JOINT IMPLEMENTATION PROJECT DESIGN DOCUMENT FORM
VERSION 01 - IN EFFECT AS OF: 15 JUNE 2006

CONTENTS

Annexes

SECTION A. General description of the project

A.1. Title of the project:

Waste Biomass Utilization at JSC Arkhangelsk Pulp and Paper Mill (APPM)
Version 1.2
31 May 2007

A.2. Description of the project:

The project is aimed at utilization of highly humid / low calorific waste biomass by its combustion in “fluidized bed” boilers, without using fossil fuel for flame stabilization, to generate energy for internal needs of APPM.

With reference to the project, waste biomass includes (i) - bark and wood waste (BWW), and (ii) - waste water sludge (WWS) [1].

BWW includes bark, sawdust, slivers, substandard chips, as well as construction wood waste, logging wood waste etc. Most of the BWW is formed at the APPM’s wood preparation shops while making pulp chips for feeding into digesters (cooking boilers), and the rest is supplied from near-by sawmills. The major part of BWW has been traditionally combusted by APPM for energy purpose in the utilizing boilers at two thermal-power plants (TPP), TPP-1 and TPP-3, with fuel oil used for flame stabilization.

However, this only applies to the least humid wood waste (i.e. sawdust, slivers, substandard chips, construction wood waste etc) and does not apply in full to bark which has extremely high humidity content (up to 70%) and low calorific value (7 GJ/dense m^3) that are far beyond the requirements and combusting abilities of the existing utilizing boilers. There are two main reasons for that:

(a) A substantial part of logs (up to 20%) is supplied to APPM and to near-by sawmills by floating down the Northern Dvina River. Logs are stored at the wood yards, and then sent further to debarking;

(b) Debarking at both APPM and the near-by sawmills is rendered using the so called wet technologies. Particularly, at APPM bark is washed off the logs by water supplied into barking drums under pressure. Only recently dry barking technology has been introduced at the newly constructed wood preparation shop #4 at APPM.

Because of that, bark is utilized partially, in proportion 20:80 (normal) or 30:70 (maximal) with wood waste, while the rest is dumped in the landfill.

WWS is formed at the station of biological treatment of waste waters coming both from APPM and the town of Novodvinsk. WWS has even higher humidity content and thus, lower net calorific value (less than 1 GJ/wet ton) and has never been utilized by APPM. Since the very beginning and up to the project, WWS has been dumped by APPM in the landfills together with bark. That was and still is the common practice in Russian pulp-and-paper industry at all. To the best of our knowledge, of all Russian pulp-and-paper mills (PPMs), only JSC Solikamskbumprom has been combusting WWS together with BWW since late 1990s when a new utilizing boiler supplied by Wellons, USA was installed there.

It’s worth noting here that dumping of WWS in special landfills is considered the best practice by the Russian environmental regulation which only requires construction and maintenance of such landfills in accordance with the established standards, and mixing WWS in a certain proportion with BWW before dumping.

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[1] Black liquor which is a by-product of pulp production can also be referred to as waste biomass since it contains up to 60% of bio-organic matters (on dry basis). In pulp-and-paper industry at large and at APPM in particular, this black liquor is combusted in special soda recovery boilers, with fossil fuel used for flame stabilization, to provide for recovery of sodium sulphate and to generate steam. However, the project has nothing to do with black liquor.

From this perspective, the idea to stop dumping highly humid bark and WWS and to utilize them instead for energy purpose was new, ambitious, and hence, challenging.

To achieve the project goals, the following measures have been envisaged in the project:

- Renovation of the utilizing boilers #1 and #2 at TPP-3 for combustion of BWW and WWS as a combined fuel without using fuel oil (or any other fossil fuel) for flame stabilization by implementation of advanced fluidized bed technology (supplied by Kvaerner Power, Finland);
- Modernization of wood preparation shop #3 (WPS-3) with installation of advanced equipment (bark-crusher and bark-press supplied by Saalasti, Finland) for crushing and dewatering of bark, before feeding into the boilers for combustion, to the parameters required by the renovated boilers, i.e. fractions no longer than 75 mm, and humidity content no higher than 60%;
- Construction of a new unit for receiving of BWW and WWS delivered by motor transport, their preparation, storage and feeding for combustion into the renovated utilizing boilers at TPP-3.

As a result of the project

- At least 140 thousand tons of additional BWW (mainly – bark) and about 100 thousand tons (wet) of WWS per annum will be utilized thus avoiding dumping in the landfill;
- Fuel oil consumption at TPP-3 will be reduced by 2.19 million GJ per annum;
- Steam supply from TPP-1 will decrease by 300 thousand GJ per annum, enabling the decrease of fossil fuel combustion at TPP-1;
- Emission of conventional pollutants (SO_2, NOx, CO) into the atmosphere will be significantly reduced;
- CO_2 emissions resulting from combustion of fossil fuel at both TPP-1 and TPP-3 will be reduced by about 180 thousand tons per annum;
- Methane emissions resulting from anaerobic decomposition of waste biomass (BWW and WWS) at the APPM landfill will decrease by about 25 thousand tons of CO_2e per annum on average over 2008-2012.

The project has been implemented on the site of JSC Arkhangelsk PPM in Novodvinsk, Arkhangelsk region, Russia, and is worth $20.2 million.

Because of high project risks and costs, the project was implemented in two stages:

Stage I:

- Reconstruction of the utilizing boiler #2 at TPP-3 with switching to fluidized bed combustion of BWW without using fuel oil (or any other fossil fuel) for flame stabilization – $2.5 million;
- Installation of bark crushing and dewatering unit at WPS-3 – $2.6 million; and

Stage II:

- Replacement of the utilizing boiler #1 at TPP-3 with a new utilizing boiler E-75-3.9-440 DFT capable for efficient fluidized bed combustion of BWW and WWS without using fuel oil (or any other fossil fuel) for flame stabilization – $12.5 million;
- Construction of a new unit for receiving, preparation, storage and feeding into the utilizing boilers at TPP-3 of BWW and WWS delivered by motor transport – $2.6 million.

Stage I started in February 2000 and was completed in December 2000. It was, in many respects, a trial stage, undertook in order to explore the possibility and check the technology of combustion of BWW without using fuel oil for flame stabilization. Besides, APPM tried at this stage to start combustion of WWS in the reconstructed boiler. However, to do this efficiently a new boiler had to be installed and some other technological issues resolved.

Stage II was designed with reference to the results achieved at Stage I. The idea here was to utilize bark and WWS locally formed at APPM and also to enhance APPM's capacity to receive and utilize BWW delivered from outside. Stage II took much longer time and required much higher investments, and was implemented in 2003 through 2005.

Now, in continuation and development of the project, APPM is considering (a) – further modernization of the utilizing boiler #2 at TPP-3 in order to reach the same efficiency of fluidized bed combustion of BWW and WWS as the new E-75-3.9-440 DFT boiler has, and (b) – construction, in the nearest future, of a new fluidized bed boiler to totally substitute the middle-pressure BWW utilizing boilers installed at TPP-1 where BWW is still combusted with fuel oil flame stabilization.

Besides, APPM is considering various measures to be undertaken at both production departments (local systems of waste water recycling) and at the station of biological waste water treatment in order to reduce the amount of WWS. However, these measures are not deemed to be a part of the project and are not considered here in the PDD.

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: Joint Stock Company "Arkhangelsk Pulp and Paper Mill"	No
Party B: EU countries	Legal entity B1: Private company "Camco International GmbH"	No

Contact information is provided in Annex 1

JSC Arkhangelsk PPM is a legal entity in the form of an open joint stock company, acting in accordance with its corporate charter and the legislation of the Russian Federation. The company's principal activities are production and sale of bleached kraft-pulp, paper, cardboard, corrugated products, fiber boards, copy-books, and provision of services.

Arkhangelsk PPM is holding its leading positions among Russian manufacturers of pulp and paper products in the conditions of an increasingly stiff competition. In 2005, the amount of pulped cellulose reached 826.6 thousand tons [R17], the share of APPM in the output of cardboard was 22.5% (1st place), that of market pulp was 9.4% (4th place). APPM accounts for a quarter of Russia's market of copy-books.

The mill has its own energy sources (three thermal power plants); facilities for manufacturing cardboard, bleached pulp, paper; wood-processing facilities; station of waste water biological treatment; auxiliary shops. APPM is a township-forming enterprise. It is responsible for supply heat to the town of Novodvinsk, as well as for sewage treatment. About 7 thousand people work at the mill.

The mill's quality management system was certified under ISO 9000 standards May 2003, and its Environmental Management System (EMS) was certified under ISO 14000 standards in June 2004.

After that, JSC Arkhangelsk PPM began to develop an integrated management system taking into account requirements of the international standards in quality control, environment protection and labor protection. As of March of 2006, the enterprise underwent the procedure of re-certification of its quality management and environmental management systems, as well as certification of its labor protection system for compliance with the requirements set forth in the international OHSAS 18001 standard.

JSC Arkhangelsk PPM is holding the 13th position in the Russian top-list of the most transparent companies in terms of environmental records. Having performed the analysis of environment protection activities of Arkhangelsk PPM, the Expert RA rating agency gave the mill a B++ environment rating, which confirms a low level of environmental risks associated with the mill's activities.

Camco International GmbH is a subsidiary of Camco International Ltd., a Jersey based public limited liability company listed at AIM in London (index CAO). Camco International is the world leading carbon asset developer and projects promoter under both joint implementation and clean development mechanism of the Kyoto Protocol. Camco's project portfolio consists of more than 70 projects, generating altogether 118 Mt CO_2e of GHG reductions all over the world. Camco operates in Eastern Europe, Africa, China, and Southeast Asia. The company has been actively operating in Russia since 2005.

A.4. Technical description of the project:

A.4.1. Location of the project:

Arkhangelsk pulp and paper mill, Novodvinsk, Arkhangelsk Region, Russia.

Fig. A.4-1. Map indicating the point of the project implementation

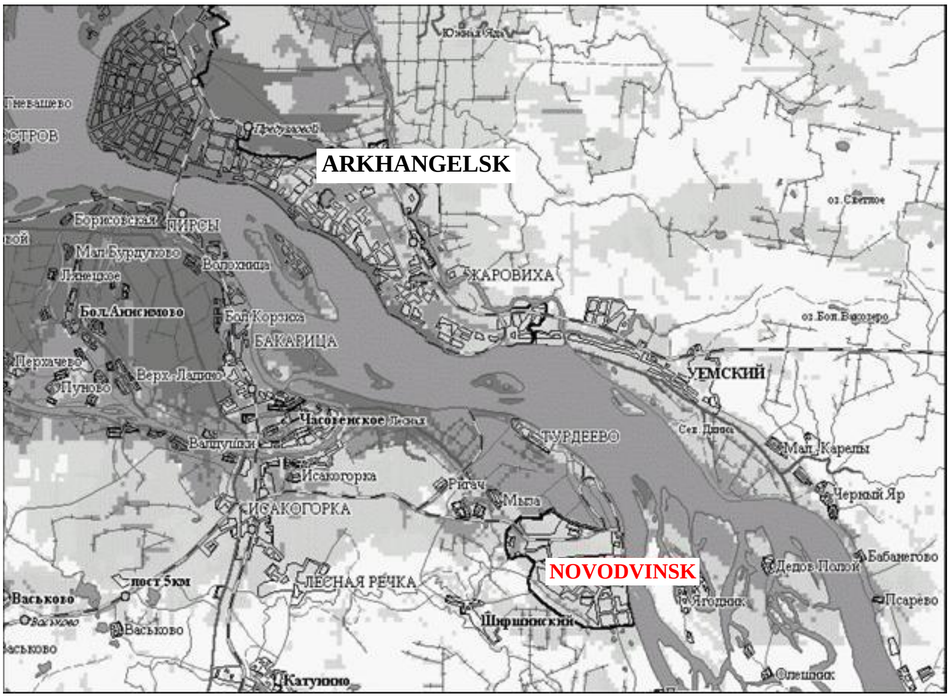

Fig. A.4-2. Location of Novodvinsk and Arkhangelsk

A.4.1.1. Host Party(ies):

Russian Federation

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

Arkhangelsk Region

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

Town of Novodvinsk

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

The project is being implemented at the production site of OJSC Arkhangelsk pulp and paper mill (APPM) in the town Novodvinsk of Arkhangelsk Region, Russia.

Geographic latitude: 64°25'
Geographic longitude: 40°49'

The town of Novodvinsk is situated on the left bank of the Northern Dvina river, 30 km away from Arkhangelsk, 11 km away from the railway station of Isakogorka of the Northern Railroad. The town's territory is confined by the Northern Dvina from the east, by industrial zone of the Arkhangelsk pulp and paper mill from the north, with the power transmission line running along its western border, with no limiting border from the south.

The climate is moderately cold, with short summer and long winter. The average annual temperature is +0.6 °C. The average January temperature is -12.5 °C, that of July is +15.6 °C.

The population of Novodvinsk was 42.9 thousand as of 2005. The nearest cities are Arkhangelsk and Severodvinsk. The leading enterprises in Novodvinsk are Arkhangelsk PPM, and Arkhangelsk plywood manufacturing plant.

The APPM area (670 hectares) is in the northern part of Novodvinsk, being its industrial zone. APPM borders the North Dvina riverside in the northeast and the east, while adjoining other industrial enterprises of Novodvinsk in the south and south-west; their areas, in their turn, adjoin the town's residential area.

APPM is linked to the railway, motorway and waterway network, and has an outlet to the White Sea through the Ekonomiya port, which is in the river's estuary, 60 km away from the mill. Besides, APPM has its own berth, which allows receiving of sea-going vessels.

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

Characteristics of technologies at the project sections prior to its implementation

Arkhangelsk PPM comprises the following departments (see the diagram in Annex 11):

- Cellulose production (including TPP-3)
- Cardboard production (including TPP-2)
- Paper production
- Fiber board (FB) production
- Wood processing facilities (WPF)
- TPP-1
- Biological treatment facilities (BTF)

Pulping is carried out at the cellulose and cardboard production departments.

The project relates to TPP-3, TPP-1, wood-processing facilities and industrial waste landfill which are described in detail below.

TPP-3

TPP-3 is a power-technological plant which provides for recovery of liquors at cellulose production department, utilization of BWW formed mostly in WPS-3, as well as generation of steam and power for cellulose production. TPP-3 covers about 75% of the annual demand of steam, and about 65% of the annual demand of electric power for cellulose production. The plant's installed electric power is 28.6 MW, while its heat power is 223 Gcal/hr. The plant is equipped with three recovery boilers (RB) and two utilizing boilers, their steam being mixed in the common collector and directed to the turbine house. The rated parameters of live steam for all the boilers are as follows: P = 40 atm, t = 440 ^{o}C.

The power plant generates electricity in three turbosets with backpressure: two P-12-35/5 turbines and one P-6-35/10 turbine. The wasted steam goes to cellulose production and is used for the plant's auxiliary needs.

The diagrams of boiler and turbine houses of TPP-3 are presented in Annexes 12, 13.

Regeneration of sulfate liquors is carried out in three parallel recovery boiler units: one Tampella boiler unit (RB-3) and two Parsons-Whittemore boiler units (RB-4 and RB-5), with the total daily input for the burnt liquor equal to 2 310 tons of absolutely dry matter (a.d.m.). Fuel oil is used as the supplementary fuel.

Two KM-75-40 (#1, #2) boiler units designed for burning wet bark and sawdust with fuel oil flame stabilization have been operating in the utilizing boiler-room of TPP-3 since late 1970s. Boilers of this type have a mechanical chain grate. The designed steam capacity for burning wood waste with moisture content up to 60% is 50 t/hr, and with fuel oil flame stabilization – 75 t/hr. The boiler layout is presented in Annex 14.

The principal annual indicators of the operation of the utilizing boiler-room as of 1999 are presented in Table A.4-1. Prior to the project (at least, over the period starting with 1990), it was year 1999 that TPP-3 burnt the biggest amount of BWW and produced maximum of steam in the utilizing boilers. Though it's unlikely that these boilers could ever achieve better results, they still could continue running at approximately the same output for another several years if duly maintained.

Table A.4-1. Principal indicators of the utilizing boiler-room of TPP-3 in 1999

Steam generation, GJ	1 259 893
Fuel oil consumption, tons	24 322
BWW consumption, tons	229 370
Total consumption of equivalent fuel, GJ	2 766 131
Working time fund, hours	16 090
Average annual efficiency factor of boilers, %	45.5

The lacking amount of live steam for full loading of the TPP-3 turbine equipment had to be generated through burning of additional amount of fuel oil in the recovery boilers above the necessary amount required for ensuring of stable combustion of black liquor. Preparation of fuel oil for TPP-3 is carried out at the fuel oil farm also serving TPP-1.

As the steam and electric power generated by TPP-3 are not sufficient for the cellulose production, a significant amount of energy is supplied from TPP-1. The pressure of steam supplied from TPP-1 is 10 atm.

The operation of TPP-3 can be monitored with the use of reports of statistical form 6-tp "Data on operation of thermal power plant". An example of report for 2002 is given in Annex 15.

TPP-1

TPP-1 is a power-generating plant intended for generating steam, hot water and electricity to be used both for industrial needs of the mill and for supplying to the town of Novodvinsk. The plant's installed electric power is 194 MW and heat power being 742 Gcal/hr. Coal, fuel oil and BWW are used as fuels.

TPP-1 has to be included in the project, as, with steam output from TPP-3 increased, supply of steam from TPP-1 for cellulose production will lower; besides, BWW combustion at TPP-1 is also forecast to fall.

The list of the main equipment installed at TPP-1 (as of July 2003) is given in Annex 16. Annex 17 presents the layout of live steam pipelines. TPP-1 comprises high pressure (HP) station and medium pressure (MP) station. The rated live steam parameters of the boilers at HP station are: P = 100 atm, t = 540 ^{o}C, and those of MP station are: P = 34-40 atm, t = 400 ^{o}C. Besides, to cover peak heating loads, an oil-fired water-heating boiler is installed at TPP-1. The above boilers are enlisted in Table A.4-2.

Table A.4-2. List of operating boilers of TPP-1 (as for July, 2003)

Station Number	Model	Fuel
Steam boiler #1	KM-75-40	Waste wood
Steam boiler #3	NZL-60-34	Waste wood
Steam boiler #4*	FShT-75-34	Waste wood
Steam boiler #5	BKZ-220-100	Fuel oil
Steam boiler #6	BKZ-220-100	Coal
Steam boiler #10	BKZ-220-9.8-13	Coal
Steam boiler #11	BKZ-220-100f	Coal
Steam boiler #12	BKZ-220-100f	Coal
Steam boiler #13	BKZ-220-100f	Coal
Steam boiler #14	BKZ-220-100f	Coal
Water-heating boiler #2	PTVM-100	Fuel oil

* - decommissioned in September 2004.

HP steam boilers run on coal and fuel oil and are equipped with chamber furnaces. Prior to combustion coal is ground in hammer mills and then is burnt in a flare. The station is equipped with the hydraulic ash removal system, which serves to remove ash and slag.

The high pressure steam collector feeds five heat-extraction turbosets with the total power of 182 MW. Four turbines have steam condensers, with cooling water supplied from the river.

Over the last years, coal has been increasingly prevailing in the fossil fuel consumption structure, while fuel oil combustion has been declining. This is determined by the fact that fuel oil is more expensive compared to coal. Today, burning fuel oil in HP boilers makes just 5% of the total equivalent fuel consumption in such boilers. Much attention is paid at APPM to renovation of coal boilers. Thus, in April 2003, a modern coal boiler #10 was put into operation in replacement of the old coal boiler #9.

MP boilers are designed for BWW utilization, with fuel oil flame stabilization. BWW is mostly delivered from WPS-2, and the rest is delivered from outside. Before 1998, there were four boilers in operation. In January 1998, the most worn boiler #2 was decommissioned.

Of the remaining boilers, boilers #1 KM-75-40 is a relatively new one. It was set into operation in 1988. Boilers #3 and #4 have been in operation since 1940s (i.e., since the APPM foundation). In 1971, under a project designed by Leningrad Polytechnic Institute (LPI), these boilers were renovated. High-speed burning furnace extensions of the V.V. Pomerantsev design for burning waste wood were installed. In 1989…1990, these boilers were once again modernized under an AFEI[1]-LPI project with switching to the layer-whirl fuel burning system. The modernization included installation of an undergrate blast feeding device, and thinning out of the clamping grate of the furnace extension.

In September 2004, boiler #4 was decommissioned. However, without the project this boiler could go on after an appropriate overhaul which was an alternative to the project.

Over the last decade, the biggest amount of BWW, 266 242 tons, was burnt in TPP-1 MP boilers in 2002. Any further increase would have been problematic, given the technical condition of the boilers.

Fuel oil accounts for 30-40% of the total equivalent fuel consumption in MP boilers.

The medium pressure steam collector feeds two backpressure turbosets, with installed power 12 MW. Actual steam parameters are much lower than those required for efficient operation of turbines. A significant part of steam from medium pressure boilers is supplied to consumers through the pressure-reducing cooler (PRC), bypassing the turbines. The annual electricity generation is insignificant and barely covers the auxiliary needs of the MP boiler station itself.

The main data regarding operation of TPP-1 may be obtained from statistic form 6-tp “Data on operation of thermal power plant”. An example of report for 2002 is presented in Annex 18.

For reference: TPP-2 serves to recovery of liquors and generation of thermal and electric power for cardboard production. Fuel oil is used as a supplementary fuel and is limited to the technological minimum required for stable combustion of liquor. The lacking power for cardboard production also comes from TPP-1. TPP-2 is beyond our consideration, as its operation does not affect the project (neither does the project affect operation of TPP-2).

All the TPPs of APPM are interconnected with steam pipelines and power transmission lines. Layout of the mill’s steam supplying system is presented in Annex 19.

The mill is connected to the external electric power grid; however the net power flows from the grid has been virtually reduced to zero over the last few years. No thermal power is supplied to the mill from

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[1] AFEI – Arkhangelsk Forest Engineering Institute

outside. Instead, the mill itself is a heat supplier for the town of Novodvinsk. Therefore, APPM may be considered an energy-independent enterprise.

Wood-processing facilities

This department provides for preparation of pulp chips and is able to process about 3.5 million dense cubic meters of wood per year. The wood-processing facilities comprise several operating shops, i.e. two wood yards, two wood-preparation shops (WPS-2 and WPS-3), a wood receiving/feeding shop, a log-receiving port. WPS-1 also existed, but it was decommissioned with the closure of sulfite production.

The bulk of pulp chips required for pulping is produced on site from pulpwood. Chips delivery from outside accounts for about 10-15% of the total volume of pulp chips.

About 80% of the annual volume of pulpwood is delivered to the mill by land (mostly, by railway), while the rest is floated from timber industry enterprises along the Northern Dvina River. Logs are stored at the wood yard, and then sent further to wood-preparation shops.

WPS-2 produces pulp chips for cardboard production. About 3/4 of wood processed at WPS-2 is softwood and is used for pulping the unbleached sulfate cellulose in cardboard production. Hardwood chips are used for pulping neutral-sulfite semichemical pulp in corrugated paper production.

WPS-3 serves to provide pulp chips for production of bleached sulfate cellulose. Hardwood is mostly processed here. The hardwood/softwood ratio is approximately 85:15.

Chips from outside are also delivered to the above specified shops where they are sorted (screened). Large and small particles not complying with the breakup standards for pulp chips are separated and go to waste.

In both WPSs, wood is debarked using the wet method. About 330 thousand dense cubic meters of BWW is annually formed, which undergo preparation (chopping and dewatering) for burning. Bark humidity after dewatering was still rather high (about 60%).

The bulk of BWW is delivered for burning via conveyors: from WPS-2 to TPP-1, and from WPS-3 to TPP-3. In case of a lack of waste to be burnt at the output of one of the WPS, the waste may be brought by motor transport from the other WPS or from the yard.

Some of the BWW is delivered to APPM by motor transport from outside wood-processing enterprises located within 50 km from the mill, mostly – from timber mills No. 2, 3, 25, and from the Arkhangelsk plywood manufacturing plant.

Some of the fine waste wood (sawdust) in the amount of up to 50 thousand dense cubic meters per year is sent for production of fiber boards (FB).

A substantial part of bark is removed to the landfill located within the APPM territory. This is not only determined by insufficient utilizing capacity of TPP-1, 3 (as it was the case prior to the project), but also by the necessity to meet the requirements for dumping of WWS in the landfill. It is required by the regulation that WWS removed to the landfill should be mixed with BWW in a certain proportion. To reduce bark removal to the landfill, it is first of all necessary to cut dumping WWS.

At present, works are being completed on construction of a new advanced WPS-4 using the dry debarking technology, where about 2 million dense cubic meters of wood for cardboard production are to be processed. It will make it possible to expand pulping yet further and to decommission the obsolete equipment of WPS-2. When fully loaded, WPS-4 is expected to produce annually about 280 thousand dense cubic meters of BWW, which (after appropriate treatment in the shop) will have a humidity of about 50%.

Preparation of waste at WPS-3 prior to the reconstruction

Wood-preparation shop #3 (WPS-3), currently used mostly for processing low-quality hardwood, generates about 330 thousand dense cubic meters of waste wood made up of bark (35%); slivers (60%); sawdust (5%).

The wood-preparation shop had three independent flows for wood processing with efficiency of 100-120 dense cubic meters per hour. For preparation of bark and slivers for combustion, the following equipment was installed at each of the flows:

- Two dehydrating drums;
- A system of belt conveyors with iron EPR-120 separators;
- Montgomery EP27 bark grinder (output: 5-8 tons of absolutely dry matter per hour);
- Two piston presses (Kovan or PMP-11), output: 9-10 tons per hour;
- Worm thinner.

Preparation of BWW in WPS-3 was carried out according to the following procedure. Not-dewatered bark was transferred from debarking drums via three flows to dehydrating drums, where it was dehydrated to humidity of 80-85%, then it was transported by conveyors equipped with iron separators to the Montgomery bark grinders for grinding into elements not larger than 150 mm. The ground bark was further delivered through the distributing devices into the presses, where it was dehydrated to humidity about 60%. The bark dewatered on the presses was fed to the worm thinners, and further – through the system of transporters – to the hopper for bark and waste wood (1300 m^3). Together with bark coming from debarking drums, the same track received a substantial amount of slivers up to 500 mm long (due to using low-quality pulpwood and imperfection of the bark preparing equipment).

The bark hopper also received large chips (50 to 100 mm) and small waste wood after sorting of chips delivered from outside, as well as chips produced in the shop.

From the hopper, bark-wood waste was fed by worm dischargers to transporters, to be delivered to the bark boiler room of TPP-3.

For receiving the bark delivered by motor transport, there used to be a special unit, which comprised an elevated access way for automobiles, a hopper and a drag-chain transporter. From the drag-chain transporter, bark was delivered to the bark track from WPS-3. Productivity of the unit for receiving BWW delivered by motor transport did not exceed 100 thousand dense cubic meters per year. At present, this unit is dismantled.

Biological treatment facilities (BTF)

The station of biological treatment of waste water from APPM and municipal sewage from the town of Novodvinsk with output of up to 27.8 thousand cubic meters an hour (see the diagram in Annex 20) is constituted with settling tanks, aerotanks, balancing tanks and concentration tanks, where waste water undergo staged treatment. WWS and BWW are sent to the same landfill. Humidity of sludge coming from the filter-presses is 70-80%. The project would not produce direct influence on operation of the biological treatment station, yet it would reduce the amount of dumped WWS.

Industrial waste landfill

On January 1, 2004, a new industrial waste landfill covering 22.5 hectares was set into operation at APPM site (see Annex 21). The new landfill has been, ever since, receiving all the industrial waste from the mill except for coal ash of TPP-1 which is removed to a special ash landfill. No gas collection systems operate at the landfill. BWW and WWS account for most of the organic-containing waste, which cause methane emissions resulting from anaerobic decomposition.

Recently, it has become possible to burn completely all waste wood, both formed on site and delivered to the mill. However, some of it is removed to the landfill to cover the sticky waste (waste water sludge) and ensure the surface loading capacity of the landfill. Actual data show that about 2.5 tons of wet BWW is received per each ton of the absolutely dry WWS.

The old waste landfill was closed at the end of 2003; its revegetation is now under consideration. Taking this into account and following the conservative approach, any cuts, due to the project, of the amount of biomass dumped in the old landfill, and any possible reductions of methane emissions at the old landfill are not considered.

Characteristic of technologies implemented under the project

Stage I

As mentioned in Section A.2, Stage I of the project includes:

- Reconstruction of the utilizing boiler #2 at TPP-3 with switching to fluidized bed combustion of BWW without using fossil fuel for flame stabilization, and
- Modernization of wood-preparation shop #3 (WPS-3), with installation of modern bark crushing and dewatering equipment supplied by Saalasti, Finland.

Reconstruction of the KM-75-40 boiler #2

In May through December 2000, Joint Venture Energosofin and JSC Belenergomash performed reconstruction of KM-75-40 boiler #2 at TPP-3, with switching to fluidized bed technology.

Burning of waste in the fluidized bed provides efficient, economical and environmentally safe combustion of highly humid and low calorific fuels. The fluidized bed is made of quartz sand by means of feeding air at a high pressure under the filling layer. The process of combustion is partly taking place in the fluidized bed, and partly – above it. The temperature of the fluidized bed is about 700-800°C and can be adjusted by air distribution.

The reconstructed boiler (KM-75-40S) is a water-tube, single-drum boiler with natural circulation (Annex 22). The furnace is provided with balanced draft, screened with close-coupled panels, their lower part lined.

Fuel is fed to the combustion chamber via two slanting chutes from the front of the boiler. Two fuel oil burners are used for lighting.

In the nominal operating mode, the modernized KM-75-40S boiler allows burning BWW with humidity of 57%, with steam capacity equal to 66 tons per hour, without fuel oil flame stabilization. The superheated steam pressure is 4.0 MPa, and its temperature being 440 °C. The boiler efficiency factor is about 85%. After the reconstruction, the hourly consumption of BWW by the boiler has become twice as high, reaching 30 tons an hour.

The trials held within the second stage of the project showed that it is also possible to obtain stable and economical combustion of the BWW/WWS mixture, with the latter accounting for up to 20-25% of the weight of BWW.

The first launch of the reconstructed boiler late in 2000 showed that the waste is ignited well at the bed temperature about 400°C. The boiler is able to develop and maintain its steam load through changing fuel consumption. However, the first period of boilers operation revealed a number of problems, which required fixing and further improvements; among them we may mention the following:

- Optimization of waste distribution through the bed area;
- Change of water feeding unit of operation;
- Alteration of air feeding system;
- Installation of steam soot blowers in the superheater zone.

All the aforesaid technical solutions were implemented which made it possible to obtain the calculated steam capacity with rated steam parameters and even to maintain yet higher steam loads – up to 75 tons per hour.

Modernization of WPS-3

Modernization of WPS-3 was aimed at improving the quality of BWW to meet the requirements set for the fuel combusted through the fluidized bed technology. The modernization was carried out in 2000, simultaneously with the reconstruction of boiler #2 of TPP-3.

As a result of modernization, three independent fuel flows were replaced with a single centralized bark preparation unit equipped with a Saalasti 0912 rotor crusher with capacity of 135 packed m^3/hr or 45 dense m^3/hr, and two Bark Master 1620 bark drum presses (also manufactured and supplied by Saalasti) with capacity of 85-125 packed m^3/hr or 28-41 dense m^3/hr each. See more details in Annexes 23 and 24. The equipment proved to be efficient at a number of the industry enterprises. Fig. A.4-3 presents a photo of the bark-wood waste preparation unit in WPS-3 after reconstruction.

Fig. A.4-3. Modern bark processing line at WPS-3 with Saalasti equipment, 2000

According to the process regulation, the humidity content of waste wood leaving the bark preparation unit should be:
- for hardwood waste: under 53%
- for softwood waste: under 56%.

The actual data for 2005 show that humidity content of waste wood after the presses was:
- for hardwood waste: 46.4%
- for softwood waste: 49.5%.

Modernization of WPS-3 made it possible to ensure a more homogenous breakup of BWW (pieces no longer than 75 mm) and to lower their humidity content down to the level of about 50%, which substantially increased the calorific value and allowed stable combustion of BWW in boiler #2 in the fluidized bed without fuel oil flame stabilization. Besides, electric power consumption required for BWW preparation was reduced by 6-8%, due to its centralization.

On the whole, implementation of measures of the first stage enabled to make the amount of BWW burnt in boiler #2 of TPP-3 more than double, while having increased significantly the efficiency of their combustion and reduced fuel oil consumption.

Stage II

As mentioned in Section A.2 above Stage II includes:

- Replacement of the utilizing boiler #1 at TPP-3 with a new utilizing boiler E-75-3.9-440 DFT capable for efficient fluidized bed combustion of BWW and WWS without using fuel oil (or any other fossil fuel) for flame stabilization, and
- Construction of a new unit for receiving, preparation, storage and feeding into the utilizing boilers at TPP-3 of BWW and WWS delivered by motor transport.

Installation of a new E-75-3.9-440 DFT boiler

Inefficient operation of the KM-75-40 #1 boiler unit used for burning BWW (given the difficulties, which arose at setting up of the previously modernized boiler #2) determined the necessity to install a new boiler – E-75-3.9-440DFT with the fluidized bed.

Replacement of the boiler #1 was held from April 2004 to July 2005. CJSC Arkhgiprobum was the project developer, while JSC Sevzapenergomontazh served as the general contractor.

Boiler E-75-3.9-440DFT is a single-drum boiler with natural circulation (Annex 25). The evaporation scheme is two-staged. The rated steam capacity is 75 t/hr, without fuel oil flame stabilization. The pressure of superheated steam is 4.0 MPa, and its temperature being 440 °C. The furnace efficiency factor is about 92%.

The main fuel was constituted by a mixture of bark, waste wood and WWS at the following designed ratio:

- bark and waste wood, t/hr	32
- waste water sludge, t/hr	4
- total fuel consumption, t/hr	36

The BWW combustion value is 1500-2100 kcal/kg, depending on the wood species and humidity content. The rated humidity of BWW is 57%. The WWS humidity is 70-80%, and its calorific value is 200-450 kcal/kg. Basic flow chart of feeding fuel and sand to the furnace of boiler E-75-3.9-440 DFT is shown in Annex 26.

Operating of the boiler allows increasing the WWS delivery to 10 t/hr, with the boiler steam capacity being reduced, accordingly. The fuel must come into the boiler well-mixed, homogenous, with the average humidity of the BWW/WWS mixture not exceeding 63%. No dimension of BWW fragments should exceed 100 mm. Fuel oil M100 is used only as starting fuel.

The boiler is equipped with the HYBEX fluidized bed grate developed and patented by Kvaerner. The grate is of the so-called “beam” type. Its advantage is efficient withdrawal of the coarse fraction out of the boiler, due to which the amount of unscheduled stoppages of the boiler is diminished.

The tests of the boiler, which took place in 2005, showed that it is possible to achieve stable and economical combustion of the BWW/WWS mixture, with the latter being 20-25% of the BWW weight.

Construction of a new unit for receiving and preparation of motor delivered BWW and WWS

To provide the utilizing boilers of TPP-3 with sufficient amount of biofuel, a unit for receiving and preparation of BWW delivered by motor transport, was assembled at WPS-3, with a section for receiving WWS from the mill’s treatment facilities. The design of the receiving unit was developed as an addition to the project of installation of boiler unit E-75-3.9-440DFT.

BWW leaving the previously reconstructed bark preparation unit at WPS-3 have the required breakup and humidity for combustion in fluidized bed boiler units. However, this does not apply to BWW delivered from outside; their breakup is presented by numerous components and may include long bands of fir bark, slivers up to 500 mm long and other inclusions. Dimensions of coming waste wood fragments (old ties, construction wood waste) reach 2500×500×300 mm. Therefore, some of the outside BWW require grinding. In general, humidity content of the delivered BWW does not exceed 60%, which is acceptable for combustion in newly renovated utilizing boilers of TPP-3.

The flow chart of the unit for receiving and processing of delivered waste includes (details in Annex 27):

- unit for receiving BWW from motor transport, with an unloading platform;
- unit for crushing large BWW;
- sorting unit;
- unit for receiving WWS;
- track of feeding waste to the utilizing boiler room of TPP-3.

The designed capacity of the BWW-feeding truck at TPP-3 was increased up to 750 thousand dense m^3/year, including up to 450 thousand dense m^3 of motor delivered BWW (here, the delivered waste also includes the waste delivered by motor transport within the mill, i.e. from WPS-2 and WPS-4). Besides, it has become possible to utilize about 100 thousand tons of wet WWS per year.

In sum, implementation of the second stage made it possible to increase radically the BWW combusting and steam generating capacity of the utilizing boilers at TPP-3, and to ensure receiving and preparation for combustion of much higher amount of BWW of heterogenous breakup as well as of WWS. As the result, consumption of fossil fuel as well as dumping of BWW and WWS, and GHG emissions have been eventually reduced.

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:

Reduction of GHG emissions under the project is caused by the increase of amount of BWW and WWS efficiently burnt at APPM for energy generation with the correspondent decrease of fossil fuels use and the amount of BWW and WWS dumped in the landfill.

GHG emissions will be reduced at TPP-3, TPP-1 and at the industrial waste landfill. All the aforesaid sources are located on the APPM’s site, and are entirely controlled by the mill.

Emissions of N_2O and CH_4 from combustion of fuel are not considered as these emissions are negligibly low compared to emissions of CO_2. CO_2 emissions from burning biomass are climatically neutral and, therefore, are assumed to be zero. The landfills of other enterprises, which will probably also receive less BWW as a result of the project, are beyond consideration, in view of the conservative approach and difficulties of monitoring. The old APPM landfill which was closed in 2003 and which is subject to revegetation is not considered either.

- **At TPP-3, CO_2 emissions from burning fuel oil will be reduced** due to (i) elimination of fuel oil use for flame stabilization which is not needed in the renovated utilizing boilers (#1, #2), and (ii) reduction of fuel oil combustion in the recovery boilers down to technological minimum required for lighting of the boilers and for stable burning of liquors. The former is determined by the improvement of the quality of waste biomass preparation for combustion and by application of modern fluidized bed combusting technique. The latter is caused by a significant increase in the amount of live steam generated in the utilizing boilers. As a result of the project, the amount of live steam produced at TPP-3 is likely to exceed the level required for ensuring the full load of the turbine equipment; the excessive steam will be directed through the pressure-reducing cooler to the cellulose production, while reducing steam delivery from TPP-1.

- **At TPP-1, the total emissions of CO_2 from burning of fuel oil and coal are likely to be reduced**. This is determined by the expected decrease of steam supply from TPP-1 for cellulose production (owing to a higher steam output from TPP-3). At the same time, it has to be noted that steam supply from the MP boiler room of TPP-1 is likely to be reduced by a slightly bigger value because of the lack of available BWW as compared to the baseline scenario (according to the conservative forecast). However, this will bring about a proportionate reduction of burnt fuel oil for flame stabilization amounting at least 30% of the total equivalent fuel consumption in the MP boiler room. Compensation of the lacking supply of steam from MP boiler room will require additional amount of coal to be burnt in the HP boilers, which however will be a few times lower than reduction of fuel oil combustion in the MP boilers due to higher efficiency of HP station.
- **At the waste landfill, CH_4 emissions from anaerobic decomposition of BWW and WWS will be reduced** since the amount of the dumped waste will lower as a result of the project. Dumping of BWW is only determined by the necessity to add it to WWS sent to the same landfill. Reduction of the dumped WWS will lead to proportionate reduction in the amount of dumped BWW.

Emissions related to additional electric energy consumption for operation of the renovated utilizing boilers and biomass preparation system, as well as additional fuel consumption for delivery of waste from outside by motor transport are relatively small and are totally offset through cutting consumption of heat and electric power for fuel oil preparation.

Without the project, the specified reductions of GHG emissions would not have occurred, as APPM would have kept operating, without serious obstacles, the same equipment for BWW utilization in the previous mode at least up to 2012. The main reasons for this are as follows:

- Technical condition of the old utilizing boilers allows maintaining their operation at the previously achieved level for another ten to twenty years;
- An increasing demand for steam could have been covered through burning additional amount of relatively inexpensive coal at TPP-1, which has a high power reserve and high efficiency;
- All required permissions for operating the equipment and the landfill, including environmental authorizations approved by the relevant supervisory bodies, were available;
- Russian nature conservation legislation is unlikely to be changed in a way, which would enforce the enterprise to abandon operating of the equipment in use prior to the project;
- No restrictions or limitations on GHG emissions have been imposed on Russia-based enterprises so far and they are not expected to be imposed up to 2012.

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

Length of the crediting period	Years
5 years	2008-2012
Year	Estimate of annual emission reductions in tonnes of CO_2 equivalent
2008	195 945
2009	200 148
2010	204 133
2011	208 519
2012	212 707
Total estimated emission reductions over the crediting period (tonnes of CO_2 equivalent)	**1 021 452**
Annual average of estimated emission reductions over the crediting period (tonnes of CO_2 equivalent)	204 290

A.5. Project approval by the Parties involved:

The Parties' Approval Letters will be received later.

SECTION B. Baseline

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

There are only two possible and reasonable scenarios to be considered. They are as follows:

Scenario 1 – reconstruction of biomass waste utilization facilities as per the project, and

Scenario 2 – further use of biomass waste utilization facilities, which existed as of 1999.

No other options are considered. Any scenarios involving APPM's refusal from BWW utilization will result in higher GHG emissions and thus can not be considered the baseline following the conservative approach. Only switch to natural gas could have been the case for APPM but there's no gas pipeline in Archangelsk and Novodvinsk so far to supply natural gas to the industry; and therefore coal and fuel oil remain the only options for APPM, of which coal is the cheapest one.

On the other hand, any scenario involving further increase of BWW utilization other than the project would involve further increase of fuel oil use for flame stabilization (in proportion of 30-40% of the BWW load in equivalent fuel) which will result in yet higher current costs than efficient burning of relatively inexpensive coal at the HP station of TPP-1 given the same energy output (see details below). Besides, APPM faced constraints both in terms of utilizing capacity of existing boilers and in terms of BWW available for combustion. To overcome these barriers, APPM had to introduce new technologies to provide for combustion of most humid waste biomass – bark and WWS, without fuel oil used for flame stabilization.

However, there was neither special need nor requirement for APPM to do this. Technical condition of existing utilizing boilers enabled maintaining their operation at the previously achieved level for another 10 to 20 years, while rendering scheduled repair works with no significant expenses required. Russian laws and regulations do not impose any material limits or restrictions on using fossil fuels, dumping waste in landfills, and/or operating old boilers and other equipment installed at APPM. Further, no limits or restrictions on GHG emissions have been placed on Russian enterprises so far and they are not expected to be introduced before 2012. There are no special requirements on the utilization of wood waste except for the requirement that WWS before its dumping in a landfill should be mixed in a certain proportion with BWW. Environmental fees, including payments for waste dumping, are quite low and do not impact APPM's financial condition, which is sound and stable.

Hence, APPM could continue utilizing as much BWW as was practical using the installed equipment while dumping most of bark together with WWS in the landfill following the existing environmental regulation and the common practice prevailing in the industry. Waste dumping would be even less expensive for APPM than construction of additional facilities for waste biomass combustion. Even with the new utilizing capacities installed, APPM could not avoid construction of bark and sludge landfill since only part of sludge can be utilized. Thus, the new landfill was opened in 2004 and the costs of landfill construction had to be borne anyway.

It's worth noting here that energy is not the core business of APPM. Energy is just an input that has to be in place. So far it is more reasonable for APPM to use available investment resources (both equity and loans) for improving and increasing of its main production capacities, including implementation of energy saving technologies which APPM has been doing since 1995. Bleached pulp and cardboard produced by APPM are experiencing growing demand in both local and international markets. During 2000-2006, production at APPM has grown by more than 25% and still has potential for further growth.

To sum up, Scenario 2 involves no risks, meets no barriers, requires no extra investments and represents APPM's business-as-usual operations under existing Russian laws and regulations. It also represents common practice in the Russian pulp-and-paper industry at all. Therefore, Scenario 2 is considered the baseline scenario.

On the contrary, Scenario 1 involves material risks, faces different barriers, requires substantial investments and is breaking the common practice prevailing in the industry. In the absence of the Kyoto Protocol and the possibilities for APPM to monetize carbon assets generated by the project it would hardly be implemented. From the very beginning APPM was seeking to sell GHG emission reductions under the project in order to offset project costs and barriers. Further in Section B.2 this statement will be elaborated in more detail. Therefore Scenario 1 can not be considered the baseline.

According to *Decision 9/CMP.1* [R1], the project may be recognized as a joint implementation project, since its technical implementation began not earlier than in the year 2000.

The methodological approach for plotting the baseline may be described as follows.

Methodology ACM0006 “Consolidated baseline methodology for grid-connected electricity generation from biomass residues” [R18] is the most suitable of the methodologies approved for projects subject to the Clean Development Mechanism (CDM). However, the project under consideration is much more complex and specific than suggested by the aforesaid methodology; therefore the latter may only be partially applied. Besides, the PDD developer for JI projects does not have to use the CDM methodologies; neither must he approve a methodology of his own.

On the whole, while working out the baseline, the developer suggests his own approach based on methodological developments of IPCC, common sense and competence, without coordinating it specifically with any of the approved CDM methodologies; yet, he should obviously coordinate it with requirements laid out in *Decision 9/CMP.1*, *Annex B* [R1]. Everything concerning assessment of emissions is sufficiently described and justified.

Unlike most of other projects on reducing GHG emissions, the APPM project is distinguished by the fact that all the construction-and-assembly works are completed, with the project being already an actually existing development bringing about physical reduction of GHG emissions.

In view of this, it is expedient to work out the most probable baseline scenario on the basis of the data already available and forecast for up to 2012, related to an already implemented project and GHG emissions within its boundaries. In other words, it seems reasonable to produce a project scenario, taking into account all the actual data, and then, using it as a basis, to justify everything related to the baseline scenario. This approach is in line with the recommendations provided in *Decision 9/CMP.1*, *Annex B, 2a*, which state, in particular, that the baseline should be set “on a project-specific basis”.

Below both scenarios are described in details. Description of the scenarios consider all the key data, factors, assumptions, which affect significantly emissions under the project and subject to the baseline. Necessary calculations are made, which are brought together in a single calculation module in the Excel format (Annex 2.1). The most crucial tables from this module have been inserted in the text. The emissions as such are calculated in section E. The year 1999, which is largely the most characteristic one prior to the project implementation, is taken as a reference point. Naturally, the initial data are the same for both the project and the baseline scenarios. Differences begin in 2000, when implementation of the project’s Stage I started.

Project scenario

Pulping

The key overall indicator characterizing the APPM operation is pulping. In connection with the project, pulping has to be considered, as it affects amounts of processed wood, and, therefore, amounts of BWW forming in the mill’s wood-preparation shops. Besides pulping volumes are directly related to the amount of liquors burnt in recovery boilers.

Pulping is carried out separately at departments for production of cardboard and cellulose. The cellulose pulped at the cardboard production department is sulfate cellulose obtained from coniferous species of wood (flow SFA-1) and neutral-sulfite semichemical cellulose made from hardwood (flow NSSC); at the cellulose production department, sulfate cellulose is pulped both from hardwood (flow SFA-2), and coniferous wood (flow SFA-3). Pulping of one ton of cellulose at the above-specified flows requires different quantities of pulp chips, therefore more accurate assessments of formed BWW may be obtained with separate information on different pulping flows BWW.

Table B.1-1 present dynamics of pulping with a forecast up to 2012. As was said above, in setting its carbon target, APPM at the same time expects amounts of pulped cellulose to be increased at least to 1 million tons by 2012.

826.6 thousand tons of cellulose was pulped in 2005. At least 830 thousand tons are planned to be pulped in 2006. APPM is making all the efforts to raise the pulping volumes, yet the mill’s technologists estimate that the limit of 850 thousand tons per year is unlikely to be exceeded with the existing pulping equipment. This figure may be achieved through further reduction of scheduled and unplanned equipment stoppages, and all kinds of small-scale activities.

It is possible to reach the mark of 1 million tons of pulped cellulose by expanding pulping facilities. Under the existing enterprise development plans, the NSSC pulping flow will be expanded. Works on expansion are expected to get under way beginning with 2007 and to be completed by the end of 2010. It will make possible to increase pulping at NSSC at least by 150 thousand tons per year, which will actually bring the total volume of pulped cellulose for the entire mill up to 1 million tons by 2012, and probably to even higher values in the years to follow.

Given the aforesaid, it was assumed that the *total pulping* will increase in a virtually linear way from 830 thousand to 850 thousand tons per year over 2006-2010. At the same time, pulping at particular flows will grow in proportion to the overall pulping. Pulping of NSSC will grow by 100 thousand tons in 2011, and by 150 thousand tons in 2012. Pulping at other flows will not grow in 2011-2012. The total pulping will reach 1000 thousand tons by 2012.

Table B.1-1. Dynamics of pulping at APPM since 1999 with forecast up to 2012

Name	Unit	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Total pulping	**t**	**662 280**	**698 545**	**673 660**	**730 435**	**770 745**	**788 220**	**826 575**	**830 000**	**835 000**	**840 000**	**845 000**	**850 000**	**950 000**	**1 000 000**
Pulping at cardboard production department	t	386 280	403 770	376 645	425 800	448 205	454 390	491 470	493 506	496 479	499 452	502 425	505 398	605 398	655 398
SFA-1 (coniferous)	t	272 560	282 300	253 630	286 205	301 765	305 170	332 220	333 597	335 606	337 616	339 625	341 635	341 635	341 635
NSSC (hardwood)	t	113 720	121 470	123 015	139 595	146 440	149 220	159 250	159 910	160 873	161 836	162 800	163 763	263 763	313 763
Pulping at cellulose production department	t	276 000	294 775	297 015	304 635	322 540	333 830	335 105	336 494	338 521	340 548	342 575	344 602	344 602	344 602
SFA-2 (hardwood)	t			258 065	261 885	297 810	307 015	311 405	312 695	314 579	316 463	318 346	320 230	320 230	320 230
SFA-3 (coniferous)	t			38 950	42 750	24 730	26 815	23 700	23 798	23 942	24 085	24 228	24 372	24 372	24 372

🟩 *- actual data* ▨ *- no requested or assessed data* ☐ *- forecast, estimate*

Waste biomass

With reference to the project, waste biomass includes BWW and WWS. The liquors burnt in recovery boilers is also biomass, though, strictly speaking, they are not waste, and, are considered below in the analysis of operation of TPP-3.

BWW

Table B.1-2 presents the weight balance of BWW with a forecast up to 2012. Below are the relevant explanations.

Formation of BWW on the site of APPM is currently taking place in WPS-2 and WPS-3 at own production of pulp chips from pulpwood, and at sorting of chips delivered from outside. New WPS-4 is expected to start operating at full load and entirely replace the old WPS-2, beginning with 2007.

Amount of formed BWW was assessed based on forecast volumes of pulped cellulose by flows (see above), specific consumption of pulp chips for pulping by flows, specific outputs of BWW (separately for bark and waste wood) for producing chips, with the species of wood (coniferous, hardwood) taken into account. Detailed information on forecast of BWW formation is presented in Annex 2.2. Calculations have shown that, with WPS-4 set in operation, volumes of formed BWW will be reduced by about 90 thousand tons per year, which is determined by smaller specific losses of wood in process of debarking, than it was in WPS-2.

Delivery of BWW from outside for 2002-2005 (according to the requested information) varied from 134 to 111 thousand tons per year. In 2006, the figure is expected to be about 120 thousand tons. This amount will be mostly delivered from the nearest timber mills only. However, the enterprise is expected to find new sources of BWW delivery from outside, including large waste wood, by 2008, as it is now technically possible to process and utilize it efficiently. The range of transfer for additional BWW is expected to reach 250 km. The total figure of 200 thousand tons per year may be regarded as a rather conservative assessment for the period between 2008 and 2012.

According to some data for 2002-2005, *consumption of waste wood for production of fiber boards and other products* were estimated to be at a constant level of 50 thousand tons per year up to 2012. Fiber board production is not expected to grow noticeably. This is not the principal APPM production activity.

Amount of dumped BWW is known since 1999. However the development of the old landfill before it was closed at the end of 2003 was decided to be left beyond consideration, as the landfill is to undergo revegetation in the nearest future. Besides, it complies well with the conservative approach. Here, it is important to analyze, what has been going at a new landfill of industrial waste opened at the beginning of 2004. The table shows that the amounts of BWW sent to the new landfill were equal to about 175 thousand years per year, for two successive years. This is determined not by an excess of BWW, but rather by the necessity to use BWW as a material for making the landfill surface stable enough for the transport, as the same landfill receives wet and sticky WWS. According to the landfill construction design, the volumes of BWW dumped for this purpose are found by experience. Upon generalization of the two-year records, the forecasts for the period up to 2012 were assumed to be put as the following *ratio*: 2.45 t of BWW per ton of absolutely dry WWS.* The absolute amount of dumped WWS is estimated below.

The balance of BWW at the mill yards for the end of the year are taken to be 5 thousand tons.

The amount of burnt BWW is confirmed by reliable data since 1999. The grounds for the forecast of BWW combustion at TPP-3 for 2006 are laid out below in the analysis of operation of modernized

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* It can be noted, that the enterprise had managed to avoid dumping large amounts of BWW in the last two or three years preceding the closure of the old landfill. It was apparently related to the fact that the last layer of waste was piled, and it was no longer required to transport vehicles above that layer.

utilizing boilers. As for TPP-1, it will be the closing link of the BWW balance consumption. The table shows that in 2006-2012 the amount of burnt BWW in TPP-1 will never exceed the amount for 2005, when MP utilizing boiler #4 was no longer in operation (the boiler had been decommissioned in September, 2004). On the contrary, the forecast predicts quite a substantial reduction of BWW combustion in TPP-1.

WWS

Table B.1-3 presents the balance of WWS with a forecast up to 2012. The amount of WWS is expressed in tons of absolutely dry matter (a.d.m.). Monitoring of WWS amount is performed by weighing the wet sludge with regular humidity measurements. Humidity may vary within the range of 70-80%.

Analysis of dynamics of WWS formation over the recent years does not reveal noticeable correlation to amounts of pulping (It was only in 1999 and 2000, that the amount of WWS was significantly lower, as a substantial part of suspended matter was released in the river due to imperfection of the waste water treatment system.). This is primarily determined by the fact that a significant constant part of waste water to be processed at the APPM biological treatment station comes from the town of Novodvinsk. The reasonable assessment of *WWS formation* will be a slight linear growth from 76 thousand tons of a.d.m. in 2006 to 80 thousand tons of a.d.m. in 2012.

Large-scale *WWS combustion* at TPP-3 began in the 4th quarter of 2005. The grounds of the further forecast are presented below in the analysis of TPP-3 operation. Owing to the project, it will be possible to reduce the amount of *dumped WWS* by about a third. According to the aforesaid, the amount of dumped BWW is expected to fall proportionally.

Table B.1-2. Balance of bark-wood waste at APPM under the project scenario

Name	Unit	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
SUPPLY	**t**				**657 224**	**701 707**	**712 846**	**702 566**	**722 940**	**668 869**	**712 037**	**715 205**	**718 373**	**754 746**	**772 932**
Available for the beginninfg of the yea	t				31	1 963	799	6 986	6 366	5 000	5 000	5 000	5 000	5 000	5 000
Formation (total)	t				534 215	565 290	589 010	585 057	596 574	503 869	507 037	510 205	513 373	549 746	567 932
Delivered from outside	t				122 978	134 455	123 038	110 524	120 000	160 000	200 000	200 000	200 000	200 000	200 000
CONSUMPTION	**t**				**657 224**	**701 707**	**712 846**	**702 566**	**722 940**	**668 869**	**712 037**	**715 205**	**718 373**	**754 746**	**772 932**
Burnt	t	426 379	386 109	521 161	601 849	630 930	481 924	473 229	536 337	487 874	529 409	530 943	532 478	567 218	583 771
TPP-3	t	229 370	180 589	300 844	335 607	367 293	303 586	282 560	421 254	438 961	438 961	438 961	438 961	438 961	438 961
TPP-1	t	197 009	205 520	220 317	266 242	263 637	178 338	190 669	115 084	48 913	90 447	91 982	93 517	128 256	144 810
Production of fiber boards and other	t				45 245	54 316	46 421	48 103	50 000	50 000	50 000	50 000	50 000	50 000	50 000
Dumped	t	105 299	116 550	25 194	8 167	15 662	177 516	174 868	131 603	125 995	127 628	129 261	130 895	132 528	134 161
Balance for the end of the year	t				1 963	799	6 986	6 366	5 000	5 000	5 000	5 000	5 000	5 000	5 000

🟩 *- actual data* ▨ *- no data requested or assessed* ☐ *- forecast, estimate*

Table B.1-3. Balance of waste water sludge at APPM under the project scenario

Name	Unit	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Formation	**t (a.d.m.)**	**39 298**	**49 033**	**72 577**	**78 037**	**76 659**	**73 255**	**76 959**	**76 000**	**76 667**	**77 333**	**78 000**	**78 667**	**79 333**	**80 000**
Burnt	t (a.d.m.)	0	0	0	0	0	0	5 561	22 284	25 240	25 240	25 240	25 240	25 240	25 240
Dumped	t (a.d.m.)	39 298	49 033	72 577	78 037	76 659	73 255	71 398	53 716	51 426	52 093	52 760	53 426	54 093	54 760

🟩 *- actual data* ▨ *- no data requested or assessed* ☐ *- forecast, estimate*

Operation of TPP-3

It is expedient to consider separately operation of the utilizing and recovery boiler rooms delivering steam to the common collector, and then – operation of TPP-3 on the whole (see Table B.1-4, 5, 6).

Operation of the utilizing boiler room

Actual data on operation of the utilizing boiler room of TPP-3 are presented since 1999, with separate data for boilers #1 and #2 available since 2001. The analysis was also based on operative data for the 1st quarter of 2006, when both boilers already operated in modes close to those predicted in the long-term forecast.

To forecast operation of the boiler room in 2008-2012, the following key parameters were set:

- *Operating hours of boilers.* The operating time of boiler #1 was taken equal to 8 000 hours per year, that of #2 – 7 800 hours per year. This assumption is quite conservative and, on the whole, complies with the available actual data. The operating time of boiler #1 is expected to be, on the average, a little longer, owing to its improved design and less time spent on its maintenance with compulsory stoppages. The enterprise is very interested in increasing the annual working time fund for renovated utilizing boilers, and will do its best to reach this goal.
- *Percentage of wet WWS to the weight of BWW.* As there is a common track for feeding waste, this figure is taken to be the same for both the boilers – 25%. The trials of boilers held in 2005 proved possibility of stable combustion of waste with the share of WWS at 20-25%. These values are specified in operating charts for operating the boilers. The enterprise is interested in raising this share for the purpose of reducing the amount of dumped WWS. However, increasing the share of WWS above 25% may bring about a significant drop in steam capacity, which is undesirable in most cases. This parameter is supposed to be, on the year-average basis, maintained as soon as in 2007, when the mill has had a sufficient operating experience.
- *Percentage of fuel oil* defined as the ratio of the annual fuel oil consumption to the annual overall fuel consumption expressed in the same energy units. With the data for the 1st quarter of 2006, percentage of fuel oil was taken equal to 0.1% for boiler #1, and 0.3% for boiler #2. Fuel oil is only used for boilers starting, using it for flame stabilization virtually excluded.
- *The average boiler gross efficiency factor* defined as the ratio of steam generation to the annual overall fuel consumption expressed in the same energy units. With the data for the 1st quarter of 2006, and taking into account intention of the TPP-3 personnel to raise this parameter, the same and quite conservative value equal to 73% was taken for both boilers.
- *The average steam capacity of boilers* over a year reduced to rated steam parameters is taken for each boiler as being about 1 t of steam per hour higher than it was in the 1st quarter of 2006: 64 t/hr for #1, and 51 t/hr for #2. The set values are significantly lower than the rated values (75 and 66 t/hr, respectively), as it is rather difficult to maintain steam capacity at a level close to the rated one at combustion of the BWW/WWS mixture. Yet, the enterprise is interested in further increase of capacity of boilers, and will try to do it.
- *The average BWW humidity* over a year is taken at the level of 53%, that is, almost at the same level as in 1999, when WPS-3 had no efficient presses for dewatering bark. Though, it has to be said that at that time quite a few dry waste wood came from the plywood manufacturing plant. Today, most of the BWW with humidity of 45-50% is delivered from the modernized unit of bark preparation of WPS-3. A substantial part of BWW is expected to be delivered by motor transport from WPS-4, its humidity also at the level of 50%. The share of waste supplied for combustion at TPP-3 from outside and having the average humidity of about 55-60% is estimated as 20-30%. The forecast of the average annual humidity assumed to be 53% for a mixture of all kinds of BWW is, therefore, quite conservative.

- *The average humidity of WWS* over a year is taken at the level of 77%, which corresponds to the average level of actual WWS humidity since the beginning of its combustion. The assumed value is conservative, given the fact that the enterprise is seeking for opportunities to reduce the WWS humidity.
- *The average net calorific value of BWW* was taken for humidity of 53% as equal to 7.914 GJ/t (0.27 tons of coal equivalent per ton), which, in general, corresponds to a number of actual data and results of thermo-technical analysis, as recalculated for the specified humidity value.
- *The average net calorific value of WWS* was taken as equal to 0.879 GJ/t of wet WWS **(**0.03 tons of coal equivalent per ton of wet WWS). On the average, it corresponds to the actual data for the period of beginning of WWS combustion. The parameter value is not high and has no significant effect on further calculations.

Further on, all the key annual indicators of operation of the utilizing boiler room over 2008-2012 were determined, the most important of which are:

- *Steam generation* – 2 611.1 thousand GJ per year[*]
- *Total fuel consumption* – 3 577.0 thousand GJ per year (122.0 thousand tons of coal equivalent per year)
- *BWW consumption* – 439.0 thousand tons per year (about 500 thousand dense cubic meters per year)
- *WWS consumption* – 109.7 thousand wet tons per year (about 25.2 thousand tons of absolutely dry matter per year)
- *Fuel oil consumption* – 0.2 thousand tons per year

Operation of the recovery boiler room

Actual data on operation of the recovery boiler room of TPP-3 are presented since 1999. Recovery boilers (RB) are used for burning sulfate liquors, fuel oil and, occasionally, an insignificant amount of sulfate soap.

To make a forecast of the boiler room operation, the parameters like *specific output of liquors per ton of cellulose, average net calorific value of liquors, average boiler gross efficiency factor*, were taken equal to the average values for the last three years (2003-2005). Therefore, *consumption of liquors* is in proportion to amount of cellulose pulped at the corresponding production facilities. No correlation between the RB efficiency factor and the share of fuel oil was revealed over a number of years. Combustion of sulfate soap is not forecast.

The key change in the boiler room operation since 2006 is connected to a significant reduction of amounts of burnt fuel oil, and to the corresponding reduction of the annual *steam generation* in RB, as the steam generation provided by the modernized boiler room utilizing BWW and WWS has now become quite sufficient for full loading of turbines at TPP-3. The available operative data suggest that as soon as in 2006 *fuel oil consumption in RB* is expected to be about 10 thousand tons per year, compared to 30-50 thousand tons in the previous years. The same value is assumed for the future period up to 2012. The share of fuel oil by coal equivalent[†] will be about 7%, which is apparently not the limit, as a smaller amount of fuel oil may be enough for stable combustion of liquors and lighting of boilers (according to the data on RB operation in TPP-2). Model calculations show that reduction of fuel oil

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[*] The calculations are made, with taking into account that 1t of steam = 2.87 GJ at the rated steam parameters $P = 4$ MPa, $t = 440\ ^{o}C$, and feed water temperature being 104 ^{o}C

[†] Fuel oil calorific value is assumed to be 40.15 GJ/t (1.37 tons of coal equivalent per ton)

combustion in RB of TPP-3 will result in growing reductions of GHG emissions. Therefore, the specified estimation equal to 10 thousand tons per year may be considered quite conservative.

Overall operation of TPP-3

Steam generation at TPP-3 is sum up of generation in both the boiler rooms. The same is applied to *fuel consumption*. The ratio of these two values expressed in the same power units gives *the average gross boiler efficiency factor* of TPP-3. Owing to the project, the efficiency is increased, and the structure of fuel consumption is changed, with increasing of the share of biomass.

Prior to implementation of the second stage of the project, all the live steam from five boilers was directed to turbines with back pressure. According to official data, before 2005, channeling steam via the PRC, by-passing the turbines, was not used. The amount of fuel oil burnt in recovery boilers was just enough for full load of turbines operating at the thermal schedule. Analyzing the data on steam and electric power generation at TPP-3 over 1999-2005, we can see that approximately the same figures are observed every year. The ratio between the steam and electricity generation is also a virtually constant value.

However, operative data and results of our calculations suggest that after installation and setup of utilizing boiler #1 the total steam generation in 2006 somewhat exceeded the value, which the turbines were able to receive, therefore, what we have is *steam delivery to PRC*, by-passing the turbines. In future, the excess of live steam is forecast to grow. Even with fuel oil combustion in RB reduced to zero, such an excess could still take place in the years to follow. At the same time, it is not expedient to cut amounts of burnt biomass to eliminate steam delivery by-passing the turbines.

However, it has to be said that, in principle, the TPP-3 turbines are able to receive all the amount of live steam generated under the project. Yet, this is hampered by the following obstacle. One of the TPP-3 turbines has a back pressure of 10 atm, and two turbines have back pressure equal to 5 atm. As a rule, cellulose production has a constantly high demand for the 10 atm steam, with its lacking amount also supplied from TPP-1. As for the 5 atm steam, its consumption is limited, so two TPP-3 turbines are not always sufficiently loaded.

Therefore, in the forecast up to 2012, *steam delivery to turbines* and *electric power generation* (and, accordingly, supply of steam spent in the turbines) will remain unchanged, as related to the baseline. Their numeric values were taken constant and equal to the average values for the last three years. But there will be an extra steam supply by-passing the turbines.

In future, it will be possible to reconstruct the turbine farm of TPP-3, which will, apparently, result in further reduction of emissions. However, in line with the conservative approach, this measure is not considered within the project.

Heat losses and consumption for the plant's auxiliary needs related to the steam flow passing through the PRC was assumed to be 5% of available heat of this steam[*]. Accordingly, *useful supply of thermal power through PRC* to external consumers (above useful thermal power, which the TPP-3 generally supplies with just the spent steam) was calculated. Further on, we are to assume that this thermal power would reduce steam supply from TPP-1 by the same value, compared to the baseline. Here, there is no need to consider the total useful supply of thermal and electric power from TPP-3. Monitoring will define useful supply of thermal power through the PRC as a difference between the total useful supply of thermal power and the useful supply of thermal power with spent steam.

The data provided by the mill's energy service show that the project has not resulted in growth of specific heat and electricity consumption for auxiliary needs of TPP-3. Specific electricity consumption

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[*] For the whole TPP-3, heat consumption for auxiliary needs is about 12% of live steam output, yet it includes a substantial share of consumption independent of additional steam generation in utilizing boilers.

per ton of steam generated by the utilizing boiler-room has even decreased, though the absolute consumption in it has had some growth. Here, it is to be emphasized that the auxiliary needs of TPP-3 do not include heat and power consumption for preparation of fuel oil for TPP-3 in the common fuel oil farm of the mill (such consumption are accounted as a separate item in the APPM energy balance), yet, it is obvious that this consumption will also be reduced. Therefore, even with the conservative approach in mind, energy consumption for the TPP-3 auxiliary needs may be left beyond consideration.

Table B.1-4. Indicators of operation of the TPP-3 utilizing boiler room under the project scenario

Name	Unit	1999	2000	2001	2002	2003	2004	2005	1-кв. 2006	2006	2007	2008	2009	2010	2011	2012
Steam generation	**GJ**	**1 259 893**	**971 016**	**1 451 177**	**1 782 896**	**1 884 464**	**1 448 137**	**1 520 534**	**604 435**	**2 479 680**	**2 611 126**	**2 611 126**	**2 611 126**	**2 611 126**	**2 611 126**	**2 611 126**
St. No. 1	GJ			577 195	605 222	613 178	168 548	474 793	364 746	1 446 480	1 469 440	1 469 440	1 469 440	1 469 440	1 469 440	1 469 440
St. No. 2	GJ			873 982	1 177 673	1 271 286	1 279 589	1 045 741	239 689	1 033 200	1 141 686	1 141 686	1 141 686	1 141 686	1 141 686	1 141 686
Operating hours of boilers	**hr**	**16 090**	**11 225**	**13 626**	**15 122**	**15 507**	**10 332**	**10 095**	**3 696**	**15 200**	**15 800**	**15 800**	**15 800**	**15 800**	**15 800**	**15 800**
St. No. 1	hr			7 397	7 370	7 433	2 361	3 085	2 027	8 000	8 000	8 000	8 000	8 000	8 000	8 000
St. No. 2	hr			6 229	7 752	8 074	7 971	7 010	1 669	7 200	7 800	7 800	7 800	7 800	7 800	7 800
Fuel consumption	**GJ**	**2 766 131**	**2 046 846**	**2 577 375**	**2 948 615**	**3 235 971**	**2 590 916**	**2 524 362**	**834 945**	**3 425 142**	**3 577 007**	**3 577 007**	**3 577 007**	**3 577 007**	**3 577 007**	**3 577 007**
BWW	t	229 370	180 589	300 844	335 607	367 293	303 586	282 560	92 619	421 254	438 961	438 961	438 961	438 961	438 961	438 961
	GJ	1 822 203	1 437 685	2 440 175	2 844 536	3 154 430	2 555 041	2 494 114	816 196	3 333 674	3 473 807	3 473 807	3 473 807	3 473 807	3 473 807	3 473 807
Fuel oil	t	24 322	15 760	3 528	2 621	2 017	888	150	30	156	167	167	167	167	167	167
	GJ	943 929	609 161	137 200	104 080	81 540	35 875	6 096	1 231	6 275	6 705	6 705	6 705	6 705	6 705	6 705
WWS	t	0	0	0	0	0	0	23 504	21 202	96 888	109 740	109 740	109 740	109 740	109 740	109 740
	GJ	0	0	0	0	0	0	24 151	17 519	85 194	96 495	96 495	96 495	96 495	96 495	96 495
Fuel consumption in St. No. 1	**GJ**			**1 034 467**	**1 007 942**	**1 093 087**	**339 586**	**765 425**	**504 422**	**2 000 395**	**2 013 000**	**2 013 000**	**2 013 000**	**2 013 000**	**2 013 000**	**2 013 000**
BWW	GJ			901 957	911 805	1 012 309	308 634	748 352	493 580	1 948 597	1 956 636	1 956 636	1 956 636	1 956 636	1 956 636	1 956 636
Fuel oil	GJ			132 511	96 137	80 778	30 951	2 843	205	2 000	2 013	2 013	2 013	2 013	2 013	2 013
WWS	GJ	0	0	0	0	0	0	14 230	10 637	49 797	54 351	54 351	54 351	54 351	54 351	54 351
Fuel consumption in St. No. 2	**GJ**			**1 542 908**	**1 940 674**	**2 142 883**	**2 251 330**	**1 758 937**	**330 523**	**1 424 748**	**1 564 007**	**1 564 007**	**1 564 007**	**1 564 007**	**1 564 007**	**1 564 007**
BWW	GJ			1 538 218	1 932 731	2 142 121	2 246 406	1 745 762	322 615	1 385 077	1 517 171	1 517 171	1 517 171	1 517 171	1 517 171	1 517 171
Fuel oil	GJ			4 690	7 943	762	4 924	3 253	1 026	4 274	4 692	4 692	4 692	4 692	4 692	4 692
WWS	GJ	0	0	0	0	0	0	9 921	6 882	35 396	42 144	42 144	42 144	42 144	42 144	42 144
Percentage of WWS to BWW by weig	**%**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**8,32**	**22,89**	**23,00**	**25,00**	**25,00**	**25,00**	**25,00**	**25,00**	**25,00**
St. No. 1	%	0,00	0,00	0,00	0,00	0,00	0,00	16,33	22,98	23,00	25,00	25,00	25,00	25,00	25,00	25,00
St. No. 2	%	0,00	0,00	0,00	0,00	0,00	0,00	4,88	22,75	23,00	25,00	25,00	25,00	25,00	25,00	25,00
Percentage of fuel oil	**%**	**34,12**	**29,76**	**5,32**	**3,53**	**2,52**	**1,38**	**0,24**	**0,15**	**0,18**	**0,19**	**0,19**	**0,19**	**0,19**	**0,19**	**0,19**
St. No. 1	%			12,81	9,54	7,39	9,11	0,37	0,04	0,10	0,10	0,10	0,10	0,10	0,10	0,10
St. No. 2	%			0,30	0,41	0,04	0,22	0,18	0,31	0,30	0,30	0,30	0,30	0,30	0,30	0,30

Table B.1-4. (continued)

Average gross boiler efficiency facto	**%**	**45,55**	**47,44**	**56,31**	**60,47**	**58,24**	**55,89**	**60,24**	**72,39**	**72,40**	**73,00**	**73,00**	**73,00**	**73,00**	**73,00**	**73,00**
St. No. 1	%			55,80	60,05	56,10	49,64	62,03	72,31	72,31	73,00	73,00	73,00	73,00	73,00	73,00
St. No. 2	%			56,65	60,69	59,33	56,84	59,46	72,52	72,52	73,00	73,00	73,00	73,00	73,00	73,00
Average steam capacity																
St. No. 1	t/hr			27,19	28,61	28,74	24,87	53,63	62,70	63,00	64,00	64,00	64,00	64,00	64,00	64,00
St. No. 2	t/hr			48,89	52,93	54,86	55,93	51,98	50,04	50,00	51,00	51,00	51,00	51,00	51,00	51,00
Average BWW consumption																
St. No. 1	t/hr			15,03	14,60	15,86	15,53	27,48	27,63	30,78	30,91	30,91	30,91	30,91	30,91	30,91
St. No. 2	t/hr			30,45	29,42	30,89	33,49	28,21	21,93	24,31	24,58	24,58	24,58	24,58	24,58	24,58
Average WWS consumption																
St. No. 1	t/hr	0,00	0,00	0,00	0,00	0,00	0,00	4,49	6,35	7,08	7,73	7,73	7,73	7,73	7,73	7,73
St. No. 2	t/hr	0,00	0,00	0,00	0,00	0,00	0,00	1,38	4,99	5,59	6,14	6,14	6,14	6,14	6,14	6,14
Characteristics of burnt waste																
Average humidity of BWW	%	53,1	52,4	51,5	50,3	49,7	50,4	48,5		53,0	53,0	53,0	53,0	53,0	53,0	53,0
Average humidity of WWS	%							76,3	77,7	77,0	77,0	77,0	77,0	77,0	77,0	77,0
Average net calorific value of BWW	GJ/t	7,944	7,961	8,111	8,476	8,588	8,416	8,827	8,812	7,914	7,914	7,914	7,914	7,914	7,914	7,914
Average net calorific value of WWS	GJ/t							1,028	0,826	0,879	0,879	0,879	0,879	0,879	0,879	0,879

🟩 *- actual data* ▒ *- no data requested or assessed* ⬜ *- forecast, estimate*

Table B.1-5. Indicators of operation of the TPP-3 recovery boiler room under the project scenario

Name	Unit	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Steam generation	**GJ**	**5 504 795**	**5 687 298**	**5 134 677**	**4 560 045**	**4 870 574**	**5 320 442**	**5 246 738**	**4 385 020**	**4 409 465**	**4 433 910**	**4 458 355**	**4 482 800**	**4 482 800**	**4 482 800**
Fuel consumption	**GJ**	**6 644 811**	**6 924 007**	**6 243 880**	**5 542 199**	**6 025 491**	**6 669 754**	**6 260 763**	**5 382 462**	**5 412 467**	**5 442 473**	**5 472 478**	**5 502 484**	**5 502 484**	**5 502 484**
Liquors	t (a.d.m.)	428 342	433 968	417 444	435 058	463 300	477 672	492 087	486 317	489 247	492 177	495 106	498 036	498 036	498 036
	GJ	4 584 993	4 723 746	4 275 039	4 434 310	4 676 381	4 944 773	5 059 082	4 980 915	5 010 920	5 040 926	5 070 931	5 100 937	5 100 937	5 100 937
Fuel oil	t	51 957	51 211	48 760	28 042	31 129	40 039	29 833	10 000	10 000	10 000	10 000	10 000	10 000	10 000
	GJ	2 016 440	1 979 439	1 897 148	1 107 889	1 256 608	1 614 190	1 201 681	401 547	401 547	401 547	401 547	401 547	401 547	401 547
Sulfate soap	t	1 987	11 446	3 645	0	4 636	5 331	0	0	0	0	0	0	0	0
	GJ	43 379	220 822	71 692	0	92 502	110 792	0	0	0	0	0	0	0	0
Average net calorific value of liquors	GJ/t (a.d.m.)	10,704	10,885	10,241	10,192	10,094	10,352	10,281	10,242	10,242	10,242	10,242	10,242	10,242	10,242
Specific output of liquors per ton of cellulose	t (a.d.m.)/t	1,552	1,472	1,405	1,428	1,436	1,431	1,468	1,445	1,445	1,445	1,445	1,445	1,445	1,445
Average gross boiler efficiency factor	%	82,85	82,14	82,24	82,28	80,84	79,77	83,81	81,47	81,47	81,47	81,47	81,47	81,47	81,47

🟩 *- actual data* ▒ *- no data requested or assessed* ⬜ *- forecast, estimate*

Table B.1-6. Overall indicators of TPP-3 operation under the project scenario

Name	Unit	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Steam generation	**GJ**	**6 764 689**	**6 658 314**	**6 585 854**	**6 342 941**	**6 755 038**	**6 768 579**	**6 767 272**	**6 864 700**	**7 020 591**	**7 045 036**	**7 069 481**	**7 093 926**	**7 093 926**	**7 093 926**
Steam delivery to the turbines	GJ	6 764 689	6 658 314	6 585 854	6 342 941	6 755 038	6 768 579	6 767 272	6 763 630	6 763 630	6 763 630	6 763 630	6 763 630	6 763 630	6 763 630
Steam delivery to the PRC	GJ	0	0	0	0	0	0	0	101 070	256 961	281 406	305 852	330 297	330 297	330 297
Useful supply of thermal power through the PRC	GJ	0	0	0	0	0	0	0	96 017	244 113	267 336	290 559	313 782	313 782	313 782
Electric power generation	**MW*hr**	**154 835**	**149 311**	**155 269**	**154 585**	**159 388**	**153 177**	**151 526**	**154 697**	**154 697**	**154 697**	**154 697**	**154 697**	**154 697**	**154 697**
Fuel consumption	**GJ**	**9 410 943**	**8 970 853**	**8 821 255**	**8 490 814**	**9 261 462**	**9 260 670**	**8 785 124**	**8 807 604**	**8 989 474**	**9 019 480**	**9 049 485**	**9 079 491**	**9 079 491**	**9 079 491**
Liquors	t (a.d.m.)	428 342	433 968	417 444	435 058	463 300	477 672	492 087	486 317	489 247	492 177	495 106	498 036	498 036	498 036
	GJ	4 584 993	4 723 746	4 275 039	4 434 310	4 676 381	4 944 773	5 059 082	4 980 915	5 010 920	5 040 926	5 070 931	5 100 937	5 100 937	5 100 937
BWW	t	229 370	180 589	300 844	335 607	367 293	303 586	282 560	421 254	438 961	438 961	438 961	438 961	438 961	438 961
	GJ	1 822 203	1 437 685	2 440 175	2 844 536	3 154 430	2 555 041	2 494 114	3 333 674	3 473 807	3 473 807	3 473 807	3 473 807	3 473 807	3 473 807
Fuel oil	t	76 279	66 971	52 288	30 663	33 146	40 927	29 983	10 156	10 167	10 167	10 167	10 167	10 167	10 167
	GJ	2 960 369	2 588 601	2 034 348	1 211 969	1 338 148	1 650 065	1 207 777	407 822	408 252	408 252	408 252	408 252	408 252	408 252
WWS	t	0	0	0	0	0	0	23 504	96 888	109 740	109 740	109 740	109 740	109 740	109 740
	GJ	0	0	0	0	0	0	24 151	85 194	96 495	96 495	96 495	96 495	96 495	96 495
Sulfate soap	t	1 987	11 446	3 645	0	4 636	5 331	0	0	0	0	0	0	0	0
	GJ	43 379	220 822	71 692	0	92 502	110 792	0	0	0	0	0	0	0	0
Average gross boiler efficiency factor	%	71,88	74,22	74,66	74,71	72,94	73,09	77,03	77,94	78,10	78,11	78,12	78,13	78,13	78,13

🟩 *- actual data* ▨ *- no data requested or assessed* ☐ *- forecast, estimate*

Operation of TPP-1

TPP-1 comprises a medium pressure (MP) station and a high pressure (HP) station. The MP station is designed for BWW utilization with fuel oil flame stabilization. The HP station operates on coal and fuel oil, and is the closing link in the APPM power system, providing the lacking thermal and electric power for all the departments of the enterprise, as well as external consumers.

In connection with the implemented project, the TPP-1 operation has to be considered for the following reasons:

- Owing to the project, the steam supply for cellulose production from TPP-3 is likely to increase. The steam supply from TPP-1 will fall, accordingly;
- The forecast suggests decreasing amounts of burnt BWW in MP utilizing boilers of TPP-1, compared to the baseline scenario, which may result in changes in operating mode of the TPP-1 HP station.

It has to be noted in advance, that the option of increasing the amounts of fuel oil burnt in MP boilers (above the value required for flame stabilization of BWW) to compensate for the lack of BWW, is not considered, as this option is certainly less efficient and more expensive, compared to the growth of power output in the TPP-1 HP station.

Here, all the changes in fuel consumption in the HP station itself are accounted for coal. This is determined by two circumstances. First, the share of fuel oil in the HP station is minimized, being just 5%. Second, when recalculated to coal equivalent, fuel oil price is approximately 2.5 times higher than price for coal (as of February 2005, the average price of fuel oil was RUR1905/t and the average price of coal was RUR450/t, while the net calorific value of fuel oil is assumed as 1.37 t c.e./t and those of coal is assumed as 0.8 t c.e./t)[1]. Therefore, any changes in operation of the HP station will mostly affect coal consumption, which, accordingly, can be regarded as the marginal fuel for TPP-1.

For the purposes of the present project, it is inexpedient to analyze absolute volumes of fuel consumption and power output at the TPP-1 HP station. It would require making the balance of power output and consumption based on dynamics of power consumption of the whole mill, as well as external consumers. Meanwhile, this dynamics is external (exogenous) and invariant relative to the project (while we are only interested in changes in the station's operation, which are directly caused by the project).

Therefore, it appears expedient to take the project (rather than the baseline) as the reference line, and assess changes in coal consumption in the HP boilers, which would have taken place in absence of the project, compared to the project. But operation of the MP station considered in full.

Operation of the MP station (utilizing boiler room)

Table B.1-7 presents actual data on operation of the utilizing boiler room from 1999 to 2005, and a forecast up to 2012.

For the forecast of the boiler room operation, such parameters as *average net calorific value of BWW, average gross boiler efficiency factor, fuel oil percentage* were taken to be equal to the average values for the last three years (2003-2005). It has to be noted that the BWW net calorific value at TPP-1 is lower than that at TPP-3, as TPP-1 is generally used for burning more humid BWW, with coniferous species prevailing.

The largest amount of BWW was burnt in 2002 and 2003 (over 260 thousand tons a year). It was practically the limiting value for the equipment in operation, in view of its technical condition. In those years, TPP-3 underwent just the first stage of the project, and the enterprise tried to burn as much BWW

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[1] See for example: http://www.akm.ru/rus/analyt/report/samples/en620_20050511.stm

as possible at TPP-1. Higher amounts of burnt materials had only taken place in 1990 and 1991, but at that time boiler #2 was in operation (decommissioned in 1998).

However, in 2004, opening of a new landfill required large amounts of bark to make the landfill surface accessible for vehicles. As a result, amounts of BWW burnt at TPP-1 fell below 200 thousand tons per year. Soon, a decision was made to decommission boiler #4 (September 2004), instead of holding its overhaul.

The forecast of *amounts of BWW burnt* at TPP-1 for 2006-2012 matches the forecast of the BWW balance (see Table B.1-2.).

Knowing the overall *fuel consumption* (BWW+fuel oil) and efficiency factor of boilers, it makes no difficulty to find *steam generation*.

It is also important to assess useful power supply from the MP station. No separate records are kept for consumption of electric and thermal power for the MP station auxiliary needs. That is why, the following expert assessments were made.

As was already noted in section A.4.2., actual steam parameters in MP boilers are generally significantly lower than those required for efficient operation of the turbines. A substantial part of steam is delivered to consumers by-passing the turbines. This situation is largely determined by wear and frequent repairs of the turbine equipment.

The data over the last few years show that just 3-3.5% of heat of the total steam generation by boilers of the MP station is spent on electric power production[1]. The annual electric power generation at turbosets of the MP station is insignificant. Thus, according to the data for 2002, steam generation was 1 724.5 thousand GJ (479.0 thousand MWh), while electric power generation was just 12.6 thousand MWh. The obtained electric power is hardly sufficient to cover the auxiliary needs of the MP station. Anyway, given the negligibility of the value itself, it would be acceptable to consider all the electricity produced at the MP station to be spent on its auxiliary needs.

As for heat consumption for auxiliary needs and internal losses, they may be assumed to be about 5-7% of steam generation.

It was eventually assumed that the MP station only *supplies thermal power* to external consumers, with the amount of this thermal power being 10% less than the steam generation in MP boilers.

The analysis made and the forecast cover all the key data required for calculation of greenhouse gas emissions under the project. The emissions themselves are assessed in section E.

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[1] To compare, at TPP-3 this parameter is about 10%, which is close to the normal value, taking into account the live steam parameters and back pressure

Table B.1-7. Indicators of operation of the TPP-1 MP station (utilizing boiler room) under the project scenario

Name	Unit	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Steam generation	**GJ**		**1 524 474**	**1 580 618**	**1 724 546**	**1 726 911**	**1 186 449**	**1 210 047**	**750 500**	**318 978**	**589 839**	**599 847**	**609 854**	**836 404**	**944 353**
Thermal power supply	GJ		1 372 027	1 422 556	1 552 091	1 554 220	1 067 804	1 089 042	675 450	287 080	530 855	539 862	548 869	752 764	849 918
Fuel consumption (total)	**GJ**		**2 093 408**	**2 202 031**	**2 417 899**	**2 428 421**	**1 706 897**	**1 820 972**	**1 087 301**	**462 126**	**854 541**	**869 040**	**883 539**	**1 211 757**	**1 368 150**
BWW	t	197 009	205 520	220 317	266 242	263 637	178 338	190 669	115 084	48 913	90 447	91 982	93 517	128 256	144 810
	GJ	1 174 803	1 200 860	1 387 477	1 662 580	1 592 852	1 143 324	1 292 219	737 690	313 533	579 772	589 608	599 445	822 128	928 235
Fuel oil	t		23 066	20 932	19 042	20 692	13 979	13 132	8 707	3 700	6 843	6 959	7 075	9 703	10 956
	GJ		892 548	814 554	755 319	835 569	563 573	528 752	349 611	148 592	274 770	279 431	284 093	389 629	439 916
Average net calorific value of BWW	GJ/t	5,963	5,843	6,298	6,245	6,042	6,411	6,777	6,410	6,410	6,410	6,410	6,410	6,410	6,410
Average gross boiler efficiency factor	%		72,83	71,78	71,33	71,11	69,51	66,45	69,03	69,03	69,03	69,03	69,03	69,03	69,03
Percentage of fuel oil	%		42,64	36,99	31,24	34,41	33,02	29,04	32,15	32,15	32,15	32,15	32,15	32,15	32,15

🟩 *- actual data* ▨ *- no data requested or assessed* □ *- forecast, estimate*

Baseline scenario

Below is a detailed analysis and calculations of all the key factors required for assessment of emissions under the most probable baseline scenario. This scenario was developed based on the already available data array of the above-described project scenario, which is in fact unfolding.

Pulping

The baseline scenario assumes the same amounts of pulped cellulose (both for APPM as a whole, and for particular flows), as those adopted under the project (see Table B.1-1). This applies also to the structure and volumes of finished products. There are no grounds to believe that the enterprise would have been abandoned its plans on increasing production in the absence of the project, or that the project has affected in any way the volumes and structure of production.

In general, the production factor is beyond the scope of the project. This means that the volumes of formed waste biomass and power consumption in shops of the mill would be the same under the project and the baseline.

Waste biomass

BWW

Table B.1-8 presents the weight balance of BWW with a forecast up to 2012.

Amount of formed BWW on the industrial site of APPM will be the same as in the project scenario. The project does not affect plans of construction and commissioning of WPS-4. Volumes of pulped cellulose remain unchanged, therefore, raw wood consumption and BWW output also remain the same.

Delivery of BWW from outside will stay at about the same level as it was over the recent years. On the average, it is about 120 thousand tons per year. This waste will only be supplied from the nearby wood-processing enterprises of the Arkhangelsk industrial junction, which have long been the mill’s partners. APPM even has certain obligations to these enterprises regarding accepting BWW. However, it has to be said that those enterprises gradually begin to contemplate other options and take some steps towards utilization of their own waste (as we can see, just 111 thousand tons was supplied from outside in 2005). Therefore, the suggested figure is hardly understated.

Here it is not unreasonable to ask, if it could be profitable for APPM to search for other sources of BWW to replace the fossil fuel in the baseline scenario as well, as it is provided by the project. We do not believe it to be profitable, as it only makes sense to utilize high amounts of BWW, if such utilization is efficient. Yet, the possibility of efficient utilization was only brought about by the project.

Our assessments show that, even without accounting for costs of transportation of extra amounts of BWW from outside the Arkhangelsk industrial junction and their subsequent preparation, utilization of this BWW (with the required 30-40% of the share of flame stabilization with expensive fuel oil[1], low efficiency factor of utilizing boilers, and low steam parameters) would have required even higher current costs than efficient burning of relatively inexpensive coal at the HP station of TPP-1.

Of course, APPM would have hardly abandoned utilization of outside BWW altogether, if only because of the contracts for receiving BWW concluded with other enterprises (many of which also supply APPM with pulp chips, by the way), but it clearly made no sense to seek for increasing the deliveries. The point is that the situation with the deliveries would have been approximately the same as it was up to the most recent time.

The figure of 120 thousand tons per year may be considered to be the upper limit of probable amounts of deliveries, which makes the forecast assessments of emissions for the adopted baseline scenario even

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[1] As mention above the cost of fuel oil is at least twice as high as the cost of coal, when recalculated by coal equivalent.

more conservative, as (in spite of the obvious inefficiency of utilization of BWW mixed with fuel oil), additionally utilized amounts still produce less emissions than efficient combustion of coal, assuming that the same amount of useful energy is generated.

In monitoring the baseline parameters, the figure of 120 thousand tons of BWW delivered from outside will be taken constant, unless the actual volumes of deliveries under the project turn out to be lower than that.

Consumption of waste wood for production of fiber boards and other will be the same as those specified in the project scenario.

Amount of dumped BWW would probably have been higher even before 2003. However, as the old landfill was closed in 2003, with its revegetation supposed (which would have most definitely taken place in the baseline scenario, as well), a decision was made to take no assessments or comparisons between the baseline and the project scenarios for this period. It makes more conservative further assessments of methane emission reductions determined by the project. Since 2004, the amount of dumped BWW has been taken in proportion to the amount of WWS sent to the same landfill. Obviously, this proportion will be the same as it is in the project scenario. Therefore, the forecast up to 2012 implies the same ratio equal to 2.45 ton of BWW per ton (a.d.m.) of WWS. The absolute amount of dumped WWS is estimated below.

The balance of BWW at the mill yards of the mill for the end of the year is taken equal to 5 thousand tons, as it is in the project scenario.

The amount of BWW burnt at TPP-3 is forecast at the level of 230 thousand tons per year. It is highly unlikely that it would have been possible to burn larger amounts of BWW with the old utilizing boilers. At least, for the period since 1990, the largest amount of waste, which it was possible to burn at TPP-3, was 229 370 tons (1999).

As for the *amount of BWW burnt at TPP-1,* TPP-1 will be the closing link of the BWW balance consumption (as it is in the project scenario).

The supposition that TPP-1, and not TPP-3, will close the BWW balance, is conservative, as special model calculations have shown that, with TPP-3 as the closing link, the obtained GHG emission reductions will be larger, though slightly.

WWS

Table B.1-9 presents the balance of WWS, with a forecast up to 2012. The dynamics of *WWS formation* is identical to that adopted in the project scenario. No *WWS combustion* takes place due to the absence of an appropriate technology. The amount of *dumped WWS* is equal to the amount of formed WWS.

Table B.1-8. Balance of bark-wood waste at APPM under the baseline scenario

Name	Unit	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
SUPPLY	**t**						**712 846**	**702 566**	**722 940**	**628 869**	**632 037**	**635 205**	**638 373**	**674 746**	**692 932**
Availability for the beginning of the ye	t				31	1 963	799	6 986	6 366	5 000	5 000	5 000	5 000	5 000	5 000
Formation (total)	t				534 215	565 290	589 010	585 057	596 574	503 869	507 037	510 205	513 373	549 746	567 932
Delivered from outside	t						123 038	110 524	120 000	120 000	120 000	120 000	120 000	120 000	120 000
CONSUMPTION	**t**						**712 846**	**702 566**	**722 940**	**628 869**	**632 037**	**635 205**	**638 373**	**674 746**	**692 932**
Burnt	t	426 379	435 520	450 317	496 242	493 637	481 924	459 608	481 740	386 035	387 570	389 105	390 639	425 379	441 932
TPP-3	t	229 370	230 000	230 000	230 000	230 000	230 000	230 000	230 000	230 000	230 000	230 000	230 000	230 000	230 000
TPP-1	t	197 009	205 520	220 317	266 242	263 637	251 924	229 608	251 740	156 035	157 570	159 105	160 639	195 379	211 932
Production of fiber boards and other	t				45 245	54 316	46 421	48 103	50 000	50 000	50 000	50 000	50 000	50 000	50 000
Dumped	t	105 299					177 516	188 488	186 200	187 833	189 467	191 100	192 733	194 367	196 000
Balance for the end of the year	t				1 963	799	6 986	6 366	5 000	5 000	5 000	5 000	5 000	5 000	5 000

🟩 *- actual data* ▨ *- no data requested or assessed* ☐ *- forecast, estimate*

Table B.1-9. Balance of waste water sludge at APPM under the baseline scenario

Name	Unit	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Formation	**t (a.d.m.)**	**39 298**	**49 033**	**72 577**	**78 037**	**76 659**	**73 255**	**76 959**	**76 000**	**76 667**	**77 333**	**78 000**	**78 667**	**79 333**	**80 000**
Burnt	t (a.d.m.)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dumped	t (a.d.m.)	39 298	49 033	72 577	78 037	76 659	73 255	76 959	76 000	76 667	77 333	78 000	78 667	79 333	80 000

🟩 *- actual data* ▨ *- no data requested or assessed* ☐ *- forecast, estimate*

Operation of TPP-3

As in the project scenario, operation of TPP-3 is considered separately for each of its two boiler rooms, and on the whole (see Tables B.1-10, 11, 12).

Operation of the utilizing boiler room

We believe that the boiler room personnel would have been able to maintain operation of utilizing boilers not worse than it was in 1999.

A forecast for operation of the TPP-3 utilizing boiler room is presented without distribution among the boilers. The following key parameters were set for the forecast of the boiler room operation:

- *Percentage of fuel oil* is taken equal to 34%.
- *The average gross boiler efficiency factor* is taken equal to 46%.
- *The average humidity of BWW* over a year is taken at the level of 53%.
- *The average net calorific value of BWW* for the specified humidity is taken equal to 7.914 GJ/t (0.27 tons of coal equivalent/ton).

The first two parameters look a bit better than they were in 1999, therefore, they may be regarded quite conservative for the baseline scenario.

The last two parameters for 2006-2012 are equal to the forecast values for the project scenario, which is also conservative, as the average humidity set for the baseline scenario could have as well been higher than it was in 1999 (due to a recent decrease in the amount of dry BWW delivered from the plywood manufacturing plant)[1].

Monitoring for the baseline scenario assumes the same average net calorific value of BWW combustion at TPP-3 as actually for the project[2].

BWW consumption is 230 thousand tons per year. The grounds for setting such value are presented above.

Eventually, the annual *steam generation* was determined, which is 1 268.5 thousand GJ per year for 2008-2012. This value is more than twice as low as the one set in the project scenario.

Operation of the recovery boiler room

The parameters as *specific output of liquors per ton of cellulose, average net calorific value of liquors, the average gross boiler efficiency factor, consumption of liquors and sulfate soap* are assumed as absolutely identical to the project scenario. We may say quite confidently that they are not affected by the project.

Steam generation in RB was defined as a difference between the total steam generation at TPP-3 (assessed below) and steam generation in the utilizing boiler room.

By the known value of efficiency factor of boilers, the *overall fuel consumption* in RB was found, which, with the deduction of liquors, would give the sought value of *fuel oil consumption*.

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[1] The Arkhangelsk plywood manufacturing plant has recently expanded its facilities for burning its waste wood, due to which supplies of "dry" BWW to APPM have fallen.

[2] It has to be noted that, although the forecast assumes the same humidity and net calorific value of BWW in the project and the baseline scenarios, it does not mean that installation of modern bark presses in WPS-3 was useless. Without these presses, the average humidity under the project could have been noticeably higher than in the baseline scenario, owing to a large share of BWW delivered from outside.

Overall operation of TPP-3

As was mentioned above in the analysis of the project scenario, it is reasonable to assume that in the forecast for 2012 *steam delivery to the turbines* and *electric power generation* (and, accordingly, supply of the steam spent in the turbines) would remain identical in both scenarios. Their numerical values were taken constant and equal to the average values for the last three years.

However, the baseline scenario will not provide for additional steam supply by-passing the turbines (through the PRC). Therefore, *steam delivery to PRC*, and, accordingly, *useful supply of thermal power through the PRC* will be equal to zero. *The total steam generation* will match the steam delivery to the turbines.

It is indeed hardly expedient to burn more of expensive fuel oil only to produce more steam, with no electricity generated. The amount of fuel oil to be burnt in RB will be just enough to load the turbine to the full extent, but not more than that. This situation is confirmed by experience of operating TPP-3 over all the previous years.

It was said above that the project has not only avoided rising specific heat and electricity consumption for the TPP-3 auxiliary needs, but has most probably cut them, therefore it was permissible not to consider them. Neither is it necessary to consider heat and power consumption for auxiliary needs in the baseline. Let us assume that specific energy consumption for auxiliary needs is the same in both scenarios, which is conservative.

Table B.1-10. Indicators of operation of the TPP-3 utilizing boiler room under the baseline scenario

Name	Unit	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Steam generation	**GJ**	**1 259 893**	**1 268 547**	**1 268 547**	**1 268 547**	**1 268 547**	**1 268 547**	**1 268 547**	**1 268 547**	**1 268 547**	**1 268 547**	**1 268 547**	**1 268 547**	**1 268 547**	**1 268 547**
Fuel consumption	**GJ**	**2 766 131**	**2 757 805**	**2 757 805**	**2 757 805**	**2 757 805**	**2 757 805**	**2 757 805**	**2 757 805**	**2 757 805**	**2 757 805**	**2 757 805**	**2 757 805**	**2 757 805**	**2 757 805**
BWW	t	229 370	230 000	230 000	230 000	230 000	230 000	230 000	230 000	230 000	230 000	230 000	230 000	230 000	230 000
	GJ	1 822 203	1 820 151	1 820 151	1 820 151	1 820 151	1 820 151	1 820 151	1 820 151	1 820 151	1 820 151	1 820 151	1 820 151	1 820 151	1 820 151
Fuel oil	t	24 322	24 259	24 111	23 613	23 194	23 209	23 070	23 351	23 351	23 351	23 351	23 351	23 351	23 351
	GJ	943 929	937 654	937 654	937 654	937 654	937 654	937 654	937 654	937 654	937 654	937 654	937 654	937 654	937 654
Percentage of fuel oil	**%**	**34,12**	**34,00**	**34,00**	**34,00**	**34,00**	**34,00**	**34,00**	**34,00**	**34,00**	**34,00**	**34,00**	**34,00**	**34,00**	**34,00**
Average gross boiler efficiency factor	**%**	**45,55**	**46,00**	**46,00**	**46,00**	**46,00**	**46,00**	**46,00**	**46,00**	**46,00**	**46,00**	**46,00**	**46,00**	**46,00**	**46,00**
Characteristics of burnt waste															
Average humidity of BWW	%	53,1	53,0	53,0	53,0	53,0	53,0	53,0	53,0	53,0	53,0	53,0	53,0	53,0	53,0
Average net calorific value of BWW	GJ/t	7,944	7,914	7,914	7,914	7,914	7,914	7,914	7,914	7,914	7,914	7,914	7,914	7,914	7,914

🟩 - *actual data* ▨ - *no data requested or assessed* ☐ - *forecast, estimate*

Table B.1-11. Indicators of operation of the TPP-3 recovery boiler room under the baseline scenario

Name	Unit	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Steam generation	**GJ**	**5 504 795**	**5 389 767**	**5 317 307**	**5 074 394**	**5 486 491**	**5 500 032**	**5 498 725**	**5 495 083**	**5 495 083**	**5 495 083**	**5 495 083**	**5 495 083**	**5 495 083**	**5 495 083**
Fuel consumption	**GJ**	**6 644 811**	**6 561 777**	**6 465 962**	**6 167 329**	**6 787 456**	**6 894 890**	**6 561 451**	**6 745 026**	**6 745 026**	**6 745 026**	**6 745 026**	**6 745 026**	**6 745 026**	**6 745 026**
Liquors	t (a.d.m.)	428 342	433 968	417 444	435 058	463 300	477 672	492 087	486 317	489 247	492 177	495 106	498 036	498 036	498 036
	GJ	4 584 993	4 723 746	4 275 039	4 434 310	4 676 381	4 944 773	5 059 082	4 980 915	5 010 920	5 040 926	5 070 931	5 100 937	5 100 937	5 100 937
Fuel oil	t	51 957	41 840	54 468	43 865	50 005	45 623	37 298	43 933	43 186	42 438	41 691	40 944	40 944	40 944
	GJ	2 016 440	1 617 209	2 119 230	1 733 019	2 018 572	1 839 325	1 502 369	1 764 111	1 734 106	1 704 100	1 674 095	1 644 089	1 644 089	1 644 089
Sulfate soap	t	1 987	11 446	3 645	0	4 636	5 331	0	0	0	0	0	0	0	0
	GJ	43 379	220 822	71 692	0	92 502	110 792	0	0	0	0	0	0	0	0
Average net calorific value of liquors	GJ/t (a.d.m.)	10,704	10,885	10,241	10,192	10,094	10,352	10,281	10,242	10,242	10,242	10,242	10,242	10,242	10,242
Specific output of liquors per ton of cellulose	t (a.d.m.)/t	1,552	1,472	1,405	1,428	1,436	1,431	1,468	1,445	1,445	1,445	1,445	1,445	1,445	1,445
Average gross boiler efficiency factor	%	82,85	82,14	82,24	82,28	80,84	79,77	83,81	81,47	81,47	81,47	81,47	81,47	81,47	81,47

🟩 *- actual data* ▨ *- no data requested or assessed* ⬜ *- forecast, estimate*

Table B.1-12. Overall indicators of TPP-3 operation under the baseline scenario

Name	Unit	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Steam generation	**GJ**	**6 764 689**	**6 658 314**	**6 585 854**	**6 342 941**	**6 755 038**	**6 768 579**	**6 767 272**	**6 763 630**	**6 763 630**	**6 763 630**	**6 763 630**	**6 763 630**	**6 763 630**	**6 763 630**
Steam delivery to the turbines	GJ	6 764 689	6 658 314	6 585 854	6 342 941	6 755 038	6 768 579	6 767 272	6 763 630	6 763 630	6 763 630	6 763 630	6 763 630	6 763 630	6 763 630
Steam delivery to the PRC	GJ	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Electric power generation	**MW*hr**	**154 835**	**149 311**	**155 269**	**154 585**	**159 388**	**153 177**	**151 526**	**154 697**	**154 697**	**154 697**	**154 697**	**154 697**	**154 697**	**154 697**
Fuel consumption	**GJ**	**9 410 943**	**9 319 582**	**9 223 766**	**8 925 134**	**9 545 260**	**9 652 694**	**9 319 255**	**9 502 831**	**9 502 831**	**9 502 831**	**9 502 831**	**9 502 831**	**9 502 831**	**9 502 831**
Liquors	t (a.d.m.)	428 342	433 968	417 444	435 058	463 300	477 672	492 087	486 317	489 247	492 177	495 106	498 036	498 036	498 036
	GJ	4 584 993	4 723 746	4 275 039	4 434 310	4 676 381	4 944 773	5 059 082	4 980 915	5 010 920	5 040 926	5 070 931	5 100 937	5 100 937	5 100 937
BWW	t	229 370	230 000	230 000	230 000	230 000	230 000	230 000	230 000	230 000	230 000	230 000	230 000	230 000	230 000
	GJ	1 822 203	1 820 151	1 820 151	1 820 151	1 820 151	1 820 151	1 820 151	1 820 151	1 820 151	1 820 151	1 820 151	1 820 151	1 820 151	1 820 151
Fuel oil	t	76 279	66 098	78 579	67 477	73 199	68 832	60 368	67 284	66 537	65 789	65 042	64 295	64 295	64 295
	GJ	2 960 369	2 554 863	3 056 884	2 670 673	2 956 226	2 776 979	2 440 023	2 701 765	2 671 759	2 641 754	2 611 748	2 581 743	2 581 743	2 581 743
WWS	t	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	GJ	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sulfate soap	t	1 987	11 446	3 645	0	4 636	5 331	0	0	0	0	0	0	0	0
	GJ	43 379	220 822	71 692	0	92 502	110 792	0	0	0	0	0	0	0	0
Average gross boiler efficiency factor	%	71,88	71,45	71,40	71,07	70,77	70,12	72,62	71,18	71,18	71,18	71,18	71,18	71,18	71,18

🟩 *- actual data* ▨ *- no data requested or assessed* ⬜ *- forecast, estimate*

Operation of TPP-1

Operation of the MP station (utilizing boiler room)

Table B.1-13 presents actual and forecast data on operation of the utilizing boiler room in the baseline scenario.

For the forecast of the boiler room operation, the parameters as *average net calorific value of BWW*, *average gross boiler efficiency factor*, *percentage of fuel oil* were taken equal to the average actual data for the last three years (2003-2005), which corresponds to the project scenario. We have no reasonable grounds to believe that these parameters are in any way affected by activities under the project.

However, beginning with 2004, *consumption of fuel* (BWW, and proportionately to that – fuel oil), as well as *steam generation* would have probably been higher than the actual and forecast data for the project, which matches the BWW balance made for the baseline scenario (see Table B.1-8). At the same time, the amount of burnt BWW will not exceed the level of 2002.

Like in the project scenario, all the electric power generated at the MP station is assumed to be spent on covering the station's auxiliary needs only, with the useful *supply of thermal power* being 10% smaller than steam generation.

Change in operation of the HP station

As was said above, there is no need to make a forecast of absolute values of fuel consumption and power generation at the HP station of TPP-1. What is important are the changes caused by the project, which were suggested to be assessed in the baseline scenario relative to the project scenario (see Table B.1-14).

Changes in fuel consumption a the HP boilers are only accounted for coal, as today fuel oil consumption in the HP boilers is already reduced to the minimum, due to its higher price, compared to the price of coal. We may say with a sufficient confidence that in the baseline scenario (likewise project scenario) coal is likely to be the marginal fuel at TPP-1.

Additional annual supply of steam for cellulose production from TPP-1 was initially calculated *with taking into account losses in steam network* compared to the project scenario, GJ:

$$\Delta HS_{1,y} = \Delta HS_{3,y} \frac{100}{100 - \varepsilon_{nw}}, \qquad \text{(B.1-1)}$$

where $\Delta HS_{3,y}$ is useful supply of steam through PRC at TPP-3 under the project scenario over a year y, GJ (see Table B.1-6);

ε_{nw} is *heat losses in steam network* (from TPP-1 to cellulose production), %.

According to the data of the mill's energy service, the heat losses in the mill's network attributed to supply of thermal power from TPP-1 are about 4%. In line with the conservative approach, we have taken a smaller value $\varepsilon_{nw} = 3\%$.

Then we calculated *change of steam supply from the MP station of TPP-1* compared to the project scenario, GJ:

$$\Delta HS_{1mp,y} = HS_{1mp,BL,y} - HS_{1mp,PJ,y}, \qquad \text{(B.1-2)}$$

where $HS_{1mp,BL,y}$ is useful supply of thermal power from the MP station of TPP-1 under the baseline scenario over a year y, GJ;

$HS_{1mp,PJ,y}$ is useful supply of thermal power from the MP station of TPP-1 under the project scenario over a year y, GJ.

Then we have *change of steam supply from the HP station* compared to the project scenario, GJ:

$$\Delta HS_{1hp,y} = \Delta HS_{1,y} - \Delta HS_{1mp,y} . \qquad \text{(B.1-3)}$$

We may suppose with certainty that the change of steam supply from the HP station will result from industrial steam extraction of turbines with the rated pressure of 10 atm, which is in the highest demand, including for the cellulose production[1].

Then, it is necessary to determine *change in delivery of live steam to the HP turbines* compared to the project scenario. This problem is complicated by the fact that a change of industrial extraction of steam is accompanied by a change in electric power generation on the basis of heat consumption, and the condensing generation changes with the opposite sign (given that the overall electric power generation would remain unchanged).

The problem was solved based on analysis of the operation diagram of the most representative type of turbines installed at the HP station of TPP-1, and namely – turbine PT-25-90/10 (VPT-25-4). The diagram is presented in Annex 2.3. The following equation was obtained with an acceptable certainty:

$$\Delta HG'_{1hp,y} = 0.665 \Delta HS_{1hp,y} . \qquad \text{(B.1-4)}$$

where $\Delta HG'_{1hp,y}$ is change in delivery of live steam to the HP turbines compared to the project scenario over a year *y*, GJ.

Change in generation of steam by HP boilers compared to the project scenario is somewhat larger than the change in steam delivery to the turbines, as there exist *heat losses and consumption for auxiliary needs*. We assumed these to be equal to ε_{aux}= 5% of the change in generation of steam[2]. Then:

$$\Delta HG_{1hp,y} = \Delta HG'_{1hp,y} \frac{100}{100 - \varepsilon_{aux}} . \qquad \text{(B.1-5)}$$

where $\Delta HG_{1hp,y}$ is change in steam generation by HP boilers compared to the project scenario over a year *y*, GJ.

Analyzing the data on operation of the HP boiler room of TPP-1, we took *the average annual efficiency factor of coal boilers* at the level of η_{coal}= 90%. Then, we have the sought value of *change of coal consumption* compared to the project scenario, GJ:

$$\Delta FC_{coal,y} = \Delta HG_{1hp,y} \frac{100}{\eta_{coal}} . \qquad \text{(B.1-6)}$$

As we can see from Table B.1-14, in the baseline scenario the amount of burnt coal would have probably been smaller, in spite of the fact that steam supply from TPP-1 to cellulose production would have been higher. This is determined by higher steam output at the MP boiler room of TPP-1 in the baseline scenario, owing to larger amounts of burnt BWW and (proportionately) larger amounts of burnt fuel oil.

It has to be noted that accuracy of the assumed coefficients and estimates for TPP-1 (both for the MP, and for the HP station) will not have significant effect on assessment of reductions of emissions for the project on the whole, as the TPP-1 contribution to the total reductions is just 5%. Nevertheless, it was

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[1] According to the APPM power service, TPP-1 provides stable supply of steam at the pressure of 10 atm and temperature about 250 ^{0}C for cellulose production.

[2] Overall heat consumption for auxiliary needs at TPP-1 is higher than 5%, however there is a large share of constant heat costs independent of additional steam output under consideration.

important to show how the total reductions of emissions will be affected by possible change in combustion of BWW at TPP-1, as well as a number of other factors, their influence being not so evident.

As was mentioned above, burning coal is even more profitable than burning BWW in MP utilizing boilers of TPP-1. On the basis of the developed model, special calculations were made, showing to what extent coal consumption in the HP boiler will increase, with fuel (BWW+fuel oil) consumption in MP boilers decreased, provided the total useful supply of both types of energy from TPP-1 remains unchanged.

Approximating the results, we may assume that a reduction of fuel consumption by 1 GJ in MP boilers will result in an increase of coal consumption by just 0.5 GJ. At the same time, 1 GJ of fuel burnt in MP boilers is made up of fuel oil and BWW, fuel oil accounting for a third. Here, GHG emissions will certainly rise.

However, according to the data available, 1 GJ of fuel oil costs at least twice as much as 1 GJ of coal. Then, if we assume that 1 GJ of coal costs 1 ruble, and 1 GJ of fuel oil – 2 rubles, with the BWW cost equal to zero, the saving which comes from fuel oil and BWW being substituted with coal, will be $0.3\times2-0.5\times1 = 0.1$ ruble per 1 GJ of fuel combusted in MP boilers, or 17%. Yet, the cost of BWW could as well be rather significant, with delivery costs taken into account.

Therefore, it was feasible to forecast smaller amounts of BWW burnt at TPP-1, and probably, in old boilers of TPP-3 as well, but then higher coal consumption in HP boilers. Yet, following the conservative approach, we decided not to include this option in our consideration. In the adopted variant, BWW consumption at TPP-1 under the baseline scenario is even higher than in the project scenario.

Table B.1-13. Indicators of operation of the TPP-1 MP station (utilizing boiler room) under the baseline scenario

Name	Unit	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Steam generation	**GJ**		**1 524 474**	**1 580 618**	**1 724 546**	**1 726 911**	**1 676 002**	**1 457 169**	**1 641 687**	**1 017 561**	**1 027 569**	**1 037 576**	**1 047 584**	**1 274 134**	**1 382 083**
Thermal power supply	GJ		1 372 027	1 422 556	1 552 091	1 554 220	1 508 402	1 311 452	1 477 518	915 805	924 812	933 819	942 825	1 146 720	1 243 874
Fuel consumption	**GJ**		**2 093 408**	**2 202 031**	**2 417 899**	**2 428 421**	**2 411 198**	**2 192 859**	**2 378 426**	**1 474 212**	**1 488 710**	**1 503 209**	**1 517 708**	**1 845 926**	**2 002 319**
BWW	t	197 009	205 520	220 317	266 242	263 637	251 924	229 608	251 740	156 035	157 570	159 105	160 639	195 379	211 932
	GJ	1 174 803	1 200 860	1 387 477	1 662 580	1592852	1 615 083	1 556 122	1 613 666	1 000 193	1 010 030	1 019 867	1 029 703	1 252 386	1 358 493
Fuel oil	t		23 066	20 932	19 042	20 692	19 747	15 813	19 045	11 805	11 921	12 037	12 153	14 781	16 034
	GJ		892 548	814 554	755 319	835 569	796 114	636 737	764 760	474 019	478 681	483 342	488 004	593 540	643 827
Average net calorific value of BWW	GJ/t	5,963	5,843	6,298	6,245	6,042	6,411	6,777	6,410	6,410	6,410	6,410	6,410	6,410	6,410
Average gross boiler efficiency factor	%		72,83	71,78	71,33	71,11	69,51	66,45	69,03	69,03	69,03	69,03	69,03	69,03	69,03
Percentage of fuel oil	%		42,64	36,99	31,24	34,41	33,02	29,04	32,15	32,15	32,15	32,15	32,15	32,15	32,15

🟩 *- actual data* ▨ *- no data requested or assessed* ☐ *- forecast, estimate*

Table B.1-14. Forecast of changes of the principal indicators of the TPP-1 HP station under the baseline scenario, compared to the project scenario

Name	Unit	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Additional steam supply for cellulose production from TPP-1, with network losses taken into account	GJ	0	0	0	0	0	0	0	98 986	251 663	275 604	299 545	323 486	323 486	323 486
Change in steam supply from the MP station	GJ	0	0	0	0	0	440 598	222 409	802 069	628 725	393 956	393 956	393 956	393 956	393 956
Change in steam supply from the HP station (assumed with the 10 atm steam extraction)	GJ	0	0	0	0	0	-440 598	-222 409	-703 082	-377 062	-118 352	-94 411	-70 470	-70 470	-70 470
Change in live steam delivery to the HP turbines	GJ	0	0	0	0	0	-292 998	-147 902	-467 550	-250 746	-78 704	-62 783	-46 863	-46 863	-46 863
Change in live steam generation by HP boilers	GJ	0	0	0	0	0	-308 418	-155 687	-492 158	-263 943	-82 847	-66 088	-49 329	-49 329	-49 329
Change in coal consumption in HP boilers	**GJ**	**0**	**0**	**0**	**0**	**0**	**-342 699**	**-172 991**	**-546 860**	**-293 280**	**-92 055**	**-73 433**	**-54 812**	**-54 812**	**-54 812**

Resource changes resulting from the project

Table B.1-15 presents the principal resource changes resulting from the project, most of which determine reductions of emissions and show that they will actually take place.

On the average, over 2008-2012, reduction of fuel oil combustion at both TPPs will offset an increase in coal combustion by more than 30 times. At that, an increase of coal combustion will be three times as small as the reduction in fuel oil combustion in the MP boiler room of TPP-1. Obviously, CO_2 emissions from burning fossil fuel will be lower.

The main reductions of CO_2 emissions will take place at TPP-3, owing to a sharp drop in fuel oil combustion. The reduction of fuel oil combustion at TPP-1 will be an order of magnitude smaller than at TPP-3.

The amount of dumped BWW will be on the average reduced by 62 thousand tons a year, and that of WWS – by 25 thousand tons of a.d.m. a year, which will determine reductions of methane emissions from the landfill that will also contribute significantly to the overall reductions of GHG emissions.

The presented mathematical model has made it possible to specify in full, where and owing to what the GHG emissions will be reduced.

Table B.1-15. Principal resource changes resulting from the project (compared to the baseline)

Name	Unit	2008	2009	2010	2011	2012	On the average for 2008-2012
Fuel (total)	**GJ**	**-1 025 465**	**-1 014 081**	**-1 002 697**	**-1 002 697**	**-1 002 697**	**-1 009 527**
TPP-3	GJ	-483 351	-453 345	-423 340	-423 340	-423 340	-441 343
TPP-1	GJ	-542 114	-560 736	-579 357	-579 357	-579 357	-568 184
Fuel oil	**GJ**	**-2 437 413**	**-2 407 407**	**-2 377 402**	**-2 377 402**	**-2 377 402**	**-2 395 405**
TPP-3	GJ	-2 233 502	-2 203 496	-2 173 491	-2 173 491	-2 173 491	-2 191 494
TPP-1	GJ	-203 911	-203 911	-203 911	-203 911	-203 911	-203 911
Coal (TPP-1)	**GJ**	**92 055**	**73 433**	**54 812**	**54 812**	**54 812**	**65 985**
BWW	**GJ**	**1 223 398**	**1 223 398**	**1 223 398**	**1 223 398**	**1 223 398**	**1 223 398**
TPP-3	GJ	1 653 656	1 653 656	1 653 656	1 653 656	1 653 656	1 653 656
TPP-1	GJ	-430 258	-430 258	-430 258	-430 258	-430 258	-430 258
WWS (TPP-3)	**GJ**	**96 495**	**96 495**	**96 495**	**96 495**	**96 495**	**96 495**
Delivery of BWW from outside	**t**	**80 000**	**80 000**	**80 000**	**80 000**	**80 000**	**80 000**
Burnt BWW	**t**	**141 839**	**141 839**	**141 839**	**141 839**	**141 839**	**141 839**
TPP-3	t	208 961	208 961	208 961	208 961	208 961	208 961
TPP-1	t	-67 123	-67 123	-67 123	-67 123	-67 123	-67 123
Dumped BWW	**t**	**-61 839**	**-61 839**	**-61 839**	**-61 839**	**-61 839**	**-61 839**
Dumped WWS	**t (a.d.m.)**	**-25 240**	**-25 240**	**-25 240**	**-25 240**	**-25 240**	**-25 240**

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

Baseline scenario assumes that APPM would continue to utilize as much BWW as it could, considering the following:

(i) capacity and technology of existing utilizing boilers at both TPPs #1 and #3,

(ii) volume of production and thus, the amount of BWW generated on site,

(iii) delivery of up to 120 000 tonnes of BWW per annum from outside, and

(iv) requirement to mix WWS with BWW before dumping WWS in the landfill.

Under these assumptions, the baseline scenario includes annual utilization of up to 440 000 tonnes of BWW in the existing boilers at TPPs #1 and #3 (with fuel oil flame stabilization) and the further utilization of 50 000 tonnes of saw dust for production of wood fiber products. WWS in the amount up to 80 000 tonnes of absolute dry matter (a.d.m.) and up to 200 000 tonnes of bark and wood waste (BWW) are dumped in the landfill annually. Remaining energy needs are satisfied by utilizing fuel oil and coal at TPPs #1 and #3.

(b) Description of the project scenario

Under the project, up to 142 thousand tons of BWW (mostly bark) and about 100 thousand tons (wet) of WWS per annum will be utilized at APPM in addition to the baseline scenario which will substitute 2 329 thousand GJ of fossil fuel per annum. The use of fuel oil will be reduced by 2 395 GJ per annum, however the use of coal will increase by 66 GJ per annum on average over 2008-2012. This will result in GHG emission reductions of 204 290 t CO_2e per annum, including 178 712 t CO_2 coming from fossil fuel combustion, and 25 579 t CO_2e of avoided methane emissions from the landfill.

(c) Additionality of emission reductions

The additionality of the project was analyzed for each stage separately by applying investment analysis and barrier analysis. Common practice analysis has been applied to the project in whole.

Stage I

Barrier analysis

Technological barriers

First of all, technological barrier should be mentioned with regard to Stage I. The existing boilers could have not been used for utilization of additional amount of bark since its high humidity content (up to 70%) was far beyond the requirements and combustion abilities of the boilers at both TPPs #1 and #3. To overcome this barrier a new technology had to be introduced by reconstruction or replacement of the existing boilers.

The fluidized bed technology which allows combustion of highly humid fuel without using fossil fuel for flame stabilization was chosen. Implementation of this technology was possible through reconstruction of the existing utilizing boiler at TPP-3. However a special unit for crushing and pressing of bark before its feeding into the boiler had to be constructed in order to meet the requirements of the boiler in terms of bark breakup and humidity content, which requirements were as follows: fractions no longer than 75 mm, and humidity content no higher than 60%.

This required certain investments which had to be efficient enough to be proved by investors (shareholders). Investment analysis of Stage I is provided further. Here investments are only mentioned as a tool to overcome technological barrier, i.e. the lack of utilizing capacity of existing boilers.

Operational barriers

APPM had never built or exploited fluidized bed boilers and was used to running much less complex equipment to utilize wood waste together with fuel oil as a supplementary high calorific fuel. Therefore during the first year after the reconstruction the boiler did not achieve the projected parameters neither in terms of BWW load nor in terms of steam output. Besides, a number of problems were identified, which required fixing and further improvement of the boiler. Among them the following can be noted:

- Optimization of waste distribution through the bed area;
- Improvement of water feeding unit operation;
- Improvement of air feeding system;
- Installation of steam soot blowers in the superheater zone.

These technical solutions were implemented that allowed obtaining the designed steam capacity with rated steam parameters. It became even possible to maintain yet higher steam loads – up to 75 tons an hour.

Investment analysis

Stage I was totally financed with APPM’s own funds (equity). As a return on investments, GHG emissions reduction, alongside with energy saving, through reduced use of fuel oil in the utilizing boiler has been considered at this stage. Otherwise, the project could hardly reach the required rate of return on investments and produce positive NPV.

Business-as-usual investments into increasing and improving of the main production capacities of APPM generate at least 20% rate of return that can be considered as a hurdle (benchmark). This rate of return is obtained through both increase in sales and energy saving per ton of pulp cooked through introduction of new technologies in pulp and cardboard production.

Thus, in 1998-1999 an investment project was implemented at APPM’s cardboard production line which allowed increasing the cardboard output and reducing the energy consumption through installation of new long-nip press at cardboard-making machine #2 and reconstruction of black liquor evaporating station. This project generated 23% rate of return. The similar project had been implemented at bleached pulp production line where the new black liquor concentrator was installed and the soda recovery boiler reconstructed in order to reduce energy losses in the liquor recovery process. The rate of return here was also higher than 20%.

In parallel with the project here presented, the reconstruction of cardboard-making machine #1 was being implemented by installing the most advanced shoe press and auxiliary equipment in order to further increase cardboard production and reduce per unit energy consumption. The expected rate of return of the project is again higher than 20%.

This means that the project described in this PDD should have generated at least 20% rate of return which number is considered the alternative cost of capital (or actually the applicable discount rate).

Assuming this discount rate and expected savings in fuel oil use in the reconstructed boiler amounting up to 20 thousand tons per year at USD70/ton price, NPV generated by the project without GHG emission trading appeared to be negative (-24 thousand USD). However, with emission trading NPV is positive (813 thousand USD) and IRR is above the benchmark (23.6%). See Table B.2-1 and Annex 2.1 for details.

Here, the project costs amounting USD5.1 million and also additional use of fuel oil (1 000 tons at USD70/ton price) to offset the temporally stopped operation of the utilizing boiler during its reconstruction are considered in 2000.

The price of fuel oil is calculated on the basis of data provided in *Oil processing industry review*[1]. The review says the internal fuel oil price in Russia has increased by 74.4% in 2000, from RUR1562.5/ton up to RUR2725/ton. The projected annual average prices of fuel oil was calculated as a weighted sum of these two prices by applying 65% weight to the price in the beginning of the year, and 35% weight to the price at the year end, taking into account the fact that the project had been considered by APPM in the beginning of 2000. This projected price happened to be RUR1969.

The average exchange rate for 2000 was calculated using the data provided by the Central Bank of Russia on daily basis[2], and appeared to be RUR28.13/USD.

Thus, the USD-equivalent price of fuel oil was assumed USD70. This price was set fixed for the whole depreciation period which was considered 15 years.

Table B.2-1. Financial indicators for Stage I

	Unit	w/o ERs	with ERs
Project costs	'000 USD	5 100	5 100
Decrease of fuel oil use for energy generation	Metric tons per annum	20 000	20 000
Reduction of GHG emissions from fuel oil combustion	tons CO_2 per annum	x	60 280
NPV	'000 USD	-77.2	759.9
IRR	% per annum	19.6%	23.3%

Sensitivity analysis shows that without emission trading 10% reduction of fuel oil savings below the projected level will result in yet lower NPV (-574.6 thousand USD) and IRR (17.3%) while with emission trading NPV will still be positive (178.7 thousand USD) and IRR higher than the benchmark (20.8%). Similarly, 10% increase of project cost over the projected level will make the project completely inefficient without emission trading (NPV = -577 thousand USD, IRR = 17.5%), while with emission trading the project still remains safe (NPV = 260 thousand USD, IRR = 21.0%).

In order to qualify the project as carbon project and to sell GHG emission reductions, APPM on 1 February 2000 entered into Protocol of Intention (MoU) with the Environmental Investment Center (EIC), a local not-for-profit organization which used to providing consulting services to the Russian real sector, especially to pulp-and-paper industry, with regard to the world environmental markets and environmental investments. Under the MoU, APPM and EIC have agreed to cooperate in generating, monitoring, and monetization of project based GHG emission reductions at APPM, including those coming from the above project, as well as in rendering GHG emissions inventory at APPM starting from the year 1990 (see Annex 4).

The idea was to sell ERUs the project would be generating in 2008-2012, and also to apply to the Russian government for AAUs to cover early reductions obtained by the project in 2001-2007. The price of ERUs was assumed USD8/t CO_2e, and the price of early reduction represented by AAUs – USD2/t CO_2e. With early reductions excluded, the project cannot stand neither 10% fall in fuel oil saving nor 10% increase of project costs. In both cases NPV turns negative and IRR falls beneath the benchmark.

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[1] See http://ecsocman.edu.ru/images/pubs/2004/07/30/0000171330/otr_npz.doc for details.

[2] http://www.cbr.ru/currency_base/dynamics.asp

Stage II

Barrier analysis

Technological barriers

The results of Stage I proved that combustion of bark and WWS required much more advanced technology than that implemented in the old boiler and even in the newly reconstructed boiler. As a solution to this barrier, the decision was made to install a new utilizing boiler to provide for efficient combustion of combined BWW and WWS fuel. In addition to the boiler, a new electric filter had to be installed to capture solid particles and other harmful emissions associated with WWS combustion. Finally, a special unit for receiving, storage and preparation for combustion of BWW and WWS had to be constructed. We only mention this technological barrier here in order to once more point out that existing technology and equipment were not sufficient to reach the target of Stage II and that additional material investments were required.

Financial barriers

Investments required to overcome technological barriers at Stage II appeared to be three times as much as at Stage I, 15.1 million USD. It was really hard (if possible) for APPM to allocate that much equity to the side project not related directly to APPM’s core business. Since 2003, APPM was implementing the biggest project in its post-1990 history, i.e. construction of the new wood preparation shop involving EUR30 million costs, in order to increase the output of pulp chips and reduce the amount of bark and WWS.

Commercial loans available at that time to APPM and to the Russian industry at all were not helpful and did not fit the case since those loans had to be repaid within 3 years as maximum while the payback period of the project was much longer, 9 years including investment (project implementation) period.

To overcome the financial barrier, APPM applied to the World Bank through National Pollution Abatement Facility (NPAF) for a long-term loan amounting $7 million under the Environmental Management Project (EMP). This financial opportunity was a unique one and was not a common commercial practice at all. The APPM’s project has been selected among hundreds of applications considering, among other project parameters, the expected reduction of GHG emissions as a result of the project (see Annex 5). It is worth noting that without the World Bank loan the project would not been viable neither in terms of financial recourses available nor in terms of financial return on investments (see below for details).

Operational barriers

Technology for preparation and combustion of BBW/WWS mixture in the fluidized bed boilers was new in Russia and was unexplored by APPM. APPM faced difficulties in identifying the correct ratio between BWW and WWS and in creating a homogenous mixture, which is necessary for stable operation of the boilers. Because of high humidity content of WWS which is even higher than that of bark, WWS loading into the boiler reduces steam output. Another big problem is a very specific chemical content of WWS that made it necessary to select a very special type of sand added into the boilers to provide for a fluidized bed effect. Otherwise, there was a risk of technological breakdown of the boilers. To provide for the smooth running of the fluidized bed boilers with combined BBW/WWS fuel, an advanced measurement and automatic control system had to be installed.

It should be noted also that operating modes of TPP-1 had to be reconsidered due to noticeable increase of steam supply from TPP-3 where the new boiler had been installed, which lead to corresponding cut of steam supply from TPP-1. The load of MP station of TPP-1 has decreased significantly since the major amount of BWW is now combusted at TPP-3. However, the additional output of steam from TPP-3 is not enough to offset the reduction of steam output from MP station of TPP-1. To compensate that, the load of HP coal boilers of TPP-1 had to be increased which required increased coal supply to APPM.

Commercial barriers

Stage II envisages 80% growth of BWW supplied from outside, from 120 to 200 thousand tons per year. This imposes certain *commercial* risks on APPM, which risks can also be considered as a barrier. The biggest commercial risk is the quality (humidity content) of BWW delivered from outside. The thing is that BWW is not considered as commodity in Russia in commercial sense of the word. So, no guarantees can be claimed from BWW suppliers in terms of quality.

The other risk is under-delivery of BWW from the nearby saw mills. This can make APPM organize collection and delivery of BWW from longer distances which will affect the BWW costs making them comparable to the cost of coal.

Even now the sell price of fuel wood is comparable with coal. According to the data provided by Russian-Sweden Biocenter[1], the price of low-grade wood is about €10 per dense m^3, and the delivery costs are about €3 per dense m^3 per 100 km. Summing up and applying the net calorific value of BWW 7 GJ/dense m^3 will result in BWW final price about €1.86 per GJ. The price of coal with delivery costs is about €45 per metric ton. Applying the net calorific value 23 GJ/ton will give €1.96 per TJ. Thus, the two values are really close. However, the efficiency of combusting coal for energy generation is much higher as compared with combusting BWW. This means that BWW supplied from 100 km distance is suboptimal as fuel for power generation.

Another factor impacting the price of BWW and its availability for local combustion is further development of the market, especially with the view of installing capacities for manufacturing of wood fuel granules (pellets) for export as an alternative to burning BWW locally. Once such capacities would be installed somewhere close to Archangelsk, the market demand for BWW as a raw material for bio-fuel production will appear and the buy price of BWW will go up. Under the above circumstances even the price of BWW generated at APPM site could not be considered zero any longer since it would become possible for APPM to sell them in the market.

Investment analysis

Stage II was financed with APPM's own funds (equity) and the loan provided by the World Bank through NPAF. For investment analysis, the required rate of return on equity was again set at 20% level representing the alternative cost of capital. The World Bank loan related inflows and outflows were included in the model directly thus avoiding the necessity of adjusting the cost of capital.

The price of fuel oil is assumed USD125/t which is higher than at Stage I since the world price of fuel oil grew up significantly during the three years which impacted the local price. The price of coal is considered USD20/ton. These prices were derived from the press-release by RAO UES of 11 September 2003[2], using the exchange rate set by the Central Bank of Russia on that particular date, RUR30.6307/USD, and some reasonable assumptions regarding there further growth. The fuel oil price was assumed to grow up by another 10% by the end of the year; while the price of coal was assumed to start growing up quickly after the price of natural gas would be released by the Russian government.

The price of BWW supplied from outside is considered negligibly small and thus ignored. However, the transportation price of BWW supplied from outside is set at USD3/ton, which is approximately RUR100/ton.

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[1] V.S. Kholodkov, A.F. Rogozin. Production of chips from waste of timber felling arising at cutting of electric mains, gas pipelines and other lines of communications. Russian-Sweden Teaching and Informational Center of Bioenergy. Lisino, Leningrad region. 2005. http://rusbiocenter.spb.ru/file14.php

[2] http://www.rao-ees.ru/ru/show_prn.cgi?news/news/pr_archiv/pr110903gra.htm

The investments in amount of USD15.1 million are made in 2003 through 2005. The boiler is stopped for replacement in 2004, and the new boiler becomes operational by the end of 2005. During these two years, 2004 and 2005, additional amounts of fuel oil had to be burnt to offset the lacking capacity of the remaining utilizing boilers.

The expected amount of fuel oil savings due to the project is 40 thousand tons per year.

The cash-flow analysis was made for the period of 18 years, including three years of investment period and 15 years of operation period up to the time the costs of the new equipment are fully depreciated.

The results of investment analysis are presented Table B.2-2 below and in Annex 2.1.

Table B.2-2. Financial indicators for Stage II

	Unit	**w/o ERs and WB loan**	**with WB loan**	**with ERs**	**with WB loan and ERs**
Project costs	‘000 USD	15 100	15 100	15 100	15 100
WB loan	‘000 USD	x	7 000	x	7 000
Decrease of fuel oil use for energy generation	Metric tons per annum	40 000	40 000	40 000	40 000
Reduction of GHG emissions from fuel oil combustion	t CO_2	x	x	120 560	120 560
NPV	‘000 USD	-1 702.5	-165.9	-55.7	1 480.9
IRR	% per annum	17.3%	19.6%	19.9%	23.3%

Without GHG emission trading the project is far from being financially viable, generating negative NPV (-1 702.5 thousand USD) and IRR far below the benchmark (17.3% against 20%). The World Bank loan improves the situation but NPV still remains negative (-165.9 thousand USD) and IRR is still beneath the hurdle (19.6%). However, with emission trading, the project demonstrates rather good results, NPV being 1 480.9 thousand USD and IRR being 23.3%. Still, without the WB loan NPV turns negative again even with emission trading.

Sensitivity analysis shows that without emission trading 10% reduction of fuel oil savings below the projected level will result in yet lower NPV (-1 399.7 thousand USD) and IRR (16.9%) while with emission trading NPV will still be positive (82.4 thousand USD) and IRR will not fall below benchmark (20.2%). Similarly, 10% increase of project costs over the projected level will make the project completely inefficient without emission trading (NPV = -1 193.7 thousand USD, IRR = 17.6%), while with emission trading the project remains safe (NPV = 453.2 thousand USD, IRR = 20.9%).

Seeking to generate revenues from GHG emissions reduction arising as a result of the project, APPM has explored different opportunities through both Kyoto and non-Kyoto mechanisms.

Particularly, in December 2002 APPM and EIC started negotiations and on 28 April 2003 entered into a Memorandum of Agreement with Environmental Defense (EDf), a US based NGO which was leading a Partnership for Climate Actions (PCA), an informal association of the world largest companies with voluntarily established GHG emission targets, with the view of selling emission reductions to the PCA members. Among PCA members were Alcan; BP; DuPont; Entergy; Ontario Power Generation; Pechiney; Shell International; and Suncor. In general, cooperation with EDf was aimed at design and implementation of a private system for the limitation of APPM’s GHG emissions and at exploring the potential for APPM to generate revenues through (1) the sale of environmental outputs such as credits, offsets, allowances, or other market instruments, (2) green marketing programs, and (3) joint implementation investments (Annex 6). In January 2004, following the above Memorandum of Agreement with EDf, APPM submitted official application to join PCA (Annex 7).

However, later, when Russia had ratified the Kyoto Protocol and it had come into force, and the EU ETS had been launched, APPM has switched to Kyoto market seeking to sell GHG emissions reductions as ERUs. For this purpose, in 2005, APPM was introduced by EIC to and on 14 February 2006 entered into Agreement with CAMCO AG (now Camco International GmbH), a Vienna (Austria) based carbon management company which has committed to undertaking, as a APPM's carbon broker, all necessary actions so as to market the project and to sell the project based ERUs in the world carbon market.

Common practice analysis

In general, combustion of wood waste is not widely practiced in Russia. In forestry focused Archangelsk region, only half of the BWW energy potential – representing up to 40 000 TJ per year – is utilized while the rest remains in forests or is dumped in the landfills. The share of bio-fuel (excluding black liquor) in the fuel balance of the region is only 9.2%. Of the total amount of wood waste utilized in the region, 55% is utilized by pulp-and-paper mills (PPMs).

By the time the first stage of the project became operational in December 2000, almost all Russian pulp-and-paper mills had been equipped with utilizing boilers allowing combustion of wood waste. In most cases these boilers are locally manufactured and require the use of fuel oil or natural gas as a supplementary high calorific fuel for flame stabilization (30-40% of total fuel load). Only a few utilizing boilers with fluidized bed furnaces or such other types of boilers which allow combustion of BWW without fossil fuel use, had been installed at Russian PPMs so far. One of them is in Syktyvkar, Komi Republic, another one – at Baikal PPM in Irkutsk oblast.

Of three PPMs located in Archangelsk oblast, none had that type of equipment up and running. In Segezha, Republic of Karelia, the project aimed at installation of fluidized bed boiler for combustion of BWW has failed.

Since wet debarking technology is typically exploited in Russian pulp-and-paper and timber industries, bark has extremely high humidity content (up to 70%) and low calorific value (some 7 GJ/dense m^3) which makes its combustion really difficult (if possible) considering locally available technologies. Thus, only a small portion of bark (up to 20%) is combusted in composition with wood waste while the rest is dumped in landfills.

As for WWS, it has even higher humidity content and lower calorific value than BWW (approximately 1 GJ per wet ton) and thus has never been considered a fuel in Russia. On the contrary, people were used to saying that WWS is good for fire extinguishing. To the best of our knowledge, only one Russian PPM, namely JSC Solikamskbumprom, has been utilizing WWS since late 1990s when a new boiler supplied by Wellons, USA was installed there.

Thus, bark and WWS are typically dumped in landfills by Russian PPMs which is considered normal even by the Russian legislation. Russian environmental regulations only require construction and maintenance of bark and sludge landfills in accordance with established standards, as well as mixing WWS with BWW before its dumping in the landfills. APPM was and still is the first and only PPM in Russia to utilize WWS and BWW as a combined fuel in fluidized bed boilers for energy purposes.

The decision to start the project and later, to proceed to Stage II was largely made by taking into account the possibility of selling the achieved GHG emission reductions under the flexible mechanism of the Kyoto Protocol or otherwise in the carbon market. Without carbon revenues and/or carbon investments, energy savings achieved by the project in terms of reduced fuel oil use for energy generation would have not been sufficient to provide required return on investments within reasonable period of time and to generate positive NPV.

Since 2000, a lot of activities have been implemented by APPM and EIC in order to prepare APPM for acting in the carbon market [R2-R15].

Thus, the years 2001 and 2002 saw preliminary inventory of GHG emissions at the mill over the years 1990 to 2001 [R2]. The inventory report underwent independent examination [R16] by international experts who highly appreciated both the inventory itself and the accounting system existing at the mill which provides, with sufficient accuracy and due diligence, for recording and storage of data related to the use of fuel and other resources (inputs) associated with GHG emissions. In 2003, a comprehensive year-by-year inventory of GHG emissions for the years 1990 through 2002 was conducted at APPM in cooperation with EIC [R5]. As of to date, APPM has a well-established corporate system of GHG emissions management, which includes the company specific methodology [R11] and software [R12] for accounting of GHG emissions. The latest results of GHG emissions inventory at APPM for the years 1990 through 2005 are presented in Annex 8.

In 2003, APPM committed, on voluntary basis, to limit its GHG emissions. The target is to keep GHG emissions at or below 88% of the 1990 levels until 2012 while at the same time increasing production of pulp by 9% over 1990 level, up to 1 million tons per year (Annex 9). This voluntary obligation was announced by the mill's General Director Mr. Vladimir Beloglazov at the 9th Conference of Parties to the UN Framework Convention on Climate Change in Milan (Italy) on December 10, 2003 [R7].

These steps place APPM at the forefront of Russian industry as it is currently the only Russian company operating under a voluntary GHG emissions cap.

Actual data of the GHG emissions and pulping over the last few years proves that implementation of the project, combined with other measures of the smaller scale, makes it possible for APPM to raise the volume of production without growth of GHG emissions (Annex 10).

It's worth noting also that the implementation of Stage II was to a large extent driven by and became possible due to a favorable loan amounting $7 million granted to APPM by the World Bank through NPAF under the Environmental Management Project (EMP). This financial opportunity was a unique one and was not a common commercial practice at all.

Summing up, the project does not represent the common practice neither at APPM nor in the Russian pulp-and-paper industry at all. It envisages (for the first time in Russia) combustion of highly humid and low calorific bark and WWS in fluidized bed boilers in combination with other wood waste without using fuel oil, or any other fossil fuel, for flame stabilization. Under the common practice, most of bark and all WWS are dumped in the landfills following the Russian environmental standards and regulations.

Referencing to the above the project is not a part of the baseline and therefore, the reductions obtained as a result of the project are additional to any that would otherwise occur.

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

Fig. B.3-1 presents the principal components and boundaries of the project. At the same time, the diagram shows the main flows of fuel, steam and biomass waste. The diagram contains the main power facilities of APPM.

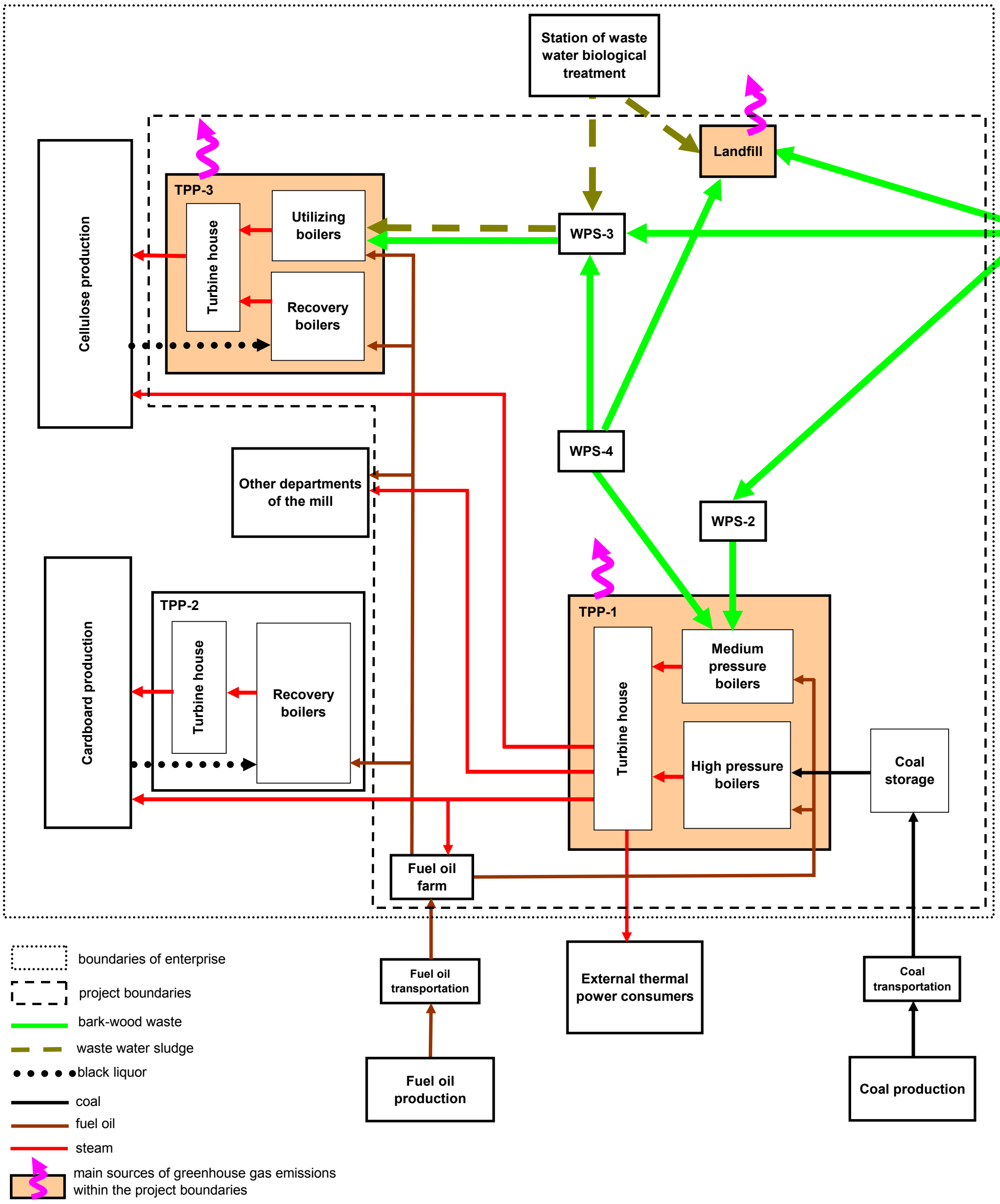

Fig. B.3-1. Principal components and boundaries of the project

The main sources of GHG emissions included in the project boundaries are:

- TPP-3;
- TPP-1;
- Landfill of industrial waste.

All specified sources are located on the territory of the mill and are fully controlled by it.

TPP-2 is excluded of the project boundaries, as it has no effect on the project (neither does the project affect operation of TPP-2). Other objects and types of activities existing at the enterprise and outside either are not at all related to the project, or affect the project negligibly, their emissions being insignificant.

Table B.3-1 specifies, which particular gases and sources are included in the project boundaries, or excluded of them. The same table indicates possible leakages of the project.

Table B.3-1. Sources of emissions included in consideration or excluded of it

	Source	**Gas**	**Incl./ Excl.**	**Justification/Explanation**
Baseline	TPP-3, burning fuel oil	**CO_2**	**Incl.**	**Main source of emissions**
		CH_4	Excl.	Considered negligible. Conservative
		N_2O	Excl.	Considered negligible. Conservative
	TPP-3, burning liquors and BWW	CO_2	Excl.	Assumed to be equal to zero
		CH_4	Excl.	Considered negligible. Conservative
		N_2O	Excl.	Considered negligible. Conservative
	TPP-1, burning fuel oil in the MP boiler room	**CO_2**	**Incl.**	**Main source of emissions**
		CH_4	Excl.	Considered negligible. Conservative
		N_2O	Excl.	Considered negligible. Conservative
	TPP-1, burning BWW in the MP boiler room	CO_2	Excl.	Assumed to be equal to zero
		CH_4	Excl.	Considered negligible. Conservative
		N_2O	Excl.	Considered negligible. Conservative
	TPP-1, change in coal combustion in the HP boiler room (compared to the project)	**CO_2**	**Incl.**	**Main source of emissions**
		CH_4	Excl.	Considered negligible
		N_2O	Excl.	Considered negligible
	Landfill of industrial waste, anaerobic decomposition of extra BWW and WWS (compared to the project)	CO_2	Excl.	Assumed to be equal to zero
		CH_4	**Incl.**	**Main source of emissions**
		N_2O	Excl.	Considered negligible. Conservative
	Fuel oil farm, extra consumption of thermal power for fuel oil preparation (compared to the project)	CO_2	Excl.*	Considered to be an insignificant source of emissions. Conservative
		CH_4	Excl.	Considered negligible. Conservative
		N_2O	Excl.	Considered negligible. Conservative

Project activities	TPP-3, burning fuel oil	**CO_2**	**Incl.**	**Main source of emissions**
		CH_4	Excl.	Considered negligible
		N_2O	Excl.	Considered negligible
	TPP-3, burning liquors, BWW and WWS	CO_2	Excl.	Assumed to be equal to zero
		CH_4	Excl.	Considered negligible
		N_2O	Excl.	Considered negligible
	TPP-1, burning fuel oil in the MP boiler room	**CO_2**	**Incl.**	**Main source of emissions**
		CH_4	Excl.	Considered negligible
		N_2O	Excl.	Considered negligible
	TPP-1, burning BWW in the MP boiler room	CO_2	Excl.	Assumed to be equal to zero
		CH_4	Excl.	Considered negligible
		N_2O	Excl.	Considered negligible
	New unit for receiving and preparation of delivered BWW and WWS, electricity consumption	CO_2	Excl.*	Considered to be an insignificant source of emissions
		CH_4	Excl.	Considered negligible
		N_2O	Excl.	Considered negligible
Leakages	Reduction in fuel oil production and transportation	CO_2	Excl.	Considered to be an insignificant source of emissions. Conservative
		CH_4	Excl.	Considered to be an insignificant source of emissions. Conservative
		N_2O	Excl.	Considered negligible. Conservative
	Change in the amount of produced and transported coal	CO_2	Excl.	Considered to be an insignificant source of emissions
		CH_4	Excl.*	Considered to be an insignificant source of emissions
		N_2O	Excl.	Considered negligible
	Growth of amounts of transported BWW	CO_2	Excl.*	Considered to be an insignificant source of emissions
		CH_4	Excl.	Considered negligible
		N_2O	Excl.	Considered negligible

*most significant of the excluded emissions, for which numerical assessments are made below

It is important to make assessments of the essential *not main* emissions, which increase or decrease as a result of the project, including leakages, to verify the extent of their mutual compensation:

1. Reduction of thermal power spent on pre-heating fuel oil in the APPM fuel oil farm

According to the records of the APPM energy service over the last few years, pre-heating fuel oil for TPP-3 in the common fuel oil farm requires about 1.5 GJ per ton of fuel oil. The amount of saved fuel oil as a result of the project only at TPP-3 will be about 55 thousand tons of fuel oil per year (on the average for 2008-2012). Then the economy of thermal power will be $1.5 \times 55\,000 = 82\,500$ GJ/year. Assuming this thermal power is generated by burning fuel oil with a net efficiency factor equal to 80%, reduction in the amount of burnt fuel oil will be $82\,500/0.8 = 103\,125$ GJ. Emission factor for fuel oil is taken equal to 77.13 kg of CO_2/GJ. Then, emissions will be $77.13 \times 103.123 = \underline{7\,954}$ tons of CO_2/year.

2. Consumption of electricity in the new unit for receiving and preparation of delivered BWW and WWS

According to the data of the APPM energy service, preparation of delivered BWW and WWS requires about 2 kW*hr of electric power per ton of waste. According to the forecast, annually about 100 thousand tons of BWW and 100 thousand tons of WWS delivered by motor transport will be burnt at TPP-3. The electric power consumption will be $200\,000 \times 0.002 = 400$ MWh per year. Assuming that electric power is generated with a net efficiency factor equal to 30% owing to burning coal, additional coal consumption will be $400/0.3 \times 3.6 = 4\,800$ GJ. Emission factor for coal is taken equal to 91.62 kg of CO_2/GJ. Then, emissions will be $91.62 \times 4.8 = \underline{440}$ tons of CO_2/year.

3. Increase in methane emissions during coal mining

According to the IPCC data [R19], specific emissions of methane during underground coal mining may be assumed equal to 12.1 tons of CH_4 per 1 thousand tons of coal. According to the forecast, on the average for 2008-2012, the project will result in an increase of coal consumption by about 66 thousand GJ/year (2 250 tons of coal equivalent/year). This is equivalent to about 3 thousand tons of coal per year. Then, emissions will be $12.1 \times 3 \times 21 = \underline{762}$ т CO_2-eq./year.

4. Fuel combustion by motor transport during delivering of additional amounts of BWW

Additional supplies of BWW from outside are expected to be up to 100 thousand tons per year. At the same time, deliveries are possible from distances significantly exceeding the radius of 50 km. We assume that this amount of BWW will be delivered by motor transport from the distance of 250 km. In this way, one trip would correspond to 500 km of mileage. We assume that the most typical Russian truck tractor (MAZ) with a semi-trailer will carry 10 tons of cargo (about 20 packed cubic meters), spending about 40 l of diesel fuel per 100 km, taking into account the low quality of roads and costs of collection and loading of BWW (normal consumption: 28 l/100 km). The specified figures are well conservative. Then the total consumption of diesel fuel per year will be $100\,000/10 \times 500/100 \times 40 = 2\,000\,000$ l/year. According to WRI 2001d [20], the calorific value and emission factor for diesel fuel may be assumed equal to 0.0371 GJ/l and 74.01 kg of CO_2/GJ. Then, the annual emissions will be $2\,000 \times 0.0371 \times 74.01 = \underline{5\,492}$ tons of CO_2/year.

The resulting additional emissions from the considered sources under the project will be: $-7\,954+440+762+5\,492=-1\,260$ tons of CO_2-eq./year. Therefore, reduction of thermal power spent for fuel oil pre-heating will compensate with excess additional emissions resulting from the project. Besides, the values of estimated emissions are not high, compared to the main reductions achieved under the project. All this makes a sufficient justification for ignoring not main emissions, including leakages, both at the stage of forecasting and at the stage of monitoring.

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

Date of BL setting – 30 September 2006

BL was developed by Environmental Investment Center (Arkhangelsk, Russia) – the Consultant to the project participants hired for the PDD development. Neither the person nor the entity is a project participant listed in Annex 1.

Contact person: Alexander Samorodov

E-mail: samor@atnet.ru

SECTION C. Duration of the project / crediting period

C.1. Starting date of the project:

February 2000

C.2. Expected operational lifetime of the project:

25 years/300 months

C.3. Length of the crediting period:

5 years/ 60 months (Kyoto Protocol first commitment period – from 1st January 2008 to 31st December 2012)

SECTION D. Monitoring plan

D.1. Description of monitoring plan chosen:

Collection of all the key parameters required for greenhouse emissions to be determined, both under the project and for the baseline scenario, is performed according to the practice established at APPM on accounting of fuel, energy, waste, and assessment of environmental impacts. Monitoring under the project requires no changes to be introduced in the existing system of accounting and collection of information. All the necessary data are determined and registered in any case. Besides, it is essential to take into account that the staff of the APPM's environmental department has been independently performing inventory of greenhouse gas emissions on a yearly basis, since 2005. Fulfillment of the inventory and that of the monitoring under the project are closely related.

Annex 3 presents detailed data on methods of monitoring of fuel quantity and quality at the enterprise, the main sources of information.

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. $FC^{m}_{oil,3,PJ,y}$	Mass fuel oil consumption at TPP-3	TPP-3	t	m	Continuously	100 %	Electronic and paper	Readings of flow meters are checked for compliance with readings of level meters in the fuel oil storage tank
2. $FC^{m}_{oil,1mp,PJ,y}$	Mass fuel oil consumption in medium pressure boilers of TPP-1	TPP-1	t	m	Continuously	100 %	Electronic and paper	Readings of flow meters are checked for compliance with readings of level meters in the fuel oil storage tank
3. $NCV_{oil,y}$	Net calorific value of fuel oil	Chemistry laboratory of APPM	GJ/t	m	For each incoming batch of fuel oil	Random	Electronic and paper	The weighted average value is determined at the end of the year.

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

Total greenhouse gas emissions under the project over a year *y*, t CO_2:

$$PE_y = PE_{oil,3,y} + PE_{oil,1mp,y}, \tag{D.1-1}$$

where $PE_{oil,3,y}$ is CO_2 emission from burning fuel oil at TPP-3 under the project over a year *y*, t of CO_2;

$PE_{oil,1mp,y}$ is CO_2 emission from burning fuel oil in boilers of the medium pressure station of TPP-1 under the project over a year *y*, t of CO_2.

$$PE_{oil,3,y} = FC_{oil,3,PJ,y} \times EF_{CO2,oil} \times 10^{-3}, \tag{D.1-2}$$

$$PE_{oil,1mp,y} = FC_{oil,1mp,PJ,y} \times EF_{CO2,oil} \times 10^{-3}, \tag{D.1-3}$$

where $FC_{oil,3,PJ,y}$ is amount of fuel oil burnt at TPP-3 under the project over a year *y*, GJ;

$FC_{oil,1mp,PJ,y}$ is amount of fuel oil burnt in boilers of the medium pressure station of TPP-1 under the project over a year *y*, GJ;

$EF_{CO2,oil}$ is emission factor of CO_2 from burning fuel oil, kg CO_2/GJ. Based on results of inventory of GHG emissions at APPM [R5], for the entire period of the project, this factor is assumed to be equal to the constant value: $EF_{CO2,oil} = 77.13$ kg CO_2/GJ (with the fraction of carbon oxidized taken into account).

$$FC_{oil,3,PJ,y} = FC^{m}_{oil,3,PJ,y} \times NCV_{oil,y}, \tag{D.1-4}$$

$$FC_{oil,1mp,PJ,y} = FC^{m}_{oil,1mp,PJ,y} \times NCV_{oil.y}, \tag{D.1-5}$$

where $FC^{m}_{oil,3,PJ,y}$ is mass of fuel oil burnt at TPP-3 under the project over a year *y*, t;

$FC^{m}_{oil,1mp,PJ,y}$ is mass of fuel oil burnt in MP boilers of TPP-1 under the project over a year *y*, t;

$NCV_{oil,y}$ is weighted average net calorific value of fuel oil over a year *y*, GJ/t.

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. $FC^{m}_{BWW,3ub,PJ,y}$	Mass BWW consumption in utilizing boilers of TPP-3	TPP-3	t	m	Continuously	100 %	Electronic and paper	Data are determined by weighing and regularly cross-checked with balance method.
5. $FC^{m}_{BWW,1mp,PJ,y}$	Mass BWW consumption in medium pressure boilers of TPP-1	TPP-1	t	m	Continuously	100 %	Electronic and paper	Data are determined by weighing and regularly cross-checked with balance method.
6. $BWW^{m}_{dump,PJ,y}$	Mass BWW removal to the landfill	Environmental department of APPM	t	m	Continuously	100 %	Electronic and paper	Data are determined by weighing and regularly cross-checked with balance method.
7. $BWW^{m}_{side,PJ,y}$	Mass BWW delivery from the outside	Environmental department of APPM	t	m	Continuously	100 %	Electronic and paper	Data are determined by weighing and regularly cross-checked with balance method.
8. $WWS^{m}_{dump,PJ,y}$	Wet mass WWS removal to the landfill	Environmental department of APPM	t	m	Continuously	100 %	Electronic and paper	Data are determined by weighing.
9. $FC^{m}_{WWS,3ub,PJ,y}$	Wet mass WWS consumption in utilizing boilers of TPP-3	Environmental department of APPM	t	m	Continuously	100 %	Electronic and paper	Data are determined by weighing.
10. $W_{WWS,y}$	WWS humidity	Chemistry laboratory of APPM	%	m	Regularly	100 %	Electronic and paper	The weighted average value is determined at the end of the year.

11. $FC^{dm}_{liq,3rb,y}$	Dry mass black liquor consumption in recovery boilers of TPP-3	TPP-3	t (a.d.m.)	m, c	Continuously	100 %	Electronic and paper	Regular humidity monitoring is performed, with wet mass converted into absolutely dry mass.
12. $FC^{m}_{oil,3rb,PJ,y}$	Mass fuel oil consumption in recovery boilers of TPP-3	TPP-3	t	m	Continuously	100 %	Electronic and paper	Readings of flow meters
13. $NCV_{BWW,3ub,y}$	Net calorific value of BWW combusted in utilizing boilers of TPP-3	Chemistry laboratory of APPM	GJ/t	m	Regularly	Random	Electronic and paper	The weighted average value is determined at the end of the year.
14. $NCV_{liq,3rb,y}$	Net calorific value of black liquor combusted in recovery boilers of TPP-3	Chemistry laboratory of APPM	GJ/t	m	Regularly	Random	Electronic and paper	The weighted average value is determined at the end of the year.
15. $HG_{3,PJ,y}$	Total gross steam generation at TPP-3	TPP-3	GJ	m	Continuously	100 %	Electronic and paper	Readings of steam-flow meters
16. $HS_{3,PJ,y}$	Total useful supply of heat from TPP-3	TPP-3	GJ	m	Continuously	100 %	Electronic and paper	Readings of steam-flow meters
17. $HS_{3backpress,PJ,y}$	Useful supply of heat from TPP-3 with backpressure steam	TPP-3	GJ	m	Continuously	100 %	Electronic and paper	Readings of steam-flow meters
18. $HG_{3rb,PJ,y}$	Gross steam generation in recovery boilers of TPP-3	TPP-3	GJ	m	Continuously	100 %	Electronic and paper	Readings of steam-flow meters
19. $HG_{1mp,PJ,y}$	Gross steam generation in medium pressure boilers of TPP-1	TPP-1	GJ	m	Continuously	100 %	Electronic and paper	Readings of steam-flow meters

20. $EF_{CO2,coal,y}$	Emission factor of CO_2 for coal	Environmental department of APPM	kg CO_2/GJ	c	Yearly	100%	Electronic and paper	Determined with taking into account types of burnt coals in a yearly inventory of GHG emissions at APPM

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

Total greenhouse gas emissions under the baseline scenario over a year *y*, t of CO_2-eq:

$$BE_y = BE_{ff,y} + \Delta BE_{dump,y}, \tag{D.1-6}$$

where $BE_{ff,y}$ is CO_2 emissions from burning fossil fuel under the baseline scenario over a year *y*, t CO_2;

$\Delta BE_{dump,y}$ is additional CH_4 emissions from the landfill over a year *y*, compared to the project scenario, t of CO_2-eq;

$$BE_{ff,y} = BE_{oil,3,y} + BE_{oil,1mp,y} + \Delta BE_{coal,y}, \tag{D.1-7}$$

where $BE_{oil,3,y}$ is CO_2 emissions from burning fuel oil at TPP-3 under the baseline scenario over a year *y*, t of CO_2;

$BE_{oil,1mp,y}$ is CO_2 emissions from burning fuel oil in boilers of the MP station of TPP-1 under the baseline scenario over a year *y*, t of CO_2;

$\Delta BE_{coal,y}$ is change in CO_2 emissions from burning coal in boilers of the HP station of TPP-1 over a year *y*, compared to the project scenario, t CO_2;

$$BE_{oil,3,y} = FC_{oil,3,BL,y} \times EF_{CO2,oil} \times 10^{-3}, \tag{D.1-8}$$

$$BE_{oil,1mp,y} = FC_{oil,1mp,BL,y} \times EF_{CO2,oil} \times 10^{-3}, \tag{D.1-9}$$

$$\Delta BE_{coal,y} = \Delta FC_{coal,y} \times EF_{CO2,coal,y} \times 10^{-3}, \tag{D.1-10}$$

where $FC_{oil,3,BL,y}$ is amount of fuel oil burnt at TPP-3 under the baseline scenario over a year *y*, GJ;

$FC_{oil,1mp,BL,y}$ is amount of fuel oil burnt in MP boilers of TPP-1 under the baseline scenario over a year *y*, GJ;

$\Delta FC_{coal,y}$ is change in amount of coal burnt at TPP-1 over a year *y*, compared to the project scenario, GJ;

$EF_{CO2,oil}$ is emission factor of CO_2 from burning fuel oil, kg CO_2/GJ. $EF_{CO2,oil} = 77.13$ kg CO_2/GJ;

$EF_{CO2,coal,y}$ is average emission factor of CO_2 from burning coal over a year *y*, kg CO_2/GJ (with the fraction of carbon oxidized taken into account). To be taken based on results of inventory of GHG emissions at APPM for the relevant year *y*. The method of determination of the factor is laid out in details in [R11] and is put into the Software-computing complex for inventory and monitoring of greenhouse gas emissions at JSC Arkhangelsk PPM [R12]. With no available inventory data, the average value for 2003-2005 equal to 91.62 kg CO_2/GJ is taken.

$$FC_{oil,3,BL,y} = FC_{oil,3ub,BL,y} + FC_{oil,3rb,BL,y}, \qquad (D.1\text{-}11)$$

where $FC_{oil,3ub,BL,y}$ is amount of fuel oil burnt in utilizing boilers of TPP-3 under the baseline scenario over a year *y*, GJ;

$FC_{oil,3rb,BL,y}$ is amount of fuel oil burnt in recovery boilers of TPP-3 under the baseline scenario over a year *y*, GJ.

$$FC_{oil,3ub,BL,y} = FC_{3ub,BL,y} - FC_{BWW,3ub,BL,y}, \qquad (D.1\text{-}12)$$

$$FC_{oil,3rb,BL,y} = FC_{3rb,BL,y} - FC_{liq,3rb,y}, \qquad (D.1\text{-}13)$$

where $FC_{3ub,BL,y}$ is total amount of fuel burnt in the utilizing boilers of TPP-3 under the baseline scenario over a year *y*, GJ;

$FC_{BWW,3ub,BL,y}$ is amount of BWW burnt in the utilizing boilers of TPP-3 under the baseline scenario over a year *y*, GJ;

$FC_{3rb,BL,y}$ is total amount of fuel burnt in recovery boilers of TPP-3 under the baseline scenario over a year *y*, GJ;

$FC_{liq,3rb,y}$ is actual amount of black liquor burnt at TPP-3 over a year *y*, GJ;

$$FC_{3ub,BL,y} = \frac{100 \times FC_{BWW,3ub,BL,y}}{100 - \beta_{oil,3ub,BL}}, \qquad (D.1\text{-}14)$$

where $\beta_{oil,3ub,BL}$ is share of fuel oil in total consumption of equivalent fuel in the utilizing boilers of TPP-3 under the baseline scenario, %. According to Section B.1, it is taken equal to $\beta_{oil,3ub,BL} = 34\%$.

$$FC_{BWW,3ub,BL,y} = FC^{m}_{BWW,3ub,BL,y} \times NCV_{BWW,3ub,y}\,, \qquad \text{(D.1-15)}$$

where $FC^{m}_{BWW,3ub,BL,y}$ is mass of BWW burnt in the utilizing boilers of TPP-3 under the baseline scenario over a year *y*, t. According to Section B.1, it is taken equal to 230 000 t per year;

$NCV_{BWW,3ub,y}$ is actual average weighted net calorific value of BWW at TPP-3 over a year *y*, GJ/t.

$$FC_{3rb,BL,y} = \frac{100 \times HG_{3rb,BL,y}}{\eta_{3rb,y}}\,, \qquad \text{(D.1-16)}$$

where $HG_{3rb,BL,y}$ is gross steam generation in the recovery boilers of TPP-3 under the baseline scenario over a year *y*, GJ;

$\eta_{3rb,y}$ is actual average weighted efficiency factor of recovery boilers of TPP-3 over a year *y*, %.

$$HG_{3rb,BL,y} = HG_{3,BL,y} - HG_{3ub,BL,y}\,, \qquad \text{(D.1-17)}$$

where $HG_{3,BL,y}$ is total gross steam generation at TPP-3 under the baseline scenario over a year *y*, GJ;

$HG_{3ub,BL,y}$ is gross steam generation in the utilizing boilers of TPP-3 under the baseline scenario over a year *y*, GJ.

$$HG_{3,BL,y} = HG_{3,PJ,y} - 100 \times HS_{3bypass,PJ,y} \Big/ \left(100 - \varepsilon_{3bypass}\right), \qquad \text{(D.1-18)}$$

where $HG_{3,PJ,y}$ is total actual (under the project) gross steam generation at TPP-3 over a year *y*, GJ;

$HS_{3bypass,PJ,y}$ is actual (under the project) useful steam supply from TPP-3 by-passing the turbines, via the PRC, over a year *y*, GJ;

$\varepsilon_{3bypass}$ is relative heat losses and consumption on the plant's auxiliary needs related to the steam flow passing through the PRC, %. According to Section B.1, it is taken equal to $\varepsilon_{3bypass} = 5\%$.

$$HS_{3bypass,PJ,y} = HS_{3,PJ,y} - HS_{3backpress,PJ,y}, \quad \text{(D.1-19)}$$

where $HS_{3,PJ,y}$ is actual (under the project) total useful heat supply from TPP-3 over a year *y*, GJ;

$HS_{3backpress,PJ,y}$ is actual (under the project) useful heat supply from TPP-3 with the steam spent in the turbines over a year *y*, GJ.

$$HG_{3ub,BL,y} = FC_{3ub,BL,y} \times \eta_{3ub,BL,y} / 100, \quad \text{(D.1-20)}$$

where $\eta_{3ub,BL,y}$ is average efficiency factor of utilizing boilers under the baseline scenario, %. According to Section B.1, it is taken equal to $\eta_{3ub,BL,y} = 46\%$.

$$\eta_{3rb,y} = HG_{3rb,PJ,y} / FC_{3rb,PJ,y} \times 100, \quad \text{(D.1-21)}$$

where $HG_{3rb,PJ,y}$ is actual (under the project) gross steam generation in the recovery boilers of TPP-3 over a year *y*, GJ;

$FC_{3rb,PJ,y}$ is actual (under the project) total fuel consumption in the recovery boilers over a year *y*, GJ.

$$FC_{3rb,PJ,y} = FC_{oil,3rb,PJ,y} + FC_{liq,3rb,y}, \quad \text{(D.1-22)}$$

where $FC_{oil,3rb,PJ,y}$ is actual (under the project) consumption of fuel oil in the recovery boilers over a year *y*, GJ.

$$FC_{oil,3rb,PJ,y} = FC^{m}{}_{oil,3rb,PJ,y} \times NCV_{oil,y}\,, \qquad (D.1\text{-}23)$$

where $FC^{m}{}_{oil,3rb,PJ,y}$ is actual (under the project) mass consumption of fuel oil in the recovery boilers over a year *y*, t.

$$FC_{liq,3rb,y} = FC^{dm}_{liq,3rb,y} \times NCV_{liq,3rb,y}\,, \qquad (D.1\text{-}24)$$

where $FC^{dm}_{liq,3rb,y}$ is actual amount of absolutely dry black liquor burnt in the recovery boilers of TPP-3 over a year *y*, t (a.d.m.);

$NCV_{liq,3rb,y}$ is actual average weighted net calorific value of black liquor at TPP-3 over a year *y*, GJ/t (a.d.m.).

$$FC_{oil,1mp,BL,y} = FC_{oil,1mp,PJ,y} \times FC^{m}{}_{BWW,1mp,BL,y} \big/ FC^{m}{}_{BWW,1mp,PJ,y}\,, \qquad (D.1\text{-}25)$$

where $FC^{m}_{BWW,1mp,BL,y}$ is mass of BWW burnt in the MP boiler room of TPP-1 under the baseline scenario over a year *y*, t;

$FC^{m}_{BWW,1mp,PJ,y}$ is actual (under the project) mass of BWW burnt in the MP boiler room of TPP-1 over a year *y*, t.

$$\begin{aligned} FC^{m}_{BWW,1mp,BL,y} &= FC^{m}_{BWW,1mp,PJ,y} + \left(FC^{m}_{BWW,3ub,PJ,y} - FC^{m}_{BWW,3ub,BL,y}\right) + \\ &+ \left(BWW^{m}_{dump,PJ,y} - BWW^{m}_{dump,BL,y}\right) - \left(BWW^{m}_{side,PJ,y} - BWW^{m}_{side,BL,y}\right) \end{aligned}\,, \qquad (D.1\text{-}26)$$

where $FC^{m}_{BWW,3ub,PJ,y}$ is actual (under the project) mass of BWW burnt in the utilizing boilers at TPP-3 over a year *y*, t;

$BWW^{m}_{dump,PJ,y}$ is actual (under the project) mass of BWW dumped to the landfill over a year *y*, t;

$BWW^{m}_{dump,BL,y}$ is mass of BWW dumped to the landfill under the baseline scenario over a year *y*, t;

$BWW^{m}_{side,PJ,y}$ is actual (under the project) mass of BWW delivered from outside over a year *y*, t;

$BWW^{m}_{side,BL,y}$ is mass of BWW delivered from outside under the baseline scenario over a year *y*, t. According to Section B.1, it is assumed equal to $BWW^{m}_{side,BL,y} = 120\,000$ t per year, but $BWW^{m}_{side,BL,y} \le BWW^{m}_{side,PJ,y}$.

$$BWW^{m}_{dump,BL,y} = BWW^{m}_{dump,PJ,y} \times WWS^{dm}_{dump,BL,y} \Big/ WWS^{dm}_{dump,PJ,y}, \qquad \text{(D.1-27)}$$

where $WWS^{dm}_{dump,BL,y}$ is amount of absolutely dry WWS dumped to the landfill under the baseline scenario over a year *y*, t (a.d.m.);

$WWS^{dm}_{dump,PJ,y}$ is actual (under the project) amount of absolutely dry WWS dumped to the landfill over a year *y*, t (a.d.m.).

$$WWS^{dm}_{dump,BL,y} = WWS^{dm}_{dump,PJ,y} + FC^{dm}_{WWS,3ub,PJ,y}, \qquad \text{(D.1-28)}$$

where $FC^{dm}_{WWS,3ub,PJ,y}$ is actual (under the project) amount of absolutely dry WWS burnt in the utilizing boilers of TPP-3 over a year *y*, t (a.d.m.).

$$WWS^{dm}_{dump,PJ,y} = WWS^{m}_{dump,PJ,y} \times \left(100 - W_{WWS,y}\right) / 100, \qquad \text{(D.1-29)}$$

$$FC^{dm}_{WWS,3ub,PJ,y} = FC^{m}_{WWS,3ub,PJ,y} \times \left(100 - W_{WWS,y}\right) / 100. \qquad \text{(D.1-30)}$$

where $WWS^{m}_{dump,PJ,y}$ is actual (under the project) mass of wet WWS dumped to the landfill over a year *y*, t;

$FC^{m}_{WWS,3ub,PJ,y}$ is actual (under the project) mass of wet WWS burnt in the utilizing boilers of TPP-3 over a year *y*, t;

$W_{WWS,y}$ is average weighted humidity of formed WWS over a year *y*, %.

$$\Delta FC_{coal,y} = \frac{100 \times \Delta HG_{1hp,y}}{\eta_{coal}}, \qquad \text{(D.1-31)}$$

where $\Delta HG_{1hp,y}$ is change in steam generation by HP boilers of TPP-1 over a year *y*, compared to the project scenario, GJ;

η_{coal} is average gross coal boiler efficiency factor, %. According to Section B.1, it is taken equal to η_{coal}= 90%.

$$\Delta HG_{1hp,y} = \Delta HG'_{1hp,y} \frac{100}{100-\varepsilon_{aux}}, \tag{D.1-32}$$

where $\Delta HG'_{1hp,y}$ is change in live steam delivery to the HP turbines of TPP-1, compared to the project scenario over a year *y*, GJ;

ε_{aux} is relative heat losses and consumption for the auxiliary needs related to additional generation of steam in HP boilers of TPP-1. According to Section B.1, it is taken equal to ε_{aux}= 5%.

$$\Delta HG'_{1hp,y} = 0.665\,\Delta HS_{1hp,y}, \tag{D.1-33}$$

where $\Delta HS_{1hp,y}$ is change in steam supply from the HP station of TPP-1, compared to the project scenario over a year *y*, GJ.

$$\Delta HS_{1hp,y} = \Delta HS_{1,y} - \Delta HS_{1mp,y}, \tag{D.1-34}$$

where $\Delta HS_{1,y}$ is additional annual steam supply for cellulose production from TPP-1, with losses in steam network taken into account, compared to the project scenario over a year *y*, GJ;

$\Delta HS_{1mp,y}$ is change in steam supply from the MP station of TPP-1, compared to the project scenario, GJ.

$$\Delta HS_{1,y} = \Delta HS_{3,y} \frac{100}{100-\varepsilon_{nw}}, \tag{D.1-35}$$

where $\Delta HS_{3,y}$ is useful steam supply via PRC at TPP-3 under the project scenario over a year *y*, GJ;

ε_{nw} relative heat losses in steam network (from TPP-1 to cellulose production), %. According to Section B.1, it is taken equal to ε_{nw}= 3%.

$$\Delta HS_{3,y} = HS_{3bypass,PJ,y} \,. \tag{D.1-36}$$

$$\Delta HS_{1mp,y} = HS_{1mp,BL,y} - HS_{1mp,PJ,y} \,, \tag{D.1-37}$$

where $HS_{1mp,BL,y}$ is useful supply of thermal power from the MP station of TPP-1 under the baseline scenario over a year *y*, GJ;

$HS_{1mp,PJ,y}$ is useful supply of thermal power from the MP station of TPP-1 under the project over a year *y*, GJ.

$$HS_{1mp,BL,y} = HS_{1mp,PJ,y} \times FC^{m}_{BWW,1mp,BL,y} \Big/ FC^{m}_{BWW,1mp,PJ,y} \,, \tag{D.1-38}$$

$$HS_{1mp,PJ,y} = HG_{1mp,PJ,y} \times (100 - \alpha)/100 \,, \tag{D.1-39}$$

where $HG_{1mp,PJ,y}$ is actual (under the project) gross steam generation in boilers of the MP station of TPP-1 over a year *y*, GJ;

α is relative consumption of heat of live steam for the auxiliary needs and electric power generation at the MP station of TPP-1, %. According to Section B.1, it is taken equal to $\alpha = 10\%$.

$$\Delta BE_{dump,y} = \Delta BE_{BWW,dump,y} + \Delta BE_{WWS,dump,y} \,, \tag{D.1-40}$$

where $\Delta BE_{BWW,dump,y}$ is additional emissions of CH_4 from the landfill because of BWW decomposition over a year *y*, compared to the project scenario, t CO_2-eq;

$\Delta BE_{WWS,dump,y}$ is additional emissions of CH_4 from the landfill because of WWS decomposition over a year *y*, compared to the project scenario, t CO_2-eq.

Numerical values of $\Delta BE_{BWW,dump,y}$ and $\Delta BE_{WWS,dump,y}$ are determined by the “Calculation of CO_2-equivalent emission reduction from BWW prevented from stockpiling or taken from stockpiles” model developed by BTG biomass technology group B.V. on the basis of [R22] (See Annexes 2.1, 2.4 and Section E.).

In this model variable parameters for year y are:

$\Delta BWW^{m}_{dump,y} = BWW^{m}_{dump,BL,y} - BWW^{m}_{dump,PJ,y}$ is additional amount of dumped BWW over a year y under the baseline scenario, compared to the project scenario, t;

$\Delta WWS^{dm}_{dump,y} = WWS^{dm}_{dump,BL,y} - WWS^{dm}_{dump,PJ,y}$ is additional amount of dumped WWS over a year y under the baseline scenario, compared to the project scenario, t (a.d.m.).

Here, data for additional amounts of BWW and WWS since 2004 (when the new landfill was opened) are used for calculation of methane emissions. The values of constants used in the model are explained and justified in Section E.

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 applied to monitoring the 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:

As shown in Section B.3 all of the leakages can be neglected

D.1.3.1. If applicable, please describe the data and information that will be collected in order to monitor leakage effects of the project:

ID number *(Please use numbers to ease cross-referencing to D.2.)*	Data variable	Source of data	Data unit	Measured (m), calculated (c), estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment

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

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

The formula to calculate emission reduction in the year *y* (ER_y) is, t CO_2:

$$ER_y = BE_y - PE_y \quad \text{(D.1-41)}$$

or

$$ER_y = ER_{CO2,y} + ER_{CH4,y}, \quad \text{(D.1-42)}$$

where BE_y is baseline emissions in the year *y*, t CO_2-eq;

PE_y is project emissions in the year *y*, t CO_2-eq;

$ER_{CO2,y}$ is emission reduction of carbon dioxide in the year *y*, t CO_2;

$ER_{CH4,y}$ is emission reduction of methane in the year *y*, t CO_2-eq;

The formula to calculate emission reduction of carbon dioxide in the year *y* ($ER_{CO2,y}$) is, t CO_2:

$$ER_{CO2,y} = ER_{CO2,oil,3,y} + ER_{CO2,oil,1mp,y} + ER_{CO2,coal,1hp,y}; \quad \text{(D.1-43)}$$

where $ER_{CO2,oil,3,y}$ is emission reduction of carbon dioxide because of fuel oil consumption at TPP-3 in the year *y*, t CO_2;

$ER_{CO2,oil,1mp,y}$ is emission reduction of carbon dioxide because of fuel oil consumption at the boiler-house of medium pressure TPP-1 in the year *y*, t CO_2;

$ER_{CO2,coal,1hp,y}$ is emission reduction of carbon dioxide because of coal consumption at the boiler-house of high pressure TPP-1 in the year y, t CO_2.

$$ER_{CO2,oil,3,y} = BE_{oil,3,y} - PE_{oil,3,y}, \tag{D.1-44}$$

$$ER_{CO2,oil,1mp,y} = BE_{oil,1mp,y} - PE_{oil,1mp,y}, \tag{D.1-45}$$

$$ER_{CO2,coal,hp1,y} = \Delta BE_{coal,y}. \tag{D.1-46}$$

The formula to calculate emission reduction of methane in the year y ($ER_{CH4,y}$) is, t CO_2-eq:

$$ER_{CH4,y} = ER_{CH4,BWW,y} + ER_{CH4,WWS,y}, \tag{D.1-47}$$

where $ER_{CH4,BWW,y}$ is reduction of methane emissions from the landfill over a year y because of BWW decomposition, t CO_2-eq;

$ER_{CH4,WWS,y}$ is reduction of methane emissions from the landfill over a year y because of WWS decomposition, t CO_2-eq.

$$ER_{CH4,BWW,y} = \Delta BE_{BWW,dump,y}, \tag{D.1-48}$$

$$ER_{CH4,WWS,y} = \Delta BE_{WWS,dump,y}. \tag{D.1-49}$$

No new measurements or data are needed than those indicated in D1.1.1 and D 1.1.3

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:

A special environmental department is operating at the enterprise. The department’s activities are guided by the acting legislation, orders and instructions of the Director General, prescriptions of the State environmental monitoring service of the Committee on natural resources of the Arkhangelsk Region. The department has at its disposal highly qualified personnel, requires no additional technological equipment and is able to ensure appropriate environmental monitoring under the project.

The department monitors:

- gas-dust emissions;

- quality of waste water and river water;
- utilization, storage, transfer and burial of industrial waste.

In process of the project implementation, analytical control over various effects on the environment will, as it is today, be exercised in compliance with the existing regulation. In particular, control over emissions of harmful substances into the atmosphere is performed according to the "Schedule of laboratory control of standard MPE at stationary emission sources of JSC Arkhangelsk PPM".

The data obtained by the analytical laboratory are processed and brought together in monthly and annual reports, which specify all the required itemized data, including those for the sections affected by the Project.

Besides, the enterprise files reports by the following official annual statistical forms:

- 2-tp (air) *Data on protection of atmospheric air*, which contains information on amounts of trapped and neutralized atmospheric pollutants, itemized emissions of specific pollutants, number of emission sources, measures on reduction of emissions into the atmosphere, emissions from particular groups of pollution sources;
- 2-tp (water resources) *Data on water use*, which presents information on consumption of water from natural sources, discharge of waste water, and content of pollutants in it, capacity of treatment facilities, etc.;
- 2-tp (waste) *Data on formation, use, neutralization, transportation and placement of industrial and household waste*, which presents the annual balance of waste flow, by waste types and hazard classes.

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.
1, 2, 12	Low	Fuel oil flow meters are regularly calibrated. Besides, readings of flow meters are checked for conformity with readings of level meters of the fuel oil storage tanks.
4, 5	Low	To be determined by weighing, through the volume and balance methods. The total enterprise BWW balance is regularly cross-checked.
6, 7	Low	To be determined mostly by weighing motor transport before and after unloading. The total enterprise BWW balance is regularly cross-checked.
8, 9	Low	Data are determined on the amount of trucks for the transportation of WWS. Mass of WWS which can be loaded into each truck is known and is checked periodically through weighing.
3, 10, 13, 14,	Low	The laboratory equipment is regularly calibrated.

11	Low	The total balance of liquor formation is regularly cross-checked with readings of flow meters. Liquor humidity is monitored daily. The instruments are regularly calibrated.
15, 16, 17, 18, 19	Low	The instruments for measuring heat output and supply are regularly calibrated. Readings of the instruments are cross-checked with the balance data.
20	Low	Calculated value determined as the average weighted by reference data on carbon content in coals from different deposits actually burnt over a year *y*.

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

Collection of information required for calculations of reductions of GHG emissions as a result of the project is performed in accordance with the procedure common for the enterprise, as monitoring requires no additional information to be obtained, apart from the data already being collected and processed.

Initial data will be submitted by the environmental department, by the energy service, and by the wood-processing facilities of APPM.
Calculations of reduction of emissions will be prepared by specialists of Environmental Investment Center, Arkhangelsk.

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

Monitoring plan was developed by Environmental Investment Center (Arkhangelsk, Russia) – the Consultant for the project participants hired for the PDD development. Neither the person nor the entity is a project participant listed in Annex 1.

Contact person: Alexander Samorodov

E-mail: samor@atnet.ru

SECTION E. Estimation of greenhouse gas emission reductions

E.1. Estimated project emissions:

GHG emissions on the project (see Table E.1-1) include the emissions of:

- CO_2 from burning fuel oil at the TPP-3;
- CO_2 from burning fuel oil at the MP boiler room of the TPP-1.

CH_4 and N_2O emissions during fuel combustion are negligibly small.

CO_2 emissions were estimated as a product of fuel consumption (in GJ) and the emission factor for its combustion.

The data on fuel consumption (in GJ) for the period till 2012 for the sources mentioned are given in the Tables B.1-6 and B.1-7.

According to the results of the research performed during the inventory of APPM GHG emissions [R5], the CO_2 emission factor for fuel oil combustion was taken equal to the constant value of $EF_{CO2,oil} = \underline{77.13}$ kg CO_2/GJ (with the consideration of the fraction of carbon oxidized) for the whole period of the project lifetime. The factor was defined with the use of reference data on the average carbon content in different fuel oil types combusted at the mill. The details are given in [R11]. The factor value is integrated into the Software-computing system for the inventory of GHG emissions at the JSC Arkhangelsk PPM [R12].

E.2. Estimated leakage:

As indicated in Section B.3 the leakages may be neglected and, therefore, were taken equal zero.

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

Since leakages can be neglected: E.1 + E.2 = E.1.

E.4. Estimated baseline emissions:

The GHG baseline emissions (see Table E.1-2) include the emissions of:

- CO_2 from burning fuel oil at the TPP-3;
- CO_2 from burning fuel oil at the MP boiler room of the TPP-1.
- Changes in CO_2 from burning coal at the HP boilers of the TPP-1 compared to the project;
- Avoided (owing to the project) CH_4 emissions from the landfill because of BWW decomposition;
- Avoided (owing to the project) CH_4 emissions from the landfill because of WWS decomposition.

CH_4 and N_2O emissions during fuel combustion are negligibly low.

CO_2 emissions have been estimated as a product of fuel consumption (in GJ) and the emission factor for its combustion.

The data on fuel consumption in GJ for the period till 2012 for the sources indicated are given in the Tables B.1-12, B.1-13 and B.1-14.

For the whole period of the project lifetime the CO_2 emission factor for fuel oil combustion was taken equal to the constant level of $EF_{CO2,oil} = \underline{77.13}$ kg CO_2/GJ (see details above).

The CO_2 emission factor for the estimation of coal combustion emissions for the period of 2000-2005 (kg CO_2/GJ) (with the consideration of fraction of carbon oxidized) was taken according to the actual results of GHG emission inventory at APPM for the corresponding years [R5, 10, 13, 15] (see Table E.1-2). The emission estimations for the years 2006-2012 have been conducted based on the average value for 2003-2005 equal 91.62 kg CO_2/GJ.

The methodology of coal emission factor evaluation was described in [R11] in detail and input into the Software-computer system for the inventory of GHG emissions at the OJSC “Arkhangelsk PPM” [R12]. The methodology is based on the calculation of the weighted average carbon content per unit of net heat value according to the reference data for the coals of specific deposits combusted during the year *y*. It’s worth noting that the precision of the coal emission factor is not greatly important as the input of these emissions in the baseline total emissions is relatively small.

Numeral evaluations of the prevented landfill methane emissions resulting from BWW and WWS anaerobic decay were conducted under the model of *“Calculation of CO_2-equivalent emission reduction from BWW prevented from stockpiling or taken from stockpiles”* developed by the *“BTG biomass technology group B.V.”* for the World Bank [R22]. The model was based on the *First Order Decay method* with experimental specification of a number of parameters for waste wood landfills. Thereat, [R22] specifies that their model may be used for other types of biomass, should corresponding determinative figures be input. Special chemical analyses have been carried out for BWW and WWS formed at APPM (see Annex 2.5). Results of analyses have shown applicability of the proposed method to WWS also.

The developers provided a specific estimation file in Excel format for evaluation purposes. BWW and WWS were estimated separately (see printouts in Annex 2.4.). Emission reductions were considered only for the new landfill opened in 2004. The input values for estimating reductions in methane emissions allowed for changing under this model are as follows:

1. *Methane concentration biogas*. Default value: 60%. Due to the conservative approach the value for BWW and WWS was accepted equal 50%.
2. *Half-life biomass.* The accepted default recommended value for BWW and WWS: 15 years.
3. *Generation factor*. The accepted default recommended value for BWW and WWS: 0.77.
4. *Methane oxidation factor.* The accepted default recommended value for BWW and WWS: 0.10.
5. *Percentage of the stockpile under aerobic conditions.* Default value: 10%. Taking into consideration that the new landfill has been opened quite recently, a more conservative value of 20% was accepted for BWW and WWS.
6. *Organic carbon content (dry basis).* The default value proposed for BWW is 53.6%; we accepted a more conservative value of 50%. Based on a number of analyses conducted formerly, the same value for WWS fluctuates between 34-55%; the value accepted was smaller: 34%.
7. *Moisture content.* The default value proposed for BWW is 50%; we accepted a more conservative value of 55%. Moisture for WWS is 0% as its quantity is input recalculated into absolutely dry matter.
8. *Lignin fraction of C.* The accepted default recommended value for BWW and: 0.25. At the whole it seems quite conservative because according to chemical analysis (Annex 2.5) lignin content of WWS actually is equal zero.
9. *Year in which fresh biomass is utilized instead of stockpiled:* The year of the new landfill opening was accepted (2004), although the reduction of methane emissions started in 2005 when

WWS became combusted. The amount of the BWW required for the cushion fill and taken to the landfill became reduced proportionally to the reduction of the WWS taken to the landfill.

10. *Year for which to calculate the CO_2-equivalent reduction.* The year of the new landfill opening was accepted (2004).
11. *Amount of fresh biomass utilized.* Annual data on the reduced amounts of BWW (tons per year) and WWS (tons of a.d.m. per year) taken to the landfill resulting from the project for the period till 2012 were input.

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

See Table E.1-3.

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

Year	Estimated project emissions (tonnes of CO_2 equivalent)	Estimated leakage (tonnes of CO_2 equivalent)	Estimated baseline emissions (tonnes of CO_2 equivalent)	Estimated emission reductions (tonnes of CO_2 equivalent)
2008	52 681	0	248 627	195 945
2009	53 041	0	253 189	200 148
2010	53 401	0	257 534	204 133
2011	61 541	0	270 059	208 519
2012	65 419	0	278 126	212 707
Total (tonnes of CO_2 equivalent)	286 083	0	1 307 535	1 021 452

Table E.1-1. Greenhouse gas emissions under the project scenario

Name	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	On the average for 2008-2012
TOTAL	**t of CO$_2$-eq.**	**268 501**	**219 736**	**151 737**	**167 659**	**170 738**	**133 939**	**58 421**	**42 949**	**52 681**	**53 041**	**53 401**	**61 541**	**65 419**	**57 217**
CO$_2$ from burning fossil fuel	**t of CO$_2$**	**268 501**	**219 736**	**151 737**	**167 659**	**170 738**	**133 939**	**58 421**	**42 949**	**52 681**	**53 041**	**53 401**	**61 541**	**65 419**	**57 217**
CO2 from burning fuel oil at TPP-3	t of CO$_2$	199 659	156 909	93 479	103 211	127 270	93 156	31 455	31 488	31 488	31 488	31 488	31 488	31 488	31 488
CO2 from burning fuel oil at the MP boiler room of TPP-1	t of CO$_2$	68 842	62 827	58 258	64 447	43 468	40 783	26 966	11 461	21 193	21 553	21 912	30 052	33 931	25 728

🟩 - *actual data* ⬜ - *forecast, estimate*

Table E.1-2. Greenhouse gas emissions under the baseline scenario

Name	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	On the average for 2008-2012
TOTAL	**t of CO$_2$-eq.**	**265 899**	**298 604**	**264 247**	**292 461**	**244 201**	**222 656**	**223 336**	**227 107**	**248 627**	**253 189**	**257 534**	**270 059**	**278 126**	**261 507**
CO$_2$ from burning fossil fuel	**t of CO$_2$**	**265 899**	**298 604**	**264 247**	**292 461**	**244 201**	**221 433**	**217 268**	**215 763**	**232 245**	**231 996**	**231 748**	**239 888**	**243 766**	**235 928**
CO2 from burning fuel oil at TPP-3	t of CO$_2$	197 057	235 777	205 989	228 014	214 188	188 199	208 387	206 073	203 758	201 444	199 130	199 130	199 130	200 518
CO2 from burning fuel oil at the MP boiler room of TPP-1	t of CO$_2$	68 842	62 827	58 258	64 447	61 404	49 112	58 986	36 561	36 921	37 280	37 640	45 780	49 658	41 456
CO2 from add. burning of coal at the HP boiler room of TPP-1	t of CO$_2$	0	0	0	0	-31 391	-15 877	-50 105	-26 871	-8 434	-6 728	-5 022	-5 022	-5 022	-6 046
Additional emissions of CH$_4$ from the landfill	**t of CO$_2$-eq.**	**0**	**0**	**0**	**0**	**0**	**1 223**	**6 068**	**11 344**	**16 382**	**21 193**	**25 786**	**30 172**	**34 360**	**25 579**
from additional dumping of BWW	t of CO$_2$-eq.	0	0	0	0	0	756	3 753	7 016	10 133	13 108	15 949	18 662	21 252	15 821
from additional dumping of WWS	t of CO$_2$-eq.	0	0	0	0	0	467	2 315	4 328	6 250	8 085	9 837	11 510	13 108	9 758

🟩 - *actual data* ⬜ - *forecast, estimate*

CO2 emission factor for coal	kg of CO$_2$/GJ	91,40	91,27	91,30	91,49	91,60	91,78	91,62	91,62	91,62	91,62	91,62	91,62	91,62

Таблица E.1-3. Reduction of greenhouse gas emissions as result of the project

Name	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	On the average for 2008-2012
TOTAL	**t of CO_2-eq.**	**-2 602**	**78 868**	**112 510**	**124 802**	**73 464**	**88 717**	**164 915**	**184 157**	**195 945**	**200 148**	**204 133**	**208 519**	**212 707**	**204 290**
CO_2 from burning fossil fuel	**t of CO_2**	**-2 602**	**78 868**	**112 510**	**124 802**	**73 464**	**87 495**	**158 847**	**172 813**	**179 563**	**178 955**	**178 347**	**178 347**	**178 347**	**178 712**
CO2 from burning fuel oil at TPP-3	t of CO_2	-2 602	78 868	112 510	124 802	86 919	95 043	176 932	174 584	172 270	169 956	167 641	167 641	167 641	169 030
CO2 from burning fuel oil at the MP boiler room of TPP-1	t of CO_2	0	0	0	0	17 936	8 329	32 020	25 100	15 728	15 728	15 728	15 728	15 728	15 728
CO2 from burning coal at the HP boiler room of TPP-1	t of CO_2	0	0	0	0	-31 391	-15 877	-50 105	-26 871	-8 434	-6 728	-5 022	-5 022	-5 022	-6 046
CH_4 from the landfill	**t of CO_2-eq.**	**0**	**0**	**0**	**0**	**0**	**1 223**	**6 068**	**11 344**	**16 382**	**21 193**	**25 786**	**30 172**	**34 360**	**25 579**
from BWW	t of CO_2-eq.	0	0	0	0	0	756	3 753	7 016	10 133	13 108	15 949	18 662	21 252	15 821
from WWS	t of CO_2-eq.	0	0	0	0	0	467	2 315	4 328	6 250	8 085	9 837	11 510	13 108	9 758

Total amount of reductions over 2008-2012: **1 021 452**

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 Order of the State Committee of the Russian Federation for Environmental Protection as of 15.04.2000 #372 'On the approval of the regulations on the assessment of the impact of the planned economic and other activity on the environment of the Russian Federation' requires that a number of permissions is granted the project before starting construction and operation of the heating plant.

According to Russian legislation, an industrial project needs a permission to go ahead with construction and operation. If the authorities have no special objections to the project, requirements and conditions will be standard. Only when construction works start shall the operator carry out an ecological expertise which need to be submitted to the authorities for approval. This expertise relates to ecological and epidemiological impacts, fire safety, social norms, as well as an assessment of positive effects on the environment and society and mitigation of any possible negative effects.

Before the start of the project implementation APPM received all the required conclusions of the state ecology examinations performed by the Natural Resource Committee of Arkhangelsk oblast, the Head Administration for Natural Resources and Environmental Protection of the Russian Ministry for Natural Resources in Arkhangelsk oblast, as well as of the Administration for Technology and Environmental Supervision in Arkhangelsk oblast.

Below you can see the estimations of the project impact on the natural environment.

Ambient air protection

Project implementation moves the APPM fuel balance towards the increase of the biomass share due to the decrease of the fuel oil share and slight increase of the coal share. This results in the decrease of greenhouse gas emissions into the atmosphere, as well as of most harmful substances of 2-4 danger categories.

Table F.1-1. represents the design data for changes in the amount of harmful substances thrown into the atmosphere on the project against the baseline. Estimations were fulfilled in compliance with the Engineering Documentation (ED) 34.02.305-98 „Definition methodology for the gross emissions of polluting substances into the atmosphere by TPP boiler units“.

Project implementation results in the reduction of sulphur dioxide emissions by 1925 t/year, carbon oxide by 221 t/year, nitrous dioxide by 210 t/year, nitrous oxide by 34 t/year but also in the increase of fluidised substance emissions by 689 t/year.

The decrease of the gross polluting substance emissions into the atmosphere for the whole project constitutes 1701 t/year.

Table F.1-1. Alterations in the harmful substance emissions into the atmosphere against the baseline (average for 2008-2012), t/year; (+) -increase, (-) -decrease)

Harmful emissions	Fuel oil	Coal	BWW	WSS	Total
Fluidised substances	-4	57	132	503	689
Sulphur dioxide (SO_2)	-2536	52	0	560	-1925
Nitrous dioxide (NO_2)	-255	13	22	10	-210
Nitrous oxide (NO)	-41	2	4	2	-34
Carbon oxide (CO)	-768	3	344	200	-221
Total emissions	-3604	128	501	1275	-1701

Water protection

The APPW industrial waste waters are discharged through a canal system into the external network of industrial sewerage system and further to biological cleaning facilities. The ash containing waters from scrubbers for wet boiler smoke fume cleaning are disposed into the same network.

Rain waters and household waste waters are disposed into corresponding external sewage networks.

The personnel number doesn’t increase upon the completion of the project implementation phase, the existing everyday facilities will be saved. Therefore, water consumption for household and drinking needs, as well as the output of household waste waters don’t change.

Setting up a new boiler #2 has neither positive nor negative influence on the water environment. There will be an indirect influence due to the reduction of BWW storing areas and, therefore, due to decreasing the pollution of storm and melt waters.

During the reconstruction of the boiler #1, there was a modern electrical filter set instead of the wet purification scrubbers. The ashes from the electrical filter are transported to the dump by trucks. Thereat, the disposal of mechanically cleaned water and the inflow of ash containing waters into the sewerage system decrease.

The consumption of mechanically cleaned water, as well as of production waste waters before and after setting the boiler #1 at TPP-3 are given in the Table F.1-2.

Table F.1-2. Water consumption before and after setting the boiler #1.
(data by CJSC Arkhgiprobum)

No.	Consumer description	Water consumption				Water disposal			
		Before the change of boiler unit №1		After changing b.u. set №1		Before the change of boiler unit №1		After changing b.u. set №1	
		m^3/h	m^3/day	m^3/h	m^3/day	m^3/h	m^3/day	m^3/h	m^3/day
1	Household disposal facilities	0.134	0.525	0.134	0.525	0.134	0.525	0.134	0.525
2	Household showers	1.0	3.0	1.0	3.0	1.0	3.0	1.0	3.0
3	Drinking aerated water	0.002	0.0315	0.002	0.0315	0.002	0.0315	0.002	0.0315
	Total:	1.136	3.56	1.136	3.56	1.136	3.56	1.136	3.56
1	Scrubbers for smoke fume wet purification	80	1920	40	960	80	1920	40	960
2	HAH canal wash	13	312	8.0	192	13	312	8.0	192
3	Boiler flux baths	17	408	8.5	204	17	408	8.5	204
4	Cooling for the mechanism bearings	2.5	60	3.0	72	2.5	60	3.0	72
5	Cooling for scraper conveyor	-	-	10	240	-	-	10	240
6	Injection to steam boilers	160	3840	160	3840	-	-	-	-
	Total of mechanic. purified water	112.5	2700	69.5	1668	112.5	2700	69.5	1668
	Total of water for production needs	272.5	6540	229.5	5508	**112.5**	2700	**69.5**	1668

The table demonstrates that the waste water dumping decreases by 112.5–69.5=43 m^3/h or by 344 000 t/year (for the boiler operating 8000 h/year).

Environmental protection in the process of waste storing

Before the modernization of the TPP-3 utilizing boilers #2 and #1, ashes from the wet scrubbers had been disposed into the plant industrial sewage system followed by rendering them to the cleaning facilities and, after mechanical dehydration, were taken to the APPM household dump together with other waste water sediments.

Since the project has been implemented, ashes from the boiler unit #2 have been disposed under the previous scheme, and the ashes from the boiler unit #2 equipped with electrical filter have been disposed to the dump by trucks. Thereat, it's planned to supply the local population with a part of the ashes from the electrical filter as a fertilizer.

It has been estimated that the project implementation leads to an increase in ash formation and, therefore, to an increase in its transportation to the industrial complex dump. Table F.1-3. demonstrates the data on the project influence on the amount of ashes, BWW and WWS disposed to the dump.

Table F.1-3. Changes in hard waste disposal to the dump according to the project against the baseline (average for 2008-2012), t/year

Description	Coal	BWW	WWS	Total
Amount of ashes delivered to the dump	+515	+2 830	+10 425	13 770
BWW disposed to the dump		-61 839		-61 839
WWS disposed to the dump, t a.d.m./year			-25 240	-25 240
Hard waste disposal to the dump				**-73 309**

As indicated in the table, the project results in an increase of ash disposal to the dump by 13 770 t/year with a simultaneous decrease in BWW disposal by 61 839 t/year and in WWS disposal by 25 240 t a.d.m./year. It could be conventionally considered that biomass becomes removed from the dump and a part of it returns to the same dump in the form of ashes.

As a result, the amount of hard industrial wastes disposed to the dump becomes decreased by 73 309 t/year.

General conclusion

The implementation of the project for additional biomass utilization at the Arkhangelsk Pulp and Paper Mill allows reducing harmful emissions from its activities into the environment. For instance:

- gross emissions of harmful substances into the atmosphere decrease by 1 701 t/year,
- the amount of hard wastes disposed to the dump decreases by 73 309 t/year,
- the amount of polluted waste water disposed decreases by 344 000 t/year.

The fundamental technical requirements correspond to the ecological requirements set by the legislation of the Russian Federation in the area of natural environment protection. The environmental impact rates are permissible.

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:

Section not needed.

SECTION G. Stakeholders' comments

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

No comments.

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ABBREVIATIONS

APPM - Arkhangelsk Pulp and Paper Mill

EIC - Environmental Investment Centre

CJSC - closed joint-stock company

OJSC - open joint-stock company

BWW - bark and wood waste

WWS - waste water sludge

WPS - wood preparation shop

FB - fibre board

GHG - greenhouse gas

MPE - Maximum permissible emissions of polluting substances into the atmosphere

TPP - thermal power plant

HP - high pressure

MP - medium pressure

RB - recovery boiler

PRC - pressure reducing cooler

ERU - emission reduction unit

t c.e. - ton of coal equivalent (1 t c.e. = 7 Gcal = 29.31 GJ)

t a.d.m. - tons of absolutely dry matter

Annex 1

CONTACT INFORMATION ON PROJECT PARTICIPANTS

Organisation:	Joint Stock Company “Arkhangelsk Pulp and Paper Mill” (JSC “APPM”)
Street/P.O.Box:	Melnikov str.
Building:	1
City:	Novodvinsk
State/Region:	Arkhangelsk Oblast
Postal code:	164900
Country:	Russia
Phone:	+7 (818 52) 6 32 02
Fax:	+7 (818 52) 6 32 31
E-mail:	info@appm.ru
URL:	www.appm.ru
Represented by:	
Title:	General director
Salutation:	Mr.
Last name:	Beloglazov
Middle name:	Ivanovich
First name:	Vladimir
Department:	
Phone (direct):	+7 (818 52) 6 32 02
Fax (direct):	
Personal e-mail:	Beloglazov.Vladimir@appm.ru

Organisation:	CAMCO International GmbH
Street/P.O.Box:	Burggasse
Building:	116
City:	1070 Wien
State/Region:	
Postal code:	
Country:	Austria
Phone:	+43 1 52520256
Fax:	f +43 1 52520266
E-mail:	
URL:	www.camco-international.com
Represented by:	
Title:	
Salutation:	Mr.
Last name:	Houston
Middle name:	
First name:	Arthur
Department:	
Phone (direct):	+43 1 525 20280
Fax (direct):	
Mobile:	+7 905 507 2293
Personal e-mail:	arthur.houston@camco-international.com

Annex 2

BASELINE INFORMATION

Annex 2.1.
Calculation module in Excel format *(attached as a separate file)*

JI project

Waste Biomass Utilization at Arkhangelsk Pulp and Paper Mill
(town of Novodvinsk, Russia)

Developed by: Environmental Investment Centre
Contact person: Alexander Samorodov
E-mail: samor@atnet.ru

Annex 2.2.
Forecast information for BWW formation at APPM

Specific chips consumption for pulping at cardboard production department		
SFA-1 (coniferous)	**4,4**	**dense m3/t**
NSSC (hardwood)	**2,6**	**dense m3/t**
average indicators for 2005		

Percentage of bark volume (of the amount of pulpwood without bark)		
coniferous	**9,5**	**%**
hardwood	**11,5**	**%**
Averaged data of Wood-Processing Facilities for various years		

Percentage of wood losses in DPS-4 (of the amount of pulpwood without bar		
coniferous	**2,8**	**%**
hardwood	**3,5**	**%**
taken from justification of building DPS-4		

Percentage of losses (sifted out) of chips delivered from outside			
	2,0	**%**	*according to the WPF data*

Density of BWW	*taken with accounting for actual data*	
	0,9	**t/dense m3**

Calculated amount of ready pulp chips from WPS-4

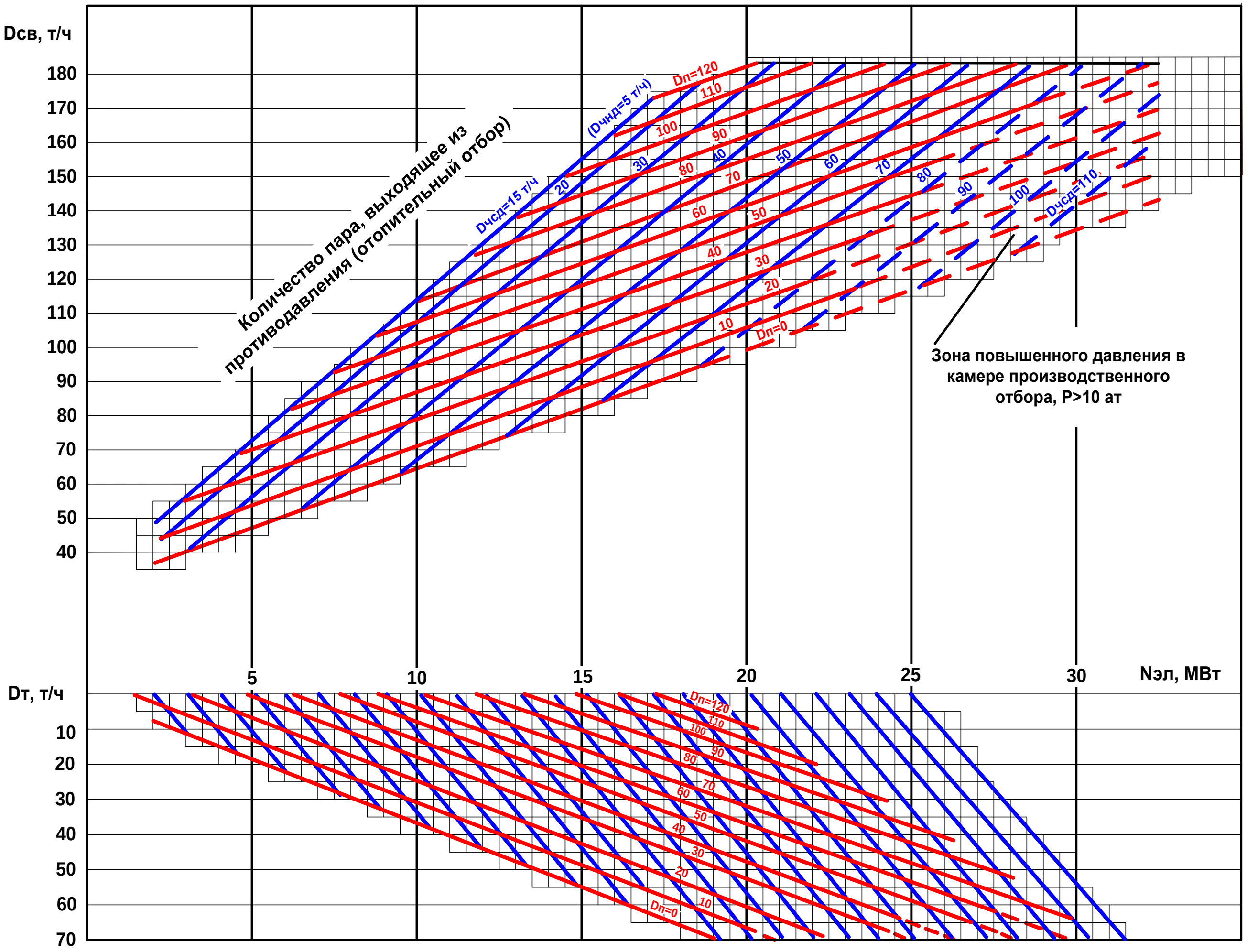
Name	Unit	2005	2006	2007	2008	2009	2010	2011	2012	
Output of ready chips	**dense m3**			**1 894 938**	**1 906 285**	**1 917 631**	**1 928 978**	**2 188 978**	**2 318 978**	
SFA-1 (coniferous)	dense m3			1 476 667	1 485 510	1 494 352	1 503 194	1 503 194	1 503 194	
NSSC (hardwood)	dense m3			418 270	420 775	423 279	425 784	685 784	815 784	
Chips produced at the mill	**dense m3**			**1 634 938**	**1 646 285**	**1 657 631**	**1 668 978**	**1 928 978**	**2 058 978**	excess of calculated output not more than 4%
SFA-1 (coniferous)	dense m3			1 229 667	1 238 510	1 247 352	1 256 194	1 256 194	1 256 194	
NSSC (hardwood)	dense m3			405 270	407 775	410 279	412 784	672 784	802 784	
Chips from outside	**dense m3**			**260 000**	**260 000**	**260 000**	**260 000**	**260 000**	**260 000**	it is necessary to observe contracts on supplies of chips from outside
SFA-1 (coniferous)	dense m3			247 000	247 000	247 000	247 000	247 000	247 000	
NSSC (hardwood)	dense m3			13 000	13 000	13 000	13 000	13 000	13 000	

Calculated total formation of BWW including bark

Name	Unit	2005	2006	2007	2008	2009	2010	2011	2012	
Formation (total)	**dense m3**	**660 125**	**662 860**	**559 854**	**563 374**	**566 894**	**570 414**	**610 828**	**631 036**	
WPS-2	dense m3	327 568	328 925	0	0	0	0	0	0	WPS-2 will be totally closed since 2007
WPS-3	dense m3	332 557	333 935	335 947	337 958	339 970	341 982	341 982	341 982	the amount of waste will grow in proportion to pulping at the Cellulose department
WPS-4	dense m3	0	0	223 908	225 416	226 924	228 432	268 847	289 054	WPS-4 supplies the Cardboard department only

Formation (total)	**t**	**585 057**	**596 574**	**503 869**	**507 037**	**510 205**	**513 373**	**549 746**	**567 932**

Annex 2.3.
Operation diagram for turbine PT-25-90/10 (VPT-25-4)



Annex 2.4.

Estimated reductions of methane emissions from landfill because of BWW and WWS anaerobic decay

Calculation of CO_2-equivalent emission reduction from BWW prevented from stockpiling or taken from stockpiles

General input data		
Conversion factor organic carbon to biogas (a)	1,87	m^3 biogas/kg carbon
GWP CH_4	21	
Density methane	0,654	kg/m^3
Methane concentration biogas	50%	
Half-life biomass (tau)	15	year
Decomposition constant (k)	0,046	$year^{-1}$
Generation factor (zeta)	0,77	
Methane oxidation factor	0,10	
Percentage of the stockpile under aerobic conditions	20%	

BWW - bark wood waste

LEGEND
db = dry basis
wb = wet basis
yellow cells = unprotected cells
red marks = comment field included

Spreadsheet model developed by:

BTG biomass technology group B.V.
P.O. Box 217
7500 AE Enschede
The Netherlands
tel: +31 53 4892897
fax: +31 53 4893116
email: office@btgworld.com
www.btgworld.com

Biomass specific input data	Biomass from stockpile	Fresh	
Organic carbon content (db)		50,0%	db
Moisture content		55%	wb
Organic carbon content (wb)	0,0%	22,5%	wb
Lignin fraction of C		0,25	

Year	Fresh biomass prevented from stockpiling or taken from stockpile			Year								
	Biomass from stockpile (ton$_w$)	Age of biomass (years)	Fresh (ton$_w$)	2004 ton CO2-eq	2005	2006	2007	2008	2009	2010	2011	2012
2004			0	0	0	0	0	0	0	0	0	0
2005			13 620		756	722	689	658	629	600	573	547
2006			54 597			3 031	2 894	2 763	2 639	2 519	2 406	2 297
2007			61 839				3 433	3 278	3 130	2 989	2 854	2 725
2008			61 839					3 433	3 278	3 130	2 989	2 854
2009			61 839						3 433	3 278	3 130	2 989
2010			61 839							3 433	3 278	3 130
2011			61 839								3 433	3 278
2012			61 839									3 433
2013												
2014												
2015												
2016												
2017												
2018												
2019												
Total	**0**		**439 249**									
	Total emission prevention			**0**	**756**	**3 753**	**7 016**	**10 133**	**13 108**	**15 949**	**18 662**	**21 252**

Calculation of CO_2-equivalent emission reduction from WWS prevented from stockpiling or taken from stockpiles

General input data		
Conversion factor organic carbon to biogas (a)	1,87	m^3 biogas/kg carbon
GWP CH_4	21	
Density methane	0,654	kg/m^3
Methane concentration biogas	50%	
Half-life biomass (tau)	15	year
Decomposition constant (k)	0,046	$year^{-1}$
Generation factor (zeta)	0,77	
Methane oxidation factor	0,10	
Percentage of the stockpile under aerobic conditions	20%	

WWS - waste water sludge

LEGEND

db = dry basis
wb = wet basis
yellow cells = unprotected cells
red marks = comment field included

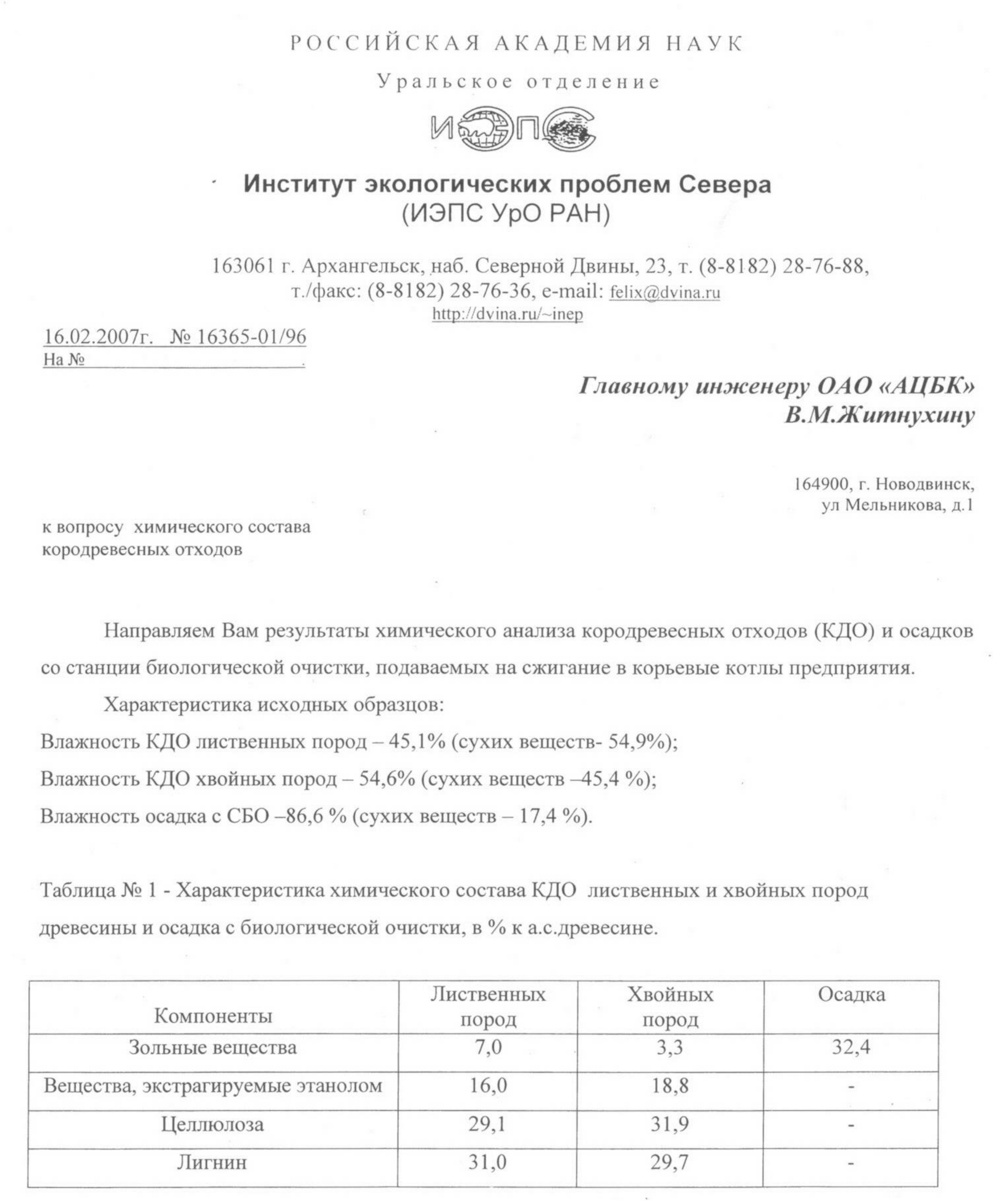
Spreadsheet model developed by:

BTG biomass technology group B.V.
P.O. Box 217
7500 AE Enschede
The Netherlands
tel: +31 53 4892897
fax: +31 53 4893116
email: office@btgworld.com
www.btgworld.com

Biomass specific input data	Biomass from stockpile	Fresh	
Organic carbon content (db)		34,0%	db
Moisture content		0%	wb
Organic carbon content (wb)	0,0%	34,0%	wb
Lignin fraction of C		0,25	

Year	Fresh biomass prevented from stockpiling or taken from stockpile			Year								
	Biomass from stockpile (ton$_w$)	Age of biomass (years)	Fresh (ton$_w$)	2004	2005	2006	2007	2008	2009	2010	2011	2012
				ton CO2-eq								
2004			0	0	0	0	0	0	0	0	0	0
2005			5 561		467	445	425	406	388	370	354	338
2006			22 284			1 869	1 785	1 704	1 627	1 554	1 484	1 417
2007			25 240				2 117	2 022	1 930	1 843	1 760	1 681
2008			25 240					2 117	2 022	1 930	1 843	1 760
2009			25 240						2 117	2 022	1 930	1 843
2010			25 240							2 117	2 022	1 930
2011			25 240								2 117	2 022
2012			25 240									2 117
2013												
2014												
2015												
2016												
2017												
2018												
2019												
Total	**0**		**179 287**									
	Total emission prevention			**0**	**467**	**2 315**	**4 328**	**6 250**	**8 085**	**9 837**	**11 510**	**13 108**

Annex 2.5.
Results of chemical analysis of BWW and WWS forming at APPM



РОССИЙСКАЯ АКАДЕМИЯ НАУК
Уральское отделение

Институт экологических проблем Севера
(ИЭПС УрО РАН)

163061 г. Архангельск, наб. Северной Двины, 23, т. (8-8182) 28-76-88,
т./факс: (8-8182) 28-76-36, e-mail: felix@dvina.ru
http://dvina.ru/~inep

16.02.2007г. № 16365-01/96
На №

Главному инженеру ОАО «АЦБК»
В.М.Житнухину

164900, г. Новодвинск,
ул Мельникова, д.1

к вопросу химического состава
кородревесных отходов

Направляем Вам результаты химического анализа кородревесных отходов (КДО) и осадков со станции биологической очистки, подаваемых на сжигание в корьевые котлы предприятия.

Характеристика исходных образцов:

Влажность КДО лиственных пород – 45,1% (сухих веществ- 54,9%);

Влажность КДО хвойных пород – 54,6% (сухих веществ –45,4 %);

Влажность осадка с СБО –86,6 % (сухих веществ – 17,4 %).

Таблица № 1 - Характеристика химического состава КДО лиственных и хвойных пород древесины и осадка с биологической очистки, в % к а.с.древесине.

Компоненты	Лиственных пород	Хвойных пород	Осадка
Зольные вещества	7,0	3,3	32,4
Вещества, экстрагируемые этанолом	16,0	18,8	-
Целлюлоза	29,1	31,9	-
Лигнин	31,0	29,7	-

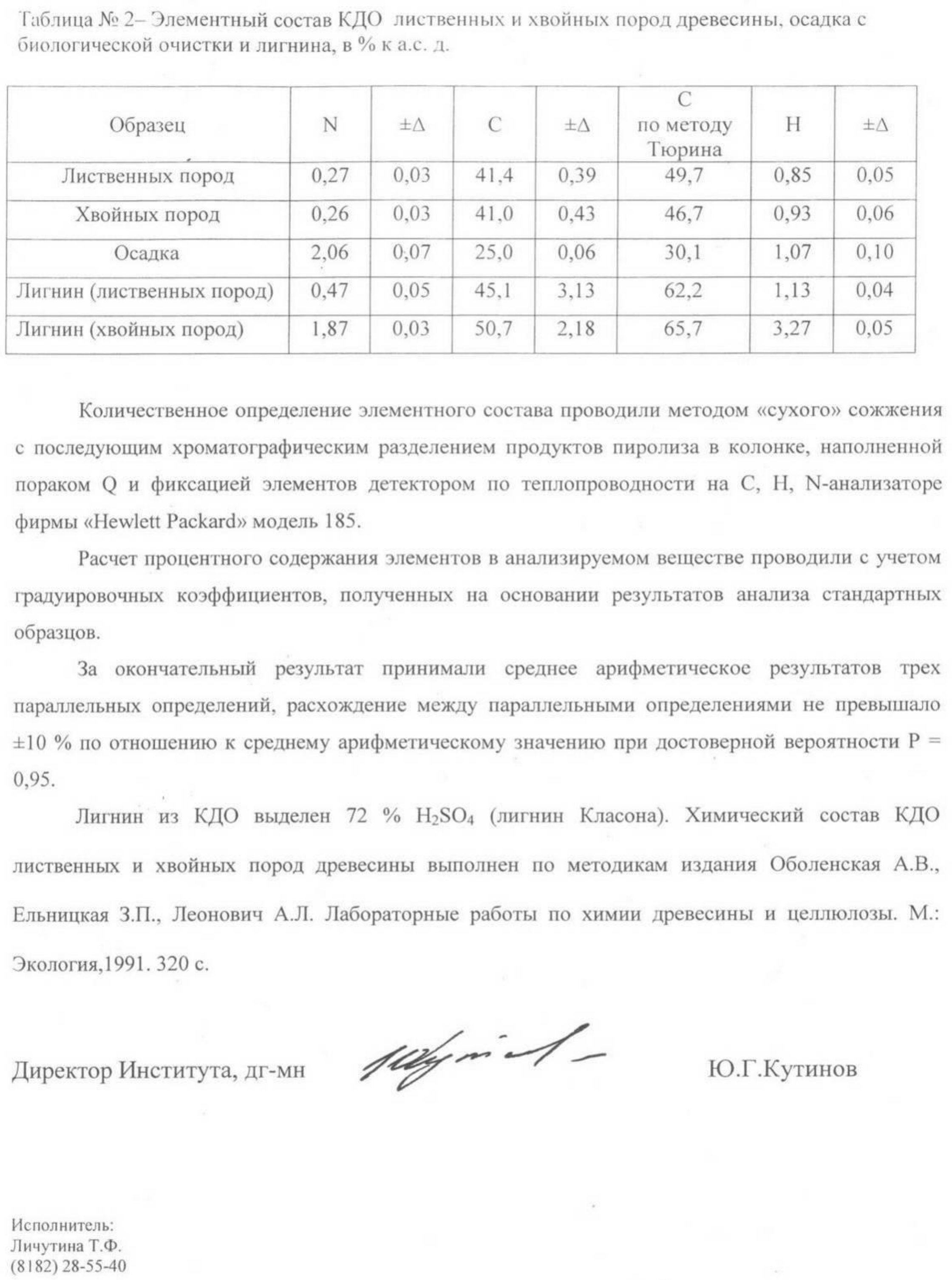


Таблица № 2– Элементный состав КДО лиственных и хвойных пород древесины, осадка с биологической очистки и лигнина, в % к а.с. д.

Образец	N	±Δ	C	±Δ	C по методу Тюрина	H	±Δ
Лиственных пород	0,27	0,03	41,4	0,39	49,7	0,85	0,05
Хвойных пород	0,26	0,03	41,0	0,43	46,7	0,93	0,06
Осадка	2,06	0,07	25,0	0,06	30,1	1,07	0,10
Лигнин (лиственных пород)	0,47	0,05	45,1	3,13	62,2	1,13	0,04
Лигнин (хвойных пород)	1,87	0,03	50,7	2,18	65,7	3,27	0,05

Количественное определение элементного состава проводили методом «сухого» сожжения с последующим хроматографическим разделением продуктов пиролиза в колонке, наполненной пораком Q и фиксацией элементов детектором по теплопроводности на C, H, N-анализаторе фирмы «Hewlett Packard» модель 185.

Расчет процентного содержания элементов в анализируемом веществе проводили с учетом градуировочных коэффициентов, полученных на основании результатов анализа стандартных образцов.

За окончательный результат принимали среднее арифметическое результатов трех параллельных определений, расхождение между параллельными определениями не превышало ±10 % по отношению к среднему арифметическому значению при достоверной вероятности P = 0,95.

Лигнин из КДО выделен 72 % H_2SO_4 (лигнин Класона). Химический состав КДО лиственных и хвойных пород древесины выполнен по методикам издания Оболенская А.В., Ельницкая З.П., Леонович А.Л. Лабораторные работы по химии древесины и целлюлозы. М.: Экология,1991. 320 с.

Директор Института, дг-мн Ю.Г.Кутинов

Исполнитель:
Личутина Т.Ф.
(8182) 28-55-40

RUSSIAN ACADEMY OF SCIENCE
Ural branch

Institute of Ecological Problems in the North
(IEPN UB RAS)

Naberezhnaya Severnoy Dviny, 23, Arkhangelsk, 163061, tel. (8-8182) 28-76-88,

tel./fax: (8-8182) 28-76-36, e-mail: felix@dvina.ru

http://dvina.ru/~inep

16.02.2007 No. 16365-01/96
To №

To: Chief engineer of OJSC«APPM»
V.M.Zhitnukhin

Melnikova Street, 1
Novodvinsk, 164900

Re: Chemical composition of bark and wood waste

We send you the results of chemical analysis of bark and wood waste (BWW) and sludge from the biological purification station that go for burning into bark boilers of the enterprise.

Characteristic of virgin samples:

Humidity of hardwood BWW – 45.1 % (dry substances – 54.9%);
Humidity of soft wood BWW – 54.6% (dry substances – 45.4 %);
Humidity of sludge from BPS – 86.6 % (dry substances – 17.4 %).

Table 1 - Characteristic of chemical composition of hardwood and soft wood bark and wood waste and sludge from the biological purification station, % to absolutely dry wood

Components	Hardwood	Soft wood	Sludge
Ash substances	7.0	3.3	32.4
Substances extractable by ethanol	16.0	18.8	-
Cellulose	29.1	31.9	-
Lignine	31.0	29.7	-

Table 2 - Elemental composition of hardwood and soft wood bark and wood waste and sludge from the biological purification station and lignine, % to absolutely dry wood

Sample	N	±Δ	C	±Δ	C according to the Tyurin method	H	±Δ
Hardwood	0.27	0.03	41.4	0.39	49.7	0.85	0.05
Soft wood	0.26	0.03	41.0	0.43	46.7	0.93	0.06
Sludge	2.06	0.07	25.0	0.06	30.1	1.07	0.10
Hardwood lignine	0.47	0.05	45.1	3.13	62.2	1.13	0.04
Soft wood lignine	1.87	0.03	50.7	2.18	65.7	3.27	0.05

Quantitative determination of elemental composition was performed with the method of “dry” burning with the further chromatographic separation of pyrolysis products in the column and elements fixing by thermal conduction detector in «Hewlett Packard» C, H, N-analyzer of model 185.

The calculation of elements percentage in the analyzed substance was performed taking into account calibration factors received on the basis of results of standard samples analysis.

Average arithmetic mean of the results of three parallel determinations with discrepancy between parallel determinations not exceeding ±10% with respect to average arithmetic mean with reliable probability P = 0.95 was assumed as final result.

Lignine from BWW is extracted by 72% H_2SO_4 (Klason lignine). Chemical composition of hardwood and soft wood bark and wood waste was performed according to methodologies in the edition Obolenskaya A.V., Elnitskaya Z.P., Leonovich A.L. Laboratory works on wood and cellulose chemistry. Moscow: Ecology, 1991. page 320.

Director of the Institute,

Doctor of Geomineralogical Science Y.G.Kutinov

Executor: Lichutina
(8182) 28-55-40

Annex 3

MONITORING PLAN

Annex 3.1.

Brief description of the quantitative and qualitative control methodologies for the fuel consumed by APPM stationary units

The data on fuel deliveries and combustion are controlled at different phases of its registration. Cooperation between the suppliers and the mill provides reliable control of the quantity and quality for the fuel supplied, which is registered in relevant documents (bills of lading, journals, etc.). Besides, fuel information can be checked by external controllers, for instance, those from the tax authorities. Therefore, the probability of intentional or accidental fuel data misrepresentation is minimal.

The plant has and continuously improves the automated dispatcher records management system (ADRMS), which allows controlling the work parameters of the main equipment in real-time operation mode including the control of liquid fuel consumption by different units. Also the system generates daily and monthly reports on the fuel consumption and stocks, which are later summarized into annual reports. However, some reports are still made manually.

The mill has its own laboratory for fuel quality control performing regular thermotechnical analysis of fuel oil, coal and waste wood samples. It defines such parameters as the low heat value, humidity, ash content, volatile matter output, sulphur content and some of the other. Carbon content is not defined. The combustion value shall be defined by means of combusting fuel samples in bomb calorimeters. The research of the combusted liquor thermotechnical characteristics is performed by external professional organizations (Arkhangelsk State Technical University), although the humidity and the content of many chemical substances are controlled by production laboratories for each shift.

The fuel quality control provides the opportunity of claiming the supplier in the events when the fuel has lower characteristics than those defined in the sales contract. Besides that, test data serve as the ground for defining the energy equivalent of the fuel combusted. Each fuel type is registered in separate journals reflecting all the information required. The measuring tools for fuel registration are checked regularly.

Let us review the registration issues for each fuel type in detail (see [R5] for the examples of fuel registration documents)

Coal

Coal is shipped in railway cars, thereat the supplier, weight and coal grade are registered for each batch. The inlet weighing involves weight bridge. The stored coal is missed and condensed. The geodetic measurement of stored coal volume is made periodically under the standard methodology.

Each batch includes a cover document indicating the supplier, shipping date, coal grade, weight in each car, as well as of the average thermotechnical parameters – humidity, ash content, sulphur content, high and low heat value, and volatile matter output.

The plant laboratory checks the coal characteristics indicated by the supplier with the sample analysis results registered in the specific journal. Sampling is made randomly.

The coal is taken from the warehouse into the receiving hoppers of the six coal dust boilers by conveyor. The conveyor route has special scales for operative measurement of coal consumption delivered to all the boilers. The amount of coal transported to each separate boiler isn't measured but, if required, it can be defined by reverse calculation based on the known values of the steam produced and the boiler efficiency factor or based on the rotation rates of the worm feeders.

The final definition of thermotechnical characteristics for the coal combusted shall be made by means of sample testing performed daily by a specific sampler set on the route of coal transportation to the boilers. Daily measurements are made only for humidity and ash content. The full coal analysis including the definition of the combustion heat, sulphur and volatile matter output is made once a week for the weighted average sample. Measurement results are registered in a separate journal. This journal's data are a ground for calculating the average characteristics of the total amount of the coal combusted during one month, one quarter or one year followed by the registration in the 6-tp form.

Fuel oil

The mill mainly combusts sulphurous and high-sulphurous furnace fuel oil of M40 and M100 brands. At the time, the plant operates two independent fuel oil units. One of them provides fuel oil preparation and feeding it to TPP-1 and to the 3rd mill site (TPP-3 and CKRI-3). Another fuel oil unit provides the 2nd site (TPP-2 and CKRI -2).

Fuel oil deliveries are made by railway tank cars, from which fuel oil is pumped into storages. Fuel oil level in tank cars and storages is measured with calibrated level meter, after which it becomes recalculated into volume and weight units according to specific tables. Fuel losses during the swap are virtually equal zero. Each fuel oil swap into storages is registered with the indication of the supplier data, shipping date, and fuel oil weight. The supplier attaches the certificate of fuel oil quality indicating the combustion heat, humidity, ash content, sulphur, viscosity, and flash temperature.

The mill laboratory performs input control of the parameters indicated for each batch received. All the certificate data and those from own tests are entered in a separate journal. Issuing from the own tests results, average monthly and annual fuel oil characteristics are calculated.

During the storage fuel oil is cleaned, heated and circulates continuously with the temperature of 70 °C. The fuel oil level in storages is measured at least twice a day. Boiler and furnace inlets are equipped with volume consumption gauges, the indications of which are used for the recalculation into mass units (provided the availability of fuel oil pressure and temperature). Individual consumption gauges are not provided for all the units but all of them have group appliances measuring fuel oil delivery to the groups of equipment similar in its characteristics and purposes (for instance, the group of wood boilers of TPP-1 is equipped with one fuel oil consumption gauge).

Bark and wood waste

The plant generates waste wood in the process of wood sawing and barking and during the production of pulp chips. The total waste wood are 16…22%, 9…12% of which are bark and the rest are beards and saw-mill.

WPS prepares the bark and wood waste for combustion before feeding to the TPP including its hacking and extraction.

The output of wood waste from each WPS is defined by the wood exchange production engineers according to the factors accepted under special methodologies and depending on the wood grade, type and regime of the barking and hacking equipment operations, method of the wood supply (river floating or shipping by land transports) and a number of other parameters.

The volume of the waste wood delivered by trucks is defined by weighing cars before and after unloading. The wood density is defined with the consideration of its humidity.

The wood waste humidity is measured for each batch delivered, as well as (occasionally) for the wastes transported by conveyor from WPS. The full analysis of the weighed average waste sample received from different sources, which includes the definition of the low heat value, ash and sulphur content, is usually performed in the end of each month. However, in many cases full tests are performed more often and separately for different waste types. Test results are entered into journals and serve as a basis for reckoning the average annual waste characteristics.

Liquors and other secondary combustible energy resources

The amount of the liquors combusted is controlled according to the indications of the volume consumption gauges locating in each RB's inlet. The measuring analysis of wetness, density and a number of chemical parameters is made at least once per shift. If the humidity and density are known, it's not too hard to recalculate the liquor amount into a.d.m. tons shown in the operational reports of the TPP-2 and TPP-3. Besides, the amount of the liquors combusted is compared with the material balance of the pulping-related processes.

The liquor combustion heat is not defined in the mill laboratory, therefore, the full liquor thermotechnical analysis is made by an external specialized organization approx. once a quarter.

Except for the sulphate and neutral-sulphite liquors, the secondary combustible energy resources generated during wood chemical procession into pulp are lignosulphonates (sulphite liquors), tall oil and sulphite soap.

Liquid gas

The amount of the liquid gas consumed is derived from accounting reports, where the number of gas cylinders is indicated. A standard cylinder includes 21 kg of gas. The factor of recalculation into equivalent fuel is taken as 1.57 t c.e. / ton.

Waste oil products

The amount of waste oil products combusted is defined through weighing or according to the volume of the reservoirs for their storage and transportation. We took its factor of recalculation into equivalent fuel as 1.37 t c.e. / ton.

Annex 3.2.

Information sources for the definition of greenhouse gas emissions by the plant

The application of the reckoning method for the definition of GHG emissions requires, except for emission factors, the availability of initial information on different types of the emission-related company operations.

As the control practice of Russian enterprises shows, the main volume of initial data may be derived from the official annual statistical statements compiled by the companies and submitted to the regional statistics committee. If a company doesn't compile some official statistical statements or if they don't include the information required, the internal company data should be used.

The available information sources mutually checking and supplementing each other allow obtaining a reliable volume of the data on company operations, which is the basis for performing reliable GHG emission control.

Let's briefly describe the main information sources (examples of filled-in APPM statistical forms are given in [R5], as well as in the Annexes 15 and 18 of this PDD).

Statistical form 6-tp „Data on the thermal power plant operations“

This form is compiled annually by all companies, which have thermal power plants on their balance sheets regardless of their property form and capacity level, as well as by district boiler plants and by the regional electric power companies.

The reports under this form include more detailed information of the thermal plant operations, such as the set electrical and heat capacity; data on the production of electrical and thermal energy; natural and equivalent fuel consumption date per fuel type (for coals – according to their fields and deposits) with the division for electric and heat energy output; specific fuel consumption per type of the energy output; annual weighed averages per each type of the fuel combusted and a number of other information.

In order to define fuel energy value (and its recalculation into tons of equivalent fuel), as a rule, power plants use the data of their own laboratory tests.

Reports under the 6-tp form are the most valuable and high-quality information sources on the fuel amount, taking into consideration that, as usual, the main part of all the GHG emissions from permanent combustion by a pulp and paper mill is produced exactly by thermo power plants. Besides that, data on the specific power consumption per type of energy output allow calculating the emission factors relating to the energy sold to the third parties.

Statistical form 11-ter „Data on the fuel, thermal power and electricity use“

This form demonstrates annual data on the electricity, heat and fuel consumed by the plant for different types of industrial operations, works, specific needs and operation types, as well as on energy consumption by the household sector. Besides that, there is the annex of "Data on the formation and use of secondary energy resources" to the 11-ter form.

The report includes power and fuel consumption, both gross and per product unit. Form 11-ter demonstrates fuel consumption in equivalent units for different types of hard, liquid and gaseous fuels. Separate lines include the fuel energy resources sold to households, fuel consumed as raw material and for non-fuel needs.

The form 11-ter-based reports are especially useful for controlling power consumption, combusted fuel consumption for both the plant as a whole and for separate technological operations and units. The corresponding lines on fuel consumption for electricity and heat production shall correspond to the data reported under the form 6-tp. The annex to the 11-ter form for secondary resources allows obtaining more specific types and amounts of the biomass combusted.

Statistical form 4-fuel „Data on the fuel balance, incomings and consumption“

The form is filled in by companies and organizations consuming fuel regardless of their legal and proprietorship form.

The report under this form includes information on the movement and consumption of all the fuel types in both natural and money equivalent expression, such as their balance by the year-beginning and end, receipt since the year-beginning; total consumption and in particular for household needs; amount of the fuel sold to households and other companies and organizations. The form is filled-in according to the data from financial statements.

The report under the 4-fuel form doesn't include any data on fuel consumption per production operation type (for instance, electricity generation), as well as on the fuel energy equivalent. It should be remembered that the fuel consumption indicated in this form includes possible fuel loses and consumption for non-fuel needs.

Due to this fact the 4-fuel form reports aren't the same information sources needed for the purposes of GG emission control as the reports under the forms of 6-tp and 11-ter are. Nevertheless, the form 4-fuel allows controlling the total fuel movement in the plant and may be a source of information for reckoning mobile unit GG emissions.

Statistical form 24-energy „Electricity balance, energy equipment structure and report on power plant (electricity generating unit) operations“

Reports under the form of 24-energy are annually compiled by industrial companies. This form indicates the amount of electricity produced and purchased, as well as its consumption per consumption type (by electric appliances for technology processes, electric engines, for lighting, for the power plant own needs, energy lost in plant networks, sold to third parties, etc.). Moreover, the main data on the electrical equipment structure and power are given.

In terms of the GHG emission control, this form can be used for detecting the electricity amount received from external networks, as well as for the specification of the electrical power sold to third parties.

Statistical form 1-tep „Data on the heat power supplied“

Form 1-tep compiled for one year gives data on the amount of heat supply split according to the types of the fuel consumed and of the capacity installed. The number of boilers and the length of the heat networks are given as well.

The information most useful for GHG control are the data on the heat power amount produced, received from third parties, sold total and to third parties in particular, heat losses. The total amount of the equivalent fuel consumed by heating sources is indicated too.

2-tp (wastes) „Data on the formation, use, sterilization, transportation and allocation of production and consumption wastes“

In the past, this form represented only the data on the toxic waste movements, and since 2002 it has been representing all the company wastes divided by types and danger categories. Some data on the waste dumps are represented as well.

This form can be used for controlling purposes due to its assistance in detecting the amount of wastes with organic content disposed to the dump during the year.

Internal information sources

Additional and detailed information on the fuel consumption and energy balance (in particular, for fuel distribution between small units) can be derived from the internal reports of the chief energy engineer and of separate TPPs.

Data on the amount of wastes with organic content disposed to the dump, on the waste water purification, etc. can be derived from annual reports of the plant environmental department.

Information on carbonate consumption in pulp production technology processes can be rendered by the production manager department.

In many cases, specific data can be received from the company accounting department.