP is fed for evaporation to CHP-2, therefore:

$$LE_{CHP-2,BL\ CPP,BL,y} = LG_{BL\ CPP,BL,y}\ , \quad \text{(B.1-37)}$$

The total quantity of liquor fed to the evaporator plant of CHP-3 is determined as:

$$LE_{CHP-3,BL,y} = LE_{CHP-3,BL\ SBPP,BL,y}\ , \quad \text{(B.1-38)}$$

where $LE_{CHP-3,BL,y}$ is the total quantity of liquors fed to the evaporator plant of CHP-3 under the baseline during the year *y*, t a.d.m.;

$LE_{CHP-3,SBPP,BL,y}$ is the quantity of BL SBPP fed to the evaporator plant of CHP-3 under the baseline during the year *y*, t a.d.m.

All BL SBPP is fed for evaporation to CHP-3, therefore:

$$LE_{CHP-3,BL\ SBPP,BL,y} = LG_{BL\ SBPP,BL,y}\ . \quad \text{(B.1-39)}$$

The total quantity of liquor fed to “UkrNIIHimMash” evaporator plant is determined as:

$$LE_{UkrNIIHimMash,BL,y} = LE_{UkrNIIHimMash,RL,BL,y}\ , \quad \text{(B.1-40)}$$

where $LE_{UkrNIIHimMash,BL,y}$ is the total quantity of liquors fed to “UkrNIIHimMash” evaporator plant under the baseline during the year *y*, t a.d.m.;

$LE_{UkrNIIHimMash,RL,BL,y}$ is the quantity of red liquor fed to “UkrNIIHimMash” evaporator plant under the baseline during the year *y*, t a.d.m.

All red liquor is fed for evaporation to “UkrNIIHimMash” plant, therefore:

$$LE_{UkrNIIHimMash,RL,BL,y} = LG_{RL,BL,y}\ . \quad \text{(B.1-41)}$$

Heat consumption by evaporator plants

Baseline heat consumption for liquor evaporation during the year *y* is calculated as follows:

$$HC_{CHP,BL,y} = HC_{CHP-2,BL,y} + HC_{CHP-3,BL,y} + HC_{UkrNIIHimMash,BL,y}\ , \quad \text{(B.1-42)}$$

where $HC_{CHP,BL,y}$ is the total heat consumption for liquor evaporation under the baseline scenario during the year *y*, GJ;

$HC_{CHP-2,BL,y}$ is the heat consumption by CHP-2 evaporator plants under the baseline during the year *y*, GJ;

$HC_{CHP-3,BL,y}$ is the heat consumption by CHP-3 evaporator plant under the baseline during the year *y*, GJ;

$HC_{UkrNIIHimMash,BL,y}$ is the heat consumption by “UkrNIIHimMash” evaporator plants under the baseline during the year *y*, GJ.

For projection calculations up until 2012, heat consumption by plants was determined using values of specific heat consumption by the evaporator plants:

$$\beta_{HC,CHP-2,BL} = \frac{HC_{CHP-2,BL,y}}{LE_{CHP-2,BL,y}}\ , \quad \text{(B.1-43)}$$

$$\beta_{HC,CHP-3,BL} = \frac{HC_{CHP-3,BL,y}}{LE_{CHP-3,BL,y}}, \quad \text{(B.1-44)}$$

$$\beta_{HC,UkrNIIHimMash,BL} = \frac{HC_{UkrNIIHimMash,BL,y}}{LE_{UkrNIIHimMash,BL,y}}, \quad \text{(B.1-45)}$$

where $\beta_{HC,CHP-2,BL}$ is the specific heat consumption by CHP-2 evaporator plants under the baseline scenario, GJ/t a.d.m.;

$\beta_{HC,CHP-3,BL}$ is the specific heat consumption by CHP-3 evaporator plant under the baseline scenario, GJ/t a.d.m.;

$\beta_{HC,UkrNIIHimMash,BL}$ is the specific heat consumption by "UkrNIIHimMash" evaporator plant under the baseline scenario, GJ/t a.d.m.

Specific heat consumption values for CHP-2 and CHP-3 in the 4th quarter of 2007 were determined as minimum values over three quarters of 2007 (this approach was chosen in order to be more conservative) (See Tables B.1-10,11). Specific heat consumption of "UkrNIIHimMash" evaporator plant in 2007 was assumed equal to the actual data for this year (even though in the 4th quarter of 2007 red liquor started to be fed to the new evaporator plant, the error of the baseline scenario calculation caused by this fact can be considered minimum).

For the projections for the period 2008-2012, specific heat consumption values for CHP-2, CHP-3 and "UkrNIIHimMash" evaporator plants are assumed constant over the years and equal to their respective average values in 2006 and 2007: $\beta_{HC,CHP-2,BL} = 6.811$GJ/t a.d.m., $\beta_{HC,CHP-3,BL} = 3.244$ GJ/t a.d.m., $\beta_{HC,UkrNIIHimMash,BL} = 18.260$ GJ/t a.d.m.

Baseline heat consumption by CHP-2, CHP-3 and "UkrNIIHimMash" evaporator plants will be determined as:

$$HC_{CHP-2,BL,y} = \beta_{HC,CHP-2,BL} \times LE_{CHP-2,BL,y}, \quad \text{(B.1-46)}$$

$$HC_{CHP-3,BL,y} = \beta_{HC,CHP-3,BL} \times LE_{CHP-3,BL,y}, \quad \text{(B.1-47)}$$

$$HC_{UkrNIIHimMash,BL,y} = \beta_{HC,UkrNIIHimMash,BL} \times LE_{UkrNIIHimMash,BL,y}. \quad \text{(B.1-48)}$$

Electricity consumption by evaporator plants

The total electricity consumption for liquor evaporation under the baseline during the year *y* is calculated as follows:

$$EC_{CHP,BL,y} = EC_{CHP-2,BL,y} + EC_{CHP-3,BL,y} + EC_{UkrNIIHimMash,BL,y}, \quad \text{(B.1-49)}$$

where $EC_{CHP,BL,y}$ is the total electricity consumption for liquor evaporation under the baseline during the year *y*, MWh;

$EC_{CHP-2,BL,y}$ is the electricity consumption by CHP-2 evaporator plants under the baseline during the year *y*, MWh;

$EC_{CHP-3,BL,y}$ is the electricity consumption by CHP-3 evaporator plant under the baseline during the year *y*, MWh;

$EC_{UkrNIIHimMash,BL,y}$ is the electricity consumption by "UkrNIIHimMash" evaporator plant under the baseline during the year *y*, MWh.

Electricity consumption by the plants up until the end of 2012 was determined using values of specific electricity consumption by evaporator plants:

$$\beta_{EC,CHP-2,BL} = \frac{EC_{CHP-2,BL,y}}{LE_{CHP-2,BL,y}}, \quad (B.1-50)$$

$$\beta_{EC,CHP-3,BL} = \frac{EC_{CHP-3,BL,y}}{LE_{CHP-3,BL,y}}, \quad (B.1-51)$$

$$\beta_{EC,UkrNIIHimMash,BL} = \frac{EC_{UkrNIIHimMash,BL,y}}{LE_{UkrNIIHimMash,BL,y}}, \quad (B.1-52)$$

where $\beta_{EC,CHP-2,BL}$ is the specific electricity consumption by CHP-2 evaporator plants under the baseline scenario, MWh/t a.d.m.;

$\beta_{EC,CHP-3,BL}$ is the specific electricity consumption by CHP-3 evaporator plant under the baseline scenario, MWh/t a.d.m.;

$\beta_{EC,UkrNIIHimMash,BL}$ is the specific electricity consumption by "UkrNIIHimMash" evaporator plant under the baseline scenario, MWh/t a.d.m.

Values of specific electricity consumption for CHP-2 and CHP-3 in the 4th quarter of 2007 were determined as minimum values over first three quarters of 2007 (this approach was chosen in order to be more conservative) (See Tables B.1-10,11). Specific electricity consumption for "UkrNIIHimMash" evaporator plant in 2007 was assumed equal to the actual data for 2007 (assuming that the estimation error due to this will be minimum).

For the purpose of projections for the period 2008-2012 specific electricity consumption values for CHP-2, CHP-3 and "UkrNIIHimMash" are assumed constant over years and equal to their respective average values in 2006 and 2007: $\beta_{EC,CHP-2,BL} = 0.0103$MWh/t a.d.m., $\beta_{EC,CHP-3,BL} = 0.0194$ MWh/t a.d.m., $\beta_{EC,UkrNIIHimMash,BL} = 0.2153$ MWh/t a.d.m.

Electricity consumption by CHP-2, CHP-3 and "UkrNIIHimMash" evaporator plants under the baseline scenario will be determined as follows:

$$EC_{CHP-2,BL,y} = \beta_{EC,CHP-2,BL} \times LE_{CHP-2,BL,y}, \quad (B.1-53)$$

$$EC_{CHP-3,BL,y} = \beta_{EC,CHP-3,BL} \times LE_{CHP-3,BL,y}, \quad (B.1-54)$$

$$EC_{UkrNIIHimMash,BL,y} = \beta_{EC,UkrNIIHimMash,BL} \times LE_{UkrNIIHimMash,BL,y}. \quad (B.1-55)$$

Reduction of heat and electricity consumption by evaporator plants due to the project

Heat savings are calculated as follows:

$$\Delta HC_{CHP,PJ,y} = HC_{CHP,BL,y} - HC_{CHP,PJ,y}, \quad (B.1-56)$$

where $\Delta HC_{CHP,PJ,y}$ is the savings of heat consumed for liquor evaporation due to the project during the year *y*, GJ.

Electricity savings are calculated as follows:

$$\Delta EC_{CHP,PJ,y} = EC_{CHP,BL,y} - EC_{CHP,PJ,y}, \quad (B.1-57)$$

where $\Delta EC_{CHP,PJ,y}$ is the savings of electricity consumed for liquor evaporation due to the project[7] during the year y, MWh.

Projected data on liquor evaporation volumes and heat and electricity consumption for each evaporator plant for the two scenarios are presented in Table B.1-13 below.

[7] It should be noted that savings of electricity consumed for liquor evaporation due to the project are negative.

Table B.1-13. Projected data on liquor volumes, heat and electricity consumption for evaporation for the period 2008-2012

Parameter	Unit	Years					
		2008	2009	2010	2011	2012	2008-2012
Project							
CHP-2 Evaporator Plant							
BL CPP	t a.d.m.	479 211	441 899	434 694	368 446	453 064	2 177 313
BL SBPP	t a.d.m.	110 751	118 852	118 685	103 839	97 949	550 076
Red liquor	t a.d.m.	27 056	37 267	40 609	59 057	59 111	223 101
Heat consumption	GJ	2 975 617	2 883 995	2 864 548	2 562 438	2 942 367	14 228 965
Electricity consumption	MWh	22 567	21 873	21 725	19 434	22 315	107 914
Specific heat consumption	GJ/t	4.823	4.823	4.823	4.823	4.823	4.823
Specific electricity consumption	MWh/t	0.0366	0.0366	0.0366	0.0366	0.0366	0.0366
CHP-3 Evaporator Plant							
BL SBPP	t a.d.m.	430 417	430 417	430 417	430 417	430 417	2 152 087
Heat consumption	GJ	1 646 196	1 646 196	1 646 196	1 646 196	1 646 196	8 230 982
Electricity consumption	MWh	8 427	8 427	8 427	8 427	8 427	42 134
Specific heat consumption	GJ/t	3.825	3.825	3.825	3.825	3.825	3.825
Specific electricity consumption	MWh/t	0.0196	0.0196	0.0196	0.0196	0.0196	0.0196
Baseline							
CHP-2 Evaporator Plants							
BL CPP	t a.d.m.	458 021	408 690	402 026	340 757	419 016	2 028 509
Heat consumption	GJ	3 119 625	2 783 631	2 738 240	2 320 929	2 853 958	13 816 384
Electricity consumption	MWh	4 699	4 193	4 125	3 496	4 299	20 813
Specific heat consumption	GJ/t	6.811	6.811	6.811	6.811	6.811	6.811
Specific electricity consumption	MWh/t	0.0103	0.0103	0.0103	0.0103	0.0103	0.0103
CHP-3 Evaporator Plant							
BL SBPP	t a.d.m.	541 169	549 270	549 102	534 256	528 366	2 702 162
Heat consumption	GJ	1 755 800	1 782 084	1 781 540	1 733 373	1 714 263	8 767 061
Electricity consumption	MWh	10 474	10 631	10 628	10 341	10 227	52 301
Specific heat consumption	GJ/t	3.244	3.244	3.244	3.244	3.244	3.244
Specific electricity consumption	MWh/t	0.0194	0.0194	0.0194	0.0194	0.0194	0.0194
"UkrNIIHimMash" Evaporator Plant							
Red liquor	t a.d.m.	27 056	37 267	40 609	59 057	59 111	223 101
Heat consumption	GJ	494 044	680 507	741 520	1 078 393	1 079 366	4 073 830
Electricity consumption	MWh	5 825	8 024	8 743	12 715	12 726	48 033
Specific heat consumption	GJ/t	18.260	18.260	18.260	18.260	18.260	18.260
Specific electricity consumption	MWh/t	0.2153	0.2153	0.2153	0.2153	0.2153	0.2153

Savings of heat and electricity for liquor evaporation due to the project							
Heat savings	GJ	747 655	716 032	750 555	924 061	1 059 025	4 197 328
Electricity savings	MWh	-9 995	-7 451	-6 656	-1 309	-3 490	-28 901

Increase in heat and electricity supply from ETHPS due to the project

Increase in heat and electricity supply from ETHPS under the project scenario compared with the baseline scenario will be due to increase of liquor-based steam production by liquor recovery boilers. Steam production will increase due to higher concentration of red liquor at the inlet to the boiler and due to larger quantities (on dry matter basis) of BL CPP being fed for combustion.

Additional production of heat in liquor recovery boilers due to increased concentration of red liquor

Before the project all red liquor flowed to "UkrNIIHimMash" evaporator plant where it was evaporated to concentration of 50-55% and then was fired in the liquor recovery boilers. After the project implementation all red liquor is now fed to the new evaporator plant of CHP-2, and then it is further evaporated in concentrators to achieve concentration of 63-65%. Such modifications made it possible to increase the net calorific value of liquor and therefore to increase heat production by the liquor recovery boilers by the following value:

$$\Delta HG_{BLRB,RL,PJ,y} = HG_{BLRB,RL,PJ,y} - HG_{BLRB,RL,BL,y}, \quad \text{(B.1-58)}$$

where $\Delta HG_{BLRB,RL,PJ,y}$ is the additional heat production by liquor recovery boilers under the project based on combustion of red liquor with a higher calorific value during the year y, GJ;

$HG_{BLRB,RL,PJ,y}$ is the heat production by liquor recovery boilers under the project scenario based on red liquor combustion during the year y, GJ;

$HG_{BLRB,RL,BL,y}$ is the heat production in liquor recovery boilers under the baseline scenario based on red liquor combustion during the year y, GJ.

Heat production by liquor recovery boilers based on red liquor combustion under the project scenario:

$$HG_{BLRB,RL,PJ,y} = LE_{CHP-2.RL,PJ,y} \times \left(NCV_{RL,PJ,y}\right)_{adm} \times \eta_{BLRB,y}, \quad \text{(B.1-59)}$$

where $LE_{CHP-2,RL,PJ,y}$ is the quantity of red liquor fed to the evaporator plant of CHP-2 under the project during the year y, t a.d.m;

$\left(NCV_{RL,PJ,y}\right)_{adm}$ is the weighted average net calorific value of red liquor referred to absolutely dry mass under the project in the year y, GJ/t a.d.m.[8];

$\eta_{BLRB,y}$ is the average efficiency of liquor recovery boilers in the year y.

Heat production by liquor recovery boilers based on red liquor combustion under the baseline scenario:

$$HG_{BLRB,RL,BL,y} = LE_{UkrNIIHimMash.RL,BL,y} \times \left(NCV_{RL,BL,y}\right)_{adm} \times \eta_{BLRB,y}, \quad \text{(B.1-60)}$$

where $LE_{UkrNIIHimMash,RL,BL,y}$ is the quantity of red liquor fed to "UkrNIIHimMash" evaporator plant under the baseline scenario during the year y, t a.d.m.;

$\left(NCV_{RL,BL,y}\right)_{adm}$ is the weighted average net calorific value of red liquor referred to absolutely dry mass under the baseline scenario in the year y, GJ/ t a.d.m.

Actual data on calorific value of red liquor and on efficiency of liquor recovery boilers for 2006, 2007 and for the first three quarters of 2008, as well as projections for the 4th quarter of 2008 are given in Table B.1-14. Actual values were determined using reporting data on performance of a group of liquor recovery boilers for the corresponding time periods (See also Annex 2.3).

[8] Calorific values of red liquors are determined on as-received (wet mass) basis but those are attributed to absolutely dry matter because the quantity of liquors is, by convention, determined on dry basis. This does not change the absolute quantity of heat energy of the liquor stream, less heat for water evaporation.

Calorific value in the 4th quarter of 2008 was assumed equal to the average value of the first three quarters of 2008. For the purposes of estimations for the period 2009-2012 the project calorific value of red liquor was assumed constant and equal to the average calorific value in 2008: $\left(NCV_{RL,PJ,y}\right)_{adm} = 9.903$ GJ/ t a.d.m. This value will be updated in the course of monitoring. For the baseline scenario calorific value of red liquor was assumed constant over the years and numerically equal to the average calorific value in 2006-2007: $\left(NCV_{RL,BL,y}\right)_{adm} = 8.845$ GJ/ t a.d.m.

Table B.1-14. Data on calorific value of red liquor and efficiency of liquor recovery boilers in 2006-2008

Parameter	Unit	2006	2007	2008				
				1st quarter	2nd quarter	3rd quarter	4th quarter	Year
Calorific value of red liquor	GJ/ t a.d.m.	8.933	8.757	10.039	9.750	9.920	9.903	9.903
Efficiency of liquor recovery boilers	%	89.21	89.70	91.21	91.37	90.73	91.10	91.10

Grey cells show actual data.

It is considered that the project will not affect the efficiency of liquor recovery boilers, and therefore in our estimations this value was assumed equaling to the average value over the first three quarters of 2008 for both scenarios: $\eta_{BLRB,y} = 0.910$. This value will be updated in the course of monitoring.

Additional production of heat by liquor recovery boilers due to combustion of more black liquor from CPP

Due to the project the yield of BL CPP per tonne of pulp has increased appreciably. With the commissioning of the new evaporator plant it became possible to extract more liquor from pulp washing at SAS-1, which became particularly appreciable in the 3rd quarter of 2008 (See Table B.1-3). Increased liquor supply for combustion resulted in the growth of heat production by liquor recovery boilers.

Both under the project and the baseline scenarios the entire stream of BL CPP is fed for evaporation to CHP-2, therefore additional heat production in the liquor recovery boilers is calculated as follows:

$$\Delta HG_{BLRB,BL\ CPP,PJ,y} = \left(LE_{CHP-2,BL\ CPP,PJ,y} - LE_{CHP-2,BL\ CPP,BL,y}\right) \times \left(NCV_{BL\ CPP,y}\right)_{adm} \times \eta_{BLRB,y}, \quad \text{(B.1-61)}$$

where $\Delta HG_{BLRB,BL\ CPP,PJ,y}$ is the additional heat production by liquor recovery boilers under the project due to combustion of increased quantity of BL CPP during the year y, GJ;

$LE_{CHP-2,BL\ CPP,PJ,y}$ is the quantity of BL CPP fed to the evaporator plant of CHP-2 under the project during the year y, t a.d.m.;

$LE_{CHP-2,BL\ CPP,BL,y}$ is the quantity of BL CPP fed to the evaporator plant of CHP-2 under the baseline during the year y, t a.d.m.;

$\left(NCV_{BL\ CPP,y}\right)_{adm}$ is the weighted average net calorific value of BL CPP referred to absolutely dry mass in the year y, GJ/t a.d.m.

Actual data on calorific value of black liquor in the first three quarters of 2008 and projected data for the 4th quarter of 2008 are given in Table B.1-15 below (See also Annex 2.3).

Table B.1-15. Data on calorific value of black liquor in 2008

Parameter	Unit	2008				
		1st quarter	2nd quarter	3rd quarter	4th quarter	Average
Black liquor calorific value	GJ/ t a.d.m.	9.689	9.711	9.769	9.723	9.723

Grey cells show actual data.

The project implementation does not have any effect on the calorific value of black liquor, and therefore the same value is assumed for the project and the baseline scenarios. For estimations the calorific value of black liquor is assumed constant over the years and numerically equal to the average calorific value in the first three quarters of 2008: $\left(NCV_{BL\ CPP,y}\right)_{adm} = 9.723$ GJ/ t a.d.m. This value will be updated in the course of monitoring.

Total additional heat output by liquor recovery boilers

$$\Delta HG_{BLRB,PJ,y} = \Delta HG_{BLRB,RL,PJ,y} + \Delta HG_{BLRB,BL\ CPP,PJ,y}, \tag{B.1-62}$$

where $\Delta HG_{BLRB,PJ,y}$ is the total additional heat output by liquor recovery boilers under the project during the year *y*, GJ.

Additional supply of heat and electricity from ETHPS

Additional quantity of steam produced by liquor recovery boilers will be fed to the turbines of ETHPS which will result in additional power generation and increased steam extraction from the turbines. The following specific parameters shall be used to determine the effective supply of heat and electricity knowing the steam production by the plant boilers.

Specific heat supply from ETHPS:

$$\varphi_{HS,CHP,y} = \frac{HS_{CHP,y}}{HG_{CHP,y}}, \tag{B.1-63}$$

where $\varphi_{HS,CHP,y}$ is the factor of specific heat supply from ETHPS during the year *y*, GJ/GJ;

$HS_{CHP,y}$ is the heat supply from ETHPS during the year *y*, GJ;

$HG_{CHP,y}$ is the total heat production by ETHPS boilers during the year *y*, GJ.

Specific supply of electricity from ETHPS:

$$\varphi_{ES,CHP,y} = \frac{ES_{CHP,y}}{HG_{CHP,y}}, \tag{B.1-64}$$

where $\varphi_{ES,CHP,y}$ is the factor of specific electricity supply from ETHPS during the year *y*, MWh/GJ;

$ES_{CHP,y}$ is the electricity supply from ETHPS during the year *y*, MWh.

Table B.1-16 below shows the required data on ETHPS performance in 2006-2007.

Table B.1-16. Production and supply of heat and electricity from ETHPS

Parameter	Units	2006	2007
Heat production by all boilers	GJ	13 351 874	12 980 228
Heat supply	GJ	10 645 753	10 201 559
Electricity supply	MWh	196 061	196 060
Specific heat supply	GJ/GJ	0.7973	0.7859
Specific electricity supply	MWh/GJ	0.0147	0.0151

Grey cells show actual data.

In the estimations for the years 2008-2012 the factors of specific heat and electricity supply from ETHPS are assumed constant over the years (this is justifiable because these values are assumed as being equivalent for the project and the baseline scenario) and numerically equal to average values in 2006-2007: $\varphi_{HS,CHP,y}$ = 0.7916 GJ/GJ, $\varphi_{ES,CHP,y}$ = 0.0149 MWh/GJ. These values will be updated in the course of monitoring.

Additional heat supply from ETHPS as a result of the project:

$$\Delta HS_{CHP,PJ,y} = \varphi_{HS,CHP,y} \times \Delta HG_{BLRB,PJ,y}, \tag{B.1-65}$$

where $\Delta HS_{CHP,PJ,y}$ is the additional heat supply from ETHPS due to higher heat output by liquor recovery boilers during the year *y*, GJ.

Additional electricity supply from ETHPS as a result of the project:

$$\Delta ES_{CHP,PJ,y} = \varphi_{ES,CHP,y} \times \Delta HG_{BLRB,PJ,y}, \tag{B.1-66}$$

where $\Delta ES_{CHP,PJ,y}$ is the additional electricity supply from ETHPS as a result of additional heat output by liquor recovery boilers during the year *y*, MWh.

The results of calculation of additional heat and electricity supply from ETHPS due to additional heat output by liquor recovery boilers are given in Table B.1-17 below.

Table B.1-17. The results of calculation of additional heat and electricity supply from ETHPS in 2008-2012

Parameter	Unit	Years					
		2008	2009	2010	2011	2012	2008-2012
Baseline data							
Red liquor based heat output by liquor recovery boilers							
Red liquor	t a.d.m.	27 056	37 267	40 609	59 057	59 111	223 101
Net calorific value of red liquor referred to absolutely dry mass	GJ/ t a.d.m.	8.845	8.845	8.845	8.845	8.845	8.845
Efficiency of liquor recovery boilers	%	91.10	91.10	91.10	91.10	91.10	91.10
Heat output by liquor recovery boilers	GJ	218 022	300 309	327 234	475 897	476 326	1 797 789
Project data							
Additional heat output by liquor recovery boilers due to increased concentration of red liquor							
Red liquor	t a.d.m.	27 056	37 267	40 609	59 057	59 111	223 101
Net calorific value of red liquor referred to absolutely dry mass	GJ/ t a.d.m.	9.903	9.903	9.903	9.903	9.903	9.903
Efficiency of liquor recovery boilers	%	91.10	91.10	91.10	91.10	91.10	91.10
Heat output by liquor recovery boilers	GJ	244 084	336 207	366 351	532 784	533 265	2 012 690
Additional heat output by liquor recovery boilers	GJ	26 062	35 898	39 116	56 887	56 938	214 901
Additional heat output by liquor recovery boilers due to increased combustion of BL CPP							
Increase of the quantity of BL CPP under the project	t a.d.m.	21 190	33 209	32 668	27 689	34 048	148 805
Net calorific value of BL CPP referred to absolutely dry mass	GJ/ t a.d.m.	9.723	9.723	9.723	9.723	9.723	9.723
Additional heat output by liquor recovery boilers	GJ	187 696	294 153	289 356	245 258	301 585	1 318 048
Total additional heat output by liquor recovery boilers							
Total additional heat output by liquor recovery boilers	GJ	213 757	330 051	328 473	302 145	358 523	1 532 949
Additional heat and electricity supply from ETHPS due to increased heat output by liquor recovery boilers under the project							
Specific heat supply	GJ/ GJ	0.7916	0.7916	0.7916	0.7916	0.7916	0.7916
Specific electricity supply	MWh/ GJ	0.0149	0.0149	0.0149	0.0149	0.0149	0.0149
Additional heat supply	GJ	169 216	261 277	260 028	239 186	283 816	1 213 523
Additional electricity supply	MWh	3 184	4 916	4 892	4 500	5 340	22 832

Heat savings due to reuse of warm water and condensates

The Mill has a high demand of hot water to meet its process needs. Due to the project the Mill now has an opportunity to reuse warm water, as well as relatively clean and treated condensates from liquor evaporation in its process flows. Thus it is possible to reduce not only fresh water demand but also heat (steam) consumption for water heating on the scale of the entire Mill.

Volumes of water and condensate from the new evaporator plant

Table B.1-18 below shows actual data for the first three quarters of 2008 and projected data for the 4th quarter of 2008 regarding volumes of cooling water and condensates, their specific consumption as well as quantities of liquor evaporated at the new evaporator plant of CHP-2.

Table B.1-18. New CHP-2 evaporator plant performance data

Parameter	Unit	2008				
		1st quarter	2nd quarter	3rd quarter	4th quarter	Year
Total liquors	t a.d.m.	152 045	150 731	154 527	159 715	617 018
Cooling water volume	m^3	4 050 950	6 979 392	8 195 213	7 931 405	27 156 960
Volume of relatively clean condensate	m^3	249 379	234 123	248 070	252 191	983 763
Volume of treated condensate	m^3	555 528	521 542	552 611	561 792	2 191 472
Specific consumption of cooling water	m^3/ t a.d.m.	26.638	46.295	53.025	49.660	49.660
Specific consumption of relatively clean condensate	m^3/ t a.d.m.	1.640	1.553	1.605	1.579	1.579
Specific consumption of treated condensate	m^3/ t a.d.m.	3.653	3.459	3.575	3.517	3.517

Grey cells show actual data.

The projections of cooling water and condensate volumes are based on their respective specific consumption per tonne of a.d.m. of evaporated liquor:

$$\varepsilon_{CWG,PJ,y} = \frac{CWG_{PJ,y}}{LE_{CHP-2,PJ,y}}, \quad \text{(B.1-67)}$$

$$\varepsilon_{PCG,PJ,y} = \frac{PCG_{PJ,y}}{LE_{CHP-2,PJ,y}}, \quad \text{(B.1-68)}$$

$$\varepsilon_{TCG,PJ,y} = \frac{TCG_{PJ,y}}{LE_{CHP-2,PJ,y}}, \quad \text{(B.1-69)}$$

where $\varepsilon_{CWG,PJ,y}$ is the specific consumption of cooling water under the project, m^3/t a.d.m.;

$\varepsilon_{PCG,PJ,y}$ is the specific consumption of relatively clean condensate under the project, m^3/t a.d.m.;

$\varepsilon_{TCG,PJ,y}$ is the specific consumption of treated condensate under the project, m^3/t a.d.m.;

$CWG_{PJ,y}$ is the volume of cooling water consumed under the project at the new evaporator plant during the year y, m^3;

$PCG_{PJ,y}$ is the volume of relatively clean condensate generated under the project at the new evaporator plant during the year y, m^3;

$TCG_{PJ,y}$ is the volume of treated condensate generated under the project at the new evaporator plant during the year y, m^3.

As shown in Table B.1-18, the specific cooling water consumption in the first quarter of 2008 differs a lot from the same data for the second and third quarters, which can be attributed to unstable operation of the new plant during the set up and adjustment period. For the estimations for the period 2008-2012 specific consumption values were assumed constant over the years and numerically equal to the respective average values for the 2nd and the 3rd quarters of 2008: $\varepsilon_{CWG,PJ,y} = 49.660$ m^3/t a.d.m.; $\varepsilon_{PCG,PJ,y} = 1.579$ m^3/t a.d.m.; $\varepsilon_{TCG,PJ,y} = 3.517$ m^3/t a.d.m.

The project volumes of cooling water, relatively clean condensate and treated condensate at the new evaporator plant during the year *y* are determined as follows:

$$CWG_{PJ,y} = \varepsilon_{CWG,PJ,y} \times LE_{CHP-2,PJ,y}, \quad \text{(B.1-70)}$$

$$PCG_{PJ,y} = \varepsilon_{PCG,PJ,y} \times LE_{CHP-2,PJ,y}, \quad \text{(B.1-71)}$$

$$TCG_{PJ,y} = \varepsilon_{TCG,PJ,y} \times LE_{CHP-2,PJ,y}. \quad \text{(B.1-72)}$$

Heat savings

Total heat savings due to reuse of cooling water and condensates is calculated using the following formula:

$$\Delta HC_{W,PJ,y} = HC_{CW,BL,y} + HC_{PC,BL,y} + HC_{TC,BL,y}, \quad \text{(B.1-73)}$$

where $\Delta HC_{W,PJ,y}$ is the total heat savings due to reuse of cooling water and condensates from the new evaporator plant during the year *y*, GJ;

$HC_{CW,BL,y}$ is the heat consumption for water heating for production needs under the baseline scenario during the year *y*, which under the project scenario will be offset by reuse of cooling water from the new evaporator plant, GJ;

$HC_{PC,BL,y}$ is the heat consumption for water heating for production needs under the baseline scenario during the year *y*, which under the project will be offset by reuse of relatively clean condensate from the new evaporator plant, GJ;

$HC_{TC,BL,y}$ is the heat consumption for water heating for production needs under the baseline scenario during the year *y*, which under the project will be offset by reuse of treated condensate from the new evaporator plant, GJ.

The projections of heat consumption are based on the following approximate formulae[9]:

$$HC_{CW,BL,y} = \frac{CWG_{PJ,y} \times (t_{2,CW,PJ,y} - t_1) \times \rho_w \times c_w}{1 \times 10^6}, \quad \text{(B.1-74)}$$

$$HC_{PC,BL,y} = \frac{PCG_{PJ,y} \times (t_{2,PC,PJ,y} - t_1) \times \rho_w \times c_w}{1 \times 10^6}, \quad \text{(B.1-75)}$$

$$HC_{TC,BL,y} = \frac{TCG_{PJ,y} \times (t_{2,TC,PJ,y} - t_1) \times \rho_w \times c_w}{1 \times 10^6}, \quad \text{(B.1-76)}$$

where t_1 is the average temperature of water at the inlet to the new evaporator plant, ^oC. It is assumed that without the project the entire volume of process water, equaling to the sum of cooling water and condensates from the new evaporator plant, would have this particular initial temperature at the inlet

[9] More precise formulae and input data will be used for monitoring (See Section D)

to the heaters. For the purpose of conservative estimation this temperature was assumed equal to t_1 = 24 °C, which is in accordance with the design data for the new evaporator plant [R2];

$t_{2,CW,PJ,y}$ is the average temperature of cooling water at the outlet from the new evaporator plant during the year *y*, °C. For estimations the value of this temperature was assumed constant over years and numerically equal to: $t_{2,CW,PJ,y} = 45$ °C; (in accordance with [R2]);

$t_{2,PC,PJ,y}$ is the average temperature of relatively clean condensate stream at the outlet from the new evaporator plant during the year *y*, °C. For estimations the value of this temperature was assumed constant over years and numerically equal to: $t_{2,PC,PJ,y} = 55$ °C (in accordance with [R2]);

$t_{2,TC,PJ,y}$ is the average temperature of treated condensate stream at the outlet from the new evaporator plant during the year *y*, °C. For estimations the value of this temperature was assumed constant over years and numerically equal to: $t_{2,TC,PJ,y} = 67$ °C; (in accordance with [R2]);

ρ_w is the water density, kg/m^3. Assumed equal to a constant value $\rho_w = 1000$ kg/m^3;

c_w is the specific thermal capacity of water, kJ/(kg×°C). Assumed equal to a constant value c_w = 4.187 kJ/(kg×°C).

The projection results for the period 2008-2012 are given in Table B.1-19 below.

Table B.1-19. Heat savings due to reuse of water and condensates from liquor evaporation process in 2008-2012

Parameters	Unit	Years					
		2008	2009	2010	2011	2012	2008-2012
Project data							
Total quantity of liquors fed to the new evaporator plant							
Liquor quantity	t a.d.m.	617 018	598 019	593 987	531 342	610 123	2 950 490
Specific consumption of cooling water and condensates							
Cooling water	m^3/t	49.660	49.660	49.660	49.660	49.660	49.660
Relatively clean condensate	m^3/t	1.579	1.579	1.579	1.579	1.579	1.579
Treated condensate	m^3/t	3.517	3.517	3.517	3.517	3.517	3.517
Volumes of cooling water and condensates							
Cooling water	m^3	27 156 960	29 697 477	29 497 229	26 386 301	30 298 558	143 036 526
Relatively clean condensate	m^3	983 763	944 277	937 909	838 993	963 389	4 668 331
Treated condensate	m^3	2 191 472	2 103 511	2 089 327	1 868 976	2 146 086	10 399 371
Average temperatures of cooling water and condensate streams after the new evaporator plant							
Cooling water	^oC	45	45	45	45	45	45
Relatively clean condensate	^oC	55	55	55	55	55	55
Treated condensate	^oC	67	67	67	67	67	67
Baseline data							
Heat consumption for water heating for process needs, which will be offset under the project by reuse of the following:							
Cooling water	GJ	2 387 830	2 611 210	2 593 603	2 320 068	2 664 061	12 576 773
Relatively clean condensate	GJ	127 689	122 564	121 738	108 899	125 045	605 935
Treated condensate	GJ	394 555	378 718	376 164	336 492	386 383	1 872 313
Total heat savings due to reuse of cooling water and condensates							
Heat savings	GJ	2 910 074	3 112 493	3 091 505	2 765 459	3 175 490	15 055 021

Heat supply from the utilizing boiler firing methanol fraction and malodorous gases

The project envisages combustion of methanol fraction and malodorous gases (which have been earlier released into the atmosphere) in a special fire-tube utilizing boiler with steam production for the Mill's production needs. Natural gas is used as a backup fuel. In the event of shutdown of the utilizing boiler, vapor-gas emissions and methanol fraction will be fired in the flare through a special burner. The backup fuel of the flare is natural gas as well.

Effective supply of heat from the utilizing boiler is calculated as per the following formula:

$$\Delta HS_{MGB,y} = HG_{MGB,y} \times \left(1 - k_B\right) \qquad (B.1\text{-}77)$$

where $\Delta HS_{MGB,y}$ is the additional supply of heat due to operation of the utilizing boiler during the year *y*, GJ;

$HG_{MGB,y}$ is the heat output by the utilizing boiler during the year *y*, GJ;

k_B is the relative heat consumption for the utilizing boiler's auxiliary needs.

The larger proportion of heat consumed for auxiliary needs of ETHPS is attributed to technological needs of LRB. According to a textbook for higher educational institutions [R9], heat consumption for heating up liquor and sulfate mixture and for heating up air in the air heater before LRB can be as much as 15% of the produced heat energy.

Bark-fired boilers have lower heat consumption for auxiliary needs; therefore the overall consumption for ETHPS is in the order of 12% (according to [R5]). But the larger proportion of it is attributed to constant technological demand which is essentially not related to additional steam production by the new fire-tube gas-fired boiler.

The value of relative heat consumption for auxiliary needs of the fire-tube boiler in accordance with the reference book on small-size boiler units [R10] could have been assumed equal to 0.02. But for conservative reasons the value of k_B was fixed at the level of 0.05.

Actual performance parameters of the fire-tube boiler over the first three quarters of 2008 and projected data for the 4th quarter of 2008 are given in the Table B.1-20 below. For conservative reasons, heat production and supply by the fire-tube boiler in the 4th quarter of 2008 are assumed to be equal to the minimum values of the respective parameters over the first three quarters of 2008.

Table B.1-20. Output and supply of heat by the utilizing boiler in 2008

Parameter	Unit	2008				
		1st quarter	2nd quarter	3rd quarter	4th quarter	Total
Heat output	GJ	33 823	28 957	35 079	28 957	126 816
Heat supply	GJ	32 131	27 509	33 325	27 509	120 475

Grey cells show actual data.

For projection calculations the boiler performance parameters for the period 2009-2012 were assumed constant and equal to their respective values in 2008 (See Table B.1-21).

Table B.1-21. Projected heat output and supply by the utilizing boiler in 2008-2012

Parameter	Unit	Years					
		2008	2009	2010	2011	2012	2008-2012
Heat output	GJ	126 816	126 816	126 816	126 816	126 816	634 079
Heat supply	GJ	120 475	120 475	120 475	120 475	120 475	602 375

Total savings of heat and electricity in the pulp production cycle

The above calculated effects of heat and electricity savings and additional heat and electricity supply as a result of the project directly relate to the principle process cycle of pulp production. The total heat savings are a sum of four effects:

$$\Delta HC_{PJ,y} = \Delta HC_{CHP,PJ,y} + \Delta HS_{CHP,PJ,y} + \Delta HC_{W,PJ,y} + \Delta HS_{MGB,y} \quad \text{(B.1-78)}$$

where $\Delta HC_{PJ,y}$ is the total heat savings in the pulp production cycle as a result of the project during the year *y*, GJ;

$\Delta HC_{CHP,PJ,y}$ is the savings of heat consumed for liquor evaporation due to the project during the year *y*, GJ;

$\Delta HS_{CHP,PJ,y}$ is the additional heat supply from ETHPS due to higher output of heat by liquor recovery boilers during the year *y*, GJ;

$\Delta HC_{W,PJ,y}$ is the total heat savings due to reuse of cooling water and condensates from the new evaporator plant during the year *y*, GJ;

$\Delta HS_{MGB,y}$ is the additional heat supply due to operation of the utilizing boiler during the year *y*, GJ.

The total savings of electricity in the pulp production cycle are a sum of two effects:

$$\Delta EC_{PJ,y} = \Delta EC_{CHP,PJ,y} + \Delta ES_{CHP,PJ,y}, \quad \text{(B.1-79)}$$

where $\Delta EC_{PJ,y}$ is the total electricity savings in the pulp production cycle as a result of the project during the year *y*, MWh;

$\Delta EC_{CHP,PJ,y}$ is the savings of electricity consumed for liquor evaporation as a result of the project during the year *y*, MWh;

$\Delta ES_{CHP,PJ,y}$ is the additional electricity supply from ETHPS due to additional heat output by liquor recover boilers during the year *y*, MWh.

Reduction of heat production by CHPP-1 boilers as a result of the project

The potential of fossil fuel savings at ETHPS had been almost completely used up even before the project. The total consumption of heavy fuel oil and natural gas by ETHPS boilers does not exceed 3% of the plant's total consumption of standard fuel, which can be considered a technological minimum. Therefore the total heat savings in the pulp production cycle should be attributed to CHPP-1 which is the external marginal source for the primary production.

Heat savings as a result of the project will lead to reduction of steam supply from the production steam extraction of CHPP-1 turbines. To determine the reduction of fuel consumption at CHPP-1 it is necessary to find the variation of fresh steam flow to the turbines.

Based on the steam-consumption diagrams of CHPP-1 turbines, equations were derived which describe variation of heat (fresh steam) flow to the turbines and variation of heat-consumption-based electricity generation depending on the variation of heat supply from the production steam extraction. It is impossible to determine precisely which turbines and for how long will participate in load regulation, therefore averaged equations were established by means of mathematical transformations taking into account the number of PT type turbines and their installed capacity (See Annex 2.4)

The variation of heat flow to the turbines depending on the variation of heat supply from production steam extraction is described by the following averaged equation:

$$\Delta Q_0 = 1,2485 \times \Delta Q_p \,, \qquad \text{(B.1-80)}$$

where ΔQ_0 is the variation of heat flow to the turbines, GJ;

ΔQ_p is the variation of heat supply from production extraction, GJ.

Taking into account losses in the Mill's steam network, heat flow factor and heat consumption for CHPP-1's auxiliary needs, the equation (B.1-80) is rearranged in the following form:

$$\Delta HG_{CHPP-1,y} = \frac{1,2485 \times \Delta HC_{PJ,y}}{(1-\omega_{HN}) \times (1-q_{CHPP-1}) \times \omega_{TF}} \,, \qquad \text{(B.1-81)}$$

where $\Delta HG_{CHPP-1,y}$ is the reduction of heat output by CHPP-1 boilers as a result of the project during the year y, GJ;

ω_{HN} is the relative losses in the Mill's steam network. This value is assumed constant over the years and equal to ω_{HN} = 0.02 (according to the Mill's data [R5]);

ω_{TF} is the heat flow factor. This value is assumed constant over the years and equal to ω_{TF} = 0.98 (according to [R3]);

q_{CHPP-1} is the relative heat consumption for the auxiliary needs of CHPP-1. This value is assumed constant over the years and equal to q_{CHPP-1} = 0.02 (According to [R3]).

<u>Reduction of electricity supply to the grid as a result of the project</u>

Reduction of steam supply to CHPP-1 turbines as a result of the project has an undesirable effect, i.e. reduction of heat-consumption-based electricity generation. Undergeneration of electricity, in general case, has to be offset by additional fuel consumption at the power plants in the grid (including CHPP-1).

The variation of electricity generation by CHPP-1 turbines depending on the variation of heat supply from the production steam extraction is described by the following averaged equation (See Annex 2.4):

$$\Delta N_t = \frac{0.2445 \times \Delta Q_p}{3.6} \,, \qquad \text{(B.1-82)}$$

where ΔN_t is the variation of heat-consumption-based electricity generation, MWh.

Taking into account losses in the Mill's steam network[10] and electricity consumption for auxiliary needs of CHPP-1, the equation (B.1-82) is rearranged in the following form:

$$\Delta ES_{CHPP-1,y} = \frac{0.2445 \times \Delta HC_{PJ,y} \left(1-e_{CHPP-1}\right)}{3.6 \times \left(1-\omega_{HN}\right)} \,, \qquad \text{(B.1-83)}$$

where $\Delta ES_{CHPP-1,y}$ is the reduction of heat-consumption-based electricity supply from CHPP-1 as a result of the project during the year y, MWh;

e_{CHPP-1} is the value of relative electricity consumption for auxiliary needs of CHPP-1.

Electricity consumption for auxiliary needs of the Mill's power plants according to [R5] amounts to around 13%, but they include a large proportion of constant demand, which does not depend on additional electricity generation (or undergeneration as is the case due to the project). It is obvious

[10] Losses in power networks were not taken into account, since they are included into CO_2 emission factor for grid electricity (See Section E).

that the variable demand proportion of the electricity consumption for auxiliary needs is significantly lower than overall electricity consumption for auxiliary needs of CHPP-1.

Due to the project implementation electricity supply from CHPP-1 is reduced. The value of relative electricity consumption for auxiliary needs of CHPP-1 (e_{CHPP-1}) influences the value of electricity supply from CHPP-1: the higher the electricity consumption for auxiliary needs - the lower the electricity supply (and the lower the negative impact of the project), and thus leakages reduce. Therefore the value of e_{CHPP-1} for conservative reasons was fixed at the level of 0.05 as recommended [R11].

Reduction of electricity supply to the grid:

$$\Delta ES_y = \Delta ES_{CHPP-1,y} - \Delta EC_{PJ,y}, \quad \text{(B.1-84)}$$

where ΔES_y is the reduction of electricity supply to the grid as a result of the project during the year y, MWh (this value determines the leakage).

Fuel savings within the project boundaries

Fuel savings within the project boundaries are a reduction of natural gas consumption[11] for steam production by CHPP-1 boilers less natural gas consumption by the utilizing boiler and the flare:

$$\Delta FC_{NG,y} = \Delta FC_{NG,CHPP-1,y} - FC_{NG,B+T,y}, \quad \text{(B.1-85)}$$

where $\Delta FC_{NG,y}$ is the savings of natural gas within the project boundaries during the year y, GJ;

$\Delta FC_{NG,CHPP-1,y}$ is the reduction of natural gas consumption at CHPP-1 as a result of the project during the year y, GJ (this value determines CO_2 emissions under the baseline scenario);

$FC_{NG,B+T,y}$ is the natural gas consumption in the utilizing boiler and in the flare during the year y, GJ (this value determines CO_2 emissions under the project scenario).

$$\Delta FC_{NG,CHPP-1,y} = \frac{\Delta HG_{CHPP-1,y}}{\eta_{B,CHPP-1}}, \quad \text{(B.1-86)}$$

where $\eta_{B,CHPP-1}$ is the efficiency of gas-fired boilers of CHPP-1. According to the Mill's data [R5] the efficiency is assumed at 93% and constant over the years.

$$FC_{NG,B+T,y} = FC_{NG,B,y} + FC_{NG,T,y}, \quad \text{(B.1-87)}$$

where $FC_{NG,B,y}$ is the natural gas consumption in the utilizing boiler during the year y, GJ;

$FC_{NG,T,y}$ is the natural gas consumption in the flare during the year y, GJ.

Actual consumption of natural gas under the project in the first three quarters of 2008 and projection data for the 4th quarter of 2008 (for conservative reasons and also in order to reduce uncertainty of the projected data these were assumed as maximum of the first three quarters) are given in Table B.1-22 below.

[11] In CHPP-1 the variation of fuel consumption was attributed entirely to natural gas consumption, both due to small volumes of coal combustion and due to conservative considerations.

Table B.1-22. Natural gas consumption in the utilizing boiler and in the flare in 2008

Parameter	Unit	2008				
		1st quarter	2nd quarter	3rd quarter	4th quarter	Total
Natural gas consumption in the utilizing boiler	GJ	23 263	23 345	25 040	25 040	96 688
Natural gas consumption in the flare	GJ	3 309	6 320	2 452	6 320	18 401

Grey cells show actual data.

For the purposes of estimations the boiler and flare performance parameters for the period 2009-2012 were assumed constant and equal to their respective values in 2008.

The final results of the project effects calculation are given in Table B.1-23 below. Data from this table represent the basis for calculation of GHG emission reductions (See Section E).

Table B.1-23. Results of calculation of the project effects for the period 2008-2012

Parameter	Units	Years					
		2008	2009	2010	2011	2012	2008-2012
Heat							
Reduction of heat consumption for liquor evaporation	GJ	747 655	716 032	750 555	924 061	1 059 025	4 197 328
Additional heat supply from ETHPS due to higher steam production by liquor recovery boilers	GJ	169 216	261 277	260 028	239 186	283 816	1 213 523
Heat savings due to reuse of cooling water and condensates for process needs	GJ	2 910 074	3 112 493	3 091 505	2 765 459	3 175 490	15 055 021
Additional heat supply due to installation of the utilizing boiler firing malodorous gases and methanol fraction	GJ	120 475	120 475	120 475	120 475	120 475	602 375
Total heat savings in the pulp production cycle	GJ	3 947 421	4 210 276	4 222 563	4 049 181	4 638 806	21 068 247
Reduction of heat output by CHPP-1 boilers	**GJ**	5 236 167	5 584 839	5 601 138	5 371 150	6 153 274	27 946 568
Electricity							
Reduction of electricity consumption for liquor evaporation	MWh	-9 995	-7 451	-6 656	-1 309	-3 490	-28 901
Additional electricity supply from ETHPS due to higher steam production by liquor recovery boilers	MWh	3 184	4 916	4 892	4 500	5 340	22 832
Total electricity savings in the pulp production cycle	MWh	-6 812	-2 535	-1 764	3 192	1 850	-6 069
Reduction of heat-consumption-based electricity supply from CHPP-1	MWh	259 920	277 228	278 037	266 620	305 444	1 387 249
Reduction of electricity supply to the grid	**MWh**	266 731	279 763	279 800	263 429	303 594	1 393 318
Fuel							
Reduction of natural gas consumption at CHPP-1	GJ	5 630 287	6 005 203	6 022 729	5 775 431	6 616 424	30 050 074
Consumption of natural gas in the utilizing boiler and in the flare	GJ	115 089	115 089	115 089	115 089	115 089	575 446
Natural gas savings within the project boundaries	**GJ**	5 515 198	5 890 114	5 907 640	5 660 341	6 501 335	29 474 627

Key parameters used for calculation of the baseline scenario parameters

Data / Parameter:	$\alpha_{BL\ CPP,BL}$
Data unit:	t a.d.m./t a.d.p.
Description:	Specific yield of BL CPP from one tonne of pulp by cooking under the baseline scenario
Time of determination:	Determined once at the stage of the project document preparation
Source of data used:	Internal data of Kotlas PPM
Value of data applied:	1.202
Justification of the choice of data or description of measurement methods and procedures applied:	For the period 2008-2012 it is assumed constant in magnitude and equal to the average value over 2006-2007. For the 4th quarter of 2007 it is assumed equal to the maximum value over the first three quarters
Any comment:	-

Data / Parameter:	$\beta_{HC,CHP-2,BL}$
Data unit:	GJ/t a.d.m.
Description:	Specific heat consumption by evaporator plants of CHP-2 under the baseline scenario
Time of determination:	Determined once at the stage of the project document preparation
Source of data used:	Internal data of Kotlas PPM
Value of data applied:	6.811
Justification of the choice of data or description of measurement methods and procedures applied:	For the period 2008-2012 it is assumed constant in magnitude and equal to the average value over 2006-2007. For the 4th quarter of 2007 it is assumed equal to the minimum value over the first three quarters
Any comment:	-

Data / Parameter:	$\beta_{HC,CHP-3,BL}$
Data unit:	GJ/t a.d.m.
Description:	Specific heat consumption by evaporator plant of CHP-3 under the baseline scenario
Time of determination:	Determined once at the stage of the project document preparation
Source of data used:	Internal data of Kotlas PPM
Value of data applied:	3.244
Justification of the choice of data or description of measurement methods and procedures applied:	For the period 2008-2012 it is assumed constant in magnitude and equal to the average value over 2006-2007. For the 4th quarter of 2007 it is assumed equal to the minimum value over the first three quarters
Any comment:	-

Data / Parameter:	$\beta_{HC,UkrNIIHimMash,BL}$
Data unit:	GJ/t a.d.m.
Description:	Specific heat consumption by UkrNIIHimMash evaporator plant under the baseline scenario

Time of determination:	Determined once at the stage of the project document preparation
Source of data used:	Internal data of Kotlas PPM
Value of data applied:	18.260
Justification of the choice of data or description of measurement methods and procedures applied:	For the period 2008-2012 it is assumed constant in magnitude and equal to the average value over 2006-2007
Any comment:	Specific heat consumption in 2007 is assumed equal to actual data for this year (although in the 4th quarter of 2007 red liquor started to be supplied to the new evaporator plant; the error of the baseline scenario calculations due to this fact can be considered as minimum)

Data / Parameter:	$\beta_{EC,CHP-2,BL}$
Data unit:	MWh/ta.d.m.
Description:	Specific electricity consumption by evaporator plants of CHP-2 under the baseline scenario
Time of determination:	Determined once at the stage of the project document preparation
Source of data used:	Internal data of Kotlas PPM
Value of data applied:	0.0103
Justification of the choice of data or description of measurement methods and procedures applied:	For the period 2008-2012 it is assumed constant in magnitude and equal to the average value over 2006-2007. For the 4th quarter of 2007 it is assumed equal to the minimum value over the first three quarters
Any comment:	-

Data / Parameter:	$\beta_{EC,CHP-3,BL}$
Data unit:	MWh/ta.d.m.
Description:	Specific electricity consumption by evaporator plant of CHP-3 under the baseline scenario
Time of determination:	Determined once at the stage of the project document preparation
Source of data used:	Internal data of Kotlas PPM
Value of data applied:	0.0194
Justification of the choice of data or description of measurement methods and procedures applied:	For the period 2008-2012 it is assumed constant in magnitude and equal to the average value over 2006-2007. For the 4th quarter of 2007 it is assumed equal to the minimum value over the first three quarters
Any comment:	-

Data / Parameter:	$\beta_{EC,UkrNIIHimMash,BL}$
Data unit:	MWh/ta.d.m.
Description:	Specific electricity consumption by UkrNIIHimMash evaporator plant under the baseline scenario
Time of determination:	Determined once at the stage of the project document preparation

Source of data used:	Internal data of Kotlas PPM
Value of data applied:	0.215
Justification of the choice of data or description of measurement methods and procedures applied:	For the period 2008-2012 it is assumed constant in magnitude and equal to the average value over 2006-2007
Any comment:	Specific electricity consumption in 2007 is assumed equal to actual data for this year (although in the 4th quarter of 2007 red liquor started to be supplied to the new evaporator plant; the error of the baseline scenario calculations due to this fact can be considered as minimum)

Data / Parameter:	$\left(NCV_{RL,BL,y}\right)_{adm}$
Data unit:	GJ/t a.d.m.
Description:	Weighted average net calorific value of red liquor referred to absolutely dry mass under the baseline scenario in the year *y*
Time of determination:	Determined once at the stage of the project document preparation
Source of data used:	Data of the analytical laboratory of Kotlas PPM
Value of data applied:	8.845
Justification of the choice of data or description of measurement methods and procedures applied:	For the period 2008-2012 it is assumed constant in magnitude and equal to the average value over 2006-2007
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:

(a) Description of the baseline scenario

The baseline scenario assumes that the existing evaporating equipment continues its operation in the previous mode with the pulp cooking volumes being maintained at the planned level. Black liquor from SAS-1 is evaporated at “Ramen” evaporator plants of CHP-2, black liquor from SAS-2 is evaporated at “Parsons&Whittemore” plant of CHP-3 and red liquor from NSSP is evaporated at “UkrNIIHimMash” plant No.2 of sulfite production (see Fig. A.4-4).

The insufficient capacity of “Ramen” plants leads to losses of black liquor during washing, and the density of red liquor is quite low because the evaporator plants of sulfite production have no concentrators. Specific steam consumption for evaporation is rather high. Warm water and condensate from evaporating units are contaminated and are, therefore, discharged into the sewer system without recycling. Harmful gases from evaporating units are emitted into the atmosphere.

(b) Description of the project scenario

The project scenario envisages construction of a new high-technology “Andritz” evaporator plant to replace “Ramen” plants which are to be decommissioned. Black liquor from SAS-1 and, partly, from SAS-2, as well as red liquor from NSSP are fed for evaporation to the new evaporator plant (see Fig. A.4-5). Methanol fraction and malodorous gases will be burnt in the utilizing boiler to be installed at CHP-2 to produce additional heat. Warm water, relatively clean and treated condensates from evaporating units will be reused in process flows.

Implementation of the project makes it possible to reduce energy intensity of production, redistribute liquor streams between evaporator plants, stabilize operation of the process equipment, increase liquor separation during pulp washing, increase net calorific value of red liquors, reduce water consumption, mitigate the Mill's negative environmental impacts, cut down on CHPP-1's fossil fuel consumption and GHG emissions.

(c) Additionality

The alternative analysis, investment analysis, barrier analysis and common practice analysis were developed to demonstrate additionality of the project.

Analysis of Alternatives

The following baseline alternatives, which in principle could ensure operation of the Mill's evaporation system with the pulp cooking volumes being kept at the planned level, were identified for the project.

Alternative 1: Continuation of the current situation.

Alternative 2: Project activity without JI and without NPAF soft loan;

Alternative 3: Project activity without JI but with NPAF soft loan.

Let us review each alternative.

Alternative 1: Continuation of the current situation.

This alternative assumes that the existing scheme of liquor evaporation is retained. Given the technical condition of the old "Ramen" evaporator plants No.1 and No.2, basically, it was possible to continue their operation for a number of years, at least until 2012, carrying out routine maintenance, which does not require large investments.

Additional expenses on the routine maintenance and repair of "Ramen" plants as compared with the cost assumptions for the new plant were estimated at 2.5 million RUR per year. However, even if the old plants were operated for another ten years, additional repair costs over this period would not amount to more than 5% of the capital investments into the new evaporator plant.

The shortage of financial resources and low profitability of the project without soft loans and additional revenues from emission reductions sale (see the Investment Analysis) make *Alternative I the most likely baseline scenario*.

Alternative 2: Project activity without JI and without NPAF soft loan.

This alternative envisages modernization of the Mill's evaporation system by replacement of the old "Ramen" evaporator plants with new modern equipment without JI mechanism and without procurement of a soft loan from NPAF.

Implementation of this proposal hits a serious financial barrier. The enterprise did not have sufficient resources for implementation of the project, and it was common commercial practice for Russian banks in the early 2000-s to extend only short-term credits. Moreover, the investment analysis shows that the return on the investments for this alternative is low. Thus*, implementation of Alternative 2 as the baseline scenario is unlikely.*

Alternative 3: Project activity without JI but with NPAF soft loan.

This alternative is similar to the previous one, the only difference being that here a significant part of the investment costs is covered by the soft loan extended by NPAF. This soft loan was provided pretty much because the project generates GHG emission reductions. In its report on the results of the investment project assessment, the ED of NPAF [R5] recommended that Kotlas PPM should take the advantage of JI mechanism to offset some of its costs. To reject such recommendation would be unreasonable on the part of the enterprise. More so that without selling the achieved reductions the project could never become sufficiently attractive in terms of financial return (see the Investment Analysis).

Thus, *implementation of Alternative 3 as the baseline scenario is unlikely*.

Summarizing the above Analysis of Alternatives and taking into account the results of the Investment Analysis, Alternative 1, which envisages continuation of the current situation, is chosen as the most likely baseline scenario.

Investment Analysis

The Investment Analysis was undertaken to evaluate investment efficiency for the following three project Alternatives:

Alternative 2: Project activity without JI and without NPAF soft loan;

Alternative 3: Project activity without JI but with NPAF soft loan;

Alternative 4: Project activity with JI and NPAF soft loan.

The Investment Analysis is based on the data, which had been available before the decision regarding the project feasibility was taken. It was expected that the project financing would become available in July 2003 and the new evaporator plant would be commissioned by the beginning of the second quarter of 2005.

The total amount of investments into the project, including import duties and VAT, was estimated at USD 21.63 million. The soft loan from NPAF amounts to USD 11 million.

The revenue sources of the project are as follows: savings of fuel purchase costs; reduction of chemicals consumption; reduction of fresh river water demand; reduction of environmental fees; cutting of repair and rehabilitation costs of "Ramen" evaporator plants (calculated as the difference between the existing repair costs of the operating equipment and the estimated costs of the new evaporator plant); and sale of GHG emission reductions (Alternative 4).

Average selling prices of ERUs (2008-2012) and early reductions (2005-2007) were assumed identical and equal to 5 $/t$CO_2$.

The discount rate was determined with the help of one of the most widely used methods, namely cumulative method of risk premium assessment[3]. This method is based on the following formula:

$$R = R_f + R_1 + ... + R_n, \qquad (B.2\text{-}1)$$

Where R is the sought discount rate;

R_f is the risk-free rate of return;

R_1, ..., R_n is the risk premium for different risk factors.

Generally, government securities are considered to be (conditionally) risk-free assets. In Russia such assets could be Russia-30 Eurobonds with a 30-year maturity period. Thus in the mid-2003 the rate of return on these bonds was around 7 p.a.[4].

Considering that the implemented technology is new to Kotlas Pulp and Paper Mill, the risk of not getting the income envisaged by the project was estimated as medium, and the respective risk premium was estimated at 10%. Other risk premiums (risk of partner unreliability, country risk) are estimated in sum at the level of 5%.

The final discount rate (hurdle rate of return) was assumed at 20%.

Detailed information on the Investment Analysis of Alternatives is given in Annexes 2.5-2.7.

[3] http://www.fd.ru/article/1716.html

[4] http://www.rcb.ru/rcb/2005-15/7020/

Table B.2-1 below shows the main economic performance indicators of the project scenario for all three alternatives.

Table B.2-1. Economic performance parameters of the project activity

Name	Units	Alternative 2	Alternative 3	Alternative 4
Investments	000 $	21 630	21 630	21 630
NPV	000 $	-3 600.6	-1 461.5	1 481.3
IRR	%	14.0	15.9	24.1

Without selling GHG emission reductions and without NPAF loan the project cannot be considered financially viable, because NPV (net present value) is negative (-3600.6 thousand USD), and IRR (internal rate of return) is below the hurdle level (14.0% against 20%).

With NPAF soft loan the project becomes more financially attractive, but yet remains unprofitable, because NPV is still negative (-1 461.5 thousand USD), and IRR is below the hurdle level (15.9% against 20%).

However, when loan procurement opportunity and emission reduction sale are taken into account, the project performance indicators improve by far: NPV becomes positive and equals to 1 481.3 thousand USD and IRR goes up to 24.1%, which is above the hurdle rate of return.

Table B.2-2 shows the project sensitivity analysis.

Table B.2-2. Sensitivity analysis of economic parameters

Name	Units	Alternative 2	Alternative 3	Alternative 4
1) Growth of investment costs by 10%				
NPV	000 $	-4 968.0	-2 828.9	113.8
IRR	%	12.3%	13.1%	20.3%
2) Reduction of the projected level of cost savings by 10%				
NPV	000 $	-4 663.2	-2 524.0	418.7
IRR	%	12.1%	12.8%	21.2%

The sensitivity analysis shows that without carbon revenues, the growth of investment costs by 10% or reduction of the projected level of cost savings by 10% make the project completely unprofitable even if the soft loan is obtained, whereas with emission reduction sale NPV remains positive and IRR does not drop below the hurdle IRR.

Thus, the undertaken analysis shows that even if the soft loan from NPAF is obtained, the project can not be reasonably profitable and will be highly sensitive to risks without carbon revenues.

Barrier Analysis

Implementation of the project by Koryazhma Branch of “Ilim Group” hits the following major barriers:

<u>Financial barriers</u>

The high cost of imported equipment, including its delivery and customs clearance, determine the high investment value of the project. Initially, capital investments were estimated at USD 21.63 million. For Kotlas PPM it was quite a problem to allocate such amount of internal resources for the project implementation. At least it was challenging in the early 2000s, when the economic growth just began in Russia. Credits from commercial banks could not significantly relieve the situation, because the maturity of such credits was up to 3 years, which is much less than the project payback period.

It was because the project had low investment attractiveness and faced financial barriers, that the management of the Mill from the very beginning considered the opportunity of raising resources for the project implementation through procurement of a soft loan and sale of emission reductions within the framework of the Kyoto Protocol.

On October 24, 2002 Kotlas PPM submitted an application for a Subloan to the Executive Directorate of NPAF for financing of the investment project “Pollution Abatement at OJSC “Kotlas Pulp and Paper Mill” Through Replacement of Evaporator Plant”. On January 15, 2003 the project was approved by the NPAF Supervisory Board. On April 23, 2003 the International Bank of Reconstruction and Development (IBRD) granted its “no objections” visa. The loan in the amount of USD 11 million did not become available until a notification thereof was received from the Russian Ministry of Finance on April 23, 2004.

The project received financing from the IBRD largely owing to its significant emission reductions and because additional carbon revenues could be used to repay the credit.

In 2003, in parallel with the execution of documents for obtaining the soft credit, Kotlas PPM submitted a tender bid under the Emission Reduction Unit Procurement Tender (ERUPT) programme implemented by SENTER Agency of the Netherlands Ministry of Economic Affairs. The project qualified, but since there was no official approval by the Russian Government of Russia’s participation in the ERUPT programme, the project had to be excluded from further consideration.

However, later on, OJSC “Ilim Group” made a decision to develop the Evaporator System Modernization Project as a JI project. To this end in 2008 the company began cooperation with CCGS Ltd., which acts as a consultant and a commercial agent of OJSC “Ilim Group”.

It should be noted that the project faced a high risk of project cost escalation. Actual value of the project as compared with the planned value has almost doubled from 21.63 to 40.56 million USD due to the rise in the cost of equipment and construction and installation works. The shortfall of investments was bridged by internal resources of the enterprise. The larger proportion of investment costs was incurred in 2006-2007.

<u>Operational barrier</u>

The Mill had never before installed/operated evaporator plants of this type. The Mill encountered a number of difficulties in the process of set up and start up of the equipment. In addition to setting-up of the plant equipment proper it also became necessary to redistribute liquor streams from the pulp cooking line between the new and the existing evaporator plants, provide for utilization of methanol fraction and malodorous gases, arrange condensate flows and cooling water streams and to provide for their recycling. Operation of state-of-the-art equipment requires from the personnel (workers, engineers and managers) a high level of motivation, morale, skills and knowledge. To ensure proper operation of such sophisticated equipment it was necessary to arrange special training for the maintenance personnel. This task required time and money.

Common practice analysis

Kotlas PPM, for the first time in Russia, implemented a unique set of technical solutions for modernization of its evaporation system using state-of-the-art technologies. In addition to the liquor evaporation proper, the process flow scheme provides for separation of condensates into relatively clean and highly contaminated streams and has an in-built stripping column for treatment of highly contaminated condensates. The scheme also envisages a system for collection and efficient utilization of sulfur-containing malodorous vapour gas emissions and methanol fraction with further desulfurization of gaseous emissions which provides for utilisation of sulfur dioxide.

Such complex evaporation system modernization projects have not been implemented at any other pulp and paper mills in Russia. Therefore this project is not common practice.

In our opinion, the above given reasons are sufficient to recognize that GHG emission reductions generated by 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:

Table B.3-1 below shows which sources and gases are included in the project boundaries and which are excluded thereof. Figures B.3-1 and B.3-2 show main components and boundaries for the project and baseline scenarios. This scheme also shows main flows of liquor, fuel, water and energy.

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

	Source	Gas	Incl./Excl.	Justification / Explanation
Baseline	CHPP-1, increase in natural gas combustion compared to the project	**CO_2**	**Incl.**	**Main emission source**
		CH_4	Excl.	Negligibly small. Conservative
		N_2O	Excl.	Negligibly small. Conservative
Project	Utilizing boiler and flare, natural gas consumption	**CO_2**	**Incl.**	**Main emission source**
		CH_4	Excl.	Negligibly small
		N_2O	Excl.	Negligibly small
	Utilizing boiler and flare, combustion of malodorous gases and methanol	CO_2	Excl.	Assumed equal to zero
		CH_4	Excl.	Negligibly small
		N_2O	Excl.	Negligibly small
	ETHPS (liquor recovery boilers), Increase in liquor combustion compared to the baseline	CO_2	Excl.	Assumed equal to zero
		CH_4	Excl.	Negligibly small
		N_2O	Excl.	Negligibly small
Leakage	Power plants in the power grid, combustion of fuel to make up for the reduction of electricity supply to the grid	**CO_2**	**Incl.**	**Significant emissions that cannot be neglected**
		CH_4	Excl.	Negligibly small
		N_2O	Excl.	Negligibly small

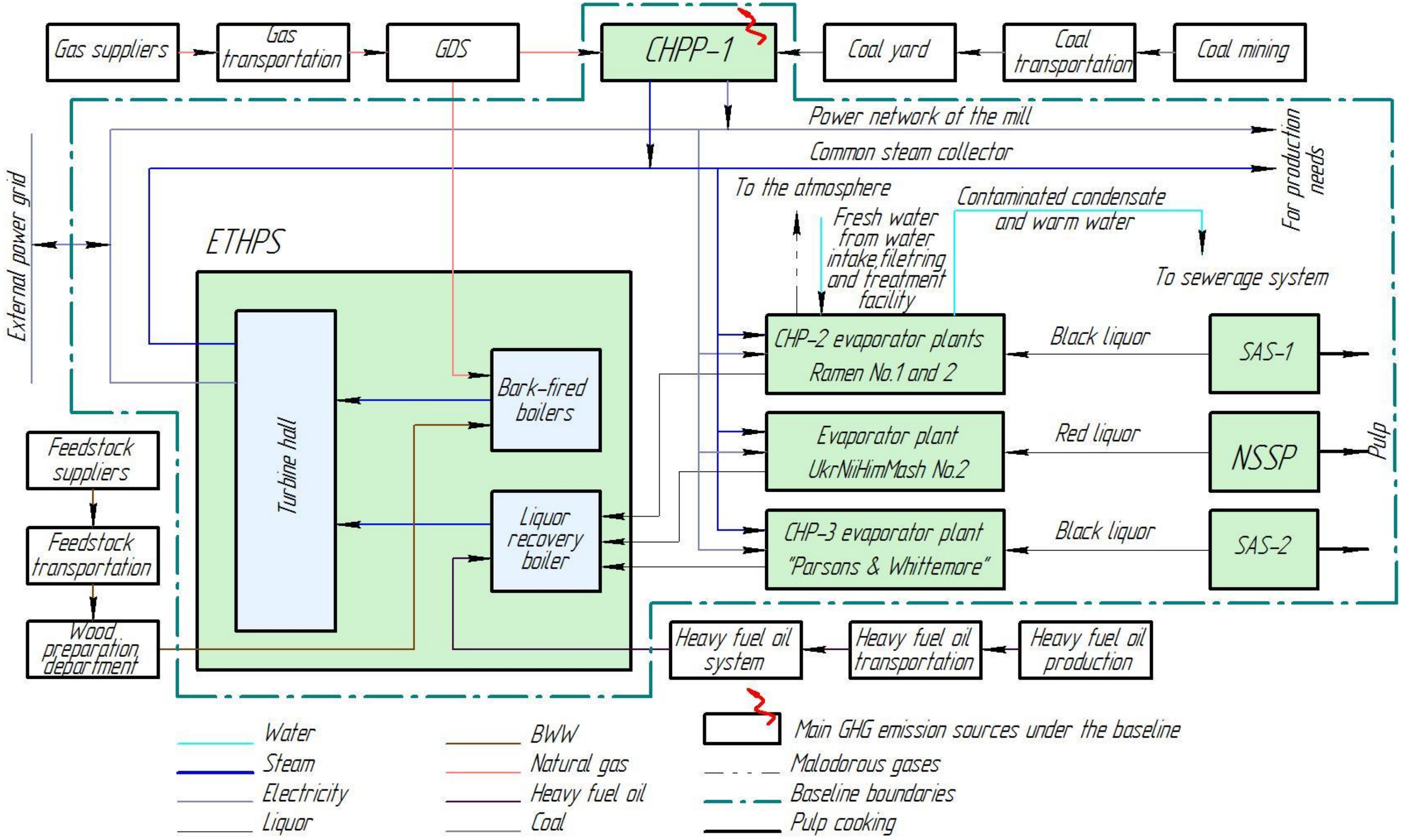

Fig. B.3-1. Main components and boundaries of the baseline scenario

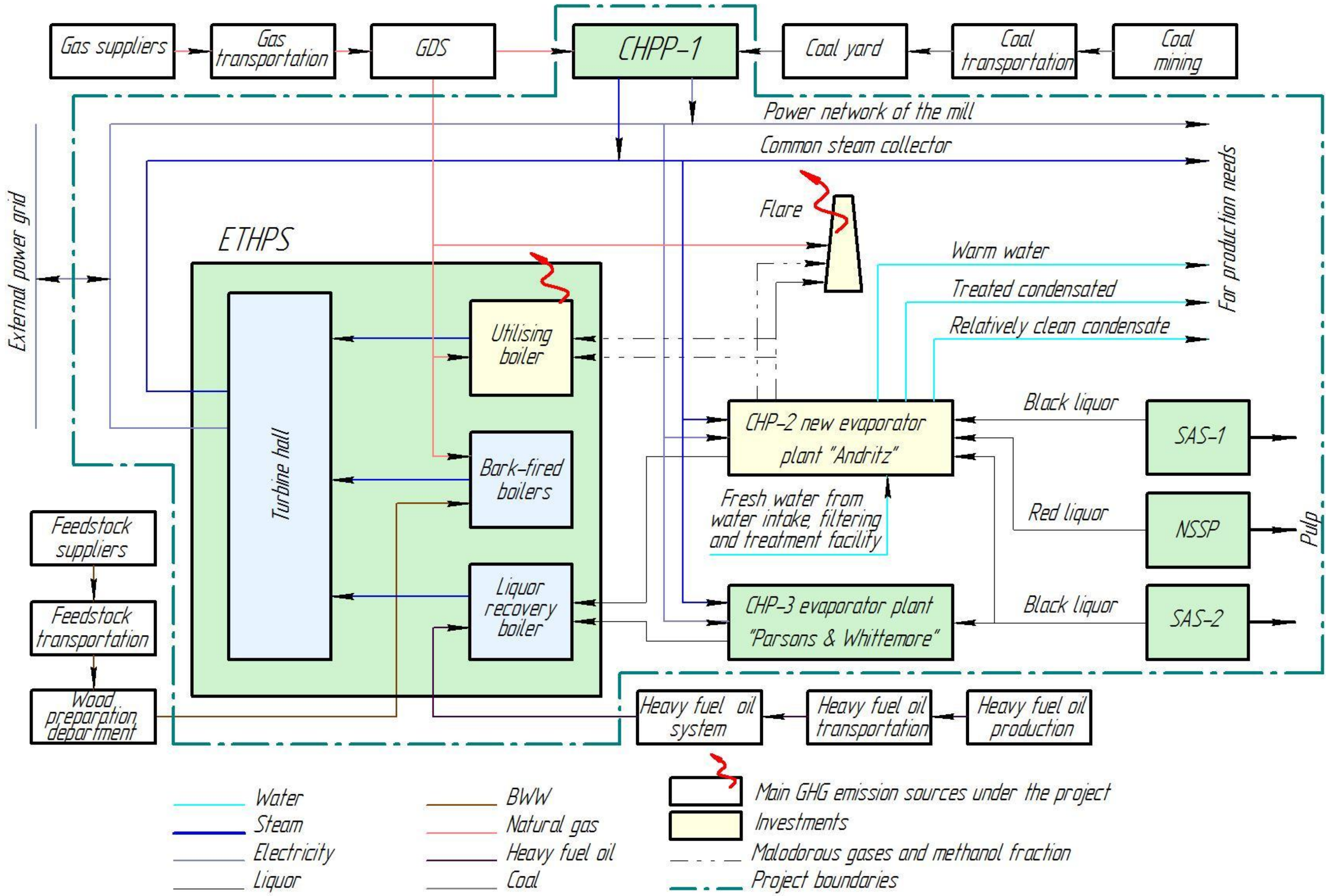

Fig. B.3-2. Main components and boundaries of the project scenario

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

Baseline development date: 20/12/2008.

Baseline was developed by CCGS Ltd. (CCGS Ltd. is not the project participant listed in Annex 1 of PDD).

Contact person: Dmitry Potashev

E-mail: d.potashev@ccgs.ru

SECTION C. Duration of the project / crediting period

C.1. Starting date of the project:

January 11, 2005 (date of the contract signed with “Andritz” for supply of evaporator plant equipment).

C.2. Expected operational lifetime of the project:

25 years / 300 months.

C.3. Length of the crediting period:

5 years / 60 months (from January 1, 2008 till December 31, 2012)

SECTION D. Monitoring plan

D.1. Description of monitoring plan chosen:

The monitoring plan was developed on the basis of our own approach in accordance with the specifics of the project and requirements of *Decision 9/CMP.1*, *Appendix B* [R1] without using any approved CDM methodologies.

Collection of data (to be recorded in any case) required for estimation of GHG emission reductions is performed in compliance with the highest sectoral standards and best practice of fuel and energy monitoring and environmental impact assessment.

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. $FC^{v}_{NG,B,y}$	Volumetric consumption of natural gas by the utilizing boiler	The Mill's Energy Service	Thousand m^3	m	Continuously	100 %	Electronic and paper	Flow meter readings
2. $FC^{v}_{NG,T,y}$	Volumetric consumption of natural gas by the flare	The Mill's Energy Service	Thousand m^3	m	Continuously	100 %	Electronic and paper	Flow meter readings
3. $NCV_{NG,y}$	Weighted average net calorific value of natural gas	Production laboratory, the Mill's Energy Service	GJ/thousand m^3	m	Once per week	100 %	Electronic and paper	Weighted average value is determined at the end of the year *y*

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 GHG emissions during the year *y*, t CO_2e:

$$PE_y = PE_{NG,y}, \quad \text{(D.1-1)}$$

where $PE_{NG,y}$ is the project emissions of CO_2 from natural gas combustion in the utilizing boiler and in the flare during the year *y*, t CO_2.

$$PE_{NG,y} = FC_{NG,B+T,y} \times EF_{CO2,NG},\qquad (D.1\text{-}2)$$

where $EF_{CO2,NG}$ is the emission factor for natural gas, t CO_2/GJ. According to IPCC [R7], and with an allowance for the oxidized carbon fraction of 0.995, this factor is assumed constant and equal to $EF_{CO2,NG}$ =0.0561×0.995=0.05582 t CO_2/GJ;

$FC_{NG,B+T,y}$ is the natural gas consumption by the utilizing boiler and the flare during the year y, GJ.

$$FC_{NG,B+T,y} = FC_{NG,B,y} + FC_{NG,T,y},\qquad (D.1\text{-}3)$$

where $FC_{NG,B,y}$ is the natural gas consumption by the utilizing boiler during the year y, GJ;

$FC_{NG,T,y}$ is the natural gas consumption by the flare during the year y, GJ.

$$FC_{NG,B,y} = FC^{v}_{NG,B,y} \times NCV_{NG,y},\qquad (D.1\text{-}4)$$

where $FC^{v}_{NG,B,y}$ is the volumetric consumption of natural gas by the utilizing boiler during the year y, thousand m^3;

$NCV_{NG,y}$ is the weighted average net calorific value of natural gas during the year y, GJ/ thousand m^3.

$$FC_{NG,T,y} = FC^{v}_{NG,T,y} \times NCV_{NG,y},\qquad (D.1\text{-}5)$$

where $FC^{v}_{NG,T,y}$ is the volumetric consumption of natural gas by the flare under the project during the year y, thousand m^3.

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
4. $P_{1,y}$	Volume of pulp produced in the pulp cooking workshop SAS-1	The Mill's commercial Department, SAS-1 cooking workshop	t a.d.p.	m	Continuously	100 %	Electronic and paper	Flow meter readings
5. $FC_{fuel\ oil,BLRB,y}$	Heavy fuel oil consumption by liquor recovery boilers under the project	The Mill's Energy Service	t	m	Continuously	100 %	Electronic and paper	Flow meter readings

6. $\left(NCV_{RL,PJ,y}\right)_{adm}$	Weighted average net calorific value of red liquor referred to absolutely dry mass under the project	Production laboratory, the Mill’s Energy Service	GJ/t a.d.m.	m	Once per week	100 %	Electronic and paper	Weighted average value is determined at the end of the year *y*
7. $\left(NCV_{BL\ CPP,y}\right)_{adm}$	Weighted average net calorific value of BL CPP referred to absolutely dry mass	Production laboratory, the Mill’s Energy Service	GJ/t a.d.m.	m	Once per week	100 %	Electronic and paper	Weighted average value is determined at the end of the year *y*
8. $\left(NCV_{BL\ SBPP,y}\right)_{adm}$	Weighted average net calorific value of BL SBPP referred to absolutely dry mass	Production laboratory, the Mill’s Energy Service	GJ/t a.d.m.	m	Once per week	100 %	Electronic and paper	Weighted average value is determined at the end of the year *y*
9. $NCV_{fuel\ oil,y}$	Weighted average net calorific value of heavy fuel oil	Fuel certificate	GJ/t a.d.m.	m	For each supplied batch of heavy fuel oil	100 %	Electronic and paper	Weighted average value is determined at the end of the year *y*
10. $HC_{CHP-3,PJ,y}$	Heat consumption at the evaporator plant of CHP-3 under the project	The Mill’s Energy Service	GJ	m	Continuously	100 %	Electronic and paper	Heat meter readings
11. $HC_{CHP-2,PJ,y}$	Heat consumption at the evaporator plant of CHP-2 under the project	The Mill’s Energy Service	GJ	m	Continuously	100 %	Electronic and paper	Heat meter readings
12. $HG_{MGB,y}$	Heat production by the utilizing boiler	The Mill’s Energy Service	GJ	m	Continuously	100 %	Electronic and paper	Heat meter readings
13. $HG_{BLRB,PJ,y}$	Total heat produced by liquor recovery boilers under the project	The Mill’s Energy Service	GJ	m	Continuously	100 %	Electronic and paper	Heat meter readings
14. $HG_{BWWB,PJ,y}$	Total heat produced by BWW-fired boilers under the project	The Mill’s Energy Service	GJ	m	Continuously	100 %	Electronic and paper	Heat meter readings
15. $HS_{CHP,PJ,y}$	Heat supply from ETHPS under the project	The Mill’s Energy Service	GJ	m	Continuously	100 %	Electronic and paper	Heat meter readings
16. $LE_{CHP-2,RL,PJ,y}$	Quantity of red liquor fed to the evaporator plant of CHP-2 under the project	The Mill’s Energy Service	t a.d.m.	m	Continuously	100 %	Electronic and paper	Flow meter readings

17. $LE_{CHP-2,BL\ CPP,PJ,y}$	Quantity of BL CPP fed to the evaporator plant of CHP-2 under the project	The Mill's Energy Service	t a.d.m.	m	Continuously	100 %	Electronic and paper	Flow meter readings
18. $LE_{CHP-2,BL\ SBPP,PJ,y}$	Quantity of BL SBPP fed to the evaporator plant of CHP-2 under the project	The Mill's Energy Service	t a.d.m.	m	Continuously	100 %	Electronic and paper	Flow meter readings
19. $LE_{CHP-3,BL\ SBPP,PJ,y}$	Quantity of BL SBPP fed to the evaporator plant of CHP-3 under the project	The Mill's Energy Service	t a.d.m.	m	Continuously	100 %	Electronic and paper	Flow meter readings
20. $CWG_{PJ,i,y}$	Volume of warm water returned for reuse under the project	The Mill's Energy Service	m^3	m	Continuously	100 %	Electronic and paper	Flow meter readings
21. $PCG_{PJ,i,y}$	Volume of relatively clean condensate returned for reuse under the project	The Mill's Energy Service	m^3	m	Continuously	100 %	Electronic and paper	Flow meter readings
22. $TCG_{PJ,i,y}$	Volume of treated condensate returned for reuse under the project	The Mill's Energy Service	m^3	m	Continuously	100 %	Electronic and paper	Flow meter readings
23. $t_{1,i,y}$	Water temperature at the inlet to the new evaporator plant	The Mill's Energy Service	^oC	m	Continuously	100 %	Electronic and paper	Temperature gage readings
24. $t_{2,CW,PJ,i,y}$	Temperature of warm water stream at the outlet from the new evaporator plant	The Mill's Energy Service	^oC	m	Continuously	100 %	Electronic and paper	Temperature gage readings
25. $t_{2,PC,PJ,i,y}$	Temperature of relatively clean condensate stream at the outlet from the new evaporator plant	The Mill's Energy Service	^oC	m	Continuously	100 %	Electronic and paper	Temperature gage readings
26. $t_{2,TC,PJ,i,y}$	Temperature of treated condensate stream at the outlet from the new evaporator plant	The Mill's Energy Service	^oC	m	Continuously	100 %	Electronic and paper	Temperature gage readings

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 during the year *y*, t CO_2e:

$$BE_y = BE_{NG,y}, \tag{D.1-6}$$

where $BE_{NG,y}$ is the baseline emissions of CO_2 from natural gas combustion during the year *y*, t CO_2.

$$BE_{NG,y} = \Delta FC_{NG,CHPP-1,y} \times EF_{CO2,NG}, \tag{D.1-7}$$

where $\Delta FC_{NG,CHPP-1,y}$ is the reduction of natural gas consumption at CHPP-1 due to the project during the year *y*, GJ;

$$\Delta FC_{NG,CHPP-1,y} = \frac{\Delta HG_{CHPP-1,y}}{\eta_{B,CHPP-1}}, \tag{D.1-8}$$

where $\eta_{B,CHPP-1}$ is the efficiency of gas-fired boilers of CHPP-1. This efficiency is assumed constant over years and equal to $\eta_{B,CHPP-1}$ = 0.93. See Section B.1;

$\Delta HG_{CHPP-1,y}$ is the reduction of heat production by CHPP-1 boilers due to the project during the year *y*, GJ.

$$\Delta HG_{CHPP-1,y} = \frac{1,2485 \times \Delta HC_{PJ,y}}{(1-\omega_{HN}) \times (1-q_{CHPP-1}) \times \omega_{TF}}, \tag{D.1-9}$$

where ω_{HN} is the relative losses in the Mill's steam network. This value is assumed constant over years and equal to ω_{HN} = 0.02. See Section B.1;

ω_{TF} is the heat flow factor. This value is assumed constant over years and equal to ω_{TF} = 0.98. See Section B.1;

q_{CHPP-1} is the relative heat consumption for auxiliary needs of CHPP-1. This value is assumed constant over years and equal to q_{CHPP-1} = 0.02. See Section B.1;

1.2485 is the factor which describes the relation between variation of fresh steam flow to turbines and variation of heat supply from production steam extraction of turbines. See Annex 2.4;

$\Delta HC_{PJ,y}$ is the total heat savings in the pulp production cycle due to the project during the year *y*, GJ.

$$\Delta HC_{PJ,y} = \Delta HC_{CHP,PJ,y} + \Delta HS_{CHP,PJ,y} + \Delta HC_{W,PJ,y} + \Delta HS_{MGB,y}, \tag{D.1-10}$$

where $\Delta HC_{CHP,PJ,y}$ is the savings of heat consumed for liquor evaporation due to the project during the year *y*, GJ;

$\Delta HS_{CHP,PJ,y}$ is the additional heat supply from ETHPS due to increased heat production by liquor recovery boilers during the year *y*, GJ;

$\Delta HC_{W,PJ,y}$ is the total heat savings due to reuse of warm water and condensates from the new evaporator plant during the year *y*, GJ;

$\Delta HS_{MGB,y}$ is the additional heat supply due to operation of the utilizing boiler during the year *y*, GJ.

$$\Delta HC_{CHP,PJ,y} = HC_{CHP,BL,y} - HC_{CHP,PJ,y}, \quad (D.1\text{-}11)$$

where $HC_{CHP,PJ,y}$ is the total project heat consumption for liquor evaporation during the year y, GJ;

$HC_{CHP,BL,y}$ is the total baseline heat consumption for liquor evaporation during the year y, GJ;

$$HC_{CHP,PJ,y} = HC_{CHP-3,PJ,y} + HC_{CHP-2,PJ,y}, \quad (D.1\text{-}12)$$

where $HC_{CHP-3,PJ,y}$ is the heat consumption by evaporator plant of CHP-3 under the project during the year y, GJ;

$HC_{CHP-2,PJ,y}$ is the heat consumption by evaporator plant of CHP-2 under the project during the year y, GJ;

$$HC_{CHP,BL,y} = HC_{CHP-2,BL,y} + HC_{CHP-3,BL,y} + HC_{UkrNIIHimMash,BL,y}, \quad (D.1\text{-}13)$$

where $HC_{CHP-2,BL,y}$ is the heat consumption by evaporator plants of CHP-2 under the baseline during the year y, GJ;

$HC_{CHP-3,BL,y}$ is the heat consumption by evaporator plant of CHP-3 under the baseline during the year y, GJ;

$HC_{UkrNIIHimMash,BL,y}$ is the heat consumption by "UkrNIIHimMash" evaporator plant of CHP-3 under the baseline during the year y, GJ;

$$HC_{CHP-2,BL,y} = \beta_{HC,CHP-2,BL} \times LE_{CHP-2,BL,y}, \quad (D.1\text{-}14)$$

where $\beta_{HC,CHP-2,BL}$ is the specific heat consumption by evaporator plant of CHP-2 under the baseline, GJ/t a.d.m. It is assumed constant over years and equal to $\beta_{HC,CHP-2,BL}$ = 6.811 GJ/t a.d.m. See Section B.1;

$LE_{CHP-2,BL,y}$ is the total quantity of liquors fed to evaporator plants of CHP-2 under the baseline during the year y, t a.d.m.;

$$LE_{CHP-2,BL,y} = LE_{CHP-2,BL\ CPP,BL,y}, \quad D.1\text{-}15)$$

where $LE_{CHP-2,BL\ CPP,BL,y}$ is the quantity of BL CPP fed to evaporator plants of CHP-2 under the baseline during the year y, t a.d.m.;

$$LE_{CHP-2,BL\ CPP,BL,y} = LG_{BL\ CPP,BL,y}, \quad (D.1\text{-}16)$$

where $LG_{BL\ CPP,BL,y}$ is the quantity of BL CPP fed for evaporation under the baseline during the year y, t a.d.m.

$$LG_{BL\ CPP,BL,y} = \alpha_{BL\ CPP,BL} \times P_{1,y}, \quad (D.1\text{-}17)$$

where $\alpha_{BL\ CPP,BL}$ is the specific yield of BL CPP under the baseline, t a.d.m./ t a.d.p. This value is assumed constant over years and equal to $\alpha_{BL\ CPP,BL}$ = 1.202 t a.d.m./t a.d.p. See Section B.1;

$P_{1,y}$ is the quantity of pulp produced in the cooking workshop SAS-1 during the year y, t a.d.p.

$$HC_{CHP-3,BL,y} = \beta_{HC,CHP-3,BL} \times LE_{CHP-3,BL,y}, \quad (D.1\text{-}18)$$

where $\beta_{HC,CHP-3,BL}$ is the specific heat consumption by evaporator plant of CHP-3 under the baseline, GJ/t a.d.m. This value is assumed constant over years and equal to $\beta_{HC,CHP-3,BL}$ = 3.244 GJ/t a.d.m. See Section B.1;

$LE_{CHP-3,BL,y}$ is the total quantity of liquors fed to evaporator plant of CHP-3 under the baseline during the year y, t a.d.m..

$$LE_{CHP-3,BL,y} = LE_{CHP-3,BL\ SBPP,BL,y}, \quad \text{(D.1-19)}$$

where $LE_{CHP-3,BL\ SBPP,BL,y}$ is the quantity of BL SBPP fed to evaporator plant of CHP-3 under the baseline during the year y, t a.d.m.;

$$LE_{CHP-3,BL\ SBPP,BL,y} = LE_{CHP-2,BL\ SBPP,PJ,y} + LE_{CHP-3,BL\ SBPP,PJ,y}, \quad \text{(D.1-20)}$$

where $LE_{CHP-2,BL\ SBPP,PJ,y}$ is the quantity of BL SBPP fed to evaporator plant of CHP-2 under the project during the year y, t a.d.m.;

$LE_{CHP-3,BL\ SBPP,PJ,y}$ is the quantity of BL SBPP fed to evaporator plant of CHP-3 under the project during the year y, t a.d.m.

$$HC_{UkrNIIHimMash,BL,y} = \beta_{HC,UkrNIIHimMash,BL} \times LE_{UkrNIIHimMash,BL,y}, \quad \text{(D.1-21)}$$

where $\beta_{HC,UkrNIIHimMash,BL}$ is the specific heat consumption by "UkrNIIHimMash" evaporator plant under the baseline, GJ/t a.d.m. It is assumed constant over years and equal to $\beta_{HC,UkrNIIHimMash,BL}$ = 18.260 GJ/t a.d.m. See Section B.1;

$LE_{UkrNIIHimMash,BL,y}$ is the total quantity of liquors fed to "UkrNIIHimMash" evaporator plant under the baseline during the year y, t a.d.m.

$$LE_{UkrNIIHimMash,BL,y} = LE_{UkrNIIHimMash,RL,BL,y}, \quad \text{(D.1-22)}$$

where $LE_{UkrNIIHimMash,RL,BL,y}$ is the quantity of red liquor fed to "UkrNIIHimMash" evaporator plant under the baseline during the year y, t a.d.m.

$$LE_{UkrNIIHimMash,RL,BL,y} = LE_{CHP-2,RL,PJ,y}, \quad \text{(D.1-23)}$$

where $LE_{CHP-2,RL,PJ,y}$ is the quantity of red liquor fed to evaporator plant of CHP-2 under the project during the year y, t a.d.m.

$$\Delta HS_{CHP,PJ,y} = \varphi_{HS,CHP,y} \times \Delta HG_{BLRB,PJ,y}, \quad \text{(D.1-24)}$$

where $\varphi_{HS,CHP,y}$ is the factor of specific heat supply from ETHPS during the year y, GJ/GJ;

$\Delta HG_{BLRB,PJ,y}$ is the total additional heat production by liquor recovery boilers under the project during the year y, GJ.

$$\varphi_{HS,CHP,y} = \frac{HS_{CHP,PJ,y}}{HG_{CHP,PJ,y}}, \quad \text{(D.1-25)}$$

where $HG_{CHP,PJ,y}$ is the total heat production by ETHPS boilers under the project during the year y, GJ;

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

$$HG_{CHP,PJ,y} = HG_{MGB,y} + HG_{BLRB,PJ,y} + HG_{BWWB,PJ,y}, \quad (D.1\text{-}26)$$

where $HG_{MGB,y}$ is the heat production by the utilizing boiler during the year y, GJ;

$HG_{BLRB,PJ,y}$ is the total heat produced by liquor recovery boilers under the project during the year y, GJ;

$HG_{BWWB,PJ,y}$ is the total heat produced by BWW-fired boilers under the project during the year y, GJ.

$$\Delta HG_{BLRB,PJ,y} = \Delta HG_{BLRB,RL,PJ,y} + \Delta HG_{BLRB,BL\ CPP,PJ,y}, \quad (D.1\text{-}27)$$

where $\Delta HG_{BLRB,RL,PJ,y}$ is the additional heat production by liquor recovery boilers under the project due to combustion of red liquor with a higher calorific value during the year y, GJ;

$\Delta HG_{BLRB,BL\ CPP,PJ,y}$ is the additional heat production by liquor recovery boilers under the project due to combustion of more BL CPP during the year y, GJ.

$$\Delta HG_{BLRB,RL,PJ,y} = HG_{BLRB,RL,PJ,y} - HG_{BLRB,RL,BL,y}, \quad (D.1\text{-}28)$$

where $HG_{BLRB,RL,PJ,y}$ is the heat production by liquor recovery boilers under the project due to combustion of red liquor during the year y, GJ;

$HG_{BLRB,RL,BL,y}$ is the heat production by liquor recovery boilers under the baseline due to combustion of red liquor during the year y, GJ.

$$HG_{BLRB,RL,PJ,y} = LE_{CHP-2,RL,PJ,y} \times \left(NCV_{RL,PJ,y}\right)_{adm} \times \eta_{BLRB,y}, \quad (D.1\text{-}29)$$

where $LE_{CHP-2,RL,PJ,y}$ is the quantity of red liquor fed to evaporator plant of CHP-2 under the project during the year y, t a.d.m.;

$\left(NCV_{RL,PJ,y}\right)_{adm}$ is the weighted average net calorific value of red liquor referred to absolutely dry mass under the project in the year y, GJ/t a.d.m.;

$\eta_{BLRB,y}$ is the average efficiency of liquor recovery boilers in the year y.

$$\eta_{BLRB,y} = \frac{HG_{BLBR,PJ,y}}{LE_{CHP-2,RL,PJ,y} \times (NCV_{RL,PJ,y})_{adm} + LE_{CHP-2,BL\ CPP,PJ,y} \times (NCV_{BL\ CPP,y})_{adm} + (LE_{CHP-2,BL\ SBPP,PJ,y} + LE_{CHP-3,BL\ SBPP,PJ,y}) \times (NCV_{BL\ SBPP,y})_{adm} + FC_{fuel\ oil,BLRB,PJ,y} \times NCV_{fuel\ oil,y}} \quad (D.1\text{-}30)$$

where $\left(NCV_{BL\ CPP,y}\right)_{adm}$ is the weighted average net calorific value of BL CPP referred to absolutely dry mass in the year *y*, GJ/t a.d.m.;

$\left(NCV_{BL\ SBPP,y}\right)_{adm}$ is the weighted average net calorific value of BL SBPP referred to absolutely dry mass in the year *y*, GJ/t a.d.m.;

$NCV_{fuel\ oil,y}$ is the weighted average net calorific value of heavy fuel oil in the year *y*, GJ/t;

$FC_{fuel\ oil,BLRB,PJ,y}$ is the total heavy fuel oil consumption by liquor recovery boilers under the project during the year *y*, t;

$LE_{CHP-2,BL\ CPP,PJ,y}$ is the quantity of BL CPP fed to evaporator plant of CHP-2 under the project during the year *y*, t a.d.m.

$$HG_{BLRB,RL,BL,y} = LE_{UkrNIIHimMash,RL,BL,y} \times \left(NCV_{RL,BL,y}\right)_{adm} \times \eta_{BLRB,y}, \quad \text{(D.1-31)}$$

where $\left(NCV_{RL,BL,y}\right)_{adm}$ is the weighted average net calorific value of red liquor referred to absolutely dry mass under the baseline scenario during the year *y*, GJ/t a.d.m. It is assumed constant over years and equal to $\left(NCV_{RL,BL,y}\right)_{adm}$ = 8.845 GJ/t a.d.m. See Section B.1.

$$\Delta HG_{BLRB,BL\ CPP,PJ,y} = \left(LE_{CHP-2,BL\ CPP,PJ,y} - LE_{CHP-2,BL\ CPP,BL,y}\right) \times \left(NCV_{BL\ CPP,y}\right)_{adm} \times \eta_{BLRB,y}, \quad \text{(D.1-32)}$$

$$\Delta HC_{W,PJ,y} = HC_{CW,BL,y} + HC_{PC,BL,y} + HC_{TC,BL,y}, \quad \text{(D.1-33)}$$

where $HC_{CW,BL,y}$ is the heat consumption for water heating to meet the process needs under the baseline scenario during the year *y*, which under the project will be substituted by reuse of warm water from the new evaporator plant, GJ;

$HC_{PC,BL,y}$ is the heat consumption for water heating to meet the process needs under the baseline scenario during the year *y*, which under the project will be substituted by reuse of relatively clean condensate from the new evaporator plant, GJ;

$HC_{TC,BL,y}$ is the heat consumption for water heating to meet the process needs under the baseline scenario during the year *y*, which under the project will be substituted by reuse of treated condensate from the new evaporator plant, GJ.

$$HC_{CW,BL,y} = \sum_{i=1}^{n} \frac{\rho_w \times c_w \times CWG_{PJ,i,y} \times (t_{2,CW,PJ,i,y} - t_{1,i,y})}{1 \times 10^6}, \quad \text{(D.1-34)}$$

where i is the index indicating that the calculations will use hourly data;

n is the operation hours of evaporator plant in the year *y*;

$\sum_{i=1}^{n}$ is the sum of all values of a given parameter in the year y (is determined every hour and then summed up);

$CWG_{PJ,i,y}$ is the volume of warm water produced under the project during i-hour of operation of the new evaporator plant from the beginning of the year y, m^3;

$t_{2,CW,PJ,i,y}$ is the average temperature of warm water under the project at the outlet from the new evaporator plant over the i-hour of evaporation from the beginning of the year y, ^oC;

$t_{1,i,y}$ is the average water temperature at the inlet over the i-hour of operation of the new evaporator plant from the beginning of the year y, ^oC;

ρ_w is the water density, kg/m^3. The water density is assumed constant: $\rho_w = 1000$ kg/m^3;

c_w is the specific thermal capacity of water, $\frac{kJ}{kg \times {}^oC}$. The specific thermal capacity of water is assumed constant: $c_w = 4.187 \frac{kJ}{kg \times {}^oC}$.

$$HC_{PC,BL,y} = \sum_{i=1}^{n} \frac{\rho_w \times c_w \times PCG_{PJ,i,y} \times (t_{2,PC,PJ,i,y} - t_{1,i,y})}{1 \times 10^6}, \qquad (D.1\text{-}35)$$

where $PCG_{PJ,i,y}$ is the volume of relatively clean condensate produced under the project during the i-hour of operation of the new evaporator plant from the beginning of the year y, m^3;

$t_{2,PC,PJ,i,y}$ is the average temperature of relatively clean condensate under the project at the outlet from evaporator plant of CHP-2 over the i- hour of operation from the beginning of the year y, ^oC.

$$HC_{TC,BL,y} = \sum_{i=1}^{n} \frac{\rho_w \times c_w \times TCG_{PJ,i,y} \times (t_{2,TC,PJ,i,y} - t_{1,i,y})}{1 \times 10^6}, \qquad (D.1\text{-}36)$$

where $TCG_{PJ,i,y}$ is the volume of treated condensate produced under the project during the i-hour of operation of the new evaporator plant from the beginning of the year y, m^3;

$t_{2,TC,PJ,i,y}$ is the average temperature of treated condensate under the project at the outlet from the new evaporator plant of CHP-2 over the i- hour of evaporation from the beginning of the year y, ^oC.

$$\Delta HS_{MGB,y} = HG_{MGB,y} \times (1 - k_B), \qquad (D.1\text{-}37)$$

where $HG_{MGB,y}$ is the heat output by the utilizing boiler firing malodorous gases and methanol fraction under the project during the year y, GJ;

k_B is the factor of heat consumption for auxiliary needs of the utilizing boiler. It is assumed constant over years and equal to k_B = 0.05. See Section B.1.

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 to the monitoring of this project.

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:

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
27. $EC_{CHP-2,PJ,y}$	Electricity consumption by evaporator plant of CHP-2 under the project	The Mill's Energy Service	MWh	m	Continuously	100 %	Electronic and paper	Electricity meter readings
28. $EC_{CHP-3,PJ,y}$	Electricity consumption by evaporator plant of CHP-3 under the project	The Mill's Energy Service	MWh	m	Continuously	100 %	Electronic and paper	Electricity meter readings
29. $ES_{CHP,PJ,y}$	Electricity supply from ETHPS under the project	The Mill's Energy Service	MWh	m	Continuously	100 %	Electronic and paper	Electricity meter readings

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

Leakages during the year *y*, t CO_2e:

$$L_y = L_{ES,y}, \qquad \text{(D.1-38)}$$

where $L_{ES,y}$ is the leakages from fuel combustion by power plants to offset the reduction of electricity supply to the grid due to the project during the year *y*, t CO_2e.

$$L_{ES,y} = \Delta ES_y \times EF_{CO_2,grid,y}, \qquad (D.1\text{-}39)$$

where $EF_{CO2,grid,y}$ is the CO_2 emission factor for grid electricity, tCO_2/MWh. For Russia according to “Operational Guidelines for Project Design Documents of Joint Implementation Projects” [R8] this factor, depending on the year under consideration, is: $EF^{2008}_{CO2,grid}$ = 0.565 t CO_2/MWh, $EF^{2009}_{CO2,grid}$ = 0.557 t CO_2/MWh, $EF^{2010}_{CO2,grid}$ =0.550 t CO_2/MWh, $EF^{2011}_{CO2,grid}$ = 0.542 t CO_2/MWh, $EF^{2012}_{CO2,grid}$ = 0.534 t CO_2/MWh;

ΔES_y is the reduction of electricity supply to the grid as a result of the project implementation during the year *y*, MWh.

$$\Delta ES_y = \Delta ES_{CHPP-1,y} - \Delta EC_{PJ,y}, \qquad (D.1\text{-}40)$$

where $\Delta EC_{PJ,y}$ is the total electricity savings in the pulp production cycle as a result of the project implementation during the year *y*, MWh;

$\Delta ES_{CHPP-1,y}$ is the reduction of heat-consumption-based electricity supply from CHPP-1 as a result of the project during the year *y*, MWh.

$$\Delta ES_{CHPP-1,y} = \frac{0.2445 \times \Delta HC_{PJ,y}\left(1 - e_{CHPP-1}\right)}{3.6 \times \left(1 - \omega_{HN}\right)}, \qquad (D.1\text{-}41)$$

where e_{CHPP-1} is the value of relative electricity consumption for auxiliary needs of CHPP-1. This value is assumed constant over years and equal to e_{CHPP-1} = 0.05. See Section B.1;

ω_{HN} is the relative losses in the Mill’s steam network. This value is assumed constant over years and equal to ω_{HN} = 0.02. See Section B.1;

0.2445 is the factor which describes the relation between variation of heat-consumption-based electricity generation and variation of steam extraction from turbines. See Section B.1;

$\Delta HC_{PJ,y}$ is the total savings of heat in the pulp production cycle as a result of the project during the year *y*, GJ. The calculation of this value is given in Section D.1.1.4.

$$\Delta EC_{PJ,y} = \Delta EC_{CHP,PJ,y} + \Delta ES_{CHP,PJ,y}, \qquad (D.1\text{-}42)$$

where $\Delta EC_{CHP,PJ,y}$ is the reduction of electricity consumption for liquor evaporation as a result of the project during the year *y*, MWh;

$\Delta ES_{CHP,PJ,y}$ is the additional electricity supply from ETHPS due to additional heat production by liquor recovery boilers during the year *y*, MWh.

$$\Delta EC_{CHP,PJ,y} = EC_{CHP,BL,y} - EC_{CHP,PJ,y}, \qquad (D.1\text{-}43)$$

where $EC_{CHP,PJ,y}$ is the total electricity consumption for liquor evaporation under the project during the year *y*, MWh;

$EC_{CHP,BL,y}$ is the total electricity consumption for liquor evaporation under the baseline during the year *y*, MWh;

$$EC_{CHP,PJ,y} = EC_{CHP-2,PJ,y} + EC_{CHP-3,PJ,y}, \quad (D.1\text{-}44)$$

where $EC_{CHP-2,PJ,y}$ is the electricity consumption by evaporator plant of CHP-2 under the project during the year *y*, MWh;

$EC_{CHP-3,PJ,y}$ is the electricity consumption by evaporator plant of CHP-3 under the project during the year *y*, MWh;

$$EC_{CHP,BL,y} = EC_{CHP-2,BL,y} + EC_{CHP-3,BL,y} + EC_{UkrNIIHimMash,BL,y}, \quad (D.1\text{-}45)$$

where $EC_{CHP-2,BL,y}$ is the electricity consumption by evaporator plants of CHP-2 under the baseline during the year *y*, MWh;

$EC_{CHP-3,BL,y}$ is the electricity consumption by evaporator plant of CHP-3 under the baseline during the year *y*, MWh;

$EC_{UkrNIIHimMash,BL,y}$ is the electricity consumption by "UkrNIIHimMash" evaporator plant under the baseline during the year *y*, MWh.

$$EC_{CHP-2,BL,y} = \beta_{EC,CHP-2,BL} \times LE_{CHP-2,BL,y}, \quad (D.1\text{-}46)$$

where $\beta_{EC,CHP-2,BL}$ is the specific electricity consumption by evaporator plant of CHP-2 under the baseline, MWh/t a.d.m. It is assumed constant over years and equal to $\beta_{EC,CHP-2,BL}$ = 0.0103 MWh/t a.d.m. See Section B.1;

$LE_{CHP-2,BL,y}$ is the total quantity of liquors fed to evaporator plant of CHP-2 under the baseline during the year *y*, t a.d.m.;

$$EC_{CHP-3,BL,y} = \beta_{EC,CHP-3,BL} \times LE_{CHP-3,BL,y}, \quad (D.1\text{-}47)$$

where $\beta_{EC,CHP-3,BL}$ is the specific electricity consumption by evaporator plant of CHP-3 under the baseline, MWh/t a.d.m. It is assumed constant over years and numerically equal to $\beta_{EC,CHP-3,BL}$ = 0.0194 MWh/t a.d.m. See Section B.1;

$LE_{CHP-3,BL,y}$ is the total quantity of liquors fed to evaporator plant of CHP-3 under the baseline during the year *y*, t a.d.m.;

$$EC_{UkrNIIHimMash,BL,y} = \beta_{EC,UkrNIIHimMash,BL} \times LE_{UkrNIIHimMash,BL,y}, \quad (D.1\text{-}48)$$

where $\beta_{EC,UkrNIIHimMash,BL}$ is the specific electricity consumption by "UkrNIIHimMash" evaporator plant under the baseline, MWh/t a.d.m. It is assumed constant over years and numerically equal to $\beta_{EC,UkrNIIHimMash,BL}$ = 0.2153 MWh/t a.d.m. See Section B.1;

$LE_{UkrNIIHimMash,BL,y}$ is the total quantity of liquors fed to UkrNIIHimMash evaporator plant under the baseline during the year *y*, t a.d.m.

$$\Delta ES_{CHP,PJ,y} = \varphi_{ES,CHP,y} \times \Delta HG_{BLRB,PJ,y}, \quad (D.1\text{-}49)$$

where $\varphi_{ES,CHP,y}$ is the factor of specific electricity supply from ETHPS under the project during the year *y*, MWh/GJ.

$\Delta HG_{BLBR,PJ,y}$ is the total additional heat production by liquor recovery boilers under the project during the year *y*, GJ. The calculation of this value is given in Section D.1.1.4.

$$\varphi_{ES,CHP,y} = \frac{ES_{CHP,PJ,y}}{HG_{CHP,PJ,y}}, \qquad \text{(D.1-50)}$$

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

$HG_{CHP,PJ,y}$ is the total heat production by ETHPS boilers under the project during the year y, GJ.

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):

GHG emission reductions during the year y, t CO_2e:

$$ER_y = BE_y - PE_y - L_y \qquad \text{(D.1-51)}$$

where BE_y is the baseline GHG emissions during the year y, t CO_2e. See Section D.1.1.4;

PE_y is the project GHG emissions during the year y, t CO_2e. See Section D.1.1.2;

L_y is the leakages during the year y, t CO_2e. See Section D.1.3.2.

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:

The Environmental Service, accountable to the Deputy Technical Manager for Environmental Protection, is responsible for industrial environmental monitoring at the enterprise. The Service consists of:

- Environmental Protection Department (EPD), comprising a production laboratory;
- Biological Treatment Facility for Industrial Effluents (BTFIE), comprising a production laboratory.

The programme of industrial environmental monitoring currently implemented by the Mill will not undergo any significantly changes after the project and will be fulfilled according to the scheme and schedule approved by the Committee for Natural Resources of the Arkhangelsk Region.

Similarly to the way it is now, the monitoring will be performed by the Mill's Environmental Service, including sanitary-industrial laboratory of EPD and production laboratory of BTFIE. The Department employs qualified specialists. Sanitary industrial laboratory and BTFIE laboratory are sufficiently equipped. Their ability to take measurements in all sectors, which fall under their responsibility, is confirmed by Calibration Certificates issued by Arkhangelsk Centre for Standardization and Metrology.

The industrial environmental monitoring covers the following:

- 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 data retrieved by the analytical laboratory are processed and summarized in monthly and annual reports, which contain all required detailed data, including data by sections and streams covered by this project.

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 legislation, the enterprise annually develops and implements environmental protection measures.

Quality, environment and industrial safety management systems at Koryazhma Branch comply with the international standards ISO 9001, ISO 14001 and OHSAS 18001. The enterprise manufactures products certified for compliance with the requirements of the Forest Stewardship Council (FSC).

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	Flow meters are used to measure consumption of natural gas in the flare and in the utilizing boiler. Measurement error is 1.0 %. Calibration interval: 5 years. Output signals from the flow meters transmitters enters the Automated Process Control System (APCS).

Table D.1.1.3. ID 4	Low	The volume of pulp produced in SAS-1 cooking workshop is measures with the help of the following: 1. Flow meter. Measurement error 1.0 %. Calibration interval: five years. 2. Concentration meter. Measurement error 1.0 %. The concentration meter is adjusted on a weekly basis according to the laboratory analysis. The instruments are installed after the digesters of SAS-1. Data from the instruments are sent to the APCS. In addition, pulp cooking volumes are cross checked by two methods: The first method is by measuring the rotation speed of the special dosing tray with known holding capacity which is used to feed chips to the digesters. Then using the pulp yield standards approved at the enterprise the volume of cooked pulp is determined. The second method is based on weighing of each type of finished marketable product and determining the quantity of pulp consumed for manufacturing of these products using special consumption coefficients approved at the enterprise. These coefficients are approved individually for each paper and cardboard making machine.
Table D. 1.1.3. ID 5	Low	Flow meters are used for measuring heavy fuel oil consumption by liquor recovery boilers. Flow meters are installed at each liquor recovery boiler. Measurement error is 1.0 %. Calibration interval: five years. Output signals from the flow meters transmitters are sent to the APCS.
Table D.1.1.1. ID 3 Table D.1.1.3. ID 6-8	Low	The calorific values of natural gas and liquors are measured in the Mill's production laboratory on a weekly basis. Instruments for measurement of calorific value of liquors and natural gas are: 1. Calorimetric bomb. Measurement error is 0.10%. Calibration interval: 1 year. 2. Weights. Accuracy class: 4. Calibration interval: 1 year. 3. Set of weights. Accuracy class: 2. Calibration interval: 1 year.
Table D.1.1.3. ID 9	Low	Calorific value of heavy fuel oil. Data of the fuel suppliers' certified laboratories are used. At the year-end weighted average value is determined.
Table D.1.1.3. ID 10-15	Low	For metering of output, supply and consumption of heat the following is used: 1. Steam flow meters. Measurement error 0.5 %. Calibration interval: 1 year; 2. Temperature meter. Accuracy class C. Calibration interval: five years; 3. Pressure meter. Measurement error 0.5 %. Calibration interval: 1 year. Signals from the instruments are sent to the APCS.
Table D.1.1.3. ID 16-19	Low	Liquor consumption is measured by the following: 1. Flow meters. Measurement error 1.0%. Calibration interval: five years. 2. Temperature meter. Measurement error 1 ^{o}C. Calibration interval: four years. 3. Density meter. Liquor density is measured by laboratory method on a daily basis. Mass flow rate of liquors is calculated in tonnes of a.d.m. based on the volume flow rate, temperature and density.

Table D.1.1.3. ID 20-22	Low	Consumption of warm water and condensate streams are measured by electromagnetic flow meters. Measurement error 1.0%. Calibration interval: five years. Output signals from flow meters are sent to the APCS.
Table D.1.1.3. ID 23-26	Low	Temperature converters are used for measurement of warm water and condensate streams after CHP-2 evaporator plant. Accuracy class C. Calibration interval: five years. Output signals from the converters are sent to the APCS.
Table D.1.3.1. ID 27-29	Low	Electricity consumption at evaporator plants and electricity supply from ETHPS are measured by electricity meters. Measurement error 0.5 %. Calibration interval: eight years.

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

Collection and record of data required for calculation of GHG emission reductions will be carried out in accordance with the metering points scheme shown in Fig.D.3-1.

Input data for emission reduction monitoring will be provided by the Environmental Protection Service, Energy Service of the Mill and by Production and Technical Department.

The management of OJSC “Ilim Group” Branch in Koryazhma is responsible for:

- normal operation of the equipment;
- timely calibration and proper maintenance of instrumentation;
- collection of all data required for calculation of GHG emission reductions under the project;
- collection of all required data on the environmental impact of the project;
- arranging and holding training sessions for the Mill’s personnel regarding collection of data required for the GHG emissions monitoring under the project.

All personnel of the evaporation plant have undergone certification in accordance with the requirements of Rostechnadzor.

Furthermore, in connection with the commissioning of the evaporator plant, the personnel underwent training within the framework of the contract with the equipment supplier, "ANDRITZ OY", in accordance with the personnel’s job content.

The procedure for collection and record of data required for calculation of GHG emission reductions is described in Table D.3-1.

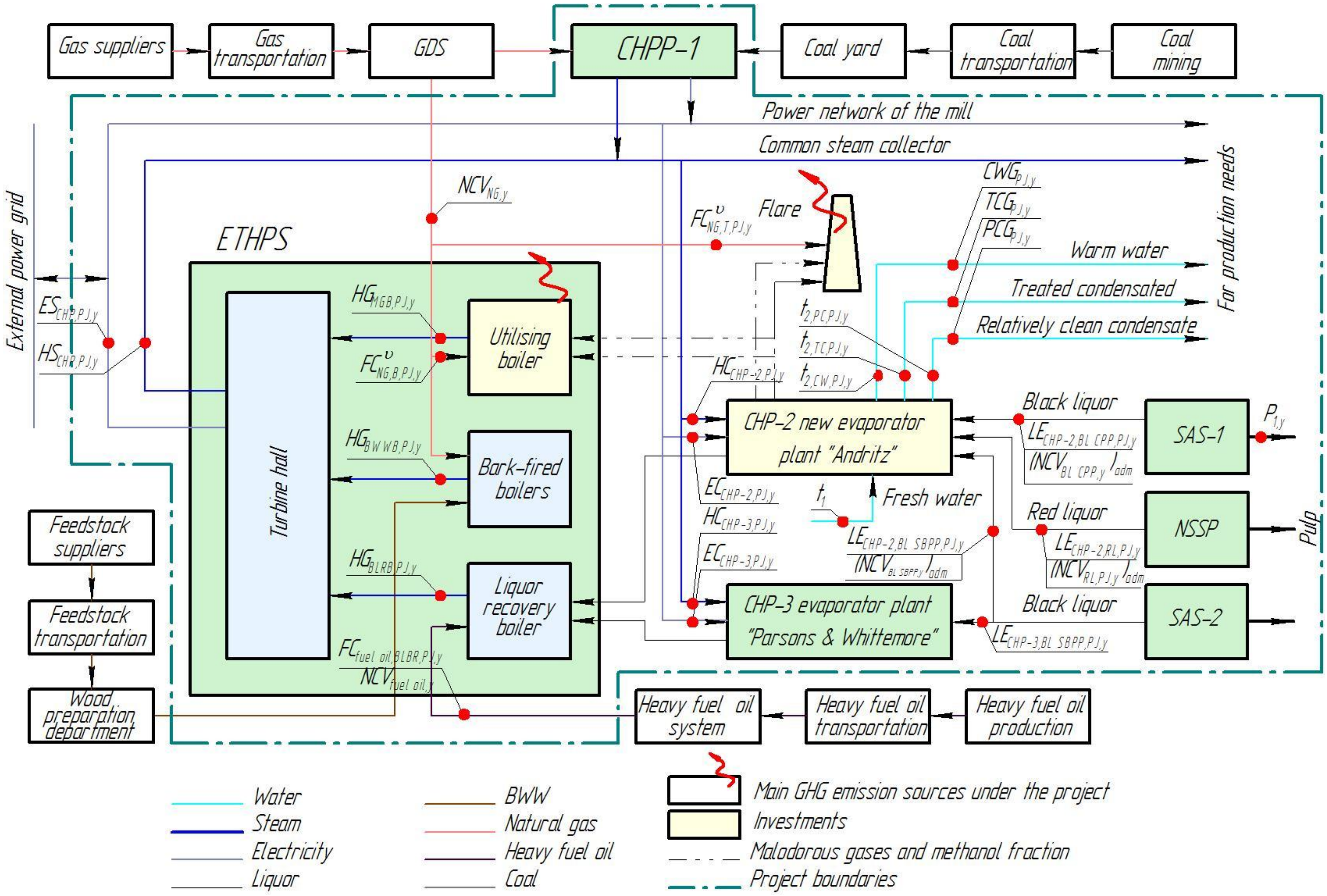

Fig. D.3-1. Location of the monitoring points

Table D.3-1. Monitoring procedures

Monitoring procedures		
Monitored parameter	**Procedure for registration, monitoring, record and storage of data (including everyday monitoring)**	**The person responsible for the parameter monitoring**
Pulp cooking volume	1. The volume of pulp produced in the pulp cooking workshop SAS-1 is continuously measured by flow meters and concentration sensor installed after the digesters. In addition, pulp cooking volumes are cross checked by two methods: The first method is by measuring the rotation speed of the special dosing tray with known holding capacity which is used to feed chips to the digesters. Then the volume of cooked pulp is determined using pulp production standards approved at the enterprise. The second method is based on weighing of each type of finished marketable products and determining the quantity of pulp consumed for manufacturing of these products using special consumption coefficients approved at the enterprise. These coefficients are approved individually for each paper and cardboard making machine. 2. Data from the instruments are sent to APCS and recorded in the Mill's automated dispatch control system (ADCS), printed in hard copy at the Mill's commercial department and stored in the computer memory for not less than one year, then the computer data are handed over to the Mill's archives. 3. The data are recorded by an operator on a daily basis in daily reports on pulp cooking workshop performance, and also handed over to the commercial department of the enterprise. Daily reports are then summarized in monthly and annual reports. 4. Pulp cooking data will be stored in the Mill's archives in electronic and paper form for at least 2 years after the end of the crediting period or the last issue of ERUs.	The Head of the Commercial Department, the Head of the Pulp Cooking Workshop .

Natural gas consumption in the utilizing boiler and in the flare	1. The consumed quantity of natural gas is continuously measured by flow meters. 2. Flow meter readings are recorded in the APCS and are shown on the displays of all computers with the required software installed. The data are printed in hard copy and stored in the computer memory for at least one year, and then sent to the Mill's electronic archive. 3. The data are recorded by CHP-2 operators on a daily basis in daily reports, which are then summarized in monthly and annual reports. 4. Natural gas consumption data will be stored in the Mill's archive in electronic and paper form for at least 2 years after the end of the crediting period or the last issue of ERUs.	Tallyman of fuel and energy resources
Consumption of heavy fuel oil by liquor recovery boilers	1. The consumed quantity of heavy fuel oil is continuously measured by flow meters. 2. Flow meter readings are recorded in the APCS and are shown on the displays of all computers with the required software installed. The data are printed in hard copy and are stored in the computer memory for at least one year, and then sent to the Mill's electronic archive. 3. The data are recorded by operators on a daily basis in daily reports, which are then summarized in monthly and annual reports. 4. Heavy fuel oil consumption data will be stored in the Mill's archive in electronic and paper form for at least 2 years after the end of the crediting period or the last issue of ERUs.	Tallyman of fuel and energy resources
Calorific values of natural gas and liquors	1. Calorific values of natural gas and liquors are determined experimentally on a weekly basis in the production laboratory of OJSC "Ilim Group" Branch in Koryazhma. 2. The test results are recorded by laboratory assistants in the logs and then transferred to the APCS where they are stored for at least one year, and then the data are sent to the Mill's electronic archive. The data are shown on the displays of all computers with the required software installed. 3. Calorific values data will be stored in the Mill's archive in electronic and paper form for at least 2 years after the end of the crediting period or the last issue of ERUs.	The Head of Production Laboratory

Calorific value of heavy fuel oil	1. The calorific value of heavy fuel oil is determined by the fuel supplier, and the fuel certificate is provided by the fuel supplier for each batch of heavy fuel oil supplied to the Mill. 2. The calorific value data are recorded in the logs and then transferred to the APCS where they are stored for at least one year, and then the data are sent to the Mill's electronic archive. The data are shown on the displays of all computers with the required software installed. 3. Calorific values data will be stored in the Mill's archive in electronic and paper form for at least 2 years after the end of the crediting period or the last issue of ERUs.	Tallyman of fuel and energy resources
Production, supply and consumption of heat	1. For monitoring of heat production, supply and consumption sensors and transmitters are used, which continuously measure flow rate, temperature and pressure of steam. 2. The meter readings are recorded in the APCS and are shown on the displays of all computers with the required software installed. The data are printed in hard copy and are stored in the computer memory for at least one year, and then sent to the Mill's electronic archive. 3. The data are recorded by operators on a daily basis in daily reports, which are then summarized in monthly and annual reports. 4. Data will be stored in the Mill's archive in electronic and paper form for at least 2 years after the end of the crediting period or the last issue of ERUs.	Tallyman of fuel and energy resources
Liquor supply to evaporator plants	1. For measurement of the quantity of liquors fed to evaporator plants, flow meters and concentration meters are used. The parameters are measured continuously. 2. The meter readings are recorded in the APCS and are shown on the displays of all computers with the required software installed. The data are printed in hard copy and are stored in the computer memory for at least one year, and then sent to the Mill's electronic archive. 3. The data are recorded by operators on a daily basis in daily reports, which are then summarized in monthly and annual reports. 4. Data on the quantity of liquors supplied to evaporator plants will be stored in the Mill's archive in electronic and paper form for at least 2 years after the end of the crediting period or the last issue of ERUs.	Tallyman of fuel and energy resources

Quantity of warm water and condensate streams fed for reuse	1. Flow meters are used for monitoring of the quantity of warm water and condensate streams supplied for production needs. The parameters are measured continuously. 2. The meter readings are recorded in the APCS and are shown on the displays of all computers with the required software installed. The data are printed in hard copy and are stored in the computer memory for at least one year, and then sent to the Mill's electronic archive. 3. The data are recorded by operators on a daily basis in daily reports, which are then summarized in monthly and annual reports. 4. Data on the quantity of reused warm water and condensate will be stored in the Mill's archive in electronic and paper form for at least 2 years after the end of the crediting period or the last issue of ERUs.	Tallyman of fuel and energy resources
Temperatures of warm water and condensates at the inlet to the evaporator plants	1. Temperature sensors are used for monitoring of warm water and condensates temperatures at the inlet to the evaporator plants. The parameters are measured continuously. 2. The meter readings are recorded in the APCS and are shown on the displays of all computers with the required software installed. The data are printed in hard copy and are stored in the computer memory for at least one year, and then sent to the Mill's electronic archive. 3. The data are recorded by operators on a daily basis in daily reports, which are then summarized in monthly and annual reports. 4. Data on the warm water and condensates temperatures will be stored in the Mill's archive in electronic and paper form for at least 2 years after the end of the crediting period or the last issue of ERUs.	Tallyman of fuel and energy resources

Electricity consumption metering	1. Electricity consumption at the evaporator plants and the electricity supply from ETHPS are continuously measured by electricity meters. 2. The meter readings are recorded in the APCS and are shown on the displays of all computers with the required software installed. The data are printed in hard copy and are stored in the computer memory for at least one year, and then sent to the Mill's electronic archive. 3. The data are recorded by operators on a daily basis in daily reports, which are then summarized in monthly and annual reports. 4. Data on electricity consumption by evaporator plants and electricity supply from ETHPS will be stored in the Mill's archive in electronic and paper form for at least 2 years after the end of the crediting period or the last issue of ERUs.	Tallyman of fuel and energy resources

More detailed information on the instrumentation is given in Annex 3.

CCGS specialists calculate GHG emission reductions using the provided data and draw up a monitoring report at the end of each reporting year. In case any doubt regarding the accuracy of the input data arises, those are checked and revised by the specialists of OJSC "Ilim Group" Branch in Koryazhma. The preliminary version of the monitoring report is submitted to the management of OJSC "Ilim Group" Branch in Koryazhma for review. In case any mistakes are identified, CCGS specialists correct the report accordingly. The final version of the report is submitted for verification to the accredited independent body.

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

The monitoring plan was developed by CCGS Ltd. (CCGS Ltd. is not the project participant listed in Annex 1 of PDD).

Contact person: Dmitry Potashev

E-mail: d.potashev@ccgs.ru

SECTION E. Estimation of greenhouse gas emission reductions

E.1. Estimated project emissions:

The project GHG emissions during the year *y*, t CO_2-e:

$$PE_y = PE_{NG,y}, \quad \text{(E.1-1)}$$

where $PE_{NG,y}$ is the project CO_2 emissions from combustion of natural gas in the utilizing boiler and flaring during the year *y*, t CO_2.

$$PE_{NG,y} = (FC_{NG,B,y} + FC_{NG,T,y}) \times EF_{CO2,NG}, \quad \text{(E.1-2)}$$

where $FC_{NG,B,y}$ is the consumption of natural gas in the utilizing boiler during the year *y*, GJ;

$FC_{NG,T,y}$ is the consumption of natural gas for flaring during the year *y*, GJ.

The overall project consumption of natural gas is given in Section B.1 Table B.1-23.

$EF_{CO2,NG}$ is the emission factor for natural gas, t CO_2/GJ. In accordance with IPCC [R7], as well as with allowance for oxidized carbon fraction of 0.995, this factor was assumed constant and equal to $EF_{CO2,NG}$ =0.0561×0.995=0.05582 t CO_2/GJ.

Table E.1-1. The project GHG emissions

Year	Estimation of the project GHG emissions, t CO_2e
2008	6 424
2009	6 424
2010	6 424
2011	6 424
2012	6 424
Total during the period 2008-2012	**32 121**

E.2. Estimated leakage:

Leakages during the year *y*, t CO_2e:

$$L_y = L_{ES,y}, \quad \text{(E.2-1)}$$

where $L_{ES,y}$ is the leakages from fuel combustion by power plants to compensate for reduction of electricity supply to the grid as a result of the project during the year *y*, t CO_{2e}.

$$L_{ES,y} = \Delta ES_y \times EF_{CO_2,grid,y}, \quad \text{(E.2-2)}$$

where $EF_{CO2,grid,y}$ is the CO_2 emission factor for grid electricity, t CO_2/MWh. For Russia according to "Operational Guidelines for Project Design Documents of Joint Implementation Projects" [R8] depending on the year under consideration this factor is: $EF^{2008}_{CO2,grid}$ = 0.565 t CO_2/MWh, $EF^{2009}_{CO2,grid}$ = 0.557 t CO_2/MWh, $EF^{2010}_{CO2,grid}$ =0.550 tCO_2/MWh, $EF^{2011}_{CO2,grid}$ = 0.542 t CO_2/MWh, $EF^{2012}_{CO2,grid}$ = 0.534 t CO_2/MWh;

ΔES_y is the reduction of electricity supply to the grid as a result of the project during the year *y*, MWh. See Section B.1, Table B.1-23.

Table E.2-1. Leakages from fuel combustion by power plant to compensate for reduction of electricity supply to the grid

Year	Estimation of the project leakages, t CO_2e
2008	150 703
2009	155 828
2010	153 890
2011	142 778
2012	162 119
Total during the period 2008-2012	**765 319**

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

Table E.3-1. The sum of the project GHG emissions and leakages

Year	The sum of the project GHG emissions and leakages, t CO_2e
2008	157 127
2009	162 252
2010	160 314
2011	149 203
2012	168 544
Total during the period 2008-2012	**797 440**

E.4. Estimated baseline emissions:

The baseline GHG emissions during the year *y*, t CO_2e:

$$BE_y = BE_{NG,y}, \qquad (E.4-1)$$

where $BE_{NG,y}$ is the CO_2 emissions from increase of natural gas consumption by CHPP-1 as compared with the project scenario during the year *y*, t CO_2.

$$BE_{NG,y} = \Delta FC_{NG,CHPP-1,y} \times EF_{CO2,NG}, \qquad (E.4-2)$$

where $\Delta FC_{NG,CHPP-1,y}$ is the reduction of natural gas consumption by CHPP-1 as a result of the project during the year *y*, GJ. See Section B.1, Table B.1-23.

Table E.4-1. Baseline GHG emissions

Year	Estimated baseline GHG emissions, t CO_2e
2008	314 280
2009	335 207
2010	336 186
2011	322 382
2012	369 325
Total during the period 2008-2012	**1 677 380**

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

Table E.5-1. Results of GHG emission reduction estimation

Year	Estimated project reductions of GHG emissions, t CO_2e
2008	157 152
2009	172 955
2010	175 871
2011	173 179
2012	200 782
Total during the period 2008-2012	**879 939**

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

Table E.6-1. Summarized estimation of GHG emissions

Year	Estimated project emissions (t CO_2e)	Estimated leakages (t CO_2e)	Estimated baseline emissions (t CO_2e)	Estimated emission reductions (t CO_2e)
2008	6 424	150 703	314 280	157 152
2009	6 424	155 828	335 207	172 955
2010	6 424	153 890	336 186	175 871
2011	6 424	142 778	322 382	173 179
2012	6 424	162 119	369 325	200 782
Total during the period 2008-2012	**32 121**	**765 319**	**1 677 380**	**879 939**

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:

The Mill is located in the industrial zone of Koryazhma, 1 km from the residential area. The modernized production is a part of the functioning pulp and paper mill and has no sanitary protection zone of its own.

Under the project the old run-down equipment is replaced by the new modern equipment purchased from "Andritz" (Finland), which provides for more complete and efficient evaporation of liquors.

Emissions into the atmosphere

Commissioning of the new evaporator plant makes it possible to completely avoid emissions of harmful substances in the process of liquor evaporation. Stabilization of operation of other evaporator plants by redistribution of liquor streams and load reduction will help to minimize overall emissions from all evaporator plants operated by the Mill (See Table F.1-1.).

Table F.1-1. Harmful emissions from all evaporator plants before and after the project, t/year

Name	Before the project	After the project	Emission reduction, %
Hydrogen sulfide	2.9	2.5	13.7
Methanol	220.7	0.0	100
Methyl disulphide	40.9	0.0	100
Dimethyl sulfide	59.1	0.0	100
Methylmercaptan	2.3	1.9	17.3
Turpentine	95.7	0.0	100
Total:	**421.6**	**4.4**	**99**

Furthermore, emissions from the liquor recovery boilers are also expected to go down because of a higher dryness of evaporated liquors fired in these boilers. Data on the amount of the Mill's emissions of the most significant pollutants before and after the project are given in Table F.1-2.

Table F.1-2. Overall emissions of pollutants from the Mill before and after the project, t/year

Name	Before the project	After the project	Emission reduction
Sulfur dioxide (SO_2)	3820.76	3820.76	0
Nitrogen oxide (NO_2)	3966.29	3780.79	185.5
Carbon oxide (CO)	6475.41	6456.41	19.0
Hydrogen sulfide	1052.98	1050.08	2.9
Methanol	487.32	266.62	220.7
Methyl disulphide	246.65	205.75	40.9
Dimethyl sulfide	217.83	158.73	59.1
Methylmercaptan	127.75	125.45	2.3
Turpentine	242.75	147.05	95.7
Total:	**16 637.74**	**16 011.64**	**626.1**

Discharge of pollutants into surface water bodies

The volume and the contamination rate of effluents will be reduced due to the project and this will decrease the load on the Mill's wastewater treatment facilities and reduce discharges into the Vychegda River.

Table F.1-3. below shows the amount of pollutants contained in the Mill's overall effluents at the inlet and outlet of the Mill's wastewater treatment facilities before and after the project.

Table F.1-3. The amount of pollutants contained in the Mill's overall effluents at the inlet and outlet of the Mill's wastewater treatment facilities before and after the project, t/year

Ingredient	Before the project		After the project		Reduction of pollutant discharge	
	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet
BOD 20	67 496.04	10 594.67	50 353.20	7 903.80	17 142.90	2 690.9
COD	214 063.70	88 455.56	166 063.70	67 365.60	48 000.00	21 090.0
Lignin sulfonates	50 217.73	37 241.98	35 217.73	26 142.00	15 000.00	11 100.0
Suspended solids	37 237.73	11 028.75	37 237.73	8 003.55	0	3 025.2
Turpentine	70.22	18.92	33.10	8.90	37.12	10.0
Methanol	8 766.82	1 519.29	4 727.61	819.30	4 039.22	700.0
Phenol	158.95	3.73	82.29	1.90	76.66	1.8

Production wastes

After the project implementation the load of the wastewater treatment facility will reduce due to better quality of the effluents, which in its turn will lead to reduction of sludge generation by 7900 t/year, which means that less sludge has to be removed from the biological treatment system.

Use of energy resources and natural fuel

Construction of a new evaporator plant which ensures lower steam consumption for liquor evaporation and recycling of warm water, slightly contaminated and treated condensates from the evaporating unit, will enable the Mill to reduce its overall natural fuel consumption by 200 000 tonnes of standard fuel per year (t e.f. per year).

Chemicals consumption

A higher rate of liquor separation and higher dryness of evaporated liquor will improve the performance of liquor recovery boilers primarily designed to recover mineral substances used in wood cooking and to return them to the production process. Modernization of the evaporator plant will make it possible to increase the rate of recovery of mineral substances and to achieve significant savings of purchased chemicals.

Reduction of chemicals consumption is expected at the wastewater treatment facilities as well, because smaller amounts of pollutants will be fed for treatment. Table F.1-4. shows data on chemicals consumption before and after the project, indicating that the overall chemicals demand of the enterprise will reduce by 10 184 t/year.

Table F.1-4. Amounts of chemicals used by the Mill before and after the project, t/year

Production, chemicals	Before the project	After the project	Savings
Printing paper production (PPP)			
Caustic soda	1 617	1 467	150
Hypochlorite	1 420	1 329	141
Chlorine	2 160	1 950	210
Chlorine dioxide	152	137	15
Sulfate Bleached Hardwood Pulp Production (SBPP)			
Caustic soda	7 195	6 505	690
Tensidef anti-foaming agents	218	109	109
Chlorine dioxide	2 816	2 538	278
Peroxide	2 346	2 326	20
Cardboard and Paper Production (CPP)			
Sodium sulfate	9 452	2 347	7 105
Alum 15%	6 586	5 270	1 316
Tensidef anti-foaming agent 212	192	96	96
Tensidef anti-foaming agent 920	54	0	54
Total:	**34 208**	**24 074**	**10 184**

Environmental impacts of the project

The most significant environmental impacts of the project are as follows:

- Improvement of the environmental situation in Koryazhma due to reduction of air emissions, including emissions of malodorous pollutants;
- Improvement of the water supply for the settlements which rely on the Vychegda and the Northern Dvina rivers as their source of industrial and drinking water, because the quality of the river water will be improved due to reduction of discharge into the Vychegda River.

Not less important is the reduction of natural fuel consumption and corresponding reduction of GHG emissions into the atmosphere, which will contribute to the Russian Federation's performance of its obligations to improve energy efficiency and reduce its GHG (CO_2) emissions. The total amount of ERUs generated by the project will amount to 176 000 t CO_2 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 does not have any significant impact upon the environment, which is confirmed by the statement of the State Environmental Expertise of the Main Office of the Russian Ministry of Natural Resources in the Arkhangelsk Region dated 31.01.2003 No. 50 (prolonged by the statement of the State Environmental Expertise approved by the order of Rostechnadzor Office in the Arkhangelsk Region dated 09.06.2006 No. 353-9).

Furthermore, the project leads to reduction of pollutant emissions, pollutant discharge into the surface water bodies, solid wastes generation, fuel and chemicals consumption and GHG emissions.

SECTION G. Stakeholders' comments

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

The project support letters have been received from:

- Administration of the Arkhangelsk Region, dated 12.11.2002;
- Municipal Administration of Koryazhma, dated 25.11.2002;
- Main Office of the Russian Ministry of Natural Resources in the Arkhangelsk Region, 05.01.2003.

Municipal Administration of Koryazhma, Administration of the Arkhangelsk Region and Main Office of the Russian Ministry of Natural Resources in the Arkhangelsk Region voiced support of the project implementation, pointing out that it is aimed to improve the environment on site of the enterprise, in the town of Koryazhma and in the Arkhangelsk Region on the whole, and they think that it is real to achieve the environmental targets set forth by the project. Changes didn't need to be introduced to the project following the comments received from these entities.

The public of the town was informed of the planned modernization of the Mill's evaporation system via the local newspaper "Kotlassky Bumazhnik", No.13, 28.03.2003.

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[R5] Energy Passport No.231/E of an industrial consumer of fuel energy resources, OJSC "Kotlas Pulp and Paper Mill".

[R6] Report on the findings of the detailed assessment of the investment project "Pollution Abatement at OJSC "Kotlas Pulp and Paper Mill" Through Replacement of Evaporator Plant". (Project Code – TPP 12).The ED of NPAF, Moscow, 2003.

[R7] 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 2, Energy

[R8] Operational Guidelines for Project Design Documents of Joint Implementation Projects. Volume 1. General Guidelines. Version 2.3. Ministry of Economic Affairs of the Netherlands. May 2004.

[R9] T.I.Nepenin. Pulp Technology. M.: Timber Industry, 1990

[R10] K.F.Roddatis – M.: Energoatomizdat, 1989

[R11] Sokolov "Heat Networks", MEI, 2001.

Annex 1

CONTACT INFORMATION ON PROJECT PARTICIPANTS

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Last name:	Andreev
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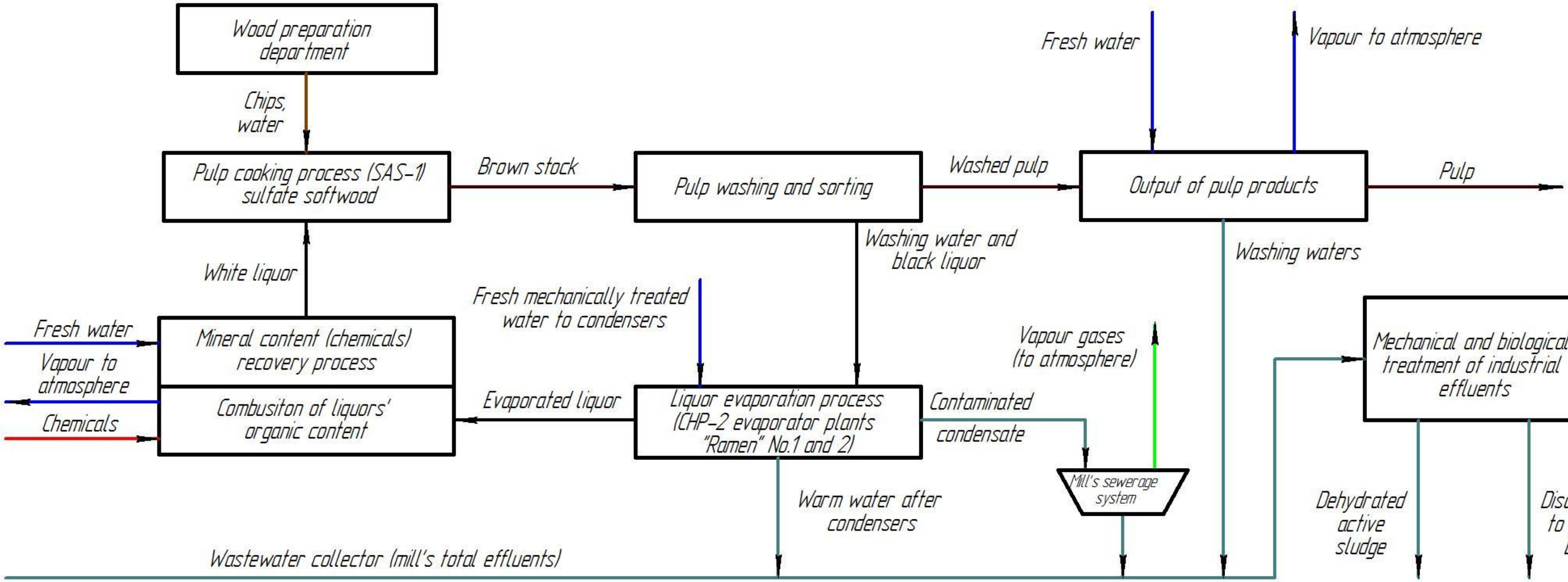
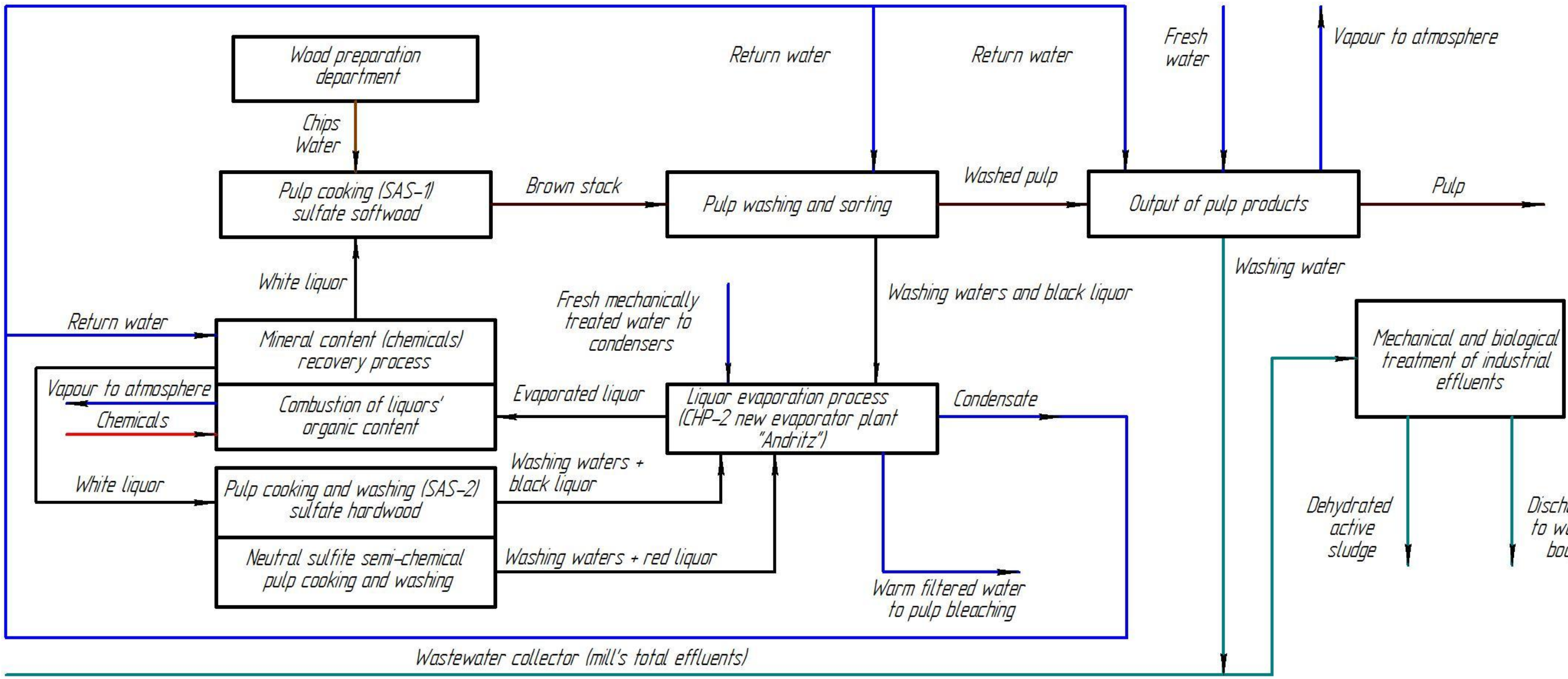
Annex 2

BASELINE INFORMATION

2.1. Schematic diagram of operation of CHP-2 evaporator plants and associated equipment before the project implementation



2.2. Schematic diagram of operation of CHP-2 evaporator plant and associated equipment after the project implementation



2.3. Reporting data on steam production and fuel consumption by a group of liquor recovery boilers

Parameter	Unit	2006	2007	1st quarter 2008	2nd quarter 2008	3rd quarter 2008
Steam production	Gcal	2 220 240	2 116 979	567 765	576 619	566 133
	GJ	9 296 145	8 863 791	2 377 232	2 414 304	2 370 399
Black liquor	t a.d.m.	926 966	920 376	253 021	255 164	252 011
	t e.f.	322 504	318 463	83 637	84 539	83 994
	GJ/t a.d.m.	10.20	10.14	9.689	9.711	9.769
Sulphite liquor	t a.d.m.	39 741	13 029	3 943	4 715	2 344
	t e.f.	21 367	6 676	2 192	2 570	1 362
Red liquor	t a.d.m.	26 156	26 394	6 908	6 217	6 796
	t e.f.	7 972	7 886	2 366	2 068	2 300
	GJ/t a.d.m.	8.933	8.757	10.039	9.750	9.920
Heavy fuel oil	t	2 673	2 962	527	705	1 069
	t e.f.	3 704	4 105	730	976	1 481
Total fuel	t e.f.	355 547	337 130	88 925	90 153	89 137
Average efficiency	-	0.8921	0.8970	0.9121	0.9137	0.9073

1 t e.f. = 29.31 GJ

2.4. Characteristics of CHPP-1 steam turbines

Heat savings due to the project implementation lead to reduction of steam extraction from CHPP-1 turbines. In order to determine reduction of fuel consumption by CHPP-1 it is necessary to find the variation of fresh steam flow to the turbines. At the same time it is also necessary to determine the reduction of electricity generation on the basis of heat consumption (which in general case has to be compensated by additional electricity generation in the grid). The input parameter will be the variation of heat supply from the production stream extraction.

To generate electricity CHPP-1 operates 7 turbine units (No.No.1 to 3 of VPT-25-4 (PT-25-90/10) type; No.4 of PT-60-90/13 type; No.No.5 and 6 of PT-60-130/13 type; No. 7 of R-50-130/13 type).

One of the turbines installed at CHPP-1 is non-condensing (R-50-130/13). As a rule, non-condensing turbines, under a stable demand of industrial steam, operate in the base mode, and regulation of heat and electricity loads is ensured by turbines with less rigid operation modes, in this case by PT turbines.

Based on the steam-consumption diagrams and energy characteristics of the turbines presented in analytical form [R4], the following pairs of equations were established:

1. Turbines of VTP-25-4 type:

$$\Delta Q_0 = 1.204 \times \Delta Q_p$$

$$\Delta N_t = \frac{0.201 \times \Delta Q_p}{3.6}$$

2. Turbine of PT-60-90/13 type:

$$\Delta Q_0 = 1.181 \times \Delta Q_p$$

$$\Delta N_t = \frac{0.178 \times \Delta Q_p}{3.6}$$

3. Turbines of PT-60-130/13 type:

$$\Delta Q_0 = 1.310 \times \Delta Q_p$$

$$\Delta N_t = \frac{0.305 \times \Delta Q_p}{3.6}$$

where ΔQ_0 is the variation of heat (fresh steam) flow to turbines, GJ;

ΔQ_p is the variation of heat supply from the production steam extraction, GJ;

ΔN_t is the variation of heat-consumption-based electricity generation, MWh;

3.6 is the GJ to MWh conversion factor.

The worst, in terms of energy efficiency, are the turbines with the lowest initial steam parameters and the highest steam parameters of steam extraction. It is such least efficient turbines that the enterprise will try to unload in the first place as the opportunity arises. At CHPP-1 of KPPM such turbine is PT-60-90/13 turbine. However in actual practice it is impossible to determine precisely which of the turbines and how long will participate in load regulation, therefore for estimating GHG emissions we shall use averaged, in terms of installed capacity, characteristics of all PT type turbines (i.e. assuming uniform reduction of the number of running hours of all turbines), which is a moderately conservative solution:

$$\Delta Q_0 = \frac{1.204 \times 3 \times 25 + 1.181 \times 1 \times 60 + 1.310 \times 2 \times 60}{3 \times 25 + 1 \times 60 + 2 \times 60} \times \Delta Q_p = 1.2485 \times \Delta Q_p$$

$$\Delta N_t = \frac{0.201 \times 3 \times 25 + 0.178 \times 1 \times 60 + 0.305 \times 2 \times 60}{3.6 \times (3 \times 25 + 1 \times 60 + 2 \times 60)} \times \Delta Q_p = \frac{0.2445 \times \Delta Q_p}{3.6}$$

2.5. Calculation of cash flows of the investment project without taking into account sources of finance

Parameters, thousand USD (1 $ = 32,0 RUR)	1	2	3	4	5	6	7	8	9	10
Operating activity										
Savings of current costs	0,00	0,00	3 467,48	4 623,31	4 623,31	4 623,31	4 623,31	4 623,31	4 623,31	4 623,31
Depreciation of aquired assets	0,00	0,00	-901,25	-1 201,67	-1 201,67	-1 201,67	-1 201,67	-1 201,67	-1 201,67	-1 201,67
Book value of fixed assets			17 123,75	15 922,08	14 720,42	13 518,75	12 317,08	11 115,42	9 913,75	8 712,08
Property tax (1,8%)	0,00	0,00	-237,25	-297,41	-275,78	-254,15	-232,52	-210,89	-189,26	-167,63
Taxable profit	0,00	0,00	2 328,98	3 124,23	3 145,86	3 167,49	3 189,12	3 210,75	3 232,38	3 254,01
Profit tax (24%)	0,00	0,00	-558,96	-749,82	-755,01	-760,20	-765,39	-770,58	-775,77	-780,96
Net profit	**0,00**	**0,00**	**1 770,03**	**2 374,42**	**2 390,86**	**2 407,29**	**2 423,73**	**2 440,17**	**2 456,61**	**2 473,05**
Depreciation of aquired assets	0,00	0,00	901,25	1 201,67	1 201,67	1 201,67	1 201,67	1 201,67	1 201,67	1 201,67
Balance of operating activity	**0,00**	**0,00**	**2 671,28**	**3 576,08**	**3 592,52**	**3 608,96**	**3 625,40**	**3 641,84**	**3 658,28**	**12 386,80**
Investment activity										
Capital expenditure, incl. import tax	-4 870,00	-11 755,00	-1 400,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
VAT on capital expenditure	-324,00	-3 261,00	-20,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Refund of VAT on capital expenditure	0,00	0,00	3 605,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Balance of investment activity	**-5 194,00**	**-15 016,00**	**2 185,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
Balance of 2 flows	**-5 194,00**	**-15 016,00**	**4 856,28**	**3 576,08**	**3 592,52**	**3 608,96**	**3 625,40**	**3 641,84**	**3 658,28**	**12 386,80**
Discounted balance of 2 flows (discount rate - 20%)	**-5 194,00**	**-17 707,33**	**-14 334,92**	**-12 265,43**	**-10 532,92**	**-9 082,56**	**-7 868,42**	**-6 852,05**	**-6 001,25**	**-3 600,61**

Parameters of commercial effectiveness	Discount rate = 20%
Net present value (NPV), thousand $	-3 600,6
Internal rate of return (IRR)	14,0%

2.6. Calculation of cash flows of the investment project with taking into account sources of finance

Parameters, thousand USD (1 $ = 32,0 RUR)	1	2	3	4	5	6	7	8	9	10
Operating activity										
Savings of current costs	0,00	0,00	3 467,48	4 623,31	4 623,31	4 623,31	4 623,31	4 623,31	4 623,31	4 623,31
Depreciation of aquired assets	0,00	0,00	-901,25	-1 201,67	-1 201,67	-1 201,67	-1 201,67	-1 201,67	-1 201,67	-1 201,67
Book value of fixed assets			17 123,75	15 922,08	14 720,42	13 518,75	12 317,08	11 115,42	9 913,75	8 712,08
Property tax (1,8%)	0,00	0,00	-237,25	-297,41	-275,78	-254,15	-232,52	-210,89	-189,26	-167,63
Taxable profit	0,00	0,00	2 328,98	3 124,23	3 145,86	3 167,49	3 189,12	3 210,75	3 232,38	3 254,01
Profit tax (24%) including lax current service of VTB credit	0,00	0,00	-242,16	-464,70	-533,25	-601,80	-670,35	-738,90	-775,77	-780,96
Net profit	**0,00**	**0,00**	**2 086,83**	**2 659,54**	**2 612,62**	**2 565,69**	**2 518,77**	**2 471,85**	**2 456,61**	**2 473,05**
Depreciation of aquired assets	0,00	0,00	901,25	1 201,67	1 201,67	1 201,67	1 201,67	1 201,67	1 201,67	1 201,67
Balance of operating activity	**0,00**	**0,00**	**2 988,08**	**3 861,20**	**3 814,28**	**3 767,36**	**3 720,44**	**3 673,52**	**3 658,28**	**12 386,80**
Investment activity										
Capital expenditure, incl. import tax	-4 870,00	-11 755,00	-1 400,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
VAT on capital expenditure	-324,00	-3 261,00	-20,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Refund of VAT on capital expenditure	0,00	0,00	3 605,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Balance of investment activity	**-5 194,00**	**-15 016,00**	**2 185,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
Financial activity										
Own funds for investments	1 944,00	7 266,00	1 420,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Own funds for debt servicing	375,31	884,06	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Final loan from NPAF	3 250,00	7 750,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Repayment of NPAF loan	0,00	0,00	0,00	-2 200,00	-2 200,00	-2 200,00	-2 200,00	-2 200,00	0,00	0,00
Remaining loan	3 250,00	11 000,00	11 000,00	8 800,00	6 600,00	4 400,00	2 200,00	0,00		
Interest on NPAF loan (12%)	-195,00	-855,00	-1 320,00	-1 188,00	-924,00	-660,00	-396,00	-132,00	0,00	0,00
Commitment charge for NPAF loan (0,75%)	-70,31	-29,06	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Payment for IP assessment (1% of NPAF loan)	-110,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Balance of financial activity	**5 194,00**	**15 016,00**	**100,00**	**-3 388,00**	**-3 124,00**	**-2 860,00**	**-2 596,00**	**-2 332,00**	**0,00**	**0,00**
Aggregate results										
Joint balance of 3 flows	0,00	0,00	5 273,08	473,20	690,28	907,36	1 124,44	1 341,52	3 658,28	12 386,80
Joint balance of 3 flows without own funds of the enterprise	-2 319,31	-8 150,06	3 853,08	473,20	690,28	907,36	1 124,44	1 341,52	3 658,28	12 386,80
Discounted balance of 3 flows without own funds of the enterprise (discount rate - 20%)	-2 319,31	-9 111,03	-6 435,28	-6 161,44	-5 828,55	-5 463,90	-5 087,33	-4 712,93	-3 862,14	-1 461,49
Cumulated balance of 3 flows	0,00	0,00	5 273,08	5 746,28	6 436,56	7 343,92	8 468,36	9 809,88	13 468,16	25 854,96

Parameters of commercial effectiveness	Discount rate= 20%
Net present value (NPV), thousand $	-1 461,5
Internal rate of return (IRR)	15,9%

2.7. Calculation of cash flows for the investment project with taking into account sources of finance and revenues from sale of GHG emission reductions

Parameters, thousand USD (1 $ = 32,0 RUR)	1	2	3	4	5	6	7	8	9	10
Operating activity										
Savings of current costs	0,00	0,00	3 467,48	4 623,31	4 623,31	4 623,31	4 623,31	4 623,31	4 623,31	4 623,31
Revenues from sale of ERUs			960,32	1 280,43	1 280,43	1 280,43	1 280,43	1 280,43	1 280,43	1 280,43
Depreciation of aquired assets	0,00	0,00	-901,25	-1 201,67	-1 201,67	-1 201,67	-1 201,67	-1 201,67	-1 201,67	-1 201,67
Book value of fixed assets			17 123,75	15 922,08	14 720,42	13 518,75	12 317,08	11 115,42	9 913,75	8 712,08
Property tax (1,8%)	0,00	0,00	-237,25	-297,41	-275,78	-254,15	-232,52	-210,89	-189,26	-167,63
Taxable profit	0,00	0,00	3 289,30	4 404,67	4 426,30	4 447,93	4 469,56	4 491,19	4 512,82	4 534,45
Profit tax (24%) including lax current service of VTB credit	0,00	0,00	-472,63	-772,00	-840,55	-909,10	-977,65	-1 046,20	-1 083,08	-1 088,27
Net profit	**0,00**	**0,00**	**2 816,67**	**3 632,67**	**3 585,74**	**3 538,82**	**3 491,90**	**3 444,98**	**3 429,74**	**3 446,18**
Depreciation of aquired assets	0,00	0,00	901,25	1 201,67	1 201,67	1 201,67	1 201,67	1 201,67	1 201,67	1 201,67
Balance of operating activity	**0,00**	**0,00**	**3 717,92**	**4 834,33**	**4 787,41**	**4 740,49**	**4 693,57**	**4 646,65**	**4 631,41**	**13 359,93**
Investment activity										
Capital expenditure, incl. import tax	-4 870,00	-11 755,00	-1 400,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
VAT on capital expenditure	-324,00	-3 261,00	-20,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Refund of VAT on capital expenditure	0,00	0,00	3 605,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Balance of investment activity	**-5 194,00**	**-15 016,00**	**2 185,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
Financial activity										
Own funds for investments	1 944,00	7 266,00	1 420,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Own funds for debt servicing	375,31	884,06	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Final loan from NPAF	3 250,00	7 750,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Repayment of NPAF loan	0,00	0,00	0,00	-2 200,00	-2 200,00	-2 200,00	-2 200,00	-2 200,00	0,00	0,00
Remaining loan	3 250,00	11 000,00	11 000,00	8 800,00	6 600,00	4 400,00	2 200,00	0,00		
Interest on NPAF loan (12%)	-195,00	-855,00	-1 320,00	-1 188,00	-924,00	-660,00	-396,00	-132,00	0,00	0,00
Commitment charge for NPAF loan (0,75%)	-70,31	-29,06	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Payment for IP assessment (1% of NPAF loan)	-110,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Balance of financial activity	**5 194,00**	**15 016,00**	**100,00**	**-3 388,00**	**-3 124,00**	**-2 860,00**	**-2 596,00**	**-2 332,00**	**0,00**	**0,00**
Aggregate results										
Joint balance of 3 flows	0,00	0,00	6 002,92	1 446,33	1 663,41	1 880,49	2 097,57	2 314,65	4 631,41	13 359,93
Joint balance of 3 flows without own funds of the enterprise	-2 319,31	-8 150,06	4 582,92	1 446,33	1 663,41	1 880,49	2 097,57	2 314,65	4 631,41	13 359,93
Discounted balance of 3 flows without own funds of the enterprise (discount rate - 20%)	-2 319,31	-9 111,03	-5 928,45	-5 091,45	-4 289,26	-3 533,54	-2 831,07	-2 185,09	-1 107,97	1 481,27
Cumulated balance of 3 flows	0,00	0,00	6 002,92	7 449,25	9 112,66	10 993,15	13 090,72	15 405,37	20 036,78	33 396,70

Parameters of commercial effectiveness	Discount rate= 20%
Net present value (NPV), thousand $	1 481,3
Internal rate of return (IRR)	24,1%

Annex 3

MONITORING PLAN

Data on metering devices for GHG emission reduction monitoring

Metered parameter	Mark and type of meter	Serial number	Set number	Measurement range	Unit	Error, accuracy class	calibration interval (month)	Last calibration data	Type of metrological control	Organisation which performs calibration
Volume of pulp produced in SAS-1 cooking workshop after blowdown:	1.Flow meter: AXFA11G,80	S5F501993617	D-341	0-360	m³/h	1.0	60	24.11.2006	Calibration	OJSC "Ilim Group" Branch in Koryazhma
	2. Concentration meter: MEK-2300	256337/1/3	D-504	2-5	%	1.0	Adjusted on a weekly basis as per laboratory analysis			OJSC "Ilim Group" Branch in Koryazhma
Volumetric consumption of natural gas by utilizing boiler	4. Natural gas flow meter: PROWIRL 72,25	8103AF02000	Ch-322	0-650	m³/h	1.0	60	18.06.2007	Calibration	OJSC "Ilim Group" Branch in Koryazhma
Volumetric consumption of natural gas by flare	5. Natural gas flow meter: PROWIRL F,40	8103B002000	Ch-320	0-650	m³/h	1.0	60	18.06.2007	Calibration	OJSC "Ilim Group" Branch in Koryazhma
Calorific value of natural gas	6. Calorimetric bomb: V-08-MA	1857	TEC	15000	J/kg	0.10%	12	07.11.2008	Verification	Arkhangelsk Centre for Standardisation and Metrology (ACSM)
	7. Weights: VLKT-2	102	S-002	0-2	kg	Class 4	12	17.11.2008	Calibration	ACSM
	8. Set of weights: G-2-210	87	T-002	1-100	g	Class 2	12	01.08.2008	Calibration	
Calorific value of liquor	9. Calorimetric bomb: V-08-M	1085	TEC	15000	J/kg	0.10%	12	07.11.2008	Verification	ACSM
	10. Weights: VLKT-500	185	S-001	0-500	g	Class 4	12	15.02.2009	Calibration	OJSC "Ilim Group" Branch in

										Koryazhma
	11. Set of weights: G-2-210	109	T-003	1-100	g	Class 2	12	01.08.2008	Verification	ACSM
Heat consumption for CHP-3 evaporator plant	12. Flow meter: HD4SD27SHO	u/n	T-365	0-63	t/h	0.5	12	15.08.2008	Calibration	OJSC “Ilim Group” Branch in Koryazhma
	13. Temperature meter: Sh4500, THK	2034746	T-152	0-300	^{0}C	1.5	24	12.02.2008	Calibration	OJSC “Ilim Group” Branch in Koryazhma
	14. Pressure meter: HT6S122SHO	44659434	T-256	0-60	bar	0.5	12	03.04.2008	Calibration	OJSC “Ilim Group” Branch in Koryazhma
Heat consumption for CHP-3 concentrators	15. Flow meter: DIFF-EL	5829	T-396	0.47	kgf/cm^2	0.5	12	15.08.2008	Calibration	OJSC “Ilim Group” Branch in Koryazhma
	16. Temperature meter: TEMP-AIR	6930	T-162	0-200	^{0}C	0.3 grade of C	12	17.01.2009	Verification	ACSM
	17. Pressure meter: PRESS-EL	3447	T-202	0-13	bar	0.5	12	28.08.2008	Calibration	OJSC “Ilim Group” Branch in Koryazhma
Heat consumption for CHP-2 evaporator plant	18. Flow meter: PMD-75	81007E0109D	Ch-300	0-0.075	bar	0.5	12	30.06.2008	Calibration	OJSC “Ilim Group” Branch in Koryazhma
	19. Temperature meter: TMT-182	810069	Ch-100	0-250	^{0}C	Class C	60	23.06.2008	Calibration	OJSC “Ilim Group” Branch in Koryazhma
	20. Pressure meter: PMP-71	8100790109C	Ch-201	0-5	bar	0.5	12	24.06.2008	Calibration	OJSC “Ilim Group” Branch in Koryazhma
Heat consumption for CHP-2 concentrators	21. Flow meter: DIFF EL	250668	S-343	0-588.4	mbar	0.5	12	29.10.2008	Calibration	OJSC “Ilim Group” Branch in Koryazhma
	22. Temperature meter: Pt 100	б/н	Ch-101	0 – 200	^{0}C	Class C	60	23.06.2008	Calibration	OJSC “Ilim Group” Branch in Koryazhma

	23. Pressure meter: PRESS EL	110664	S-228	0-4	bar	0.5	12	11.09.2008	Verification	ACSM
Heat production by utilizing boiler	24. Flow meter: Deltabar S, PMD75 type	81009A0109D	Ch-316	0.230; 0-2.8	bar; kg/s	0.5	12	25.06.2008	Calibration	OJSC "Ilim Group" Branch in Koryazhma
	25. Temperature meter: TR88-AA4B1D2R3000	810061	Ch-143	0-220	^0C	Class C	60	26.06.2008	Calibration	OJSC "Ilim Group" Branch in Koryazhma
	26. Pressure meter: Cerabar S, PMP71 type	81008F0109C	Ch-222	0-20	bar	0.5	12	07.06.2008	Calibration	OJSC "Ilim Group" Branch in Koryazhma
Quantity of red liquor fed to CHP-2 evaporator plant	27. Flow meter: OPTI FLUX4000F,150	81008F0115	Ch-333	0-250	m^3/h	1.0	60	28.10.2008	Calibration	OJSC "Ilim Group" Branch in Koryazhma
	28. Temperature meter:	556	____	0-150	^0C	1 grade of C	48	23.01.2006	Calibration	OJSC "Ilim Group" Branch in Koryazhma
	29. Density meter:	BY LABORATORY METHOD								OJSC "Ilim Group" Branch in Koryazhma
Quantity of black liquor from CPP fed to CHP-2 evaporator plant	30. Flow meter: 50XM12,50	2X1003/A6	D-913	0-20	m^3/h	1.0	60	04.09.2008	Calibration	OJSC "Ilim Group" Branch in Koryazhma
	31. Temperature meter:	555	____	0-150	^0C	1 grade of C	48	23.01.2006	Calibration	OJSC "Ilim Group" Branch in Koryazhma
	32. Density meter:	BY LABORATORY METHOD								OJSC "Ilim Group" Branch in Koryazhma
Quantity of black liquor from SBPP fed to CHP-2 evaporator plant	33. Flow meter: OPTI FLUX4000F	150A0732429	B-391	0 – 450	m^3/h	1.0	60	29.09.2006	Calibration	OJSC "Ilim Group" Branch in Koryazhma

	34. Temperature meter: 13TD73	7528	B-112	0-100	^{0}C	1.5	12	14.10.2008	Calibration	OJSC “Ilim Group” Branch in Koryazhma
	35. Density meter:	BY LABORATORY METHOD								OJSC “Ilim Group” Branch in Koryazhma
Quantity of black liquor from SBPP fed to CHP-3 evaporator plant	36. Flow meter: DMPK100	07932	T-370	6300	kgf/m^2	1.5	12	28.08.2008	Calibration	OJSC “Ilim Group” Branch in Koryazhma
	37. Temperature meter:	125	____	0-150	^{0}C	1 grade of C	48	23.01.2006	Calibration	OJSC “Ilim Group” Branch in Koryazhma
	38. Density meter: DIFF AIR	7997	T-017	0-300	kgf/m^2	1.0	12	28.08.2008	Calibration	OJSC “Ilim Group” Branch in Koryazhma
Volume of warm water after condenser of CHP-2 evaporator plant fed for production needs	39. Flow meter: OPTI FLUX5000F,600	A06 61894	Ch-328	0-10	m^3/h	1.0	60	15.08.2007	Calibration	OJSC “Ilim Group” Branch in Koryazhma
Temperature of warm water after the condenser of CHP-2 evaporator plant fed for production needs	40. Temperature meter: TR15 1xPT100/A/4	88008F14154	Ч-151	0-120	^{0}C	Class C	60	17.08.2007	Calibration	OJSC “Ilim Group” Branch in Koryazhma
Volume of condensate after CHP-2 evaporator plant, fed for production needs from condensate accumulation tank	41. Flow meter: Deltabar S PMD72 type	81007F0109D	Ch-301	0-42	l/s	0.5	12	27.06.2008	Calibration	OJSC “Ilim Group” Branch in Koryazhma
Electricity consumption by CHP-2 evaporator plant	42. Electricity meter: ELCTIEA	1138305	—	10000	kW/h	0.5	96	2nd quarter of 2006	Calibration	OJSC “Ilim Group” Branch in Koryazhma
Electricity consumption by CHP-3 evaporator plant	43. Electricity meter: ELCTIEA	1138304	___	10000	kW/h	0.5	96	2nd quarter of 2006	Calibration	OJSC “Ilim Group” Branch in Koryazhma